Asserted Claim of '533 Patent	FitBit Charge HR
	Syncing your tracker data to your Fitbit account Once you've set up and started using Charge HR, you'll need to make sure it regularly transfers (syncs) its data to Fitbit so you can track your progress, see your exercise history, earn badges, analyze your sleep logs, and more on your Fitbit dashboard. A daily sync is recommended but not required. The Fitbit apps use Bluetooth Low Energy (BLE) technology to sync with your Fitbit tracker. Each time you open the app it will sync if the tracker is nearby, and the app will also sync periodically throughout the day if you have the all-day sync setting enabled. If you're running the Fitbit app on a Windows 10 PC that doesn't have Bluetooth, you'll need to make sure the tracker is connected to the computer. Fitbit Connect on a Mac® also uses Bluetooth for syncing (if available), otherwise you'll need to make sure your wireless sync dongle is plugged into the computer. You can force Fitbit Connect to sync at any time or it will happen automatically every 15 minutes if: • The tracker is within 20 feet of your computer. • The computer is powered on, awake, and connected to the internet. (Charge HR Manual, p. 4)

<table>
<tr><th>Asserted Claim of ’533 Patent</th><th>FitBit Charge HR</th></tr>
<tr><td></td><td>
Automatic tracking with Fitbit Charge HR
Your Charge HR has you covered day and night.

Tracking all-day stats
Your Charge HR automatically tracks the following all-day stats:
• Steps taken
• Current heart rate
• Distance covered
• Calories burned
• Floors climbed

In addition to the stats displayed on your Charge HR, the following stats are also tracked but shown only on your fitbit.com dashboard or in the Fitbit app:
• Detailed heart rate history, including time spent in heart rate zones
• Active minutes
• Hours slept and quality of sleep

To scroll through your stats simply press the button on the side of your Charge HR. You'll see the time followed by an icon and stat in turn. If you have an alarm set, your display will also show the next alarm time.


When you sync your Charge HR, your all-day stats are uploaded to your fitbit.com dashboard.

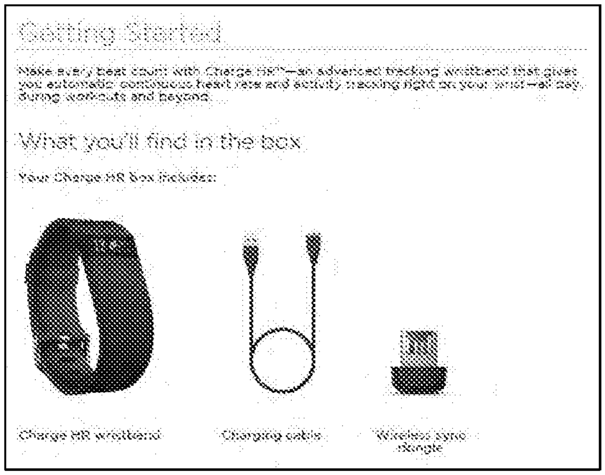
Your Charge HR starts tracking your stats for the next day at midnight based on your time zone. Though your stats reset to zero at midnight, this does not delete the previous day's data; that data will be uploaded to fitbit.com the next time you sync your tracker.

You can adjust your time zone at www.fitbit.com/user/profile/edit.
(Charge HR Manual, p. 8)
</td></tr>
</table>

Asserted Claim of '533 Patent	FitBit Charge HR
	Tracking sleep Your Charge HR automatically tracks the hours you sleep and your movement during the night to help you understand your sleep quality. You don't need to press any buttons or otherwise enter a "sleep mode" to begin tracking sleep. Simply wear your Charge HR to bed. To see your sleep data, sync your tracker and then view the fitbit.com dashboard or Fitbit app. On the dashboard you can look at the sleep tiles or go to Log > Sleep. In the Fitbit app, tap your sleep tile. If you choose, you can also set a goal for number of hours slept. (Charge HR Manual, p. 10) **Tracking Exercise with Fitbit Charge HR** Charge HR will automatically detect many exercises and record them in your exercise history using our SmartTrack™ feature. For more precision you can also tell your tracker when exercise starts and stops and see a workout summary right on your wrist. All workouts appear in your exercise history for deeper analysis and comparison. **Using SmartTrack** Our SmartTrack feature automatically recognizes and records select exercises to ensure you get credit for your most active moments of the day. When you sync your tracker after a SmartTrack-detected exercise, you can find several stats in your exercise history including duration, calories burned, impact on your day, and more. By default SmartTrack detects continuous movement at least 15 minutes in length. You can increase the minimum duration or disable SmartTrack for one or more exercise types. SmartTrack does not record more precise exercise stats. If you want to track a specific exercise with precise stats, you should use exercise mode on your Charge HR. For more information about customizing and using SmartTrack, see [illegible] (Charge HR Manual, p. 12)

Asserted Claim of '533 Patent	FitBit Charge HR
	Using exercise mode Exercise mode works similar to the trip mode on a car's odometer. For example, if you put your tracker in exercise mode and use an elliptical machine, you can view stats measured for that exercise, such as heart rate and calories burned. When you end exercise mode and sync your data, you'll see an entry for a "Workout" exercise on your dashboard. The entry provides a summary of the activity's stats as well as a minute-by-minute graph. To use exercise mode: 1. Press and hold the button until a stopwatch icon appears. Your tracker vibrates, the timer starts counting immediately, and elapsed time is shown. 2. To view stats being tracked during the exercise, press the button to advance through the stats, which appear in the following order: • Elapsed time • Current heart rate and heart rate zone • Calories burned • Steps taken • Distance covered • Floors climbed • Time of day 3. When you finish the activity, press and hold the button to end exercise mode. 4. Sync your tracker to see your exercise in your activity history. a. Click the Fitbit Connect icon located near the date and time on your computer. b. With your Charge HR nearby, click Sync Now. (Charge HR Manual, p. 12-13)

Asserted Claim of '533 Patent	FitBit Charge HR
	Managing your tracker from fitbit.com To manage your tracker from fitbit.com, click the gear icon in the top-right corner of the page and choose Settings from the left sidebar. Using the navigation tabs you can find and change a variety of settings: • Display Settings: Hide and show items to customize what you see on your tracker's OLED display. You can also drag items up and down to change the order in which they appear. • Daily Goal Progress: Choose which goal you want your Charge HR to track for you throughout the day. You can edit the value of this goal from the Fitbit app or on the fitbit.com dashboard. • Tap Gesture: If you want your Charge HR to respond to taps, choose which stat you want to appear when you double tap your device. • Clock Display: Choose from four different clock styles. • Dominant Hand: To get the most accurate data readings, choose which wrist you wear your tracker on. • Heart Rate Tracking: Specify Auto, On, or Off. The default setting of Auto is appropriate for most people. It indicates that the heart rate tracker is active when you're wearing your tracker and inactive when you're not. If there are times when your heart rate isn't being tracked even though you're wearing your Charge HR, you can choose On. If you aren't interested in heart rate tracking or want to maximize battery life, you can choose Off. • Sleep Tracking: Set the sensitivity of your sleep tracking by changing this setting. The Normal setting, which is the default, is appropriate for most people. If you are a sound sleeper, you can choose Sensitive to capture the smallest movements of your body. • Silent Alarms: Add, edit and delete silent alarms on your tracker. • Heart Rate Zones: Accept the default zones or specify a custom zone. You must sync your tracker to apply any changed settings. (Charge HR Manual, p. 17) **Memory** Charge HR holds detailed minute-by-minute information for the most recent 7 days and 30 days of daily summaries. Heart rate data is stored at one-second intervals when in exercise mode and at five-second intervals at all other times. Your recorded data consists of steps taken, distance traveled, calories burned, floors climbed, active minutes, heart rate, and sleep tracked. Sync your Charge HR regularly to have the most detailed data available to view on your fitbit.com dashboard. (Charge HR Manual, p. 20)
[13] A measurement system comprising	To the extent the preamble is limiting, FitBit Charge HR discloses and/or renders obvious "a measurement system." *See* CHART ONE: '533 Patent, Claim Element 5 above.

Asserted Claim of '533 Patent	FitBit Charge HR
[13A] a wearable measurement device for measuring one or more physiological parameters, including a light source comprising a plurality of semiconductor sources that are light emitting diodes, the light emitting diodes configured to generate an output optical beam with one or more optical wavelengths,	FitBit Charge HR discloses and/or renders obvious "a wearable measurement device for measuring one or more physiological parameters, including a light source comprising a plurality of semiconductor sources that are light emitting diodes, the light emitting diodes configured to generate an output optical beam with one or more optical wavelengths."  (Charge HR Manual, p. 1)

Asserted Claim of '533 Patent	FitBit Charge HR
	Wrist placement Your Charge HR should be worn on your wrist. While it may track stats such as steps and floors when placed in a pocket or backpack, it is most accurate on the wrist. For all-day wear, your Charge HR should usually rest a finger's width below your wrist bone and lay flat (as you'd normally wear a watch). As with all heart-rate tracking technology, whether a chest strap or a wrist-based sensor, accuracy is affected by personal physiology, location of wear, and type of movement. In other words, not every person will get a perfectly accurate reading with every type of exercise. For best heart rate accuracy keep these tips in mind: 1. Experiment with wearing the tracker higher on your wrist during exercise. Because blood flow in your arm increases the farther up you go, moving the tracker up a couple inches can improve the heart rate signal. Also, many exercises such as spinning cause you to bend your wrist frequently, which is more likely to interfere with the heart rate signal if the tracker is lower on your wrist. 2. Do not wear your tracker too tight; a tight band restricts blood flow, potentially affecting the heart rate signal. That being said, the tracker should also be slightly tighter (snug but not constricting) during exercise than during all-day wear. 3. With high-intensity interval training or other activities where your wrist is moving vigorously and non-rhythmically, the movement may prevent the sensor from finding an accurate heart rate. Similarly, with exercises such as weight lifting or rowing, your wrist muscles may flex in such a way that the band tightens and loosens during exercise. Try relaxing your wrist and staying still briefly (about 10 seconds), after which you should see an accurate heart rate reading. (Charge HR Manual, p. 5) **Sensors and motors** Your Charge HR uses a MEMS 3-axis accelerometer to measure your motion patterns and determine your steps taken, distance traveled, calories burned, and sleep quality. Charge HR also contains: • An altimeter, which measures floors climbed • A vibration motor, which allows it to vibrate when alarms go off, when you reach a goal, and when you receive call notifications • An optical heart rate tracker, which measures your beats per minute (BPM) at rest and when you are exercising (Charge HR Manual, p. 20) *See, e.g.*, U.S. Pat. No. 8,954,135 to Yuen et al. assigned to FitBit, Inc. and titled "Portable biometric devices and methods of operating same" (suggesting that FitBit's products use LEDs with multiple wavelengths to detect heart rate).
[13B] wherein at least a portion of the one or more optical	FitBit Charge HR discloses and/or renders obvious "wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers."

Asserted Claim of '533 Patent	FitBit Charge HR
wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers,	*See* CHART ONE: '533 Patent, Claim Element 5B above.
[13C] the light source configured to increase signal-to-noise ratio by increasing a light intensity from at least one of the plurality of semiconductor sources and by increasing a pulse rate of at least one of the plurality of semiconductor sources;	FitBit Charge HR discloses and/or renders obvious "the light source configured to increase signal-to-noise ratio by increasing a light intensity from at least one of the plurality of semiconductor sources and by increasing a pulse rate of at least one of the plurality of semiconductor sources." *See* CHART ONE: '533 Patent, Claim Element 5C above.
[13D] the wearable measurement device comprising a plurality of lenses configured to receive a portion of the output optical beam and to deliver an analysis output beam to a sample;	FitBit Charge HR discloses and/or renders obvious "the wearable measurement device comprising a plurality of lenses configured to receive a portion of the output optical beam and to deliver an analysis output beam to a sample." *See* CHART ONE: '533 Patent, Claim Element 5D above.
[13E] the wearable measurement device further comprising a receiver configured to receive and process at least a portion of the analysis output beam reflected or transmitted from the sample and to generate an output signal	FitBit Charge HR discloses and/or renders obvious "the wearable measurement device further comprising a receiver configured to receive and process at least a portion of the analysis output beam reflected or transmitted from the sample and to generate an output signal." *See* CHART ONE: '533 Patent, Claim Element 5E above.
[13F] wherein the wearable measurement device receiver is configured to be synchronized to pulses of the light source;	FitBit Charge HR discloses and/or renders obvious "wherein the wearable measurement device receiver is configured to be synchronized to pulses of the light source." *See* CHART ONE: '533 Patent, Claim Element 5F above.

Asserted Claim of '533 Patent	FitBit Charge HR
[13G] a personal device comprising a wireless receiver, a wireless transmitter, a display, a microphone, a speaker, one or more buttons or knobs, a microprocessor and a touch screen,	FitBit Charge HR discloses and/or renders obvious "a personal device comprising a wireless receiver, a wireless transmitter, a display, a microphone, a speaker, one or more buttons or knobs, a microprocessor and a touch screen." *See* CHART ONE: '533 Patent, Claim Element 5G above.
[13H] the personal device configured to receive and process at least a portion of the output signal,	FitBit Charge HR discloses and/or renders obvious "the personal device configured to receive and process at least a portion of the output signal, wherein the personal device is configured to store and display the processed output signal." *See* CHART ONE: '533 Patent, Claim Element 5H above.
[13I] wherein the personal device is configured to store and display the processed output signal, and	FitBit Charge HR discloses and/or renders obvious "wherein the personal device is configured to store and display the processed output signal." *See* CHART ONE: '533 Patent, Claim Element 5I above.
[13J] wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link; and	FitBit Charge HR discloses and/or renders obvious "wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link." *See* CHART ONE: '533 Patent, Claim Element 5J above.
[13K] a remote device configured to receive over the wireless transmission link an output status comprising the at least a portion of the processed output signal, to process the received output status to generate processed data and to store the processed data, and	FitBit Charge HR discloses and/or renders obvious "a remote device configured to receive over the wireless transmission link an output status comprising the at least a portion of the processed output signal, to process the received output status to generate processed data and to store the processed data." *See* CHART ONE: '533 Patent, Claim Element 5K above.

Asserted Claim of '533 Patent	FitBit Charge HR
[13L] wherein the remote device is capable of storing a history of at least a portion of the received output status over a specified period of time.	FitBit Charge HR discloses and/or renders obvious "wherein the remote device is capable of storing a history of at least a portion of the received output status over a specified period of time." *See* CHART ONE: '533 Patent, Claim Element 10 above.
[16] The system of claim 13, wherein the receiver is located a first distance from a first one of the plurality of light emitting diodes and a different, second distance from a second one of the plurality of light emitting diodes such that the receiver receives a first signal from the first light emitting diode and a second signal from the second light emitting diode.	FitBit Charge HR discloses and/or renders obvious "[t]he system of claim 13, wherein the receiver is located a first distance from a first one of the plurality of light emitting diodes and a different, second distance from a second one of the plurality of light emitting diodes such that the receiver receives a first signal from the first light emitting diode and a second signal from the second light emitting diode." *See* CHART ONE: '533 Patent, Claim Element 8 above.
[17] The system of claim 16, wherein the output signal is generated in part by comparing the first and second signals.	FitBit Charge HR discloses and/or renders obvious "[t]he system of claim 16, wherein the output signal is generated in part by comparing the first and second signals." *See* CHART ONE: '533 Patent, Claim Element 9 above.

EXHIBIT AA-2

U.S. Patent No. 9,757,040 vs FitBit Charge HR

Priority Date/Publication Date: between 2012 and 2014 Prior Art Status: §§ 102(a) and (b)

The FitBit Charge HR manufactured by FitBit ("FitBit Charge HR") anticipates the asserted claims of U.S. Patent No. 9,757,040 ("the '040 Patent") or renders those claims obvious alone and/or in view of at least any of the references identified in Apple's Obviousness Combinations Chart.

This chart is based on the following disclosures about the FitBit Charge HR:

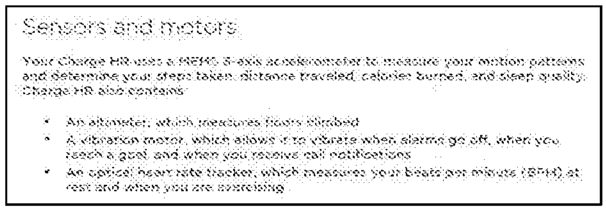
- FitBit Charge HR Product Manual Version 1.2 ("Charge HR Manual")

Discovery is ongoing, and Apple reserves the right to amend this chart based on new information about the FitBit Charge HR.

As set forth in Apple's Invalidity Contentions, the below contentions apply the prior art in part in accordance with Apple's assumption that Omni contends the claims are not invalid under 35 U.S.C. § 112. However, Apple's below contentions do not represent Apple's agreement or view as to the meaning, definiteness, written description support for, or enablement of any of the asserted claims. For each dependent claim, the disclosures cited for the claim from which it depends are incorporated by reference.

CHART TWO: U.S. Patent No. 9,757,040 vs FitBit Charge HR

Asserted Claim of '040 Patent	FitBit Charge HR
[1] A wearable device for use with a smart phone or tablet, the wearable device comprising:	To the extent the preamble is limiting, FitBit Charge HR discloses and/or renders obvious "[a] wearable device for use with a smart phone or tablet." *See* CHART ONE: '533 Patent, Claim Elements 5, 5G, and 13A above.
[1A] a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters	FitBit Charge HR discloses and/or renders obvious "a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters." *See* CHART ONE: '533 Patent, Claim Element 13A above.
[1B] the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an input optical beam having one or more optical wavelengths,	FitBit Charge HR discloses and/or renders obvious "the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an input optical beam having one or more optical wavelengths." Sensors and motors Your Charge HR uses a MEMS 3-axis accelerometer to measure your motion patterns and determine your steps taken, distance traveled, calories burned, and sleep quality. Charge HR also contains: • An altimeter, which measures floors climbed • A vibration motor, which allows it to vibrate when alarms go off, when you reach a goal, and when you receive call notifications • An optical heart rate tracker, which measures your beats per minute (BPM) at rest and when you are exercising (Charge HR Manual, p. 20) *See, e.g.*, U.S. Pat. No. 8,954,135 to Yuen et al. assigned to FitBit, Inc. and titled "Portable biometric devices and methods of operating same" (suggesting that FitBit's products use various modulation techniques).
[1C] wherein at least a portion of the one or more optical wavelengths is a near-infrared	FitBit Charge HR discloses and/or renders obvious "wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers."

Asserted Claim of '040 Patent	FitBit Charge HR
wavelength between 700 nanometers and 2500 nanometers;	*See* CHART ONE: '533 Patent, Claim Element 5B above.
[1D] the measurement device comprising one or more lenses configured to receive and to deliver a portion of the input optical beam to tissue, wherein the tissue reflects at least a portion of the input optical beam delivered to the tissue;	FitBit Charge HR discloses and/or renders obvious "the measurement device comprising one or more lenses configured to receive and to deliver a portion of the input optical beam to tissue, wherein the tissue reflects at least a portion of the input optical beam delivered to the tissue." *See* CHART ONE: '533 Patent, Claim Element 5D above.
[1E] the measurement device further comprising a reflective surface configured to receive and redirect at least a portion of light reflected from the tissue;	FitBit Charge HR discloses and/or renders obvious "the measurement device further comprising a reflective surface configured to receive and redirect at least a portion of light reflected from the tissue."  Sensors and motors Your Charge HR uses a MEMS 3-axis accelerometer to measure your motion patterns and determine your steps taken, distance traveled, calories burned, and sleep quality. Charge HR also contains: • An altimeter, which measures floors climbed • A vibration motor, which allows it to vibrate when alarms go off, when you reach a goal, and when you receive call notifications • An optical heart rate tracker, which measures your beats per minute (BPM) at rest and when you are exercising (Charge HR Manual, p. 20) *See, e.g.*, U.S. Pat. No. 8,954,135 to Yuen et al. assigned to FitBit, Inc. and titled "Portable biometric devices and methods of operating same" (suggesting that FitBit's products use reflective materials).
[1F] the measurement device further comprising a receiver configured to:	FitBit Charge HR discloses and/or renders obvious "the measurement device further comprising a receiver configured to: capture light while the LEDs are off and convert the captured light into a first signal and capture light while at least one of the LEDs is on and convert the captured light

Asserted Claim of '040 Patent	FitBit Charge HR
capture light while the LEDs are off and convert the captured light into a first signal and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the input optical beam reflected from the tissue;	into a second signal, the captured light including at least a portion of the input optical beam reflected from the tissue." Sensors and motors Your Charge HR uses a MEMS 3-axis accelerometer to measure your motion patterns and determine your steps taken, distance traveled, calories burned, and sleep quality. Charge HR also contains: • An altimeter, which measures floors climbed • A vibration motor, which allows it to vibrate when alarms go off, when you reach a goal, and when you receive call notifications • An optical heart rate tracker, which measures your beats per minute (BPM) at rest and when you are exercising (Charge HR Manual, p. 20) *See, e.g.*, U.S. Pat. No. 8,954,135 to Yuen et al. assigned to FitBit, Inc. and titled "Portable biometric devices and methods of operating same" (suggesting that FitBit's products use various modulation techniques).
[1G] the measurement device configured to improve a signal-to-noise ratio of the input optical beam reflected from the tissue by differencing the first signal and the second signal;	FitBit Charge HR discloses and/or renders obvious "the measurement device configured to improve a signal-to-noise ratio of the input optical beam reflected from the tissue by differencing the first signal and the second signal." Sensors and motors Your Charge HR uses a MEMS 3-axis accelerometer to measure your motion patterns and determine your steps taken, distance traveled, calories burned, and sleep quality. Charge HR also contains: • An altimeter, which measures floors climbed • A vibration motor, which allows it to vibrate when alarms go off, when you reach a goal, and when you receive call notifications • An optical heart rate tracker, which measures your beats per minute (BPM) at rest and when you are exercising (Charge HR Manual, p. 20) *See, e.g.*, U.S. Pat. No. 8,954,135 to Yuen et al. assigned to FitBit, Inc. and titled "Portable biometric devices and methods of operating same" (suggesting that FitBit's products use various modulation techniques).

Asserted Claim of '040 Patent	FitBit Charge HR
[1H] the light source configured to further improve the signal-to-noise ratio of the input optical beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs;	FitBit Charge HR discloses and/or renders obvious "the light source configured to further improve the signal-to-noise ratio of the input optical beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs." *See* CHART ONE: '533 Patent, Claim Element 5C above.
[1I] the measurement device further configured to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue; and	FitBit Charge HR discloses and/or renders obvious "the measurement device further configured to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue." *See* CHART ONE: '533 Patent, Claim Element 10 above.
[1J] the wearable device configured to communicate with the smart phone or tablet, the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a voice input module, a speaker, and a touch screen, the smart phone or tablet configured to receive and to process at least a portion of the output signal,	FitBit Charge HR discloses and/or renders obvious "the wearable device configured to communicate with the smart phone or tablet, the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a voice input module, a speaker, and a touch screen, the smart phone or tablet configured to receive and to process at least a portion of the output signal." *See* CHART ONE: '533 Patent, Claim Elements 5G and 5H above.
[1K] wherein the smart phone or tablet is configured to store and display the processed output signal, wherein at least a portion	FitBit Charge HR discloses and/or renders obvious "wherein the smart phone or tablet is configured to store and display the processed output signal, wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link."

Asserted Claim of '040 Patent	FitBit Charge HR
of the processed output signal is configured to be transmitted over a wireless transmission link.	*See* CHART ONE: '533 Patent, Claim Elements 5Iand 5J above.
[2] The wearable device of claim 1, wherein the receiver is configured to be synchronized to the modulation of the at least one of the LEDs.	FitBit Charge HR discloses and/or renders obvious "[t]he wearable device of claim 1, wherein the receiver is configured to be synchronized to the modulation of the at least one of the LEDs." *See* CHART ONE: '533 Patent, Claim Element 5F above.
[4] The wearable device of claim 1, wherein the receiver is located a first distance from a first one of the LEDs and a different distance from a second one of the LEDs such that the receiver can capture a third signal from the first LED and a fourth signal from the second LED, and wherein the output signal is generated in part by comparing the third and fourth signals.	FitBit Charge HR discloses and/or renders obvious "[t]he wearable device of claim 1, wherein the receiver is located a first distance from a first one of the LEDs and a different distance from a second one of the LEDs such that the receiver can capture a third signal from the first LED and a fourth signal from the second LED, and wherein the output signal is generated in part by comparing the third and fourth signals." *See* CHART ONE: '533 Patent, Claim Element 8 above.

EXHIBIT AA-3

U.S. Patent No. 9,861,286 vs FitBit Charge HR

Priority Date/Publication Date: between 2012 and 2014 Prior Art Status: §§ 102(a) and (b)

The FitBit Charge HR manufactured by FitBit ("FitBit Charge HR") anticipates the asserted claims of U.S. Patent No. 9,861,286 ("the '286 Patent") or renders those claims obvious alone and/or in view of at least any of the references identified in Apple's Obviousness Combinations Chart.

This chart is based on the following disclosures about the FitBit Charge HR:

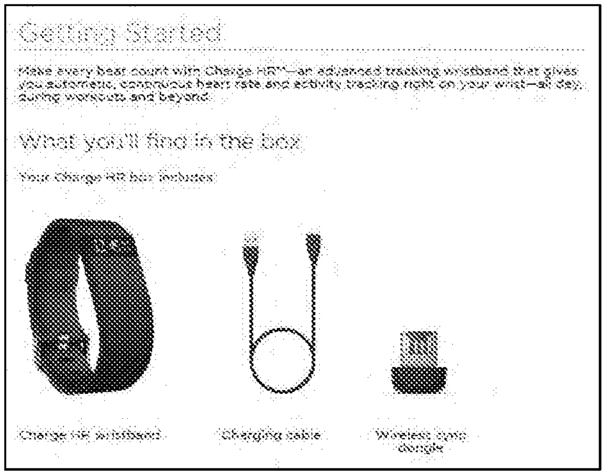
- FitBit Charge HR Product Manual Version 1.2 ("Charge HR Manual")

Discovery is ongoing, and Apple reserves the right to amend this chart based on new information about the FitBit Charge HR.

As set forth in Apple's Invalidity Contentions, the below contentions apply the prior art in part in accordance with Apple's assumption that Omni contends the claims are not invalid under 35 U.S.C. § 112. However, Apple's below contentions do not represent Apple's agreement or view as to the meaning, definiteness, written description support for, or enablement of any of the asserted claims. For each dependent claim, the disclosures cited for the claim from which it depends are incorporated by reference.

CHART THREE: U.S. Patent No. 9,861,286 vs FitBit Charge HR

Asserted Claim of '286 Patent	FitBit Charge HR
[16] A wearable device for use with a smart phone or tablet, the wearable device comprising:	To the extent the preamble is limiting, FitBit Charge HR discloses and/or renders obvious "[a] wearable device for use with a smart phone or tablet." *See* CHART ONE: '533 Patent, Claim Elements 5, 5G, and 13A above.
[16A] a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters,	FitBit Charge HR discloses and/or renders obvious "a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters." *See* CHART ONE: '533 Patent, Claim Element 13A above.
[16B] the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an optical beam having a plurality of optical wavelengths,	FitBit Charge HR discloses and/or renders obvious "the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an optical beam having a plurality of optical wavelengths." *See* CHART TWO: '040 Patent, Claim Element 1B above.
[16C] wherein at least a portion of the plurality of optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers;	FitBit Charge HR discloses and/or renders obvious "wherein at least a portion of the plurality of optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers." *See* CHART ONE: '533 Patent, Claim Element 5B above.
[16D] the measurement device comprising one or more lenses configured to receive and to deliver a portion of the optical beam to tissue, wherein the tissue reflects at least a portion of the	FitBit Charge HR discloses and/or renders obvious "the measurement device comprising one or more lenses configured to receive and to deliver a portion of the optical beam to tissue, wherein the tissue reflects at least a portion of the optical beam delivered to the tissue, and wherein the measurement device is adapted to be placed on a wrist or an ear of a user." *See* CHART ONE: '533 Patent, Claim Element 5D above.

Asserted Claim of '286 Patent	FitBit Charge HR
optical beam delivered to the tissue, and	
[16E] wherein the measurement device is adapted to be placed on a wrist or an ear of a user;	FitBit Charge HR discloses and/or renders obvious "wherein the measurement device is adapted to be placed on a wrist or an ear of a user."  Getting Started Make every beat count with Charge HR™—an advanced tracking wristband that gives you automatic, continuous heart rate and activity tracking right on your wrist—all day, during workouts and beyond. What you'll find in the box Your Charge HR box includes: Charge HR wristband Charging cable Wireless sync dongle (Charge HR Manual, p. 1)

Asserted Claim of '286 Patent	FitBit Charge HR
	Wrist placement Your Charge HR should be worn on your wrist. While it may track stats such as steps and floors when placed in a pocket or backpack, it is most accurate on the wrist. For all-day wear, your Charge HR should usually rest a finger's width below your wrist bone and lay flat (as you'd normally wear a watch). As with all heart-rate tracking technology, whether a chest strap or a wrist-based sensor, accuracy is affected by personal physiology, location of wear, and type of movement. In other words, not every person will get a perfectly accurate reading with every type of exercise. For best heart rate accuracy keep these tips in mind: 1. Experiment with wearing the tracker higher on your wrist during exercise. Because blood flow in your arm increases the farther up you go, moving the tracker up a couple inches can improve the heart rate signal. Also, many exercises such as spinning cause you to bend your wrist frequently, which is more likely to interfere with the heart rate signal if the tracker is lower on your wrist. 2. Do not wear your tracker too tight; a tight band restricts blood flow, potentially affecting the heart rate signal. That being said, the tracker should also be slightly tighter (snug but not constricting) during exercise than during all-day wear. 3. With high-intensity interval training or other activities where your wrist is moving vigorously and non-rhythmically, the movement may prevent the sensor from finding an accurate heart rate. Similarly, with exercises such as weight lifting or rowing, your wrist muscles may flex in such a way that the band tightens and loosens during exercise. Try relaxing your wrist and staying still briefly (about 10 seconds), after which you should see an accurate heart rate reading. (Charge HR Manual, p. 5)
[16F] the measurement device further comprising a receiver configured to: capture light while the LEDs are off and convert the captured light into a first signal and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the optical beam reflected from the tissue;	FitBit Charge HR discloses and/or renders obvious "the measurement device further comprising a receiver configured to: capture light while the LEDs are off and convert the captured light into a first signal and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the optical beam reflected from the tissue." *See* CHART TWO: '040 Patent, Claim Element 1F above.

Asserted Claim of '286 Patent	FitBit Charge HR
[16G] the measurement device configured to improve a signal-to-noise ratio of the optical beam reflected from the tissue by differencing the first signal and the second signal;	FitBit Charge HR discloses and/or renders obvious "the measurement device configured to improve a signal-to-noise ratio of the optical beam reflected from the tissue by differencing the first signal and the second signal." *See* CHART TWO: '040 Patent, Claim Element 1G above.
[16H] the light source configured to further improve the signal-to-noise ratio of the optical beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs;	FitBit Charge HR discloses and/or renders obvious "the light source configured to further improve the signal-to-noise ratio of the optical beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs." *See* CHART ONE: '533 Patent, Claim Element 5C above.
[16I] the measurement device further configured to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue; and	FitBit Charge HR discloses and/or renders obvious "the measurement device further configured to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue." *See* CHART ONE: '533 Patent, Claim Element 10 above.
[16J] wherein the receiver includes a plurality of spatially separated detectors,	FitBit Charge HR discloses and/or renders obvious "wherein the receiver includes a plurality of spatially separated detectors."

Asserted Claim of '286 Patent	FitBit Charge HR
	Sensors and motors Your Charge HR uses a MEMS 3-axis accelerometer to measure your motion patterns and determine your steps taken, distance traveled, calories burned, and sleep quality. Charge HR also contains: • An altimeter, which measures floors climbed • A vibration motor, which allows it to vibrate when alarms go off, when you reach a goal, and when you receive call notifications • An optical heart rate tracker, which measures your beats per minute (BPM) at rest and when you are exercising (Charge HR Manual, p. 20) *See, e.g.*, U.S. Pat. No. 8,954,135 to Yuen et al. assigned to FitBit, Inc. and titled "Portable biometric devices and methods of operating same" (suggesting that FitBit's products use photodetectors to receive signals).
[16K] wherein at least one analog to digital converter is coupled to the spatially separated detectors.	FitBit Charge HR discloses and/or renders obvious "wherein at least one analog to digital converter is coupled to the spatially separated detectors." Sensors and motors Your Charge HR uses a MEMS 3-axis accelerometer to measure your motion patterns and determine your steps taken, distance traveled, calories burned, and sleep quality. Charge HR also contains: • An altimeter, which measures floors climbed • A vibration motor, which allows it to vibrate when alarms go off, when you reach a goal, and when you receive call notifications • An optical heart rate tracker, which measures your beats per minute (BPM) at rest and when you are exercising (Charge HR Manual, p. 20) *See, e.g.*, U.S. Pat. No. 8,954,135 to Yuen et al. assigned to FitBit, Inc. and titled "Portable biometric devices and methods of operating same" (suggesting that FitBit's products use analog to digital converters).
[17] The wearable device of claim 16, wherein at least one LED emits at a first wavelength and at least another LED emits at a second wavelength, and wherein the first wavelength has a	FitBit Charge HR discloses and/or renders obvious "[t]he wearable device of claim 16, wherein at least one LED emits at a first wavelength and at least another LED emits at a second wavelength, and wherein the first wavelength has a first penetration depth into the tissue and wherein the second wavelength has a second penetration depth into the tissue different from the first penetration depth.."

Asserted Claim of '286 Patent	FitBit Charge HR
first penetration depth into the tissue and wherein the second wavelength has a second penetration depth into the tissue different from the first penetration depth.	Sensors and motors Your Charge HR uses a MEMS 3-axis accelerometer to measure your motion patterns and determine your steps taken, distance traveled, calories burned, and sleep quality. Charge HR also contains: • An altimeter, which measures floors climbed • A vibration motor, which allows it to vibrate when alarms go off, when you reach a goal, and when you receive call notifications • An optical heart rate tracker, which measures your beats per minute (BPM) at rest and when you are exercising (Charge HR Manual, p. 20) *See, e.g.*, U.S. Pat. No. 8,954,135 to Yuen et al. assigned to FitBit, Inc. and titled "Portable biometric devices and methods of operating same" (suggesting that FitBit's products use LEDs with multiple wavelengths to detect heart rate).
[19] The wearable device of claim 16, wherein the receiver is configured to be synchronized to the modulating of at least one of the LEDs.	FitBit Charge HR discloses and/or renders obvious "[t]he wearable device of claim 16, wherein the receiver is configured to be synchronized to the modulating of at least one of the LEDs." *See* CHART ONE: '533 Patent, Claim Element 5F above.
[20] The wearable device of claim 16, wherein the receiver is located a first distance from a first one of the LEDs and a different distance from a second one of the LEDs such that the receiver can capture a third signal from the first LED and a fourth signal from the second LED, and wherein the output signal is generated in part by comparing the third and fourth signals.	FitBit Charge HR discloses and/or renders obvious "[t]he wearable device of claim 16, wherein the receiver is located a first distance from a first one of the LEDs and a different distance from a second one of the LEDs such that the receiver can capture a third signal from the first LED and a fourth signal from the second LED, and wherein the output signal is generated in part by comparing the third and fourth signals.." *See* CHART ONE: '533 Patent, Claim Element 8 above.

EXHIBIT AA-4

U.S. Patent No. 9,885,698 vs FitBit Charge HR

Priority Date/Publication Date: between 2012 and 2014 Prior Art Status: §§ 102(a) and (b)

The FitBit Charge HR manufactured by FitBit ("FitBit Charge HR") anticipates the asserted claims of U.S. Patent No. 9,885,698 ("the '698 Patent") or renders those claims obvious alone and/or in view of at least any of the references identified in Apple's Obviousness Combinations Chart.

This chart is based on the following disclosures about the FitBit Charge HR:

- FitBit Charge HR Product Manual Version 1.2 ("Charge HR Manual")

Discovery is ongoing, and Apple reserves the right to amend this chart based on new information about the FitBit Charge HR.

As set forth in Apple's Invalidity Contentions, the below contentions apply the prior art in part in accordance with Apple's assumption that Omni contends the claims are not invalid under 35 U.S.C. § 112. However, Apple's below contentions do not represent Apple's agreement or view as to the meaning, definiteness, written description support for, or enablement of any of the asserted claims. For each dependent claim, the disclosures cited for the claim from which it depends are incorporated by reference.

CHART FOUR: U.S. Patent No. 9,885,698 vs FitBit Charge HR

Asserted Claim of '698 Patent	FitBit Charge HR
[1] A wearable device, comprising:	To the extent the preamble is limiting, FitBit Charge HR discloses and/or renders obvious "[a] wearable device." *See* CHART ONE: '533 Patent, Claim Elements 5 and 13A above.
[1A] a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters,	FitBit Charge HR discloses and/or renders obvious "a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters." *See* CHART ONE: '533 Patent, Claim Element 13A above.
[1B] the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an input optical beam having one or more optical wavelengths,	FitBit Charge HR discloses and/or renders obvious "the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an input optical beam having one or more optical wavelengths." *See* CHART TWO: '040 Patent, Claim Element 1B above.
[1C] wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers;	FitBit Charge HR discloses and/or renders obvious "wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers." *See* CHART ONE: '533 Patent, Claim Element 5B above.
[1D] the measurement device comprising one or more lenses configured to receive and to deliver a portion of the input optical beam to tissue, wherein	FitBit Charge HR discloses and/or renders obvious "the measurement device comprising one or more lenses configured to receive and to deliver a portion of the input optical beam to tissue, wherein the tissue reflects at least a portion of the input optical beam delivered to the tissue." *See* CHART ONE: '533 Patent, Claim Element 5D above.

Asserted Claim of '698 Patent	FitBit Charge HR
the tissue reflects at least a portion of the input optical beam delivered to the tissue;	
[1E] the measurement device further comprising a receiver, wherein the receiver includes a plurality of spatially separated detectors, the detectors configured to: capture light while the LEDs are off and convert the captured light into a first signal; and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the input optical beam reflected from the tissue;	FitBit Charge HR discloses and/or renders obvious "the measurement device further comprising a receiver, wherein the receiver includes a plurality of spatially separated detectors, the detectors configured to: capture light while the LEDs are off and convert the captured light into a first signal; and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the input optical beam reflected from the tissue." *See* CHART TWO: '040 Patent, Claim Element 1F and CHART THREE: '286 Patent, Claim Element 16J above.
[1F] wherein at least one analog to digital converter is coupled to the spatially separated detectors and is configured to generate at least a first data signal from the first signal and at least a second data signal from the second signal;	FitBit Charge HR discloses and/or renders obvious "wherein at least one analog to digital converter is coupled to the spatially separated detectors and is configured to generate at least a first data signal from the first signal and at least a second data signal from the second signal." *See* CHART TWO: '040 Patent, Claim Element 1F and CHART THREE: '286 Patent, Claim Element 16K above.

Asserted Claim of '698 Patent	FitBit Charge HR
[1G] the measurement device configured to improve a signal-to-noise ratio of the input optical beam reflected from the tissue by differencing the first data signal and the second data signal to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue; and	FitBit Charge HR discloses and/or renders obvious "the measurement device configured to improve a signal-to-noise ratio of the input optical beam reflected from the tissue by differencing the first data signal and the second data signal to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue." *See* CHART ONE: '533 Patent, Claim Element 10 and CHART TWO: '040 Patent, Claim Element 1G above.
[1H] wherein the modulating at least one of the LEDs has a modulation frequency, and wherein the receiver is configured to use a lock-in technique that detects the modulation frequency.	FitBit Charge HR discloses and/or renders obvious "wherein the modulating at least one of the LEDs has a modulation frequency, and wherein the receiver is configured to use a lock-in technique that detects the modulation frequency." Sensors and motors Your Charge HR uses a MEMS 3-axis accelerometer to measure your motion patterns and determine your steps taken, distance traveled, calories burned, and sleep quality. Charge HR also contains: • An altimeter, which measures floors climbed • A vibration motor, which allows it to vibrate when alarms go off, when you reach a goal, and when you receive call notifications • An optical heart rate tracker, which measures your beats per minute (BPM) at rest and when you are exercising (Charge HR Manual, p. 20) *See, e.g.*, U.S. Pat. No. 8,954,135 to Yuen et al. assigned to FitBit, Inc. and titled "Portable biometric devices and methods of operating same" (suggesting that FitBit's products use various modulation techniques).
[2] The wearable device of claim 1, wherein the plurality of LEDs and the plurality of spatially separated detectors are mounted on a common structure, and	FitBit Charge HR discloses and/or renders obvious "[t]he wearable device of claim 1, wherein the plurality of LEDs and the plurality of spatially separated detectors are mounted on a common structure, and wherein the plurality of LEDs are coupled electrically to a power supply.."

Asserted Claim of '698 Patent	FitBit Charge HR
wherein the plurality of LEDs are coupled electrically to a power supply.	Battery life and charging With normal use, your fully charged Charge HR should last up to five days before needing a charge. You can check the level of your battery by logging into fitbit.com and clicking the gear icon on the top-right corner of the page. Determining your current battery level When you press the button on your Charge HR to cycle through your stats, the first screen will show a low battery icon if there is approximately one day or less of battery life remaining. If you want to receive a mobile notification or email when your battery is low: 1. Log in to your fitbit.com dashboard. 2. Click the gear icon in the top-right corner of the page and select Settings. 3. Using the navigation tabs on the left, find Notifications and choose which ones you would like to receive. 4. Click Save. (Charge HR Manual, p. 6-7) Sensors and motors Your Charge HR uses a MEMS 3-axis accelerometer to measure your motion patterns and determine your steps taken, distance traveled, calories burned, and sleep quality. Charge HR also contains: • An altimeter, which measures floors climbed • A vibration motor, which allows it to vibrate when alarms go off, when you reach a goal, and when you receive call notifications • An optical heart rate tracker, which measures your beats per minute (BPM) at rest and when you are exercising (Charge HR Manual, p. 20) Battery Charge HR contains a rechargeable lithium-polymer battery. (Charge HR Manual, p. 20) *See, e.g.*, U.S. Pat. No. 8,954,135 to Yuen et al. assigned to FitBit, Inc. and titled "Portable biometric devices and methods of operating same" (suggesting that FitBit's products use LEDs with multiple wavelengths to detect heart rate).
[3] The wearable device of claim 1, wherein the light source is configured to further improve the	FitBit Charge HR discloses and/or renders obvious "[t]he wearable device of claim 1, wherein the light source is configured to further improve the signal-to-noise ratio of the input beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least

Asserted Claim of '698 Patent	FitBit Charge HR
signal-to-noise ratio of the input beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs, and wherein the receiver is configured to be synchronized to at least one of the LEDs.	one of the LEDs, and wherein the receiver is configured to be synchronized to at least one of the LEDs." *See* CHART ONE: '533 Patent, Claim Elements 5C and 5F above.
[5] The wearable device of claim 1, wherein the wearable device is configured to communicate with a smart phone or tablet, the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a voice input module, a speaker, and a touch screen, the smart phone or tablet configured to receive and to process at least a portion of the output signal, wherein the smart phone or tablet is configured to store and display the processed output signal, wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link.	FitBit Charge HR discloses and/or renders obvious "[t]he wearable device of claim 1, wherein the wearable device is configured to communicate with a smart phone or tablet, the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a voice input module, a speaker, and a touch screen, the smart phone or tablet configured to receive and to process at least a portion of the output signal, wherein the smart phone or tablet is configured to store and display the processed output signal, wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link." *See* CHART ONE: '533 Patent, Claim Elements 5G, 5H, 5I, and 5J above.

EXHIBIT B

EXHIBIT B-1

U.S. Patent No. 9,651,533 vs Rulkov

Priority Date/Publication Date:	October 4, 2011/May 8, 2012	Prior Art Status:	§§ 102(a), (b), and (e) (pre-AIA) §§ 102(a), (b), and (d)

U.S. Patent No. 8,172,761 to Rulkov et al. ("Rulkov") anticipates the asserted claims of U.S. Patent No. 9,651,533 ("the '533 Patent") or renders those claims obvious alone and/or in view of at least any of the references identified in Apple's Obviousness Combinations Chart.

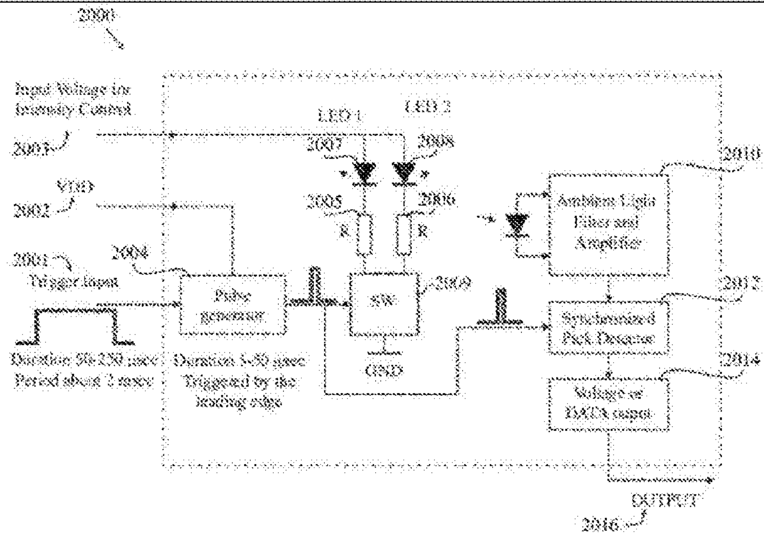
As set forth in Apple's Invalidity Contentions, the below contentions apply the prior art in part in accordance with Apple's assumption that Omni contends the claims are not invalid under 35 U.S.C. § 112. However, Apple's below contentions do not represent Apple's agreement or view as to the meaning, definiteness, written description support for, or enablement of any of the asserted claims. For each dependent claim, the disclosures cited for the claim from which it depends are incorporated by reference.

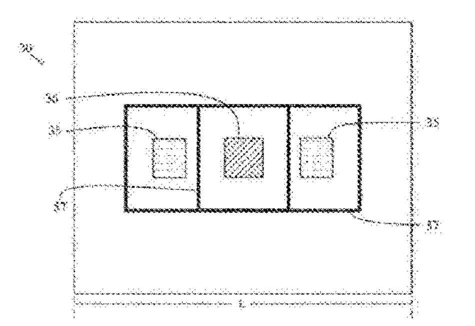
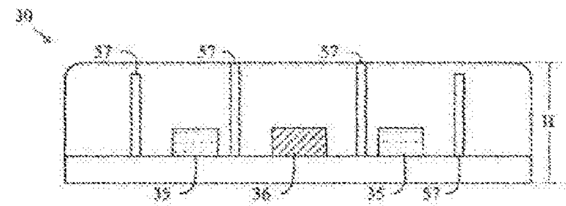
CHART ONE: U.S. Patent No. 9,651,533 vs Rulkov

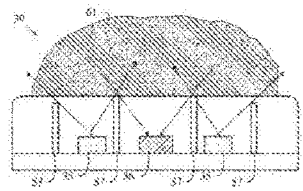
Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
[5] A measurement system, comprising:	To the extent the preamble is limiting, Rulkov discloses and/or renders obvious "[a] measurement system." "A monitoring device for monitoring the vital signs of a user is disclosed herein." Rulkov at Abstract. "The present invention is related to real-time vital sign monitoring devices. More specifically, the present invention relates to a device for monitoring a user's vital signs that is used in conjunction with a Smartphone." Rulkov at 1:42-45. "One aspect of the present invention is a method for monitoring a real-time vital sign of a user by using a signal from an optical sensor and a signal from a multiple axis accelerometer that generates an X-axis signal, a Y-axis signal and a Z-axis signal." Rulkov at 2:63-67. *See also* Rulkov at 3:3-27, 4:36-44, 48-60, Claims 1-4.
[5A] a light source comprising a plurality of semiconductor sources that are light emitting diodes, the light emitting diodes configured to generate an output optical beam with one or more optical wavelengths,	Rulkov discloses and/or renders obvious "a light source comprising a plurality of semiconductor sources that are light emitting diodes, the light emitting diodes configured to generate an output optical beam with one or more optical wavelengths." *See* CHART ONE: '533 Patent, Claim Element 13A below.
[5B] wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers,	Rulkov discloses and/or renders obvious "wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers." "Pulse oximeter devices typically contain two light emitting diodes: one in the red band of light (660 nanometers) and one in the infrared band of light (940 nanometers)." Rulkov at 1:53-55.

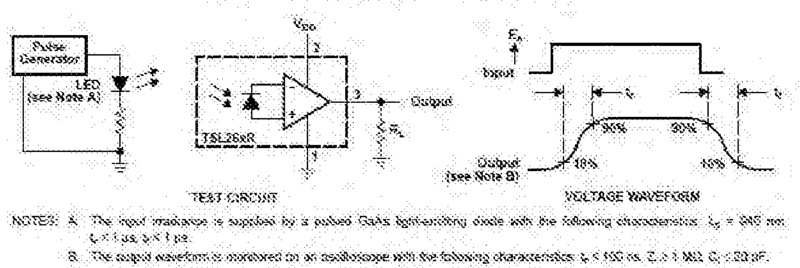
Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	"In a preferred embodiment, the optical sensor 30 is a plurality of light emitting diodes ("LED") 35 based on green light wherein the LEDs 35 generate green light (wavelength of 500-570 nm), and a photodetector 36 detects the green light. Yet in an alternative embodiment, the optical sensor 30 is a photodetector 36 and a single LED 35 transmitting light at a wavelength of approximately 900 nanometers as a pulsed infrared LED. Yet further, the optical sensor is a combination of a green light LED and a pulsed infrared LED to offset noise affects of ambient light and sunlight. As the heart pumps blood through the arteries in the user's arm, ankle or wrist, the photodetector 36, which is typically a photodiode, detects reflectance/transmission at the wavelengths (green, red or infrared), and in response generates a radiation-induced signal." Rulkov at 5:16-30.
[5C] the light source configured to increase signal-to-noise ratio by increasing a light intensity from at least one of the plurality of semiconductor sources and by increasing a pulse rate of at least one of the plurality of semiconductor sources;	Rulkov discloses and/or renders obvious "the light source configured to increase signal-to-noise ratio by increasing a light intensity from at least one of the plurality of semiconductor sources and by increasing a pulse rate of at least one of the plurality of semiconductor sources." "The light source 35 is preferably a plurality of LEDs 35. The intensity of the light is preferably controlled by an integrator 300." Rulkov at 9:64-66. "FIG. 17 is a preferred method 500 for controlling the light intensity of the optical sensor 30. At block 505, the light intensity of the light source 35 is monitored. At block 510, the sensor/photodetector is determined to be saturated by the light source. At block 515, the intensity of the light source is modified by adjusting the resistance and the flow of current to the light source 35. At block 520, the light intensity is again monitored and adjusted if necessary. In a preferred embodiment, this automatic gain mechanism prevents the green light from overwhelming the photodetector 36 thereby maintaining an accurate reading no matter where the optical sensor is placed on the user." Rulkov at 11:20-31. "FIG. 16 illustrates how the control mechanism operates to maintain a proper light intensity. As the signal reaches the upper limit, the photodetector becomes saturated and the processor lowers the current flow, which results in a break in the signal. Then as the signal is lowered it becomes too low and the processor increases the light intensity resulting in a break in the signal." Rulkov at 11:32-38.

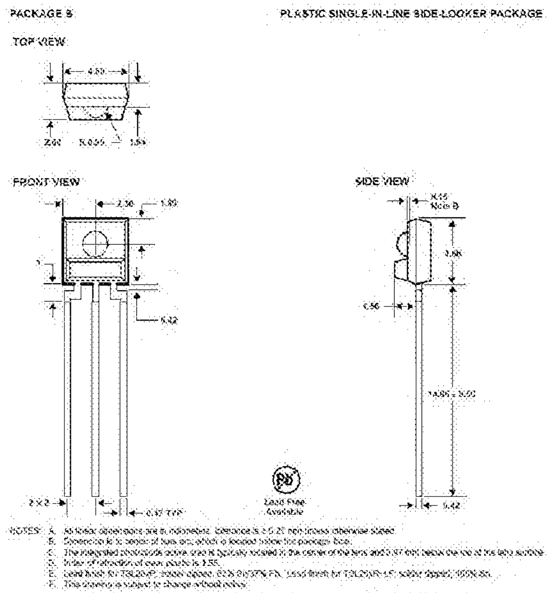
Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	"The microprocessor 741 has a LED control 715 connected to DAC 702 for controlling the intensity of the LEDs 737." Rulkov at 11:43-45. "The use of short-term pulses reduces ambient light. In the preferred embodiment, voltage is collected at the sensor output every 2 msec. Inside the microprocessor 741, an average 8 consecutive samples improve the SNR (signal to noise ratio) and then work with the averaged numbers. Therefore the sampling rate for raw data is preferably 2 msec, however if 8-samples averaging is utilized in the integrated sensor the data output rate is reduced to sending a new averaged value every 16 msec. An ADC is used with a 12-bit resolution. The response of TSL 12T is acceptable. 100 Hz is the low limit for LPF cutoff. The selection of pulse duration is preferably based on the speed of the LED drivers, sensor electronics and output pick detection. The higher the low frequency cutoff that is implemented for the selected pulse duration, the better SNR." Rulkov at 13:11-25.

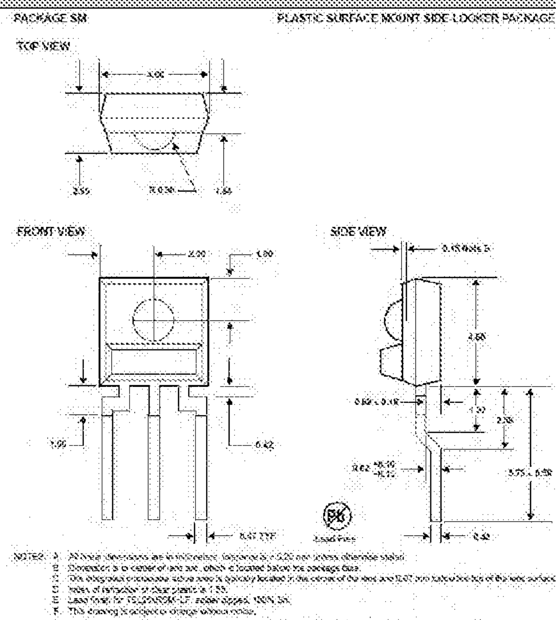
Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	 FIG. 12 *See also* Rulkov, Figs. 16-18.
[5D] an apparatus comprising a plurality of lenses configured to receive a portion of the output optical beam and to deliver an analysis output beam to a sample	Rulkov discloses and/or renders obvious "an apparatus comprising a plurality of lenses configured to receive a portion of the output optical beam and to deliver an analysis output beam to a sample."

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	 FIG. 9 Rulkov at Fig. 9.  FIG. 10 Rulkov at Fig. 10.

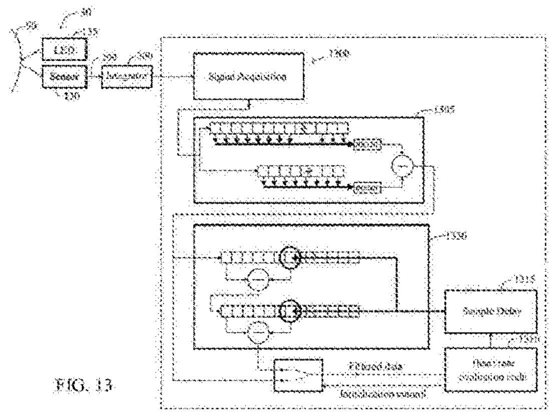
Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	 FIG. 11 Rulkov at Fig. 11. Rulkov discloses the use of specific types of LEDs, namely TSL261, TSL261R, and TSL245R, "A preferred optical sensor 30 utilizing green light is a TRS1755 sensor from TAOS, Inc of Plano Tex. The TRS1755 comprises a green LED light source (567 nm wavelength) and a light-to-voltage converter. The output voltage is directly proportional to the reflected light intensity. Another preferred photodetector 36 is a light-to-voltage photodetector such as the TSL260R and TSL261, TSL261R photodetectors available from TAOS, Inc of Plano Tex. Alternatively, the photodetector 130 is a light-to-frequency photodetector such as the TSL245R, which is also available from TAOS, Inc. The light-to-voltage photodetectors have an integrated transimpedance amplifier on a single monolithic integrated circuit, which reduces the need for ambient light filtering. The TSL261 photodetector preferably operates at a wavelength greater than 750 nanometers, and optimally at 940 nanometers, which would preferably have a LED that radiates light at those wavelengths." Rulkov at 5:31-47. "A general method is as follows. The light source 35 transmits light through at least one artery of the user. The photodetector 36 detects the light." Rulkov at 6:52-54. "FIG. 11 is an isolated cross section view of an optical sensor for a monitoring device with light reflecting off of an artery of a user." Rulkov at 3:61-63.

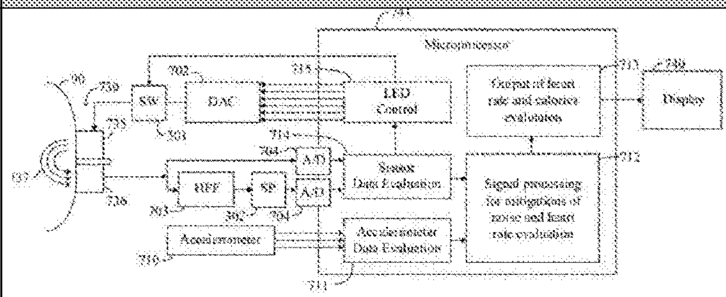
Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	"The optical sensor 730 is placed on or near an artery 90 of a user of the monitoring device 20. The optical sensor 730 is has a pair of LEDs 735 and a photodetector 736, which receives reflected light 737 from the LEDs 735." Rulkov at 11:40-43. Rulkov specifically provides that its system can use a sensor made by TAOS, Inc., such as the TSL260R, TSL261, and TSL261R. Rulkov, 5:31-46. Therefore, the features and properties of the TSL260R, TSL261, and TSL261R are inherently disclosed in Rulkov. The TAOS TSL260 Datasheet ("TAOS") describes the properties and features of the TSL optical sensors. Exemplary passages from TAOS are set forth below. TAOS "The TSL260R, TSL261R, and TSL262R are infrared light-to-voltage optical sensors, each combining a photodiode and a transimpedance amplifier (feedback resistor = 16 MW, 8 MW, and 2.8 MW respectively) on a single monolithic IC. Output voltage is directly proportional to the light intensity (irradiance) on the photodiode. These devices have improved amplifier offset-voltage stability and low power consumption and are supplied in a 3-lead plastic sidelooker package with an integral visible light cutoff filter and lens. When supplied in the lead (Pb) free package, the device is RoHS compliant." TAOS, 1. PARAMETER MEASUREMENT INFORMATION  Figure 1. Switching Times TAOS, 4.

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	"The TSL260R, TSL261R, and TSL262R are supplied in a clear 3-lead through-hole package with a molded lens. The integrated photodiode active area is typically 1,0 mm2 (0.0016 in2) for TSL260R, 0,5 mm2 (0.00078 in2) for the TSL261R, and 0,26 mm2 (0.0004 in2) for the TSL262R." TAOS, 10.  Figure 13. Package 8 — Single-In-Line Side-Looker Package Configuration TAOS, 10.

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	 Figure 14. Package SM — Surface Mount Side-Looker Package Configuration TAOS, 11.
[5E] a receiver configured to receive and process at least a portion of the analysis output beam reflected or transmitted from the sample and to generate an output signal,	Rulkov discloses and/or renders obvious "a receiver configured to receive and process at least a portion of the analysis output beam reflected or transmitted from the sample and to generate an output signal."

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	"The optical sensor 30 preferably comprises a photodetector 36, and first and second LEDs 35 which transmit light. Using two LEDs on each side of a photodetector creates a more mechanically stable optical sensor 30." Rulkov at 6:21-25. "A general method is as follows. The light source 35 transmits light through at least one artery of the user. The photodetector 36 detects the light." Rulkov at 6:52-54. "A preferred optical sensor 30 utilizing green light is a TRS1755 sensor from TAOS, Inc of Plano Tex. The TRS1755 comprises a green LED light source (567 nm wavelength) and a light-to-voltage converter. The output voltage is directly proportional to the reflected light intensity. Another preferred photodetector 36 is a light-to-voltage photodetector such as the TSL260R and TSL261, TSL261R photodetectors available from TAOS, Inc of Plano Tex. Alternatively, the photodetector 130 is a light-to-frequency photodetector such as the TSL245R, which is also available from TAOS, Inc. The light-to-voltage photodetectors have an integrated transimpedance amplifier on a single monolithic integrated circuit, which reduces the need for ambient light filtering. The TSL261 photodetector preferably operates at a wavelength greater than 750 nanometers, and optimally at 940 nanometers, which would preferably have a LED that radiates light at those wavelengths." Rulkov at 5:31-47. "A block diagram for vital sign signal processing is shown in FIG. 18. The optical sensor 730 is placed on or near an artery 90 of a user of the monitoring device 20. The optical sensor 730 has a pair of LEDs 735 and a photodetector 736, which receives reflected light 737 from the LEDs 735. The microprocessor 741 has a LED control 715 connected to DAC 702 for controlling the intensity of the LEDs 737. The signal from the photodetector 736 is transmitted to a high pass filter (HPF) 703 which sends it to an analog to digital converter 704, and the signal from the photodetector 737 is also sent directly to a second analog to digital converter 704." Rulkov at 11:39-49. "A microprocessor processes the signal generated from the optical sensor 30 to generate the plurality of vital sign information for the user which is displayed on the display member 40." Rulkov at 6:1-4.

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	 FIG. 13 Rulkov at Fig. 13.

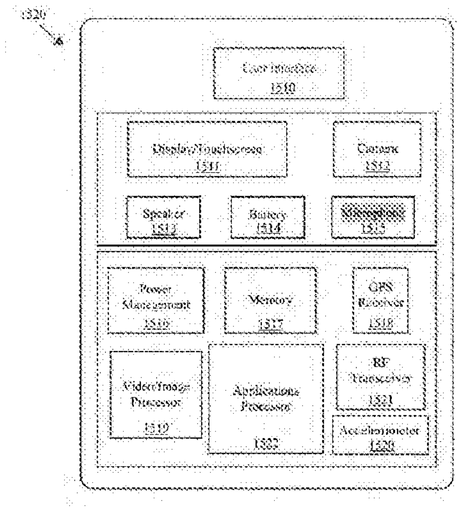
Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	 FIG. 18 Rulkov at Fig. 18. *See also* Rulkov at 9:60-10:31, 11:12-17, 11:39-60, 13:34-42, Claim 1.
[5F] wherein the receiver is configured to be synchronized to the light source;	Rulkov discloses and/or renders obvious "wherein the receiver is configured to be synchronized to the light source." "The preferred embodiment uses 250 microsecond LED pulses and a 12T photodetector 36 with second order active high pass filter (100 Hz cutoff). The DC output of the sensor 30 is monitored to ensure that it is not saturated by the effects of ambient light. The use of short-term pulses reduces ambient light. In the preferred embodiment, voltage is collected at the sensor output every 2 msec. Inside the microprocessor 741, an average 8 consecutive samples improve the SNR (signal to noise ratio) and then work with the averaged numbers. Therefore the sampling rate for raw data is preferably 2 msec, however if 8-samples averaging is utilized in the integrated sensor the data output rate is reduced to sending a new averaged value every 16 msec. An ADC is used with a 12-bit resolution. The response of TSL 12T is acceptable. 100 Hz is the low limit for LPF cutoff. The selection of pulse duration is preferably based on the speed of the LED drivers, sensor

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	electronics and output pick detection. The higher the low frequency cutoff that is implemented for the selected pulse duration, the better SNR." Rulkov at 13:6-25. "Ambient light filter and amplifier 2010 transits to synchronized pick detector 2012 for a voltage or data output 2014 as an output signal 2016." Rulkov at 13:40-42. "The output voltage is directly proportional to the reflected light intensity. The signal 299 is sent to the microprocessor. At block 1300, the signal acquisition is performed. In reference to FIGS. 14 and 15, in the pulse mode the LED 35 is periodically activated for short intervals of time by a signal from the microcontroller. The reflected pulse of light is received by the sensor, with the generation of a voltage pulse having an amplitude proportional to the intensity of the reflected light." Rulkov at 10:2-9. "At block 1305, a band pass filter is implemented preferably with two sets of data from the analog-to-digital converter. At block 1305, an average of the values of data samples within each of a first set of samples is calculated by the microprocessor. For example, the values of data samples within forty-four samples are summed and then divided by forty-four to generate an average value for the first set of samples. Next, an average of the values of data samples within a second set of samples is calculated by the microprocessor. For example, the values of data samples within twenty-two samples are summed and then divided by twenty-two to generate an average value for the second set of samples. Preferably, the second set of samples is less than the first set of samples. Next, the average value of the second set of samples is subtracted from the average value for the first set of samples to generate a first filtered pulse data value." Rulkov at 10:32-47. "The preferred embodiment uses 250 microsecond LED pulses and a 12T photodetector 36 with second order active high pass filter (100 Hz cutoff). The DC output of the sensor 30 is monitored to ensure that it is not saturated by the effects of ambient light. The use of short-term pulses reduces ambient light. In the preferred embodiment, voltage is collected at the sensor output every 2 msec. Inside the microprocessor 741, an average 8 consecutive samples improve the SNR (signal to noise ratio) and then work with the averaged numbers. Therefore the sampling rate for raw data is preferably 2 msec, however if 8-samples averaging is utilized in the integrated sensor the data output rate is reduced to sending a new averaged value every 16 msec. An ADC is used

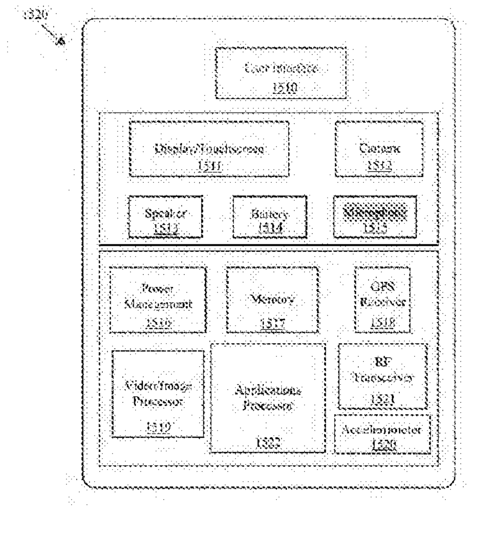
Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	with a 12-bit resolution. The response of TSL 12T is acceptable. 100 Hz is the low limit for LPF cutoff. The selection of pulse duration is preferably based on the speed of the LED drivers, sensor electronics and output pick detection. The higher the low frequency cutoff that is implemented for the selected pulse duration, the better SNR." Rulkov at 13:6-25.
[5G] a personal device comprising a wireless receiver, a wireless transmitter, a display, a microphone, a speaker, one or more buttons or knobs, a microprocessor and a touch screen,	Rulkov discloses and/or renders obvious "a personal device comprising a wireless receiver, a wireless transmitter, a display, a microphone, a speaker, one or more buttons or knobs, a microprocessor and a touch screen." "A monitoring device for monitoring the vital signs of a user is disclosed herein." Rulkov at Abstract. "The present invention is related to real-time vital sign monitoring devices. More specifically, the present invention relates to a device for monitoring a user's vital signs that is used in conjunction with a Smartphone." Rulkov at 1:42-45. "FIG. 26 is an illustration of a system including a monitoring device and a mobile phone which receives a signal from the monitoring device." Rulkov at 4:23-27. "The monitoring device 20 alternatively has a short-range wireless transceiver which is preferably a transmitter operating on a wireless protocol, e.g. BLUETOOTH, part-15, or 802.11. "Part-15" refers to a conventional low-power, short-range wireless protocol, such as that used in cordless telephones. Other communication protocols include a part 15 low power short range radio, standard BLUETOOTH or BLUETOOTH Low Energy to conserve power or other low power short range communications means. The short-range wireless transmitter (e.g., a BLUETOOTH transmitter) receives information from the microprocessor and transmits this information in the form of a packet through an antenna. An external laptop computer or hand-held device features a similar antenna coupled to a matched wireless, short-range receiver that receives the packet. In certain embodiments, the hand-held device is a cellular telephone with a Bluetooth circuit integrated directly into a chipset used in the cellular telephone. In this case, the cellular telephone may include a software application that receives, processes, and displays the information. The secondary wireless component may also include a long-range wireless transmitter that transmits

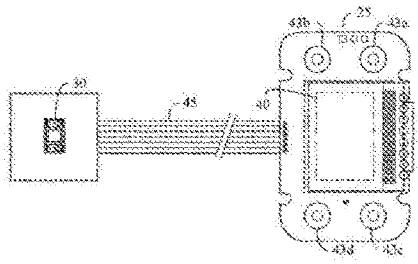
Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	information over a terrestrial, satellite, or 802.11-based wireless network. Suitable networks include those operating at least one of the following protocols: CDMA, GSM, GPRS, Mobitex, DataTac, iDEN, and analogs and derivatives thereof. Alternatively, the handheld device is a pager or PDA." Rulkov at 6:26-51. "One aspect of the present invention is a system for monitoring at least one vital sign of a user. The system comprises a smartphone and a monitoring device. The smartphone comprises a short range wireless transceiver, a processor and a display screen. The monitoring device comprises a housing, an optical sensor for measuring blood flow through an artery of a wrist, arm or ankle of the user, a processor, a short range wireless transceiver, and a power source. The short range wireless transceiver operates on a communication protocol using a 9 kHz communication format, a 125 kHz RFID communication format, a 13.56 MHz communication format, a 433 MHz communication format, a 433 MHz RFID communication format, or a 900 MHz RFID communication format." Rulkov at 13:55-67. "In one embodiment, discussed below, the display member 40 is removed and the signal is sent to a device such as a personal digital assistant, laptop computer, mobile telephone, exercise equipment, or the like for display and even processing of the user's real-time vital signs information. Alternatively, the circuitry assembly includes a flexible microprocessor board which is a low power, micro-size easily integrated board which provides blood oxygenation level, pulse rate (heart rate), signal strength bargraph, plethysmogram and status bits data. The microprocessor can also store data. The microprocessor can process the data to display pulse rate, blood oxygenation levels, calories expended by the user of a pre-set time period, target zone activity, time and dynamic blood pressure. Further, microprocessor preferably includes an automatic gain control for preventing saturation of the photodetector, which allows for the device to be used on different portions of the human body. The display member 40 is preferably a light emitting diode ("LED"). Alternatively, the display member 40 is a liquid crystal display ("LCD") or other similar display device." Rulkov at 5:48-67. "To enter the user's personal data, the middle button 43b is depressed for 2 seconds and then released. The user will enter gender, age, mass, height and resting heart rate. Entering the data

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	entails pushing the middle button to select a category (gender, age, . . .) and then pushing the right or left button to scroll through the available options or to enter a value (e.g. age of the user). The middle button 43b is pressed again to save the entry. This process is preformed until the user's has entered all of the data that the user wishes to enter into the microprocessor. The display member 40 will then display a heart rate and current calories burned value. A preset resting heart rate for men and women is preferably stored on the microprocessor, and used as a default resting heart rate. However, the user may enter their own resting heart rate value if the user is aware of that value. To access daily calories, the left button 43a is pushed by the user and the display member 40 will illustrate the value for daily calories burned by the user. If the left button 43a is pushed again, the value for total calories burned by the user will be displayed on the display member 40. The left button 43a is pushed again to return to a heart rate value on the display member 40." Rulkov at 7:18-38. "As shown in FIGS. 25-28, the system includes a monitoring device 20 and a mobile communication device 1520. The monitoring device 20 transmits data 1515 to the mobile communication device 1520 for display on a screen 1525 of the mobile communication device 1520. The user 1800 preferably wears both the mobile communication device 1520 and the monitoring device 20. Such a mobile communication device preferably includes the IPHONE.RTM. smartphone or IPAD.TM. tablet computer, both from Apple, Inc., BLACKBERRY.RTM. smartphones from Research In Motion, the ANDROID.RTM. smartphone from Google, Inc., the TRE.RTM. smartphone from Palm, Inc., and many more." Rulkov at 13:43-54. Rulkov at Fig. 25.

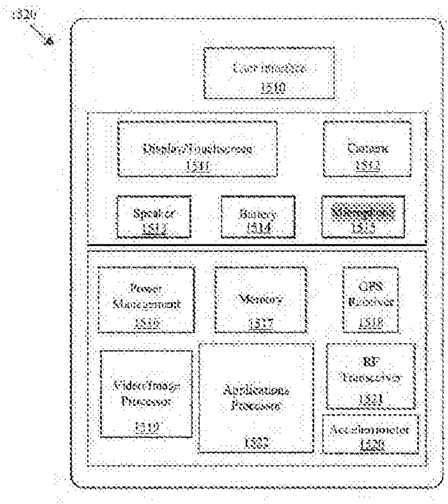
Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	 FIG. 25 Rulkov at Fig. 6.
[5H] the personal device configured to receive and process at least a portion of the output signal,	Rulkov discloses and/or renders obvious "the personal device configured to receive and process at least a portion of the output signal." "In one embodiment, discussed below, the display member 40 is removed and the signal is sent to a device such as a personal digital assistant, laptop computer, mobile telephone, exercise equipment, or the like for display and even processing of the user's real-time vital signs information. Alternatively, the circuitry assembly includes a flexible microprocessor board which is a low power, micro-size easily integrated board which provides blood oxygenation level, pulse

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	rate (heart rate), signal strength bargraph, plethysmogram and status bits data. The microprocessor can also store data. The microprocessor can process the data to display pulse rate, blood oxygenation levels, calories expended by the user of a pre-set time period, target zone activity, time and dynamic blood pressure. Further, microprocessor preferably includes an automatic gain control for preventing saturation of the photodetector, which allows for the device to be used on different portions of the human body. The display member 40 is preferably a light emitting diode ("LED"). Alternatively, the display member 40 is a liquid crystal display ("LCD") or other similar display device." Rulkov at 5:48-67. "The monitoring device 20 may also be able to download the information to a computer for further processing and storage of information. The download may be wireless or through cable connection. The information can generate an activity log or a calorie chart." Rulkov at 8:16-20. "As shown in FIGS. 25-28, the system includes a monitoring device 20 and a mobile communication device 1520. The monitoring device 20 transmits data 1515 to the mobile communication device 1520 for display on a screen 1525 of the mobile communication device 1520. The user 1800 preferably wears both the mobile communication device 1520 and the monitoring device 20. Such a mobile communication device preferably includes the IPHONE.RTM. smartphone or IPAD.TM. tablet computer, both from Apple, Inc., BLACKBERRY.RTM. smartphones from Research In Motion, the ANDROID.RTM. smartphone from Google, Inc., the TRE.RTM. smartphone from Palm, Inc., and many more." Rulkov at 13:43-54. Rulkov at Fig. 25.

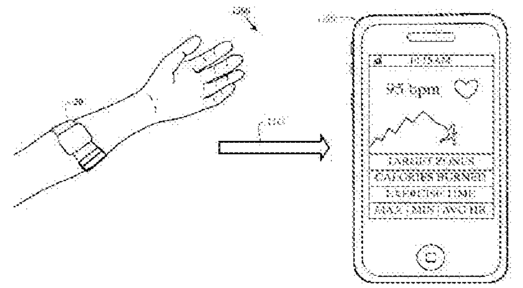
Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	 FIG. 25 <u>Rulkov</u> at Fig. 6.

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	 FIG. 6 *See also* Rulkov at 4:36-44, 5:48-64, 6:1-7:64, 14:1-5, 14:15-15:35, Fig. 26-28.
[5I] wherein the personal device is configured to store and display the processed output signal,	Rulkov discloses and/or renders obvious "wherein the personal device is configured to store and display the processed output signal." "The monitoring device preferably transmits raw heart rate and accelerometer data to a smartphone. The data is preferably stored or real-time data." Rulkov at 15:6-8. "A smartphone application preferably interprets data, displays, and stores it. Such data might include items like heart rate, calories burned, exercise time, max/min/average heart rate, and others. This allows for use of the greater processing power on the smartphone." Rulkov at 15:9-13. "A microprocessor processes the signal generated from the optical sensor 30 to generate the plurality of vital sign information for the user which is displayed on the display member 40. The control components 43a-c are connected to the processor to control the input of information and the output of information displayed on the display member 40." Rulkov at 6:1-6.

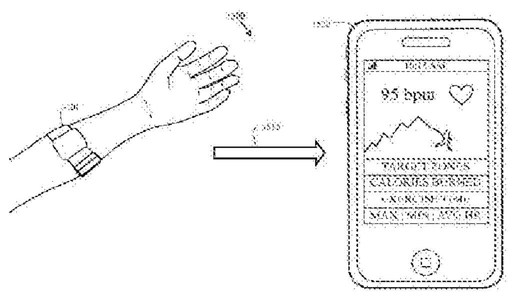
Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	"This information is sent to the microprocessor for creation of user's real-time pulse rate. The microprocessor further processes the information to display pulse rate, calories expended by the user of a pre-set period, target zones of activity, time and/or dynamic blood pressure. The information is displayed on a display member or electro-optical display." Rulkov at 6:56-62. "FIG. 25 is a block diagram of a mobile communication device such as a mobile phone. FIG. 26 is an illustration of a system including a monitoring device and a mobile phone which receives a signal from the monitoring device." Rulkov at 4:23-27. Rulkov at Fig. 25.

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	 FIG. 25 *See also* Rulkov at 6:63-7:64, 15:17-19, Claim 1; *see generally* passages cited in the "A personal device comprising a wireless receiver…" element, *supra.*
[5J] and wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link; and	Rulkov discloses and/or renders obvious "and wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link." "The monitoring device 20 alternatively has a short-range wireless transceiver which is preferably a transmitter operating on a wireless protocol, e.g. BLUETOOTH, part-15, or 802.11. "Part-15"

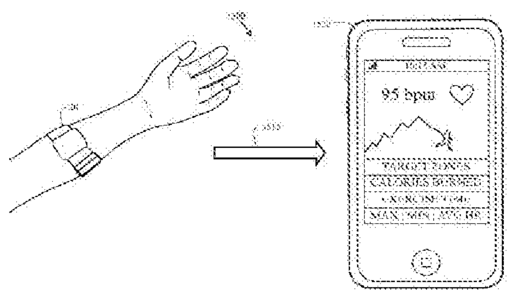
Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	refers to a conventional low-power, short-range wireless protocol, such as that used in cordless telephones. Other communication protocols include a part 15 low power short range radio, standard BLUETOOTH or BLUETOOTH Low Energy to conserve power or other low power short range communications means. The short-range wireless transmitter (e.g., a BLUETOOTH transmitter) receives information from the microprocessor and transmits this information in the form of a packet through an antenna. An external laptop computer or hand-held device features a similar antenna coupled to a matched wireless, short-range receiver that receives the packet. In certain embodiments, the hand-held device is a cellular telephone with a Bluetooth circuit integrated directly into a chipset used in the cellular telephone. In this case, the cellular telephone may include a software application that receives, processes, and displays the information. The secondary wireless component may also include a long-range wireless transmitter that transmits information over a terrestrial, satellite, or 802.11-based wireless network. Suitable networks include those operating at least one of the following protocols: CDMA, GSM, GPRS, Mobitex, DataTac, iDEN, and analogs and derivatives thereof. Alternatively, the handheld device is a pager or PDA." Rulkov at 6:26-51. "The monitoring device 20 may also be able to download the information to a computer for further processing and storage of information. The download may be wireless or through cable connection. The information can generate an activity log or a calorie chart." Rulkov at 8:16-20. "One aspect of the present invention is a system for monitoring at least one vital sign of a user. The system comprises a smartphone and a monitoring device. The smartphone comprises a short range wireless transceiver, a processor and a display screen. The monitoring device comprises a housing, an optical sensor for measuring blood flow through an artery of a wrist, arm or ankle of the user, a processor, a short range wireless transceiver, and a power source. The short range wireless transceiver operates on a communication protocol using a 9 kHz communication format, a 125 kHz RFID communication format, a 13.56 MHz communication format, a 433 MHz communication format, a 433 MHz RFID communication format, or a 900 MHz RFID communication format." Rulkov at 13:55-67.

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	 FIG. 26 *See also* Rulkov at Figs. 27-28.
[5K] a remote device configured to receive over the wireless transmission link an output status comprising the at least a portion of the processed output signal, to process the received output status to generate processed data and to store the processed data.	Rulkov discloses and/or renders obvious "a remote device configured to receive over the wireless transmission link an output status comprising the at least a portion of the processed output signal, to process the received output status to generate processed data and to store the processed data." "Fig. 28 is an isolated view of a mobile phone with a display of information generated from a signal from a monitoring device." Rulkov at 4:30-32. "The monitoring device 20 may also be able to download the information to a computer for further processing and storage of information. The download may be wireless or through cable connection. The information can generate an activity log or a calorie chart." Rulkov at 8:16-20. "The monitoring device preferably transmits raw heart rate and accelerometer data to a smartphone. The data is preferably stored or real-time data." Rulkov at 15:6-8. "A smartphone application preferably interprets data, displays, and stores it. Such data might include items like heart rate, calories burned, exercise time, max/min/average heart rate, and

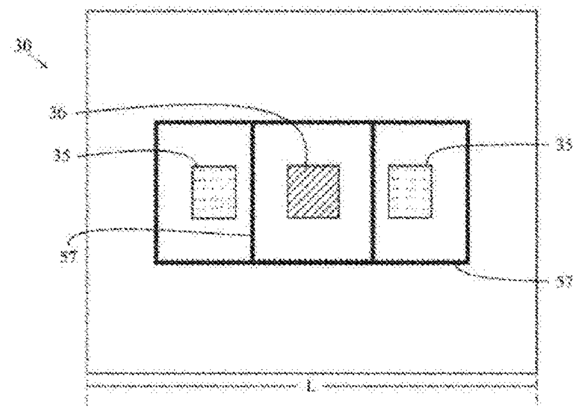
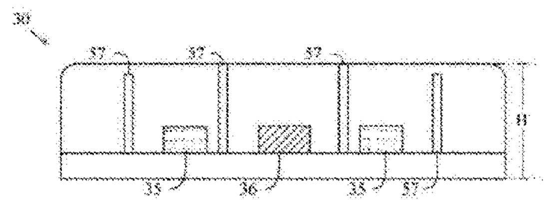
Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	others. This allows for use of the greater processing power on the smartphone." Rulkov at 15:9-13. "The monitoring device 20 alternatively has a short-range wireless transceiver which is preferably a transmitter operating on a wireless protocol, e.g. BLUETOOTH, part-15, or 802.11. "Part-15" refers to a conventional low-power, short-range wireless protocol, such as that used in cordless telephones. Other communication protocols include a part 15 low power short range radio, standard BLUETOOTH or BLUETOOTH Low Energy to conserve power or other low power short range communications means. The short-range wireless transmitter (e.g., a BLUETOOTH transmitter) receives information from the microprocessor and transmits this information in the form of a packet through an antenna. An external laptop computer or hand-held device features a similar antenna coupled to a matched wireless, short-range receiver that receives the packet. In certain embodiments, the hand-held device is a cellular telephone with a Bluetooth circuit integrated directly into a chipset used in the cellular telephone. In this case, the cellular telephone may include a software application that receives, processes, and displays the information. The secondary wireless component may also include a long-range wireless transmitter that transmits information over a terrestrial, satellite, or 802.11-based wireless network. Suitable networks include those operating at least one of the following protocols: CDMA, GSM, GPRS, Mobitex, DataTac, iDEN, and analogs and derivatives thereof. Alternatively, the handheld device is a pager or PDA." Rulkov at 6:26-51. "As shown in FIGS. 25-28, the system includes a monitoring device 20 and a mobile communication device 1520. The monitoring device 20 transmits data 1515 to the mobile communication device 1520 for display on a screen 1525 of the mobile communication device 1520. The user 1800 preferably wears both the mobile communication device 1520 and the monitoring device 20. Such a mobile communication device preferably includes the IPHONE.RTM. smartphone or IPAD.TM. tablet computer, both from Apple, Inc., BLACKBERRY.RTM. smartphones from Research In Motion, the ANDROID.RTM. smartphone from Google, Inc., the TRE.RTM. smartphone from Palm, Inc., and many more." Rulkov at 13:43-54.

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	Rulkov at Fig. 26.  FIG. 26 *See also* Rulkov at 4:45-47, 5:48-64, 6:1-7:64, 14:1-5, 14:15-15:35, Fig. 27-28.
[7] The system of claim 5, wherein the remote device is further configured to transmit at least a portion of the processed data to one or more other locations, wherein the one or more other locations is selected from the group consisting of the personal device, a doctor, a healthcare provider, a cloud-based server and one or more designated recipients, and wherein the remote device is capable of transmitting	Rulkov discloses and/or renders obvious "[t]he system of claim 5, wherein the remote device is further configured to transmit at least a portion of the processed data to one or more other locations, wherein the one or more other locations is selected from the group consisting of the personal device, a doctor, a healthcare provider, a cloud-based server and one or more designated recipients, and wherein the remote device is capable of transmitting information related to a time and a position associated with the at least a portion of the processed data." "The monitoring device 20 may also be able to download the information to a computer for further processing and storage of information. The download may be wireless or through cable connection. The information can generate an activity log or a calorie chart." Rulkov at 8:16-20. "A smartphone application preferably interprets data, displays, and stores it. Such data might include items like heart rate, calories burned, exercise time, max/min/average heart rate, and

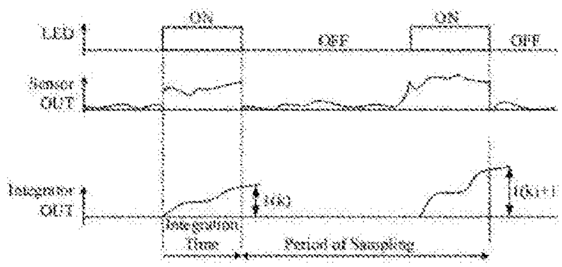
Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
information related to a time and a position associated with the at least a portion of the processed data.	others. This allows for use of the greater processing power on the smartphone." Rulkov at 15:9-13. "The monitoring device 20 alternatively has a short-range wireless transceiver which is preferably a transmitter operating on a wireless protocol, e.g. BLUETOOTH, part-15, or 802.11. "Part-15" refers to a conventional low-power, short-range wireless protocol, such as that used in cordless telephones. Other communication protocols include a part 15 low power short range radio, standard BLUETOOTH or BLUETOOTH Low Energy to conserve power or other low power short range communications means. The short-range wireless transmitter (e.g., a BLUETOOTH transmitter) receives information from the microprocessor and transmits this information in the form of a packet through an antenna. An external laptop computer or hand-held device features a similar antenna coupled to a matched wireless, short-range receiver that receives the packet. In certain embodiments, the hand-held device is a cellular telephone with a Bluetooth circuit integrated directly into a chipset used in the cellular telephone. In this case, the cellular telephone may include a software application that receives, processes, and displays the information. The secondary wireless component may also include a long-range wireless transmitter that transmits information over a terrestrial, satellite, or 802.11-based wireless network. Suitable networks include those operating at least one of the following protocols: CDMA, GSM, GPRS, Mobitex, DataTac, iDEN, and analogs and derivatives thereof. Alternatively, the handheld device is a pager or PDA." Rulkov at 6:26-51. "As shown in FIGS. 25-28, the system includes a monitoring device 20 and a mobile communication device 1520. The monitoring device 20 transmits data 1515 to the mobile communication device 1520 for display on a screen 1525 of the mobile communication device 1520. The user 1800 preferably wears both the mobile communication device 1520 and the monitoring device 20. Such a mobile communication device preferably includes the IPHONE.RTM. smartphone or IPAD.TM. tablet computer, both from Apple, Inc., BLACKBERRY.RTM. smartphones from Research In Motion, the ANDROID.RTM. smartphone from Google, Inc., the TRE.RTM. smartphone from Palm, Inc., and many more." Rulkov at 13:43-54.

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	Rulkov at Fig. 26.  FIG. 26 *See also* Rulkov at 4:45-47, 5:48-64, 6:1-7:64, 14:1-5, 14:15-15:35, Fig. 27-28.
[8] The system of claim 5, wherein the receiver is located a first distance from a first one of the plurality of light emitting diodes and a different, second distance from a second one of the plurality of light emitting diodes such that the receiver receives a first signal from the first light emitting diode and a second signal from the second light emitting diode.	Rulkov discloses and/or renders obvious "[t]he system of claim 5, wherein the receiver is located a first distance from a first one of the plurality of light emitting diodes and a different, second distance from a second one of the plurality of light emitting diodes such that the receiver receives a first signal from the first light emitting diode and a second signal from the second light emitting diode." "FIGS. 9-11 illustrate the sensor **30**. The sensor **30** has a photodetector **36**, at least two LEDs **35** and an opaque light shield **57**. The LEDs **35** are preferably green light LEDs. The sensor **30** preferably has a length, L, of 7-10 mm on each side, as shown in FIG. 9. The sensor **30** preferably has a height, H, of 1-1.5 mm, as shown in FIG. 10. The opaque light shield **57** blocks the direct light from the LEDs **35** to the photodetector **36**. Only the green light diffused and translucent through the media (skin of the user) **61**, as shown in FIG. 11, is allowed

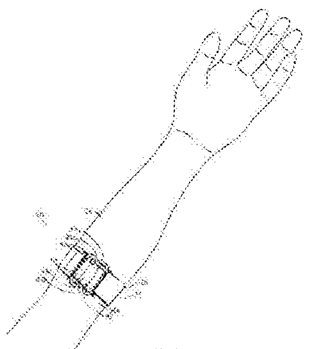
Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	to enter the chamber of the photodetector **36**. This provides for a more accurate heart rate or vital sign signal. In a preferred design of the sensor **30**, the distance between the centers of active areas of LEDs **35** is preferably 5-6 mm. The active area (photodetector 36) of a sensor 30 is placed in the middle of that distance. In the custom sensor, the distance of a custom sensor is preferably in the range of 3-4 mm (which means the spacing between the centers of photodetector 36 and LEDs 35 is about 1.5-2 mm). The distance is preferably sufficient for the placement of an opaque barrier between them. To control the amplitude of the LED intensity pulse a sufficient current (voltage) range of intensity ramp is used to control the LEDs **35** and to achieve the same levels of intensity in both LEDs **35** within a given range. The electrical characteristics of 520 nm SunLED in terms of voltage range for intensity ramp is sufficient. The top surface of the sensor **30** is preferably flat and in steady contact with the skin. Under a strong motion condition, the skin moves at the border of the contact surface. The sizes of the sensor area and flat skin contact area are selected to reduce the border motion effects. If the distance between the LEDs and sensor is reduced, a lighted area of the skin is smaller, and the contact area is reduced (5×5 mm is acceptable). LGA enables an easy way to seal the contact area from moisture." Rulkov at 12:41-13:6. Rulkov at Figs. 9 and 10.

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	 FIG. 9  FIG. 10

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
[9] The system of claim 5, wherein the output signal is generated in part by comparing the first and second signals	Rulkov discloses and/or renders obvious "[t]he system of claim 5, wherein the output signal is generated in part by comparing the first and second signals." "Yet further, the optical sensor is a combination of a green light LED and a pulsed infrared LED to offset noise effects of ambient light and sunlight." Rulkov at 5:23-25. "Immediately prior to deactivation of the LED, the analog-to-digital converter acquires the value of the voltage integrated across the capacitor, C. The analog-to-digital converter generates a data sample in digital form which is utilized by the microcontroller for evaluation of the heart rate the wearer. Subsequent to the sample being acquired by the analog-to-digital converter, the LED is deactivated and the capacitor, C, is shortcut by switch, SW, to reset the integrator, RC. A signal indicating sensor saturation is also sent to the microcontroller for light control of the LEDs. This states remains unchanged for a given time interval after which the process is repeated, which is illustrated in FIG. 15. The signals are shown in FIG. 15, with the raw sensor signal received from the sensor amplifier shown as varying between reflected light when the LEDs are on and an ambient light level when the LEDs are off. The filtered signal from the high pass filter ("HPF") is shown as the filtered sensor signal in FIG. 14. The integrator reset signal is shown as integrator out signal in FIG. 15, and the integrator reset signal in FIG. 14. At block 1305, a band pass filter is implemented preferably with two sets of data from the analog-to-digital converter. At block 1305, an average of the values of data samples within each of a first set of samples is calculated by the microprocessor. For example, the values of data samples within forty-four samples are summed and then divided by forty-four to generate an average value for the first set of samples. Next, an average of the values of data samples within a second set of samples is calculated by the microprocessor. For example, the values of data samples within twenty-two samples are summed and then divided by twenty-two to generate an average value for the second set of samples. Preferably, the second set of samples is less than the first set of samples. Next, the average value of the second set of samples is subtracted from the average value for the first set of samples to generate a first filtered pulse data value." Rulkov at 10:13-47. Rulkov at Fig. 15.

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	 FIG. 15
[10] The system of claim 5, wherein the output signal comprises one or more physiological parameters, and the remote device is capable of storing a history of at least a portion of the one or more physiological parameters over a specified period of time.	Rulkov discloses and/or renders obvious "[t]he system of claim 5, wherein the output signal comprises one or more physiological parameters, and the remote device is capable of storing a history of at least a portion of the one or more physiological parameters over a specified period of time." "The system for monitoring a real-time vital sign of a user comprises a monitoring device comprising an optical sensor for generating a real-time digitized optical signal corresponding to a flow of blood through an artery of the user and an accelerometer for generating real-time accelerometer data comprising a X-axis signal, a Y-axis signal and a Z-axis signal based on a movement of the user." <u>Rulkov</u> at 3:3-9. "As the heart pumps blood through the arteries in the user's arm, ankle or wrist, the photodetector 36, which is typically a photodiode, detects reflectance/transmission at the wavelengths (green, red or infrared), and in response generates a radiation-induced signal." <u>Rulkov</u> at 5:16-30. "The microprocessor can also store data. The microprocessor can process the data to display pulse rate, blood oxygenation levels, calories expended by the user of a pre-set time period, target zone activity, time and dynamic blood pressure." <u>Rulkov</u> at 5:57-61.

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	"The display member 40 is preferably a light emitting diode ("LED"). Alternatively, the display member 40 is a liquid crystal display ("LCD") or other similar display device." 5:65-67. "This information is sent to the microprocessor for creation of user's real-time pulse rate. The microprocessor further processes the information to display pulse rate, calories expended by the user of a pre-set time period, target zones of activity, time and/or dynamic blood pressure. The information is displayed on a display member or electro-optical display. Rulkov at 6:56-63. "At block 1310, the filtered pulse data value is processed using a heart rate evaluation code to generate a first heart rate value. In a preferred method, the heart rate evaluation code obtains the heart rate by calculating the distance between crossing points of the voltage through zero. Once the first heart rate value is known, then an adaptive resonant filter is utilized to generate a filtered second heart rate value by attenuating interference caused by motion artifacts. At block 1315, a sample delay is computed as the period of evaluated heart rate divided by two." Rulkov at 10:48-57. "The monitoring device preferably transmits raw heart rate and accelerometer data to a smartphone. The data is preferably stored or real-time data." Rulkov at 15:6-8. *See also* Rulkov at 11:12-19, 13:55-62, Figs. 13, 18-20, Claim 1.
[13] A measurement system comprising	To the extent the preamble is limiting, Rulkov discloses and/or renders obvious "a measurement system." *See* CHART ONE: '533 Patent, Claim Element 5 above.
[13A] a wearable measurement device for measuring one or more physiological parameters, including a light source comprising a plurality of semiconductor sources that are light emitting diodes, the light	Rulkov discloses and/or renders obvious "a wearable measurement device for measuring one or more physiological parameters, including a light source comprising a plurality of semiconductor sources that are light emitting diodes, the light emitting diodes configured to generate an output optical beam with one or more optical wavelengths." "Fig. 1 is a plan view of a preferred embodiment of a monitoring device worn by a user."

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
emitting diodes configured to generate an output optical beam with one or more optical wavelengths,	 FIG. 1 "As shown in FIGS. 1-5, a monitoring device is generally designated 20. The monitoring device 20 preferably includes an article 25 and an attachment band 26 having an exterior surface 26a and interior surface 26b. The monitoring device 20 is preferably secured with VELCRO.RTM. hook and loop material 31a and 31b. The article 25 preferably includes an optical sensor 30, control components 43a-43c and optionally a display member 40. The monitoring device 20 is preferably worn on a user's wrist, arm or ankle." Rulkov at 4:36-44. "Although the monitoring device 20 is described in reference to an article worn on a user's arm, wrist or ankle, those skilled in the pertinent art will recognize that the monitoring device 20 may take other forms such as eyewear disclosed in Brady et al, U.S. Pat. No. 7,648,463, for a Monitoring Device, Method And System, which is hereby incorporated by reference in its entirety or a glove such as disclosed in Rulkov et al., U.S. Pat. No. 7,887,492, for a Monitoring Device, Method And System, which is hereby incorporated by reference in its entirety." Rulkov at 4:61-5:3. "The optical sensor 30 of the monitoring device 20 is preferably positioned over the radial artery or ulnar artery if the article 25 is worn on the user's arm. The optical sensor 30 of the monitoring

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	device 20 is preferably positioned over the posterior tibial artery of a user if the article 25 is worn on the user's ankle. However, those skilled in the pertinent art will recognize that the optical sensor may be placed over other arteries of the user without departing from the scope and spirit of the present invention. Further, the optical sensor 30 need only be in proximity to an artery of the user in order to obtain a reading or signal." Rulkov at 5:4-15. "As shown in FIGS. 25-28, the system includes a monitoring device 20 and a mobile communication device 1520. The monitoring device 20 transmits data 1515 to the mobile communication device 1520 for display on a screen 1525 of the mobile communication device 1520. The user 1800 preferably wears both the mobile communication device 1520 and the monitoring device 20. Such a mobile communication device preferably includes the IPHONE.RTM. smartphone or IPAD.TM. tablet computer, both from Apple, Inc., BLACKBERRY.RTM. smartphones from Research In Motion, the ANDROID.RTM. smartphone from Google, Inc., the TRE.RTM. smartphone from Palm, Inc., and many more." Rulkov at 13:43-54. "Such a device may detect the electrical pulses from the heart such as the chest belt monitors, however a preferred application would be a more convenient monitor that would be worn on the arm of the game player, but would be motion resistant as well as continuous." Rulkov at 14:58-63. "A user can run or do other exercise while wearing the monitoring device and the smartphone. The smartphone then becomes a "mobile exercise device." Rulkov at 15:30-32. "The system for monitoring a real-time vital sign of a user comprises a monitoring device comprising an optical sensor for generating a real-time digitized optical signal corresponding to a flow of blood through an artery of the user and an accelerometer for generating real-time accelerometer data comprising a X-axis signal, a Y-axis signal and a Z-axis signal based on a movement of the user." Rulkov at 3:3-9.

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	"As the heart pumps blood through the arteries in the user's arm, ankle or wrist, the photodetector 36, which is typically a photodiode, detects reflectance/transmission at the wavelengths (green, red or infrared), and in response generates a radiation-induced signal." Rulkov at 5:16-30. "This information is sent to the microprocessor for creation of user's real-time pulse rate. The microprocessor further processes the information to display pulse rate, calories expended by the user of a pre-set time period, target zones of activity, time and/or dynamic blood pressure. The information is displayed on a display member or electro-optical display. Rulkov at 6:56-63. "At block 1310, the filtered pulse data value is processed using a heart rate evaluation code to generate a first heart rate value. In a preferred method, the heart rate evaluation code obtains the heart rate by calculating the distance between crossing points of the voltage through zero. Once the first heart rate value is known, then an adaptive resonant filter is utilized to generate a filtered second heart rate value by attenuating interference caused by motion artifacts. At block 1315, a sample delay is computed as the period of evaluated heart rate divided by two." Rulkov at 10:48-57. "The optical sensor preferably comprises a photo-detector and a plurality of light emitting diodes." Rulkov at Abstract. "Pulse oximeter devices typically contain two light emitting diodes: one in the red band of light (660 nanometers) and one in the infrared band of light (940 nanometers)." Rulkov at 1:53-55. "In a preferred embodiment, the optical sensor 30 is a plurality of light emitting diodes ("LED") 35 based on green light wherein the LEDs 35 generate green light (wavelength of 500-570 nm), and a photodetector 36 detects the green light. Yet in an alternative embodiment, the optical sensor 30 is a photodetector 36 and a single LED 35 transmitting light at a wavelength of approximately 900 nanometers as a pulsed infrared LED. Yet further, the optical sensor is a combination of a green light LED and a pulsed infrared LED to offset noise affects of ambient light and sunlight. As the heart pumps blood through the arteries in the user's arm, ankle or wrist, the photodetector

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	36, which is typically a photodiode, detects reflectance/transmission at the wavelengths (green, red or infrared), and in response generates a radiation-induced signal." Rulkov at 5:16-30. "The light source 35 is preferably a plurality of LEDs 35." Rulkov at 9:64-65. *See also* Rulkov at 5:43-47, 6:21-25, 11:12-19, 11:39-53, 12:41-51, 13:55-62, Figs. 13, 18-20, 26-28, Claim 1.
[13B] wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers,	Rulkov discloses and/or renders obvious "wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers." *See* CHART ONE: '533 Patent, Claim Element 5B above.
[13C] the light source configured to increase signal-to-noise ratio by increasing a light intensity from at least one of the plurality of semiconductor sources and by increasing a pulse rate of at least one of the plurality of semiconductor sources;	Rulkov discloses and/or renders obvious "the light source configured to increase signal-to-noise ratio by increasing a light intensity from at least one of the plurality of semiconductor sources and by increasing a pulse rate of at least one of the plurality of semiconductor sources." *See* CHART ONE: '533 Patent, Claim Element 5C above.
[13D] the wearable measurement device comprising a plurality of lenses configured to receive a portion of the output optical beam and to deliver an analysis output beam to a sample;	Rulkov discloses and/or renders obvious "the wearable measurement device comprising a plurality of lenses configured to receive a portion of the output optical beam and to deliver an analysis output beam to a sample." *See* CHART ONE: '533 Patent, Claim Element 5D above.

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
[13E] the wearable measurement device further comprising a receiver configured to receive and process at least a portion of the analysis output beam reflected or transmitted from the sample and to generate an output signal	Rulkov discloses and/or renders obvious "the wearable measurement device further comprising a receiver configured to receive and process at least a portion of the analysis output beam reflected or transmitted from the sample and to generate an output signal." *See* CHART ONE: '533 Patent, Claim Element 5E above.
[13F] wherein the wearable measurement device receiver is configured to be synchronized to pulses of the light source;	Rulkov discloses and/or renders obvious "wherein the wearable measurement device receiver is configured to be synchronized to pulses of the light source." *See* CHART ONE: '533 Patent, Claim Element 5F above.
[13G] a personal device comprising a wireless receiver, a wireless transmitter, a display, a microphone, a speaker, one or more buttons or knobs, a microprocessor and a touch screen,	Rulkov discloses and/or renders obvious "a personal device comprising a wireless receiver, a wireless transmitter, a display, a microphone, a speaker, one or more buttons or knobs, a microprocessor and a touch screen." *See* CHART ONE: '533 Patent, Claim Element 5G above.
[13H] the personal device configured to receive and process at least a portion of the output signal,	Rulkov discloses and/or renders obvious "the personal device configured to receive and process at least a portion of the output signal, wherein the personal device is configured to store and display the processed output signal." *See* CHART ONE: '533 Patent, Claim Element 5H above.
[13I] wherein the personal device is configured to store and display the processed output signal, and	Rulkov discloses and/or renders obvious "wherein the personal device is configured to store and display the processed output signal." *See* CHART ONE: '533 Patent, Claim Element 5I above.

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
[13J] wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link; and	Rulkov discloses and/or renders obvious "wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link." *See* CHART ONE: '533 Patent, Claim Element 5J above.
[13K] a remote device configured to receive over the wireless transmission link an output status comprising the at least a portion of the processed output signal, to process the received output status to generate processed data and to store the processed data, and	Rulkov discloses and/or renders obvious "a remote device configured to receive over the wireless transmission link an output status comprising the at least a portion of the processed output signal, to process the received output status to generate processed data and to store the processed data." *See* CHART ONE: '533 Patent, Claim Element 5K above.
[13L] wherein the remote device is capable of storing a history of at least a portion of the received output status over a specified period of time.	Rulkov discloses and/or renders obvious "wherein the remote device is capable of storing a history of at least a portion of the received output status over a specified period of time." *See* CHART ONE: '533 Patent, Claim Element 10 above.
[16] The system of claim 13, wherein the receiver is located a first distance from a first one of the plurality of light emitting diodes and a different, second distance from a second one of the plurality of light emitting diodes such that the receiver receives a first signal from the first light emitting diode and a second signal from the second light emitting diode.	Rulkov discloses and/or renders obvious "[t]he system of claim 13, wherein the receiver is located a first distance from a first one of the plurality of light emitting diodes and a different, second distance from a second one of the plurality of light emitting diodes such that the receiver receives a first signal from the first light emitting diode and a second signal from the second light emitting diode." *See* CHART ONE: '533 Patent, Claim Element 8 above.

Asserted Claim of '533 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
[17] The system of claim 16, wherein the output signal is generated in part by comparing the first and second signals.	Rulkov discloses and/or renders obvious "[t]he system of claim 16, wherein the output signal is generated in part by comparing the first and second signals." *See* CHART ONE: '533 Patent, Claim Element 9 above.

EXHIBIT B-2

U.S. Patent No. 9,757,040 vs Rulkov

Priority Date/Publication Date:	October 4, 2011/May 8, 2012	Prior Art Status:	§§ 102(a), (b), and (e) (pre-AIA) §§ 102(a), (b), and (d)

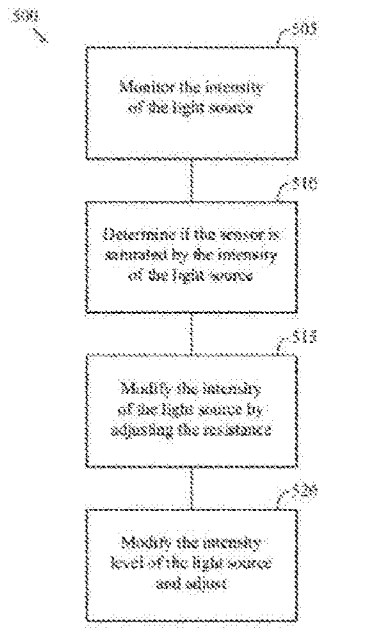
U.S. Patent No. 8,172,761 to Rulkov et al. ("Rulkov") anticipates the asserted claims of U.S. Patent No. 9,757,040 ("the '040 Patent") or renders those claims obvious alone and/or in view of at least any of the references identified in Apple's Obviousness Combinations Chart.

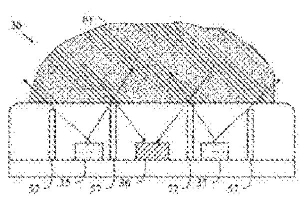
As set forth in Apple's Invalidity Contentions, the below contentions apply the prior art in part in accordance with Apple's assumption that Omni contends the claims are not invalid under 35 U.S.C. § 112. However, Apple's below contentions do not represent Apple's agreement or view as to the meaning, definiteness, written description support for, or enablement of any of the asserted claims. For each dependent claim, the disclosures cited for the claim from which it depends are incorporated by reference.

CHART TWO: U.S. Patent No. 9,757,040 vs Rulkov

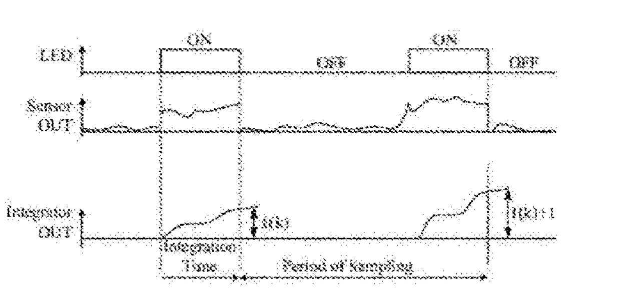
Asserted Claim of '040 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
[1] A wearable device for use with a smart phone or tablet, the wearable device comprising:	To the extent the preamble is limiting, Rulkov discloses and/or renders obvious "[a] wearable device for use with a smart phone or tablet." *See* CHART ONE: '533 Patent, Claim Elements 5, 5G, and 13A above.
[1A] a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters	Rulkov discloses and/or renders obvious "a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters." *See* CHART ONE: '533 Patent, Claim Element 13A above.
[1B] the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an input optical beam having one or more optical wavelengths,	Rulkov discloses and/or renders obvious "the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an input optical beam having one or more optical wavelengths." "In reference to FIGS. 14 and 15, in the pulse mode the LED 35 is periodically activated for short intervals of time by a signal from the microcontroller. The reflected pulse of light is received by the sensor, with the generation of a voltage pulse having an amplitude proportional to the intensity of the reflected light. When the LED is activated, the switch, SW, is open by the action of the control signal from the microcontroller, and the capacitor, C, integrates the pulse generated from the sensor by charging through the resistor R. Immediately prior to deactivation of the LED, the analog-to-digital converter acquires the value of the voltage integrated across the capacitor, C. The analog-to-digital converter generates a data sample in digital form which is utilized by the microcontroller for evaluation of the heart rate the wearer. Subsequent to the sample being acquired by the analog-to-digital converter, the LED is deactivated and the capacitor, C, is shortcut by switch, SW, to reset the integrator, RC. A signal indicating sensor saturation is also sent to the microcontroller for light control of the LEDs. This states remains unchanged for a given time interval after which the process is repeated, which is illustrated in FIG. 15. The signals are shown in FIG. 15, with the raw sensor signal received from the sensor amplifier shown as varying between reflected light when the LEDs are on and an ambient light level when the LEDs

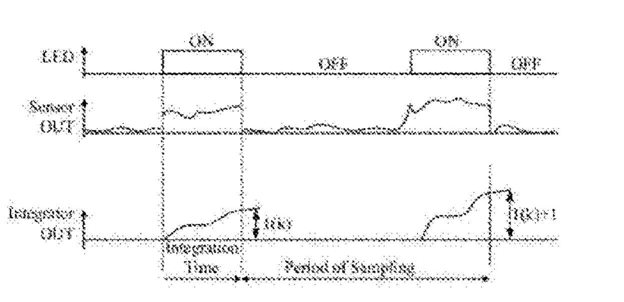
Asserted Claim of '040 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	are off. The filtered signal from the high pass filter ("HPF") is shown as the filtered sensor signal in FIG. 14. The integrator reset signal is shown as integrator out signal in FIG. 15, and the integrator reset signal in FIG. 14." Rulkov at 10:4-31. "The preferred embodiment uses 250 microsecond LED pulses and a 12T photodetector 36 with second order active high pass filter (100 Hz cutoff). The DC output of the sensor 30 is monitored to ensure that it is not saturated by the effects of ambient light. The use of short-term pulses reduces ambient light. In the preferred embodiment, voltage is collected at the sensor output every 2 msec. Inside the microprocessor 741, an average 8 consecutive samples improve the SNR (signal to noise ratio) and then work with the averaged numbers. Therefore the sampling rate for raw data is preferably 2 msec, however if 8-samples averaging is utilized in the integrated sensor the data output rate is reduced to sending a new averaged value every 16 msec. An ADC is used with a 12-bit resolution. The response of TSL 12T is acceptable. 100 Hz is the low limit for LPF cutoff. The selection of pulse duration is preferably based on the speed of the LED drivers, sensor electronics and output pick detection. The higher the low frequency cutoff that is implemented for the selected pulse duration, the better SNR." Rulkov at 13:6-25. "Ambient light filter and amplifier 2010 transits to synchronized pick detector 2012 for a voltage or data output 2014 as an output signal 2016." Rulkov at 13:40-42. "FIG. 16 illustrates how the control mechanism operates to maintain a proper light intensity. As the signal reaches the upper limit, the photodetector becomes saturated and the processor lowers the current flow, which results in a break in the signal. Then as the signal is lowered it becomes too low and the processor increases the light intensity resulting in a break in the signal. Rulkov at 11:32-38. "The microprocessor 741 has a LED control 715 connected to DAC 702 for controlling the intensity of the LEDs 737." Rulkov at 11:43-45. "The light source 35 is preferably a plurality of LEDs 35. The intensity of the light is preferably controlled by an integrator 300." Rulkov at 9:64-66.

Asserted Claim of '040 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	Rulkov at 11:20-31, Fig. 17.  FIG. 17 *See also* Rulkov, Figs. 16, 18.

Asserted Claim of '040 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
[1C] wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers;	Rulkov discloses and/or renders obvious "wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers." *See* CHART ONE: '533 Patent, Claim Element 5B above.
[1D] the measurement device comprising one or more lenses configured to receive and to deliver a portion of the input optical beam to tissue, wherein the tissue reflects at least a portion of the input optical beam delivered to the tissue;	Rulkov discloses and/or renders obvious "the measurement device comprising one or more lenses configured to receive and to deliver a portion of the input optical beam to tissue, wherein the tissue reflects at least a portion of the input optical beam delivered to the tissue." *See* CHART ONE: '533 Patent, Claim Element 5D above.
[1E] the measurement device further comprising a reflective surface configured to receive and redirect at least a portion of light reflected from the tissue;	Rulkov discloses and/or renders obvious "the measurement device further comprising a reflective surface configured to receive and redirect at least a portion of light reflected from the tissue." Rulkov at Fig. 11.  FIG. 11 "FIGS. 9-11 illustrate the sensor 30. The sensor 30 has a photodetector 36, at least two LEDs 35 and an opaque light shield 57. The LEDs 35 are preferably green light LEDs. The sensor 30 preferably has a length, L, of 7-10 mm on each side, as shown in FIG. 9. The sensor 30 preferably

Asserted Claim of '040 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	has a height, H, of 1-1.5 mm, as shown in FIG. 10. The opaque light shield 57 blocks the direct light from the LEDs 35 to the photodetector 36. Only the green light diffused and translucent through the media (skin of the user) 61, as shown in FIG. 11, is allowed to enter the chamber of the photodetector 36. This provides for a more accurate heart rate or vital sign signal." Rulkov at 12:41-51. *See also* Rulkov at Figs. 9-10.
[1F] the measurement device further comprising a receiver configured to: capture light while the LEDs are off and convert the captured light into a first signal and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the input optical beam reflected from the tissue;	Rulkov discloses and/or renders obvious "the measurement device further comprising a receiver configured to: capture light while the LEDs are off and convert the captured light into a first signal and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the input optical beam reflected from the tissue." "Immediately prior to deactivation of the LED, the analog-to-digital converter acquires the value of the voltage integrated across the capacitor, C. The analog-to-digital converter generates a data sample in digital form which is utilized by the microcontroller for evaluation of the heart rate the wearer. Subsequent to the sample being acquired by the analog-to-digital converter, the LED is deactivated and the capacitor, C, is shortcut by switch, SW, to reset the integrator, RC. A signal indicating sensor saturation is also sent to the microcontroller for light control of the LEDs. This states remains unchanged for a given time interval after which the process is repeated, which is illustrated in FIG. 15. The signals are shown in FIG. 15, with the raw sensor signal received from the sensor amplifier shown as varying between reflected light when the LEDs are on and an ambient light level when the LEDs are off. The filtered signal from the high pass filter ("HPF") is shown as the filtered sensor signal in FIG. 14. The integrator reset signal is shown as integrator out signal in FIG. 15, and the integrator reset signal in FIG. 14. At block 1305, a band pass filter is implemented preferably with two sets of data from the analog-to-digital converter. At block 1305, an average of the values of data samples within each of a first set of samples is calculated by the microprocessor. For example, the values of data samples within forty-four samples are summed and then divided by forty-four to generate an average value for the first set of samples. Next, an average of the values of data samples within a second set of samples

Asserted Claim of '040 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	is calculated by the microprocessor. For example, the values of data samples within twenty-two samples are summed and then divided by twenty-two to generate an average value for the second set of samples. Preferably, the second set of samples is less than the first set of samples. Next, the average value of the second set of samples is subtracted from the average value for the first set of samples to generate a first filtered pulse data value." Rulkov at 10:13-47. Rulkov at Fig. 15.  FIG. 15
[1G] the measurement device configured to improve a signal-to-noise ratio of the input optical beam reflected from the tissue by differencing the first signal and the second signal;	Rulkov discloses and/or renders obvious "the measurement device configured to improve a signal-to-noise ratio of the input optical beam reflected from the tissue by differencing the first signal and the second signal." "Immediately prior to deactivation of the LED, the analog-to-digital converter acquires the value of the voltage integrated across the capacitor, C. The analog-to-digital converter generates a data sample in digital form which is utilized by the microcontroller for evaluation of the heart rate the wearer. Subsequent to the sample being acquired by the analog-to-digital converter, the LED is deactivated and the capacitor, C, is shortcut by switch, SW, to reset the integrator, RC. A signal indicating sensor saturation is also sent to the microcontroller for light control of the LEDs. This states remains unchanged for a given time interval after which the process is repeated, which is

Asserted Claim of '040 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	illustrated in FIG. 15. The signals are shown in FIG. 15, with the raw sensor signal received from the sensor amplifier shown as varying between reflected light when the LEDs are on and an ambient light level when the LEDs are off. The filtered signal from the high pass filter ("HPF") is shown as the filtered sensor signal in FIG. 14. The integrator reset signal is shown as integrator out signal in FIG. 15, and the integrator reset signal in FIG. 14. At block 1305, a band pass filter is implemented preferably with two sets of data from the analog-to-digital converter. At block 1305, an average of the values of data samples within each of a first set of samples is calculated by the microprocessor. For example, the values of data samples within forty-four samples are summed and then divided by forty-four to generate an average value for the first set of samples. Next, an average of the values of data samples within a second set of samples is calculated by the microprocessor. For example, the values of data samples within twenty-two samples are summed and then divided by twenty-two to generate an average value for the second set of samples. Preferably, the second set of samples is less than the first set of samples. Next, the average value of the second set of samples is subtracted from the average value for the first set of samples to generate a first filtered pulse data value." Rulkov at 10:13-47. Rulkov at Fig. 15.  FIG. 15

Asserted Claim of '040 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
[1H] the light source configured to further improve the signal-to-noise ratio of the input optical beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs;	Rulkov discloses and/or renders obvious "the light source configured to further improve the signal-to-noise ratio of the input optical beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs." *See* CHART ONE: '533 Patent, Claim Element 5C above.
[1I] the measurement device further configured to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue; and	Rulkov discloses and/or renders obvious "the measurement device further configured to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue." *See* CHART ONE: '533 Patent, Claim Element 10 above.
[1J] the wearable device configured to communicate with the smart phone or tablet, the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a voice input module, a speaker, and a touch screen, the smart phone or tablet configured to receive and to process at least a portion of the output signal,	Rulkov discloses and/or renders obvious "the wearable device configured to communicate with the smart phone or tablet, the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a voice input module, a speaker, and a touch screen, the smart phone or tablet configured to receive and to process at least a portion of the output signal." *See* CHART ONE: '533 Patent, Claim Elements 5G and 5H above.
[1K] wherein the smart phone or tablet is configured to store and display the processed output signal, wherein at least a portion	Rulkov discloses and/or renders obvious "wherein the smart phone or tablet is configured to store and display the processed output signal, wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link."

Asserted Claim of '040 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
of the processed output signal is configured to be transmitted over a wireless transmission link.	*See* CHART ONE: '533 Patent, Claim Elements 5I and 5J above.
[2] The wearable device of claim 1, wherein the receiver is configured to be synchronized to the modulation of the at least one of the LEDs.	Rulkov discloses and/or renders obvious "[t]he wearable device of claim 1, wherein the receiver is configured to be synchronized to the modulation of the at least one of the LEDs." *See* CHART ONE: '533 Patent, Claim Element 5F above.
[4] The wearable device of claim 1, wherein the receiver is located a first distance from a first one of the LEDs and a different distance from a second one of the LEDs such that the receiver can capture a third signal from the first LED and a fourth signal from the second LED, and wherein the output signal is generated in part by comparing the third and fourth signals.	Rulkov discloses and/or renders obvious "[t]he wearable device of claim 1, wherein the receiver is located a first distance from a first one of the LEDs and a different distance from a second one of the LEDs such that the receiver can capture a third signal from the first LED and a fourth signal from the second LED, and wherein the output signal is generated in part by comparing the third and fourth signals." *See* CHART ONE: '533 Patent, Claim Element 8 above.

EXHIBIT B-3

U.S. Patent No. 9,861,286 vs Rulkov

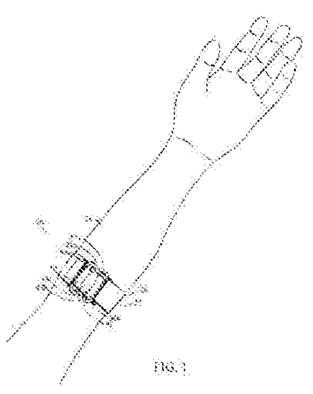
Priority Date/Publication Date:	October 4, 2011/May 8, 2012	Prior Art Status:	§§ 102(a), (b), and (e) (pre-AIA) §§ 102(a), (b), and (d)

U.S. Patent No. 8,172,761 to Rulkov et al. ("Rulkov") anticipates the asserted claims of U.S. Patent No. 9,861,286 ("the '286 Patent") or renders those claims obvious alone and/or in view of at least any of the references identified in Apple's Obviousness Combinations Chart.

As set forth in Apple's Invalidity Contentions, the below contentions apply the prior art in part in accordance with Apple's assumption that Omni contends the claims are not invalid under 35 U.S.C. § 112. However, Apple's below contentions do not represent Apple's agreement or view as to the meaning, definiteness, written description support for, or enablement of any of the asserted claims. For each dependent claim, the disclosures cited for the claim from which it depends are incorporated by reference.

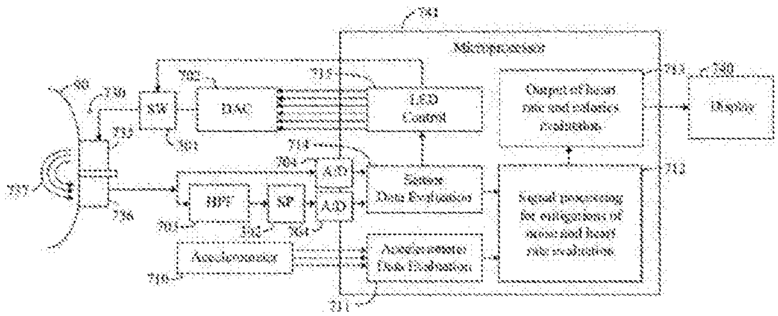
CHART THREE: U.S. Patent No. 9,861,286 vs Rulkov

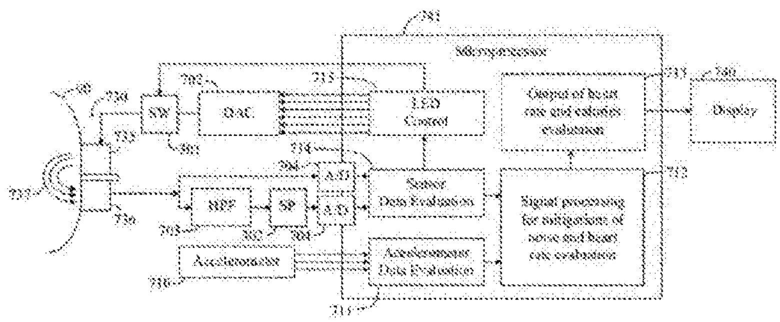
Asserted Claim of '286 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
[16] A wearable device for use with a smart phone or tablet, the wearable device comprising:	To the extent the preamble is limiting, Rulkov discloses and/or renders obvious "[a] wearable device for use with a smart phone or tablet." *See* CHART ONE: '533 Patent, Claim Elements 5, 5G, and 13A above.
[16A] a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters,	Rulkov discloses and/or renders obvious "a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters." *See* CHART ONE: '533 Patent, Claim Element 13A above.
[16B] the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an optical beam having a plurality of optical wavelengths,	Rulkov discloses and/or renders obvious "the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an optical beam having a plurality of optical wavelengths." *See* CHART TWO: '040 Patent, Claim Element 1B above.
[16C] wherein at least a portion of the plurality of optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers;	Rulkov discloses and/or renders obvious "wherein at least a portion of the plurality of optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers." *See* CHART ONE: '533 Patent, Claim Element 5B above.
[16D] the measurement device comprising one or more lenses configured to receive and to deliver a portion of the optical beam to tissue, wherein the tissue reflects at least a portion of the	Rulkov discloses and/or renders obvious "the measurement device comprising one or more lenses configured to receive and to deliver a portion of the optical beam to tissue, wherein the tissue reflects at least a portion of the optical beam delivered to the tissue, and wherein the measurement device is adapted to be placed on a wrist or an ear of a user." *See* CHART ONE: '533 Patent, Claim Element 5D above.

Asserted Claim of '286 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
optical beam delivered to the tissue, and	
[16E] wherein the measurement device is adapted to be placed on a wrist or an ear of a user;	Rulkov discloses and/or renders obvious "wherein the measurement device is adapted to be placed on a wrist or an ear of a user." "Fig. 1 is a plan view of a preferred embodiment of a monitoring device worn by a user."  "As shown in FIGS. 1-5, a monitoring device is generally designated 20. The monitoring device 20 preferably includes an article 25 and an attachment band 26 having an exterior surface 26a and interior surface 26b. The monitoring device 20 is preferably secured with VELCRO.RTM. hook and loop material 31a and 31b. The article 25 preferably includes an optical sensor 30, control components 43a-43c and optionally a display member 40. The monitoring device 20 is preferably worn on a user's wrist, arm or ankle." Rulkov at 4:36-44. "Although the monitoring device 20 is described in reference to an article worn on a user's arm, wrist or ankle, those skilled in the pertinent art will recognize that the monitoring device 20 may take other forms such as eyewear disclosed in Brady et al, U.S. Pat. No. 7,648,463, for a

Asserted Claim of '286 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	Monitoring Device, Method And System, which is hereby incorporated by reference in its entirety or a glove such as disclosed in Rulkov et al., U.S. Pat. No. 7,887,492, for a Monitoring Device, Method And System, which is hereby incorporated by reference in its entirety." Rulkov at 4:61-5:3. "The optical sensor 30 of the monitoring device 20 is preferably positioned over the radial artery or ulnar artery if the article 25 is worn on the user's arm. The optical sensor 30 of the monitoring device 20 is preferably positioned over the posterior tibial artery of a user if the article 25 is worn on the user's ankle. However, those skilled in the pertinent art will recognize that the optical sensor may be placed over other arteries of the user without departing from the scope and spirit of the present invention. Further, the optical sensor 30 need only be in proximity to an artery of the user in order to obtain a reading or signal." Rulkov at 5:4-15. "Such a device may detect the electrical pulses from the heart such as the chest belt monitors, however a preferred application would be a more convenient monitor that would be worn on the arm of the game player, but would be motion resistant as well as continuous." Rulkov at 14:58-63. *See also* Rulkov at Figs. 26-28.
[16F] the measurement device further comprising a receiver configured to: capture light while the LEDs are off and convert the captured light into a first signal and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the	Rulkov discloses and/or renders obvious "the measurement device further comprising a receiver configured to: capture light while the LEDs are off and convert the captured light into a first signal and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the optical beam reflected from the tissue." *See* CHART TWO: '040 Patent, Claim Element 1F above.

Asserted Claim of '286 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
optical beam reflected from the tissue;	
[16G] the measurement device configured to improve a signal-to-noise ratio of the optical beam reflected from the tissue by differencing the first signal and the second signal;	Rulkov discloses and/or renders obvious "the measurement device configured to improve a signal-to-noise ratio of the optical beam reflected from the tissue by differencing the first signal and the second signal." *See* CHART TWO: '040 Patent, Claim Element 1G above.
[16H] the light source configured to further improve the signal-to-noise ratio of the optical beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs;	Rulkov discloses and/or renders obvious "the light source configured to further improve the signal-to-noise ratio of the optical beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs." *See* CHART ONE: '533 Patent, Claim Element 5C above.
[16I] the measurement device further configured to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue; and	Rulkov discloses and/or renders obvious "the measurement device further configured to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue." *See* CHART ONE: '533 Patent, Claim Element 10 above.
[16J] wherein the receiver includes a plurality of spatially separated detectors,	Rulkov discloses and/or renders obvious "wherein the receiver includes a plurality of spatially separated detectors." Rulkov at Fig. 18.

Asserted Claim of '286 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	 FIG. 18 "Immediately prior to deactivation of the LED, the analog-to-digital converter acquires the value of the voltage integrated across the capacitor, C. The analog-to-digital converter generates a data sample in digital form which is utilized by the microcontroller for evaluation of the heart rate the wearer. Subsequent to the sample being acquired by the analog-to-digital converter, the LED is deactivated and the capacitor, C, is shortcut by switch, SW, to reset the integrator, RC." Rulkov at 10:13-21. "The signal from the photodetector 736 is transmitted to a high pass filter (HPF) 703 which sends it to an analog to digital converter 704, and the signal from the photodetector 737 is also sent directly to a second analog to digital converter 704." Rulkov at 11:45-49. *See also* Rulkov at 10:32-33.

Asserted Claim of '286 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
[16K] wherein at least one analog to digital converter is coupled to the spatially separated detectors.	Rulkov discloses and/or renders obvious "wherein at least one analog to digital converter is coupled to the spatially separated detectors." Rulkov at Fig. 18.  FIG. 18 "Immediately prior to deactivation of the LED, the analog-to-digital converter acquires the value of the voltage integrated across the capacitor, C. The analog-to-digital converter generates a data sample in digital form which is utilized by the microcontroller for evaluation of the heart rate the wearer. Subsequent to the sample being acquired by the analog-to-digital converter, the LED is deactivated and the capacitor, C, is shortcut by switch, SW, to reset the integrator, RC." Rulkov at 10:13-21. "The signal from the photodetector 736 is transmitted to a high pass filter (HPF) 703 which sends it to an analog to digital converter 704, and the signal from the photodetector 737 is also sent directly to a second analog to digital converter 704." Rulkov at 11:45-49.

Asserted Claim of '286 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	See also Rulkov at 10:32-33.
[17] The wearable device of claim 16, wherein at least one LED emits at a first wavelength and at least another LED emits at a second wavelength, and wherein the first wavelength has a first penetration depth into the tissue and wherein the second wavelength has a second penetration depth into the tissue different from the first penetration depth.	Rulkov discloses and/or renders obvious "[t]he wearable device of claim 16, wherein at least one LED emits at a first wavelength and at least another LED emits at a second wavelength, and wherein the first wavelength has a first penetration depth into the tissue and wherein the second wavelength has a second penetration depth into the tissue different from the first penetration depth.." "Yet further, the optical sensor is a combination of a green light LED and a pulsed infrared LED to offset noise effects of ambient light and sunlight." Rulkov at 5:23-25. "Pulse oximeter devices typically contain two light emitting diodes: one in the red band of light (660 nanometers) and one in the infrared band of light (940 nanometers). Oxyhemoglobin absorbs infrared light while deoxyhemoglobin absorbs visible red light." Rulkov at 1:53-57.
[19] The wearable device of claim 16, wherein the receiver is configured to be synchronized to the modulating of at least one of the LEDs.	Rulkov discloses and/or renders obvious "[t]he wearable device of claim 16, wherein the receiver is configured to be synchronized to the modulating of at least one of the LEDs." *See* CHART ONE: '533 Patent, Claim Element 5F above.
[20] The wearable device of claim 16, wherein the receiver is located a first distance from a first one of the LEDs and a different distance from a second one of the LEDs such that the receiver can capture a third signal from the first LED and a fourth signal from the second LED, and wherein the output signal is generated in part	Rulkov discloses and/or renders obvious "[t]he wearable device of claim 16, wherein the receiver is located a first distance from a first one of the LEDs and a different distance from a second one of the LEDs such that the receiver can capture a third signal from the first LED and a fourth signal from the second LED, and wherein the output signal is generated in part by comparing the third and fourth signals.." *See* CHART ONE: '533 Patent, Claim Element 8 above.

Asserted Claim of '286 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
by comparing the third and fourth signals.	

EXHIBIT B-4

U.S. Patent No. 9,885,698 vs Rulkov

Priority Date/Publication Date:	October 4, 2011/May 8, 2012	Prior Art Status:	§§ 102(a), (b), and (e) (pre-AIA) §§ 102(a), (b), and (d)

U.S. Patent No. 8,172,761 to Rulkov et al. ("Rulkov") anticipates the asserted claims of U.S. Patent No. 9,885,698 ("the '698 Patent") or renders those claims obvious alone and/or in view of at least any of the references identified in Apple's Obviousness Combinations Chart.

As set forth in Apple's Invalidity Contentions, the below contentions apply the prior art in part in accordance with Apple's assumption that Omni contends the claims are not invalid under 35 U.S.C. § 112. However, Apple's below contentions do not represent Apple's agreement or view as to the meaning, definiteness, written description support for, or enablement of any of the asserted claims. For each dependent claim, the disclosures cited for the claim from which it depends are incorporated by reference.

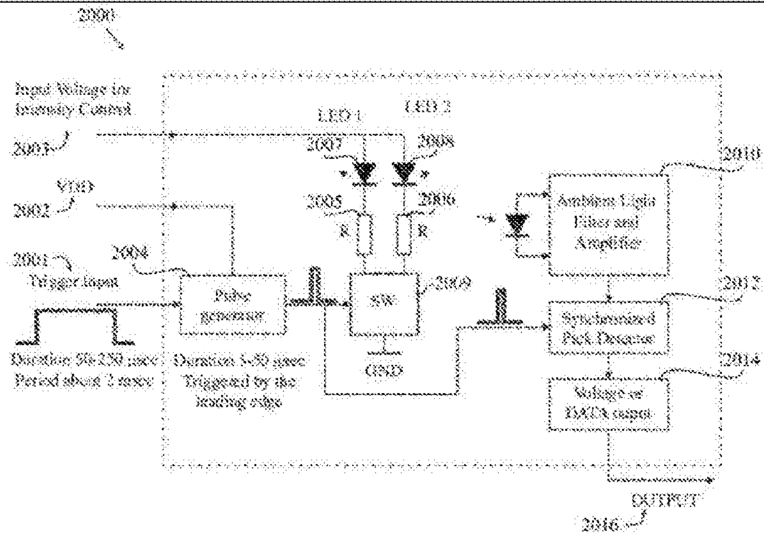
CHART FOUR: U.S. Patent No. 9,885,698 vs Rulkov

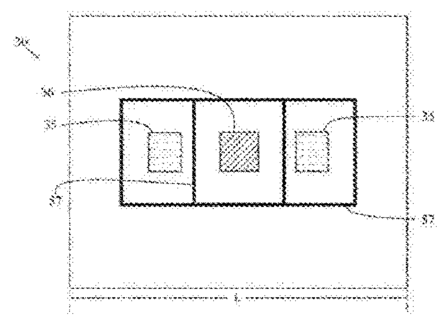
Asserted Claim of '698 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
[1] A wearable device, comprising:	To the extent the preamble is limiting, Rulkov discloses and/or renders obvious "[a] wearable device." *See* CHART ONE: '533 Patent, Claim Elements 5 and 13A above.
[1A] a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters,	Rulkov discloses and/or renders obvious "a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters." *See* CHART ONE: '533 Patent, Claim Element 13A above.
[1B] the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an input optical beam having one or more optical wavelengths,	Rulkov discloses and/or renders obvious "the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an input optical beam having one or more optical wavelengths." *See* CHART TWO: '040 Patent, Claim Element 1B above.
[1C] wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers;	Rulkov discloses and/or renders obvious "wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers." *See* CHART ONE: '533 Patent, Claim Element 5B above.
[1D] the measurement device comprising one or more lenses configured to receive and to deliver a portion of the input optical beam to tissue, wherein	Rulkov discloses and/or renders obvious "the measurement device comprising one or more lenses configured to receive and to deliver a portion of the input optical beam to tissue, wherein the tissue reflects at least a portion of the input optical beam delivered to the tissue." *See* CHART ONE: '533 Patent, Claim Element 5D above.

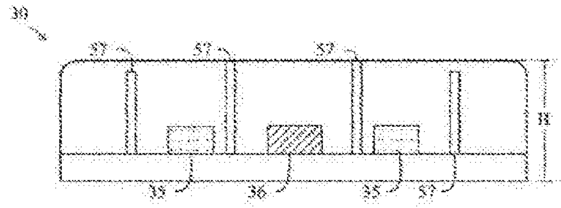
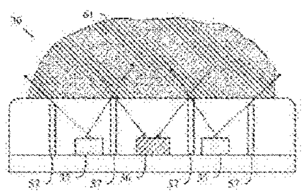
Asserted Claim of '698 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
the tissue reflects at least a portion of the input optical beam delivered to the tissue;	
[1E] the measurement device further comprising a receiver, wherein the receiver includes a plurality of spatially separated detectors, the detectors configured to: capture light while the LEDs are off and convert the captured light into a first signal; and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the input optical beam reflected from the tissue;	Rulkov discloses and/or renders obvious "the measurement device further comprising a receiver, wherein the receiver includes a plurality of spatially separated detectors, the detectors configured to: capture light while the LEDs are off and convert the captured light into a first signal; and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the input optical beam reflected from the tissue." *See* CHART TWO: '040 Patent, Claim Element 1F and CHART THREE: '286 Patent, Claim Element 16J above.
[1F] wherein at least one analog to digital converter is coupled to the spatially separated detectors and is configured to generate at least a first data signal from the first signal and at least a second data signal from the second signal;	Rulkov discloses and/or renders obvious "wherein at least one analog to digital converter is coupled to the spatially separated detectors and is configured to generate at least a first data signal from the first signal and at least a second data signal from the second signal." *See* CHART TWO: '040 Patent, Claim Element 1F and CHART THREE: '286 Patent, Claim Element 16K above.

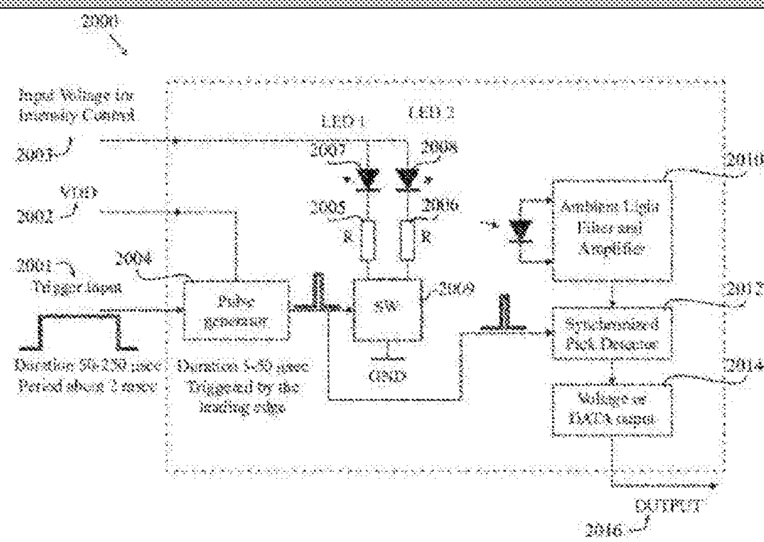
Asserted Claim of '698 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
[1G] the measurement device configured to improve a signal-to-noise ratio of the input optical beam reflected from the tissue by differencing the first data signal and the second data signal to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue; and	Rulkov discloses and/or renders obvious "the measurement device configured to improve a signal-to-noise ratio of the input optical beam reflected from the tissue by differencing the first data signal and the second data signal to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue." *See* CHART ONE: '533 Patent, Claim Element 10 and CHART TWO: '040 Patent, Claim Element 1G above.
[1H] wherein the modulating at least one of the LEDs has a modulation frequency, and wherein the receiver is configured to use a lock-in technique that detects the modulation frequency.	Rulkov discloses and/or renders obvious "wherein the modulating at least one of the LEDs has a modulation frequency, and wherein the receiver is configured to use a lock-in technique that detects the modulation frequency." "The preferred embodiment uses 250 microsecond LED pulses and a 12T photodetector 36 with second order active high pass filter (100 Hz cutoff). The DC output of the sensor 30 is monitored to ensure that it is not saturated by the effects of ambient light. The use of short-term pulses reduces ambient light. In the preferred embodiment, voltage is collected at the sensor output every 2 msec. Inside the microprocessor 741, an average 8 consecutive samples improve the SNR (signal to noise ratio) and then work with the averaged numbers. Therefore the sampling rate for raw data is preferably 2 msec, however if 8-samples averaging is utilized in the integrated sensor the data output rate is reduced to sending a new averaged value every 16 msec. An ADC is used with a 12-bit resolution. The response of TSL 12T is acceptable. 100 Hz is the low limit for LPF cutoff. The selection of pulse duration is preferably based on the speed of the LED drivers, sensor electronics and output pick detection. The higher the low frequency cutoff that is implemented for the selected pulse duration, the better SNR." Rulkov at 13:6-25. "Ambient light filter and amplifier 2010 transits to synchronized pick detector 2012 for a voltage or data output 2014 as an output signal 2016." Rulkov at 13:40-42.

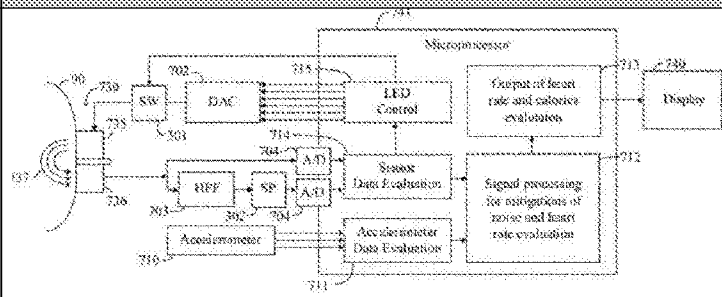
Asserted Claim of '698 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	"The output voltage is directly proportional to the reflected light intensity. The signal 299 is sent to the microprocessor. At block 1300, the signal acquisition is performed. In reference to FIGS. 14 and 15, in the pulse mode the LED 35 is periodically activated for short intervals of time by a signal from the microcontroller. The reflected pulse of light is received by the sensor, with the generation of a voltage pulse having an amplitude proportional to the intensity of the reflected light." Rulkov at 10:2-9. "At block 1305, a band pass filter is implemented preferably with two sets of data from the analog-to-digital converter. At block 1305, an average of the values of data samples within each of a first set of samples is calculated by the microprocessor. For example, the values of data samples within forty-four samples are summed and then divided by forty-four to generate an average value for the first set of samples. Next, an average of the values of data samples within a second set of samples is calculated by the microprocessor. For example, the values of data samples within twenty-two samples are summed and then divided by twenty-two to generate an average value for the second set of samples. Preferably, the second set of samples is less than the first set of samples. Next, the average value of the second set of samples is subtracted from the average value for the first set of samples to generate a first filtered pulse data value." Rulkov at 10:32-47. "The preferred embodiment uses 250 microsecond LED pulses and a 12T photodetector 36 with second order active high pass filter (100 Hz cutoff). The DC output of the sensor 30 is monitored to ensure that it is not saturated by the effects of ambient light. The use of short-term pulses reduces ambient light. In the preferred embodiment, voltage is collected at the sensor output every 2 msec. Inside the microprocessor 741, an average 8 consecutive samples improve the SNR (signal to noise ratio) and then work with the averaged numbers. Therefore the sampling rate for raw data is preferably 2 msec, however if 8-samples averaging is utilized in the integrated sensor the data output rate is reduced to sending a new averaged value every 16 msec. An ADC is used with a 12-bit resolution. The response of TSL 12T is acceptable. 100 Hz is the low limit for LPF cutoff. The selection of pulse duration is preferably based on the speed of the LED drivers, sensor electronics and output pick detection. The higher the low frequency cutoff that is implemented for the selected pulse duration, the better SNR." Rulkov at 13:6-25.

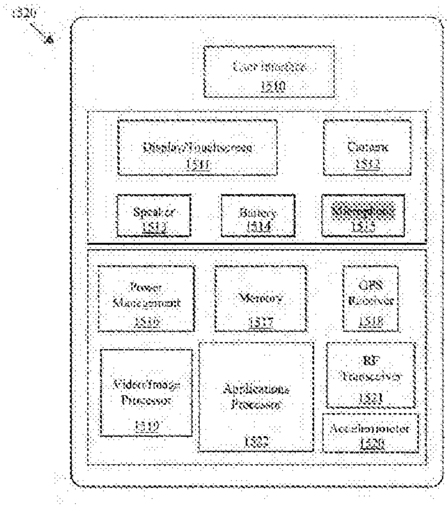
Asserted Claim of '698 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	 FIG. 12
[2] The wearable device of claim 1, wherein the plurality of LEDs and the plurality of spatially separated detectors are mounted on a common structure, and wherein the plurality of LEDs are coupled electrically to a power supply.	Rulkov discloses and/or renders obvious "[t]he wearable device of claim 1, wherein the plurality of LEDs and the plurality of spatially separated detectors are mounted on a common structure, and wherein the plurality of LEDs are coupled electrically to a power supply.." "The monitoring device 20 is preferably powered by a power source positioned on the article 25. Preferably the power source is a battery. The power source 360 is preferably an AA or AAA disposable or rechargeable battery. The power source is alternatively a lithium ion rechargeable battery such as available from NEC-Tokin. The power source preferably has an accessible port for recharging. The circuit assembly of the monitoring device preferably requires 5 volts and draws a

Asserted Claim of '698 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	current of 20- to 40 milliamps. The power source preferably provides at least 900 milliamp hours of power to the monitoring device 20." Rulkov, 6:7-17.  FIG. 9 <u>Rulkov</u> at Fig. 9.

Asserted Claim of '698 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	 FIG. 10 Rulkov at Fig. 10.  FIG. 11 Rulkov at Fig. 11.

Asserted Claim of '698 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	 FIG. 12

Asserted Claim of '698 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	 FIG. 18

Asserted Claim of '698 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
	 FIG. 25
[3] The wearable device of claim 1, wherein the light source is configured to further improve the signal-to-noise ratio of the input beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the	Rulkov discloses and/or renders obvious "[t]he wearable device of claim 1, wherein the light source is configured to further improve the signal-to-noise ratio of the input beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs, and wherein the receiver is configured to be synchronized to at least one of the LEDs." *See* CHART ONE: '533 Patent, Claim Elements 5C and 5F above.

Asserted Claim of '698 Patent	U.S. Patent No. 8,172,761 ("Rulkov")
LEDs, and wherein the receiver is configured to be synchronized to at least one of the LEDs.	
[5] The wearable device of claim 1, wherein the wearable device is configured to communicate with a smart phone or tablet, the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a voice input module, a speaker, and a touch screen, the smart phone or tablet configured to receive and to process at least a portion of the output signal, wherein the smart phone or tablet is configured to store and display the processed output signal, wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link.	Rulkov discloses and/or renders obvious "[t]he wearable device of claim 1, wherein the wearable device is configured to communicate with a smart phone or tablet, the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a voice input module, a speaker, and a touch screen, the smart phone or tablet configured to receive and to process at least a portion of the output signal, wherein the smart phone or tablet is configured to store and display the processed output signal, wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link." *See* CHART ONE: '533 Patent, Claim Elements 5G, 5H, 5I, and 5J above.

EXHIBIT BB

EXHIBIT BB-1

U.S. Patent No. 9,651,533 vs FitBit One

Priority Date/Publication Date: by December 2012 Prior Art Status: §§ 102(a) and (b)

The FitBit One manufactured by FitBit ("FitBit One") renders the asserted claims of U.S. Patent No. 9,651,533 ("the '533 Patent") obvious in view of at least any of the references identified in Apple's Obviousness Combinations Chart.

This chart is based on the following disclosures about the FitBit One:

- FitBit One User Manual ("User Manual 1.0")
- FitBit One User Manual Version 1.2 ("User Manual 1.2")

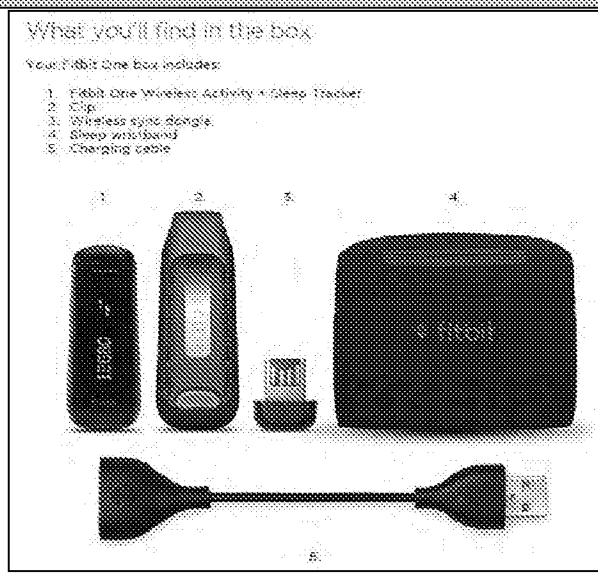
Discovery is ongoing, and Apple reserves the right to amend this chart based on new information about the FitBit One.

As set forth in Apple's Invalidity Contentions, the below contentions apply the prior art in part in accordance with Apple's assumption that Omni contends the claims are not invalid under 35 U.S.C. § 112. However, Apple's below contentions do not represent Apple's agreement or view as to the meaning, definiteness, written description support for, or enablement of any of the asserted claims. For each dependent claim, the disclosures cited for the claim from which it depends are incorporated by reference.

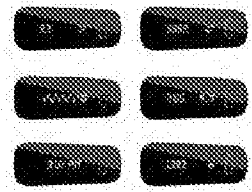
CHART ONE: U.S. Patent No. 9,651,533 vs FitBit One

Asserted Claim of '533 Patent	FitBit One
[5] A measurement system, comprising:	To the extent the preamble is limiting, FitBit One renders obvious "[a] measurement system."  (User Manual 1.0, Cover)

Asserted Claim of '533 Patent	FitBit One
	 (User Manual 1.2, Cover)

Asserted Claim of '533 Patent	FitBit One
	 (User Manual 1.2, p. 1)

Asserted Claim of '533 Patent	FitBit One
	Setting up your Fitbit One To make the most of your One, use the free Fitbit app available for iOS®, Android™, and Windows® 10 mobile devices. If you don't have a compatible mobile device, you can use a computer and fitbit.com instead. Setting up your tracker on your mobile device The Fitbit app is compatible with more than 200 mobile devices that support iOS, Android, and Windows 10 operating systems. To get started: 1. Make sure the Fitbit app is compatible with your mobile device by checking http://www.fitbit.com/devices. 2. Find the Fitbit app in one of these locations, depending on your device: • The Apple® App Store® for iOS devices such as an iPhone® or iPad®. • The Google Play™ Store for Android devices such as the Samsung® Galaxy® S5 and Motorola Droid Turbo. • The Microsoft® Windows Store for Windows 10 mobile such as the Lumia™ phone or Surface™ tablet. 3. Install the app. Note that you'll need an account with the applicable store before you can download even a free app such as Fitbit. 4. When the app is installed, open it and tap Join Fitbit to get started. You'll be guided through the process of creating a Fitbit account and connecting (pairing) your One to your mobile device. Pairing makes sure the tracker and mobile device can communicate with one another (sync their data). Note that the personal information you're asked during setup is used to calculate your basal metabolic rate (BMR), which helps determine your estimated calorie expenditure. This information is private unless you go into your Privacy settings and opt in share age, height, or weight with Fitbit friends. After setup you're ready to get moving. (User Manual 1.2, p. 3)

Asserted Claim of '533 Patent	FitBit One
	Tracking with Fitbit One Your One tracks a variety of stats automatically whenever you're wearing it. Your tracker's latest data is uploaded to your Fitbit dashboard whenever you sync. **Viewing all-day stats** Press the button on your One to see the time of day and cycle through these all-day stats: • Steps taken • Floors climbed • Recent activity levels (represented by an expanding flower) • Distance traveled • Calories burned  Note that your One resets at midnight according to the time zone you've selected for your account. The reset ensures that One can track your daily totals correctly, and does not delete the previous day's data. All your data will appear on your dashboard when you sync your tracker. (User Manual 1.2, p. 8) **Using the display** When you first set up your One and press the button to scroll through your stats, you see the stat category (e.g. STEPS) followed by the stat and its icon. After you've cycled through each screen 5 times and can recognize the stat icon, the stat category no longer appears so that you can scroll more quickly. Any time your tracker is reset, it will enter "beginner mode" and show the stat category again for the first 5 cycles. This will happen if you shut down and then restart your tracker, upgrade your tracker, or charge your tracker after the battery drained completely. (User Manual 1.2, p. 8)

Asserted Claim of '533 Patent	FitBit One
	Tracking sleep You can use your One to track how long and how well you sleep. The One will track your movement throughout the night to provide you with information about the quality of your sleep. 1. Place your tracker into the slot in your wristband and wrap it around your non-dominant wrist 2. Once you are in bed and ready to fall asleep, press and hold the tracker's button for 2+ seconds. You will see a blinking stopwatch and clock. The other icons will also blink, indicating that your tracker is in sleep mode. 3. When you wake up, press and hold the button for 2+ seconds to stop the sleep recording. The icons will stop blinking to indicate you've exited sleep mode. Once you exit sleep mode, your tracker will resume displaying your daily totals. Once the data syncs, graphs on your dashboard will reveal how long you slept and the number of times you woke up. You can also use your dashboard to set a goal for hours slept. Note: If you forgot to press the button on your tracker, but were wearing it while you slept, you can enter your sleep times manually in your online sleep log. (User Manual 1.2, p. 8-9) **Tracking exercise** Though your One automatically tracks several stats throughout the day, you can also track stats for a specific exercise or workout as well. Similar to the trip mode on a car's odometer, activity mode brings closer scrutiny to a specific time period. For example, if you put your One in activity mode and go for a run, you can view stats measured for that run, such as calories burned or steps taken. When you end activity mode at the end of the run and sync your data, your can log in to your fitbit.com dashboard and see a summary of the activity's stats such as pace, duration, and more. To start a recording, hold your tracker's button down for 2-3 seconds until a flashing stopwatch and running numbers appear as they do in sleep mode. During the activity the display icons will blink. When you press the tracker's button to cycle between screens, the stats represent the activity that has occurred since the recording started. To exit activity mode, hold your tracker's button down for 2-3 seconds until the icons and numbers on the display stop flashing. (User Manual 1.2, p. 9)
[5A] a light source comprising a plurality of semiconductor sources that are light emitting diodes, the light emitting diodes	FitBit One renders obvious "a light source comprising a plurality of semiconductor sources that are light emitting diodes, the light emitting diodes configured to generate an output optical beam with one or more optical wavelengths."

Asserted Claim of '533 Patent	FitBit One
configured to generate an output optical beam with one or more optical wavelengths,	*See* CHART ONE: '533 Patent, Claim Element 13A below.
[5B] wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers,	FitBit One renders obvious "wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers."
[5C] the light source configured to increase signal-to-noise ratio by increasing a light intensity from at least one of the plurality of semiconductor sources and by increasing a pulse rate of at least one of the plurality of semiconductor sources;	FitBit One renders obvious "the light source configured to increase signal-to-noise ratio by increasing a light intensity from at least one of the plurality of semiconductor sources and by increasing a pulse rate of at least one of the plurality of semiconductor sources."
[5D] an apparatus comprising a plurality of lenses configured to receive a portion of the output optical beam and to deliver an analysis output beam to a sample	FitBit One renders obvious "an apparatus comprising a plurality of lenses configured to receive a portion of the output optical beam and to deliver an analysis output beam to a sample."
[5E] a receiver configured to receive and process at least a portion of the analysis output beam reflected or transmitted from the sample and to generate an output signal,	FitBit One renders obvious "a receiver configured to receive and process at least a portion of the analysis output beam reflected or transmitted from the sample and to generate an output signal."

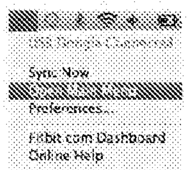
Asserted Claim of '533 Patent	FitBit One
[5F] wherein the receiver is configured to be synchronized to the light source;	FitBit One renders obvious "wherein the receiver is configured to be synchronized to the light source."
[5G] a personal device comprising a wireless receiver, a wireless transmitter, a display, a microphone, a speaker, one or more buttons or knobs, a microprocessor and a touch screen,	FitBit One renders obvious "a personal device comprising a wireless receiver, a wireless transmitter, a display, a microphone, a speaker, one or more buttons or knobs, a microprocessor and a touch screen."

Asserted Claim of '533 Patent	FitBit One
	 (User Manual 1.0, Cover)

<table>
<tr><th>Asserted Claim of '533 Patent</th><th>FitBit One</th></tr>
<tr><td></td><td>
Wireless sync to a computer

Wireless syncing to Fitbit.com is automatic as long as:
· Your computer is powered on, awake, and connected to the internet.
· The Wireless Sync Dongle is plugged in and your tracker is within 15 feet of it.
· Fitbit Connect is installed and running.

You can force sync your tracker by clicking the Fitbit Connect icon, which is located by the time and date on your computer, and then selecting Sync Now.



NOTE: If you experience any trouble syncing your tracker with your computer, you can visit help.fitbit.com for help.

(User Manual 1.0, p. 7)

Memory

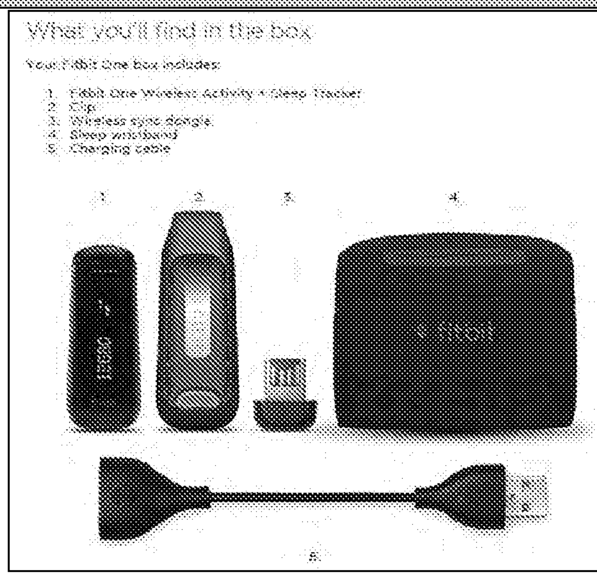
The One tracker stores minute-by-minute data for one week. After 7 days, that data is converted to a daily total, which is stored for an additional 23 days.

When you sync your tracker, its data is uploaded to your Fitbit.com Dashboard and securely stored on Fitbit's servers. As long as you sync your tracker within thirty days of activity, you'll be able to transmit that data to your Fitbit.com Dashboard.

NOTE: Every night at midnight, your tracker will reset itself. This means your goal progress and daily data will begin at zero again. This does not delete the data stored on your tracker. That data will be uploaded to your Dashboard the next time you sync your tracker. The time this reset occurs is based on the time zone set on your Fitbit.com profile.

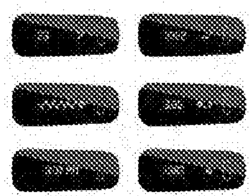
(User Manual 1.0, p. 14)
</td></tr>
</table>

Asserted Claim of '533 Patent	FitBit One
	 (User Manual 1.2, Cover)

Asserted Claim of '533 Patent	FitBit One
	 (User Manual 1.2, p. 1)

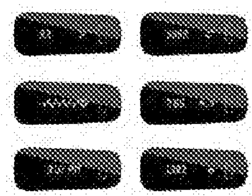
Asserted Claim of '533 Patent	FitBit One
	Setting up your Fitbit One To make the most of your One, use the free Fitbit app available for iOS®, Android™, and Windows® 10 mobile devices. If you don't have a compatible mobile device, you can use a computer and fitbit.com instead. **Setting up your tracker on your mobile device** The Fitbit app is compatible with more than 200 mobile devices that support iOS, Android, and Windows 10 operating systems. To get started: 1. Make sure the Fitbit app is compatible with your mobile device by checking [illegible]. 2. Find the Fitbit app in one of these locations, depending on your device: • The Apple® App Store® for iOS devices such as an iPhone® or iPad®. • The Google Play™ Store for Android devices such as the Samsung® Galaxy® S5 and Motorola Droid Turbo. • The Microsoft® Windows Store for Windows 10 mobile such as the Lumia™ phone or Surface™ tablet. 3. Install the app. Note that you'll need an account with the applicable store before you can download even a free app such as Fitbit. 4. When the app is installed, open it and tap Join Fitbit to get started. You'll be guided through the process of creating a Fitbit account and connecting (pairing) your One to your mobile device. Pairing makes sure the tracker and mobile device can communicate with one another (sync their data). Note that the personal information you're asked during setup is used to calculate your basal metabolic rate (BMR), which helps determine your estimated calorie expenditure. This information is private unless you go into your Privacy settings and opt in to share age, height, or weight with Fitbit friends. After setup you're ready to get moving. (User Manual 1.2, p. 3) **Setting up your tracker on your PC (Windows 10 only)** If you don't have a mobile device, you can set up and sync your tracker on your Windows 10 PC using the same Fitbit app available for Windows mobile devices. To get the app, click the Start button and open the Windows Store (called Store). Search for "Fitbit app." Note that if you've never downloaded an app from the store to your computer, you'll be prompted to create an account. Open the app and follow the instructions to create a Fitbit account and set up your One. You can set up and sync wirelessly if your computer has Bluetooth®, otherwise you'll need to use the wireless sync dongle that came in the box with your Fitbit One. (User Manual 1.2, p. 3)

Asserted Claim of '533 Patent	FitBit One
	Setting up your tracker on your PC (Windows 8.1 and below) If you don't have a compatible mobile device, you can set up your tracker with a computer and see your Fitbit stats on fitbit.com. To use this setup method you'll first install a free software application called Fitbit Connect that lets One sync its data with your fitbit.com dashboard. To install Fitbit Connect and set up your tracker: 1. Go to http://www.fitbit.com/setup. 2. Scroll down and click the option to download. 3. When prompted, save the file that appears. 4. Double-click the file (FitbitConnect_Win.exe). The Fitbit Connect installer opens. 5. Click Continue to move through the installer. 6. When prompted, choose Set up a New Fitbit Device. 7. Follow the onscreen instructions to create a Fitbit account and connect your One. If your computer has Bluetooth, setup can take place wirelessly. If not you'll be prompted to plug in the wireless sync dongle that came in the box with your Fitbit One. Note that the personal information you're asked during setup is used to calculate your basal metabolic rate (BMR), which helps determine your estimated calorie expenditure. This information is private unless you go into your Privacy settings and opt to share age, height, or weight with Fitbit friends. (User Manual 1.2, p. 4) **Setting up your tracker on your Mac** If you don't have a compatible mobile device, you can set up your tracker with a computer and see your Fitbit stats on fitbit.com. To use this setup method you'll first install a free software application called Fitbit Connect that lets One sync its data with your fitbit.com dashboard. To install Fitbit Connect and set up your tracker: 1. Go to http://www.fitbit.com/setup. 2. Scroll down and click the option to download. 3. When prompted, save the file that appears. 4. Double-click the file (Install Fitbit Connect.pkg). The Fitbit Connect installer opens. 5. Click Continue to move through the installer. 6. When prompted, choose Set up a New Fitbit Device. 7. Follow the onscreen instructions to create a Fitbit account and connect your One. Note that the personal information you're asked during setup is used to calculate your basal metabolic rate (BMR), which helps determine your estimated calorie expenditure. This information is private unless you go into your Privacy settings and opt to share age, height, or weight with Fitbit friends. (User Manual 1.2, p. 4)

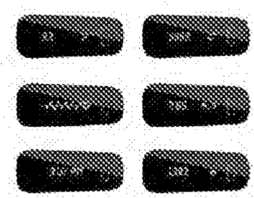
Asserted Claim of '533 Patent	FitBit One
	Syncing your tracker data to your Fitbit account Once you've set up and started using One, you'll need to make sure it regularly transfers (syncs) its data to Fitbit so you can track your progress, see your exercise history, earn badges, analyze your sleep logs, and more on your Fitbit dashboard. A daily sync is recommended but not required. The Fitbit apps use Bluetooth Low Energy (BLE) technology to sync with your Fitbit tracker. Each time you open the app it will sync if the tracker is nearby, and the app will also sync periodically throughout the day if you have the all-day sync setting enabled. If you're running the Fitbit app on a Windows 10 PC that doesn't have Bluetooth, you'll need to make sure the tracker is connected to the computer. Fitbit Connect on a Mac® also uses Bluetooth for syncing (if available), otherwise you'll need to make sure your wireless sync dongle is plugged into the computer. Fitbit Connect on a PC requires that you plug in your wireless sync dongle. You can force Fitbit Connect to sync at any time or it will happen automatically every 15 minutes if: • Your tracker is within 20 feet of your computer and has new data to upload (meaning that if you haven't moved, an automatic sync won't occur). • The computer is powered on, awake, and connected to the internet. (User Manual 1.2, p. 5) **Tracking with Fitbit One** Your One tracks a variety of stats automatically whenever you're wearing it. Your tracker's latest data is uploaded to your Fitbit dashboard whenever you sync. **Viewing all-day stats** Press the button on your One to see the time of day and cycle through these all-day stats: • Steps taken • Floors climbed • Recent activity levels (represented by an expanding flower) • Distance traveled • Calories burned  Note that your One resets at midnight according to the time zone you've selected for your account. The reset ensures that One can track your daily totals correctly, and does not delete the previous day's data. All your data will appear on your dashboard when you sync your tracker. (User Manual 1.2, p. 8)

Asserted Claim of '533 Patent	FitBit One
	Using the display When you first set up your One and press the button to scroll through your stats, you see the stat category (e.g. STEPS) followed by the stat and its icon. After you've cycled through each screen 5 times and can recognize the stat icon, the stat category no longer appears so that you can scroll more quickly. Any time your tracker is reset, it will enter "beginner mode" and show the stat category again for the first 5 cycles. This will happen if you shut down and then restart your tracker, upgrade your tracker, or charge your tracker after the battery drained completely. (User Manual 1.2, p. 8) **Tracking sleep** You can use your One to track how long and how well you sleep. The One will track your movement throughout the night to provide you with information about the quality of your sleep. 1. Place your tracker into the slot in your wristband and wrap it around your non-dominant wrist. 2. Once you are in bed and ready to fall asleep, press and hold the tracker's button for 2+ seconds. You will see a blinking stopwatch and clock. The other icons will also blink, indicating that your tracker is in sleep mode. 3. When you wake up, press and hold the button for 2+ seconds to stop the sleep recording. The icons will stop blinking to indicate you've exited sleep mode. Once you exit sleep mode, your tracker will resume, displaying your daily totals. Once the data syncs, graphs on your dashboard will reveal how long you slept and the number of times you woke up. You can also use your dashboard to set a goal for hours slept. Note: If you forgot to press the button on your tracker but were wearing it while you slept, you can enter your sleep times manually in your online sleep log. (User Manual 1.2, p. 8-9)

Asserted Claim of '533 Patent	FitBit One
	Tracking exercise Though your One automatically tracks several stats throughout the day, you can also track stats for a specific exercise or workout as well. Similar to the trip mode on a car's odometer, activity mode brings closer scrutiny to a specific time period. For example, if you put your One in activity mode and go for a run, you can view stats measured for that run, such as calories burned or steps taken. When you end activity mode at the end of the run and sync your data, your can log in to your fitbit.com dashboard and see a summary of the activity's stats such as pace, duration, and more. To start a recording, hold your tracker's button down for 2-3 seconds until a flashing stopwatch and running numbers appear as they do in sleep mode. During the activity the display icons will blink. When you press the tracker's button to cycle between screens, the stats represent the activity that has occurred since the recording started. To exit activity mode, hold your tracker's button down for 2-3 seconds until the icons and numbers on the display stop flashing. (User Manual 1.2, p. 9) Managing your One from fitbit.com To manage various settings for your account, click the gear icon in the top right corner of your fitbit.com dashboard and select Settings. From here you can edit your personal information, your notification preferences, your privacy settings, and much more. The Devices page allows you to monitor or edit: • The date and time of your last sync. • Your tracker's battery level. • The firmware version running on your tracker. • Your time zone. • Your sleep tracking sensitivity option. • Your handedness preference: left-handed or right-handed. • Your tracker's greeting. (User Manual 1.2, p. 11)
[5H] the personal device configured to receive and process at least a portion of the output signal,	FitBit One renders obvious "the personal device configured to receive and process at least a portion of the output signal."

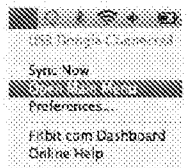
Asserted Claim of '533 Patent	FitBit One
	Memory The One tracker stores minute-by-minute data for one week. After 7 days, that data is converted to a daily total, which is stored for an additional 23 days. When you sync your tracker, its data is uploaded to your Fitbit.com Dashboard, and securely stored on Fitbit's servers. As long as you sync your tracker within thirty days of activity, you'll be able to transmit that data to your Fitbit.com Dashboard. NOTE: Every night at midnight, your tracker will reset itself. This means your goal progress and daily data will begin at zero again. This does not delete the data stored on your tracker. That data will be uploaded to your Dashboard the next time you sync your tracker. The time this reset occurs is based on the time zone set on your Fitbit.com profile. (User Manual 1.0, p. 14) **Tracking with Fitbit One** Your One tracks a variety of stats automatically whenever you're wearing it. Your tracker's latest data is uploaded to your Fitbit dashboard whenever you sync. **Viewing all-day stats** Press the button on your One to see the time of day and cycle through these all-day stats: • Steps taken • Floors climbed • Recent activity levels (represented by an expanding flower) • Distance traveled • Calories Burned  Note that your One resets at midnight according to the time zone you've selected for your account. The reset ensures that One can track your daily totals correctly, and does not delete the previous day's data. All your data will appear on your dashboard when you sync your tracker. (User Manual 1.2, p. 8)

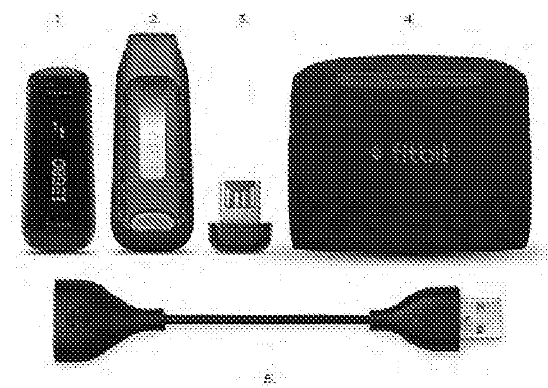
Asserted Claim of '533 Patent	FitBit One
	Tracking sleep You can use your One to track how long and how well you sleep. The One will track your movement throughout the night to provide you with information about the quality of your sleep. 1. Place your tracker into the slot in your wristband and wrap it around your non-dominant wrist 2. Once you are in bed and ready to fall asleep, press and hold the tracker's button for 2+ seconds. You will see a blinking stopwatch and clock. The other icons will also blink, indicating that your tracker is in sleep mode. 3. When you wake up, press and hold the button for 2+ seconds to stop the sleep recording. The icons will stop blinking to indicate you've exited sleep mode. Once you exit sleep mode, your tracker will resume displaying your daily totals. Once the data syncs, graphs on your dashboard will reveal how long you slept and the number of times you woke up. You can also use your dashboard to set a goal for hours slept. Note: If you forgot to press the button on your tracker, but were wearing it while you slept, you can enter your sleep times manually in your online sleep log. (User Manual 1.2, p. 8-9) **Tracking exercise** Though your One automatically tracks several stats throughout the day, you can also track stats for a specific exercise or workout as well. Similar to the trip mode on a car's odometer, activity mode brings closer scrutiny to a specific time period. For example, if you put your One in activity mode and go for a run, you can view stats measured for that run, such as calories burned or steps taken. When you end activity mode at the end of the run and sync your data, your can log in to your fitbit.com dashboard and see a summary of the activity's stats such as pace, duration, and more. To start a recording, hold your tracker's button down for 2-3 seconds until a flashing stopwatch and running numbers appear as they do in sleep mode. During the activity the display icons will blink. When you press the tracker's button to cycle between screens, the stats represent the activity that has occurred since the recording started. To exit activity mode, hold your tracker's button down for 2-3 seconds until the icons and numbers on the display stop flashing. (User Manual 1.2, p. 9)
[5I] wherein the personal device is configured to store and display the processed output signal,	FitBit One renders obvious "wherein the personal device is configured to store and display the processed output signal."

Asserted Claim of '533 Patent	FitBit One
	Memory The One tracker stores minute-by-minute data for one week. After 7 days, that data is converted to a daily total, which is stored for an additional 23 days. When you sync your tracker, its data is uploaded to your Fitbit.com Dashboard, and securely stored on Fitbit's servers. As long as you sync your tracker within thirty days of activity, you'll be able to transmit that data to your Fitbit.com Dashboard. NOTE: Every night at midnight, your tracker will reset itself. This means your goal progress and daily data will begin at zero again. This does not delete the data stored on your tracker. That data will be uploaded to your Dashboard the next time you sync your tracker. The time this reset occurs is based on the time zone set on your Fitbit.com profile. (User Manual 1.0, p. 14) Tracking with Fitbit One Your One tracks a variety of stats automatically whenever you're wearing it. Your tracker's latest data is uploaded to your Fitbit dashboard whenever you sync. Viewing all-day stats Press the button on your One to see the time of day and cycle through these all-day stats: • Steps taken • Floors climbed • Recent activity levels (represented by an expanding flower) • Distance traveled • Calories Burned  Note that your One resets at midnight according to the time zone you've selected for your account. The reset ensures that One can track your daily totals correctly, and does not delete the previous day's data. All your data will appear on your dashboard when you sync your tracker. (User Manual 1.2, p. 8)

Asserted Claim of '533 Patent	FitBit One
	Using the display When you first set up your One and press the button to scroll through your stats, you see the stat category (e.g. STEPS) followed by the stat and its icon. After you've cycled through each screen 5 times and can recognize the stat icon, the stat category no longer appears so that you can scroll more quickly. Any time your tracker is reset, it will enter "beginner mode" and show the stat category again for the first 5 cycles. This will happen if you shut down and then restart your tracker, upgrade your tracker, or charge your tracker after the battery drained completely. (User Manual 1.2, p. 8) **Tracking sleep** You can use your One to track how long and how well you sleep. The One will track your movement throughout the night to provide you with information about the quality of your sleep. 1. Place your tracker into the slot in your wristband and wrap it around your non-dominant wrist. 2. Once you are in bed and ready to fall asleep, press and hold the tracker's button for 2+ seconds. You will see a blinking stopwatch and clock. The other icons will also blink, indicating that your tracker is in sleep mode. 3. When you wake up, press and hold the button for 2+ seconds to stop the sleep recording. The icons will stop blinking to indicate you've exited sleep mode. Once you exit sleep mode, your tracker will resume, displaying your daily totals. Once the data syncs, graphs on your dashboard will reveal how long you slept and the number of times you woke up. You can also use your dashboard to set a goal for hours slept. Note: If you forgot to press the button on your tracker but were wearing it while you slept, you can enter your sleep times manually in your online sleep log. (User Manual 1.2, p. 8-9)

Asserted Claim of '533 Patent	FitBit One
	Tracking exercise Though your One automatically tracks several stats throughout the day, you can also track stats for a specific exercise or workout as well. Similar to the trip mode on a car's odometer, activity mode brings closer scrutiny to a specific time period. For example, if you put your One in activity mode and go for a run, you can view stats measured for that run, such as calories burned or steps taken. When you end activity mode at the end of the run and sync your data, you can log in to your fitbit.com dashboard and see a summary of the activity's stats such as pace, duration, and more. To start a recording, hold your tracker's button down for 2-3 seconds until a flashing stopwatch and running numbers appear as they do in sleep mode. During the activity the display icons will blink. When you press the tracker's button to cycle between screens, the stats represent the activity that has occurred since the recording started. To exit activity mode, hold your tracker's button down for 2-3 seconds until the icons and numbers on the display stop flashing. (User Manual 1.2, p. 9)
[5J] and wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link; and	FitBit One renders obvious "and wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link."

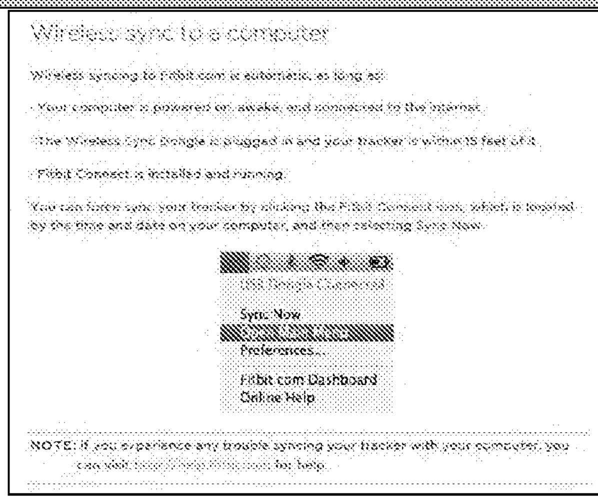
Asserted Claim of '533 Patent	FitBit One
	Wireless sync to a computer Wireless syncing to Fitbit.com is automatic, as long as: · Your computer is powered on, awake, and connected to the internet. · The Wireless Sync Dongle is plugged in and your tracker is within 15 feet of it. · Fitbit Connect is installed and running. You can force sync your tracker by clicking the Fitbit Connect icon, which is located by the time and date on your computer, and then selecting Sync Now.  NOTE: If you experience any trouble syncing your tracker with your computer, you can visit [illegible] for help. (User Manual 1.0, p. 7)

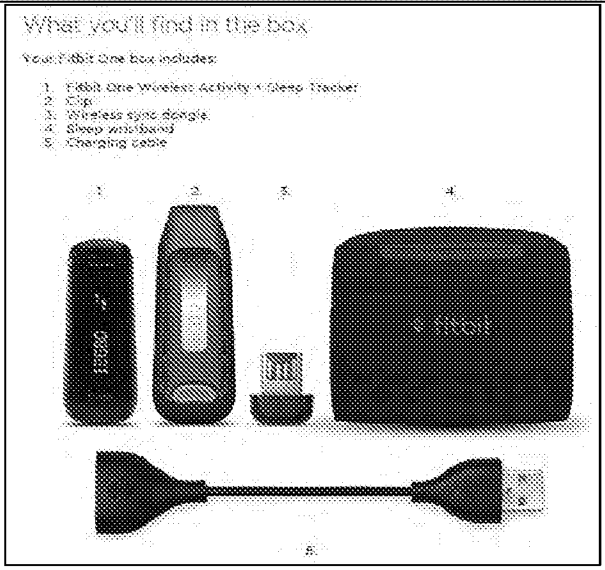
Asserted Claim of '533 Patent	FitBit One
	What you'll find in the box Your Fitbit One box includes: 1. Fitbit One Wireless Activity + Sleep Tracker 2. Clip 3. Wireless sync dongle 4. Sleep wristband 5. Charging cable  (User Manual 1.2, p. 1)

Asserted Claim of '533 Patent	FitBit One
	Setting up your Fitbit One To make the most of your One, use the free Fitbit app available for iOS®, Android™, and Windows® 10 mobile devices. If you don't have a compatible mobile device, you can use a computer and fitbit.com instead. **Setting up your tracker on your mobile device** The Fitbit app is compatible with more than 200 mobile devices that support iOS, Android, and Windows 10 operating systems. To get started: 1. Make sure the Fitbit app is compatible with your mobile device by checking http://www.fitbit.com/devices. 2. Find the Fitbit app in one of these locations, depending on your device: • The Apple® App Store® for iOS devices such as an iPhone® or iPad®. • The Google Play™ Store for Android devices such as the Samsung® Galaxy® S5 and Motorola Droid Turbo. • The Microsoft® Windows Store for Windows 10 mobile such as the Lumia™ phone or Surface™ tablet. 3. Install the app. Note that you'll need an account with the applicable store before you can download even a free app such as Fitbit. 4. When the app is installed, open it and tap Join Fitbit to get started. You'll be guided through the process of creating a Fitbit account and connecting (pairing) your One to your mobile device. Pairing makes sure the tracker and mobile device can communicate with one another (sync their data). Note that the personal information you're asked during setup is used to calculate your basal metabolic rate (BMR), which helps determine your estimated calorie expenditure. This information is private unless you go into your Privacy settings and opt to share age, height, or weight with Fitbit friends. After setup you're ready to get moving. (User Manual 1.2, p. 3) **Setting up your tracker on your PC (Windows 10 only)** If you don't have a mobile device, you can set up and sync your tracker on your Windows 10 PC using the same Fitbit app available for Windows mobile devices. To get the app, click the Start button and open the Windows Store (called Store). Search for "Fitbit app." Note that if you've never downloaded an app from the store to your computer, you'll be prompted to create an account. Open the app and follow the instructions to create a Fitbit account and set up your One. You can set up and sync wirelessly if your computer has Bluetooth®, otherwise you'll need to use the wireless sync dongle that came in the box with your Fitbit One. (User Manual 1.2, p. 3)

Asserted Claim of '533 Patent	FitBit One
	Setting up your tracker on your PC (Windows 8.1 and below) If you don't have a compatible mobile device, you can set up your tracker with a computer and see your Fitbit stats on fitbit.com. To use this setup method you'll first install a free software application called Fitbit Connect that lets One sync its data with your fitbit.com dashboard. To install Fitbit Connect and set up your tracker: 1. Go to [illegible]. 2. Scroll down and click the option to download. 3. When prompted, save the file that appears. 4. Double-click the file (FitbitConnect_Win.exe). The Fitbit Connect installer opens. 5. Click Continue to move through the installer. 6. When prompted, choose Set up a New Fitbit Device. 7. Follow the onscreen instructions to create a Fitbit account and connect your One. If your computer has Bluetooth, setup can take place wirelessly. If not you'll be prompted to plug in the wireless sync dongle that came in the box with your Fitbit One. Note that the personal information you're asked during setup is used to calculate your basal metabolic rate (BMR), which helps determine your estimated calorie expenditure. This information is private unless you go into your Privacy settings and opt to share age, height, or weight with Fitbit friends. (User Manual 1.2, p. 4) **Setting up your tracker on your Mac** If you don't have a compatible mobile device, you can set up your tracker with a computer and see your Fitbit stats on fitbit.com. To use this setup method you'll first install a free software application called Fitbit Connect that lets One sync its data with your fitbit.com dashboard. To install Fitbit Connect and set up your tracker: 1. Go to [illegible]. 2. Scroll down and click the option to download. 3. When prompted, save the file that appears. 4. Double-click the file (Install Fitbit Connect.pkg). The Fitbit Connect installer opens. 5. Click Continue to move through the installer. 6. When prompted, choose Set up a New Fitbit Device. 7. Follow the onscreen instructions to create a Fitbit account and connect your One. Note that the personal information you're asked during setup is used to calculate your basal metabolic rate (BMR), which helps determine your estimated calorie expenditure. This information is private unless you go into your Privacy settings and opt to share age, height, or weight with Fitbit friends. (User Manual 1.2, p. 4)

Asserted Claim of '533 Patent	FitBit One
	Syncing your tracker data to your Fitbit account Once you've set up and started using One, you'll need to make sure it regularly transfers (syncs) its data to Fitbit so you can track your progress, see your exercise history, earn badges, analyze your sleep logs, and more on your Fitbit dashboard. A daily sync is recommended but not required. The Fitbit apps use Bluetooth Low Energy (BLE) technology to sync with your Fitbit tracker. Each time you open the app it will sync if the tracker is nearby, and the app will also sync periodically throughout the day if you have the all-day sync setting enabled. If you're running the Fitbit app on a Windows 10 PC that doesn't have Bluetooth, you'll need to make sure the tracker is connected to the computer. Fitbit Connect on a Mac® also uses Bluetooth for syncing (if available), otherwise you'll need to make sure your wireless sync dongle is plugged into the computer. Fitbit Connect on a PC requires that you plug in your wireless sync dongle. You can force Fitbit Connect to sync at any time or it will happen automatically every 15 minutes if: • Your tracker is within 20 feet of your computer and has new data to upload (meaning that if you haven't moved, an automatic sync won't occur). • The computer is powered on, awake, and connected to the internet. (User Manual 1.2, p. 5) **Managing your One from fitbit.com** To manage various settings for your account, click the gear icon in the top right corner of your fitbit.com dashboard and select Settings. From here you can edit your personal information, your notification preferences, your privacy settings, and much more. The Devices page allows you to monitor or edit: • The date and time of your last sync. • Your tracker's battery level. • The firmware version running on your tracker. • Your time zone. • Your sleep tracking sensitivity option. • Your handedness preference, left-handed or right-handed. • Your tracker's greeting. (User Manual 1.2, p. 11)
[5K] a remote device configured to receive over the wireless transmission link an output status comprising the at least a portion of the processed output signal, to process the received output status	FitBit One renders obvious "a remote device configured to receive over the wireless transmission link an output status comprising the at least a portion of the processed output signal, to process the received output status to generate processed data and to store the processed data."

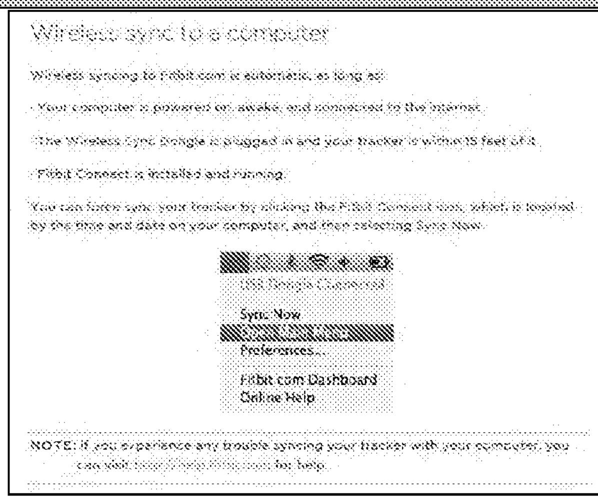
Asserted Claim of '533 Patent	FitBit One
to generate processed data and to store the processed data.	 Wireless sync to a computer Wireless syncing to Fitbit.com is automatic, as long as: · Your computer is powered on, awake, and connected to the Internet. · The Wireless Sync Dongle is plugged in and your tracker is within 15 feet of it. · Fitbit Connect is installed and running. You can force sync your tracker by clicking the Fitbit Connect icon, which is located by the time and date on your computer, and then selecting Sync Now. Sync Now Preferences... Fitbit.com Dashboard Online Help NOTE: If you experience any trouble syncing your tracker with your computer, you can visit http://help.fitbit.com for help. (User Manual 1.0, p. 7)

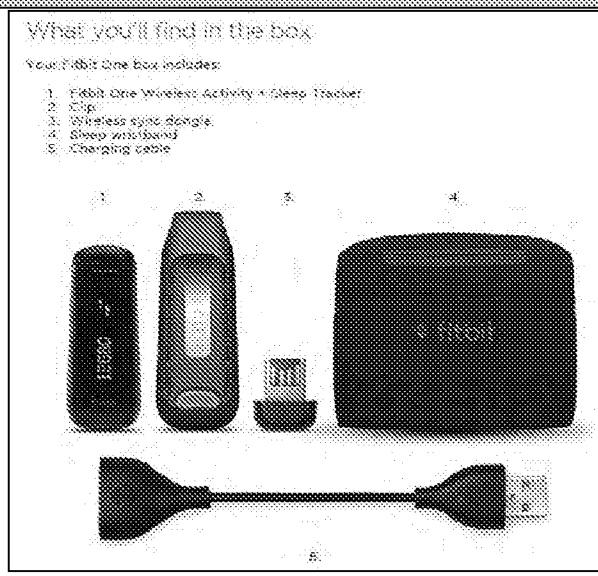
Asserted Claim of '533 Patent	FitBit One
	 (User Manual 1.2, p. 1)

Asserted Claim of '533 Patent	FitBit One
	Setting up your Fitbit One To make the most of your One, use the free Fitbit app available for iOS®, Android™, and Windows® 10 mobile devices. If you don't have a compatible mobile device, you can use a computer and fitbit.com instead. **Setting up your tracker on your mobile device** The Fitbit app is compatible with more than 200 mobile devices that support iOS, Android, and Windows 10 operating systems. To get started: 1. Make sure the Fitbit app is compatible with your mobile device by checking [illegible]. 2. Find the Fitbit app in one of these locations, depending on your device: • The Apple® App Store® for iOS devices such as an iPhone® or iPad®. • The Google Play™ Store for Android devices such as the Samsung® Galaxy® S5 and Motorola Droid Turbo. • The Microsoft® Windows Store for Windows 10 mobile such as the Lumia™ phone or Surface™ tablet. 3. Install the app. Note that you'll need an account with the applicable store before you can download even a free app such as Fitbit. 4. When the app is installed, open it and tap Join Fitbit to get started. You'll be guided through the process of creating a Fitbit account and connecting (pairing) your One to your mobile device. Pairing makes sure the tracker and mobile device can communicate with one another (sync their data). Note that the personal information you're asked during setup is used to calculate your basal metabolic rate (BMR), which helps determine your estimated calorie expenditure. This information is private unless you go into your Privacy settings and opt to share age, height, or weight with Fitbit friends. After setup you're ready to get moving. (User Manual 1.2, p. 3) **Setting up your tracker on your PC (Windows 10 only)** If you don't have a mobile device, you can set up and sync your tracker on your Windows 10 PC using the same Fitbit app available for Windows mobile devices. To get the app, click the Start button and open the Windows Store (called Store). Search for "Fitbit app." Note that if you've never downloaded an app from the store to your computer, you'll be prompted to create an account. Open the app and follow the instructions to create a Fitbit account and set up your One. You can set up and sync wirelessly if your computer has Bluetooth®, otherwise you'll need to use the wireless sync dongle that came in the box with your Fitbit One. (User Manual 1.2, p. 3)

Asserted Claim of '533 Patent	FitBit One
	Setting up your tracker on your PC (Windows 8.1 and below) If you don't have a compatible mobile device, you can set up your tracker with a computer and see your Fitbit stats on fitbit.com. To use this setup method you'll first install a free software application called Fitbit Connect that lets One sync its data with your fitbit.com dashboard. To install Fitbit Connect and set up your tracker: 1. Go to http://www.fitbit.com/setup. 2. Scroll down and click the option to download. 3. When prompted, save the file that appears. 4. Double-click the file (FitbitConnect_Win.exe). The Fitbit Connect installer opens. 5. Click Continue to move through the installer. 6. When prompted, choose Set up a New Fitbit Device. 7. Follow the onscreen instructions to create a Fitbit account and connect your One. If your computer has Bluetooth, setup can take place wirelessly. If not you'll be prompted to plug in the wireless sync dongle that came in the box with your Fitbit One. Note that the personal information you're asked during setup is used to calculate your basal metabolic rate (BMR), which helps determine your estimated calorie expenditure. This information is private unless you go into your Privacy settings and opt to share age, height, or weight with Fitbit friends. (User Manual 1.2, p. 4) **Setting up your tracker on your Mac** If you don't have a compatible mobile device, you can set up your tracker with a computer and see your Fitbit stats on fitbit.com. To use this setup method you'll first install a free software application called Fitbit Connect that lets One sync its data with your fitbit.com dashboard. To install Fitbit Connect and set up your tracker: 1. Go to http://www.fitbit.com/setup. 2. Scroll down and click the option to download. 3. When prompted, save the file that appears. 4. Double-click the file (Install Fitbit Connect.pkg). The Fitbit Connect installer opens. 5. Click Continue to move through the installer. 6. When prompted, choose Set up a New Fitbit Device. 7. Follow the onscreen instructions to create a Fitbit account and connect your One. Note that the personal information you're asked during setup is used to calculate your basal metabolic rate (BMR), which helps determine your estimated calorie expenditure. This information is private unless you go into your Privacy settings and opt to share age, height, or weight with Fitbit friends. (User Manual 1.2, p. 4)

Asserted Claim of '533 Patent	FitBit One
	Syncing your tracker data to your Fitbit account Once you've set up and started using One, you'll need to make sure it regularly transfers (syncs) its data to Fitbit so you can track your progress, see your exercise history, earn badges, analyze your sleep logs, and more on your Fitbit dashboard. A daily sync is recommended but not required. The Fitbit apps use Bluetooth Low Energy (BLE) technology to sync with your Fitbit tracker. Each time you open the app it will sync if the tracker is nearby, and the app will also sync periodically throughout the day if you have the all-day sync setting enabled. If you're running the Fitbit app on a Windows 10 PC that doesn't have Bluetooth, you'll need to make sure the tracker is connected to the computer. Fitbit Connect on a Mac® also uses Bluetooth for syncing (if available), otherwise you'll need to make sure your wireless sync dongle is plugged into the computer. Fitbit Connect on a PC requires that you plug in your wireless sync dongle. You can force Fitbit Connect to sync at any time or it will happen automatically every 15 minutes if: • Your tracker is within 20 feet of your computer and has new data to upload (meaning that if you haven't moved, an automatic sync won't occur). • The computer is powered on, awake, and connected to the internet. (User Manual 1.2, p. 5) **Managing your One from fitbit.com** To manage various settings for your account, click the gear icon in the top right corner of your fitbit.com dashboard and select Settings. From here you can edit your personal information, your notification preferences, your privacy settings, and much more. The Devices page allows you to monitor or edit: • The date and time of your last sync. • Your tracker's battery level. • The firmware version running on your tracker. • Your time zone. • Your sleep tracking sensitivity option. • Your handedness preference, left-handed or right-handed. • Your tracker's greeting. (User Manual 1.2, p. 11)
[7] The system of claim 5, wherein the remote device is further configured to transmit at least a portion of the processed data to one or more other locations, wherein the one or more other locations is selected	FitBit One renders obvious "[t]he system of claim 5, wherein the remote device is further configured to transmit at least a portion of the processed data to one or more other locations, wherein the one or more other locations is selected from the group consisting of the personal device, a doctor, a healthcare provider, a cloud-based server and one or more designated recipients, and wherein the remote device is capable of transmitting information related to a time and a position associated with the at least a portion of the processed data."

Asserted Claim of '533 Patent	FitBit One
from the group consisting of the personal device, a doctor, a healthcare provider, a cloud-based server and one or more designated recipients, and wherein the remote device is capable of transmitting information related to a time and a position associated with the at least a portion of the processed data.	 Wireless sync to a computer Wireless syncing to Fitbit.com is automatic, as long as: · Your computer is powered on, awake, and connected to the Internet. · The Wireless Sync Dongle is plugged in and your tracker is within 15 feet of it. · Fitbit Connect is installed and running. You can force sync your tracker by clicking the Fitbit Connect icon, which is located by the time and date on your computer, and then selecting Sync Now. NOTE: If you experience any trouble syncing your tracker with your computer, you can visit [illegible] for help. (User Manual 1.0, p. 7)

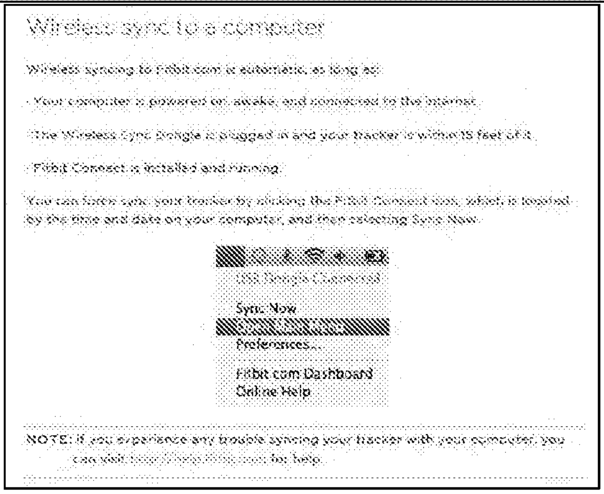
Asserted Claim of '533 Patent	FitBit One
	 (User Manual 1.2, p. 1)

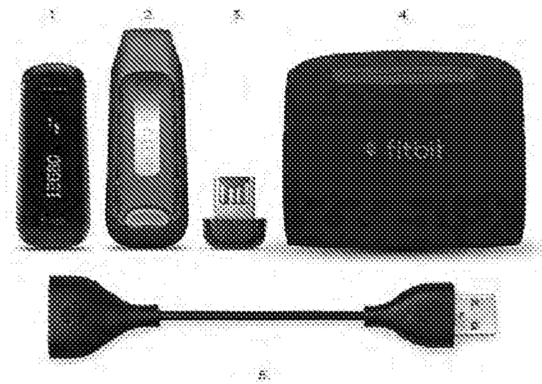
Asserted Claim of '533 Patent	FitBit One
	Setting up your Fitbit One To make the most of your One, use the free Fitbit app available for iOS®, Android™, and Windows® 10 mobile devices. If you don't have a compatible mobile device, you can use a computer and fitbit.com instead. **Setting up your tracker on your mobile device** The Fitbit app is compatible with more than 200 mobile devices that support iOS, Android, and Windows 10 operating systems. To get started: 1. Make sure the Fitbit app is compatible with your mobile device by checking [illegible]. 2. Find the Fitbit app in one of these locations, depending on your device: • The Apple® App Store® for iOS devices such as an iPhone® or iPad®. • The Google Play™ Store for Android devices such as the Samsung® Galaxy® S5 and Motorola Droid Turbo. • The Microsoft® Windows Store for Windows 10 mobile such as the Lumia™ phone or Surface™ tablet. 3. Install the app. Note that you'll need an account with the applicable store before you can download even a free app such as Fitbit. 4. When the app is installed, open it and tap Join Fitbit to get started. You'll be guided through the process of creating a Fitbit account and connecting (pairing) your One to your mobile device. Pairing makes sure the tracker and mobile device can communicate with one another (sync their data). Note that the personal information you're asked during setup is used to calculate your basal metabolic rate (BMR), which helps determine your estimated calorie expenditure. This information is private unless you go into your Privacy settings and opt in to share age, height, or weight with Fitbit friends. After setup you're ready to get moving. (User Manual 1.2, p. 3) **Setting up your tracker on your PC (Windows 10 only)** If you don't have a mobile device, you can set up and sync your tracker on your Windows 10 PC using the same Fitbit app available for Windows mobile devices. To get the app, click the Start button and open the Windows Store (called Store). Search for "Fitbit app." Note that if you've never downloaded an app from the store to your computer, you'll be prompted to create an account. Open the app and follow the instructions to create a Fitbit account and set up your One. You can set up and sync wirelessly if your computer has Bluetooth®, otherwise you'll need to use the wireless sync dongle that came in the box with your Fitbit One. (User Manual 1.2, p. 3)

Asserted Claim of '533 Patent	FitBit One
	Setting up your tracker on your PC (Windows 8.1 and below) If you don't have a compatible mobile device, you can set up your tracker with a computer and see your Fitbit stats on fitbit.com. To use this setup method you'll first install a free software application called Fitbit Connect that lets One sync its data with your fitbit.com dashboard. To install Fitbit Connect and set up your tracker: 1. Go to [illegible]. 2. Scroll down and click the option to download. 3. When prompted, save the file that appears. 4. Double-click the file (FitbitConnect_Win.exe). The Fitbit Connect installer opens. 5. Click Continue to move through the installer. 6. When prompted, choose Set up a New Fitbit Device. 7. Follow the onscreen instructions to create a Fitbit account and connect your One. If your computer has Bluetooth, setup can take place wirelessly. If not you'll be prompted to plug in the wireless sync dongle that came in the box with your Fitbit One. Note that the personal information you're asked during setup is used to calculate your basal metabolic rate (BMR), which helps determine your estimated calorie expenditure. This information is private unless you go into your Privacy settings and opt to share age, height, or weight with Fitbit friends. (User Manual 1.2, p. 4) **Setting up your tracker on your Mac** If you don't have a compatible mobile device, you can set up your tracker with a computer and see your Fitbit stats on fitbit.com. To use this setup method you'll first install a free software application called Fitbit Connect that lets One sync its data with your fitbit.com dashboard. To install Fitbit Connect and set up your tracker: 1. Go to [illegible]. 2. Scroll down and click the option to download. 3. When prompted, save the file that appears. 4. Double-click the file (Install Fitbit Connect.pkg). The Fitbit Connect installer opens. 5. Click Continue to move through the installer. 6. When prompted, choose Set up a New Fitbit Device. 7. Follow the onscreen instructions to create a Fitbit account and connect your One. Note that the personal information you're asked during setup is used to calculate your basal metabolic rate (BMR), which helps determine your estimated calorie expenditure. This information is private unless you go into your Privacy settings and opt to share age, height, or weight with Fitbit friends. (User Manual 1.2, p. 4)

Asserted Claim of '533 Patent	FitBit One
	Syncing your tracker data to your Fitbit account Once you've set up and started using One, you'll need to make sure it regularly transfers (syncs) its data to Fitbit so you can track your progress, see your exercise history, earn badges, analyze your sleep logs, and more on your Fitbit dashboard. A daily sync is recommended but not required. The Fitbit apps use Bluetooth Low Energy (BLE) technology to sync with your Fitbit tracker. Each time you open the app it will sync if the tracker is nearby, and the app will also sync periodically throughout the day if you have the all-day sync setting enabled. If you're running the Fitbit app on a Windows 10 PC that doesn't have Bluetooth, you'll need to make sure the tracker is connected to the computer. Fitbit Connect on a Mac® also uses Bluetooth for syncing (if available), otherwise you'll need to make sure your wireless sync dongle is plugged into the computer. Fitbit Connect on a PC requires that you plug in your wireless sync dongle. You can force Fitbit Connect to sync at any time or it will happen automatically every 15 minutes if: • Your tracker is within 20 feet of your computer and has new data to upload (meaning that if you haven't moved, an automatic sync won't occur). • The computer is powered on, awake, and connected to the internet. (User Manual 1.2, p. 5) **Managing your One from fitbit.com** To manage various settings for your account, click the gear icon in the top right corner of your fitbit.com dashboard and select Settings. From here you can edit your personal information, your notification preferences, your privacy settings, and much more. The Devices page allows you to monitor or edit: • The date and time of your last sync. • Your tracker's battery level. • The firmware version running on your tracker. • Your time zone. • Your sleep tracking sensitivity option. • Your handedness preference: left-handed or right-handed. • Your tracker's greeting. (User Manual 1.2, p. 11)
[8] The system of claim 5, wherein the receiver is located a first distance from a first one of the plurality of light emitting diodes and a different, second distance from a second one of the plurality of light emitting diodes	FitBit One renders obvious "[t]he system of claim 5, wherein the receiver is located a first distance from a first one of the plurality of light emitting diodes and a different, second distance from a second one of the plurality of light emitting diodes such that the receiver receives a first signal from the first light emitting diode and a second signal from the second light emitting diode."

Asserted Claim of '533 Patent	FitBit One
such that the receiver receives a first signal from the first light emitting diode and a second signal from the second light emitting diode.	
[9] The system of claim 8, wherein the output signal is generated in part by comparing the first and second signals	FitBit One renders obvious "[t]he system of claim 5, wherein the output signal is generated in part by comparing the first and second signals."
[10] The system of claim 5, wherein the output signal comprises one or more physiological parameters, and the remote device is capable of storing a history of at least a portion of the one or more physiological parameters over a specified period of time.	FitBit One renders obvious "[t]he system of claim 5, wherein the output signal comprises one or more physiological parameters, and the remote device is capable of storing a history of at least a portion of the one or more physiological parameters over a specified period of time." Memory The One tracker stores minute-by-minute data for one week. After 7 days, that data is converted to a daily total which is stored for an additional 23 days. When you sync your tracker, its data is uploaded to your Fitbit.com Dashboard and securely stored on Fitbit's servers. As long as you sync your tracker within thirty days of activity, you'll be able to transmit that data to your Fitbit.com Dashboard. NOTE: Every night at midnight, your tracker will reset itself. This means your goal progress and daily data will begin at zero again. This does not delete the data stored on your tracker. That data will be uploaded to your Dashboard the next time you sync your tracker. The time this reset occurs is based on the time zone set on your Fitbit.com profile. (User Manual 1.0, p. 14)

Asserted Claim of '533 Patent	FitBit One
	 Wireless sync to a computer Wireless syncing to Fitbit.com is automatic, as long as: · Your computer is powered on, awake, and connected to the internet. · The Wireless Sync Dongle is plugged in and your tracker is within 15 feet of it. · Fitbit Connect is installed and running. You can force sync your tracker by clicking the Fitbit Connect icon, which is located by the time and date on your computer, and then selecting Sync Now. USB Dongle Connected Sync Now Preferences... Fitbit.com Dashboard Online Help NOTE: If you experience any trouble syncing your tracker with your computer, you can visit http://help.fitbit.com for help. (User Manual 1.0, p. 7)

Asserted Claim of '533 Patent	FitBit One
	What you'll find in the box Your Fitbit One box includes: 1. Fitbit One Wireless Activity + Sleep Tracker 2. Clip 3. Wireless sync dongle 4. Sleep wristband 5. Charging cable  (User Manual 1.2, p. 1)

Asserted Claim of '533 Patent	FitBit One
	Setting up your Fitbit One To make the most of your One, use the free Fitbit app available for iOS®, Android™, and Windows® 10 mobile devices. If you don't have a compatible mobile device, you can use a computer and fitbit.com instead. **Setting up your tracker on your mobile device** The Fitbit app is compatible with more than 200 mobile devices that support iOS, Android, and Windows 10 operating systems. To get started: 1. Make sure the Fitbit app is compatible with your mobile device by checking http://www.fitbit.com/devices. 2. Find the Fitbit app in one of these locations, depending on your device: • The Apple® App Store® for iOS devices such as an iPhone® or iPad®. • The Google Play™ Store for Android devices such as the Samsung® Galaxy® S5 and Motorola Droid Turbo. • The Microsoft® Windows Store for Windows 10 mobile such as the Lumia™ phone or Surface™ tablet. 3. Install the app. Note that you'll need an account with the applicable store before you can download even a free app such as Fitbit. 4. When the app is installed, open it and tap Join Fitbit to get started. You'll be guided through the process of creating a Fitbit account and connecting (pairing) your One to your mobile device. Pairing makes sure the tracker and mobile device can communicate with one another (sync their data). Note that the personal information you're asked during setup is used to calculate your basal metabolic rate (BMR), which helps determine your estimated calorie expenditure. This information is private unless you go into your Privacy settings and opt to share age, height, or weight with Fitbit friends. After setup you're ready to get moving. (User Manual 1.2, p. 3) **Setting up your tracker on your PC (Windows 10 only)** If you don't have a mobile device, you can set up and sync your tracker on your Windows 10 PC using the same Fitbit app available for Windows mobile devices. To get the app, click the Start button and open the Windows Store (called Store). Search for "Fitbit app." Note that if you've never downloaded an app from the store to your computer, you'll be prompted to create an account. Open the app and follow the instructions to create a Fitbit account and set up your One. You can set up and sync wirelessly if your computer has Bluetooth®, otherwise you'll need to use the wireless sync dongle that came in the box with your Fitbit One. (User Manual 1.2, p. 3)

Asserted Claim of '533 Patent	FitBit One
	Setting up your tracker on your PC (Windows 8.1 and below) If you don't have a compatible mobile device, you can set up your tracker with a computer and see your Fitbit stats on fitbit.com. To use this setup method you'll first install a free software application called Fitbit Connect that lets One sync its data with your fitbit.com dashboard. To install Fitbit Connect and set up your tracker: 1. Go to [illegible]. 2. Scroll down and click the option to download. 3. When prompted, save the file that appears. 4. Double-click the file (FitbitConnect_Win.exe). The Fitbit Connect installer opens. 5. Click Continue to move through the installer. 6. When prompted, choose Set up a New Fitbit Device. 7. Follow the onscreen instructions to create a Fitbit account and connect your One. If your computer has Bluetooth, setup can take place wirelessly. If not you'll be prompted to plug in the wireless sync dongle that came in the box with your Fitbit One. Note that the personal information you're asked during setup is used to calculate your basal metabolic rate (BMR), which helps determine your estimated calorie expenditure. This information is private unless you go into your Privacy settings and opt to share age, height, or weight with Fitbit friends. (User Manual 1.2, p. 4) **Setting up your tracker on your Mac** If you don't have a compatible mobile device, you can set up your tracker with a computer and see your Fitbit stats on fitbit.com. To use this setup method you'll first install a free software application called Fitbit Connect that lets One sync its data with your fitbit.com dashboard. To install Fitbit Connect and set up your tracker: 1. Go to [illegible]. 2. Scroll down and click the option to download. 3. When prompted, save the file that appears. 4. Double-click the file (Install Fitbit Connect.pkg). The Fitbit Connect installer opens. 5. Click Continue to move through the installer. 6. When prompted, choose Set up a New Fitbit Device. 7. Follow the onscreen instructions to create a Fitbit account and connect your One. Note that the personal information you're asked during setup is used to calculate your basal metabolic rate (BMR), which helps determine your estimated calorie expenditure. This information is private unless you go into your Privacy settings and opt to share age, height, or weight with Fitbit friends. (User Manual 1.2, p. 4)

Asserted Claim of '533 Patent	FitBit One
	Syncing your tracker data to your Fitbit account Once you've set up and started using One, you'll need to make sure it regularly transfers (syncs) its data to Fitbit so you can track your progress, see your exercise history, earn badges, analyze your sleep logs, and more on your Fitbit dashboard. A daily sync is recommended but not required. The Fitbit apps use Bluetooth Low Energy (BLE) technology to sync with your Fitbit tracker. Each time you open the app it will sync if the tracker is nearby, and the app will also sync periodically throughout the day if you have the all-day sync setting enabled. If you're running the Fitbit app on a Windows 10 PC that doesn't have Bluetooth, you'll need to make sure the tracker is connected to the computer. Fitbit Connect on a Mac® also uses Bluetooth for syncing (if available), otherwise you'll need to make sure your wireless sync dongle is plugged into the computer. Fitbit Connect on a PC requires that you plug in your wireless sync dongle. You can force Fitbit Connect to sync at any time or it will happen automatically every 15 minutes if: • Your tracker is within 20 feet of your computer and has new data to upload (meaning that if you haven't moved, an automatic sync won't occur). • The computer is powered on, awake, and connected to the internet. (User Manual 1.2, p. 5) **Managing your One from fitbit.com** To manage various settings for your account, click the gear icon in the top right corner of your fitbit.com dashboard and select Settings. From here you can edit your personal information, your notification preferences, your privacy settings, and much more. The Devices page allows you to monitor or edit: • The date and time of your last sync. • Your tracker's battery level. • The firmware version running on your tracker. • Your time zone. • Your sleep tracking sensitivity option. • Your handedness preference, left-handed or right-handed. • Your tracker's greeting. (User Manual 1.2, p. 11)
[13] A measurement system comprising	To the extent the preamble is limiting, FitBit One renders obvious "a measurement system." *See* CHART ONE: '533 Patent, Claim Element 5 above.
[13A] a wearable measurement device for measuring one or more physiological parameters,	FitBit One renders obvious "a wearable measurement device for measuring one or more physiological parameters, including a light source comprising a plurality of semiconductor sources

Asserted Claim of '533 Patent	FitBit One
including a light source comprising a plurality of semiconductor sources that are light emitting diodes, the light emitting diodes configured to generate an output optical beam with one or more optical wavelengths,	that are light emitting diodes, the light emitting diodes configured to generate an output optical beam with one or more optical wavelengths."
[13B] wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers,	FitBit One renders obvious "wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers." *See* CHART ONE: '533 Patent, Claim Element 5B above.
[13C] the light source configured to increase signal-to-noise ratio by increasing a light intensity from at least one of the plurality of semiconductor sources and by increasing a pulse rate of at least one of the plurality of semiconductor sources;	FitBit One renders obvious "the light source configured to increase signal-to-noise ratio by increasing a light intensity from at least one of the plurality of semiconductor sources and by increasing a pulse rate of at least one of the plurality of semiconductor sources." *See* CHART ONE: '533 Patent, Claim Element 5C above.
[13D] the wearable measurement device comprising a plurality of lenses configured to receive a portion of the output optical beam and to deliver an analysis output beam to a sample;	FitBit One renders obvious "the wearable measurement device comprising a plurality of lenses configured to receive a portion of the output optical beam and to deliver an analysis output beam to a sample." *See* CHART ONE: '533 Patent, Claim Element 5D above.

Asserted Claim of '533 Patent	FitBit One
[13E] the wearable measurement device further comprising a receiver configured to receive and process at least a portion of the analysis output beam reflected or transmitted from the sample and to generate an output signal	FitBit One renders obvious "the wearable measurement device further comprising a receiver configured to receive and process at least a portion of the analysis output beam reflected or transmitted from the sample and to generate an output signal." *See* CHART ONE: '533 Patent, Claim Element 5E above.
[13F] wherein the wearable measurement device receiver is configured to be synchronized to pulses of the light source;	FitBit One renders obvious "wherein the wearable measurement device receiver is configured to be synchronized to pulses of the light source." *See* CHART ONE: '533 Patent, Claim Element 5F above.
[13G] a personal device comprising a wireless receiver, a wireless transmitter, a display, a microphone, a speaker, one or more buttons or knobs, a microprocessor and a touch screen,	FitBit One renders obvious "a personal device comprising a wireless receiver, a wireless transmitter, a display, a microphone, a speaker, one or more buttons or knobs, a microprocessor and a touch screen." *See* CHART ONE: '533 Patent, Claim Element 5G above.
[13H] the personal device configured to receive and process at least a portion of the output signal,	FitBit One renders obvious "the personal device configured to receive and process at least a portion of the output signal, wherein the personal device is configured to store and display the processed output signal." *See* CHART ONE: '533 Patent, Claim Element 5H above.
[13I] wherein the personal device is configured to store and display the processed output signal, and	FitBit One renders obvious "wherein the personal device is configured to store and display the processed output signal." *See* CHART ONE: '533 Patent, Claim Element 5I above.

Asserted Claim of '533 Patent	FitBit One
[13J] wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link; and	FitBit One renders obvious "wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link." *See* CHART ONE: '533 Patent, Claim Element 5J above.
[13K] a remote device configured to receive over the wireless transmission link an output status comprising the at least a portion of the processed output signal, to process the received output status to generate processed data and to store the processed data, and	FitBit One renders obvious "a remote device configured to receive over the wireless transmission link an output status comprising the at least a portion of the processed output signal, to process the received output status to generate processed data and to store the processed data." *See* CHART ONE: '533 Patent, Claim Element 5K above.
[13L] wherein the remote device is capable of storing a history of at least a portion of the received output status over a specified period of time.	FitBit One renders obvious "wherein the remote device is capable of storing a history of at least a portion of the received output status over a specified period of time." *See* CHART ONE: '533 Patent, Claim Element 10 above.
[16] The system of claim 13, wherein the receiver is located a first distance from a first one of the plurality of light emitting diodes and a different, second distance from a second one of the plurality of light emitting diodes such that the receiver receives a first signal from the first light emitting diode and a second signal from the second light emitting diode.	FitBit One renders obvious "[t]he system of claim 13, wherein the receiver is located a first distance from a first one of the plurality of light emitting diodes and a different, second distance from a second one of the plurality of light emitting diodes such that the receiver receives a first signal from the first light emitting diode and a second signal from the second light emitting diode." *See* CHART ONE: '533 Patent, Claim Element 8 above.

Asserted Claim of '533 Patent	FitBit One
[17] The system of claim 16, wherein the output signal is generated in part by comparing the first and second signals.	FitBit One renders obvious "[t]he system of claim 16, wherein the output signal is generated in part by comparing the first and second signals." *See* CHART ONE: '533 Patent, Claim Element 9 above.

EXHIBIT BB-2

U.S. Patent No. 9,757,040 vs FitBit One

Priority Date/Publication Date: by December 2012 Prior Art Status: §§ 102(a) and (b)

The FitBit One manufactured by FitBit ("FitBit One") renders the asserted claims of U.S. Patent No. 9,757,040 ("the '040 Patent") obvious in view of at least any of the references identified in Apple's Obviousness Combinations Chart.

This chart is based on the following disclosures about the FitBit One:

- FitBit One User Manual ("User Manual 1.0")
- FitBit One User Manual Version 1.2 ("User Manual 1.2")

Discovery is ongoing, and Apple reserves the right to amend this chart based on new information about the FitBit One.

As set forth in Apple's Invalidity Contentions, the below contentions apply the prior art in part in accordance with Apple's assumption that Omni contends the claims are not invalid under 35 U.S.C. § 112. However, Apple's below contentions do not represent Apple's agreement or view as to the meaning, definiteness, written description support for, or enablement of any of the asserted claims. For each dependent claim, the disclosures cited for the claim from which it depends are incorporated by reference.

CHART TWO: U.S. Patent No. 9,757,040 vs FitBit One

Asserted Claim of '040 Patent	FitBit One
[1] A wearable device for use with a smart phone or tablet, the wearable device comprising:	To the extent the preamble is limiting, FitBit One renders obvious "[a] wearable device for use with a smart phone or tablet." *See* CHART ONE: '533 Patent, Claim Elements 5, 5G, and 13A above.
[1A] a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters	FitBit One renders obvious "a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters." *See* CHART ONE: '533 Patent, Claim Element 13A above.
[1B] the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an input optical beam having one or more optical wavelengths,	FitBit One renders obvious "the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an input optical beam having one or more optical wavelengths."
[1C] wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers;	FitBit One renders obvious "wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers." *See* CHART ONE: '533 Patent, Claim Element 5B above.
[1D] the measurement device comprising one or more lenses configured to receive and to deliver a portion of the input optical beam to tissue, wherein	FitBit One renders obvious "the measurement device comprising one or more lenses configured to receive and to deliver a portion of the input optical beam to tissue, wherein the tissue reflects at least a portion of the input optical beam delivered to the tissue." *See* CHART ONE: '533 Patent, Claim Element 5D above.

Asserted Claim of '040 Patent	FitBit One
the tissue reflects at least a portion of the input optical beam delivered to the tissue;	
[1E] the measurement device further comprising a reflective surface configured to receive and redirect at least a portion of light reflected from the tissue;	FitBit One renders obvious "the measurement device further comprising a reflective surface configured to receive and redirect at least a portion of light reflected from the tissue."
[1F] the measurement device further comprising a receiver configured to: capture light while the LEDs are off and convert the captured light into a first signal and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the input optical beam reflected from the tissue;	FitBit One renders obvious "the measurement device further comprising a receiver configured to: capture light while the LEDs are off and convert the captured light into a first signal and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the input optical beam reflected from the tissue."
[1G] the measurement device configured to improve a signal-to-noise ratio of the input optical beam reflected from the tissue by differencing the first signal and the second signal;	FitBit One renders obvious "the measurement device configured to improve a signal-to-noise ratio of the input optical beam reflected from the tissue by differencing the first signal and the second signal."

Asserted Claim of '040 Patent	FitBit One
[1H] the light source configured to further improve the signal-to-noise ratio of the input optical beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs;	FitBit One renders obvious "the light source configured to further improve the signal-to-noise ratio of the input optical beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs." *See* CHART ONE: '533 Patent, Claim Element 5C above.
[1I] the measurement device further configured to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue; and	FitBit One renders obvious "the measurement device further configured to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue." *See* CHART ONE: '533 Patent, Claim Element 10 above.
[1J] the wearable device configured to communicate with the smart phone or tablet, the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a voice input module, a speaker, and a touch screen, the smart phone or tablet configured to receive and to process at least a portion of the output signal,	FitBit One renders obvious "the wearable device configured to communicate with the smart phone or tablet, the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a voice input module, a speaker, and a touch screen, the smart phone or tablet configured to receive and to process at least a portion of the output signal." *See* CHART ONE: '533 Patent, Claim Elements 5G and 5H above.
[1K] wherein the smart phone or tablet is configured to store and display the processed output signal, wherein at least a portion	FitBit One renders obvious "wherein the smart phone or tablet is configured to store and display the processed output signal, wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link."

Asserted Claim of '040 Patent	FitBit One
of the processed output signal is configured to be transmitted over a wireless transmission link.	*See* CHART ONE: '533 Patent, Claim Elements 5I and 5J above.
[2] The wearable device of claim 1, wherein the receiver is configured to be synchronized to the modulation of the at least one of the LEDs.	FitBit One renders obvious "[t]he wearable device of claim 1, wherein the receiver is configured to be synchronized to the modulation of the at least one of the LEDs." *See* CHART ONE: '533 Patent, Claim Element 5F above.
[4] The wearable device of claim 1, wherein the receiver is located a first distance from a first one of the LEDs and a different distance from a second one of the LEDs such that the receiver can capture a third signal from the first LED and a fourth signal from the second LED, and wherein the output signal is generated in part by comparing the third and fourth signals.	FitBit One renders obvious "[t]he wearable device of claim 1, wherein the receiver is located a first distance from a first one of the LEDs and a different distance from a second one of the LEDs such that the receiver can capture a third signal from the first LED and a fourth signal from the second LED, and wherein the output signal is generated in part by comparing the third and fourth signals." *See* CHART ONE: '533 Patent, Claim Element 8 above.

EXHIBIT BB-3

U.S. Patent No. 9,861,286 vs FitBit One

Priority Date/Publication Date: by December 2012 Prior Art Status: §§ 102(a) and (b)

The FitBit One manufactured by FitBit ("FitBit One") renders the asserted claims of U.S. Patent No. 9,861,286 ("the '286 Patent") obvious in view of at least any of the references identified in Apple's Obviousness Combinations Chart.

This chart is based on the following disclosures about the FitBit One:

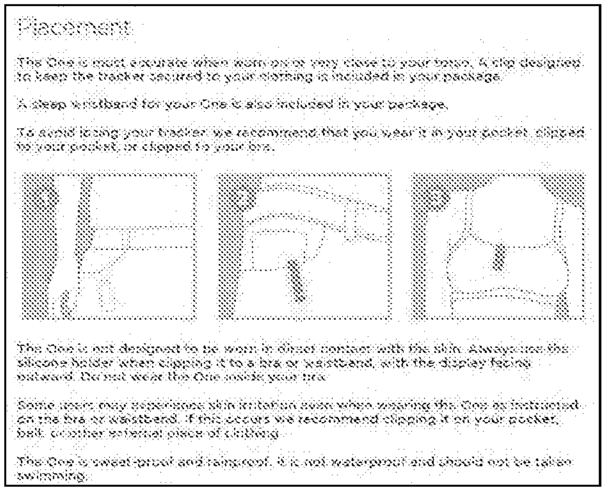
- FitBit One User Manual ("User Manual 1.0")
- FitBit One User Manual Version 1.2 ("User Manual 1.2")

Discovery is ongoing, and Apple reserves the right to amend this chart based on new information about the FitBit One.

As set forth in Apple's Invalidity Contentions, the below contentions apply the prior art in part in accordance with Apple's assumption that Omni contends the claims are not invalid under 35 U.S.C. § 112. However, Apple's below contentions do not represent Apple's agreement or view as to the meaning, definiteness, written description support for, or enablement of any of the asserted claims. For each dependent claim, the disclosures cited for the claim from which it depends are incorporated by reference.

CHART THREE: U.S. Patent No. 9,861,286 vs FitBit One

Asserted Claim of '286 Patent	FitBit One
[16] A wearable device for use with a smart phone or tablet, the wearable device comprising:	To the extent the preamble is limiting, FitBit One renders obvious "[a] wearable device for use with a smart phone or tablet." *See* CHART ONE: '533 Patent, Claim Elements 5, 5G, and 13A above.
[16A] a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters,	FitBit One renders obvious "a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters." *See* CHART ONE: '533 Patent, Claim Element 13A above.
[16B] the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an optical beam having a plurality of optical wavelengths,	FitBit One renders obvious "the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an optical beam having a plurality of optical wavelengths." *See* CHART TWO: '040 Patent, Claim Element 1B above.
[16C] wherein at least a portion of the plurality of optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers;	FitBit One renders obvious "wherein at least a portion of the plurality of optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers." *See* CHART ONE: '533 Patent, Claim Element 5B above.
[16D] the measurement device comprising one or more lenses configured to receive and to deliver a portion of the optical beam to tissue, wherein the tissue reflects at least a portion of the	FitBit One renders obvious "the measurement device comprising one or more lenses configured to receive and to deliver a portion of the optical beam to tissue, wherein the tissue reflects at least a portion of the optical beam delivered to the tissue, and wherein the measurement device is adapted to be placed on a wrist or an ear of a user." *See* CHART ONE: '533 Patent, Claim Element 5D above.

<table>
<tr><th>Asserted Claim of '286 Patent</th><th>FitBit One</th></tr>
<tr><td>optical beam delivered to the tissue, and</td><td></td></tr>
<tr><td>[16E] wherein the measurement device is adapted to be placed on a wrist or an ear of a user;</td><td>FitBit One renders obvious “wherein the measurement device is adapted to be placed on a wrist or an ear of a user.”

Placement
The One is most accurate when worn on or very close to your torso. A clip designed to keep the tracker secured to your clothing is included in your package.
A sleep wristband for your One is also included in your package.
To avoid losing your tracker we recommend that you wear it in your pocket, clipped to your pocket, or clipped to your bra.
The One is not designed to be worn in direct contact with the skin. Always use the silicone holder when clipping it to a bra or waistband, with the display facing outward. Do not wear the One inside your bra.
Some users may experience skin irritation even when wearing the One as instructed on the bra or waistband. If this occurs we recommend clipping it on your pocket, belt, or other external piece of clothing.
The One is sweat-proof and rainproof. It is not waterproof and should not be taken swimming.
(User Manual 1.2, p. 6)</td></tr>
<tr><td>[16F] the measurement device further comprising a receiver configured to:
capture light while the LEDs are off and convert the captured light into a first signal and</td><td>FitBit One renders obvious “the measurement device further comprising a receiver configured to: capture light while the LEDs are off and convert the captured light into a first signal and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the optical beam reflected from the tissue.”
See CHART TWO: '040 Patent, Claim Element 1F above.</td></tr>
</table>

Asserted Claim of '286 Patent	FitBit One
capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the optical beam reflected from the tissue;	
[16G] the measurement device configured to improve a signal-to-noise ratio of the optical beam reflected from the tissue by differencing the first signal and the second signal;	FitBit One renders obvious "the measurement device configured to improve a signal-to-noise ratio of the optical beam reflected from the tissue by differencing the first signal and the second signal." *See* CHART TWO: '040 Patent, Claim Element 1G above.
[16H] the light source configured to further improve the signal-to-noise ratio of the optical beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs;	FitBit One renders obvious "the light source configured to further improve the signal-to-noise ratio of the optical beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs." *See* CHART ONE: '533 Patent, Claim Element 5C above.
[16I] the measurement device further configured to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue; and	FitBit One renders obvious "the measurement device further configured to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue." *See* CHART ONE: '533 Patent, Claim Element 10 above.

Asserted Claim of '286 Patent	FitBit One
[16J] wherein the receiver includes a plurality of spatially separated detectors,	FitBit One renders obvious "wherein the receiver includes a plurality of spatially separated detectors."
[16K] wherein at least one analog to digital converter is coupled to the spatially separated detectors.	FitBit One renders obvious "wherein at least one analog to digital converter is coupled to the spatially separated detectors."
[17] The wearable device of claim 16, wherein at least one LED emits at a first wavelength and at least another LED emits at a second wavelength, and wherein the first wavelength has a first penetration depth into the tissue and wherein the second wavelength has a second penetration depth into the tissue different from the first penetration depth.	FitBit One renders obvious "[t]he wearable device of claim 16, wherein at least one LED emits at a first wavelength and at least another LED emits at a second wavelength, and wherein the first wavelength has a first penetration depth into the tissue and wherein the second wavelength has a second penetration depth into the tissue different from the first penetration depth.."
[19] The wearable device of claim 16, wherein the receiver is configured to be synchronized to the modulating of at least one of the LEDs.	FitBit One renders obvious "[t]he wearable device of claim 16, wherein the receiver is configured to be synchronized to the modulating of at least one of the LEDs." *See* CHART ONE: '533 Patent, Claim Element 5F above.
[20] The wearable device of claim 16, wherein the receiver is located a first distance from a first one of the LEDs and a different distance from a second one of the	FitBit One renders obvious "[t]he wearable device of claim 16, wherein the receiver is located a first distance from a first one of the LEDs and a different distance from a second one of the LEDs such that the receiver can capture a third signal from the first LED and a fourth signal from the second LED, and wherein the output signal is generated in part by comparing the third and fourth signals.."

Asserted Claim of '286 Patent	FitBit One
LEDs such that the receiver can capture a third signal from the first LED and a fourth signal from the second LED, and wherein the output signal is generated in part by comparing the third and fourth signals.	*See* CHART ONE: '533 Patent, Claim Element 8 above.

EXHIBIT BB-4

U.S. Patent No. 9,885,698 vs FitBit One

Priority Date/Publication Date: by December 2012 Prior Art Status: §§ 102(a) and (b)

The FitBit One manufactured by FitBit ("FitBit One") renders the asserted claims of U.S. Patent No. 9,885,698 ("the '698 Patent") obvious in view of at least any of the references identified in Apple's Obviousness Combinations Chart.

This chart is based on the following disclosures about the FitBit One:

- FitBit One User Manual ("User Manual 1.0")
- FitBit One User Manual Version 1.2 ("User Manual 1.2")

Discovery is ongoing, and Apple reserves the right to amend this chart based on new information about the FitBit One.

As set forth in Apple's Invalidity Contentions, the below contentions apply the prior art in part in accordance with Apple's assumption that Omni contends the claims are not invalid under 35 U.S.C. § 112. However, Apple's below contentions do not represent Apple's agreement or view as to the meaning, definiteness, written description support for, or enablement of any of the asserted claims. For each dependent claim, the disclosures cited for the claim from which it depends are incorporated by reference.

CHART FOUR: U.S. Patent No. 9,885,698 vs FitBit One

Asserted Claim of '698 Patent	FitBit One
[1] A wearable device, comprising:	To the extent the preamble is limiting, FitBit One renders obvious "[a] wearable device." *See* CHART ONE: '533 Patent, Claim Elements 5 and 13A above.
[1A] a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters,	FitBit One renders obvious "a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters." *See* CHART ONE: '533 Patent, Claim Element 13A above.
[1B] the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an input optical beam having one or more optical wavelengths,	FitBit One renders obvious "the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an input optical beam having one or more optical wavelengths." *See* CHART TWO: '040 Patent, Claim Element 1B above.
[1C] wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers;	FitBit One renders obvious "wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers." *See* CHART ONE: '533 Patent, Claim Element 5B above.
[1D] the measurement device comprising one or more lenses configured to receive and to deliver a portion of the input optical beam to tissue, wherein the tissue reflects at least a	FitBit One renders obvious "the measurement device comprising one or more lenses configured to receive and to deliver a portion of the input optical beam to tissue, wherein the tissue reflects at least a portion of the input optical beam delivered to the tissue." *See* CHART ONE: '533 Patent, Claim Element 5D above.

Asserted Claim of '698 Patent	FitBit One
portion of the input optical beam delivered to the tissue;	
[1E] the measurement device further comprising a receiver, wherein the receiver includes a plurality of spatially separated detectors, the detectors configured to: capture light while the LEDs are off and convert the captured light into a first signal; and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the input optical beam reflected from the tissue;	FitBit One renders obvious "the measurement device further comprising a receiver, wherein the receiver includes a plurality of spatially separated detectors, the detectors configured to: capture light while the LEDs are off and convert the captured light into a first signal; and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the input optical beam reflected from the tissue." *See* CHART TWO: '040 Patent, Claim Element 1F and CHART THREE: '286 Patent, Claim Element 16J above.
[1F] wherein at least one analog to digital converter is coupled to the spatially separated detectors and is configured to generate at least a first data signal from the first signal and at least a second data signal from the second signal;	FitBit One renders obvious "wherein at least one analog to digital converter is coupled to the spatially separated detectors and is configured to generate at least a first data signal from the first signal and at least a second data signal from the second signal." *See* CHART TWO: '040 Patent, Claim Element 1F and CHART THREE: '286 Patent, Claim Element 16K above.
[1G] the measurement device configured to improve a signal-to-	FitBit One renders obvious "the measurement device configured to improve a signal-to-noise ratio of the input optical beam reflected from the tissue by differencing the first data signal and the

Asserted Claim of '698 Patent	FitBit One
noise ratio of the input optical beam reflected from the tissue by differencing the first data signal and the second data signal to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue; and	second data signal to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue." *See* CHART ONE: '533 Patent, Claim Element 10 and CHART TWO: '040 Patent, Claim Element 1G above.
[1H] wherein the modulating at least one of the LEDs has a modulation frequency, and wherein the receiver is configured to use a lock-in technique that detects the modulation frequency.	FitBit One renders obvious "wherein the modulating at least one of the LEDs has a modulation frequency, and wherein the receiver is configured to use a lock-in technique that detects the modulation frequency."
[2] The wearable device of claim 1, wherein the plurality of LEDs and the plurality of spatially separated detectors are mounted on a common structure, and wherein the plurality of LEDs are coupled electrically to a power supply.	FitBit One renders obvious "[t]he wearable device of claim 1, wherein the plurality of LEDs and the plurality of spatially separated detectors are mounted on a common structure, and wherein the plurality of LEDs are coupled electrically to a power supply.."
[3] The wearable device of claim 1, wherein the light source is configured to further improve the signal-to-noise ratio of the input beam reflected from the tissue by increasing the light intensity relative to the initial light	FitBit One renders obvious "[t]he wearable device of claim 1, wherein the light source is configured to further improve the signal-to-noise ratio of the input beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs, and wherein the receiver is configured to be synchronized to at least one of the LEDs." *See* CHART ONE: '533 Patent, Claim Elements 5C and 5F above.

Asserted Claim of '698 Patent	FitBit One
intensity from at least one of the LEDs, and wherein the receiver is configured to be synchronized to at least one of the LEDs.	
[5] The wearable device of claim 1, wherein the wearable device is configured to communicate with a smart phone or tablet, the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a voice input module, a speaker, and a touch screen, the smart phone or tablet configured to receive and to process at least a portion of the output signal, wherein the smart phone or tablet is configured to store and display the processed output signal, wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link.	FitBit One renders obvious "[t]he wearable device of claim 1, wherein the wearable device is configured to communicate with a smart phone or tablet, the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a voice input module, a speaker, and a touch screen, the smart phone or tablet configured to receive and to process at least a portion of the output signal, wherein the smart phone or tablet is configured to store and display the processed output signal, wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link." *See* CHART ONE: '533 Patent, Claim Elements 5G, 5H, 5I, and 5J above.

EXHIBIT C

EXHIBIT C-1

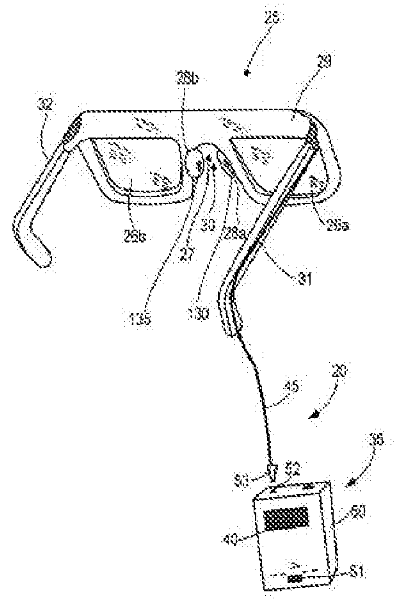
U.S. Patent No. 9,651,533 vs Elhag

Priority Date/Publication Date: December 15, 2005 Prior Art Status: §§ 102(a) and (b)

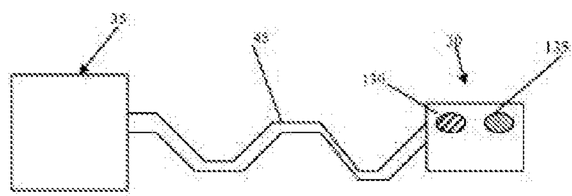
U.S. Patent No. 7,648,463, naming inventors Sammy I Elhag, Nikolai Rulkov, Mark Hunt, Donald Brady, and Steve Lui ("Elhag") anticipates the asserted claims of U.S. Patent No. 9,651,533 ("the '533 Patent") or renders those claims obvious alone and/or in view of at least any of the references identified in Apple's Obviousness Combinations Chart.

As set forth in Apple's Invalidity Contentions, the below contentions apply the prior art in part in accordance with Apple's assumption that Omni contends the claims are not invalid under 35 U.S.C. § 112. However, Apple's below contentions do not represent Apple's agreement or view as to the meaning, definiteness, written description support for, or enablement of any of the asserted claims. For each dependent claim, the disclosures cited for the claim from which it depends are incorporated by reference.

CHART ONE: U.S. Patent No. 9,651,533 vs Elhag

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
[5] A measurement system, comprising:	To the extent the preamble is limiting, Elhag discloses and/or renders obvious "[a] measurement system."  FIGURE 1 (Elhag, Fig. 1)

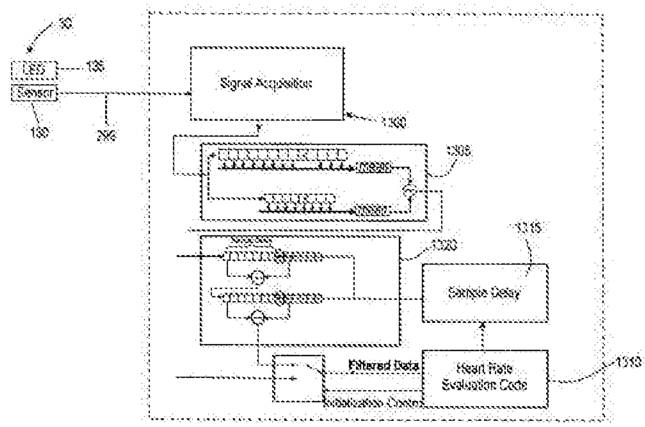
Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	"Yet another aspect of the present invention is a monitoring device for monitoring the health of a user. The monitoring device includes eyewear, measuring means, calculating means, display means and control means. The eyewear includes a lens, temporal members and a nose support. The measuring means measures blood flowing through at least one artery of the user and is disposed on the eyewear." (Elhag, 5:55-61). "The monitoring device 20 may also include controls to search for information to be displayed on the display screen, to set time periods for measurement of calories or the like, and to reset the monitoring device 20." (Elhag, 11:41-44)
[5A] a light source comprising a plurality of semiconductor sources that are light emitting diodes, the light emitting diodes configured to generate an output optical beam with one or more optical wavelengths,	Elhag discloses and/or renders obvious "a light source comprising a plurality of semiconductor sources that are light emitting diodes, the light emitting diodes configured to generate an output optical beam with one or more optical wavelengths." *See* CHART ONE: '533 Patent, Claim Element 13A below.
[5B] wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers,	Elhag discloses and/or renders obvious "wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers." "Yet in an alternative embodiment, the optical sensor 30 is a photodetector 130 and a single LED 135 transmitting light at a wavelength of approximately 900 nanometers as a pulsed infrared LED. Yet further, the optical sensor is a combination of a green light LED and a pulsed infrared LED to offset noise affects of ambient light and sunlight. As the heart pumps blood through the arteries of the user, blood cells absorb and transmit varying amounts of the light depending on how much oxygen binds to the cells' hemoglobin. The photodetector 30, which is typically a photodiode, detects reflectance/transmission at the wavelengths (green, red or infrared), and in response generates a radiation-induced signal." (Elhag, 8:22-34) "Alternatively, the optical sensor 30 is a pulse oximetry device with a light source 135 that typically includes LEDs that generate both red (λ˜660 nm) and infrared (λ˜900 nm) radiation. As the heart pumps blood through the user's arteries, blood cells absorb and transmit varying amounts

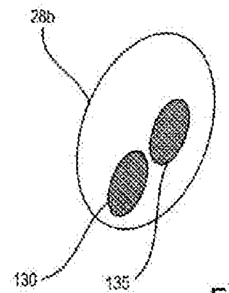
Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	of the red and infrared radiation depending on how much oxygen binds to the cells' hemoglobin. The photodetector 130, which is typically a photodiode, detects transmission at the red and infrared wavelengths, and in response generates a radiation-induced signal." (Elhag, 8:35-44) "Another preferred photodetector 130 is a light-to-voltage photodetector such as the TSL260R and TSL261, TSL261R photodetectors available from TAOS, Inc of Plano Tex. Alternatively, the photodetector 130 is a light-to-frequency photodetector such as the TSL245R, which is also available from TAOS, Inc. The light-to-voltage photodetectors have an integrated transimpedance amplifier on a single monolithic integrated circuit, which reduces the need for ambient light filtering. The TSL261 photodetector preferably operates at a wavelength greater than 750 nanometers, and optimally at 940 nanometers, which would preferably have a LED that radiates light at those wavelengths." (Elhag, 8:52-61)
[5C] the light source configured to increase signal-to-noise ratio by increasing a light intensity from at least one of the plurality of semiconductor sources and by increasing a pulse rate of at least one of the plurality of semiconductor sources;	Elhag discloses and/or renders obvious "the light source configured to increase signal-to-noise ratio by increasing a light intensity from at least one of the plurality of semiconductor sources and by increasing a pulse rate of at least one of the plurality of semiconductor sources."  FIG. 16 (Elhag, Fig. 16) "In a preferred embodiment, the optical sensor 30 is a single light emitting diode ("LED") 135 based on green light wherein the LED 135 generates green light (λ˜500-600 nm), and a photodetector 130 detects the green light. Yet in an alternative embodiment, the optical sensor 30

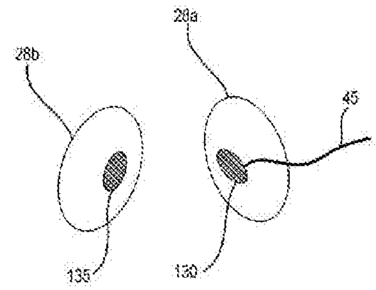
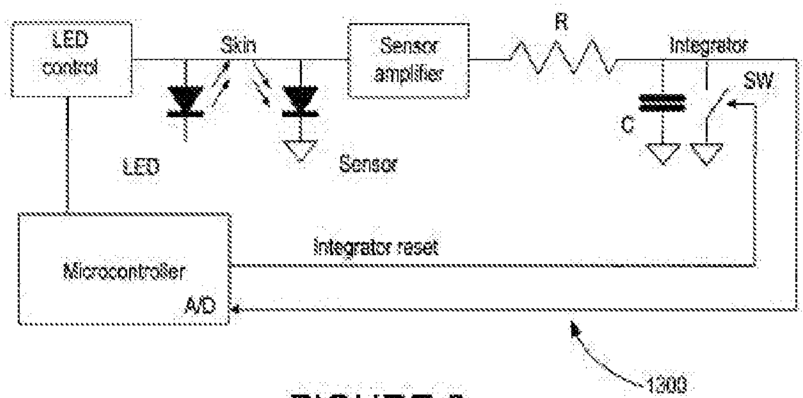
Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	is a photodetector 130 and a single LED 135 transmitting light at a wavelength of approximately 900 nanometers as a pulsed infrared LED. Yet further, the optical sensor is a combination of a green light LED and a pulsed infrared LED to offset noise affects of ambient light and sunlight. As the heart pumps blood through the arteries of the user, blood cells absorb and transmit varying amounts of the light depending on how much oxygen binds to the cells' hemoglobin. The photodetector 30, which is typically a photodiode, detects reflectance/transmission at the wavelengths (green, red or infrared), and in response generates a radiation-induced signal." (Elhag, 8:19-34). "At block 1300, the signal acquisition is performed, which is shown in greater detail in FIG. 8. In the pulse mode the LED 135 is periodically activated for short intervals of time by a signal from the microcontroller. The reflected pulse of light is received by the sensor, with the generation of a voltage pulse having an amplitude proportional to the intensity of the reflected light. When the LED is activated, the switch, SW, is open by the action of the control signal from the microcontroller, and the capacitor, C, integrates the pulse generated from the sensor by charging through the resistor R. Immediately prior to deactivation of the LED, the analog-to-digital converter acquires the value of the voltage integrated across the capacitor, C. The analog-to-digital converter generates a data sample in digital form which is utilized by the microcontroller for evaluation of the heart rate the wearer. Subsequent to the sample being acquired by the analog-to-digital converter, the LED is deactivated and the capacitor, C, is shortcut by switch, SW, to reset the integrator, RC. This states remains unchanged for a given time interval after which the process is repeated, which is illustrated in FIG. 9. A noise reduction and power reduction process is discussed below in reference to FIGS. 13 and 14." (Elhag, 14:60-15:14) "FIG. 13 illustrates a noise reduction method of the present invention. Due to the desire to minimize power consumption of the monitoring device 20, and achieve very accurate signal measurements using the optical sensor 30, the present invention preferably utilizes the method 250 illustrated in FIG. 13. At block 252, the processor 41 is deactivated for a deactivation period in order to conserve power and to eliminate noise for a signal measurement. The deactivation period ranges from 128 to 640 microseconds, more preferably from 200 microseconds to 400 microseconds, and more preferably from 225 microseconds to 300 microseconds. In reference to FIG. 6, this deactivation period occurs during block 1300. At block 254, during the deactivation

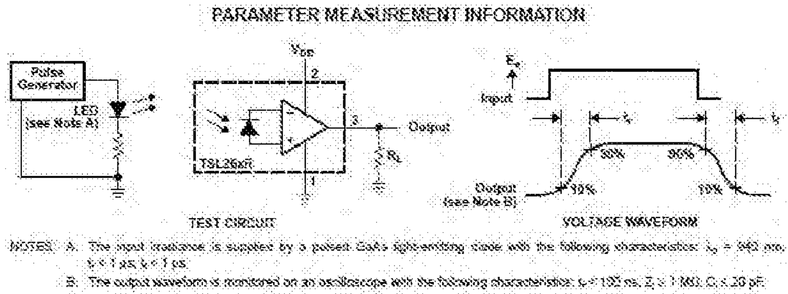
Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	period, the optical sensor 30 is activated to obtain multiple readings using the light source 135 and the photodetector 130. Preferably 4 to 25 sub-readings or sub-samples are obtained during the deactivation period. The sub-readings or sub-samples are averaged for noise reduction to provide a reading or sample value. In a single second, from 500 to 1500 sub-readings or sub-samples are obtained by the optical sensor 30. At block 256, the processor 41 is reactivated and the reading values are processed by processor 41. At block 258, heart rate data is generated from the readings by the processor 41. At block 260, health related data is generated from the heart rate data, and the health related data and the heart rate data are displayed on the display member 40." (Elhag, 16:4-29) "FIG. 14 illustrates a more specific method 300 for noise reduction during a signal reading. At block 302, a high speed clock of a processor 41 is deactivated for a deactivation period as discussed above. At block 304, the optical sensor 30 is activated during the deactivation period to obtain multiple readings as discussed above. At block 306, the processor 41 is reactivated and the readings are processed. The optical sensor 30 is also deactivated. At block 308, heart rate data is generated from the readings by the processor 41. At block 310, health related data is generated from the heart rate data, and the health related data and the heart rate data are displayed on the display member 40." (Elhag, 16:30-41) "FIG. 17 illustrates a mechanism for controlling the intensity of the light source 135 using a plurality of resistors 405, 410 and 415 in parallel. Usually, an optical sensor 30 has a light source 135 set for a single intensity for placement at a single location on a typically user. However, if the optical sensor 30 is positioned differently or if the user is not a typical user, then the intensity of the light source 135 may be too great for the photodetector 130 and lead to saturation of the photodetector 130 which terminates the signal reading. The present invention preferably adjusts the intensity of the light source 135 using feedback from the photodetector 130 to indicate whether the light intensity is too high or too low." (Elhag, 16:42-53) "FIG. 18 is a preferred method 500 for controlling the light intensity of the optical sensor 30. At block 505, the light intensity of the light source 135 is monitored. At block 510, the sensor/photodetector is determined to be saturated by the light source. At block 515, the intensity of the light source is modified by adjusting the resistance and the flow of current to the light

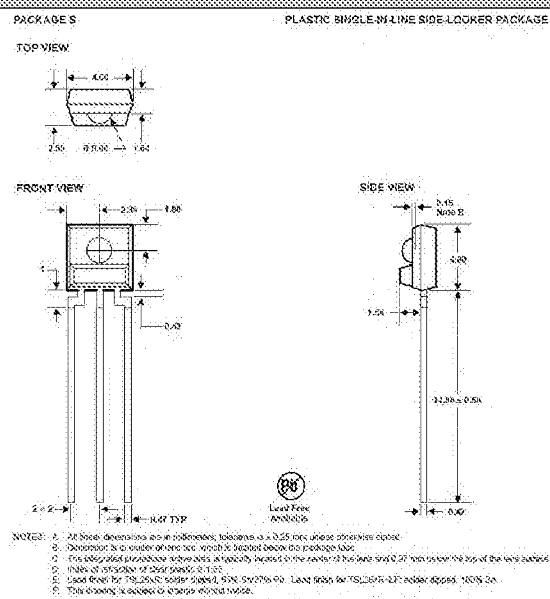
Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	source 135. At block 520, the light intensity is again monitored and adjusted if necessary. In a preferred embodiment, this automatic gain mechanism prevents the green light from overwhelming the photodetector thereby maintaining an accurate reading no matter where the optical sensor is placed on the user." (Elhag, 17:10-21) "FIG. 19 illustrates how the control mechanism operates to maintain a proper light intensity. As the signal reaches the upper limit, the photodetector becomes saturated and the processor lowers the current flow, which results in a break in the signal. Then as the signal is lowered it becomes too low and the processor increases the light intensity resulting in a break in the signal." (Elhag, 17:22-28) *See also* Elhag, 16:53-17:9, Figs. 13, 14, 17, 18, 19.
[5D] an apparatus comprising a plurality of lenses configured to receive a portion of the output optical beam and to deliver an analysis output beam to a sample	Elhag discloses and/or renders obvious "an apparatus comprising a plurality of lenses configured to receive a portion of the output optical beam and to deliver an analysis output beam to a sample." "A preferred optical sensor 30 utilizing green light is a TRS1755 sensor from TAOS, Inc of Plano Tex. The TRS1755 comprises a green LED light source (567 nm wavelength) and a light-to-voltage converter. The output voltage is directly proportional to the reflected light intensity. Another preferred photodetector 130 is a light-to-voltage photodetector such as the TSL260R and TSL261, TSL261R photodetectors available from TAOS, Inc of Plano Tex. Alternatively, the photodetector 130 is a light-to-frequency photodetector such as the TSL245R, which is also available from TAOS, Inc. The light-to-voltage photodetectors have an integrated transimpedance amplifier on a single monolithic integrated circuit, which reduces the need for ambient light filtering. The TSL261 photodetector preferably operates at a wavelength greater than 750 nanometers, and optimally at 940 nanometers, which would preferably have a LED that radiates light at those wavelengths." (Elhag, 8:45-61)

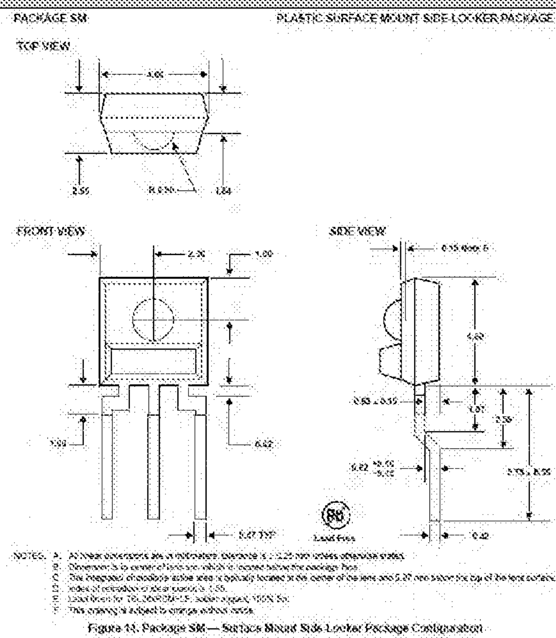
Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	 FIGURE 6 (Elhag, Fig. 6) "FIG. 6 illustrates a flow chart of a signal processing method of the present invention. As shown in FIG. 6, the photodetector 130 of the optical sensor 30 receives light from the light source 135 while in proximity to the user's nose 90 (reference to FIG. 4) or ear 98 (reference to FIG. 7). In a preferred embodiment, the optical sensor 30 is a TRS1755 which includes a green LED light source (567 nm wavelength) and a light-to-voltage converter. The output voltage is directly proportional to the reflected light intensity. The signal 299 is sent to the microprocessor 41. At block 1300, the signal acquisition is performed, which is shown in greater detail in FIG. 8. In the pulse mode the LED 135 is periodically activated for short intervals of time by a signal from the microcontroller. The reflected pulse of light is received by the sensor, with the generation of a voltage pulse having an amplitude proportional to the intensity of the reflected light. When the LED is activated, the switch, SW, is open by the action of the control signal from the microcontroller, and the capacitor, C, integrates the pulse generated from the sensor by charging through the resistor R. Immediately prior to deactivation of the LED, the analog-to-digital converter acquires the value of the voltage integrated across the capacitor, C. The analog-to-digital

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	converter generates a data sample in digital form which is utilized by the microcontroller for evaluation of the heart rate the wearer. Subsequent to the sample being acquired by the analog-to-digital converter, the LED is deactivated and the capacitor, C, is shortcut by switch, SW, to reset the integrator, RC. This states remains unchanged for a given time interval after which the process is repeated, which is illustrated in FIG. 9. A noise reduction and power reduction process is discussed below in reference to FIGS. 13 and 14." (Elhag, 14:51-15:14)  FIGURE 1A

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	 FIGURE 1B  FIGURE 8

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	Elhag specifically provides that its system can use a sensor made by TAOS, Inc., such as the TSL260R, TSL261, and TSL261R. Elhag, 8:45-61. Therefore, the features and properties of the TSL260R, TSL261, and TSL261R are inherently disclosed in Elhag. The TAOS TSL260 Datasheet ("TAOS") describes the properties and features of the TSL optical sensors. Exemplary passages from TAOS are set forth below. <u>TAOS</u> "The TSL260R, TSL261R, and TSL262R are infrared light-to-voltage optical sensors, each combining a photodiode and a transimpedance amplifier (feedback resistor = 16 MW, 8 MW, and 2.8 MW respectively) on a single monolithic IC. Output voltage is directly proportional to the light intensity (irradiance) on the photodiode. These devices have improved amplifier offset-voltage stability and low power consumption and are supplied in a 3-lead plastic sidelooker package with an integral visible light cutoff filter and lens. When supplied in the lead (Pb) free package, the device is RoHS compliant." TAOS, 1.  Figure 1. Switching Times TAOS, 4. "The TSL260R, TSL261R, and TSL262R are supplied in a clear 3-lead through-hole package with a molded lens. The integrated photodiode active area is typically 1,0 mm2 (0.0016 in2) for TSL260R, 0,5 mm2 (0.00078 in2) for the TSL261R, and 0,26 mm2 (0.0004 in2) for the TSL262R." TAOS, 10.

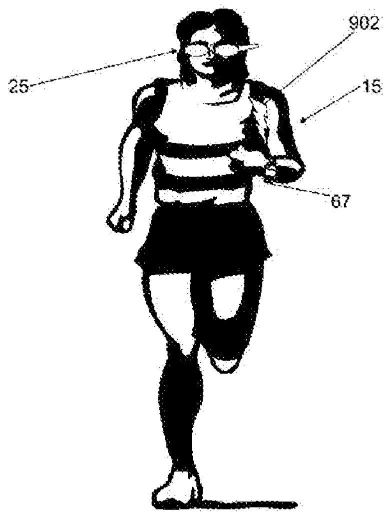
Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	 Figure 13. Package S — Single-In-Line Side-Looker Package Configuration TAOS, 10.

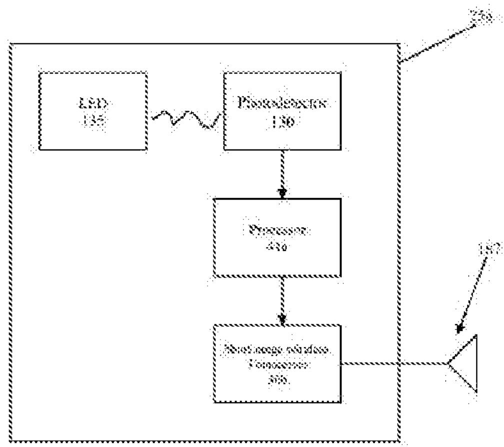
Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	 TAOS, 11.
[5E] a receiver configured to receive and process at least a portion of the analysis output beam reflected or transmitted from the sample and to generate an output signal,	Elhag discloses and/or renders obvious "a receiver configured to receive and process at least a portion of the analysis output beam reflected or transmitted from the sample and to generate an output signal." "Alternatively, the controller receives the signal from the photodetector 130 and processes the information using a microprocessor within a housing 65 of the controller 43. The controller 43 also preferably has function controls 63 and a display screen 64. The user uses the function

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	controls 63 to change the health information displayed on the display screen 64. In this embodiment, the controller 43 would receive and process all of the information from the optical device 30 to generate the plurality of health parameters. The controller optionally can display the plurality of health parameters on its display screen 64. In such an alternative embodiment, the controller 43 could control the audio feed of information from the digital storage and processing device 35. The controller 43 could also operate with other portable audio devices such as CD players, walkman style cassettes, minidisk players." (Elhag, 10:11-25) "Alternatively, the optical sensor 30 is a pulse oximetry device with a light source 135 that typically includes LEDs that generate both red (λ˜660 nm) and infrared (λ˜900 nm) radiation. As the heart pumps blood through the user's arteries, blood cells absorb and transmit varying amounts of the red and infrared radiation depending on how much oxygen binds to the cells' hemoglobin. The photodetector 130, which is typically a photodiode, detects transmission at the red and infrared wavelengths, and in response generates a radiation-induced signal." (Elhag, 8:35-44)
[5F] wherein the receiver is configured to be synchronized to the light source;	Elhag discloses and/or renders obvious "wherein the receiver is configured to be synchronized to the light source." "A preferred optical sensor 30 utilizing green light is a TRS1755 sensor from TAOS, Inc of Plano Tex. The TRS1755 comprises a green LED light source (567 nm wavelength) and a light-to-voltage converter. The output voltage is directly proportional to the reflected light intensity. Another preferred photodetector 130 is a light-to-voltage photodetector such as the TSL260R and TSL261, TSL261R photodetectors available from TAOS, Inc of Plano Tex. Alternatively, the photodetector 130 is a light-to-frequency photodetector such as the TSL245R, which is also available from TAOS, Inc. The light-to-voltage photodetectors have an integrated transimpedance amplifier on a single monolithic integrated circuit, which reduces the need for ambient light filtering. The TSL261 photodetector preferably operates at a wavelength greater than 750 nanometers, and optimally at 940 nanometers, which would preferably have a LED that radiates light at those wavelengths." (Elhag, 8:45-61)

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	"FIG. 6 illustrates a flow chart of a signal processing method of the present invention. As shown in FIG. 6, the photodetector 130 of the optical sensor 30 receives light from the light source 135 while in proximity to the user's nose 90 (reference to FIG. 4) or ear 98 (reference to FIG. 7). In a preferred embodiment, the optical sensor 30 is a TRS1755 which includes a green LED light source (567 nm wavelength) and a light-to-voltage converter. The output voltage is directly proportional to the reflected light intensity. The signal 299 is sent to the microprocessor 41. At block 1300, the signal acquisition is performed, which is shown in greater detail in FIG. 8. In the pulse mode the LED 135 is periodically activated for short intervals of time by a signal from the microcontroller. The reflected pulse of light is received by the sensor, with the generation of a voltage pulse having an amplitude proportional to the intensity of the reflected light. When the LED is activated, the switch, SW, is open by the action of the control signal from the microcontroller, and the capacitor, C, integrates the pulse generated from the sensor by charging through the resistor R. Immediately prior to deactivation of the LED, the analog-to-digital converter acquires the value of the voltage integrated across the capacitor, C. The analog-to-digital converter generates a data sample in digital form which is utilized by the microcontroller for evaluation of the heart rate the wearer. Subsequent to the sample being acquired by the analog-to-digital converter, the LED is deactivated and the capacitor, C, is shortcut by switch, SW, to reset the integrator, RC. This states remains unchanged for a given time interval after which the process is repeated, which is illustrated in FIG. 9. A noise reduction and power reduction process is discussed below in reference to FIGS. 13 and 14." (Elhag, 14:51-15:14) "At block 1305, a band pass filter is implemented preferably with two sets of data from the analog-to-digital converter. At block 1305, an average of the values of data samples within each of a first set of samples is calculated by the microprocessor. For example, the values of data samples within forty-four samples are summed and then divided by forty-four to generate an average value for the first set of samples. Next, an average of the values of data samples within a second set of samples is calculated by the microprocessor. For example, the values of data samples within twenty-two samples are summed and then divided by twenty-two to generate an average value for the second set of samples. Preferably, the second set of samples is less than the first set of samples. Next, the average value of the second set of samples is subtracted from the average value for the first set of samples to generate a first filtered pulse data value." (Elhag, 15:15-30)

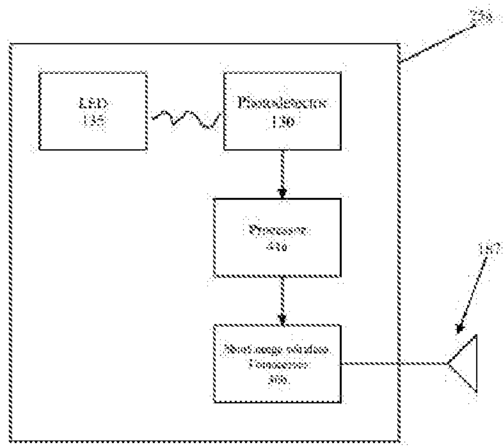
Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	"FIG. 13 illustrates a noise reduction method of the present invention. Due to the desire to minimize power consumption of the monitoring device 20, and achieve very accurate signal measurements using the optical sensor 30, the present invention preferably utilizes the method 250 illustrated in FIG. 13. At block 252, the processor 41 is deactivated for a deactivation period in order to conserve power and to eliminate noise for a signal measurement. The deactivation period ranges from 128 to 640 microseconds, more preferably from 200 microseconds to 400 microseconds, and more preferably from 225 microseconds to 300 microseconds. In reference to FIG. 6, this deactivation period occurs during block 1300. At block 254, during the deactivation period, the optical sensor 30 is activated to obtain multiple readings using the light source 135 and the photodetector 130. Preferably 4 to 25 sub-readings or sub-samples are obtained during the deactivation period. The sub-readings or sub-samples are averaged for noise reduction to provide a reading or sample value. In a single second, from 500 to 1500 sub-readings or sub-samples are obtained by the optical sensor 30. At block 256, the processor 41 is reactivated and the reading values are processed by processor 41. At block 258, heart rate data is generated from the readings by the processor 41. At block 260, health related data is generated from the heart rate data, and the health related data and the heart rate data are displayed on the display member 40." (Elhag, 16:4-41)
[5G] a personal device comprising a wireless receiver, a wireless transmitter, a display, a microphone, a speaker, one or more buttons or knobs, a microprocessor and a touch screen,	Elhag discloses and/or renders obvious "a personal device comprising a wireless receiver, a wireless transmitter, a display, a microphone, a speaker, one or more buttons or knobs, a microprocessor and a touch screen."

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	 FIG. 10 (Elhag, Fig. 10)

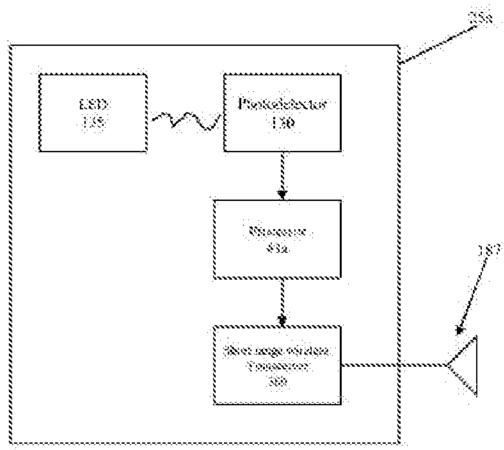
Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	 FIG. 11 (Elhag, Fig. 11) "The digital storage and processing unit 35 is preferably a MP3 player such as the IPOD™ MP3 player from Apple Computer of Cupertino Calif., or other similar devices available from Hewlett Packard or Dell Computer. The use of a MP3 player with the monitoring device 20 allows for the user to listen to music or other audio information through earphone 85 while monitoring the user's health parameters with the optical device 30. Alternatively, the digital storage device 35 is a PDA such as a BLACKBERRY™ device from Research In Motion Company, or a SMARTPHONE™ TREO™ device from Palm Company." (Elhag, 8:62-9:5) "Yet further, in reference to FIG. 10, the digital storage device is a watch 67 which receives a wireless transmission 902 from the circuitry on the eyewear 25 while worn on an arm of the user 15. The watch is capable of displaying the user's real-time vital signs on a display member on the face of the watch. As shown in FIG. 11, the eyewear circuitry 25 a comprises the LED 135 and

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	photodetector 130, a processor 41 a, a short range wireless transceiver 36 b and an antenna 187. The radiation induced signal from the photodetector 130 is sent to the processor 41 a for processing. The processed information is sent by the short range wireless transceiver 36 b to the watch 67 via the antenna 187." (Elhag, 9:6-17) "As shown in FIGS. 1 and 2, the digital storage and processing unit 35 preferably includes a housing 50, a display screen 40, a function control 51 and a connection cable receptor 52. Within the housing 50 of the digital storage and processing unit 35 are preferably a microprocessor, a memory, a battery, a communication interface, and an earphone interface. The microprocessor can process the data to display the health parameters such as a pulse rate, blood oxygenation levels, calories expended by the user of a pre-set time period, target zone activity, time and dynamic blood pressure. The memory can store the health parameters. The memory may also store digital music. The display screen of the digital storage and processing unit 35 is preferably a liquid crystal display ("LCD"). Alternatively, the display screen 40 is a light emitting diode ("LED"), a combination of a LCD and LED, or other similar display device. As shown in FIG. 4, the display screen 40 displays the health parameters of the user." (Elhag, 9:18-36) "The digital storage and processing unit 35 may optionally have a short range wireless transceiver for transmitting processed information processed from the digital storage and processing unit 35 to a handheld device 150 or a computer, not shown. The short-range wireless transceiver is preferably a transmitter operating on a wireless protocol, e.g. BLUETOOTH™, part-15, or 802.11. "Part-15" refers to a conventional low-power, short-range wireless protocol, such as that used in cordless telephones. The short-range wireless transmitter (e.g., a BLUETOOTH™ transmitter) receives information from the microprocessor and transmits this information in the form of a packet through an antenna. The external laptop computer or hand-held device 150 features a similar antenna coupled to a matched wireless, short-range receiver that receives the packet. In certain embodiments, the hand-held device 150 is a cellular telephone with a BLUETOOTH™ circuit integrated directly into a chipset used in the cellular telephone. In this case, the cellular telephone may include a software application that receives, processes, and displays the information. The secondary wireless component may also include a long-range

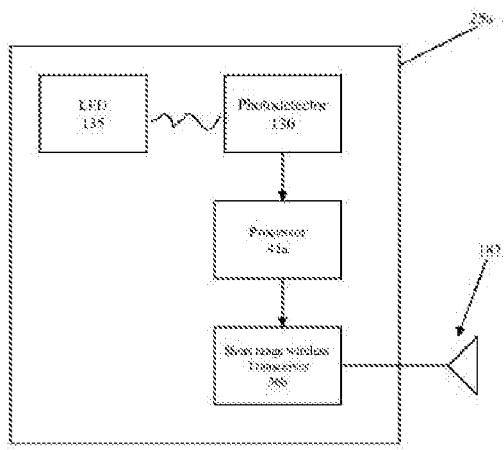
Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	wireless transmitter that transmits information over a terrestrial, satellite, or 802.11-based wireless network. Suitable networks include those operating at least one of the following protocols: CDMA, GSM, GPRS, Mobitex, DataTac, iDEN, and analogs and derivatives thereof. Alternatively, the handheld device 150 is a pager or PDA." (Elhag, 9:36-63) "Alternatively, the controller receives the signal from the photodetector 130 and processes the information using a microprocessor within a housing 65 of the controller 43. The controller 43 also preferably has function controls 63 and a display screen 64. The user uses the function controls 63 to change the health information displayed on the display screen 64. In this embodiment, the controller 43 would receive and process all of the information from the optical device 30 to generate the plurality of health parameters. The controller optionally can display the plurality of health parameters on its display screen 64. In such an alternative embodiment, the controller 43 could control the audio feed of information from the digital storage and processing device 35. The controller 43 could also operate with other portable audio devices such as CD players, walkman style cassettes, minidisk players." (Elhag, 10:11-25)
[5H] the personal device configured to receive and process at least a portion of the output signal,	Elhag discloses and/or renders obvious "the personal device configured to receive and process at least a portion of the output signal."

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	 FIG. 11 (Elhag, Fig. 11) "The digital storage and processing unit 35 is preferably a MP3 player such as the IPOD™ MP3 player from Apple Computer of Cupertino Calif., or other similar devices available from Hewlett Packard or Dell Computer. The use of a MP3 player with the monitoring device 20 allows for the user to listen to music or other audio information through earphone 85 while monitoring the user's health parameters with the optical device 30. Alternatively, the digital storage device 35 is a PDA such as a BLACKBERRY™ device from Research In Motion Company, or a SMARTPHONE™ TREO™ device from Palm Company." (Elhag, 8:62-9:5) "Yet further, in reference to FIG. 10, the digital storage device is a watch 67 which receives a wireless transmission 902 from the circuitry on the eyewear 25 while worn on an arm of the user 15. The watch is capable of displaying the user's real-time vital signs on a display member on the face of the watch. As shown in FIG. 11, the eyewear circuitry 25 a comprises the LED 135 and

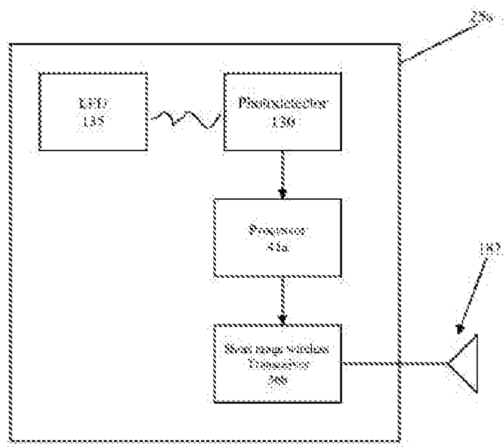
Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	photodetector 130, a processor 41 a, a short range wireless transceiver 36 b and an antenna 187. The radiation induced signal from the photodetector 130 is sent to the processor 41 a for processing. The processed information is sent by the short range wireless transceiver 36 b to the watch 67 via the antenna 187." (Elhag, 9:6-17) "As shown in FIGS. 1 and 2, the digital storage and processing unit 35 preferably includes a housing 50, a display screen 40, a function control 51 and a connection cable receptor 52. Within the housing 50 of the digital storage and processing unit 35 are preferably a microprocessor, a memory, a battery, a communication interface, and an earphone interface. The microprocessor can process the data to display the health parameters such as a pulse rate, blood oxygenation levels, calories expended by the user of a pre-set time period, target zone activity, time and dynamic blood pressure. The memory can store the health parameters. The memory may also store digital music." (Elhag, 9:18-30) "The digital storage and processing unit 35 may optionally have a short range wireless transceiver for transmitting processed information processed from the digital storage and processing unit 35 to a handheld device 150 or a computer, not shown. The short-range wireless transceiver is preferably a transmitter operating on a wireless protocol, e.g. BLUETOOTH™, part-15, or 802.11. "Part-15" refers to a conventional low-power, short-range wireless protocol, such as that used in cordless telephones. The short-range wireless transmitter (e.g., a BLUETOOTH™ transmitter) receives information from the microprocessor and transmits this information in the form of a packet through an antenna. The external laptop computer or hand-held device 150 features a similar antenna coupled to a matched wireless, short-range receiver that receives the packet. In certain embodiments, the hand-held device 150 is a cellular telephone with a BLUETOOTH™ circuit integrated directly into a chipset used in the cellular telephone. In this case, the cellular telephone may include a software application that receives, processes, and displays the information. The secondary wireless component may also include a long-range wireless transmitter that transmits information over a terrestrial, satellite, or 802.11-based wireless network. Suitable networks include those operating at least one of the following protocols: CDMA, GSM, GPRS, Mobitex, DataTac, iDEN, and analogs and derivatives thereof. Alternatively, the handheld device 150 is a pager or PDA." (Elhag, 9:36-63)

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	"The monitoring device 20 may also be able to download the information to a computer for further processing and storage of information. The download may be wireless or through cable connection. The information can generate an activity log or a calorie chart." (Elhag, 11:47-51)
[5I] wherein the personal device is configured to store and display the processed output signal,	Elhag discloses and/or renders obvious "wherein the personal device is configured to store and display the processed output signal."  FIG. 11 (Elhag, Fig. 11) "Yet further, in reference to FIG. 10, the digital storage device is a watch 67 which receives a wireless transmission 902 from the circuitry on the eyewear 25 while worn on an arm of the user 15. The watch is capable of displaying the user's real-time vital signs on a display member on the face of the watch. As shown in FIG. 11, the eyewear circuitry 25 a comprises the LED 135 and photodetector 130, a processor 41 a, a short range wireless transceiver 36 b and an antenna 187.

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	The radiation induced signal from the photodetector 130 is sent to the processor 41 a for processing. The processed information is sent by the short range wireless transceiver 36 b to the watch 67 via the antenna 187." (Elhag, 9:6-17) "As shown in FIGS. 1 and 2, the digital storage and processing unit 35 preferably includes a housing 50, a display screen 40, a function control 51 and a connection cable receptor 52. Within the housing 50 of the digital storage and processing unit 35 are preferably a microprocessor, a memory, a battery, a communication interface, and an earphone interface. The microprocessor can process the data to display the health parameters such as a pulse rate, blood oxygenation levels, calories expended by the user of a pre-set time period, target zone activity, time and dynamic blood pressure. The memory can store the health parameters. The memory may also store digital music. The display screen of the digital storage and processing unit 35 is preferably a liquid crystal display ("LCD"). Alternatively, the display screen 40 is a light emitting diode ("LED"), a combination of a LCD and LED, or other similar display device. As shown in FIG. 4, the display screen 40 displays the health parameters of the user." (Elhag, 9:18-36) "The digital storage and processing unit 35 may optionally have a short range wireless transceiver for transmitting processed information processed from the digital storage and processing unit 35 to a handheld device 150 or a computer, not shown. The short-range wireless transceiver is preferably a transmitter operating on a wireless protocol, e.g. BLUETOOTH™, part-15, or 802.11. "Part-15" refers to a conventional low-power, short-range wireless protocol, such as that used in cordless telephones. The short-range wireless transmitter (e.g., a BLUETOOTH™ transmitter) receives information from the microprocessor and transmits this information in the form of a packet through an antenna. The external laptop computer or hand-held device 150 features a similar antenna coupled to a matched wireless, short-range receiver that receives the packet. In certain embodiments, the hand-held device 150 is a cellular telephone with a BLUETOOTH™ circuit integrated directly into a chipset used in the cellular telephone. In this case, the cellular telephone may include a software application that receives, processes, and displays the information. The secondary wireless component may also include a long-range wireless transmitter that transmits information over a terrestrial, satellite, or 802.11-based wireless

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	network. Suitable networks include those operating at least one of the following protocols: CDMA, GSM, GPRS, Mobitex, DataTac, iDEN, and analogs and derivatives thereof. Alternatively, the handheld device 150 is a pager or PDA." (Elhag, 9:36-63) "The monitoring device 20 may also be able to download the information to a computer for further processing and storage of information. The download may be wireless or through cable connection. The information can generate an activity log or a calorie chart." (Elhag, 11:47-51)
[5J] and wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link; and	Elhag discloses and/or renders obvious "and wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link."  FIG. 11 (Elhag, Fig. 11)

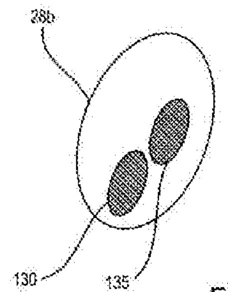
Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	"Yet further, in reference to FIG. 10, the digital storage device is a watch 67 which receives a wireless transmission 902 from the circuitry on the eyewear 25 while worn on an arm of the user 15. The watch is capable of displaying the user's real-time vital signs on a display member on the face of the watch. As shown in FIG. 11, the eyewear circuitry 25 a comprises the LED 135 and photodetector 130, a processor 41 a, a short range wireless transceiver 36 b and an antenna 187. The radiation induced signal from the photodetector 130 is sent to the processor 41 a for processing. The processed information is sent by the short range wireless transceiver 36 b to the watch 67 via the antenna 187." (Elhag, 9:6-17) "The digital storage and processing unit 35 may optionally have a short range wireless transceiver for transmitting processed information processed from the digital storage and processing unit 35 to a handheld device 150 or a computer, not shown. The short-range wireless transceiver is preferably a transmitter operating on a wireless protocol, e.g. BLUETOOTH™, part-15, or 802.11. "Part-15" refers to a conventional low-power, short-range wireless protocol, such as that used in cordless telephones. The short-range wireless transmitter (e.g., a BLUETOOTH™ transmitter) receives information from the microprocessor and transmits this information in the form of a packet through an antenna. The external laptop computer or hand-held device 150 features a similar antenna coupled to a matched wireless, short-range receiver that receives the packet. In certain embodiments, the hand-held device 150 is a cellular telephone with a BLUETOOTH™ circuit integrated directly into a chipset used in the cellular telephone. In this case, the cellular telephone may include a software application that receives, processes, and displays the information. The secondary wireless component may also include a long-range wireless transmitter that transmits information over a terrestrial, satellite, or 802.11-based wireless network. Suitable networks include those operating at least one of the following protocols: CDMA, GSM, GPRS, Mobitex, DataTac, iDEN, and analogs and derivatives thereof. Alternatively, the handheld device 150 is a pager or PDA." (Elhag, 9:36-63) "The monitoring device 20 may also be able to download the information to a computer for further processing and storage of information. The download may be wireless or through cable connection. The information can generate an activity log or a calorie chart." (Elhag, 11:47-51)

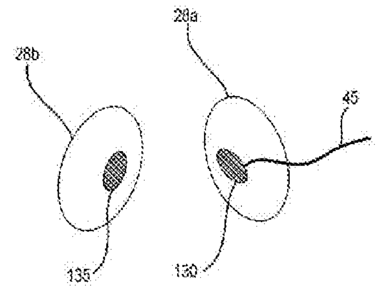
Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
[5K] a remote device configured to receive over the wireless transmission link an output status comprising the at least a portion of the processed output signal, to process the received output status to generate processed data and to store the processed data.	Elhag discloses and/or renders obvious "a remote device configured to receive over the wireless transmission link an output status comprising the at least a portion of the processed output signal, to process the received output status to generate processed data and to store the processed data."  FIG. 11 (Elhag, Fig. 11) "Yet further, in reference to FIG. 10, the digital storage device is a watch 67 which receives a wireless transmission 902 from the circuitry on the eyewear 25 while worn on an arm of the user 15. The watch is capable of displaying the user's real-time vital signs on a display member on the face of the watch. As shown in FIG. 11, the eyewear circuitry 25 a comprises the LED 135 and photodetector 130, a processor 41 a, a short range wireless transceiver 36 b and an antenna 187. The radiation induced signal from the photodetector 130 is sent to the processor 41 a for

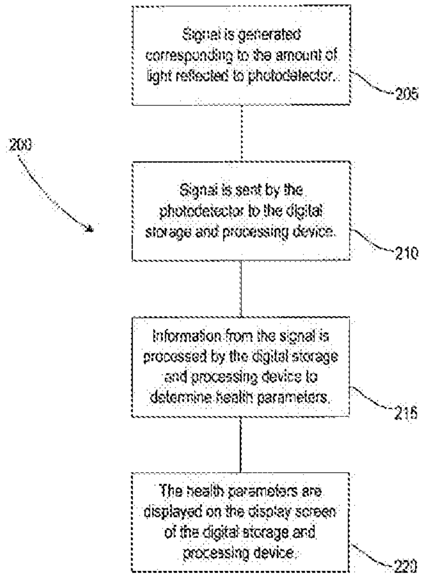
Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	processing. The processed information is sent by the short range wireless transceiver 36 b to the watch 67 via the antenna 187." (Elhag, 9:6-17) "The digital storage and processing unit 35 may optionally have a short range wireless transceiver for transmitting processed information processed from the digital storage and processing unit 35 to a handheld device 150 or a computer, not shown. The short-range wireless transceiver is preferably a transmitter operating on a wireless protocol, e.g. BLUETOOTH™, part-15, or 802.11. "Part-15" refers to a conventional low-power, short-range wireless protocol, such as that used in cordless telephones. The short-range wireless transmitter (e.g., a BLUETOOTH™ transmitter) receives information from the microprocessor and transmits this information in the form of a packet through an antenna. The external laptop computer or hand-held device 150 features a similar antenna coupled to a matched wireless, short-range receiver that receives the packet. In certain embodiments, the hand-held device 150 is a cellular telephone with a BLUETOOTH™ circuit integrated directly into a chipset used in the cellular telephone. In this case, the cellular telephone may include a software application that receives, processes, and displays the information. The secondary wireless component may also include a long-range wireless transmitter that transmits information over a terrestrial, satellite, or 802.11-based wireless network. Suitable networks include those operating at least one of the following protocols: CDMA, GSM, GPRS, Mobitex, DataTac, iDEN, and analogs and derivatives thereof. Alternatively, the handheld device 150 is a pager or PDA." (Elhag, 9:36-63) "The monitoring device 20 may also be able to download the information to a computer for further processing and storage of information. The download may be wireless or through cable connection. The information can generate an activity log or a calorie chart." (Elhag, 11:47-51)
[7] The system of claim 5, wherein the remote device is further configured to transmit at least a portion of the processed data to one or more other locations, wherein the one or more other locations is selected	Elhag discloses and/or renders obvious "[t]he system of claim 5, wherein the remote device is further configured to transmit at least a portion of the processed data to one or more other locations, wherein the one or more other locations is selected from the group consisting of the personal device, a doctor, a healthcare provider, a cloud-based server and one or more designated recipients, and wherein the remote device is capable of transmitting information related to a time and a position associated with the at least a portion of the processed data."

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
from the group consisting of the personal device, a doctor, a healthcare provider, a cloud-based server and one or more designated recipients, and wherein the remote device is capable of transmitting information related to a time and a position associated with the at least a portion of the processed data.	"The present invention provides a solution to the shortcomings of the prior art. The present invention is accurate, comfortable to wear by a user on their face for extended time periods, allows for input and controlled output by the user, is light weight, and provides sufficient real-time information to the user about the user's health." (Elhag, 5:9-14) "Another aspect of the present invention is a system for monitoring the health of a user. The system includes a monitoring device and a handheld device. The monitoring device includes eyewear, an optical sensor, a digital music player, a controller and transmitting means. The eyewear has a lens or two lenses, temporal members and a nose support member. The optical sensor is integrated into the eyewear, either one of the temporal members or the nose support member. The optical sensor is capable generating a signal corresponding to the flow of blood through at least one facial artery of the user. The controller is connected to the eyewear and the digital music player. The transmitting means transmits a plurality of health information about the user. The handheld device or computer is capable of storing the plurality of health information transmitted by the monitoring device." (Elhag, 5:40-54) "Alternatively, the controller receives the signal from the photodetector 130 and processes the information using a microprocessor within a housing 65 of the controller 43. The controller 43 also preferably has function controls 63 and a display screen 64. The user uses the function controls 63 to change the health information displayed on the display screen 64. In this embodiment, the controller 43 would receive and process all of the information from the optical device 30 to generate the plurality of health parameters. The controller optionally can display the plurality of health parameters on its display screen 64. In such an alternative embodiment, the controller 43 could control the audio feed of information from the digital storage and processing device 35. The controller 43 could also operate with other portable audio devices such as CD players, walkman style cassettes, minidisk players." (Elhag, 10:11-25) "The digital storage and processing unit 35 may optionally have a short range wireless transceiver for transmitting processed information processed from the digital storage and processing unit 35 to a handheld device 150 or a computer, not shown. The short-range wireless transceiver is

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	preferably a transmitter operating on a wireless protocol, e.g. BLUETOOTH™, part-15, or 802.11. "Part-15" refers to a conventional low-power, short-range wireless protocol, such as that used in cordless telephones. The short-range wireless transmitter (e.g., a BLUETOOTH™ transmitter) receives information from the microprocessor and transmits this information in the form of a packet through an antenna. The external laptop computer or hand-held device 150 features a similar antenna coupled to a matched wireless, short-range receiver that receives the packet. In certain embodiments, the hand-held device 150 is a cellular telephone with a BLUETOOTH™ circuit integrated directly into a chipset used in the cellular telephone. In this case, the cellular telephone may include a software application that receives, processes, and displays the information. The secondary wireless component may also include a long-range wireless transmitter that transmits information over a terrestrial, satellite, or 802.11-based wireless network. Suitable networks include those operating at least one of the following protocols: CDMA, GSM, GPRS, Mobitex, DataTac, iDEN, and analogs and derivatives thereof. Alternatively, the handheld device 150 is a pager or PDA." (Elhag, 9:36-63) "The monitoring device 20 may also be able to download the information to a computer for further processing and storage of information. The download may be wireless or through cable connection. The information can generate an activity log or a calorie chart." (Elhag, 11:47-51)
[8] The system of claim 5, wherein the receiver is located a first distance from a first one of the plurality of light emitting diodes and a different, second distance from a second one of the plurality of light emitting diodes such that the receiver receives a first signal from the first light emitting diode and a second signal from the second light emitting diode.	Elhag discloses and/or renders obvious "[t]he system of claim 5, wherein the receiver is located a first distance from a first one of the plurality of light emitting diodes and a different, second distance from a second one of the plurality of light emitting diodes such that the receiver receives a first signal from the first light emitting diode and a second signal from the second light emitting diode." "The lens 26 includes a recessed nose area 27 including a nose support 28 (or 28 a and 28 b in FIG. 1) which allows the eyewear 25 to be supported on the user's face (not shown) in the manner conventionally known in the art. An optical sensor 30, as discussed below, is attached to the nose support 28. The optical sensor 30 has a light source 135 and a photodetector 130, which is connected to connection cable 45. An integral lens support portion 29 is provided on the eyewear 25 for supporting the lens 26 in the desired position within the user's forward field of vision. The connection cable 45 is preferably attached and/or integrated into the lens support position 29. As

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	illustrated in FIG. 2, the lens support portion 29 is preferably integrally formed on the lens 26 from a similar transparent material so as to allow the user to see objects through the lens support portion 29. As shown in FIG. 1A, a reflective mode optical sensor 30 has the light source 135 and the photodetector 130 on nose support 28 b. As shown in FIG. 1B, in an alternative embodiment, a transmission mode optical sensor 30 has the optical sensor 30 with the light source 135 in the nose support 28 b and the photodetector 130 in the nose support 28 a. In a preferred embodiment, the light source 135 and the photodetector 130 are integrated into the body of the nose support 28 b, or nose supports 28 a and 28 b, so as to have little affect on the user, and to prevent adverse light from affecting the signal reading of the photodetector 130." (Elhag, 7:18-42)  FIGURE 1A

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	 FIGURE 1B A general method of using the monitoring device 20 begins with the light source 135 transmitting red and/or infrared light through a nose of the user. The photo-detector 130 detects the light. The pulse rate is determined by the signals received by the photo-detector 130. The ratio of the fluctuation of the red and/or infrared light signals is used to calculate the blood oxygen saturation level of the user. An optical sensor 30 with a photodetector 130 and single LED 135 is preferably utilized. Alternatively, a pulse oximetry device with two LEDs and a photodetector is utilized. Next, this information is sent to pulse oximetry board in the digital storage and processing device 35 for creation of blood oxygenation level, pulse rate, signal strength bargraph, plethysmogram and/or status bits data. Next, the microprocessor further processes the information to display pulse rate, blood oxygenation levels, calories expended by the user of a pre-set time period, target zones of activity, time and dynamic blood pressure. Next, the information is displayed on the display member 40. (Elhag, 11:52-12:2)
[9] The system of claim 5, wherein the output signal is	Elhag discloses and/or renders obvious "[t]he system of claim 5, wherein the output signal is generated in part by comparing the first and second signals."

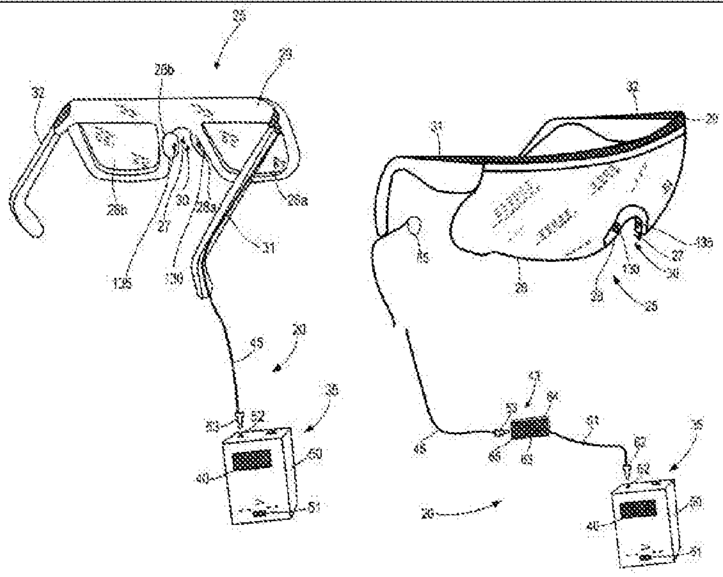
Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
generated in part by comparing the first and second signals	 FIGURE 5 (Elhag, Fig. 5) "As shown in FIG. 5, a general method is indicated as 200. At block 205, the light source 135 of the optical device 30 transmits light at the nose 90 of the user. The photo-detector 130 detects the light. The pulse rate is determined by the signals received by the photo-detector 130. The ratio of the fluctuation of the red and/or infrared light signals is used to calculate the blood oxygen saturation level of the user. At block 210, a signal is sent to digital storage and processing unit 35 for creation of blood oxygenation level, pulse rate, signal strength bar graph, plethysmogram

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	and/or status bits data. At block 215, a microprocessor on the digital storage and processing device 35 further processes the information to display pulse rate, blood oxygenation levels, calories expended by the user of a pre-set time period, target zones of activity, time and/or dynamic blood pressure. At block 220, the information is displayed on the display screen 40 of the digital storage and processing unit 35." (Elhag, 10:51-67) An alternative method includes the light source 135 of the optical device 30 transmitting light at the nose 90 of the user. The photo-detector 130 detects the light. The pulse rate is determined by the signals received by the photo-detector 130. The ratio of the fluctuation of the red and/or infrared light signals is used to calculate the blood oxygen saturation level of the user. Then, the signal is sent to the controller 43 to be converted into a usable format for the digital storage and processing unit 35. Then, the signal is sent from the controller 43 to the digital storage and processing unit 35. Then, the information contained in the signal is processed by the microprocessor on the digital storage and processing unit 35 to generate blood oxygenation level, pulse rate, signal strength bar graph, plethysmogram and/or status bits data. Further processing of the information is performed by the microprocessor to generate pulse rate, blood oxygenation levels, calories expended by the user of a pre-set time period, target zones of activity, time and dynamic blood pressure. Then, the information is displayed on the display screen 40 of the digital storage and processing unit 35. Another alternative method includes the light source 135 of the optical device 30 transmitting light at the nose 90 of the user. The photo-detector 130 detects the light. The pulse rate is determined by the signals received by the photo-detector 130. The ratio of the fluctuation of the red and/or infrared light signals is used to calculate the blood oxygen saturation level of the user. Then, the signal is sent to the controller 43 to be converted into a usable format for the digital storage and processing unit 35. The information contained in the signal is processed by the microprocessor on the controller 43 to generate blood oxygenation level, pulse rate, signal strength bar graph, plethysmogram and/or status bits data. Further processing of the information is performed by the microprocessor to generate pulse rate, blood oxygenation levels, calories expended by the user of a pre-set time period, target zones of activity, time and/or dynamic blood pressure. Then, a health information signal is sent from the controller 43 to the digital storage and processing unit 35. Then, the information is displayed on the display screen 40 of the digital storage and processing unit 35." (Elhag, 11:1-40)

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	A general method of using the monitoring device 20 begins with the light source 135 transmitting red and/or infrared light through a nose of the user. The photo-detector 130 detects the light. The pulse rate is determined by the signals received by the photo-detector 130. The ratio of the fluctuation of the red and/or infrared light signals is used to calculate the blood oxygen saturation level of the user. An optical sensor 30 with a photodetector 130 and single LED 135 is preferably utilized. Alternatively, a pulse oximetry device with two LEDs and a photodetector is utilized. Next, this information is sent to pulse oximetry board in the digital storage and processing device 35 for creation of blood oxygenation level, pulse rate, signal strength bargraph, plethysmogram and/or status bits data. Next, the microprocessor further processes the information to display pulse rate, blood oxygenation levels, calories expended by the user of a pre-set time period, target zones of activity, time and dynamic blood pressure. Next, the information is displayed on the display member 40. (Elhag, 11:52-12:2)
[10] The system of claim 5, wherein the output signal comprises one or more physiological parameters, and the remote device is capable of storing a history of at least a portion of the one or more physiological parameters over a specified period of time.	Elhag discloses and/or renders obvious "[t]he system of claim 5, wherein the output signal comprises one or more physiological parameters, and the remote device is capable of storing a history of at least a portion of the one or more physiological parameters over a specified period of time." "Another aspect of the present invention is a system for monitoring the health of a user. The system includes a monitoring device and a handheld device. The monitoring device includes eyewear, an optical sensor, a digital music player, a controller and transmitting means. The eyewear has a lens or two lenses, temporal members and a nose support member. The optical sensor is integrated into the eyewear, either one of the temporal members or the nose support member. The optical sensor is capable generating a signal corresponding to the flow of blood through at least one facial artery of the user. The controller is connected to the eyewear and the digital music player. The transmitting means transmits a plurality of health information about the user. The handheld device or computer is capable of storing the plurality of health information transmitted by the monitoring device." (Elhag, 5:40-54)"As shown in FIGS. 1 and 2, the digital storage and processing unit 35 preferably includes a housing 50, a display screen 40, a function control 51 and a connection cable receptor 52. Within the housing 50 of the digital storage and processing unit 35 are preferably a microprocessor, a memory, a battery, a communication interface, and an earphone interface. The microprocessor can process the data to display the health

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	parameters such as a pulse rate, blood oxygenation levels, calories expended by the user of a pre-set time period, target zone activity, time and dynamic blood pressure. The memory can store the health parameters. The memory may also store digital music." (Elhag, 9:18-30) "Alternatively, the controller receives the signal from the photodetector 130 and processes the information using a microprocessor within a housing 65 of the controller 43. The controller 43 also preferably has function controls 63 and a display screen 64. The user uses the function controls 63 to change the health information displayed on the display screen 64. In this embodiment, the controller 43 would receive and process all of the information from the optical device 30 to generate the plurality of health parameters. The controller optionally can display the plurality of health parameters on its display screen 64. In such an alternative embodiment, the controller 43 could control the audio feed of information from the digital storage and processing device 35. The controller 43 could also operate with other portable audio devices such as CD players, walkman style cassettes, minidisk players." (Elhag, 10:11-25) "Yet further, in reference to FIG. 10, the digital storage device is a watch 67 which receives a wireless transmission 902 from the circuitry on the eyewear 25 while worn on an arm of the user 15. The watch is capable of displaying the user's real-time vital signs on a display member on the face of the watch. As shown in FIG. 11, the eyewear circuitry 25 a comprises the LED 135 and photodetector 130, a processor 41 a, a short range wireless transceiver 36 b and an antenna 187. The radiation induced signal from the photodetector 130 is sent to the processor 41 a for processing. The processed information is sent by the short range wireless transceiver 36 b to the watch 67 via the antenna 187." (Elhag, 9:6-17) "The digital storage and processing unit 35 may optionally have a short range wireless transceiver for transmitting processed information processed from the digital storage and processing unit 35 to a handheld device 150 or a computer, not shown. The short-range wireless transceiver is preferably a transmitter operating on a wireless protocol, e.g. BLUETOOTH™, part-15, or 802.11. "Part-15" refers to a conventional low-power, short-range wireless protocol, such as that used in cordless telephones. The short-range wireless transmitter (e.g., a BLUETOOTH™ transmitter) receives information from the microprocessor and transmits this information in the form of a packet through an antenna. The external laptop computer or hand-held device 150

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	features a similar antenna coupled to a matched wireless, short-range receiver that receives the packet. In certain embodiments, the hand-held device 150 is a cellular telephone with a BLUETOOTH™ circuit integrated directly into a chipset used in the cellular telephone. In this case, the cellular telephone may include a software application that receives, processes, and displays the information. The secondary wireless component may also include a long-range wireless transmitter that transmits information over a terrestrial, satellite, or 802.11-based wireless network. Suitable networks include those operating at least one of the following protocols: CDMA, GSM, GPRS, Mobitex, DataTac, iDEN, and analogs and derivatives thereof. Alternatively, the handheld device 150 is a pager or PDA." (Elhag, 9:36-63) "The monitoring device 20 may also be able to download the information to a computer for further processing and storage of information. The download may be wireless or through cable connection. The information can generate an activity log or a calorie chart." (Elhag, 11:47-51)
[13] A measurement system comprising	To the extent the preamble is limiting, Elhag discloses and/or renders obvious "a measurement system." *See* CHART ONE: '533 Patent, Claim Element 5 above.
[13A] a wearable measurement device for measuring one or more physiological parameters, including a light source comprising a plurality of semiconductor sources that are light emitting diodes, the light emitting diodes configured to generate an output optical beam with one or more optical wavelengths,	Elhag discloses and/or renders obvious "a wearable measurement device for measuring one or more physiological parameters, including a light source comprising a plurality of semiconductor sources that are light emitting diodes, the light emitting diodes configured to generate an output optical beam with one or more optical wavelengths."

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	 FIGURE 1 FIGURE 2 (Elhag, Fig. 1-2) "As shown in FIGS. 1-3, a monitoring device is generally designated 20. In a preferred embodiment shown in FIG. 1, the monitoring device 20 comprises eyewear 25, an optical sensor 30, a digital storage and processing unit 35 and a connection cable 45. In an alternative embodiment shown in FIG. 2, the monitoring device 20 includes eyewear 25, an optical sensor 30, a digital storage and processing unit 35, a controller 43, a connection cable 45 and a controller cable 61." (Elhag, 6:63-7:3) "A general method of using the monitoring device 20 begins with the light source 135 transmitting red and/or infrared light through a nose of the user. The photo-detector 130 detects the light. The

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	pulse rate is determined by the signals received by the photo-detector 130. The ratio of the fluctuation of the red and/or infrared light signals is used to calculate the blood oxygen saturation level of the user. An optical sensor 30 with a photodetector 130 and single LED 135 is preferably utilized. Alternatively, a pulse oximetry device with two LEDs and a photodetector is utilized. Next, this information is sent to pulse oximetry board in the digital storage and processing device 35 for creation of blood oxygenation level, pulse rate, signal strength bargraph, plethysmogram and/or status bits data. Next, the microprocessor further processes the information to display pulse rate, blood oxygenation levels, calories expended by the user of a pre-set time period, target zones of activity, time and dynamic blood pressure. Next, the information is displayed on the display member 40." (Elhag, 11:52-12:2) "In a preferred embodiment, the optical sensor 30 is a single light emitting diode ("LED") 135 based on green light wherein the LED 135 generates green light (λ˜500-600 nm), and a photodetector 130 detects the green light. Yet in an alternative embodiment, the optical sensor 30 is a photodetector 130 and a single LED 135 transmitting light at a wavelength of approximately 900 nanometers as a pulsed infrared LED. Yet further, the optical sensor is a combination of a green light LED and a pulsed infrared LED to offset noise affects of ambient light and sunlight. As the heart pumps blood through the arteries of the user, blood cells absorb and transmit varying amounts of the light depending on how much oxygen binds to the cells' hemoglobin. The photodetector 30, which is typically a photodiode, detects reflectance/transmission at the wavelengths (green, red or infrared), and in response generates a radiation-induced signal." (Elhag, 8:19-34) "Alternatively, the optical sensor 30 is a pulse oximetry device with a light source 135 that typically includes LEDs that generate both red (λ˜660 nm) and infrared (λ˜900 nm) radiation. As the heart pumps blood through the user's arteries, blood cells absorb and transmit varying amounts of the red and infrared radiation depending on how much oxygen binds to the cells' hemoglobin. The photodetector 130, which is typically a photodiode, detects transmission at the red and infrared wavelengths, and in response generates a radiation-induced signal." (Elhag, 8:35-44)

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
[13B] wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers,	Elhag discloses and/or renders obvious "wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers." *See* CHART ONE: '533 Patent, Claim Element 5B above.
[13C] the light source configured to increase signal-to-noise ratio by increasing a light intensity from at least one of the plurality of semiconductor sources and by increasing a pulse rate of at least one of the plurality of semiconductor sources;	Elhag discloses and/or renders obvious "the light source configured to increase signal-to-noise ratio by increasing a light intensity from at least one of the plurality of semiconductor sources and by increasing a pulse rate of at least one of the plurality of semiconductor sources." *See* CHART ONE: '533 Patent, Claim Element 5C above.
[13D] the wearable measurement device comprising a plurality of lenses configured to receive a portion of the output optical beam and to deliver an analysis output beam to a sample;	Elhag discloses and/or renders obvious "the wearable measurement device comprising a plurality of lenses configured to receive a portion of the output optical beam and to deliver an analysis output beam to a sample." *See* CHART ONE: '533 Patent, Claim Element 5D above.
[13E] the wearable measurement device further comprising a receiver configured to receive and process at least a portion of the analysis output beam reflected or transmitted from the sample and to generate an output signal	Elhag discloses and/or renders obvious "the wearable measurement device further comprising a receiver configured to receive and process at least a portion of the analysis output beam reflected or transmitted from the sample and to generate an output signal." *See* CHART ONE: '533 Patent, Claim Element 5E above.
[13F] wherein the wearable measurement device receiver is	Elhag discloses and/or renders obvious "wherein the wearable measurement device receiver is configured to be synchronized to pulses of the light source."

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
configured to be synchronized to pulses of the light source;	*See* CHART ONE: '533 Patent, Claim Element 5F above.
[13G] a personal device comprising a wireless receiver, a wireless transmitter, a display, a microphone, a speaker, one or more buttons or knobs, a microprocessor and a touch screen,	Elhag discloses and/or renders obvious "a personal device comprising a wireless receiver, a wireless transmitter, a display, a microphone, a speaker, one or more buttons or knobs, a microprocessor and a touch screen." *See* CHART ONE: '533 Patent, Claim Element 5G above.
[13H] the personal device configured to receive and process at least a portion of the output signal,	Elhag discloses and/or renders obvious "the personal device configured to receive and process at least a portion of the output signal, wherein the personal device is configured to store and display the processed output signal." *See* CHART ONE: '533 Patent, Claim Element 5H above.
[13I] wherein the personal device is configured to store and display the processed output signal, and	Elhag discloses and/or renders obvious "wherein the personal device is configured to store and display the processed output signal." *See* CHART ONE: '533 Patent, Claim Element 5I above.
[13J] wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link; and	Elhag discloses and/or renders obvious "wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link." *See* CHART ONE: '533 Patent, Claim Element 5J above.
[13K] a remote device configured to receive over the wireless transmission link an output status comprising the at least a portion of the processed output signal, to process the received output status	Elhag discloses and/or renders obvious "a remote device configured to receive over the wireless transmission link an output status comprising the at least a portion of the processed output signal, to process the received output status to generate processed data and to store the processed data." *See* CHART ONE: '533 Patent, Claim Element 5K above.

Asserted Claim of '533 Patent	U.S. Patent No. 7,648,463 ("Elhag")
to generate processed data and to store the processed data, and	
[13L] wherein the remote device is capable of storing a history of at least a portion of the received output status over a specified period of time.	Elhag discloses and/or renders obvious "wherein the remote device is capable of storing a history of at least a portion of the received output status over a specified period of time." *See* CHART ONE: '533 Patent, Claim Element 10 above.
[16] The system of claim 13, wherein the receiver is located a first distance from a first one of the plurality of light emitting diodes and a different, second distance from a second one of the plurality of light emitting diodes such that the receiver receives a first signal from the first light emitting diode and a second signal from the second light emitting diode.	Elhag discloses and/or renders obvious "[t]he system of claim 13, wherein the receiver is located a first distance from a first one of the plurality of light emitting diodes and a different, second distance from a second one of the plurality of light emitting diodes such that the receiver receives a first signal from the first light emitting diode and a second signal from the second light emitting diode." *See* CHART ONE: '533 Patent, Claim Element 8 above.
[17] The system of claim 16, wherein the output signal is generated in part by comparing the first and second signals.	Elhag discloses and/or renders obvious "[t]he system of claim 16, wherein the output signal is generated in part by comparing the first and second signals." *See* CHART ONE: '533 Patent, Claim Element 9 above.

EXHIBIT C-2

U.S. Patent No. 9,757,040 vs Elhag

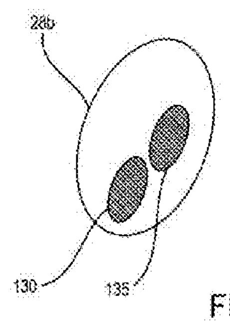
Priority Date/Publication Date: December 15, 2005 Prior Art Status: §§ 102(a) and (b)

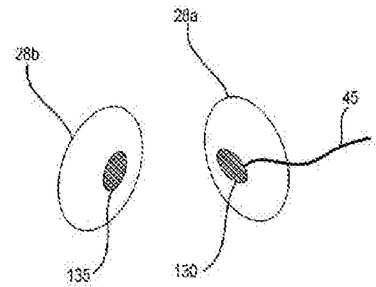
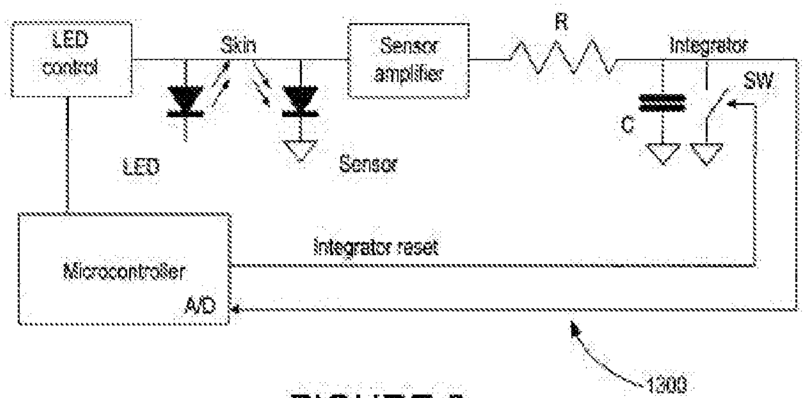
U.S. Patent No. 7,648,463, naming inventors Sammy I Elhag, Nikolai Rulkov, Mark Hunt, Donald Brady, and Steve Lui ("Elhag") anticipates the asserted claims of U.S. Patent No. 9,757,040 ("the '040 Patent") or renders those claims obvious alone and/or in view of at least any of the references identified in Apple's Obviousness Combinations Chart.

As set forth in Apple's Invalidity Contentions, the below contentions apply the prior art in part in accordance with Apple's assumption that Omni contends the claims are not invalid under 35 U.S.C. § 112. However, Apple's below contentions do not represent Apple's agreement or view as to the meaning, definiteness, written description support for, or enablement of any of the asserted claims. For each dependent claim, the disclosures cited for the claim from which it depends are incorporated by reference.

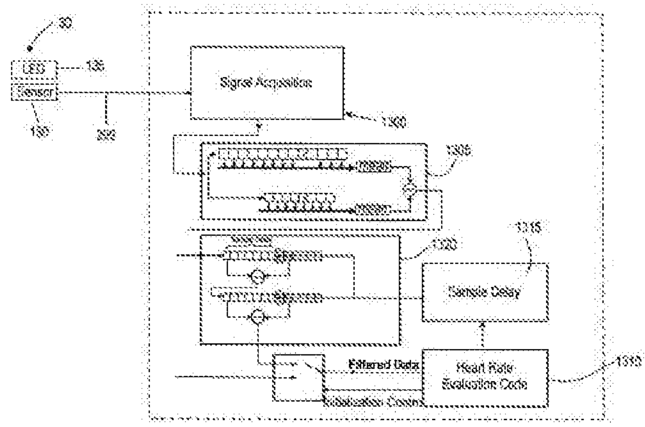
CHART TWO: U.S. Patent No. 9,757,040 vs Elhag

Asserted Claim of '040 Patent	U.S. Patent No. 7,648,463 ("Elhag")
[1] A wearable device for use with a smart phone or tablet, the wearable device comprising:	To the extent the preamble is limiting, Elhag discloses and/or renders obvious "[a] wearable device for use with a smart phone or tablet." *See* CHART ONE: '533 Patent, Claim Elements 5, 5G, and 13A above.
[1A] a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters	Elhag discloses and/or renders obvious "a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters." *See* CHART ONE: '533 Patent, Claim Element 13A above.
[1B] the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an input optical beam having one or more optical wavelengths,	Elhag discloses and/or renders obvious "the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an input optical beam having one or more optical wavelengths." "Alternatively, the optical sensor 30 is a pulse oximetry device with a light source 135 that typically includes LEDs that generate both red (λ˜660 nm) and infrared (λ˜900 nm) radiation. As the heart pumps blood through the user's arteries, blood cells absorb and transmit varying amounts of the red and infrared radiation depending on how much oxygen binds to the cells' hemoglobin. The photodetector 130, which is typically a photodiode, detects transmission at the red and infrared wavelengths, and in response generates a radiation-induced signal." (Elhag, 8:35-44)
[1C] wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers;	Elhag discloses and/or renders obvious "wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers." *See* CHART ONE: '533 Patent, Claim Element 5B above.

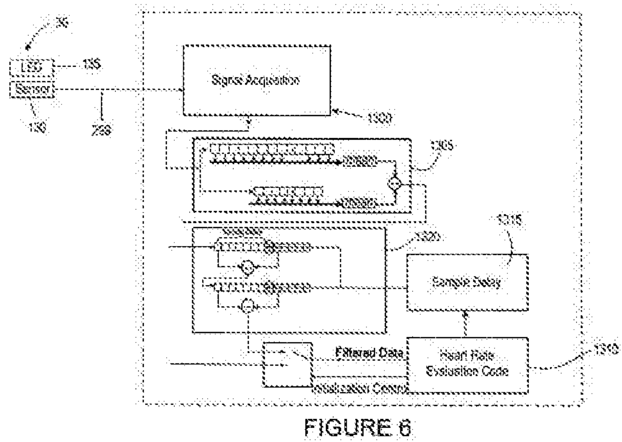
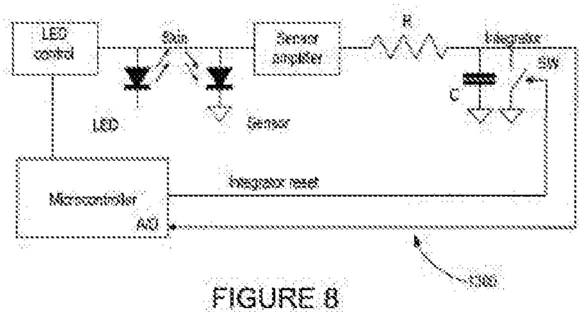
Asserted Claim of '040 Patent	U.S. Patent No. 7,648,463 ("Elhag")
[1D] the measurement device comprising one or more lenses configured to receive and to deliver a portion of the input optical beam to tissue, wherein the tissue reflects at least a portion of the input optical beam delivered to the tissue;	Elhag discloses and/or renders obvious "the measurement device comprising one or more lenses configured to receive and to deliver a portion of the input optical beam to tissue, wherein the tissue reflects at least a portion of the input optical beam delivered to the tissue." *See* CHART ONE: '533 Patent, Claim Element 5D above.
[1E] the measurement device further comprising a reflective surface configured to receive and redirect at least a portion of light reflected from the tissue;	Elhag discloses and/or renders obvious "the measurement device further comprising a reflective surface configured to receive and redirect at least a portion of light reflected from the tissue."  FIGURE 1A

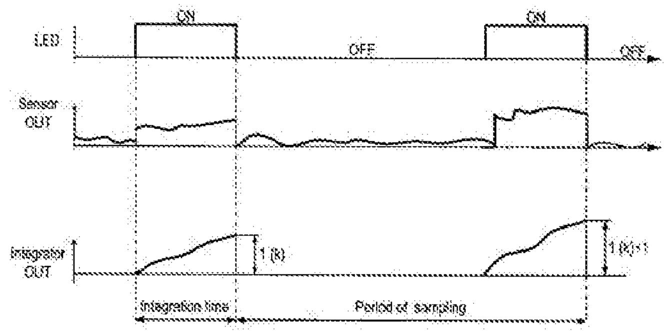
Asserted Claim of '040 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	 FIGURE 1B  FIGURE 8

Asserted Claim of '040 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	"The lens 26 includes a recessed nose area 27 including a nose support 28 (or 28 a and 28 b in FIG. 1) which allows the eyewear 25 to be supported on the user's face (not shown) in the manner conventionally known in the art. An optical sensor 30, as discussed below, is attached to the nose support 28. The optical sensor 30 has a light source 135 and a photodetector 130, which is connected to connection cable 45. An integral lens support portion 29 is provided on the eyewear 25 for supporting the lens 26 in the desired position within the user's forward field of vision. The connection cable 45 is preferably attached and/or integrated into the lens support position 29. As illustrated in FIG. 2, the lens support portion 29 is preferably integrally formed on the lens 26 from a similar transparent material so as to allow the user to see objects through the lens support portion 29. As shown in FIG. 1A, a reflective mode optical sensor 30 has the light source 135 and the photodetector 130 on nose support 28 b. As shown in FIG. 1B, in an alternative embodiment, a transmission mode optical sensor 30 has the optical sensor 30 with the light source 135 in the nose support 28 b and the photodetector 130 in the nose support 28 a. In a preferred embodiment, the light source 135 and the photodetector 130 are integrated into the body of the nose support 28 b, or nose supports 28 a and 28 b, so as to have little affect on the user, and to prevent adverse light from affecting the signal reading of the photodetector 130." (Elhag, 7:18-42) "In an alternative embodiment, the optical sensor 30 is positioned or embedded within one of the temporal members 31 or 32, using the reflective mode optical sensor 30. The optical sensor 30 is preferably in contact or in proximity to the superficial temporal artery 97 near the wearer's ear 98 as shown in FIG. 7." (Elhag, 8:5-10) "In a preferred embodiment, the optical sensor 30 is a single light emitting diode ("LED") 135 based on green light wherein the LED 135 generates green light (λ˜500-600 nm), and a photodetector 130 detects the green light. Yet in an alternative embodiment, the optical sensor 30 is a photodetector 130 and a single LED 135 transmitting light at a wavelength of approximately 900 nanometers as a pulsed infrared LED. Yet further, the optical sensor is a combination of a green light LED and a pulsed infrared LED to offset noise affects of ambient light and sunlight. As the heart pumps blood through the arteries of the user, blood cells absorb and transmit varying amounts of the light depending on how much oxygen binds to the cells' hemoglobin. The photodetector 30, which is typically a photodiode, detects reflectance/transmission at the

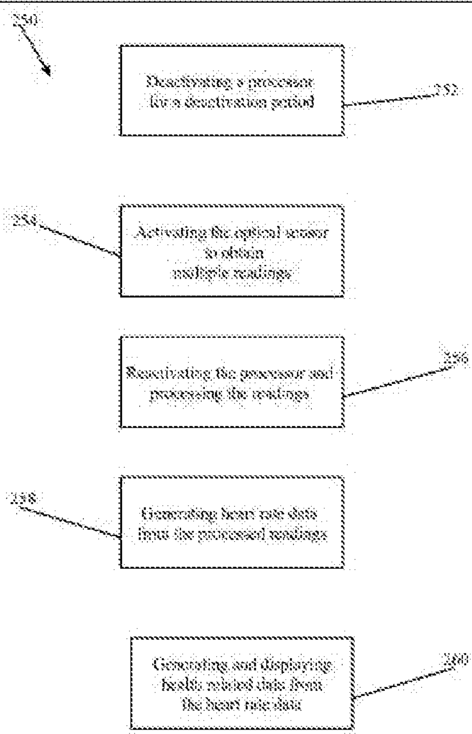
Asserted Claim of '040 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	wavelengths (green, red or infrared), and in response generates a radiation-induced signal." (Elhag, 8:19-34)  FIGURE 6 (Elhag, Fig. 6) "FIG. 6 illustrates a flow chart of a signal processing method of the present invention. As shown in FIG. 6, the photodetector 130 of the optical sensor 30 receives light from the light source 135 while in proximity to the user's nose 90 (reference to FIG. 4) or ear 98 (reference to FIG. 7). In a preferred embodiment, the optical sensor 30 is a TRS1755 which includes a green LED light source (567 nm wavelength) and a light-to-voltage converter. The output voltage is directly proportional to the reflected light intensity. The signal 299 is sent to the microprocessor 41. At block 1300, the signal acquisition is performed, which is shown in greater detail in FIG. 8. In the pulse mode the LED 135 is periodically activated for short intervals of time by a signal from the microcontroller. The reflected pulse of light is received by the sensor, with the generation of a voltage pulse having an amplitude proportional to the intensity of the reflected light. When the LED is activated, the switch, SW, is open by the action of the control signal from the

Asserted Claim of '040 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	microcontroller, and the capacitor, C, integrates the pulse generated from the sensor by charging through the resistor R. Immediately prior to deactivation of the LED, the analog-to-digital converter acquires the value of the voltage integrated across the capacitor, C. The analog-to-digital converter generates a data sample in digital form which is utilized by the microcontroller for evaluation of the heart rate the wearer. Subsequent to the sample being acquired by the analog-to-digital converter, the LED is deactivated and the capacitor, C, is shortcut by switch, SW, to reset the integrator, RC. This states remains unchanged for a given time interval after which the process is repeated, which is illustrated in FIG. 9. A noise reduction and power reduction process is discussed below in reference to FIGS. 13 and 14." (Elhag, 14:51-15:14)
[1F] the measurement device further comprising a receiver configured to: capture light while the LEDs are off and convert the captured light into a first signal and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the input optical beam reflected from the tissue;	Elhag discloses and/or renders obvious "the measurement device further comprising a receiver configured to: capture light while the LEDs are off and convert the captured light into a first signal and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the input optical beam reflected from the tissue."

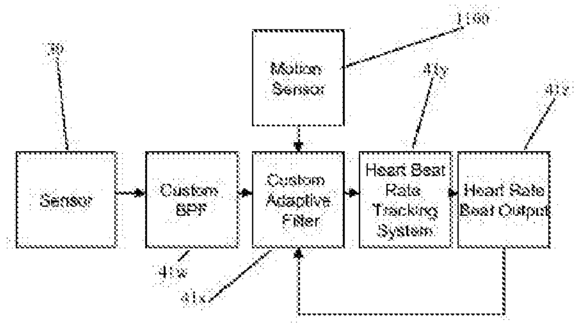
Asserted Claim of '040 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	 (Elhag Fig. 6)  (Elhag Fig. 8)

Asserted Claim of '040 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	 FIGURE 9 (Elhag, Fig. 9) "FIG. 6 illustrates a flow chart of a signal processing method of the present invention. As shown in FIG. 6, the photodetector 130 of the optical sensor 30 receives light from the light source 135 while in proximity to the user's nose 90 (reference to FIG. 4) or ear 98 (reference to FIG. 7). In a preferred embodiment, the optical sensor 30 is a TRS1755 which includes a green LED light source (567 nm wavelength) and a light-to-voltage converter. The output voltage is directly proportional to the reflected light intensity. The signal 299 is sent to the microprocessor 41. At block 1300, the signal acquisition is performed, which is shown in greater detail in FIG. 8. In the pulse mode the LED 135 is periodically activated for short intervals of time by a signal from the microcontroller. The reflected pulse of light is received by the sensor, with the generation of a voltage pulse having an amplitude proportional to the intensity of the reflected light. When the LED is activated, the switch, SW, is open by the action of the control signal from the microcontroller, and the capacitor, C, integrates the pulse generated from the sensor by charging through the resistor R. Immediately prior to deactivation of the LED, the analog-to-digital converter acquires the value of the voltage integrated across the capacitor, C. The analog-to-digital converter generates a data sample in digital form which is utilized by the microcontroller for evaluation of the heart rate the wearer. Subsequent to the sample being acquired by the analog-to-

Asserted Claim of '040 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	digital converter, the LED is deactivated and the capacitor, C, is shortcut by switch, SW, to reset the integrator, RC. This states remains unchanged for a given time interval after which the process is repeated, which is illustrated in FIG. 9. A noise reduction and power reduction process is discussed below in reference to FIGS. 13 and 14." (Elhag, 14:51-15:14) "At block 1305, a band pass filter is implemented preferably with two sets of data from the analog-to-digital converter. At block 1305, an average of the values of data samples within each of a first set of samples is calculated by the microprocessor. For example, the values of data samples within forty-four samples are summed and then divided by forty-four to generate an average value for the first set of samples. Next, an average of the values of data samples within a second set of samples is calculated by the microprocessor. For example, the values of data samples within twenty-two samples are summed and then divided by twenty-two to generate an average value for the second set of samples. Preferably, the second set of samples is less than the first set of samples. Next, the average value of the second set of samples is subtracted from the average value for the first set of samples to generate a first filtered pulse data value." (Elhag, 15:15-30)

Asserted Claim of '040 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	 FIG. 13 (Elhag, Fig. 13)

Asserted Claim of '040 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	"FIG. 13 illustrates a noise reduction method of the present invention. Due to the desire to minimize power consumption of the monitoring device 20, and achieve very accurate signal measurements using the optical sensor 30, the present invention preferably utilizes the method 250 illustrated in FIG. 13. At block 252, the processor 41 is deactivated for a deactivation period in order to conserve power and to eliminate noise for a signal measurement. The deactivation period ranges from 128 to 640 microseconds, more preferably from 200 microseconds to 400 microseconds, and more preferably from 225 microseconds to 300 microseconds. In reference to FIG. 6, this deactivation period occurs during block 1300. At block 254, during the deactivation period, the optical sensor 30 is activated to obtain multiple readings using the light source 135 and the photodetector 130. Preferably 4 to 25 sub-readings or sub-samples are obtained during the deactivation period. The sub-readings or sub-samples are averaged for noise reduction to provide a reading or sample value. In a single second, from 500 to 1500 sub-readings or sub-samples are obtained by the optical sensor 30. At block 256, the processor 41 is reactivated and the reading values are processed by processor 41. At block 258, heart rate data is generated from the readings by the processor 41. At block 260, health related data is generated from the heart rate data, and the health related data and the heart rate data are displayed on the display member 40." (Elhag, 16:4-29)
[1G] the measurement device configured to improve a signal-to-noise ratio of the input optical beam reflected from the tissue by differencing the first signal and the second signal;	Elhag discloses and/or renders obvious "the measurement device configured to improve a signal-to-noise ratio of the input optical beam reflected from the tissue by differencing the first signal and the second signal." "In a preferred embodiment, the optical sensor 30 is a single light emitting diode ("LED") 135 based on green light wherein the LED 135 generates green light (λ˜500-600 nm), and a photodetector 130 detects the green light. Yet in an alternative embodiment, the optical sensor 30 is a photodetector 130 and a single LED 135 transmitting light at a wavelength of approximately 900 nanometers as a pulsed infrared LED. Yet further, the optical sensor is a combination of a green light LED and a pulsed infrared LED to offset noise affects of ambient light and sunlight. As the heart pumps blood through the arteries of the user, blood cells absorb and transmit varying amounts of the light depending on how much oxygen binds to the cells' hemoglobin. The photodetector 30, which is typically a photodiode, detects reflectance/transmission at the

Asserted Claim of '040 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	wavelengths (green, red or infrared), and in response generates a radiation-induced signal." (Elhag, 8:19-34)  FIG. 12 (Elhag, Fig. 12) "As shown in FIG. 12, a motion sensor 1100 is included in an alternative embodiment to assist in identifying motion noise and filtering the noise from the signal sent by the sensor 30. The motion sensor 1100, such as an accelerometer, is integrated into the circuitry and software of the monitoring device 20. As the motion sensor detects an arm swinging, the noise component is utilized with the signal processing noise filtering techniques to provide additional filtering to remove the noise element and improve the accuracy of the monitoring device 20. More specifically, the signal from the sensor 30 is transmitted to the processor where a custom blood pressure filter 41 w processes the signal which is further processed at by custom adaptive filter 41 x before being sent to a heart beat tracking system 41 y and then transmitted to a heart rate beat output 41 z. The heart rate beat output 41 z provides feedback to the custom adaptive filter 41 x which also receives input from the motion sensor 1100." (Elhag, 15:54-16:3)

Asserted Claim of '040 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	"At block 1300, the signal acquisition is performed, which is shown in greater detail in FIG. 8. In the pulse mode the LED 135 is periodically activated for short intervals of time by a signal from the microcontroller. The reflected pulse of light is received by the sensor, with the generation of a voltage pulse having an amplitude proportional to the intensity of the reflected light. When the LED is activated, the switch, SW, is open by the action of the control signal from the microcontroller, and the capacitor, C, integrates the pulse generated from the sensor by charging through the resistor R. Immediately prior to deactivation of the LED, the analog-to-digital converter acquires the value of the voltage integrated across the capacitor, C. The analog-to-digital converter generates a data sample in digital form which is utilized by the microcontroller for evaluation of the heart rate the wearer. Subsequent to the sample being acquired by the analog-to-digital converter, the LED is deactivated and the capacitor, C, is shortcut by switch, SW, to reset the integrator, RC. This states remains unchanged for a given time interval after which the process is repeated, which is illustrated in FIG. 9. A noise reduction and power reduction process is discussed below in reference to FIGS. 13 and 14." (Elhag, 14:60-15:14) "FIG. 13 illustrates a noise reduction method of the present invention. Due to the desire to minimize power consumption of the monitoring device 20, and achieve very accurate signal measurements using the optical sensor 30, the present invention preferably utilizes the method 250 illustrated in FIG. 13. At block 252, the processor 41 is deactivated for a deactivation period in order to conserve power and to eliminate noise for a signal measurement. The deactivation period ranges from 128 to 640 microseconds, more preferably from 200 microseconds to 400 microseconds, and more preferably from 225 microseconds to 300 microseconds. In reference to FIG. 6, this deactivation period occurs during block 1300. At block 254, during the deactivation period, the optical sensor 30 is activated to obtain multiple readings using the light source 135 and the photodetector 130. Preferably 4 to 25 sub-readings or sub-samples are obtained during the deactivation period. The sub-readings or sub-samples are averaged for noise reduction to provide a reading or sample value. In a single second, from 500 to 1500 sub-readings or sub-samples are obtained by the optical sensor 30. At block 256, the processor 41 is reactivated and the reading values are processed by processor 41. At block 258, heart rate data is generated from the readings by the processor 41. At block 260, health related data is generated from the heart rate data, and the

Asserted Claim of '040 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	health related data and the heart rate data are displayed on the display member 40." (Elhag, 16:4-29) "FIG. 14 illustrates a more specific method 300 for noise reduction during a signal reading. At block 302, a high speed clock of a processor 41 is deactivated for a deactivation period as discussed above. At block 304, the optical sensor 30 is activated during the deactivation period to obtain multiple readings as discussed above. At block 306, the processor 41 is reactivated and the readings are processed. The optical sensor 30 is also deactivated. At block 308, heart rate data is generated from the readings by the processor 41. At block 310, health related data is generated from the heart rate data, and the health related data and the heart rate data are displayed on the display member 40." (Elhag, 16:30-41) "FIG. 17 illustrates a mechanism for controlling the intensity of the light source 135 using a plurality of resistors 405, 410 and 415 in parallel. Usually, an optical sensor 30 has a light source 135 set for a single intensity for placement at a single location on a typically user. However, if the optical sensor 30 is positioned differently or if the user is not a typical user, then the intensity of the light source 135 may be too great for the photodetector 130 and lead to saturation of the photodetector 130 which terminates the signal reading. The present invention preferably adjusts the intensity of the light source 135 using feedback from the photodetector 130 to indicate whether the light intensity is too high or too low." (Elhag, 16:42-53) "FIG. 18 is a preferred method 500 for controlling the light intensity of the optical sensor 30. At block 505, the light intensity of the light source 135 is monitored. At block 510, the sensor/photodetector is determined to be saturated by the light source. At block 515, the intensity of the light source is modified by adjusting the resistance and the flow of current to the light source 135. At block 520, the light intensity is again monitored and adjusted if necessary. In a preferred embodiment, this automatic gain mechanism prevents the green light from overwhelming the photodetector thereby maintaining an accurate reading no matter where the optical sensor is placed on the user." (Elhag, 17:10-21) "FIG. 19 illustrates how the control mechanism operates to maintain a proper light intensity. As the signal reaches the upper limit, the photodetector becomes saturated and the processor lowers

Asserted Claim of '040 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	the current flow, which results in a break in the signal. Then as the signal is lowered it becomes too low and the processor increases the light intensity resulting in a break in the signal." (Elhag, 17:22-28) *See also* Elhag, 16:53-17:9, Figs. 13, 14, 17, 18, 19.
[1H] the light source configured to further improve the signal-to-noise ratio of the input optical beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs;	Elhag discloses and/or renders obvious "the light source configured to further improve the signal-to-noise ratio of the input optical beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs." *See* CHART ONE: '533 Patent, Claim Element 5C above.
[1I] the measurement device further configured to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue; and	Elhag discloses and/or renders obvious "the measurement device further configured to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue." *See* CHART ONE: '533 Patent, Claim Element 10 above.
[1J] the wearable device configured to communicate with the smart phone or tablet, the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a voice input module, a speaker, and a touch screen, the smart phone or tablet configured to receive and to	Elhag discloses and/or renders obvious "the wearable device configured to communicate with the smart phone or tablet, the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a voice input module, a speaker, and a touch screen, the smart phone or tablet configured to receive and to process at least a portion of the output signal." *See* CHART ONE: '533 Patent, Claim Elements 5G and 5H above.

Asserted Claim of '040 Patent	U.S. Patent No. 7,648,463 ("Elhag")
process at least a portion of the output signal,	
[1K] wherein the smart phone or tablet is configured to store and display the processed output signal, wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link.	Elhag discloses and/or renders obvious "wherein the smart phone or tablet is configured to store and display the processed output signal, wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link." *See* CHART ONE: '533 Patent, Claim Elements 5I and 5J above.
[2] The wearable device of claim 1, wherein the receiver is configured to be synchronized to the modulation of the at least one of the LEDs.	Elhag discloses and/or renders obvious "[t]he wearable device of claim 1, wherein the receiver is configured to be synchronized to the modulation of the at least one of the LEDs." *See* CHART ONE: '533 Patent, Claim Element 5F above.
[4] The wearable device of claim 1, wherein the receiver is located a first distance from a first one of the LEDs and a different distance from a second one of the LEDs such that the receiver can capture a third signal from the first LED and a fourth signal from the second LED, and wherein the output signal is generated in part by comparing the third and fourth signals.	Elhag discloses and/or renders obvious "[t]he wearable device of claim 1, wherein the receiver is located a first distance from a first one of the LEDs and a different distance from a second one of the LEDs such that the receiver can capture a third signal from the first LED and a fourth signal from the second LED, and wherein the output signal is generated in part by comparing the third and fourth signals." *See* CHART ONE: '533 Patent, Claim Element 8 above.

EXHIBIT C-3

U.S. Patent No. 9,861,286 vs Elhag

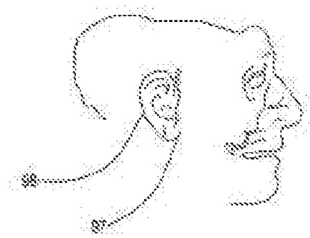
Priority Date/Publication Date: December 15, 2005 Prior Art Status: §§ 102(a) and (b)

U.S. Patent No. 7,648,463, naming inventors Sammy I Elhag, Nikolai Rulkov, Mark Hunt, Donald Brady, and Steve Lui ("Elhag") anticipates the asserted claims of U.S. Patent No. 9,861,286 ("the '286 Patent") or renders those claims obvious alone and/or in view of at least any of the references identified in Apple's Obviousness Combinations Chart.

As set forth in Apple's Invalidity Contentions, the below contentions apply the prior art in part in accordance with Apple's assumption that Omni contends the claims are not invalid under 35 U.S.C. § 112. However, Apple's below contentions do not represent Apple's agreement or view as to the meaning, definiteness, written description support for, or enablement of any of the asserted claims. For each dependent claim, the disclosures cited for the claim from which it depends are incorporated by reference.

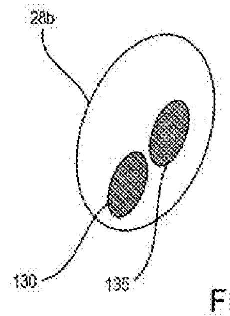
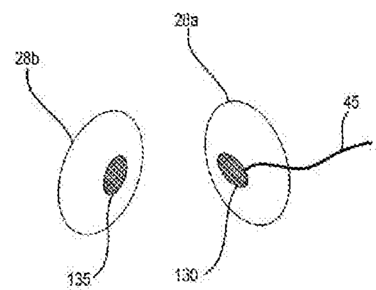
CHART THREE: U.S. Patent No. 9,861,286 vs Elhag

Asserted Claim of '286 Patent	U.S. Patent No. 7,648,463 ("Elhag")
[16] A wearable device for use with a smart phone or tablet, the wearable device comprising:	To the extent the preamble is limiting, Elhag discloses and/or renders obvious "[a] wearable device for use with a smart phone or tablet." *See* CHART ONE: '533 Patent, Claim Elements 5, 5G, and 13A above.
[16A] a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters,	Elhag discloses and/or renders obvious "a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters." *See* CHART ONE: '533 Patent, Claim Element 13A above.
[16B] the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an optical beam having a plurality of optical wavelengths,	Elhag discloses and/or renders obvious "the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an optical beam having a plurality of optical wavelengths." *See* CHART TWO: '040 Patent, Claim Element 1B above.
[16C] wherein at least a portion of the plurality of optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers;	Elhag discloses and/or renders obvious "wherein at least a portion of the plurality of optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers." *See* CHART ONE: '533 Patent, Claim Element 5B above.
[16D] the measurement device comprising one or more lenses configured to receive and to deliver a portion of the optical beam to tissue, wherein the tissue reflects at least a portion of the	Elhag discloses and/or renders obvious "the measurement device comprising one or more lenses configured to receive and to deliver a portion of the optical beam to tissue, wherein the tissue reflects at least a portion of the optical beam delivered to the tissue, and wherein the measurement device is adapted to be placed on a wrist or an ear of a user." *See* CHART ONE: '533 Patent, Claim Element 5D above.

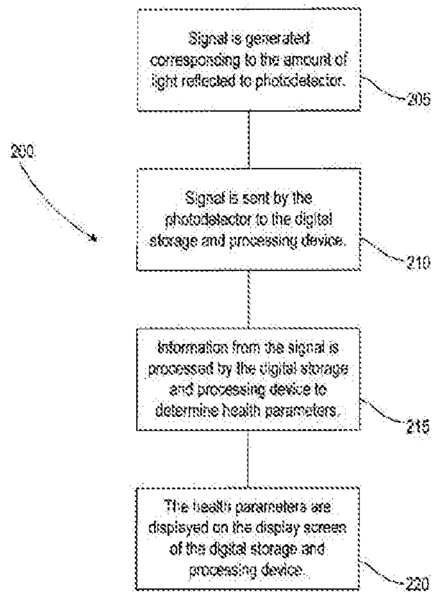
Asserted Claim of '286 Patent	U.S. Patent No. 7,648,463 ("Elhag")
optical beam delivered to the tissue, and	
[16E] wherein the measurement device is adapted to be placed on a wrist or an ear of a user;	Elhag discloses and/or renders obvious "wherein the measurement device is adapted to be placed on a wrist or an ear of a user."  FIGURE 7 (Elhag, Fig. 7) "In an alternative embodiment, the optical sensor 30 is positioned or embedded within one of the temporal members 31 or 32, using the reflective mode optical sensor 30. The optical sensor 30 is preferably in contact or in proximity to the superficial temporal artery 97 near the wearer's ear 98 as shown in FIG. 7." (Elhag, 8:5-10) "FIG. 6 illustrates a flow chart of a signal processing method of the present invention. As shown in FIG. 6, the photodetector 130 of the optical sensor 30 receives light from the light source 135 while in proximity to the user's nose 90 (reference to FIG. 4) or ear 98 (reference to FIG. 7)." (Elhag, 14:51-55). "Mault et al, U.S. Patent Application Publication Number 2002/0109600 ("Mault") discloses a smart activity monitor ("SAM") which is a pedometer based device which includes an electronic clock, a sensor, entry means for recording food consumption and exercise activities and a memory for storing such information. Mault fails to disclose the details of the display other than to mention that the SAM has a time display, an exercise display and a food display, with the exercise and

Asserted Claim of '286 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	food displays having a bar-graph style. Mault fails to disclose an optical sensor in detail, and only states that photo-plethysmography may be used to determine the heart rate by a sensor provided on the rear of a wrist mounted SAM." (Elhag, 2:61-3:5) "Yasukawa et al., U.S. Pat. No. 5,735,800 ("Yasukawa"), discloses a wrist-worn device which is intended for limited motion about the user's wrist. Yasukawa discloses an optical sensor that uses a blue LED with a phototransistor in conjunction with an analog to digital converter to provide a digital signal to a data processing circuit." (Elhag, 3:8-13)
[16F] the measurement device further comprising a receiver configured to: capture light while the LEDs are off and convert the captured light into a first signal and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the optical beam reflected from the tissue;	Elhag discloses and/or renders obvious "the measurement device further comprising a receiver configured to: capture light while the LEDs are off and convert the captured light into a first signal and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the optical beam reflected from the tissue." *See* CHART TWO: '040 Patent, Claim Element 1F above.
[16G] the measurement device configured to improve a signal-to-noise ratio of the optical beam reflected from the tissue by differencing the first signal and the second signal;	Elhag discloses and/or renders obvious "the measurement device configured to improve a signal-to-noise ratio of the optical beam reflected from the tissue by differencing the first signal and the second signal." *See* CHART TWO: '040 Patent, Claim Element 1G above.

Asserted Claim of '286 Patent	U.S. Patent No. 7,648,463 ("Elhag")
[16H] the light source configured to further improve the signal-to-noise ratio of the optical beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs;	Elhag discloses and/or renders obvious "the light source configured to further improve the signal-to-noise ratio of the optical beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs." *See* CHART ONE: '533 Patent, Claim Element 5C above.
[16I] the measurement device further configured to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue; and	Elhag discloses and/or renders obvious "the measurement device further configured to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue." *See* CHART ONE: '533 Patent, Claim Element 10 above.
[16J] wherein the receiver includes a plurality of spatially separated detectors,	Elhag discloses and/or renders obvious "wherein the receiver includes a plurality of spatially separated detectors." "The lens 26 includes a recessed nose area 27 including a nose support 28 (or 28 a and 28 b in FIG. 1) which allows the eyewear 25 to be supported on the user's face (not shown) in the manner conventionally known in the art. An optical sensor 30, as discussed below, is attached to the nose support 28. The optical sensor 30 has a light source 135 and a photodetector 130, which is connected to connection cable 45. An integral lens support portion 29 is provided on the eyewear 25 for supporting the lens 26 in the desired position within the user's forward field of vision. The connection cable 45 is preferably attached and/or integrated into the lens support position 29. As illustrated in FIG. 2, the lens support portion 29 is preferably integrally formed on the lens 26 from a similar transparent material so as to allow the user to see objects through the lens support portion 29. As shown in FIG. 1A, a reflective mode optical sensor 30 has the light source 135 and the photodetector 130 on nose support 28 b. As shown in FIG. 1B, in an alternative embodiment, a transmission mode optical sensor 30 has the optical sensor 30 with the light source 135 in the nose support 28 b and the photodetector 130 in the nose support 28 a. In a preferred embodiment, the

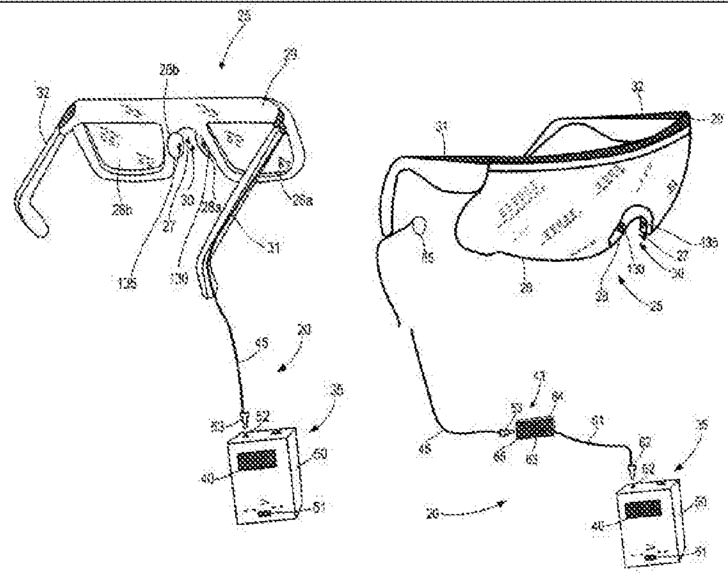
Asserted Claim of '286 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	light source 135 and the photodetector 130 are integrated into the body of the nose support 28 b, or nose supports 28 a and 28 b, so as to have little affect on the user, and to prevent adverse light from affecting the signal reading of the photodetector 130." (Elhag, 7:18-42)  FIGURE 1A  FIGURE 1B "Alternatively, the optical sensor 30 is a pulse oximetry device with a light source 135 that typically includes LEDs that generate both red (λ˜660 nm) and infrared (λ˜900 nm) radiation. As

Asserted Claim of '286 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	the heart pumps blood through the user's arteries, blood cells absorb and transmit varying amounts of the red and infrared radiation depending on how much oxygen binds to the cells' hemoglobin. The photodetector 130, which is typically a photodiode, detects transmission at the red and infrared wavelengths, and in response generates a radiation-induced signal." (Elhag, 8:35-44) "A preferred optical sensor 30 utilizing green light is a TRS1755 sensor from TAOS, Inc of Plano Tex. The TRS1755 comprises a green LED light source (567 nm wavelength) and a light-to-voltage converter. The output voltage is directly proportional to the reflected light intensity. Another preferred photodetector 130 is a light-to-voltage photodetector such as the TSL260R and TSL261, TSL261R photodetectors available from TAOS, Inc of Plano Tex. Alternatively, the photodetector 130 is a light-to-frequency photodetector such as the TSL245R, which is also available from TAOS, Inc. The light-to-voltage photodetectors have an integrated transimpedance amplifier on a single monolithic integrated circuit, which reduces the need for ambient light filtering. The TSL261 photodetector preferably operates at a wavelength greater than 750 nanometers, and optimally at 940 nanometers, which would preferably have a LED that radiates light at those wavelengths." (Elhag, 8:45-61)

Asserted Claim of '286 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	 FIGURE 5 (Elhag, Fig. 5) "An alternative method includes the light source 135 of the optical device 30 transmitting light at the nose 90 of the user. The photo-detector 130 detects the light. The pulse rate is determined by the signals received by the photo-detector 130. The ratio of the fluctuation of the red and/or infrared light signals is used to calculate the blood oxygen saturation level of the user. Then, the signal is sent to the controller 43 to be converted into a usable format for the digital storage and processing unit 35. Then, the signal is sent from the controller 43 to the digital storage and

Asserted Claim of '286 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	processing unit 35. Then, the information contained in the signal is processed by the microprocessor on the digital storage and processing unit 35 to generate blood oxygenation level, pulse rate, signal strength bar graph, plethysmogram and/or status bits data. Further processing of the information is performed by the microprocessor to generate pulse rate, blood oxygenation levels, calories expended by the user of a pre-set time period, target zones of activity, time and dynamic blood pressure. Then, the information is displayed on the display screen 40 of the digital storage and processing unit 35." (Elhag, 11:1-20)
[16K] wherein at least one analog to digital converter is coupled to the spatially separated detectors.	Elhag discloses and/or renders obvious "wherein at least one analog to digital converter is coupled to the spatially separated detectors." "FIG. 6 illustrates a flow chart of a signal processing method of the present invention. As shown in FIG. 6, the photodetector 130 of the optical sensor 30 receives light from the light source 135 while in proximity to the user's nose 90 (reference to FIG. 4) or ear 98 (reference to FIG. 7). In a preferred embodiment, the optical sensor 30 is a TRS1755 which includes a green LED light source (567 nm wavelength) and a light-to-voltage converter. The output voltage is directly proportional to the reflected light intensity. The signal 299 is sent to the microprocessor 41. At block 1300, the signal acquisition is performed, which is shown in greater detail in FIG. 8. In the pulse mode the LED 135 is periodically activated for short intervals of time by a signal from the microcontroller. The reflected pulse of light is received by the sensor, with the generation of a voltage pulse having an amplitude proportional to the intensity of the reflected light. When the LED is activated, the switch, SW, is open by the action of the control signal from the microcontroller, and the capacitor, C, integrates the pulse generated from the sensor by charging through the resistor R. Immediately prior to deactivation of the LED, the analog-to-digital converter acquires the value of the voltage integrated across the capacitor, C. The analog-to-digital converter generates a data sample in digital form which is utilized by the microcontroller for evaluation of the heart rate the wearer. Subsequent to the sample being acquired by the analog-to-digital converter, the LED is deactivated and the capacitor, C, is shortcut by switch, SW, to reset the integrator, RC. This states remains unchanged for a given time interval after which the process

Asserted Claim of '286 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	is repeated, which is illustrated in FIG. 9. A noise reduction and power reduction process is discussed below in reference to FIGS. 13 and 14." (Elhag, 14:51-15:14) "Yasukawa et al., U.S. Pat. No. 5,735,800 ("Yasukawa"), discloses a wrist-worn device which is intended for limited motion about the user's wrist. Yasukawa discloses an optical sensor that uses a blue LED with a phototransistor in conjunction with an analog to digital converter to provide a digital signal to a data processing circuit." (Elhag, 3:8-13)
[17] The wearable device of claim 16, wherein at least one LED emits at a first wavelength and at least another LED emits at a second wavelength, and wherein the first wavelength has a first penetration depth into the tissue and wherein the second wavelength has a second penetration depth into the tissue different from the first penetration depth.	Elhag discloses and/or renders obvious "[t]he wearable device of claim 16, wherein at least one LED emits at a first wavelength and at least another LED emits at a second wavelength, and wherein the first wavelength has a first penetration depth into the tissue and wherein the second wavelength has a second penetration depth into the tissue different from the first penetration depth.."

Asserted Claim of '286 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	 FIGURE 1 FIGURE 2 (Elhag, Fig. 1-2) "As shown in FIGS. 1-3, a monitoring device is generally designated 20. In a preferred embodiment shown in FIG. 1, the monitoring device 20 comprises eyewear 25, an optical sensor 30, a digital storage and processing unit 35 and a connection cable 45. In an alternative embodiment shown in FIG. 2, the monitoring device 20 includes eyewear 25, an optical sensor 30, a digital storage and processing unit 35, a controller 43, a connection cable 45 and a controller cable 61." (Elhag, 6:63-7:3) "A general method of using the monitoring device 20 begins with the light source 135 transmitting red and/or infrared light through a nose of the user. The photo-detector 130 detects the light. The

Asserted Claim of '286 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	pulse rate is determined by the signals received by the photo-detector 130. The ratio of the fluctuation of the red and/or infrared light signals is used to calculate the blood oxygen saturation level of the user. An optical sensor 30 with a photodetector 130 and single LED 135 is preferably utilized. Alternatively, a pulse oximetry device with two LEDs and a photodetector is utilized. Next, this information is sent to pulse oximetry board in the digital storage and processing device 35 for creation of blood oxygenation level, pulse rate, signal strength bargraph, plethysmogram and/or status bits data. Next, the microprocessor further processes the information to display pulse rate, blood oxygenation levels, calories expended by the user of a pre-set time period, target zones of activity, time and dynamic blood pressure. Next, the information is displayed on the display member 40." (Elhag, 11:52-12:2) "In a preferred embodiment, the optical sensor 30 is a single light emitting diode ("LED") 135 based on green light wherein the LED 135 generates green light (λ˜500-600 nm), and a photodetector 130 detects the green light. Yet in an alternative embodiment, the optical sensor 30 is a photodetector 130 and a single LED 135 transmitting light at a wavelength of approximately 900 nanometers as a pulsed infrared LED. Yet further, the optical sensor is a combination of a green light LED and a pulsed infrared LED to offset noise affects of ambient light and sunlight. As the heart pumps blood through the arteries of the user, blood cells absorb and transmit varying amounts of the light depending on how much oxygen binds to the cells' hemoglobin. The photodetector 30, which is typically a photodiode, detects reflectance/transmission at the wavelengths (green, red or infrared), and in response generates a radiation-induced signal." (Elhag, 8:19-34) "Alternatively, the optical sensor 30 is a pulse oximetry device with a light source 135 that typically includes LEDs that generate both red (λ˜660 nm) and infrared (λ˜900 nm) radiation. As the heart pumps blood through the user's arteries, blood cells absorb and transmit varying amounts of the red and infrared radiation depending on how much oxygen binds to the cells' hemoglobin. The photodetector 130, which is typically a photodiode, detects transmission at the red and infrared wavelengths, and in response generates a radiation-induced signal." (Elhag, 8:35-44)

Asserted Claim of '286 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	"Malinouskas, U.S. Pat. No. 4,807,630, discloses a method for exposing a patient's extremity, such as a finger, to light of two wavelengths and detecting the absorbance of the extremity at each of the wavelengths." (Elhag, 2:15-18)
[19] The wearable device of claim 16, wherein the receiver is configured to be synchronized to the modulating of at least one of the LEDs.	Elhag discloses and/or renders obvious "[t]he wearable device of claim 16, wherein the receiver is configured to be synchronized to the modulating of at least one of the LEDs." *See* CHART ONE: '533 Patent, Claim Element 5F above.
[20] The wearable device of claim 16, wherein the receiver is located a first distance from a first one of the LEDs and a different distance from a second one of the LEDs such that the receiver can capture a third signal from the first LED and a fourth signal from the second LED, and wherein the output signal is generated in part by comparing the third and fourth signals.	Elhag discloses and/or renders obvious "[t]he wearable device of claim 16, wherein the receiver is located a first distance from a first one of the LEDs and a different distance from a second one of the LEDs such that the receiver can capture a third signal from the first LED and a fourth signal from the second LED, and wherein the output signal is generated in part by comparing the third and fourth signals.." *See* CHART ONE: '533 Patent, Claim Element 8 above.

EXHIBIT C-4

U.S. Patent No. 9,885,698 vs Elhag

Priority Date/Publication Date: December 15, 2005 Prior Art Status: §§ 102(a) and (b)

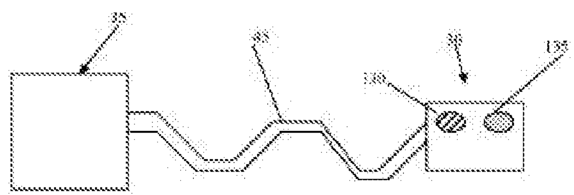
U.S. Patent No. 7,648,463, naming inventors Sammy I Elhag, Nikolai Rulkov, Mark Hunt, Donald Brady, and Steve Lui ("Elhag") anticipates the asserted claims of U.S. Patent No. 9,885,698 ("the '698 Patent") or renders those claims obvious alone and/or in view of at least any of the references identified in Apple's Obviousness Combinations Chart.

As set forth in Apple's Invalidity Contentions, the below contentions apply the prior art in part in accordance with Apple's assumption that Omni contends the claims are not invalid under 35 U.S.C. § 112. However, Apple's below contentions do not represent Apple's agreement or view as to the meaning, definiteness, written description support for, or enablement of any of the asserted claims. For each dependent claim, the disclosures cited for the claim from which it depends are incorporated by reference.

CHART FOUR: U.S. Patent No. 9,885,698 vs Elhag

Asserted Claim of '698 Patent	U.S. Patent No. 7,648,463 ("Elhag")
[1] A wearable device, comprising:	To the extent the preamble is limiting, Elhag discloses and/or renders obvious "[a] wearable device." *See* CHART ONE: '533 Patent, Claim Elements 5 and 13A above.
[1A] a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters,	Elhag discloses and/or renders obvious "a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters." *See* CHART ONE: '533 Patent, Claim Element 13A above.
[1B] the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an input optical beam having one or more optical wavelengths,	Elhag discloses and/or renders obvious "the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an input optical beam having one or more optical wavelengths." *See* CHART TWO: '040 Patent, Claim Element 1B above.
[1C] wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers;	Elhag discloses and/or renders obvious "wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers." *See* CHART ONE: '533 Patent, Claim Element 5B above.
[1D] the measurement device comprising one or more lenses configured to receive and to deliver a portion of the input optical beam to tissue, wherein	Elhag discloses and/or renders obvious "the measurement device comprising one or more lenses configured to receive and to deliver a portion of the input optical beam to tissue, wherein the tissue reflects at least a portion of the input optical beam delivered to the tissue." *See* CHART ONE: '533 Patent, Claim Element 5D above.

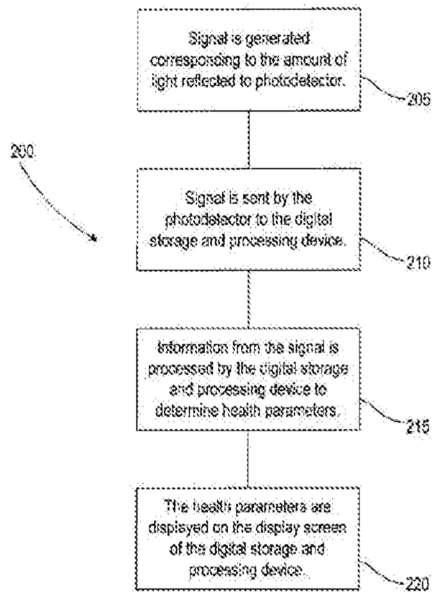
Asserted Claim of '698 Patent	U.S. Patent No. 7,648,463 ("Elhag")
the tissue reflects at least a portion of the input optical beam delivered to the tissue;	
[1E] the measurement device further comprising a receiver, wherein the receiver includes a plurality of spatially separated detectors, the detectors configured to: capture light while the LEDs are off and convert the captured light into a first signal; and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the input optical beam reflected from the tissue;	Elhag discloses and/or renders obvious "the measurement device further comprising a receiver, wherein the receiver includes a plurality of spatially separated detectors, the detectors configured to: capture light while the LEDs are off and convert the captured light into a first signal; and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the input optical beam reflected from the tissue." *See* CHART TWO: '040 Patent, Claim Element 1F and CHART THREE: '286 Patent, Claim Element 16J above.
[1F] wherein at least one analog to digital converter is coupled to the spatially separated detectors and is configured to generate at least a first data signal from the first signal and at least a second data signal from the second signal;	Elhag discloses and/or renders obvious "wherein at least one analog to digital converter is coupled to the spatially separated detectors and is configured to generate at least a first data signal from the first signal and at least a second data signal from the second signal." *See* CHART TWO: '040 Patent, Claim Element 1F and CHART THREE: '286 Patent, Claim Element 16K above.

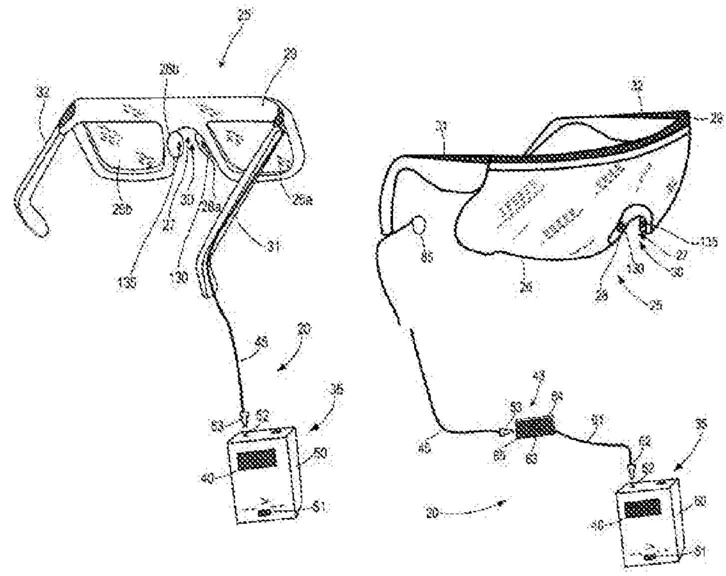
Asserted Claim of '698 Patent	U.S. Patent No. 7,648,463 ("Elhag")
[1G] the measurement device configured to improve a signal-to-noise ratio of the input optical beam reflected from the tissue by differencing the first data signal and the second data signal to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue; and	Elhag discloses and/or renders obvious "the measurement device configured to improve a signal-to-noise ratio of the input optical beam reflected from the tissue by differencing the first data signal and the second data signal to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue." *See* CHART ONE: '533 Patent, Claim Element 10 and CHART TWO: '040 Patent, Claim Element 1G above.
[1H] wherein the modulating at least one of the LEDs has a modulation frequency, and wherein the receiver is configured to use a lock-in technique that detects the modulation frequency.	Elhag discloses and/or renders obvious "the light source configured to increase signal-to-noise ratio by increasing a light intensity from at least one of the plurality of semiconductor sources and by increasing a pulse rate of at least one of the plurality of semiconductor sources."  FIG. 16 (Elhag, Fig. 16) "In a preferred embodiment, the optical sensor 30 is a single light emitting diode ("LED") 135 based on green light wherein the LED 135 generates green light (λ˜500-600 nm), and a photodetector 130 detects the green light. Yet in an alternative embodiment, the optical sensor 30 is a photodetector 130 and a single LED 135 transmitting light at a wavelength of approximately

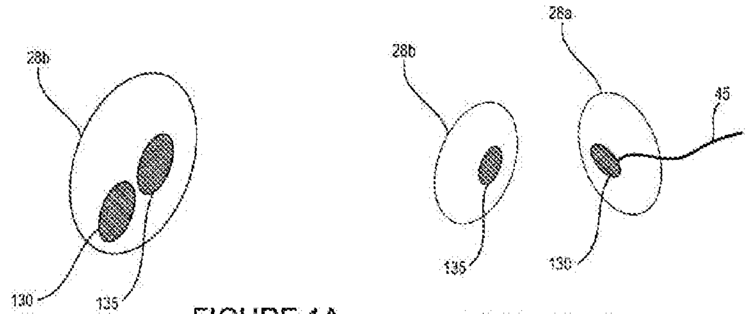
Asserted Claim of '698 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	900 nanometers as a pulsed infrared LED. Yet further, the optical sensor is a combination of a green light LED and a pulsed infrared LED to offset noise affects of ambient light and sunlight. As the heart pumps blood through the arteries of the user, blood cells absorb and transmit varying amounts of the light depending on how much oxygen binds to the cells' hemoglobin. The photodetector 30, which is typically a photodiode, detects reflectance/transmission at the wavelengths (green, red or infrared), and in response generates a radiation-induced signal." (Elhag, 8:19-34). "At block 1300, the signal acquisition is performed, which is shown in greater detail in FIG. 8. In the pulse mode the LED 135 is periodically activated for short intervals of time by a signal from the microcontroller. The reflected pulse of light is received by the sensor, with the generation of a voltage pulse having an amplitude proportional to the intensity of the reflected light. When the LED is activated, the switch, SW, is open by the action of the control signal from the microcontroller, and the capacitor, C, integrates the pulse generated from the sensor by charging through the resistor R. Immediately prior to deactivation of the LED, the analog-to-digital converter acquires the value of the voltage integrated across the capacitor, C. The analog-to-digital converter generates a data sample in digital form which is utilized by the microcontroller for evaluation of the heart rate the wearer. Subsequent to the sample being acquired by the analog-to-digital converter, the LED is deactivated and the capacitor, C, is shortcut by switch, SW, to reset the integrator, RC. This states remains unchanged for a given time interval after which the process is repeated, which is illustrated in FIG. 9. A noise reduction and power reduction process is discussed below in reference to FIGS. 13 and 14." (Elhag, 14:60-15:14) "FIG. 13 illustrates a noise reduction method of the present invention. Due to the desire to minimize power consumption of the monitoring device 20, and achieve very accurate signal measurements using the optical sensor 30, the present invention preferably utilizes the method 250 illustrated in FIG. 13. At block 252, the processor 41 is deactivated for a deactivation period in order to conserve power and to eliminate noise for a signal measurement. The deactivation period ranges from 128 to 640 microseconds, more preferably from 200 microseconds to 400 microseconds, and more preferably from 225 microseconds to 300 microseconds. In reference to FIG. 6, this deactivation period occurs during block 1300. At block 254, during the deactivation period, the optical sensor 30 is activated to obtain multiple readings using the light source 135 and

Asserted Claim of '698 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	the photodetector 130. Preferably 4 to 25 sub-readings or sub-samples are obtained during the deactivation period. The sub-readings or sub-samples are averaged for noise reduction to provide a reading or sample value. In a single second, from 500 to 1500 sub-readings or sub-samples are obtained by the optical sensor 30. At block 256, the processor 41 is reactivated and the reading values are processed by processor 41. At block 258, heart rate data is generated from the readings by the processor 41. At block 260, health related data is generated from the heart rate data, and the health related data and the heart rate data are displayed on the display member 40." (Elhag, 16:4-29) "FIG. 14 illustrates a more specific method 300 for noise reduction during a signal reading. At block 302, a high speed clock of a processor 41 is deactivated for a deactivation period as discussed above. At block 304, the optical sensor 30 is activated during the deactivation period to obtain multiple readings as discussed above. At block 306, the processor 41 is reactivated and the readings are processed. The optical sensor 30 is also deactivated. At block 308, heart rate data is generated from the readings by the processor 41. At block 310, health related data is generated from the heart rate data, and the health related data and the heart rate data are displayed on the display member 40." (Elhag, 16:30-41) "FIG. 17 illustrates a mechanism for controlling the intensity of the light source 135 using a plurality of resistors 405, 410 and 415 in parallel. Usually, an optical sensor 30 has a light source 135 set for a single intensity for placement at a single location on a typically user. However, if the optical sensor 30 is positioned differently or if the user is not a typical user, then the intensity of the light source 135 may be too great for the photodetector 130 and lead to saturation of the photodetector 130 which terminates the signal reading. The present invention preferably adjusts the intensity of the light source 135 using feedback from the photodetector 130 to indicate whether the light intensity is too high or too low." (Elhag, 16:42-53) "FIG. 18 is a preferred method 500 for controlling the light intensity of the optical sensor 30. At block 505, the light intensity of the light source 135 is monitored. At block 510, the sensor/photodetector is determined to be saturated by the light source. At block 515, the intensity of the light source is modified by adjusting the resistance and the flow of current to the light source 135. At block 520, the light intensity is again monitored and adjusted if necessary. In a

Asserted Claim of '698 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	preferred embodiment, this automatic gain mechanism prevents the green light from overwhelming the photodetector thereby maintaining an accurate reading no matter where the optical sensor is placed on the user." (Elhag, 17:10-21) "FIG. 19 illustrates how the control mechanism operates to maintain a proper light intensity. As the signal reaches the upper limit, the photodetector becomes saturated and the processor lowers the current flow, which results in a break in the signal. Then as the signal is lowered it becomes too low and the processor increases the light intensity resulting in a break in the signal." (Elhag, 17:22-28) *See also* Elhag, 16:53-17:9, Figs. 13, 14, 17, 18, 19.
[2] The wearable device of claim 1, wherein the plurality of LEDs and the plurality of spatially separated detectors are mounted on a common structure, and wherein the plurality of LEDs are coupled electrically to a power supply.	Elhag discloses and/or renders obvious "[t]he wearable device of claim 1, wherein the plurality of LEDs and the plurality of spatially separated detectors are mounted on a common structure, and wherein the plurality of LEDs are coupled electrically to a power supply.."

Asserted Claim of '698 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	 FIGURE 5 (Elhag, Fig. 5) "An alternative method includes the light source 135 of the optical device 30 transmitting light at the nose 90 of the user. The photo-detector 130 detects the light. The pulse rate is determined by the signals received by the photo-detector 130. The ratio of the fluctuation of the red and/or infrared light signals is used to calculate the blood oxygen saturation level of the user. Then, the signal is sent to the controller 43 to be converted into a usable format for the digital storage and processing unit 35. Then, the signal is sent from the controller 43 to the digital storage and

Asserted Claim of '698 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	processing unit 35. Then, the information contained in the signal is processed by the microprocessor on the digital storage and processing unit 35 to generate blood oxygenation level, pulse rate, signal strength bar graph, plethysmogram and/or status bits data. Further processing of the information is performed by the microprocessor to generate pulse rate, blood oxygenation levels, calories expended by the user of a pre-set time period, target zones of activity, time and dynamic blood pressure. Then, the information is displayed on the display screen 40 of the digital storage and processing unit 35." (Elhag, 11:1-20)  FIGURE 1 FIGURE 2 (Elhag, Fig. 1-2)

Asserted Claim of '698 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	 FIGURE 1A FIGURE 1B (Elhag, Fig. 1A-1B) "The lens 26 includes a recessed nose area 27 including a nose support 28 (or 28 a and 28 b in FIG. 1) which allows the eyewear 25 to be supported on the user's face (not shown) in the manner conventionally known in the art. An optical sensor 30, as discussed below, is attached to the nose support 28. The optical sensor 30 has a light source 135 and a photodetector 130, which is connected to connection cable 45. An integral lens support portion 29 is provided on the eyewear 25 for supporting the lens 26 in the desired position within the user's forward field of vision. The connection cable 45 is preferably attached and/or integrated into the lens support position 29. As illustrated in FIG. 2, the lens support portion 29 is preferably integrally formed on the lens 26 from a similar transparent material so as to allow the user to see objects through the lens support portion 29. As shown in FIG. 1A, a reflective mode optical sensor 30 has the light source 135 and the photodetector 130 on nose support 28 b. As shown in FIG. 1B, in an alternative embodiment, a transmission mode optical sensor 30 has the optical sensor 30 with the light source 135 in the nose support 28 b and the photodetector 130 in the nose support 28 a. In a preferred embodiment, the light source 135 and the photodetector 130 are integrated into the body of the nose support 28 b, or nose supports 28 a and 28 b, so as to have little affect on the user, and to prevent adverse light from affecting the signal reading of the photodetector 130." (Elhag, 7:18-42)

Asserted Claim of '698 Patent	U.S. Patent No. 7,648,463 ("Elhag")
	"The connection cable 45 preferably is a bundle of several wires preferably including a power wire, an audio communication wire, a ground wire and a photodetection transmission wire. The photodetection transmission wire transmits the signal, preferably a digital signal, from the photodetector 130 to the digital storage and processing unit 35. Signal noise reduction means for the connection wire 45 are discussed below in reference to FIG. 16." (Elhag, 8:11-18) "The monitoring device 20 may also include controls to search for information to be displayed on the display screen, to set time periods for measurement of calories or the like, and to reset the monitoring device 20. Further, a battery, not shown, is utilized to power the various components of the monitoring device 20." (Elhag, 11:41-46)
[3] The wearable device of claim 1, wherein the light source is configured to further improve the signal-to-noise ratio of the input beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs, and wherein the receiver is configured to be synchronized to at least one of the LEDs.	Elhag discloses and/or renders obvious "[t]he wearable device of claim 1, wherein the light source is configured to further improve the signal-to-noise ratio of the input beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs, and wherein the receiver is configured to be synchronized to at least one of the LEDs." *See* CHART ONE: '533 Patent, Claim Elements 5C and 5F above.
[5] The wearable device of claim 1, wherein the wearable device is configured to communicate with a smart phone or tablet, the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a voice input module, a speaker, and a touch screen, the smart phone or	Elhag discloses and/or renders obvious "[t]he wearable device of claim 1, wherein the wearable device is configured to communicate with a smart phone or tablet, the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a voice input module, a speaker, and a touch screen, the smart phone or tablet configured to receive and to process at least a portion of the output signal, wherein the smart phone or tablet is configured to store and display the processed output signal, wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link." *See* CHART ONE: '533 Patent, Claim Elements 5G, 5H, 5I, and 5J above

Asserted Claim of '698 Patent	U.S. Patent No. 7,648,463 ("Elhag")
tablet configured to receive and to process at least a portion of the output signal, wherein the smart phone or tablet is configured to store and display the processed output signal, wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link.	

EXHIBIT CC

EXHIBIT CC-1

U.S. Patent No. 9,651,533 vs Asada Combinations

Publication Dates: July 2001, May/June 2003, 2010 Prior Art Status: § 103

To the extent Asada et al., "Mobile monitoring with wearable photoplethysmographic biosensors," IEEE Engineering in Medicine and Biology Magazine (May/June 2003) ("Asada 2003"), does not anticipate the asserted claims of U.S. Patent No. 9,651,533 ("the '533 Patent") or render those claims obvious alone and/or in view of at least any of the references identified in Apple's Obviousness Combinations Chart, the claims are obvious based on the combination of Asada 2003 with one or both of:

> Rhee et al., Artifact-Resistant Power-Efficient Design of Finger-Ring Plethsymographic Sensors," IEEE Transactions on Biomedical Engineering, Vol. 48, No. 7 (July 2001) ("Asada 2001");
>
> Asada, The MIT Ring: History, Technology, and Challenges of Wearable Health Monitoring, MIT Industrial Liason Program 2010 R&D Conference ("Asada 2010")

("Asada Combinations").

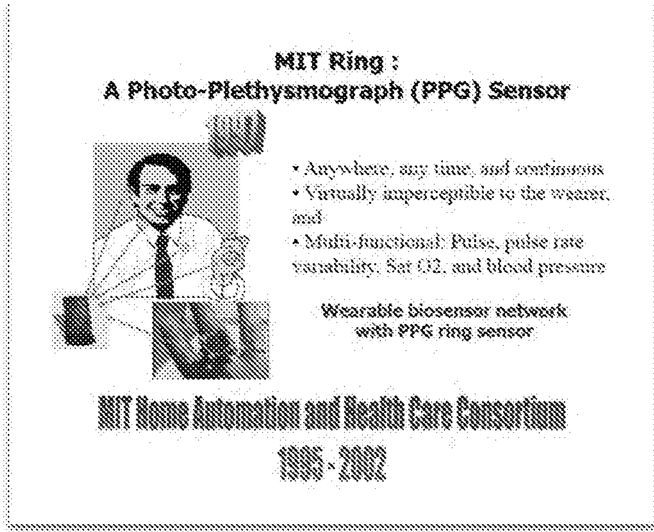
As set forth in Apple's Invalidity Contentions, the below contentions apply the prior art in part in accordance with Apple's assumption that Omni contends the claims are not invalid under 35 U.S.C. § 112. However, Apple's below contentions do not represent Apple's agreement or view as to the meaning, definiteness, written description support for, or enablement of any of the asserted claims. For each dependent claim, the disclosures cited for the claim from which it depends are incorporated by reference.

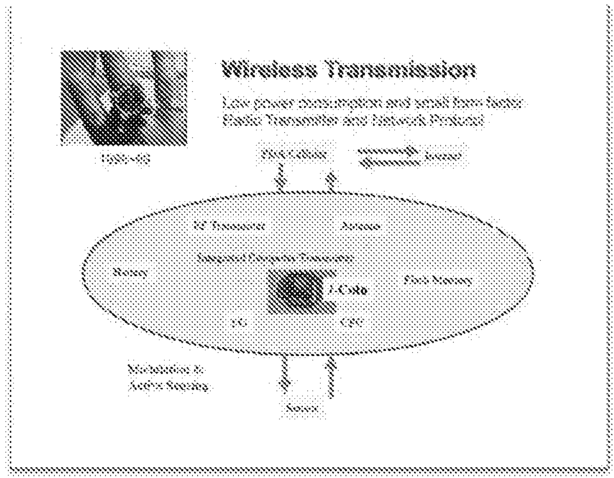
CHART ONE: U.S. Patent No. 9,651,533 vs Asada Combinations

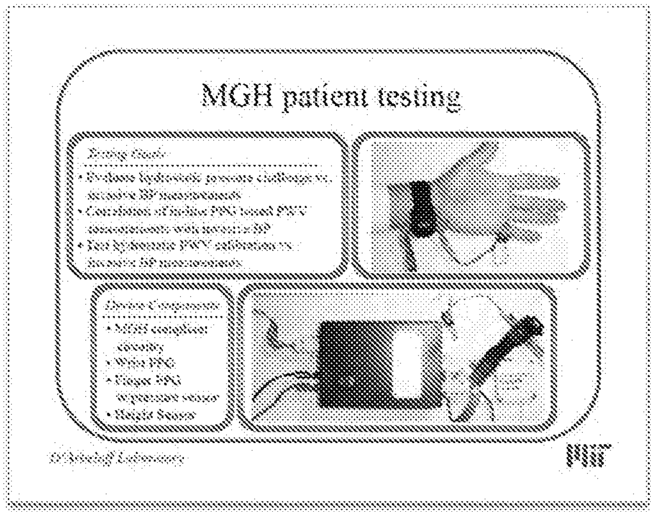
Asserted Claim of '533 Patent	Asada Combinations
[5] A measurement system, comprising:	To the extent the preamble is limiting, the Asada Combinations disclose and/or render obvious "[a] measurement system." *See generally* Asada 2003 Figures 6, 9, 11, 15 and descriptions of Prototypes A, B, and C. "Wearable biosensors (WBS) will permit continuous cardiovascular (CV) monitoring in a number of novel settings. Benefits may be realized in the diagnosis and treatment of a number of major diseases. WBS, in conjunction with appropriate alarm algorithms, can increase surveillance capabilities for CV catastrophe for high-risk subjects. WBS could also play a role in the treatment of chronic diseases, by providing information that enables precise titration of therapy or detecting lapses in patient compliance. WBS could play an important role in the wireless surveillance of people during hazardous operations (military, fire-fighting, etc.), or such sensors could be dispensed during a mass civilian casualty occurrence. Given that CV physiologic parameters make up the "vital signs" that are the most important information in emergency medical situations, WBS might enable a wireless monitoring system for large numbers of at-risk subjects. This same approach may also have utility in monitoring the waiting room of today's overcrowded emergency departments. For hospital inpatients who require CV monitoring, current biosensor technology typically tethers patients in a tangle of cables, whereas wearable CV sensors could increase inpatient comfort and may even reduce the risk of tripping and falling, a perennial problem for hospital patients who are ill, medicated, and in an unfamiliar setting." Asada 2003 at 28. "In this article we will address both technical and clinical issues of WBS. First, design concepts of a WBS will be presented, with emphasis on the ring sensor developed by the author's group at MIT. The ring sensor is an ambulatory, telemetric, continuous health-monitoring device. This WBS combines miniaturized data acquisition features with advanced photoplethysmographic (PPG) techniques to acquire data related to the patient's cardiovascular state using a method that is far superior to existing fingertip PPG sensors [1]. In particular, the ring sensor is capable of reliably monitoring a patient's heart rate, oxygen saturation, and heart rate variability. Technical issues, including motion artifact, interference with blood circulation, and battery power issues,

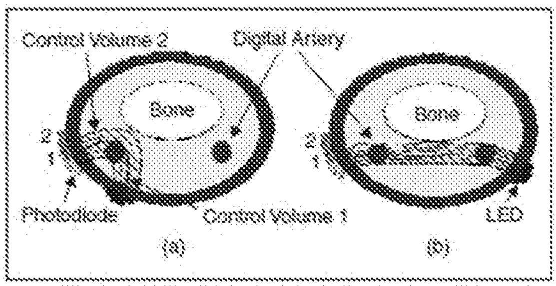
Asserted Claim of '533 Patent	Asada Combinations
	will be addressed, and effective engineering solutions to alleviate these problems will be presented. Second, based on the ring sensor technology the clinical potentials of WBS monitoring will be addressed." Asada 2003 at 28. "The WBS hardware solution must be adequate to make reliable physiologic measurements during activities of daily living or even more demanding circumstances such as fitness training or military battle. There must exist data processing and decision-making algorithms for the waveform data. These algorithms must prompt some action that improves health outcomes. Finally, the systems must be cost effective when compared with less expensive, lower technology alternatives." Asada 2003 at 28. "The monitoring environments for out-of-hospital, wearable devices demand a new paradigm in noninvasive sensor design. There are several design requirements central to such devices. Compactness, stability of signal, motion and other disturbance rejection, durability, data storage and transmission, and low power consumption comprise the major design considerations. Additionally, since WBS devices are to be worn without direct doctor supervision, it is imperative that they are simple to use and comfortable to wear for long periods of time. A challenge unique to wearable sensor design is the trade-off between patient comfort, or long-term wearability, and reliable sensor attachment. While it is nearly needless to say that WBS technology must be safe, it should be noted that there have been tragic reports of serious injury resulting from early home monitoring technology [2]." Asada 2003 28-29. "WBS solutions, in various stages of technologic maturity, exist for measuring established cardiopulmonary 'vital signs': heart rate, arterial blood pressure, arterial oxygen saturation, respiratory rate, temperature, and even cardiac output. In addition, there are numerous WBS modalities that can offer physiologic measurements not conventional in contemporary medical monitoring applications, including acoustic sensors, electrochemical sensors, optical sensors, electromyography and electroencephalography, and other bioanalytic sensors (to be sure, some of these sensors have well-established medical utility, but not for automated surveillance)." Asada 2003 at 29.

Asserted Claim of '533 Patent	Asada Combinations
	"This article focuses on a wearable ring pulse-oximeter solution, which measures the PPG as well as the arterial oxygen saturation. The PPG contains information about the vascular pressure wave-forms and compliances. Efforts to extract unique circulatory in- formation, especially an ABP surrogate, from the PPG waveform are discussed later in this article. The PPG provides an effective heart rate (measuring heart beats that generate identifiable forward-flow), useful for circulatory considerations though less useful for strict electrophysiologic considerations. For instance, the PPG signal may reveal heart rate variability, provided ectopic heart beats, which corrupt the association with autonomic tone, can be excluded." Asada 2003 at 29-30. "To evaluate how a pressure applied to the finger base interferes with blood circulation, the blood flow toward the fingertip was measured by using Nellcor's PPG sensor attached to the fingertip." Asada 2003 at 36. "The ring sensor is a miniaturized, telemetric, monitoring device worn by a patient as a finger ring. The ring encapsulates PPG, pulse oximetry combined with wireless communication and miniaturization technologies. This device optically captures the pulsation and oxygen saturation of the arterial blood flow, and transmits the signals to a host computer via a radio-frequency (RF) transmitter. Fig. 1 shows a conceptual diagram of the ring sensor [5], [6]. The ring sensor consists of optoelectronic components, a CPU, a RF transmitter, a battery, and a ring chassis. The optoelectronic components, i.e., micro photodiodes and LEDs, detect the blood-volume waveforms and oxygen-saturation level at the patient's digital artery. The CPU controls the LED lighting sequence as well as the data acquisition and transmission process. These signals are locally processed by the on-board CPU and transmitted to a host computer for diagnosis of the patient's cardiovascular conditions. The ring sensor is completely wireless and miniaturized so that the patient can wear the device comfortably 24 h/day." Asada 2001 at 796.

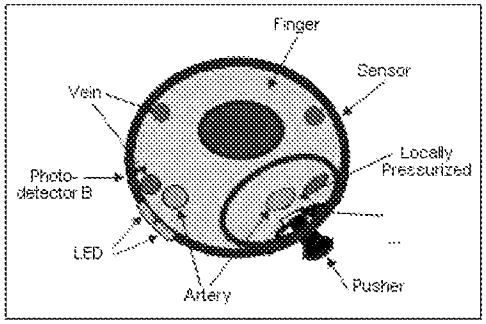
Asserted Claim of '533 Patent	Asada Combinations
	Asada 2010 page 3  Asada 2010 page 9

Asserted Claim of '533 Patent	Asada Combinations
	 Asada 2010 – Page 62

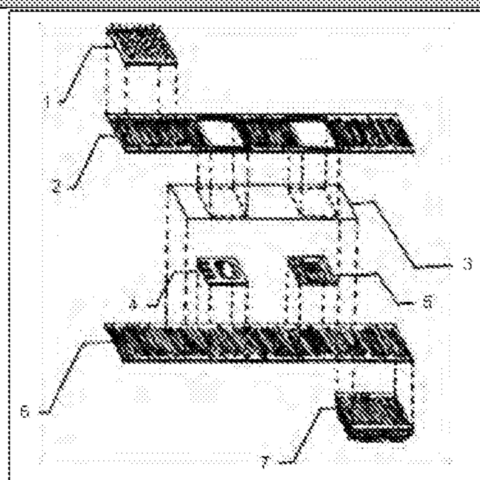
Asserted Claim of '533 Patent	Asada Combinations
	
[5A] a light source comprising a plurality of semiconductor sources that are light emitting diodes, the light emitting diodes configured to generate an output optical beam with one or more optical wavelengths,	The Asada Combinations disclose and/or render obvious "a light source comprising a plurality of semiconductor sources that are light emitting diodes, the light emitting diodes configured to generate an output optical beam with one or more optical wavelengths." "Furthermore, wearable PPG sensors are exposed to diverse ambient lighting conditions, ranging from direct sunlight to flickering room light. In addition, wearable PPG sensors must be designed for reduced power consumption. Carrying a large battery pack is not acceptable for long-term applications. The whole sensor system must run continually using a small battery. Several ways to cope with these difficulties are:

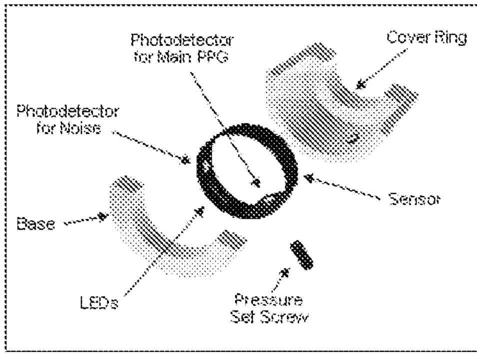
Asserted Claim of '533 Patent	Asada Combinations
	➤ secure the LEDs and the photodetector (PD for short) at a location along the finger skin such that the dc component may be influenced less by the finger motion ➤ modulate the LEDs to attenuate the influence of uncorrelated ambient light as well as to reduce power consumption…" Asada 2003 at 30.  Fig. 2. (a) For the reflective illumination method, movement of the photodiode relative to the LED (position 1 to position 2) leads to a photon path that no longer contains the digital artery. (b) For the transmittal illumination method, movement of the photodetector relative to the LED still contains photon paths that pass through the digital artery. "The location of the LEDs and a PD relative to the finger is an important design issue determining signal quality and robustness against motion artifact. Figure 2 shows a cross-sectional view of the finger with the ring sensor. The LEDs and PD are placed on the flanks of the finger rather than the dorsal and palmar sides." Asada 2003 at 30-31. "For these reasons, at least one optical device, either the PD or the LED, should be placed on one lateral face of the finger near the digital artery. The question is where to place the other device. Figure 2 shows two distinct cases. One case places both the PD and the LED on the same side of

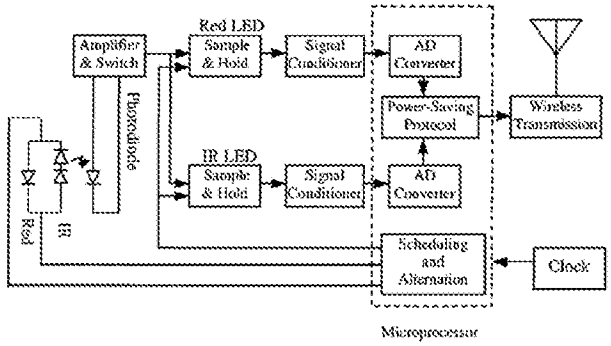
Asserted Claim of '533 Patent	Asada Combinations
	the finger-base, and the other places them on opposite sides of the finger. Placing both the PD and the LED on the same side creates a type of reflective PPG, while placing each of them on opposite sides makes a type of transmittal PPG. In the figure the average pathway of photons is shown for the two sensor arrangements. Although the exact photon path is difficult to obtain, due to the heterogeneous nature of the finger tissue and blood, a banana-shaped arc connecting the LED and PD, as shown in the figure, can approximate its average path [19]." Asada 2003 at 31. "Reflective PPG needs more secure attachments of the LED and PD to the skin surface, when compared to transmittal PPG. Once an air gap is created between the skin surface and the optical components due to some disturbance, a direct optical path from the LED to the PD may be created. This direct path exposes the PD directly to the light source and consequently leads to saturation. To avoid this short circuit, the LED light beam must be focused only in the normal direction, and the PD must also have a strong directional property (i.e., polarity), so that it is sensitive to only the incoming light normal to the device surface. Such strong directional properties, however, work adversely when a disturbance pressure acts on the sensor bodies, since it deflects the direction of the LED and PD leading to fluctuations in the out- put signal. As a result, reflective PPG configurations are more susceptive to disturbances." Asada 2003 at 31. "Furthermore, transmittal PPG is less sensitive to local disturbances acting on the finger, since the LED irradiates a larger volume of the finger. In the transmittal PPG configuration, the percentage of the measured signal does not significantly change although some peripheral capillary beds are collapsed. The percentage change is greater for reflective PPG, since this volume is smaller." Asada 2003 at 31. "Figure 3 shows an experimental comparison between transmittal and reflective PPGs. Two sets of PPG sensors, one reflective and one transmittal, were attached to the same finger. Both were at rest initially, and then shaken. The transmittal PPG was quite stable, while the reflective PPG was susceptive to the motion disturbances." Asada 2003 at 31.

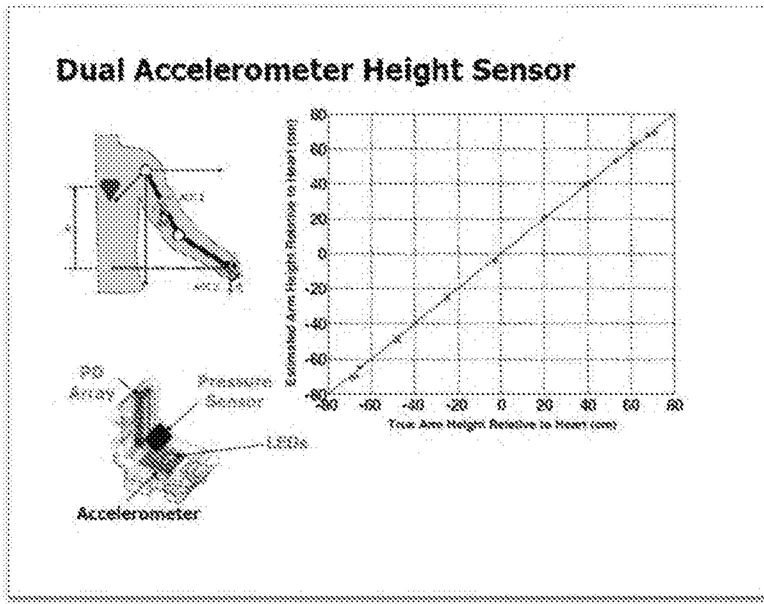
Asserted Claim of '533 Patent	Asada Combinations
	 **Fig. 8.** The schematic of a locally pressurized sensor band.  **Fig. 9.** First prototype ring sensor with RF transmitter powered by a coin-size cell battery.

Asserted Claim of '533 Patent	Asada Combinations
	"Figure 9 shows the first ring sensor prototype that contains an optical sensor unit, analog and digital processing units, and an RF transmitter, all of which are encapsulated in a compact body and powered by a tiny cell battery used for wristwatches. The ring has a PIC microcomputer performing all the device controls and low-level signal processing, including LED modulation, data acquisition, filtering, and bi-directional RF communication. The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz. The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "In this early development, the power consumption of the LEDs and the imbedded CPU clock were a major bottleneck limiting the design. The distance between the LEDs and PDs had to be shortened for power saving considerations, and the CPU clock was minimized in order to extend the battery life to a few weeks. See [30] for power budget and design details." Asada 2003 at 34.

Asserted Claim of '533 Patent	Asada Combinations
	 Fig. 11. Redesigned sensor band that protects optical components from direct contact with skin and hides wires from outside environment. "To improve motion artifact resistance and accuracy, a transmittal PPG ring sensor, Prototype B, has been built and field-tested. Prototype B has high-speed optical devices enabling the lowering of the LED duty rate to 1/1,000. The LED used is 6.7 times brighter than that of Prototype A, while the resultant power consumption is 173 times smaller than before. The sensor band was redesigned with the use of bio-compatible elastic materials to better hold the LED's and PD's, maintain a proper level of pressure, optically shield the sensor unit, and secure the contact with the skin consistently in the face of finger motion (see Figure 11). As a result, the waveform of this transmittal PPG was quite stable. Figure 3 presented earlier is the experiment of Prototype B. Note that the transmittal PPG (Prototype B) signal did not collapse even when the hand was shaken. Additionally, the analog filtering circuit was optimized for quality of signal. These modifications

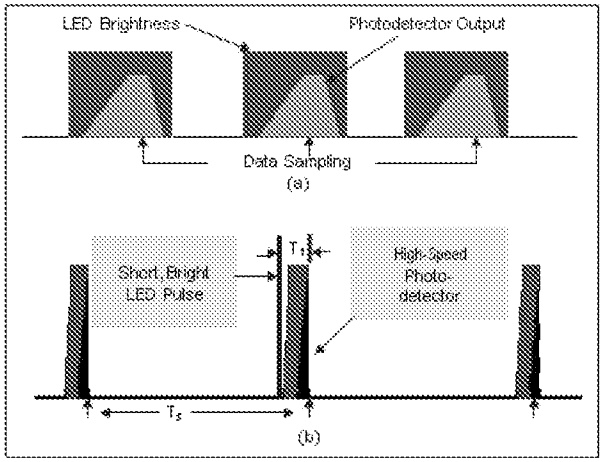
Asserted Claim of '533 Patent	Asada Combinations
	greatly improved the ability of the device to measure traditionally difficult variables such as heart rate variability (Table 1, Figure 12)." Asada 2003 at 35.  Fig. 15. The schematic of the Prototype C ring sensor. "The local pressurization and motion detection methods described previously have been implemented for further improvement. Figure 15 shows the schematic of the Prototype C ring sensor. Both transmittal (PD-A) and reflective (PD-B) PPGs were mounted on the sensor band. The former is placed on top of a locally pressurizing mechanism with an adjustable setscrew. The latter is mounted on the low-pressure side in order to detect motion." Asada 2003 at 36. Asada 2001 -- Figure 4:

Asserted Claim of '533 Patent	Asada Combinations
	 Fig. 4. Block diagram of electronic circuit. "Fig. 4 shows a block diagram of the ring sensor circuitry. The basic circuit configuration is a standard PPG circuit combined with a wireless transmitter. There are a single photodiode and LEDs of two different wavelengths, red and near infrared, involved in the circuit. The output from the photodiode is am- plified and conditioned at the first stage operational amplifier. While the red and infrared LEDs are alternately turned on and off, the signal from the first stage op-amp is sampled by the two sample-and-hold circuits at different timings in order to obtain the reflected light intensity from each LED. Each channel of the signal is conditioned and converted to a digital signal with an AD converter. Using the standard RS-232 protocol, the two channels of digital signals are transmitted via a RF transmitter." Asada 2001 at 797. Asada 2010 – page 50

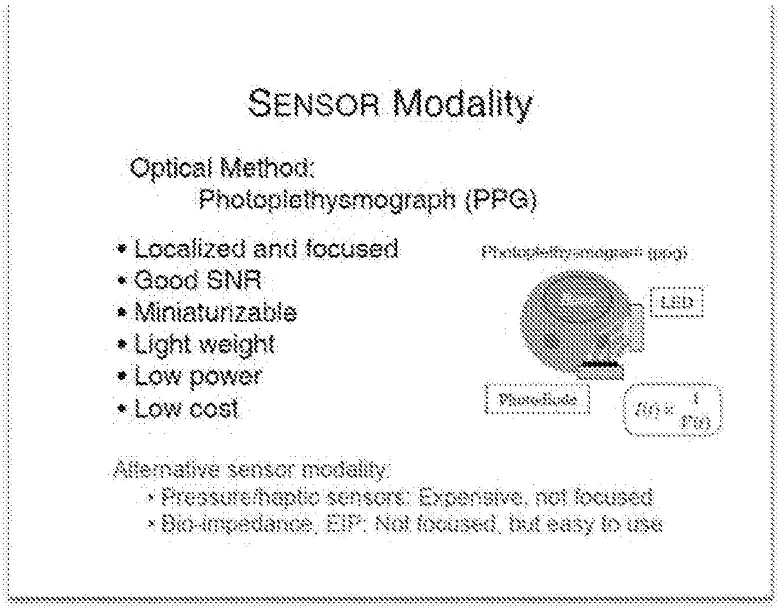
Asserted Claim of '533 Patent	Asada Combinations
	
[5B] wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers,	The Asada Combinations disclose and/or render obvious "wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers."

Asserted Claim of '533 Patent	Asada Combinations
	"Figure 9 shows the first ring sensor prototype that contains an optical sensor unit, analog and digital processing units, and an RF transmitter, all of which are encapsulated in a compact body and powered by a tiny cell battery used for wristwatches. The ring has a PIC microcomputer performing all the device controls and low-level signal processing, including LED modulation, data acquisition, filtering, and bi-directional RF communication. The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz. The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "High-speed LEDs and PDs, which have become available at low cost in recent years, can be used for this purpose. Figure 4 shows a schematic of high-frequency, low-duty cycle modulation implemented to minimize LED power consumption. Utilizing fast rise-time optical detectors, it is possible to incorporate a modulation frequency of 1 kHz with a duty ratio of 0.1%, a theoretical power usage that is 1,000 times less than conventional full-cycle modulation methods [23]." Asada 2003 at 32. "In this early development, the power consumption of the LEDs and the imbedded CPU clock were a major bottleneck limiting the design. The distance between the LEDs and PDs had to be shortened for power saving considerations, and the CPU clock was minimized in order to extend the battery life to a few weeks. See [30] for power budget and design details." Asada 2003 at 34. "To improve motion artifact resistance and accuracy, a transmittal PPG ring sensor, Prototype B, has been built and field-tested. Prototype B has high-speed optical devices enabling the lowering of the LED duty rate to 1/1,000. The LED used is 6.7 times brighter than that of Prototype A, while the resultant power consumption is 173 times smaller than before." Asada 2003 at 35.

Asserted Claim of '533 Patent	Asada Combinations
	"*LEDs and Photodiode*: One red LED and two infrared LEDs are used as the light sources. The peak wavelength of the red LED is 660 nm, and that of the infrared LEDs is 940 nm. The photodiode has the peak wavelength of 940 nm and the spectral sensitivity ranges from 500 nm to 1000 nm, which meets our needs. The voltage drop across the red LED is 1.6 V and that of the infrared LEDs is 1.2 V, and two infra-red LEDs are connected in serial. These LEDs are in a die form with a size of 0.3 mm x 0.3 mm." Asada 2001 at 800.
[5C] the light source configured to increase signal-to-noise ratio by increasing a light intensity from at least one of the plurality of semiconductor sources and by increasing a pulse rate of at least one of the plurality of semiconductor sources;	The Asada Combinations disclose and/or render obvious "the light source configured to increase signal-to-noise ratio by increasing a light intensity from at least one of the plurality of semiconductor sources and by increasing a pulse rate of at least one of the plurality of semiconductor sources." "Furthermore, wearable PPG sensors are exposed to diverse ambient lighting conditions, ranging from direct sunlight to flickering room light. In addition, wearable PPG sensors must be designed for reduced power consumption. Carrying a large battery pack is not acceptable for long-term applications. The whole sensor system must run continually using a small battery. Several ways to cope with these difficulties are: ➤ secure the LEDs and the photodetector (PD for short) at a location along the finger skin such that the dc component may be influenced less by the finger motion ➤ modulate the LEDs to attenuate the influence of uncorrelated ambient light as well as to reduce power consumption ➤ increase the amplitude of the ac component so that the signal-to-noise ratio may increase ➤ measure the finger motion with another sensor or a second PD and use it as a noise reference for verifying the signal as well as for canceling the disturbance and noise.

Asserted Claim of '533 Patent	Asada Combinations
	In the following sections these methods will briefly be discussed, followed by specific sensor designs and performance tests." Asada 2003 at 30.  **Fig. 4.** (a) The slow response time of the photodetector meant that the LED had to be modulated at lower frequencies for data sampling. (b) A faster photodetector response time makes it possible to increase the modulation frequency of the LED. "Transmittal PPG must have a powerful LED for transmitting light across the finger. This power consumption problem can be solved with a lighting modulation technique using high-speed devices. Instead of lighting the skin continually, the LED is turned on only for a short time, say 100 ~ 1000 ns, and the signal is sampled within this period. High-speed LEDs and PDs, which have become available at low cost in recent years, can be used for this purpose. Figure 4 shows a schematic of high-frequency, low-duty cycle modulation implemented to minimize LED power consumption. Utilizing fast rise-time optical detectors, it is possible to incorporate a modulation

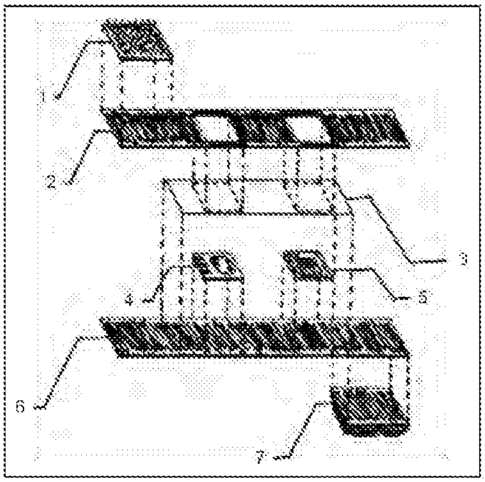
Asserted Claim of '533 Patent	Asada Combinations
	frequency of 1 kHz with a duty ratio of 0.1%, a theoretical power usage that is 1,000 times less than conventional full-cycle modulation methods [23]." Asada 2003 at 32. "In addition to saving power, the modulation of LED lighting provides an effective means for reducing ambient light disturbances. Reading the PD output while the LED is turned off yields the baseline PPG level attributed to the ambient light alone. Subtracting this reading from the one acquired with the LED illuminated gives the net output correlated with the LED lighting. More sophisticated modulation schemes can be applied by controlling the LED brightness as a periodic time function. Computational power requirements often prohibit complex modulation, however. Design trade-offs must be considered to find the best modulation scheme." Asada 2003 at 32. Asada 2003 explains that "according to the Lambert-Beer law, the brightness decreases exponentially as the distance from the light source increases." In order to improve the signal-to-noise ratio, brightness of the light is increased by "application of an external pressure on the tissue surrounding the artery" in order to increase the detected amplitude of arterial pulsations. Asada 2003 at 32. "Figure 5 shows the pulsatile amplitude of a finger base PPG for varied pressures generated by a finger cuff. As the cuff pressure increases, the PPG amplitude increases until it reaches a maximum." Asada 2003 at 32. "See [30] for power budget and design details." Asada 2003 at 34. "Among others, LED is one of the most power-consuming parts involved in the ring sensor. Therefore, the intensity of the LEDs must be lowered along with the reduction of duty cycle. This, however, incurs a poor signal-to-noise ratio problem. The signals obtained with dark LEDs are weak and must, therefore, be amplified many thousand times. As a result, it becomes susceptive to any disturbances. There are a number of existing techniques for dealing with artifact and disturbance rejection. The most common is signal processing, as reviewed by [11]. Another standard method is to identify and reject corrupt signals by comparing pulse features with a predetermined template. Other methods use modulation by controlling the power level of multiple lighting sources [11]." Asada 2001 at 796.

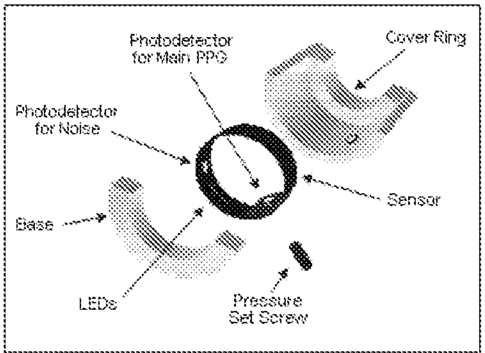
Asserted Claim of '533 Patent	Asada Combinations
	"For the prototype ring sensor, the sample-and-hold frequency was set to f = 1000 Hz. The choice of this frequency depends on applications. A lower sampling frequency can be used when required accuracy is lower." Asada 2001 at 800. Asada 2010 Page 52 

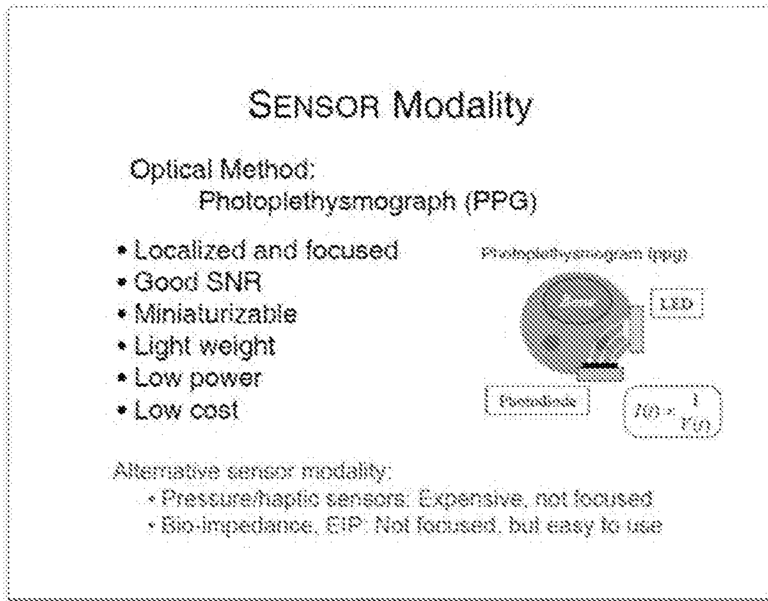
Omni MedSci, Inc. v. Apple Inc.
Case No. 2:18-cv-134-RWS (E.D. Tex.)

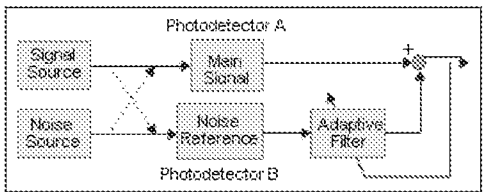
EXHIBIT CC-1, p. 20

Asserted Claim of '533 Patent	Asada Combinations
[5D] an apparatus comprising a plurality of lenses configured to receive a portion of the output optical beam and to deliver an analysis output beam to a sample	The Asada Combinations disclose and/or render obvious "an apparatus comprising a plurality of lenses configured to receive a portion of the output optical beam and to deliver an analysis output beam to a sample." "Reflective PPG needs more secure attachments of the LED and PD to the skin surface, when compared to transmittal PPG. Once an air gap is created between the skin surface and the optical components due to some disturbance, a direct optical path from the LED to the PD may be created. This direct path exposes the PD directly to the light source and consequently leads to saturation. To avoid this short circuit, the LED light beam must be focused only in the normal direction, and the PD must also have a strong directional property (i.e., polarity), so that it is sensitive to only the incoming light normal to the device surface." Asada 2003 at 31.  Fig. 9. First prototype ring sensor with RF transmitter powered by a coin-size cell battery.

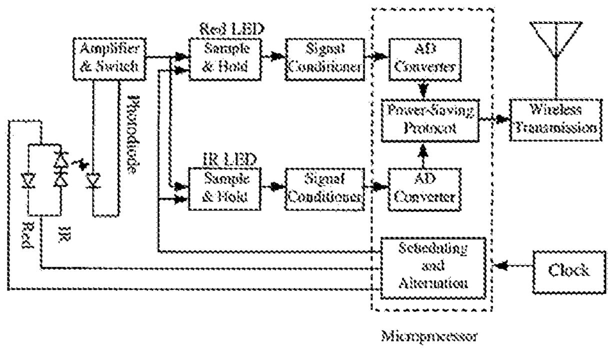
Asserted Claim of '533 Patent	Asada Combinations
	"Figure 9 shows the first ring sensor prototype that contains an optical sensor unit, analog and digital processing units, and an RF transmitter, all of which are encapsulated in a compact body and powered by a tiny cell battery used for wristwatches. The ring has a PIC microcomputer performing all the device controls and low-level signal processing, including LED modulation, data acquisition, filtering, and bi-directional RF communication. The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz. The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "See [30] for power budget and design details." Asada 2003 at 34.  Fig. 11. Redesigned sensor band that protects optical components from direct contact with skin and hides wires from outside environment.

Asserted Claim of '533 Patent	Asada Combinations
	"To improve motion artifact resistance and accuracy, a transmittal PPG ring sensor, Prototype B, has been built and field-tested. Prototype B has high-speed optical devices enabling the lowering of the LED duty rate to 1/1,000. The LED used is 6.7 times brighter than that of Prototype A, while the resultant power consumption is 173 times smaller than before. The sensor band was redesigned with the use of bio-compatible elastic materials to better hold the LED's and PD's, maintain a proper level of pressure, optically shield the sensor unit, and secure the contact with the skin consistently in the face of finger motion (see Figure 11). As a result, the waveform of this transmittal PPG was quite stable. Figure 3 presented earlier is the experiment of Prototype B. Note that the transmittal PPG (Prototype B) signal did not collapse even when the hand was shaken. Additionally, the analog filtering circuit was optimized for quality of signal. These modifications greatly improved the ability of the device to measure traditionally difficult variables such as heart rate variability (Table 1, Figure 12)." Asada 2003 at 35.  Fig. 15. The schematic of the Prototype C ring sensor. "The local pressurization and motion detection methods described previously have been implemented for further improvement. Figure 15 shows the schematic of the Prototype C ring sensor. Both transmittal (PD-A) and reflective (PD-B) PPGs were mounted on the sensor band.

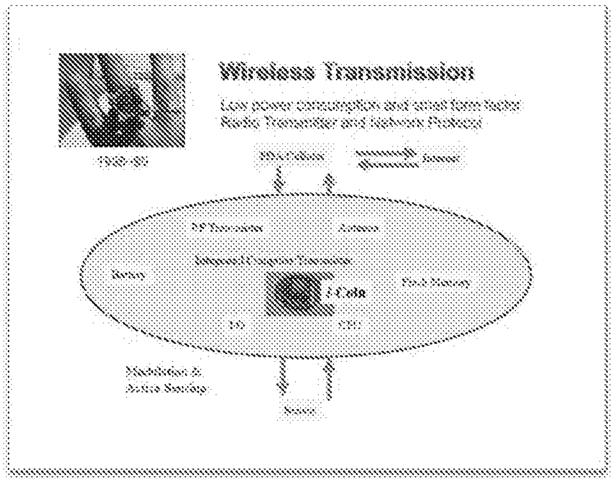
Asserted Claim of '533 Patent	Asada Combinations
	The former is placed on top of a locally pressurizing mechanism with an adjustable setscrew. The latter is mounted on the low-pressure side in order to detect motion." Asada 2003 at 36. Asada 2010 – page 52 
[5E] a receiver configured to receive and process at least a portion of the analysis output beam reflected or transmitted	The Asada Combinations disclose and/or render obvious "a receiver configured to receive and process at least a portion of the analysis output beam reflected or transmitted from the sample and to generate an output signal."

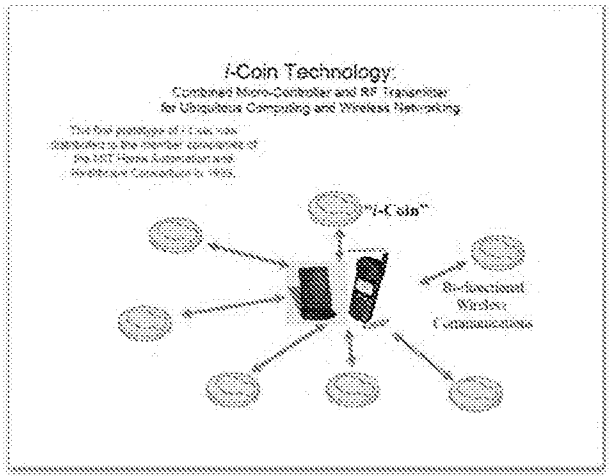
Asserted Claim of '533 Patent	Asada Combinations
from the sample and to generate an output signal,	"In this article we will address both technical and clinical issues of WBS. First, design concepts of a WBS will be presented, with emphasis on the ring sensor developed by the author's group at MIT. The ring sensor is an ambulatory, telemetric, continuous health-monitoring device. This WBS combines miniaturized data acquisition features with advanced photoplethysmographic (PPG) techniques to acquire data related to the patient's cardiovascular state using a method that is far superior to existing fingertip PPG sensors [1]." Asada 2003 at 28. "Figure 2 shows two distinct cases. One case places both the PD and the LED on the same side of the finger-base, and the other places them on opposite sides of the finger. Placing both the PD and the LED on the same side of the finger-base, and the other places them on opposite sides of the finger. Placing both the PD and the LED on the same side creates a type of reflective PPG, while placing each of them on opposite sides makes a type of transmittal PPG. In the figure the average pathway of photons is shown for the two sensor arrangements. Although the exact photon path is difficult to obtain, due to the heterogeneous nature of the finger tissue and blood, a banana-shaped arc connecting the LED and PD, as shown in the figure, can approximate its average path [19]." Asada 2003 at 31.  Fig. 8. Block diagram of adaptive noise cancellation using second PPG sensor as noise reference. "The motion detector can be used not only for monitoring the presence of motion but also for canceling noise. By using PD-B as a noise reference, a noise cancellation filter can be built to eliminate the noise of PD-A that correlates with the noise reference signal. Assuming that the hemo-dynamic process observed by PPG is stationary and that the noise is additive, adaptive noise canceling methods, such as the classical Widrow method [29], can be applied in order to recover the true pulsation signal from corrupted wave- forms. As shown in Figure 8, the noise-canceling

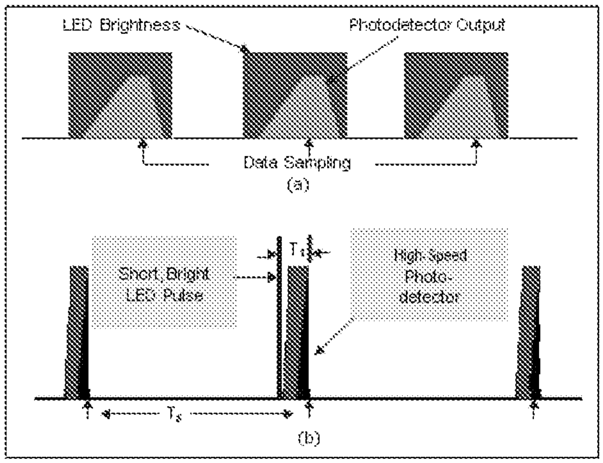
Asserted Claim of '533 Patent	Asada Combinations
	filter combines two sensor signals; one is the main signal captured by PD-A and the other is the noise reference obtained by PD-B. The main signal mostly consists of the true pulsatile signal, but it does contain some noise. If we know the proportion of the noise contained in the main signal, we can generate the noise of the same magnitude by attenuating the noise reference signal and then subtract the noise from the main signal to recover the true pulsatile signal. If the noise magnitude is not known a priori, it must be determined adaptively during the measurement. Various algorithms for adaptive filtering can be applied to tune the filter in real time. Some can determine optimal filter gains and parameters based on the evaluation of the recovered signal, as shown in Figure 8 by the feedback from the output to the adaptive filter block. Details of this adaptive filtering method are beyond the scope of this article. The dual photodetector design shown in Figure 6 provides both main signal and noise reference that are distinct. This allows us to implement noise-canceling filters effectively despite complex motion artifact." Asada 2003 at 33-34.  Fig. 9. First prototype ring sensor with RF transmitter powered by a coin-size cell battery.

Asserted Claim of '533 Patent	Asada Combinations
	"Figure 9 shows the first ring sensor prototype that contains an optical sensor unit, analog and digital processing units, and an RF transmitter, all of which are encapsulated in a compact body and powered by a tiny cell battery used for wristwatches. The ring has a PIC microcomputer performing all the device controls and low-level signal processing, including LED modulation, data acquisition, filtering, and bi-directional RF communication. The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz. The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "In this early development, the power consumption of the LEDs and the imbedded CPU clock were a major bottleneck limiting the design. The distance between the LEDs and PDs had to be shortened for power saving considerations, and the CPU clock was minimized in order to extend the battery life to a few weeks. See [30] for power budget and design details." Asada 2003 at 34. Asada 2001 – Figure 4:  Fig. 4. Block diagram of electronic circuit.

Asserted Claim of '533 Patent	Asada Combinations
	"Fig. 4 shows a block diagram of the ring sensor circuitry. The basic circuit configuration is a standard PPG circuit combined with a wireless transmitter. There are a single photodiode and LEDs of two different wavelengths, red and near infrared, involved in the circuit. The output from the photodiode is amplified and conditioned at the first stage operational amplifier. While the red and infrared LEDs are alternately turned on and off, the signal from the first stage op-amp is sampled by the two sample-and-hold circuits at different timings in order to obtain the reflected light intensity from each LED. Each channel of the signal is conditioned and converted to a digital signal with an AD converter. Using the standard RS-232 protocol, the two channels of digital signals are transmitted via a RF transmitter." Asada 2001 at 797. "The other electronic components of the ring sensor include multiple op-amps, switches, sample-and-hold, and filters." Asada 2001 at 800. "*CPU*: The on-board CPU controls all the operations of the ring sensor, ranging from the sequence control of LED lighting and data acquisition to the conversion of analogue data to digital signals in the RS-232 format for wireless transmission. A PIC16C711 microprocessor from Microchip was selected be- cause of its unique design for low power consumption. It consumes less than 25 A for 32-kHz clock frequency in the normal operation mode and almost no power consumption in the sleep mode. This CPU has 4 channels of embedded A/D converter, 13 channels of digital input–output line. It has 1 KB of EPROM that is good enough to store the whole code needed for computation. The resolution of the A/D converters are all 8-bits. In case that higher resolution is necessary, other CPUs such as PIC16C773 which has 12-bit A/D converters can be used." Asada 2001 at 800. Asada 2010 – page 9

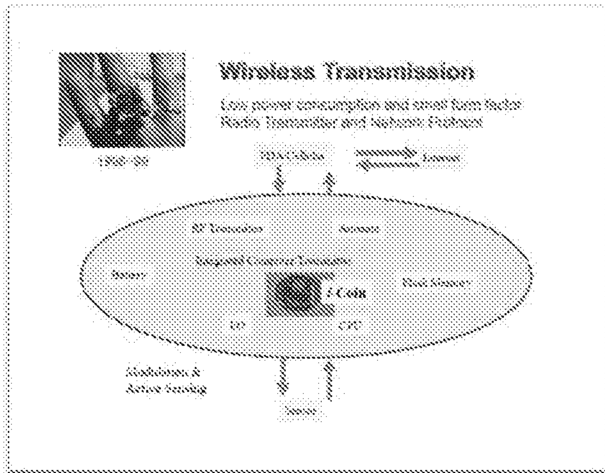
Asserted Claim of '533 Patent	Asada Combinations
	 Asada 2010 – page 10:

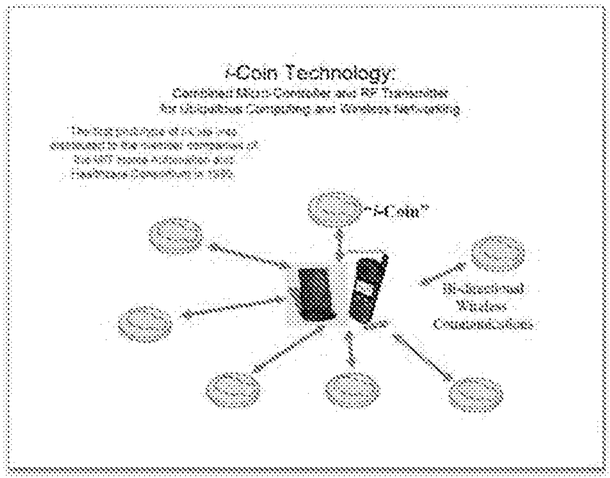
Asserted Claim of '533 Patent	Asada Combinations
	
[5F] wherein the receiver is configured to be synchronized to the light source;	The Asada Combinations disclose and/or render obvious "wherein the receiver is configured to be synchronized to the light source." "Furthermore, wearable PPG sensors are exposed to diverse ambient lighting conditions, ranging from direct sunlight to flickering room light. In addition, wearable PPG sensors must be designed for reduced power consumption. Carrying a large battery pack is not acceptable for long-term applications. The whole sensor system must run continually using a small battery. Several ways to cope with these difficulties are: ➤ secure the LEDs and the photodetector (PD for short) at a location along the finger skin such that the dc component may be influenced less by the finger motion

Asserted Claim of '533 Patent	Asada Combinations
	➤ modulate the LEDs to attenuate the influence of uncorrelated ambient light as well as to reduce power consumption ➤ increase the amplitude of the ac component so that the signal-to-noise ratio may increase ➤ measure the finger motion with another sensor or a second PD and use it as a noise reference for verifying the signal as well as for canceling the disturbance and noise. In the following sections these methods will briefly be discussed, followed by specific sensor designs and performance tests." Asada 2003 at 30.  **Fig. 4.** (a) The slow response time of the photodetector meant that the LED had to be modulated at lower frequencies for data sampling. (b) A faster photodetector response time makes it possible to increase the modulation frequency of the LED.

Asserted Claim of '533 Patent	Asada Combinations
	"Transmittal PPG must have a powerful LED for transmitting light across the finger. This power consumption problem can be solved with a lighting modulation technique using high-speed devices. Instead of lighting the skin continually, the LED is turned on only for a short time, say 100 ~ 1000 ns, and the signal is sampled within this period. High-speed LEDs and PDs, which have become available at low cost in recent years, can be used for this purpose. Figure 4 shows a schematic of high-frequency, low-duty cycle modulation implemented to minimize LED power consumption. Utilizing fast rise-time optical detectors, it is possible to incorporate a modulation frequency of 1 kHz with a duty ratio of 0.1%, a theoretical power usage that is 1,000 times less than conventional full-cycle modulation methods [23]." Asada 2003 at 32. "In addition to saving power, the modulation of LED lighting provides an effective means for reducing ambient light disturbances. Reading the PD output while the LED is turned off yields the baseline PPG level attributed to the ambient light alone. Subtracting this reading from the one acquired with the LED illuminated gives the net output correlated with the LED lighting. More sophisticated modulation schemes can be applied by controlling the LED brightness as a periodic time function. Computational power requirements often prohibit complex modulation, however. Design trade-offs must be considered to find the best modulation scheme." Asada 2003 at 32. "In this early development, the power consumption of the LEDs and the imbedded CPU clock were a major bottleneck limiting the design. The distance between the LEDs and PDs had to be shortened for power saving considerations, and the CPU clock was minimized in order to extend the battery life to a few weeks. See [30] for power budget and design details." Asada 2003 at 34. "See [30] for power budget and design details." Asada 2003 at 34.

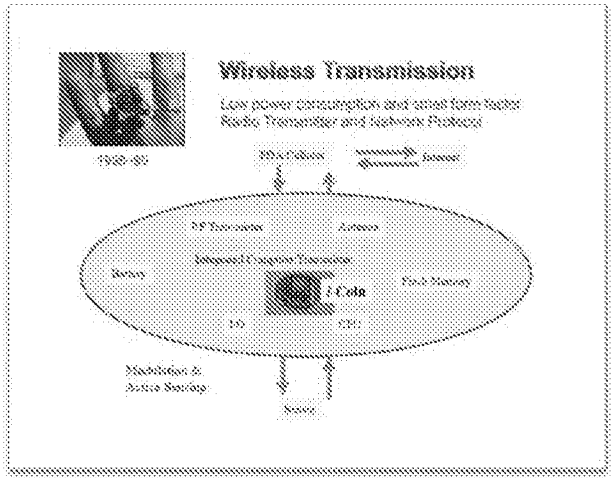
Asserted Claim of '533 Patent	Asada Combinations
	"*LED*: LEDs consume a large amount of power when emitting light continuously. Therefore they must be switched on only for a short interval when light must be emitted. Namely, the LEDs must be on only when the photodiode is detecting the reflected light for measuring the pulsation. Synchronizing the sampling of the photodetector with the LED switching reduces the duty ratio of the LEDs, and thereby reduces the power consumption. In the prototype system, this coordination is per- formed by the microprocessor. First, the LEDs are turned on; second, the photo detector signal is sampled at the next CPU cycle; the LEDs are switched off at the third CPU cycle. This sequence control is performed for both red and infrared LEDs." Asada 2001 at 798. "For the prototype ring sensor, the sample-and-hold frequency was set to f = 1000 Hz. The choice of this frequency depends on applications. A lower sampling frequency can be used when required accuracy is lower." Asada 2001 at 800.
[5G] a personal device comprising a wireless receiver, a wireless transmitter, a display, a microphone, a speaker, one or more buttons or knobs, a microprocessor and a touch screen,	The Asada Combinations disclose and/or render obvious "a personal device comprising a wireless receiver, a wireless transmitter, a display, a microphone, a speaker, one or more buttons or knobs, a microprocessor and a touch screen." "WBS could play an important role in the wireless surveillance of people during hazardous operations (military, fire-fighting, etc.), or such sensors could be dispensed during a mass civilian casualty occurrence. Given that CV physiologic parameters make up the 'vital signs' that are the most important information in emergency medical situations, WBS might enable a wireless monitoring system for large numbers of at-risk subjects." Asada 2003 at 28. "The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "The ring sensor is a miniaturized, telemetric, monitoring de- vice worn by a patient as a finger ring. The ring encapsulates PPG, pulse oximetry combined with wireless communication and miniaturization technologies. This device optically captures the pulsation and oxygen saturation of the arterial blood flow, and transmits the signals to a host computer via a radio-frequency (RF)

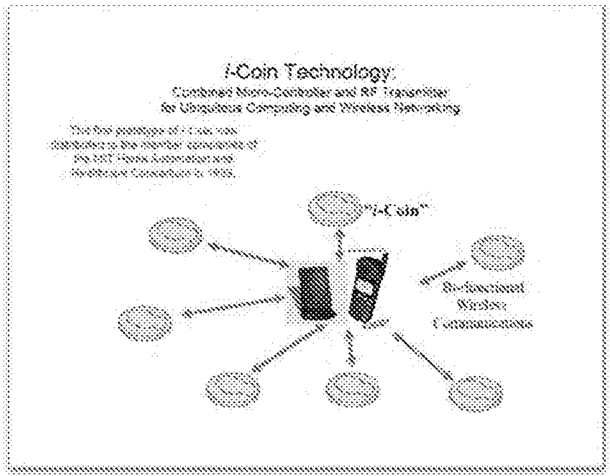
Asserted Claim of '533 Patent	Asada Combinations
	transmitter. Fig. 1 shows a conceptual diagram of the ring sensor [5], [6]. The ring sensor consists of optoelectronic components, a CPU, a RF transmitter, a battery, and a ring chassis. The optoelectronic components, i.e., micro photodiodes and LEDs, detect the blood-volume waveforms and oxygen-saturation level at the patient's digital artery. The CPU controls the LED lighting sequence as well as the data acquisition and transmission process. These signals are locally processed by the on-board CPU and transmitted to a host computer for diagnosis of the patient's cardiovascular conditions. The ring sensor is completely wireless and miniaturized so that the patient can wear the device comfortably 24 h/day." Asada 2001 at 796. Asada 2010 – page 9 

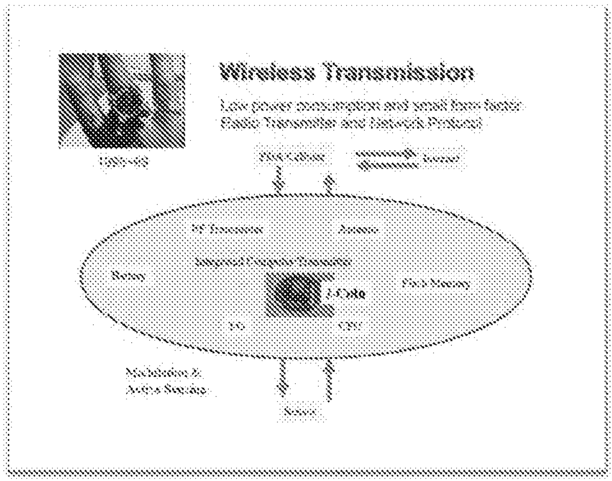
Asserted Claim of '533 Patent	Asada Combinations
	Asada 2010 – page 10: 
[5H] the personal device configured to receive and process at least a portion of the output signal,	The Asada Combinations disclose and/or render obvious "the personal device configured to receive and process at least a portion of the output signal." "At the same time, the physiologic information generated by WBS technology must trigger some appropriate system action to improve health outcomes. Abnormal states must be efficiently recognized while false alarms are minimized. This requires carefully designed WBS devices, as well as innovative postprocessing and intelligent data interpretation. Post-processing of sensor data can improve usability, as illustrated by recent improvements in pulse oximetry technology [3]-[5].

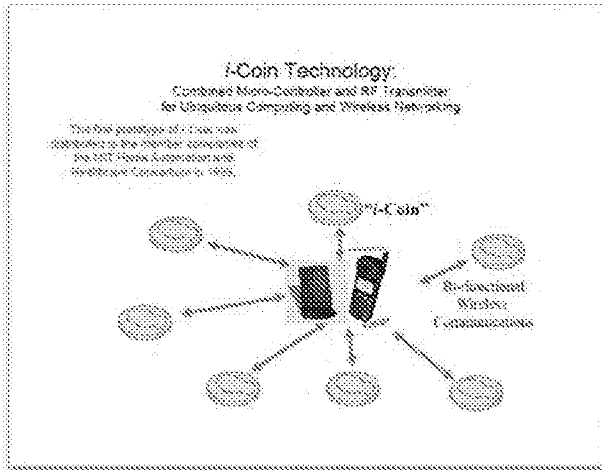
Asserted Claim of '533 Patent	Asada Combinations
	Data interpretation can occur in real time (as is necessary for detecting cardiovascular-related catastrophes) or offline (as is the standard-of-care for arrhythmia surveillance using Holter and related monitoring). Real-time alarm "algorithms" using simple thresholds for measured parameters, like heart rate and oxygen saturation, have demonstrated high rates of false alarms [6], [7]. Algorithms for off-line, retrospective data analysis are also in a developmental stage. Studies of novel automated "triage" software used to interpret hours of continuous noninvasive ECG data of monitored outpatients suggest that the software's diagnostic yield is not equal to a human's when it comes to arrhythmia detection [8], [9]." Asada 2003 at 29. "The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "WBS, in conjunction with diagnostic algorithms and some specific response (which might be human or automated in nature), stand to ameliorate physiologic catastrophes occurring outside conventional clinical environments. For instance, WBS can play an important role in the wireless surveillance of people during hazardous operations (military, fire-fighting, etc.), or such sensors can be dispensed during a mass civilian casualty occurrence. In an overcrowded Emergency Department, patients who are in the waiting room for hours with an undifferentiated medical complaint will receive state-of-the-art physiologic monitoring. For hospital in-patients who require CV monitoring, current biosensor technology typically tethers patients in a tangle of cables. For convalescing patients in a hospital, or a rehabilitation center, there would no longer be a dichotomy between optimal bed-bound monitoring and optimal rehabilitation consisting of ambulation and a full scope of physical activities. Given the physical freedom when monitored by WBS, inpatients may experience less physical deconditioning, and these two factors together may impact the not insignificant problem of dangerous inpatient falls in the elderly (an incidence on the order of 1-5% per admission [32], [33])." Asada 2003 at 37. "WBS measuring circulation could also be used to monitor geriatric subjects living alone, offering an automatic 911 call in the event of a catastrophe and peace of mind for the subject and concerned family the rest of the time." Asada 2003 at 37.

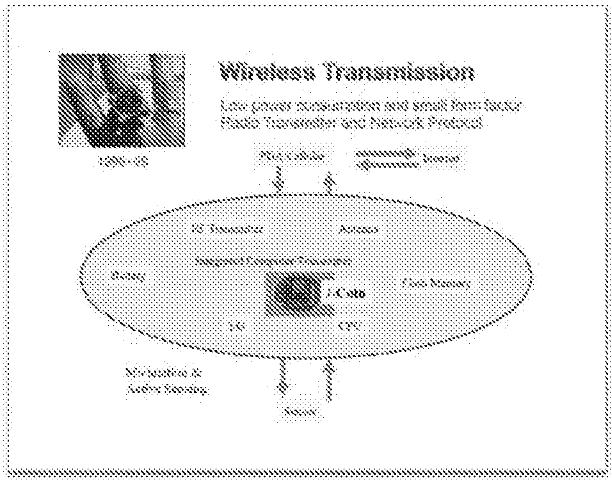
Asserted Claim of '533 Patent	Asada Combinations
	"The ring sensor is a miniaturized, telemetric, monitoring device worn by a patient as a finger ring. The ring encapsulates PPG, pulse oximetry combined with wireless communication and miniaturization technologies. This device optically captures the pulsation and oxygen saturation of the arterial blood flow, and transmits the signals to a host computer via a radio-frequency (RF) transmitter. Fig. 1 shows a conceptual diagram of the ring sensor [5], [6]. The ring sensor consists of optoelectronic components, a CPU, a RF transmitter, a battery, and a ring chassis. The optoelectronic components, i.e., micro photodiodes and LEDs, detect the blood-volume waveforms and oxygen-saturation level at the patient's digital artery. The CPU controls the LED lighting sequence as well as the data acquisition and transmission process. These signals are locally processed by the on-board CPU and transmitted to a host computer for diagnosis of the patient's cardiovascular conditions. The ring sensor is completely wireless and miniaturized so that the patient can wear the device comfortably 24 h/day." Asada 2001 at 796. Asada 2010 – page 9

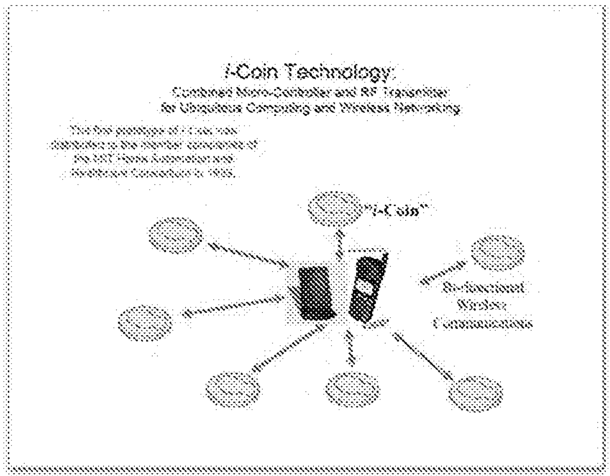
Asserted Claim of '533 Patent	Asada Combinations
	 Asada 2010 – page 10:

Asserted Claim of '533 Patent	Asada Combinations
	
[5I] wherein the personal device is configured to store and display the processed output signal,	The Asada Combinations disclose and/or render obvious "wherein the personal device is configured to store and display the processed output signal." "However, healthcare providers have only intermittent values of blood pressure on which to base therapy decisions; it is possible that continuous blood pressure monitoring would permit enhanced titration of therapy and reductions in mortality. Similarly, WBS would be able to log the physiologic signature of a patient's exercise efforts (manifested as changes in heart rate and blood pressure), permitting the patient and healthcare provider to assess compliance with a regimen proven to improve health outcomes." Asada 2003 at 28. "The monitoring environments for out-of-hospital, wearable devices demand a new paradigm in noninvasive sensor design. There are several design requirements central to such devices. Compactness, stability of signal, motion and other disturbance rejection, durability, data storage

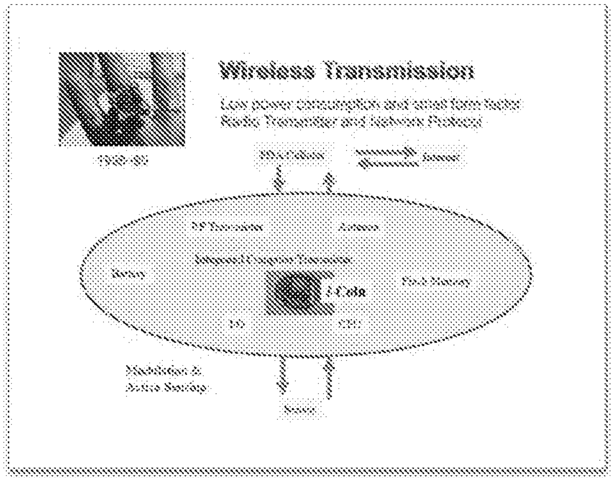
Asserted Claim of '533 Patent	Asada Combinations
	and transmission, and low power consumption comprise the major design considerations." Asada 2003 at 28. "The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. Asada 2010 – page 9  Asada 2010 – page 10:

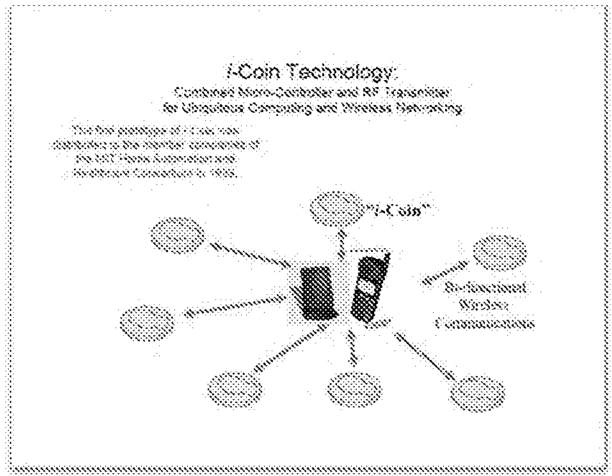
Asserted Claim of '533 Patent	Asada Combinations
	
[5J] and wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link; and	The Asada Combinations disclose and/or render obvious "and wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link." "WBS could play an important role in the wireless surveillance of people during hazardous operations (military, fire-fighting, etc.), or such sensors could be dispensed during a mass civilian casualty occurrence. Given that CV physiologic parameters make up the 'vital signs' that are the most important information in emergency medical situations, WBS might enable a wireless monitoring system for large numbers of at-risk subjects." Asada 2003 at 28. "The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34.

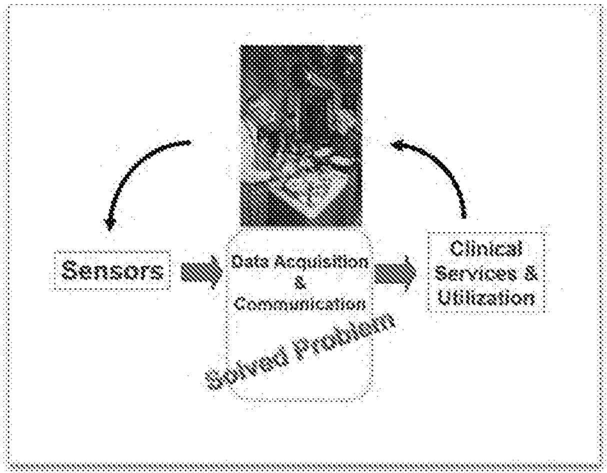
Asserted Claim of '533 Patent	Asada Combinations
	Asada 2010 – page 9  Asada 2010 – page 10:

Asserted Claim of '533 Patent	Asada Combinations
	
[5K] a remote device configured to receive over the wireless transmission link an output status comprising the at least a portion of the processed output signal, to process the received output status to generate processed data and to store the processed data.	The Asada Combinations disclose and/or render obvious "a remote device configured to receive over the wireless transmission link an output status comprising the at least a portion of the processed output signal, to process the received output status to generate processed data and to store the processed data." "At the same time, the physiologic information generated by WBS technology must trigger some appropriate system action to improve health outcomes. Abnormal states must be efficiently recognized while false alarms are minimized. This requires carefully designed WBS devices, as well as innovative postprocessing and intelligent data interpretation. Post-processing of sensor data can improve usability, as illustrated by recent improvements in pulse oximetry technology [3]-[5]. Data interpretation can occur in real time (as is necessary for detecting cardiovascular-related catastrophes) or offline (as is the standard-of-care for arrhythmia surveillance using Holter and related monitoring). Real-time alarm "algorithms" using simple thresholds for measured parameters, like heart rate and oxygen saturation, have demonstrated high rates of false alarms [6],

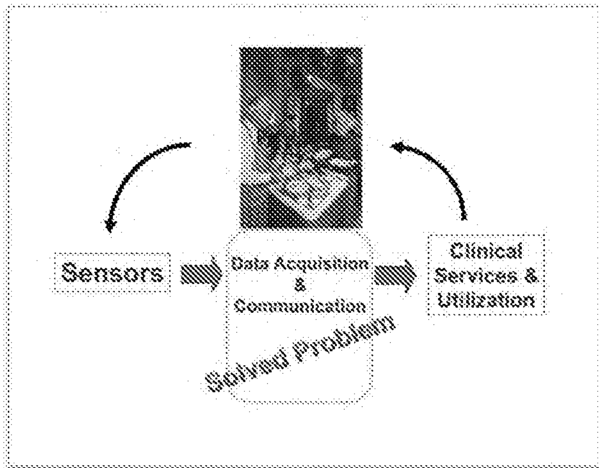
Asserted Claim of '533 Patent	Asada Combinations
	[7]. Algorithms for off-line, retrospective data analysis are also in a developmental stage. Studies of novel automated "triage" software used to interpret hours of continuous noninvasive ECG data of monitored outpatients suggest that the software's diagnostic yield is not equal to a human's when it comes to arrhythmia detection [8], [9]." Asada 2003 at 29. "The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "WBS, in conjunction with diagnostic algorithms and some specific response (which might be human or automated in nature), stand to ameliorate physiologic catastrophes occurring outside conventional clinical environments. For instance, WBS can play an important role in the wireless surveillance of people during hazardous operations (military, fire-fighting, etc.), or such sensors can be dispensed during a mass civilian casualty occurrence. In an overcrowded Emergency Department, patients who are in the waiting room for hours with an undifferentiated medical complaint will receive state-of-the-art physiologic monitoring. For hospital in-patients who require CV monitoring, current biosensor technology typically tethers patients in a tangle of cables. For convalescing patients in a hospital, or a rehabilitation center, there would no longer be a dichotomy between optimal bed-bound monitoring and optimal rehabilitation consisting of ambulation and a full scope of physical activities. Given the physical freedom when monitored by WBS, inpatients may experience less physical deconditioning, and these two factors together may impact the not insignificant problem of dangerous inpatient falls in the elderly (an incidence on the order of 1-5% per admission [32], [33])." Asada 2003 at 37. Asada 2010 – page 9

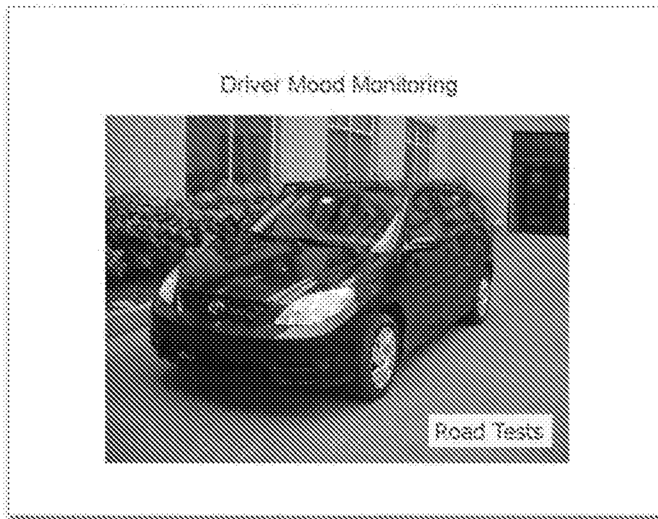
Asserted Claim of '533 Patent	Asada Combinations
	 Asada 2010 – page 10:

Asserted Claim of '533 Patent	Asada Combinations
	 Asada 2010 – page 13

Asserted Claim of '533 Patent	Asada Combinations
	
[7] The system of claim 5, wherein the remote device is further configured to transmit at least a portion of the processed data to one or more other locations, wherein the one or more other locations is selected from the group consisting of the personal device, a doctor, a healthcare provider, a cloud-based server and one or more designated recipients, and wherein the remote device is capable of transmitting	The Asada Combinations disclose and/or render obvious "[t]he system of claim 5, wherein the remote device is further configured to transmit at least a portion of the processed data to one or more other locations, wherein the one or more other locations is selected from the group consisting of the personal device, a doctor, a healthcare provider, a cloud-based server and one or more designated recipients, and wherein the remote device is capable of transmitting information related to a time and a position associated with the at least a portion of the processed data." WBS could play an important role in the wireless surveillance of people during hazardous operations (military, fire-fighting, etc.), or such sensors could be dispensed during a mass civilian casualty occurrence. Given that CV physiologic parameters make up the 'vital signs' that are the most important information in emergency medical situations, WBS might enable a wireless monitoring system for large numbers of at-risk subjects." Asada 2003 at 28. "However, healthcare providers have only intermittent values of blood pressure on which to base therapy decisions; it is possible that continuous blood pressure monitoring would permit enhanced

Asserted Claim of '533 Patent	Asada Combinations
information related to a time and a position associated with the at least a portion of the processed data.	titration of therapy and reductions in mortality. Similarly, WBS would be able to log the physiologic signature of a patient's exercise efforts (manifested as changes in heart rate and blood pressure), permitting the patient and healthcare provider to assess compliance with a regimen proven to improve health outcomes." Asada 2003 at 28. "The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "WBS, in conjunction with diagnostic algorithms and some specific response (which might be human or automated in nature), stand to ameliorate physiologic catastrophes occurring outside conventional clinical environments. For instance, WBS can play an important role in the wireless surveillance of people during hazardous operations (military, fire-fighting, etc.), or such sensors can be dispensed during a mass civilian casualty occurrence. In an overcrowded Emergency Department, patients who are in the waiting room for hours with an undifferentiated medical complaint will receive state-of-the-art physiologic monitoring. For hospital in-patients who require CV monitoring, current biosensor technology typically tethers patients in a tangle of cables. For convalescing patients in a hospital, or a rehabilitation center, there would no longer be a dichotomy between optimal bed-bound monitoring and optimal rehabilitation consisting of ambulation and a full scope of physical activities. Given the physical freedom when monitored by WBS, inpatients may experience less physical deconditioning, and these two factors together may impact the not insignificant problem of dangerous inpatient falls in the elderly (an incidence on the order of 1-5% per admission [32], [33])." Asada 2003 at 37. "WBS measuring circulation could also be used to monitor geriatric subjects living alone, offering an automatic 911 call in the event of a catastrophe and peace of mind for the subject and concerned family the rest of the time." Asada 2003 at 37. "The ring sensor is a miniaturized, telemetric, monitoring de- vice worn by a patient as a finger ring. The ring encapsulates PPG, pulse oximetry combined with wireless communication and miniaturization technologies. This device optically captures the pulsation and oxygen saturation of the arterial blood flow, and transmits the signals to a host computer via a radio-frequency (RF)

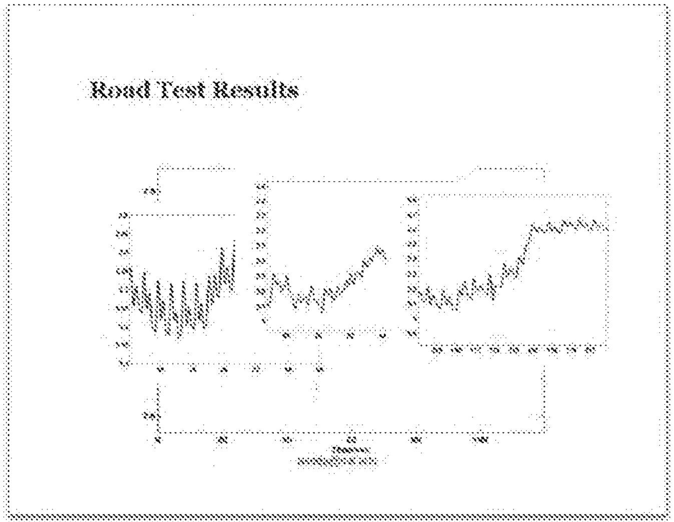
Asserted Claim of '533 Patent	Asada Combinations
	transmitter. Fig. 1 shows a conceptual diagram of the ring sensor [5], [6]. The ring sensor consists of optoelectronic components, a CPU, a RF transmitter, a battery, and a ring chassis. The optoelectronic components, i.e., micro photodiodes and LEDs, detect the blood-volume waveforms and oxygen-saturation level at the patient's digital artery. The CPU controls the LED lighting sequence as well as the data acquisition and transmission process. These signals are locally processed by the on-board CPU and transmitted to a host computer for diagnosis of the patient's cardiovascular conditions. The ring sensor is completely wireless and miniaturized so that the patient can wear the device comfortably 24 h/day." Asada 2001 at 796. Asada 2010 – page 13  Asada 2010 – pages 26-31

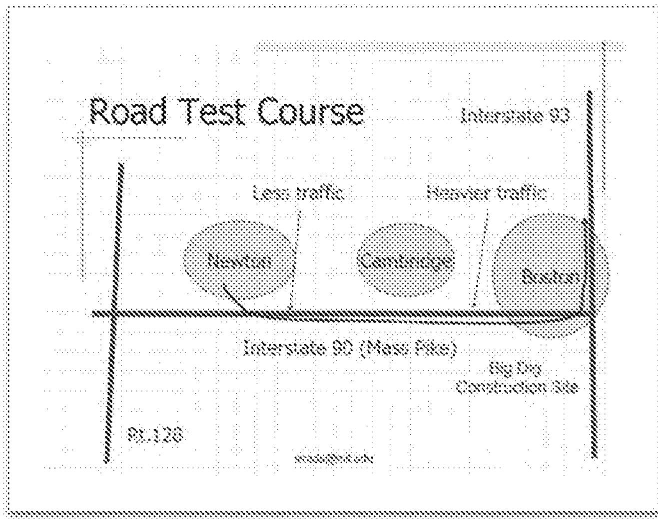
Asserted Claim of '533 Patent	Asada Combinations
	

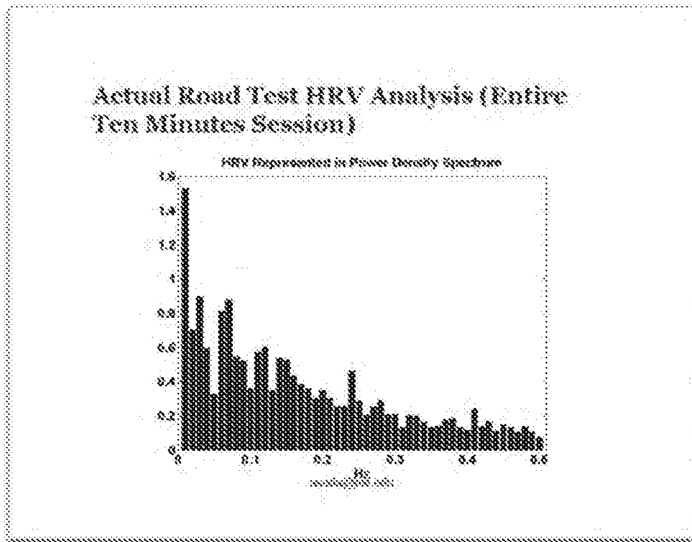
Asserted Claim of '533 Patent	Asada Combinations
	

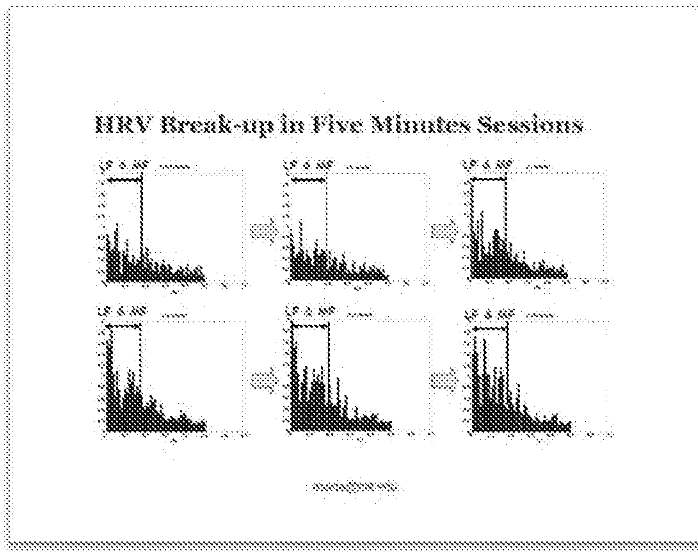
Omni MedSci, Inc. v. Apple Inc.
Case No. 2:18-cv-134-RWS (E.D. Tex.)

EXHIBIT CC-1, p. 51

Asserted Claim of '533 Patent	Asada Combinations
	

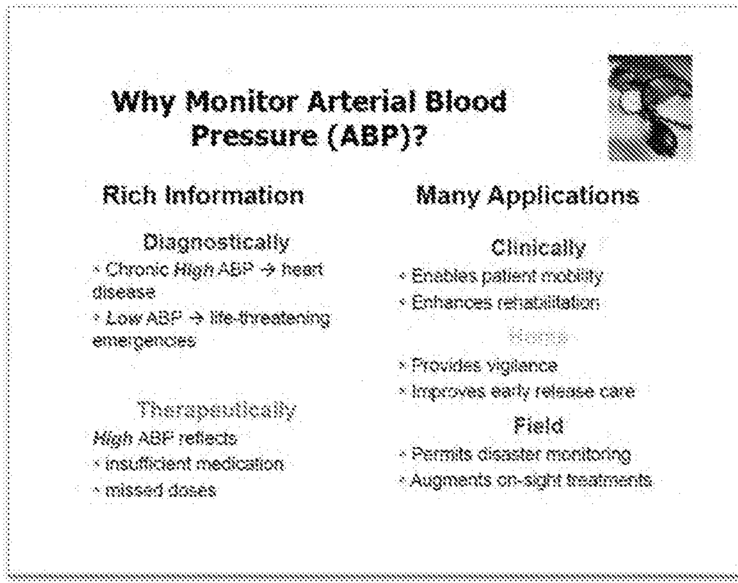
Asserted Claim of '533 Patent	Asada Combinations
	

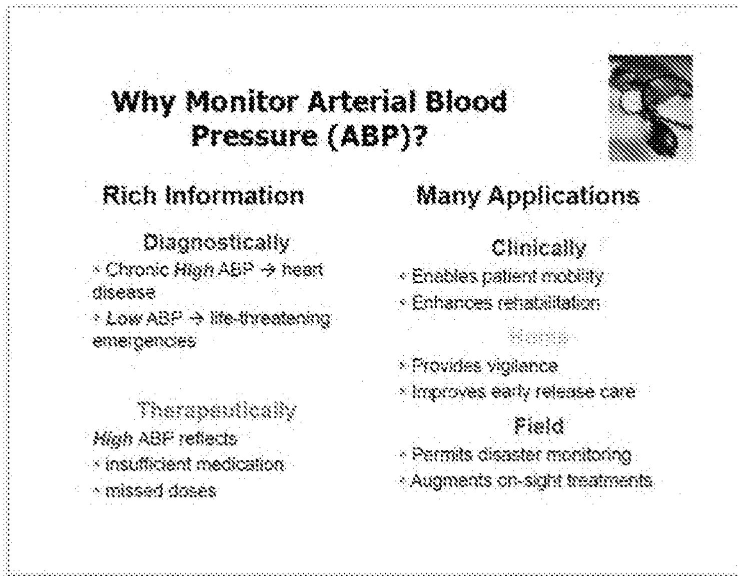
Asserted Claim of '533 Patent	Asada Combinations
	

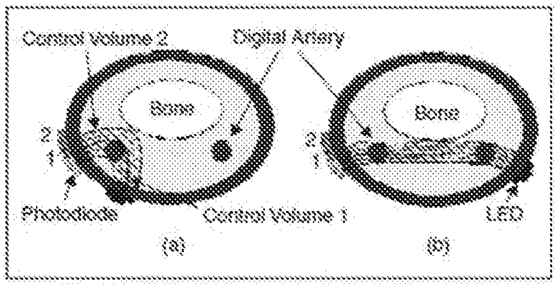
Asserted Claim of '533 Patent	Asada Combinations
	 Asada 2010 Page 35

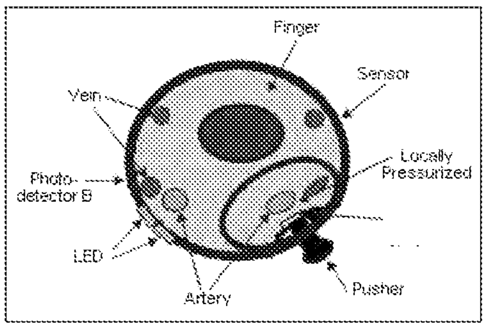
Omni MedSci, Inc. v. Apple Inc.
Case No. 2:18-cv-134-RWS (E.D. Tex.)

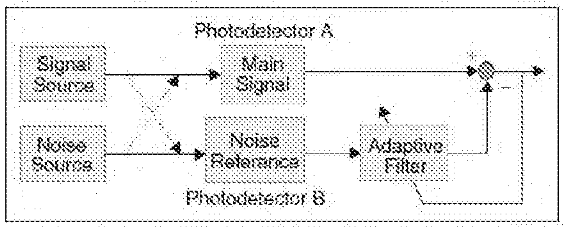
EXHIBIT CC-1, p. 55

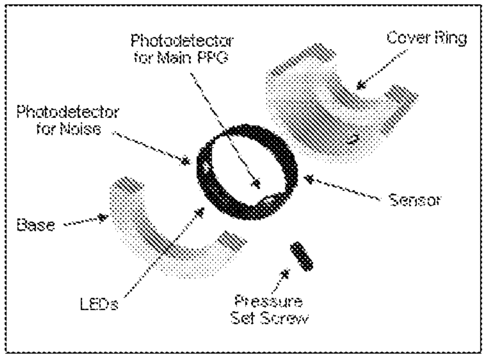
Asserted Claim of '533 Patent	Asada Combinations
	 Asada 2010 Figure 66

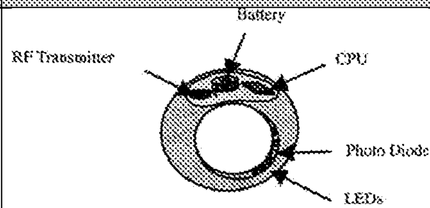
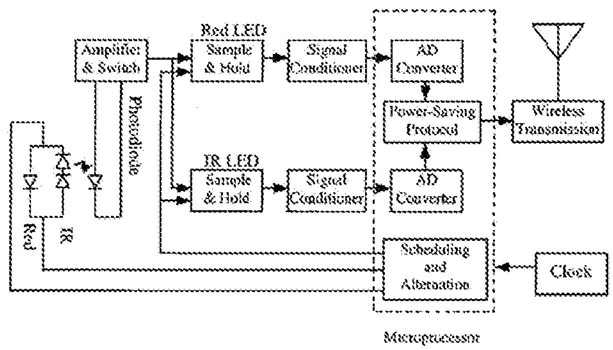
Asserted Claim of '533 Patent	Asada Combinations
	
[8] The system of claim 5, wherein the receiver is located a first distance from a first one of the plurality of light emitting diodes and a different, second distance from a second one of the plurality of light emitting diodes such that the receiver receives a first signal from the first light emitting diode and a second	The Asada Combinations disclose and/or render obvious "[t]he system of claim 5, wherein the receiver is located a first distance from a first one of the plurality of light emitting diodes and a different, second distance from a second one of the plurality of light emitting diodes such that the receiver receives a first signal from the first light emitting diode and a second signal from the second light emitting diode."

Asserted Claim of '533 Patent	Asada Combinations
signal from the second light emitting diode.	 Fig. 2. (a) For the reflective illumination method, movement of the photodiode relative to the LED (position 1 to position 2) leads to a photon path that no longer contains the digital artery. (b) For the transmittal illumination method, movement of the photodetector relative to the LED still contains photon paths that pass through the digital artery. "The location of the LEDs and a PD relative to the finger is an important design issue determining signal quality and robustness against motion artifact. Figure 2 shows a cross-sectional view of the finger with the ring sensor. The LEDs and PD are placed on the flanks of the finger rather than the dorsal and palmar sides." Asada 2003 at 30-31. "For these reasons, at least one optical device, either the PD or the LED, should be placed on one lateral face of the finger near the digital artery. The question is where to place the other device. Figure 2 shows two distinct cases. One case places both the PD and the LED on the same side of the finger-base, and the other places them on opposite sides of the finger. Placing both the PD and the LED on the same side creates a type of reflective PPG, while placing each of them on opposite sides makes a type of transmittal PPG. In the figure the average pathway of photons is shown for the two sensor arrangements. Although the exact photon path is difficult to obtain, due to the

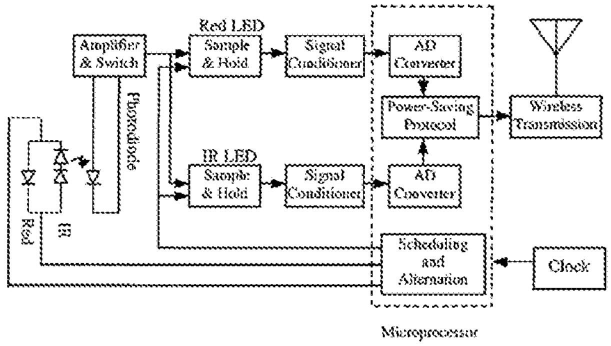
Asserted Claim of '533 Patent	Asada Combinations
	heterogeneous nature of the finger tissue and blood, a banana-shaped arc connecting the LED and PD, as shown in the figure, can approximate its average path [19]." Asada 2003 at 31. "Reflective PPG needs more secure attachments of the LED and PD to the skin surface, when compared to transmittal PPG. Once an air gap is created between the skin surface and the optical components due to some disturbance, a direct optical path from the LED to the PD may be created. This direct path exposes the PD directly to the light source and consequently leads to saturation. To avoid this short circuit, the LED light beam must be focused only in the normal direction, and the PD must also have a strong directional property (i.e., polarity), so that it is sensitive to only the incoming light normal to the device surface. Such strong directional properties, however, work adversely when a disturbance pressure acts on the sensor bodies, since it deflects the direction of the LED and PD leading to fluctuations in the out- put signal. As a result, reflective PPG configurations are more susceptive to disturbances." Asada 2003 at 31. "Figure 3 shows an experimental comparison between transmittal and reflective PPGs. Two sets of PPG sensors, one reflective and one transmittal, were attached to the same finger. Both were at rest initially, and then shaken. The transmittal PPG was quite stable, while the reflective PPG was susceptive to the motion disturbances." Asada 2003 at 31. 

Asserted Claim of '533 Patent	Asada Combinations
	Fig. 6. The schematic of a locally pressurized sensor band  Fig. 8. Block diagram of adaptive noise cancellation using second PPG sensor as noise reference "The motion detector can be used not only for monitoring the presence of motion but also for canceling noise. By using PD-B as a noise reference, a noise cancellation filter can be built to eliminate the noise of PD-A that correlates with the noise reference signal. Assuming that the hemodynamic process observed by PPG is stationary and that the noise is additive, adaptive noise canceling methods, such as the classical Widrow method [29], can be applied in order to recover the true pulsation signal from corrupted waveforms. As shown in Figure 8, the noise-canceling filter combines two sensor signals; one is the main signal captured by PD-A and the other is the noise reference obtained by PD-B. The main signal mostly consists of the true pulsatile signal, but it does contain some noise. If we know the proportion of the noise contained in the main signal, we can generate the noise of the same magnitude by attenuating the noise reference signal and then subtract the noise from the main signal to recover the true pulsatile signal." Asada 2003 at 33.

Asserted Claim of '533 Patent	Asada Combinations
	 **Fig. 15.** The schematic of the Prototype C ring sensor. "The local pressurization and motion detection methods described previously have been implemented for further improvement. Figure 15 shows the schematic of the Prototype C ring sensor. Both transmittal (PD-A) and reflective (PD-B) PPGs were mounted on the sensor band. The former is placed on top of a locally pressurizing mechanism with an adjustable setscrew. The latter is mounted on the low-pressure side in order to detect motion." Asada 2003 at 36. "See [30] for power budget and design details." Asada 2003 at 34. Asada 2001 – Figure 1

Asserted Claim of '533 Patent	Asada Combinations
	Fig. 1. Conceptual diagram of the ring sensor. Asada 2001 – Figure 4: Fig. 4. Block diagram of electronic circuit. "Fig. 4 shows a block diagram of the ring sensor circuitry. The basic circuit configuration is a standard PPG circuit combined with a wireless transmitter. There are a single photodiode and LEDs of two different wavelengths, red and near infrared, involved in the circuit. The output from the photodiode is amplified and conditioned at the first stage operational amplifier. While the red and infrared LEDs are alternately turned on and off, the signal from the first stage op-amp

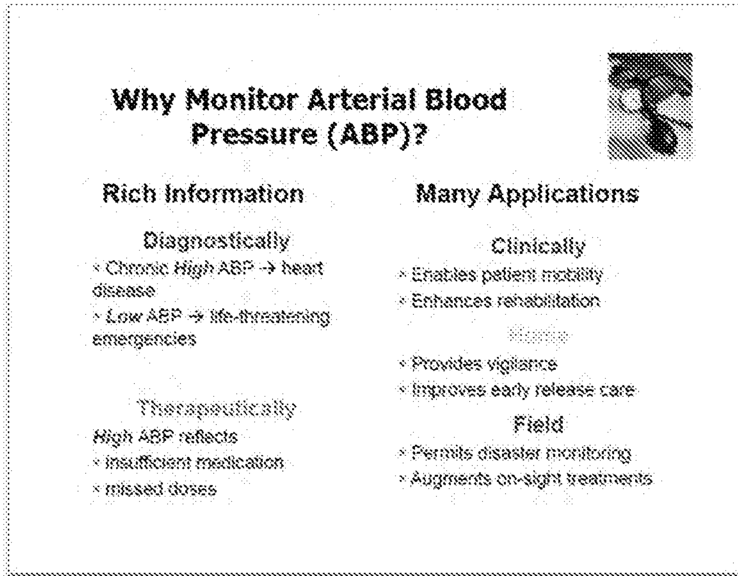
Asserted Claim of '533 Patent	Asada Combinations
	is sampled by the two sample-and-hold circuits at different timings in order to obtain the reflected light intensity from each LED. Each channel of the signal is conditioned and converted to a digital signal with an AD converter. Using the standard RS-232 protocol, the two channels of digital signals are transmitted via a RF transmitter." Asada 2001 at 797.
[9] The system of claim 5, wherein the output signal is generated in part by comparing the first and second signals	The Asada Combinations disclose and/or render obvious "[t]he system of claim 5, wherein the output signal is generated in part by comparing the first and second signals." "The motion detector can be used not only for monitoring the presence of motion but also for canceling noise. By using PD-B as a noise reference, a noise cancellation filter can be built to eliminate the noise of PD-A that correlates with the noise reference signal. Assuming that the hemodynamic process observed by PPG is stationary and that the noise is additive, adaptive noise canceling methods, such as the classical Widrow method [29], can be applied in order to recover the true pulsation signal from corrupted waveforms. As shown in Figure 8, the noise-canceling filter combines two sensor signals; one is the main signal captured by PD-A and the other is the noise reference obtained by PD-B. The main signal mostly consists of the true pulsatile signal, but it does contain some noise. If we know the proportion of the noise contained in the main signal, we can generate the noise of the same magnitude by attenuating the noise reference signal and then subtract the noise from the main signal to recover the true pulsatile signal." Asada 2003 at 33. "See [30] for power budget and design details." Asada 2003 at 34. Asada 2001 – Figure 4:

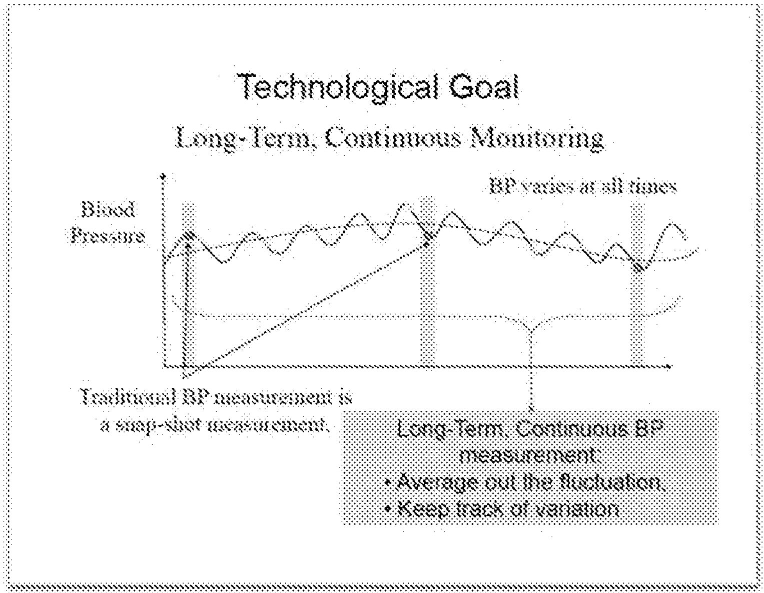
Asserted Claim of '533 Patent	Asada Combinations
	 Fig. 4. Block diagram of electronic circuit. "Fig. 4 shows a block diagram of the ring sensor circuitry. The basic circuit configuration is a standard PPG circuit combined with a wireless transmitter. There are a single photodiode and LEDs of two different wavelengths, red and near infrared, involved in the circuit. The output from the photodiode is amplified and conditioned at the first stage operational amplifier. While the red and infrared LEDs are alternately turned on and off, the signal from the first stage op-amp is sampled by the two sample-and-hold circuits at different timings in order to obtain the reflected light intensity from each LED. Each channel of the signal is conditioned and converted to a digital signal with an AD converter. Using the standard RS-232 protocol, the two channels of digital signals are transmitted via a RF transmitter." Asada 2001 at 797.
[10] The system of claim 5, wherein the output signal comprises one or more physiological parameters, and the	The Asada Combinations disclose and/or render obvious "[t]he system of claim 5, wherein the output signal comprises one or more physiological parameters, and the remote device is capable of

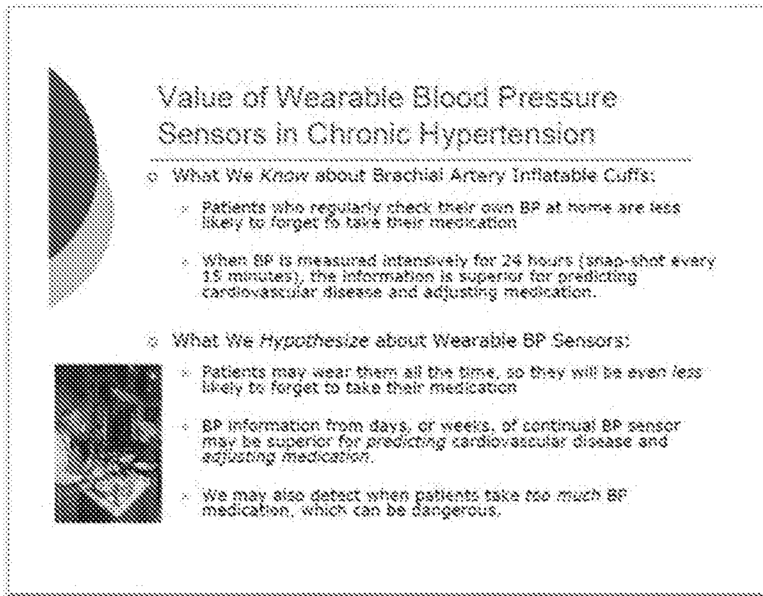
Asserted Claim of '533 Patent	Asada Combinations
remote device is capable of storing a history of at least a portion of the one or more physiological parameters over a specified period of time.	storing a history of at least a portion of the one or more physiological parameters over a specified period of time." "Wearable biosensors (WBS) will permit continuous cardiovascular (CV) monitoring in a number of novel settings." Asada 2003 at 28. "WBS could play an important role in the wireless surveillance of people during hazardous operations (military, fire-fighting, etc.), or such sensors could be dispensed during a mass civilian casualty occurrence. Given that CV physiologic parameters make up the 'vital signs' that are the most important information in emergency medical situations, WBS might enable a wireless monitoring system for large numbers of at-risk subjects." Asada 2003 at 28. "The WBS hardware solution must be adequate to make reliable physiologic measurements during activities of daily living or even more demanding circumstances such as fitness training or military battle." Asada 2003 at 28. "However, healthcare providers have only intermittent values of blood pressure on which to base therapy decisions; it is possible that continuous blood pressure monitoring would permit enhanced titration of therapy and reductions in mortality. Similarly, WBS would be able to log the physiologic signature of a patient's exercise efforts (manifested as changes in heart rate and blood pressure), permitting the patient and healthcare provider to assess compliance with a regimen proven to improve health outcomes." Asada 2003 at 28. "In this article we will address both technical and clinical issues of WBS. First, design concepts of a WBS will be presented, with emphasis on the ring sensor developed by the author's group at MIT. The ring sensor is an ambulatory, telemetric, continuous health-monitoring device. This WBS com- bines miniaturized data acquisition features with advanced photoplethysmographic (PPG) techniques to acquire data related to the patient's cardiovascular state using a method that is far superior to existing fingertip PPG sensors [1]. In particular, the ring sensor is capable of reliably monitoring a patient's heart rate, oxygen saturation, and heart rate variability. Technical issues, including motion artifact, interference with blood circulation, and battery power issues, will be addressed, and effective engineering solutions to alleviate these problems will be

Asserted Claim of '533 Patent	Asada Combinations
	presented. Second, based on the ring sensor technology the clinical potentials of WBS monitoring will be addressed." Asada 2003 at 28. "WBS solutions, in various stages of technologic maturity, exist for measuring established cardiopulmonary 'vital signs': heart rate, arterial blood pressure, arterial oxygen saturation, respiratory rate, temperature, and even cardiac output." Asada 2003 at 29. "At the same time, the physiologic information generated by WBS technology must trigger some appropriate system action to improve health outcomes. Abnormal states must be efficiently recognized while false alarms are minimized. This requires carefully designed WBS devices, as well as innovative postprocessing and intelligent data interpretation. Post-processing of sensor data can improve usability, as illustrated by recent improvements in pulse oximetry technology [3]-[5]. Data interpretation can occur in real time (as is necessary for detecting cardiovascular-related catastrophes) or offline (as is the standard-of-care for arrhythmia surveillance using Holter and related monitoring). Real-time alarm "algorithms" using simple thresholds for measured parameters, like heart rate and oxygen saturation, have demonstrated high rates of false alarms [6], [7]. Algorithms for off-line, retrospective data analysis are also in a developmental stage. Studies of novel automated "triage" software used to interpret hours of continuous noninvasive ECG data of monitored outpatients suggest that the software's diagnostic yield is not equal to a human's when it comes to arrhythmia detection [8], [9]." Asada 2003 at 29. "The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "WBS, in conjunction with diagnostic algorithms and some specific response (which might be human or automated in nature), stand to ameliorate physiologic catastrophes occurring outside conventional clinical environments. For instance, WBS can play an important role in the wireless surveillance of people during hazardous operations (military, fire-fighting, etc.), or such sensors can be dispensed during a mass civilian casualty occurrence. In an overcrowded Emergency Department, patients who are in the waiting room for hours with an undifferentiated medical complaint will receive state-of-the-art physiologic monitoring. For hospital in-patients who require

Asserted Claim of '533 Patent	Asada Combinations
	CV monitoring, current biosensor technology typically tethers patients in a tangle of cables. For convalescing patients in a hospital, or a rehabilitation center, there would no longer be a dichotomy between optimal bed-bound monitoring and optimal rehabilitation consisting of ambulation and a full scope of physical activities. Given the physical freedom when monitored by WBS, inpatients may experience less physical deconditioning, and these two factors together may impact the not insignificant problem of dangerous inpatient falls in the elderly (an incidence on the order of 1-5% per admission [32], [33])." Asada 2003 at 37. "AS THE population of aged people increases, vital sign monitoring is increasingly important for securing their independent lives. On-line, continuous monitoring allows us to detect emergencies and abrupt changes in the patient conditions. Especially for cardiac patients, on-line, long-term monitoring plays a pivotal role. It provides critical information for long-term assessment and preventive diagnosis for which long-term trends and signal patterns are of special importance. Such trends and patterns can hardly be identified by traditional examinations. Those cardiac problems that occur frequently during normal daily activities may disappear the moment the patient is hospitalized, causing diagnostic difficulties and consequently possible therapeutic errors. Continuous and ambulatory monitoring systems such as ambulatory electrocardiogram (EKG) are, therefore, needed to detect the trait….In general, long-term, ambulatory monitoring systems have not yet reached a technical level that is widely accepted by both clinicians and patients. Such long-term, ambulatory devices must be compact, lightweight, and comfortable to wear at all times. They must be designed for low power consumption for long-term use. Furthermore, they must be able to detect signals reliably and stably in the face of motion artifact and various disturbances. Unlike traditional monitoring systems, these devices are used under no supervision of clinicians. Data is collected from daily lives of patients in an unstructured environment. The goal of this paper is to develop technology for reducing motion artifact and obtaining reliable measurements of vital signs for long-term use." Asada 2001 at 795. "A prototype ring sensor has been designed, built, and tested. Experiments have verified that the ring sensor can detect beat-to-beat pulsation in the face of interfering force and acceleration acting on the ring body. With small battery cells, the ring sensor can continuously detect and transmit

Asserted Claim of '533 Patent	Asada Combinations
	plethysmograph signals for 23.3 days, while the battery life can be extended to several months with an intermittent measurement schedule." Asada 2001 at 805. Asada 2010 Pages 26-31 Asada 2010 Page 35 

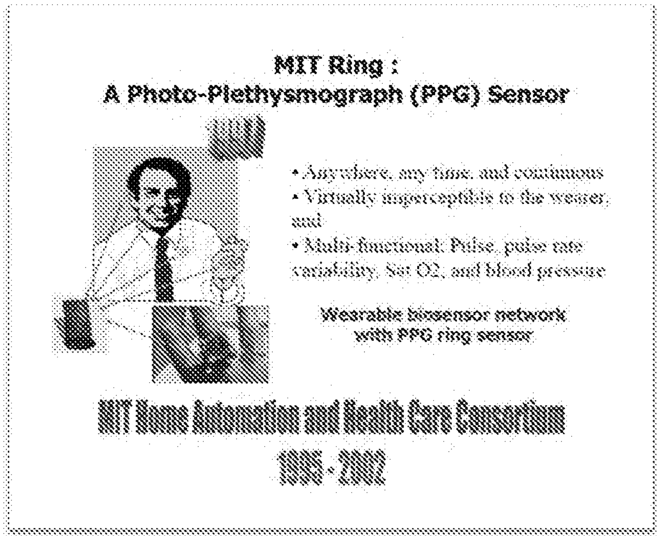
Asserted Claim of '533 Patent	Asada Combinations
	Asada 2010 Page 37  Asada 2010 Page 66

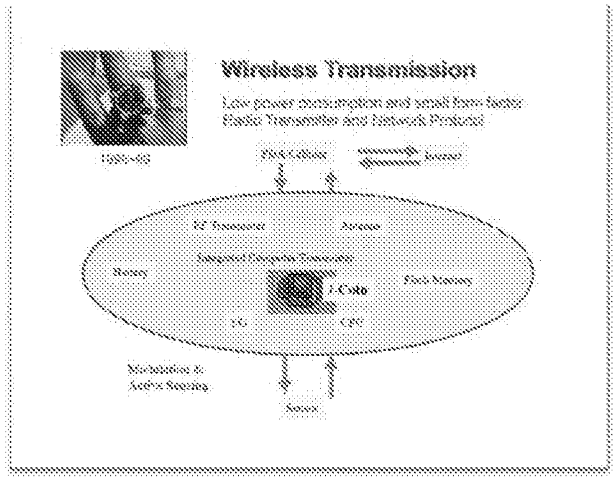
Asserted Claim of '533 Patent	Asada Combinations
	
[13] A measurement system comprising	To the extent the preamble is limiting, The Asada Combinations disclose and/or render obvious "[a] measurement system." *See generally* Asada 2003 Figures 6, 9, 11, 15 and descriptions of Prototypes A, B, and C. "Wearable biosensors (WBS) will permit continuous cardiovascular (CV) monitoring in a number of novel settings. Benefits may be realized in the diagnosis and treatment of a number of major diseases. WBS, in conjunction with appropriate alarm algorithms, can increase surveillance capabilities for CV catastrophe for high-risk subjects. WBS could also play a role in the treatment

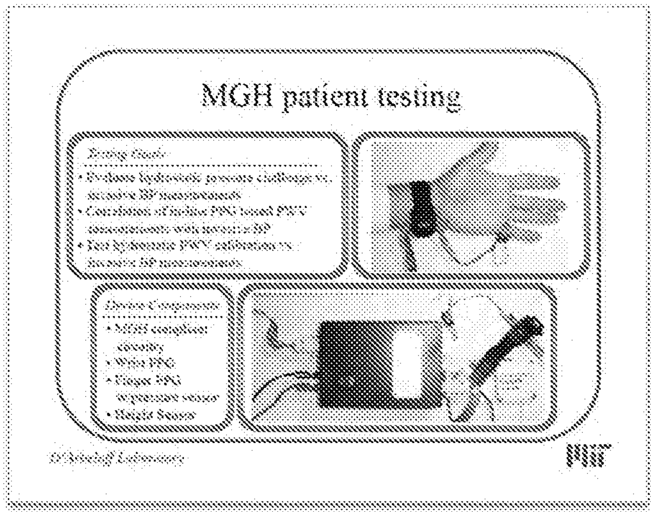
Asserted Claim of '533 Patent	Asada Combinations
	of chronic diseases, by providing information that enables precise titration of therapy or detecting lapses in patient compliance. WBS could play an important role in the wireless surveillance of people during hazardous operations (military, fire-fighting, etc.), or such sensors could be dispensed during a mass civilian casualty occurrence. Given that CV physiologic parameters make up the "vital signs" that are the most important information in emergency medical situations, WBS might enable a wireless monitoring system for large numbers of at-risk subjects. This same approach may also have utility in monitoring the waiting room of today's overcrowded emergency departments. For hospital inpatients who require CV monitoring, current biosensor technology typically tethers patients in a tangle of cables, whereas wearable CV sensors could increase inpatient comfort and may even reduce the risk of tripping and falling, a perennial problem for hospital patients who are ill, medicated, and in an unfamiliar setting." Asada 2003 28. "In this article we will address both technical and clinical issues of WBS. First, design concepts of a WBS will be presented, with emphasis on the ring sensor developed by the author's group at MIT. The ring sensor is an ambulatory, telemetric, continuous health-monitoring device. This WBS combines miniaturized data acquisition features with advanced photoplethysmographic (PPG) techniques to acquire data related to the patient's cardiovascular state using a method that is far superior to existing fingertip PPG sensors [1]. In particular, the ring sensor is capable of reliably monitoring a patient's heart rate, oxygen saturation, and heart rate variability. Technical issues, including motion artifact, interference with blood circulation, and battery power issues, will be addressed, and effective engineering solutions to alleviate these problems will be presented. Second, based on the ring sensor technology the clinical potentials of WBS monitoring will be addressed." Asada 2003 at 28. "The WBS hardware solution must be adequate to make reliable physiologic measurements during activities of daily living or even more demanding circumstances such as fitness training or military battle. There must exist data processing and decision-making algorithms for the waveform data. These algorithms must prompt some action that improves health outcomes. Finally, the systems

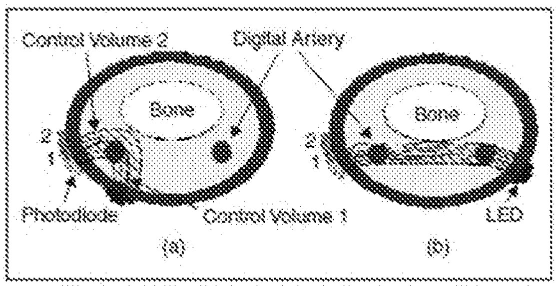
Asserted Claim of '533 Patent	Asada Combinations
	must be cost effective when compared with less expensive, lower technology alternatives." Asada 2003 at 28. "The monitoring environments for out-of-hospital, wearable devices demand a new paradigm in noninvasive sensor design. There are several design requirements central to such devices. Compactness, stability of signal, motion and other disturbance rejection, durability, data storage and transmission, and low power consumption comprise the major design considerations. Additionally, since WBS devices are to be worn without direct doctor supervision, it is imperative that they are simple to use and comfortable to wear for long periods of time. A challenge unique to wearable sensor design is the trade-off between patient comfort, or long-term wearability, and reliable sensor attachment. While it is nearly needless to say that WBS technology must be safe, it should be noted that there have been tragic reports of serious injury resulting from early home monitoring technology [2]." Asada 2003 28-29. "WBS solutions, in various stages of technologic maturity, exist for measuring established cardiopulmonary 'vital signs': heart rate, arterial blood pressure, arterial oxygen saturation, respiratory rate, temperature, and even cardiac output. In addition, there are numerous WBS modalities that can offer physiologic measurements not conventional in contemporary medical monitoring applications, including acoustic sensors, electrochemical sensors, optical sensors, electromyography and electroencephalography, and other bioanalytic sensors (to be sure, some of these sensors have well-established medical utility, but not for automated surveillance)." Asada 2003 at 29. "This article focuses on a wearable ring pulse-oximeter solution, which measures the PPG as well as the arterial oxygen saturation. The PPG contains information about the vascular pressure wave-forms and compliances. Efforts to extract unique circulatory in- formation, especially an ABP surrogate, from the PPG waveform are discussed later in this article. The PPG provides an effective heart rate (measuring heart beats that generate identifiable forward-flow), useful for circulatory consider- ations though less useful for strict electrophysiologic considerations. For instance, the PPG signal may reveal heart rate variability, provided ectopic heart beats, which corrupt the association with autonomic tone, can be excluded." Asada 2003 at 29-30.

Asserted Claim of '533 Patent	Asada Combinations
	"To evaluate how a pressure applied to the finger base interferes with blood circulation, the blood flow toward the fingertip was measured by using Nellcor's PPG sensor attached to the fingertip." Asada 2003 at 36. "The ring sensor is a miniaturized, telemetric, monitoring device worn by a patient as a finger ring. The ring encapsulates PPG, pulse oximetry combined with wireless communication and miniaturization technologies. This device optically captures the pulsation and oxygen saturation of the arterial blood flow, and transmits the signals to a host computer via a radio-frequency (RF) transmitter. Fig. 1 shows a conceptual diagram of the ring sensor [5], [6]. The ring sensor consists of optoelectronic components, a CPU, a RF transmitter, a battery, and a ring chassis. The optoelectronic components, i.e., micro photodiodes and LEDs, detect the blood-volume waveforms and oxygen-saturation level at the patient's digital artery. The CPU controls the LED lighting sequence as well as the data acquisition and transmission process. These signals are locally processed by the on-board CPU and transmitted to a host computer for diagnosis of the patient's cardiovascular conditions. The ring sensor is completely wireless and miniaturized so that the patient can wear the device comfortably 24 h/day." Asada 2001 at 796. Asada 2010 page 3

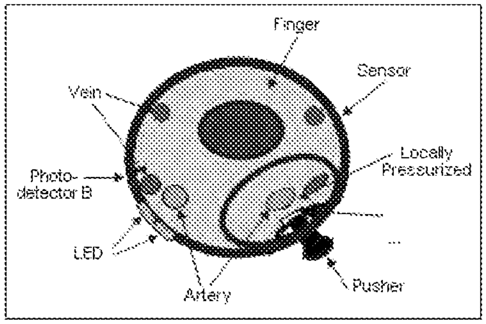
Asserted Claim of '533 Patent	Asada Combinations
	 Asada 2010 page 9

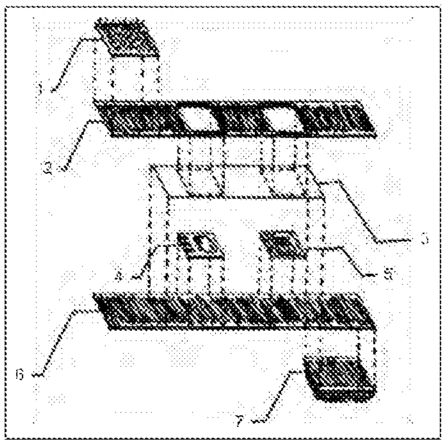
Asserted Claim of '533 Patent	Asada Combinations
	 Asada 2010 – Page 62

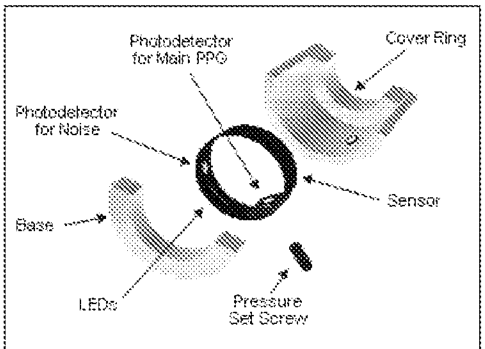
Asserted Claim of '533 Patent	Asada Combinations
	
[13A] a wearable measurement device for measuring one or more physiological parameters, including a light source comprising a plurality of semiconductor sources that are light emitting diodes, the light emitting diodes configured to generate an output optical beam	The Asada Combinations disclose and/or render obvious "a light source comprising a plurality of semiconductor sources that are light emitting diodes, the light emitting diodes configured to generate an output optical beam with one or more optical wavelengths." "Furthermore, wearable PPG sensors are exposed to diverse ambient lighting conditions, ranging from direct sunlight to flickering room light. In addition, wearable PPG sensors must be designed for reduced power consumption. Carrying a large battery pack is not acceptable for long-term applications. The whole sensor system must run continually using a small battery. Several ways to cope with these difficulties are:

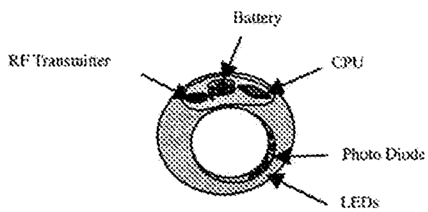
Asserted Claim of '533 Patent	Asada Combinations
with one or more optical wavelengths,	➤ secure the LEDs and the photodetector (PD for short) at a location along the finger skin such that the dc component may be influenced less by the finger motion ➤ modulate the LEDs to attenuate the influence of uncorrelated ambient light as well as to reduce power consumption…" Asada 2003 at 30.  Fig. 2. (a) For the reflective illumination method, movement of the photodiode relative to the LED (position 1 to position 2) leads to a photon path that no longer contains the digital artery. (b) For the transmittal illumination method, movement of the photodetector relative to the LED still contains photon paths that pass through the digital artery. "The location of the LEDs and a PD relative to the finger is an important design issue determining signal quality and robustness against motion artifact. Figure 2 shows a cross-sectional view of the finger with the ring sensor. The LEDs and PD are placed on the flanks of the finger rather than the dorsal and palmar sides." Asada 2003 at 30-31. "For these reasons, at least one optical device, either the PD or the LED, should be placed on one lateral face of the finger near the digital artery. The question is where to place the other device. Figure 2 shows two distinct cases. One case places both the PD and the LED on the same side of

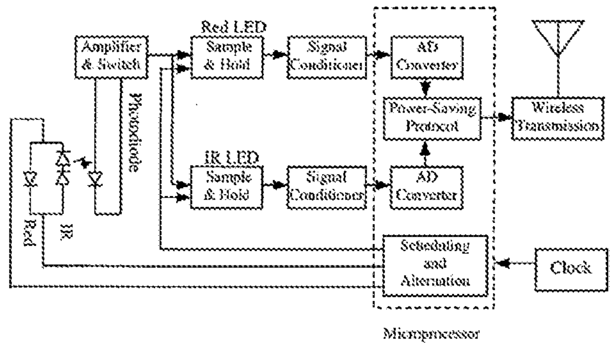
Asserted Claim of '533 Patent	Asada Combinations
	the finger-base, and the other places them on opposite sides of the finger. Placing both the PD and the LED on the same side creates a type of reflective PPG, while placing each of them on opposite sides makes a type of transmittal PPG. In the figure the average pathway of photons is shown for the two sensor arrangements. Although the exact photon path is difficult to obtain, due to the heterogeneous nature of the finger tissue and blood, a banana-shaped arc connecting the LED and PD, as shown in the figure, can approximate its average path [19]." Asada 2003 at 31. "Reflective PPG needs more secure attachments of the LED and PD to the skin surface, when compared to transmittal PPG. Once an air gap is created between the skin surface and the optical components due to some disturbance, a direct optical path from the LED to the PD may be created. This direct path exposes the PD directly to the light source and consequently leads to saturation. To avoid this short circuit, the LED light beam must be focused only in the normal direction, and the PD must also have a strong directional property (i.e., polarity), so that it is sensitive to only the incoming light normal to the device surface. Such strong directional properties, however, work adversely when a disturbance pressure acts on the sensor bodies, since it deflects the direction of the LED and PD leading to fluctuations in the out- put signal. As a result, reflective PPG configurations are more susceptive to disturbances." Asada 2003 at 31. "Furthermore, transmittal PPG is less sensitive to local disturbances acting on the finger, since the LED irradiates a larger volume of the finger. In the transmittal PPG configuration, the percentage of the measured signal does not significantly change although some peripheral capillary beds are collapsed. The percentage change is greater for reflective PPG, since this volume is smaller." Asada 2003 at 31. "Figure 3 shows an experimental comparison between transmittal and reflective PPGs. Two sets of PPG sensors, one reflective and one transmittal, were attached to the same finger. Both were at rest initially, and then shaken. The transmittal PPG was quite stable, while the reflective PPG was susceptive to the motion disturbances." Asada 2003 at 31.

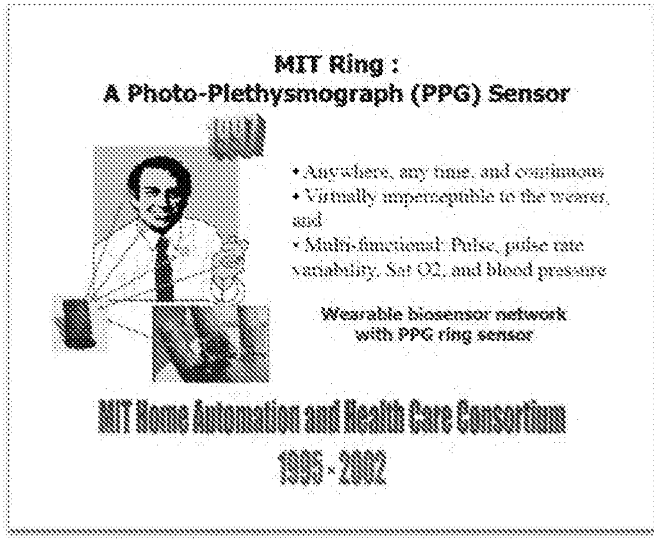
Asserted Claim of '533 Patent	Asada Combinations
	 **Fig. 8.** The schematic of a locally pressurized sensor band.  **Fig. 9.** First prototype ring sensor with RF transmitter powered by a coin-size cell battery.

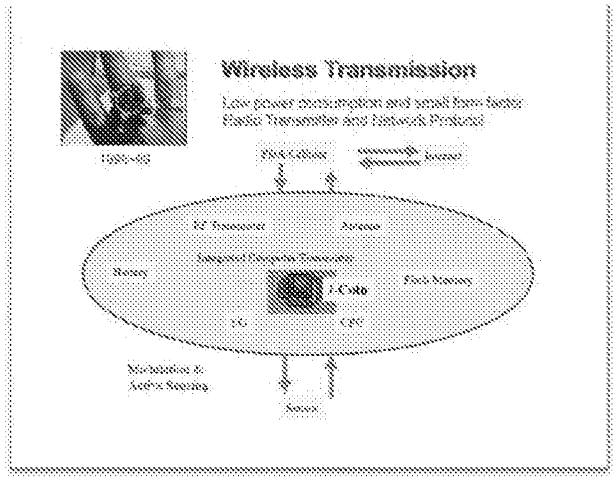
Asserted Claim of '533 Patent	Asada Combinations
	"Figure 9 shows the first ring sensor prototype that contains an optical sensor unit, analog and digital processing units, and an RF transmitter, all of which are encapsulated in a compact body and powered by a tiny cell battery used for wristwatches. The ring has a PIC microcomputer performing all the device controls and low-level signal processing, including LED modulation, data acquisition, filtering, and bi-directional RF communication. The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz. The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "In this early development, the power consumption of the LEDs and the imbedded CPU clock were a major bottleneck limiting the design. The distance between the LEDs and PDs had to be shortened for power saving considerations, and the CPU clock was minimized in order to extend the battery life to a few weeks. See [30] for power budget and design details." Asada 2003 at 34. 

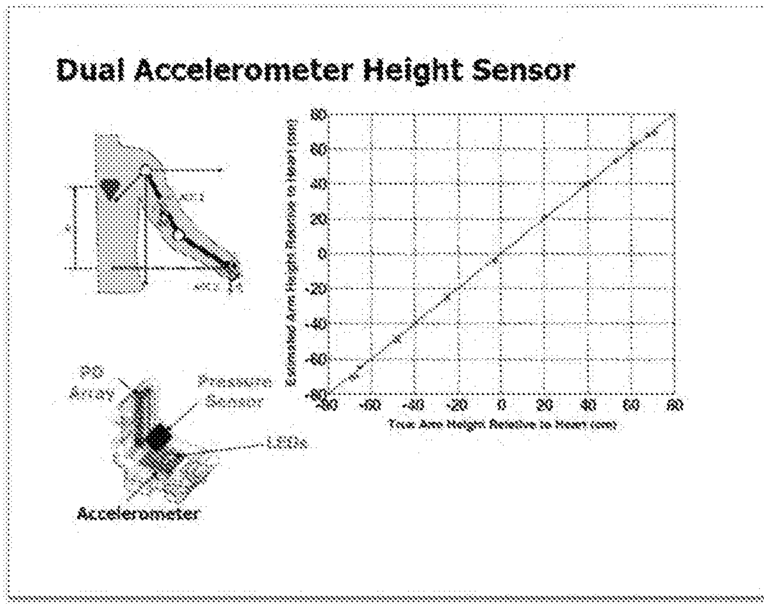
Asserted Claim of '533 Patent	Asada Combinations
	Fig. 11. Redesigned sensor band that protects optical components from direct contact with skin and hides wires from outside environment. "To improve motion artifact resistance and accuracy, a transmittal PPG ring sensor, Prototype B, has been built and field-tested. Prototype B has high-speed optical devices enabling the lowering of the LED duty rate to 1/1,000. The LED used is 6.7 times brighter than that of Prototype A, while the resultant power consumption is 173 times smaller than before. The sensor band was redesigned with the use of bio-compatible elastic materials to better hold the LED's and PD's, maintain a proper level of pressure, optically shield the sensor unit, and secure the contact with the skin consistently in the face of finger motion (see Figure 11). As a result, the waveform of this transmittal PPG was quite stable. Figure 3 presented earlier is the experiment of Prototype B. Note that the transmittal PPG (Prototype B) signal did not collapse even when the hand was shaken. Additionally, the analog filtering circuit was optimized for quality of signal. These modifications greatly improved the ability of the device to measure traditionally difficult variables such as heart rate variability (Table 1, Figure 12)." Asada 2003 at 35.  **Fig. 15.** The schematic of the Prototype C ring sensor.

Asserted Claim of '533 Patent	Asada Combinations
	"The local pressurization and motion detection methods described previously have been implemented for further improvement. Figure 15 shows the schematic of the Prototype C ring sensor. Both transmittal (PD-A) and reflective (PD-B) PPGs were mounted on the sensor band. The former is placed on top of a locally pressurizing mechanism with an adjustable setscrew. The latter is mounted on the low-pressure side in order to detect motion." Asada 2003 at 36. "The ring sensor is a miniaturized, telemetric, monitoring device worn by a patient as a finger ring. The ring encapsulates PPG, pulse oximetry combined with wireless communication and miniaturization technologies. This device optically captures the pulsation and oxygen saturation of the arterial blood flow, and transmits the signals to a host computer via a radio-frequency (RF) transmitter. Fig. 1 shows a conceptual diagram of the ring sensor [5], [6]. The ring sensor consists of optoelectronic components, a CPU, a RF transmitter, a battery, and a ring chassis. The optoelectronic components, i.e., micro photodiodes and LEDs, detect the blood-volume waveforms and oxygen-saturation level at the patient's digital artery. The CPU controls the LED lighting sequence as well as the data acquisition and transmission process. These signals are locally processed by the on-board CPU and transmitted to a host computer for diagnosis of the patient's cardiovascular conditions. The ring sensor is completely wireless and miniaturized so that the patient can wear the device comfortably 24 h/day." Asada 2001 at 796. Asada 2001 – Figure 1  Fig. 1. Conceptual diagram of the ring sensor.

Asserted Claim of '533 Patent	Asada Combinations
	Asada 2001 – Figure 4:  Fig. 4. Block diagram of electronic circuit. "Fig. 4 shows a block diagram of the ring sensor circuitry. The basic circuit configuration is a standard PPG circuit combined with a wireless transmitter. There are a single photodiode and LEDs of two different wavelengths, red and near infrared, involved in the circuit. The output from the photodiode is amplified and conditioned at the first stage operational amplifier. While the red and infrared LEDs are alternately turned on and off, the signal from the first stage op-amp is sampled by the two sample-and-hold circuits at different timings in order to obtain the reflected light intensity from each LED. Each channel of the signal is conditioned and converted to a digital signal with an AD converter. Using the standard RS-232 protocol, the two channels of digital signals are transmitted via a RF transmitter." Asada 2001 at 797.

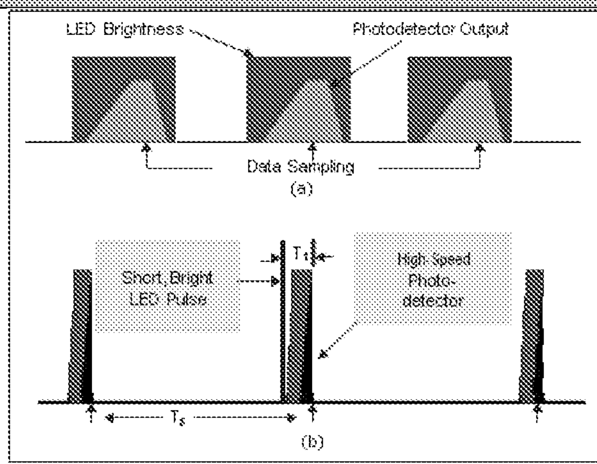
Asserted Claim of '533 Patent	Asada Combinations
	Asada 2010 page 3  Asada 2010 page 9

Asserted Claim of '533 Patent	Asada Combinations
	 Asada 2010 – Page 50

Asserted Claim of '533 Patent	Asada Combinations
	
[13B] wherein at least a portion of the one or more optical wavelengths is a near-infrared	The Asada Combinations disclose and/or render obvious "wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers."

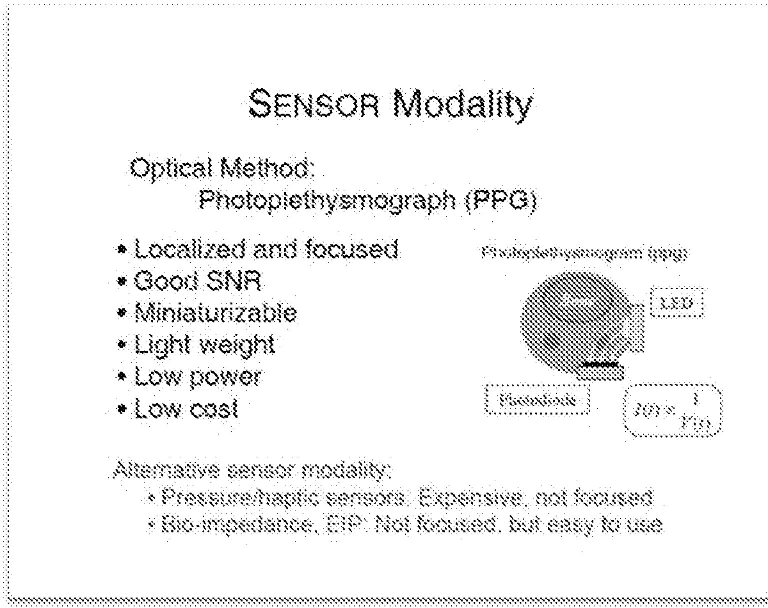
Asserted Claim of '533 Patent	Asada Combinations
wavelength between 700 nanometers and 2500 nanometers,	"Figure 9 shows the first ring sensor prototype that contains an optical sensor unit, analog and digital processing units, and an RF transmitter, all of which are encapsulated in a compact body and powered by a tiny cell battery used for wristwatches. The ring has a PIC microcomputer performing all the device controls and low-level signal processing, including LED modulation, data acquisition, filtering, and bi-directional RF communication. The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz. The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "High-speed LEDs and PDs, which have become available at low cost in recent years, can be used for this purpose. Figure 4 shows a schematic of high-frequency, low-duty cycle modulation implemented to minimize LED power consumption. Utilizing fast rise-time optical detectors, it is possible to incorporate a modulation frequency of 1 kHz with a duty ratio of 0.1%, a theoretical power usage that is 1,000 times less than conventional full-cycle modulation methods [23]." Asada 2003 at 32. "See [30] for power budget and design details." Asada 2003 at 34. "To improve motion artifact resistance and accuracy, a transmittal PPG ring sensor, Prototype B, has been built and field-tested. Prototype B has high-speed optical devices enabling the lowering of the LED duty rate to 1/1,000. The LED used is 6.7 times brighter than that of Prototype A, while the resultant power consumption is 173 times smaller than before." Asada 2003 at 35. "*LEDs and Photodiode*: One red LED and two infrared LEDs are used as the light sources. The peak wavelength of the red LED is 660 nm, and that of the infrared LEDs is 940 nm. The photodiode has the peak wavelength of 940 nm and the spectral sensitivity ranges from 500 nm to 1000 nm, which meets our needs. The voltage drop across the red LED is 1.6 V and that of the infrared LEDs is 1.2 V, and two infra-red LEDs are connected in serial. These LEDs are in a die form with a size of 0.3 mm x 0.3 mm." Asada 2001 at 800.
[13C] the light source configured to increase signal-to-noise ratio by increasing a light intensity	The Asada Combinations disclose and/or render obvious "the light source configured to increase signal-to-noise ratio by increasing a light intensity from at least one of the plurality of

Asserted Claim of '533 Patent	Asada Combinations
from at least one of the plurality of semiconductor sources and by increasing a pulse rate of at least one of the plurality of semiconductor sources;	semiconductor sources and by increasing a pulse rate of at least one of the plurality of semiconductor sources." "Furthermore, wearable PPG sensors are exposed to diverse ambient lighting conditions, ranging from direct sunlight to flickering room light. In addition, wearable PPG sensors must be designed for reduced power consumption. Carrying a large battery pack is not acceptable for long-term applications. The whole sensor system must run continually using a small battery. Several ways to cope with these difficulties are: ➤ secure the LEDs and the photodetector (PD for short) at a location along the finger skin such that the dc component may be influenced less by the finger motion ➤ modulate the LEDs to attenuate the influence of uncorrelated ambient light as well as to reduce power consumption ➤ increase the amplitude of the ac component so that the signal-to-noise ratio may increase ➤ measure the finger motion with another sensor or a second PD and use it as a noise reference for verifying the signal as well as for canceling the disturbance and noise. In the following sections these methods will briefly be discussed, followed by specific sensor designs and performance tests." Asada 2003 at 30.

Asserted Claim of '533 Patent	Asada Combinations
	 **Fig. 4.** (a) The slow response time of the photodetector meant that the LED had to be modulated at lower frequencies for data sampling. (b) A faster photodetector response time makes it possible to increase the modulation frequency of the LED. "Transmittal PPG must have a powerful LED for transmitting light across the finger. This power consumption problem can be solved with a lighting modulation technique using high-speed devices. Instead of lighting the skin continually, the LED is turned on only for a short time, say 100 ~ 1000 ns, and the signal is sampled within this period. High-speed LEDs and PDs, which have become available at low cost in recent years, can be used for this purpose. Figure 4 shows a schematic of high-frequency, low-duty cycle modulation implemented to minimize LED power consumption. Utilizing fast rise-time optical detectors, it is possible to incorporate a modulation frequency of 1 kHz with a duty ratio of 0.1%, a theoretical power usage that is 1,000 times less than conventional full-cycle modulation methods [23]." Asada 2003 at 32.

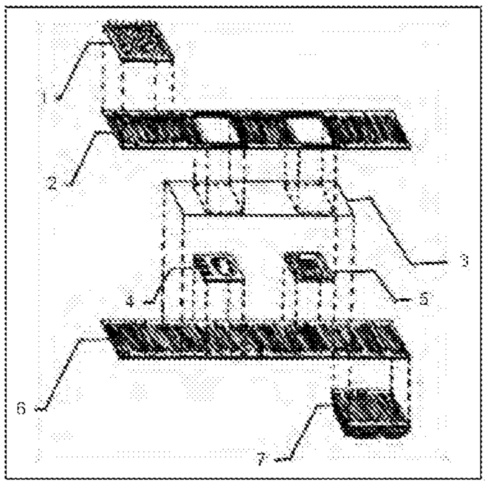
Asserted Claim of '533 Patent	Asada Combinations
	"In addition to saving power, the modulation of LED lighting provides an effective means for reducing ambient light disturbances. Reading the PD output while the LED is turned off yields the baseline PPG level attributed to the ambient light alone. Subtracting this reading from the one acquired with the LED illuminated gives the net output correlated with the LED lighting. More sophisticated modulation schemes can be applied by controlling the LED brightness as a periodic time function. Computational power requirements often prohibit complex modulation, however. Design trade-offs must be considered to find the best modulation scheme." Asada 2003 at 32. Asada 2003 explains that "according to the Lambert-Beer law, the brightness decreases exponentially as the distance from the light source increases." In order to improve the signal-to-noise ratio, brightness of the light is increased by "application of an external pressure on the tissue surrounding the artery" in order to increase the detected amplitude of arterial pulsations. Asada 2003 at 32. "Figure 5 shows the pulsatile amplitude of a finger base PPG for varied pressures generated by a finger cuff. As the cuff pressure increases, the PPG amplitude increases until it reaches a maximum." Asada 2003 at 32. "See [30] for power budget and design details." Asada 2003 at 34. "Among others, LED is one of the most power-consuming parts involved in the ring sensor. Therefore, the intensity of the LEDs must be lowered along with the reduction of duty cycle. This, however, incurs a poor signal-to-noise ratio problem. The signals obtained with dark LEDs are weak and must, therefore, be amplified many thousand times. As a result, it becomes susceptive to any disturbances. There are a number of existing techniques for dealing with artifact and disturbance rejection. The most common is signal processing, as reviewed by [11]. Another standard method is to identify and reject corrupt signals by comparing pulse features with a predetermined template. Other methods use modulation by controlling the power level of multiple lighting sources [11]." Asada 2001 at 796. "For the prototype ring sensor, the sample-and-hold frequency was set to f = 1000 Hz. The choice of this frequency depends on applications. A lower sampling frequency can be used when required accuracy is lower." Asada 2001 at 800.

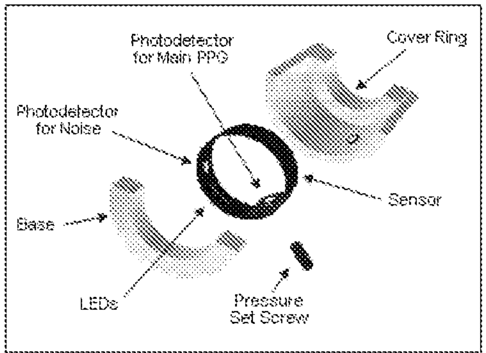
<table>
<tr><th>Asserted Claim of '533 Patent</th><th>Asada Combinations</th></tr>
<tr><td></td><td>Asada 2010 Page 52


</td></tr>
<tr><td>[13D] the wearable measurement device comprising a plurality of lenses configured to receive a portion of the output optical beam and to deliver an analysis output beam to a sample;</td><td>The Asada Combinations disclose and/or render obvious "the wearable measurement device comprising a plurality of lenses configured to receive a portion of the output optical beam and to deliver an analysis output beam to a sample."

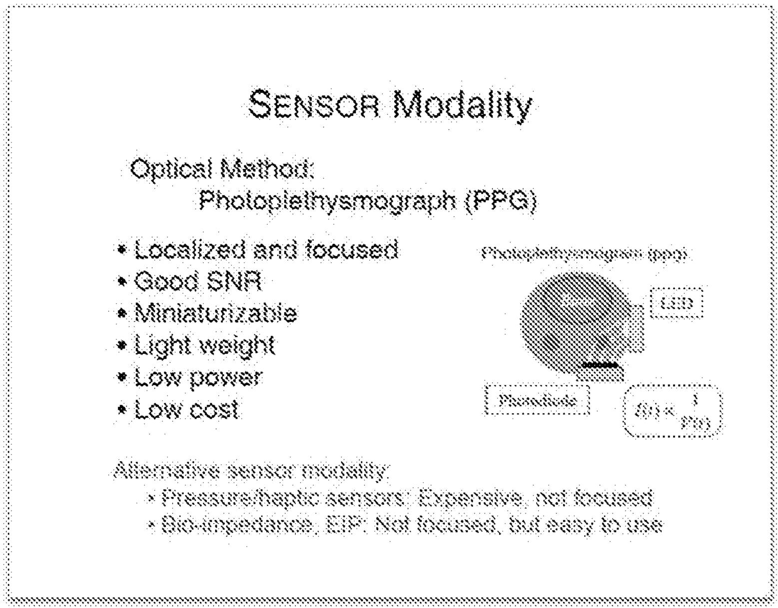
"Reflective PPG needs more secure attachments of the LED and PD to the skin surface, when compared to transmittal PPG. Once an air gap is created between the skin surface and the optical components due to some disturbance, a direct optical path from the LED to the PD may be created.</td></tr>
</table>

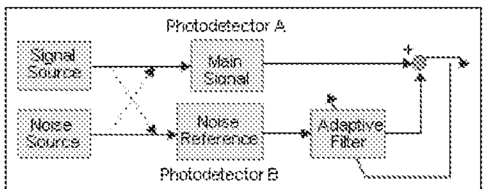
Asserted Claim of '533 Patent	Asada Combinations
	This direct path exposes the PD directly to the light source and consequently leads to saturation. To avoid this short circuit, the LED light beam must be focused only in the normal direction, and the PD must also have a strong directional property (i.e., polarity), so that it is sensitive to only the incoming light normal to the device surface." Asada 2003 at 31.  Fig. 9. First prototype ring sensor with RF transmitter powered by a coin-size cell battery.

Asserted Claim of '533 Patent	Asada Combinations
	"Figure 9 shows the first ring sensor prototype that contains an optical sensor unit, analog and digital processing units, and an RF transmitter, all of which are encapsulated in a compact body and powered by a tiny cell battery used for wristwatches. The ring has a PIC microcomputer performing all the device controls and low-level signal processing, including LED modulation, data acquisition, filtering, and bi-directional RF communication. The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz. The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "See [30] for power budget and design details." Asada 2003 at 34.  Fig. 11. Redesigned sensor band that protects optical components from direct contact with skin and hides wires from outside environment.

Asserted Claim of '533 Patent	Asada Combinations
	"To improve motion artifact resistance and accuracy, a transmittal PPG ring sensor, Prototype B, has been built and field-tested. Prototype B has high-speed optical devices enabling the lowering of the LED duty rate to 1/1,000. The LED used is 6.7 times brighter than that of Prototype A, while the resultant power consumption is 173 times smaller than before. The sensor band was redesigned with the use of bio-compatible elastic materials to better hold the LED's and PD's, maintain a proper level of pressure, optically shield the sensor unit, and secure the contact with the skin consistently in the face of finger motion (see Figure 11). As a result, the waveform of this transmittal PPG was quite stable. Figure 3 presented earlier is the experiment of Prototype B. Note that the transmittal PPG (Prototype B) signal did not collapse even when the hand was shaken. Additionally, the analog filtering circuit was optimized for quality of signal. These modifications greatly improved the ability of the device to measure traditionally difficult variables such as heart rate variability (Table 1, Figure 12)." Asada 2003 at 35.  Fig. 15. The schematic of the Prototype C ring sensor. "The local pressurization and motion detection methods described previously have been implemented for further improvement. Figure 15 shows the schematic of the Prototype C ring sensor. Both transmittal (PD-A) and reflective (PD-B) PPGs were mounted on the sensor band.

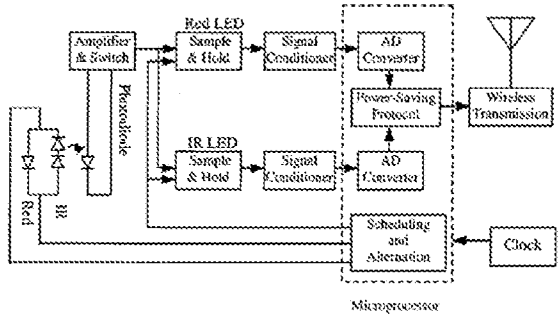
Asserted Claim of '533 Patent	Asada Combinations
	The former is placed on top of a locally pressurizing mechanism with an adjustable setscrew. The latter is mounted on the low-pressure side in order to detect motion." Asada 2003 at 36. Asada 2010 Page 52

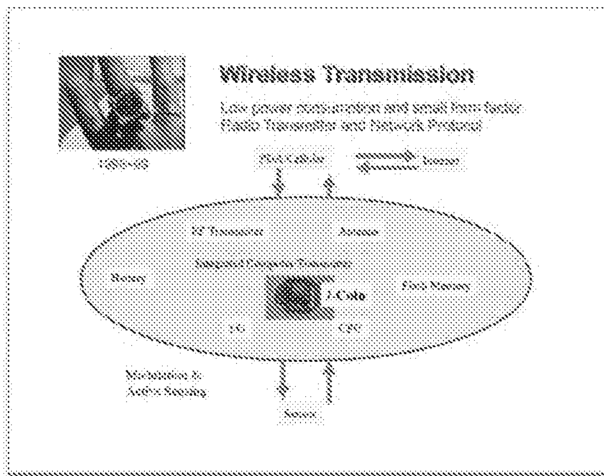


Asserted Claim of '533 Patent	Asada Combinations
[13E] the wearable measurement device further comprising a receiver configured to receive and process at least a portion of the analysis output beam reflected or transmitted from the sample and to generate an output signal	The Asada Combinations disclose and/or render obvious "the wearable measurement device further comprising a receiver configured to receive and process at least a portion of the analysis output beam reflected or transmitted from the sample and to generate an output signal." "In this article we will address both technical and clinical issues of WBS. First, design concepts of a WBS will be presented, with emphasis on the ring sensor developed by the author's group at MIT. The ring sensor is an ambulatory, telemetric, continuous health-monitoring device. This WBS combines miniaturized data acquisition features with advanced photoplethysmographic (PPG) techniques to acquire data related to the patient's cardiovascular state using a method that is far superior to existing fingertip PPG sensors [1]." Asada 2003 at 28. "Figure 2 shows two distinct cases. One case places both the PD and the LED on the same side of the finger-base, and the other places them on opposite sides of the finger. Placing both the PD and the LED on the same side of the finger-base, and the other places them on opposite sides of the finger. Placing both the PD and the LED on the same side creates a type of reflective PPG, while placing each of them on opposite sides makes a type of transmittal PPG. In the figure the average pathway of photons is shown for the two sensor arrangements. Although the exact photon path is difficult to obtain, due to the heterogeneous nature of the finger tissue and blood, a banana-shaped arc connecting the LED and PD, as shown in the figure, can approximate its average path [19]." Asada 2003 at 31.  **Fig. 8.** Block diagram of adaptive noise cancellation using second PPG sensor as noise reference. "The motion detector can be used not only for monitoring the presence of motion but also for canceling noise. By using PD-B as a noise reference, a noise cancellation filter can be built to

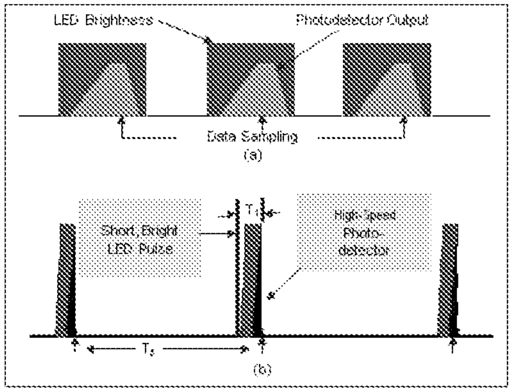
Asserted Claim of '533 Patent	Asada Combinations
	eliminate the noise of PD-A that correlates with the noise reference signal. Assuming that the hemo-dynamic process observed by PPG is stationary and that the noise is additive, adaptive noise canceling methods, such as the classical Widrow method [29], can be applied in order to recover the true pulsation signal from corrupted wave- forms. As shown in Figure 8, the noise-canceling filter combines two sensor signals; one is the main signal captured by PD-A and the other is the noise reference obtained by PD-B. The main signal mostly consists of the true pulsatile signal, but it does contain some noise. If we know the proportion of the noise contained in the main signal, we can generate the noise of the same magnitude by attenuating the noise reference signal and then subtract the noise from the main signal to recover the true pulsatile signal. If the noise magnitude is not known a priori, it must be determined adaptively during the measurement. Various algorithms for adaptive filtering can be applied to tune the filter in real time. Some can determine optimal filter gains and parameters based on the evaluation of the recovered signal, as shown in Figure 8 by the feedback from the output to the adaptive filter block. Details of this adaptive filtering method are beyond the scope of this article. The dual photodetector design shown in Figure 6 provides both main signal and noise reference that are distinct. This allows us to implement noise-canceling filters effectively despite complex motion artifact." Asada 2003 at 33-34. 

Asserted Claim of '533 Patent	Asada Combinations
	Fig. 9. First prototype ring sensor with RF transmitter powered by a coin-size cell battery. "Figure 9 shows the first ring sensor prototype that contains an optical sensor unit, analog and digital processing units, and an RF transmitter, all of which are encapsulated in a compact body and powered by a tiny cell battery used for wristwatches. The ring has a PIC microcomputer performing all the device controls and low-level signal processing, including LED modulation, data acquisition, filtering, and bi-directional RF communication. The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz. The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "In this early development, the power consumption of the LEDs and the imbedded CPU clock were a major bottleneck limiting the design. The distance between the LEDs and PDs had to be shortened for power saving considerations, and the CPU clock was minimized in order to extend the battery life to a few weeks. See [30] for power budget and design details." Asada 2003 at 34. Asada 2001 – Figure 4:

Asserted Claim of '533 Patent	Asada Combinations
	 Fig. 4. Block diagram of electronic circuit. "Fig. 4 shows a block diagram of the ring sensor circuitry. The basic circuit configuration is a standard PPG circuit combined with a wireless transmitter. There are a single photodiode and LEDs of two different wavelengths, red and near infrared, involved in the circuit. The output from the photodiode is amplified and conditioned at the first stage operational amplifier. While the red and infrared LEDs are alternately turned on and off, the signal from the first stage op-amp is sampled by the two sample-and-hold circuits at different timings in order to obtain the reflected light intensity from each LED. Each channel of the signal is conditioned and converted to a digital signal with an AD converter. Using the standard RS-232 protocol, the two channels of digital signals are transmitted via a RF transmitter." Asada 2001 at 797. "The other electronic components of the ring sensor include multiple op-amps, switches, sample-and-hold, and filters." Asada 2001 at 800.

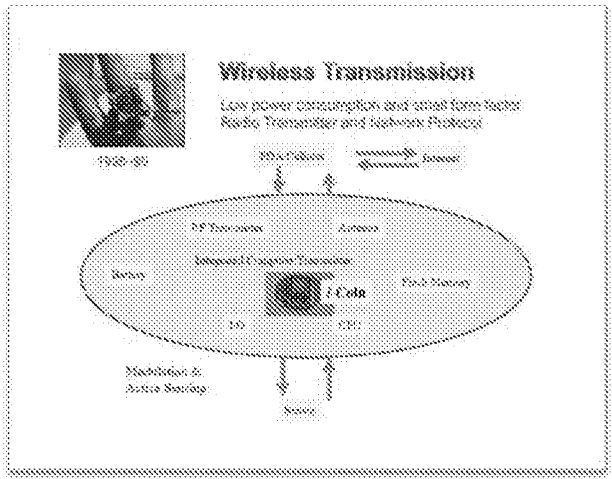
Asserted Claim of '533 Patent	Asada Combinations
	"*CPU*: The on-board CPU controls all the operations of the ring sensor, ranging from the sequence control of LED lighting and data acquisition to the conversion of analogue data to digital signals in the RS-232 format for wireless transmission. A PIC16C711 microprocessor from Microchip was selected be- cause of its unique design for low power consumption. It consumes less than 25 A for 32-kHz clock frequency in the normal operation mode and almost no power consumption in the sleep mode. This CPU has 4 channels of embedded A/D converter, 13 channels of digital input–output line. It has 1 KB of EPROM that is good enough to store the whole code needed for computation. The resolution of the A/D converters are all 8-bits. In case that higher resolution is necessary, other CPUs such as PIC16C773 which has 12-bit A/D converters can be used." Asada 2001 at 800. Asada 2010 Page 9 

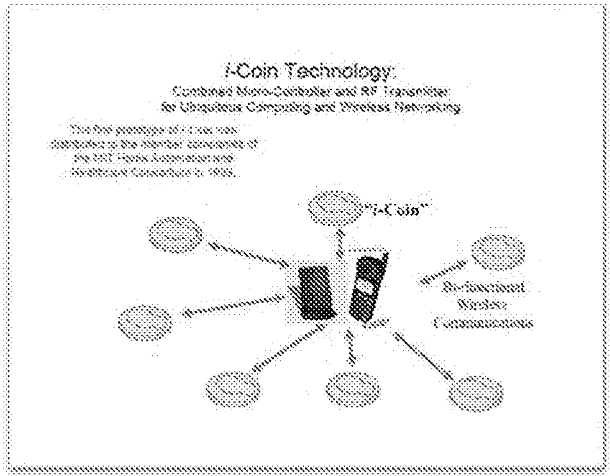
Asserted Claim of '533 Patent	Asada Combinations
[13F] wherein the wearable measurement device receiver is configured to be synchronized to pulses of the light source;	The Asada Combinations disclose and/or render obvious "wherein the receiver is configured to be synchronized to pulses of the light source." "Furthermore, wearable PPG sensors are exposed to diverse ambient lighting conditions, ranging from direct sunlight to flickering room light. In addition, wearable PPG sensors must be designed for reduced power consumption. Carrying a large battery pack is not acceptable for long-term applications. The whole sensor system must run continually using a small battery. Several ways to cope with these difficulties are: ➤ secure the LEDs and the photodetector (PD for short) at a location along the finger skin such that the dc component may be influenced less by the finger motion ➤ modulate the LEDs to attenuate the influence of uncorrelated ambient light as well as to reduce power consumption ➤ increase the amplitude of the ac component so that the signal-to-noise ratio may increase ➤ measure the finger motion with another sensor or a second PD and use it as a noise reference for verifying the signal as well as for canceling the disturbance and noise. In the following sections these methods will briefly be discussed, followed by specific sensor designs and performance tests." Asada 2003 at 30.

Asserted Claim of '533 Patent	Asada Combinations
	 **Fig. 4.** (a) The slow response time of the photodetector meant that the LED had to be modulated at lower frequencies for data sampling. (b) A faster photodetector response time makes it possible to increase the modulation frequency of the LED. "Transmittal PPG must have a powerful LED for transmitting light across the finger. This power consumption problem can be solved with a lighting modulation technique using high-speed devices. Instead of lighting the skin continually, the LED is turned on only for a short time, say 100 ~ 1000 ns, and the signal is sampled within this period. High-speed LEDs and PDs, which have become available at low cost in recent years, can be used for this purpose. Figure 4 shows a schematic of high-frequency, low-duty cycle modulation implemented to minimize LED power consumption. Utilizing fast rise-time optical detectors, it is possible to incorporate a modulation frequency of 1 kHz with a duty ratio of 0.1%, a theoretical power usage that is 1,000 times less than conventional full-cycle modulation methods [23]." Asada 2003 at 32. "In addition to saving power, the modulation of LED lighting provides an effective means for reducing ambient light disturbances. Reading the PD output while the LED is turned off yields the baseline PPG level attributed to the ambient light alone. Subtracting this reading from the one

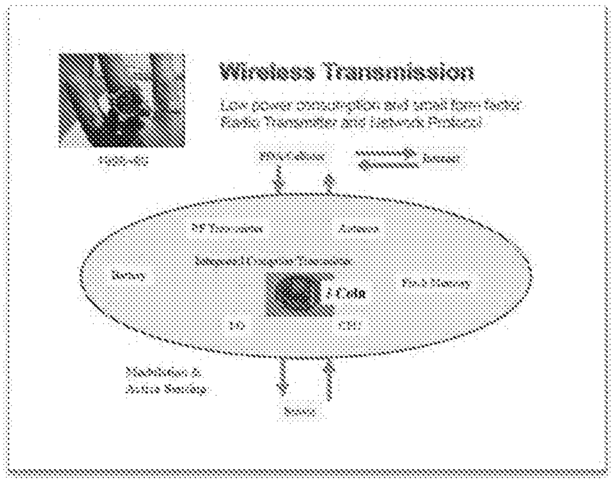
Asserted Claim of '533 Patent	Asada Combinations
	acquired with the LED illuminated gives the net output correlated with the LED lighting. More sophisticated modulation schemes can be applied by controlling the LED brightness as a periodic time function. Computational power requirements often prohibit complex modulation, however. Design trade-offs must be considered to find the best modulation scheme." Asada 2003 at 32. "In this early development, the power consumption of the LEDs and the imbedded CPU clock were a major bottleneck limiting the design. The distance between the LEDs and PDs had to be shortened for power saving considerations, and the CPU clock was minimized in order to extend the battery life to a few weeks. See [30] for power budget and design details." Asada 2003 at 34. "*LED*: LEDs consume a large amount of power when emitting light continuously. Therefore they must be switched on only for a short interval when light must be emitted. Namely, the LEDs must be on only when the photodiode is detecting the reflected light for measuring the pulsation. Synchronizing the sampling of the photodetector with the LED switching reduces the duty ratio of the LEDs, and thereby reduces the power consumption. In the prototype system, this coordination is per- formed by the microprocessor. First, the LEDs are turned on; second, the photo detector signal is sampled at the next CPU cycle; the LEDs are switched off at the third CPU cycle. This sequence control is performed for both red and infrared LEDs." Asada 2001 at 798. "For the prototype ring sensor, the sample-and-hold frequency was set to f = 1000 Hz. The choice of this frequency depends on applications. A lower sampling frequency can be used when required accuracy is lower." Asada 2001 at 800.
[13G] a personal device comprising a wireless receiver, a wireless transmitter, a display, a microphone, a speaker, one or more buttons or knobs, a microprocessor and a touch screen,	The Asada Combinations disclose and/or render obvious "a personal device comprising a wireless receiver, a wireless transmitter, a display, a microphone, a speaker, one or more buttons or knobs, a microprocessor and a touch screen." "WBS could play an important role in the wireless surveillance of people during hazardous operations (military, fire-fighting, etc.), or such sensors could be dispensed during a mass civilian casualty occurrence. Given that CV physiologic parameters make up the 'vital signs' that are the most important information in emergency medical situations, WBS might enable a wireless monitoring system for large numbers of at-risk subjects." Asada 2003 at 28.

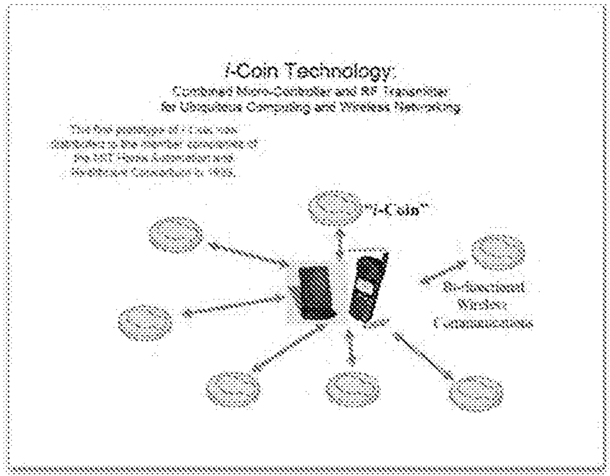
Asserted Claim of '533 Patent	Asada Combinations
	"The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "The ring sensor is a miniaturized, telemetric, monitoring de- vice worn by a patient as a finger ring. The ring encapsulates PPG, pulse oximetry combined with wireless communication and miniaturization technologies. This device optically captures the pulsation and oxygen saturation of the arterial blood flow, and transmits the signals to a host computer via a radio-frequency (RF) transmitter. Fig. 1 shows a conceptual diagram of the ring sensor [5], [6]. The ring sensor consists of optoelectronic components, a CPU, a RF transmitter, a battery, and a ring chassis. The optoelectronic components, i.e., micro photodiodes and LEDs, detect the blood-volume waveforms and oxygen-saturation level at the patient's digital artery. The CPU controls the LED lighting sequence as well as the data acquisition and transmission process. These signals are locally processed by the on-board CPU and transmitted to a host computer for diagnosis of the patient's cardiovascular conditions. The ring sensor is completely wireless and miniaturized so that the patient can wear the device comfortably 24 h/day." Asada 2001 at 796. Asada 2010 Page 9

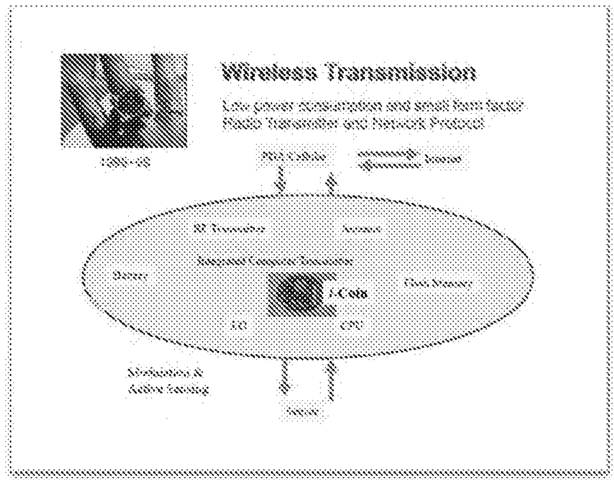
Asserted Claim of '533 Patent	Asada Combinations
	 Asada 2010 Page 10

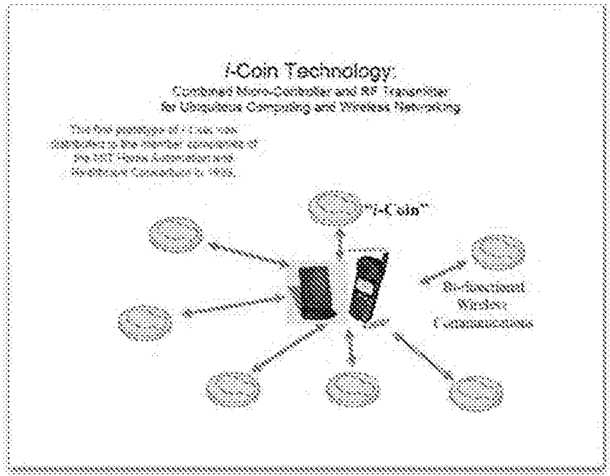
Asserted Claim of '533 Patent	Asada Combinations
	
[13H] the personal device configured to receive and process at least a portion of the output signal,	The Asada Combinations disclose and/or render obvious "the personal device configured to receive and process at least a portion of the output signal." "At the same time, the physiologic information generated by WBS technology must trigger some appropriate system action to improve health outcomes. Abnormal states must be efficiently recognized while false alarms are minimized. This requires carefully designed WBS devices, as well as innovative postprocessing and intelligent data interpretation. Post-processing of sensor data can improve usability, as illustrated by recent improvements in pulse oximetry technology [3]-[5]. Data interpretation can occur in real time (as is necessary for detecting cardiovascular-related catastrophes) or offline (as is the standard-of-care for arrhythmia surveillance using Holter and related monitoring). Real-time alarm "algorithms" using simple thresholds for measured parameters, like heart rate and oxygen saturation, have demonstrated high rates of false alarms [6], [7]. Algorithms for off-line, retrospective data analysis are also in a developmental stage. Studies of novel automated "triage" software used to interpret hours of continuous noninvasive ECG data

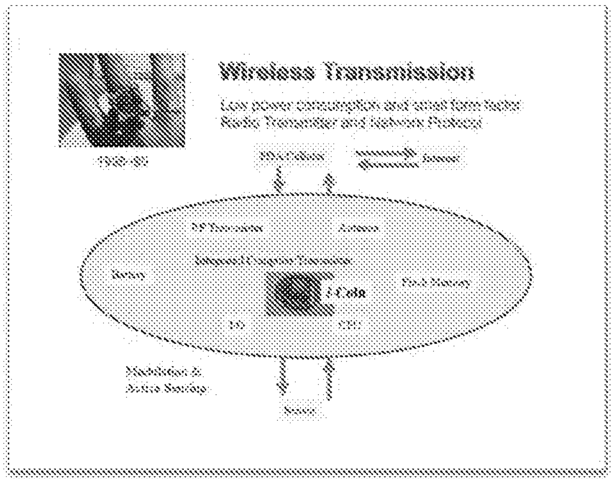
Asserted Claim of '533 Patent	Asada Combinations
	of monitored outpatients suggest that the software's diagnostic yield is not equal to a human's when it comes to arrhythmia detection [8], [9]." Asada 2003 at 29. "The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "WBS, in conjunction with diagnostic algorithms and some specific response (which might be human or automated in nature), stand to ameliorate physiologic catastrophes occurring outside conventional clinical environments. For instance, WBS can play an important role in the wireless surveillance of people during hazardous operations (military, fire-fighting, etc.), or such sensors can be dispensed during a mass civilian casualty occurrence. In an overcrowded Emergency Department, patients who are in the waiting room for hours with an undifferentiated medical complaint will receive state-of-the-art physiologic monitoring. For hospital in-patients who require CV monitoring, current biosensor technology typically tethers patients in a tangle of cables. For convalescing patients in a hospital, or a rehabilitation center, there would no longer be a dichotomy between optimal bed-bound monitoring and optimal rehabilitation consisting of ambulation and a full scope of physical activities. Given the physical freedom when monitored by WBS, inpatients may experience less physical deconditioning, and these two factors together may impact the not insignificant problem of dangerous inpatient falls in the elderly (an incidence on the order of 1-5% per admission [32], [33])." Asada 2003 at 37. "WBS measuring circulation could also be used to monitor geriatric subjects living alone, offering an automatic 911 call in the event of a catastrophe and peace of mind for the subject and concerned family the rest of the time." Asada 2003 at 37. "The ring sensor is a miniaturized, telemetric, monitoring de- vice worn by a patient as a finger ring. The ring encapsulates PPG, pulse oximetry combined with wireless communication and miniaturization technologies. This device optically captures the pulsation and oxygen saturation of the arterial blood flow, and transmits the signals to a host computer via a radio-frequency (RF) transmitter. Fig. 1 shows a conceptual diagram of the ring sensor [5], [6]. The ring sensor consists of optoelectronic components, a CPU, a RF transmitter, a battery, and a ring chassis. The

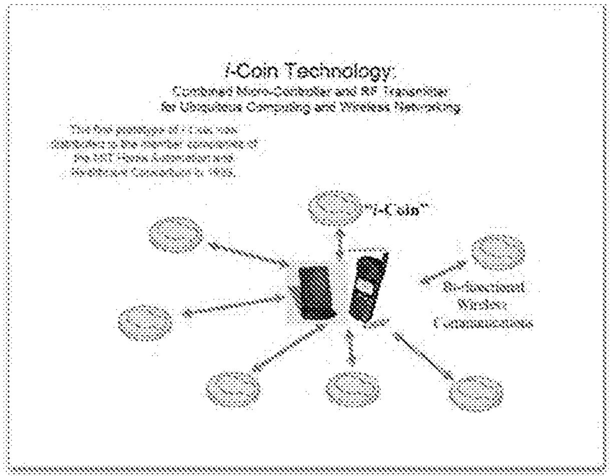
Asserted Claim of '533 Patent	Asada Combinations
	optoelectronic components, i.e., micro photodiodes and LEDs, detect the blood-volume waveforms and oxygen-saturation level at the patient's digital artery. The CPU controls the LED lighting sequence as well as the data acquisition and transmission process. These signals are locally processed by the on-board CPU and transmitted to a host computer for diagnosis of the patient's cardiovascular conditions. The ring sensor is completely wireless and miniaturized so that the patient can wear the device comfortably 24 h/day." Asada 2001 at 796. Asada 2010 Page 9  Asada 2010 Page 10

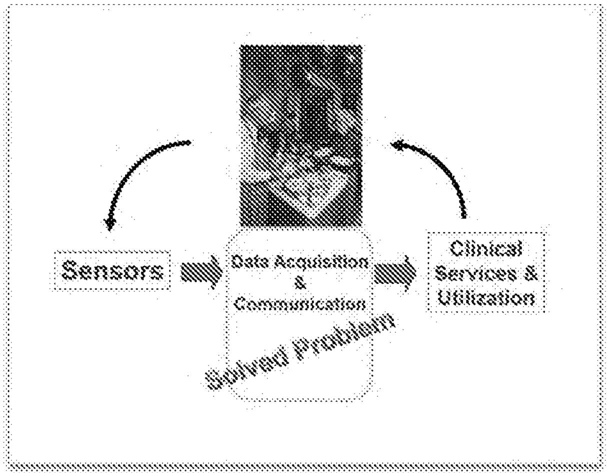
Asserted Claim of '533 Patent	Asada Combinations
	
[13I] wherein the personal device is configured to store and display the processed output signal, and	The Asada Combinations disclose and/or render obvious "wherein the personal device is configured to store and display the processed output signal." "However, healthcare providers have only intermittent values of blood pressure on which to base therapy decisions; it is possible that continuous blood pressure monitoring would permit enhanced titration of therapy and reductions in mortality. Similarly, WBS would be able to log the physiologic signature of a patient's exercise efforts (manifested as changes in heart rate and blood pressure), permitting the patient and healthcare provider to assess compliance with a regimen proven to improve health outcomes." Asada 2003 at 28. "The monitoring environments for out-of-hospital, wearable devices demand a new paradigm in noninvasive sensor design. There are several design requirements central to such devices. Compactness, stability of signal, motion and other disturbance rejection, durability, data storage

Asserted Claim of '533 Patent	Asada Combinations
	and transmission, and low power consumption comprise the major design considerations." Asada 2003 at 28. "The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. Asada 2010 Page 9  Asada 2010 Page 10

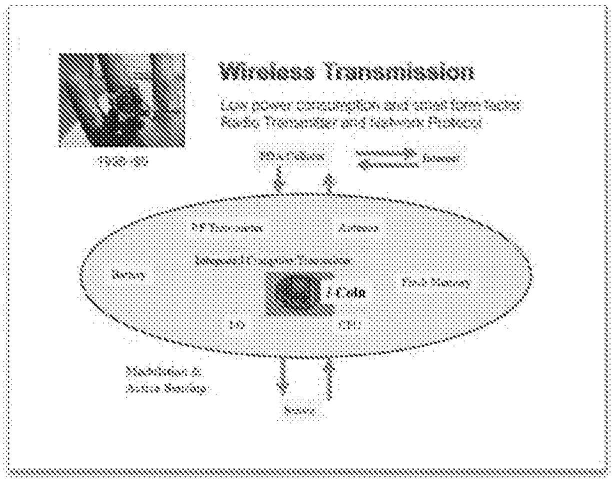
Asserted Claim of '533 Patent	Asada Combinations
	
[13J] wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link; and	The Asada Combinations disclose and/or render obvious "and wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link." "WBS could play an important role in the wireless surveillance of people during hazardous operations (military, fire-fighting, etc.), or such sensors could be dispensed during a mass civilian casualty occurrence. Given that CV physiologic parameters make up the 'vital signs' that are the most important information in emergency medical situations, WBS might enable a wireless monitoring system for large numbers of at-risk subjects." Asada 2003 at 28. "The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. Asada 2010 Page 9

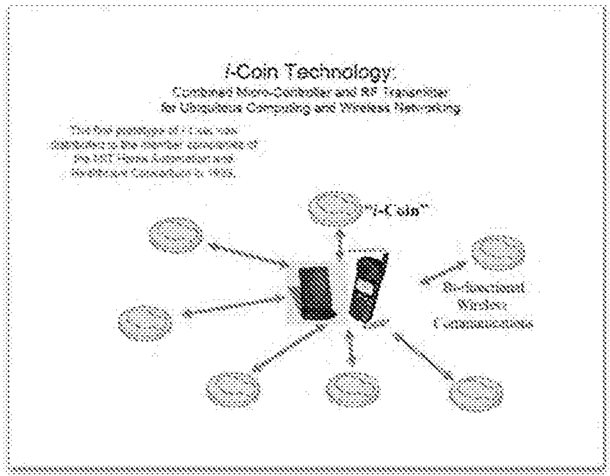
Asserted Claim of '533 Patent	Asada Combinations
	 Asada 2010 Page 10

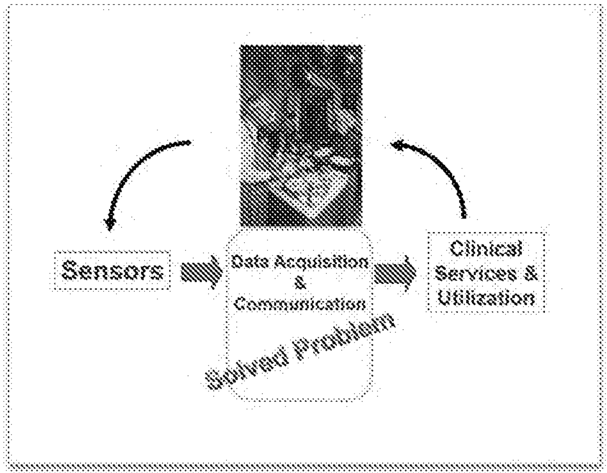
Asserted Claim of '533 Patent	Asada Combinations
	 Asada 2010 Page 13

Asserted Claim of '533 Patent	Asada Combinations
	
[13K] a remote device configured to receive over the wireless transmission link an output status comprising the at least a portion of the processed output signal, to process the received output status to generate processed data and to store the processed data, and	The Asada Combinations disclose and/or render obvious "a remote device configured to receive over the wireless transmission link an output status comprising the at least a portion of the processed output signal, to process the received output status to generate processed data and to store the processed data." "At the same time, the physiologic information generated by WBS technology must trigger some appropriate system action to improve health outcomes. Abnormal states must be efficiently recognized while false alarms are minimized. This requires carefully designed WBS devices, as well as innovative postprocessing and intelligent data interpretation. Post-processing of sensor data can improve usability, as illustrated by recent improvements in pulse oximetry technology [3]-[5]. Data interpretation can occur in real time (as is necessary for detecting cardiovascular-related catastrophes) or offline (as is the standard-of-care for arrhythmia surveillance using Holter and related monitoring). Real-time alarm "algorithms" using simple thresholds for measured parameters, like heart rate and oxygen saturation, have demonstrated high rates of false alarms [6],

Asserted Claim of '533 Patent	Asada Combinations
	[7]. Algorithms for off-line, retrospective data analysis are also in a developmental stage. Studies of novel automated "triage" software used to interpret hours of continuous noninvasive ECG data of monitored outpatients suggest that the software's diagnostic yield is not equal to a human's when it comes to arrhythmia detection [8], [9]." Asada 2003 at 29. "The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "WBS, in conjunction with diagnostic algorithms and some specific response (which might be human or automated in nature), stand to ameliorate physiologic catastrophes occurring outside conventional clinical environments. For instance, WBS can play an important role in the wireless surveillance of people during hazardous operations (military, fire-fighting, etc.), or such sensors can be dispensed during a mass civilian casualty occurrence. In an overcrowded Emergency Department, patients who are in the waiting room for hours with an undifferentiated medical complaint will receive state-of-the-art physiologic monitoring. For hospital in-patients who require CV monitoring, current biosensor technology typically tethers patients in a tangle of cables. For convalescing patients in a hospital, or a rehabilitation center, there would no longer be a dichotomy between optimal bed-bound monitoring and optimal rehabilitation consisting of ambulation and a full scope of physical activities. Given the physical freedom when monitored by WBS, inpatients may experience less physical deconditioning, and these two factors together may impact the not insignificant problem of dangerous inpatient falls in the elderly (an incidence on the order of 1-5% per admission [32], [33])." Asada 2003 at 37. Asada 2010 Page 9

Asserted Claim of '533 Patent	Asada Combinations
	 Asada 2010 Page 10

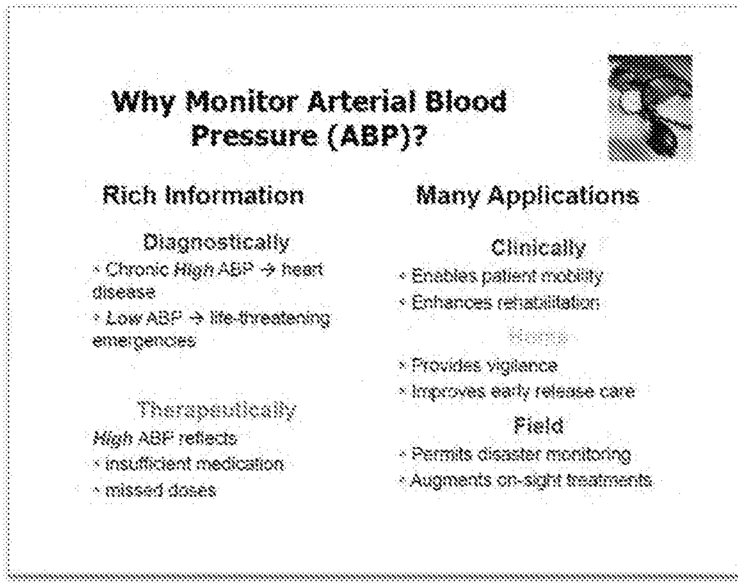
Asserted Claim of '533 Patent	Asada Combinations
	 Asada 2010 Page 13

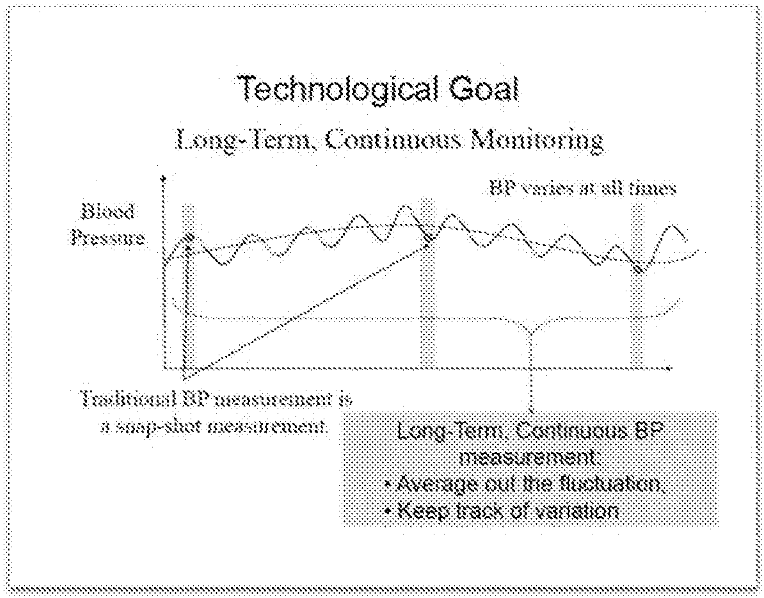
Asserted Claim of '533 Patent	Asada Combinations
	
[13L] wherein the remote device is capable of storing a history of at least a portion of the received output status over a specified period of time.	The Asada Combinations disclose and/or render obvious "[t]he system of claim 5, wherein the output signal comprises one or more physiological parameters, and the remote device is capable of storing a history of at least a portion of the one or more physiological parameters over a specified period of time." "Wearable biosensors (WBS) will permit continuous cardiovascular (CV) monitoring in a number of novel settings." Asada 2003 at 28. "WBS could play an important role in the wireless surveillance of people during hazardous operations (military, fire-fighting, etc.), or such sensors could be dispensed during a mass civilian casualty occurrence. Given that CV physiologic parameters make up the 'vital signs' that are the most important information in emergency medical situations, WBS might enable a wireless monitoring system for large numbers of at-risk subjects." Asada 2003 at 28.

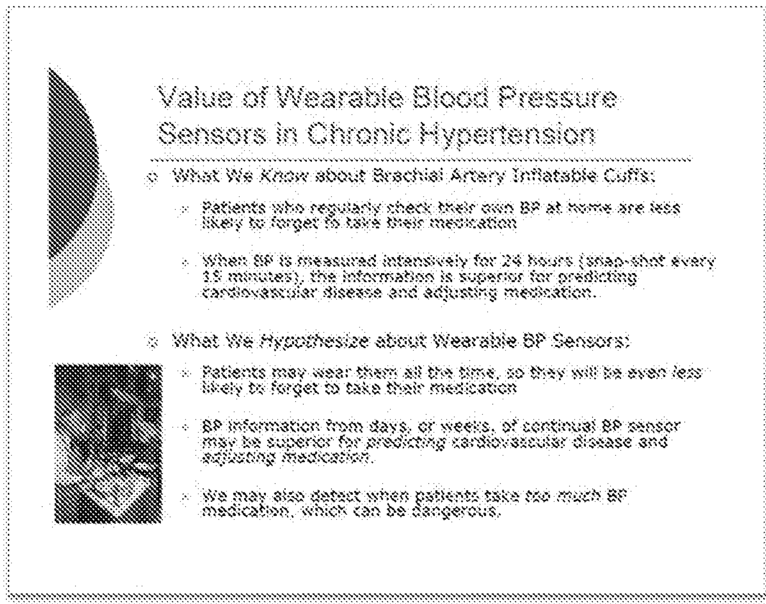
Asserted Claim of '533 Patent	Asada Combinations
	"The WBS hardware solution must be adequate to make reliable physiologic measurements during activities of daily living or even more demanding circumstances such as fitness training or military battle." Asada 2003 at 28. "However, healthcare providers have only intermittent values of blood pressure on which to base therapy decisions; it is possible that continuous blood pressure monitoring would permit enhanced titration of therapy and reductions in mortality. Similarly, WBS would be able to log the physiologic signature of a patient's exercise efforts (manifested as changes in heart rate and blood pressure), permitting the patient and healthcare provider to assess compliance with a regimen proven to improve health outcomes." Asada 2003 at 28. "WBS solutions, in various stages of technologic maturity, exist for measuring established cardiopulmonary 'vital signs': heart rate, arterial blood pressure, arterial oxygen saturation, respiratory rate, temperature, and even cardiac output." Asada 2003 at 29. "At the same time, the physiologic information generated by WBS technology must trigger some appropriate system action to improve health outcomes. Abnormal states must be efficiently recognized while false alarms are minimized. This requires carefully designed WBS devices, as well as innovative postprocessing and intelligent data interpretation. Post-processing of sensor data can improve usability, as illustrated by recent improvements in pulse oximetry technology [3]-[5]. Data interpretation can occur in real time (as is necessary for detecting cardiovascular-related catastrophes) or offline (as is the standard-of-care for arrhythmia surveillance using Holter and related monitoring). Real-time alarm "algorithms" using simple thresholds for measured parameters, like heart rate and oxygen saturation, have demonstrated high rates of false alarms [6], [7]. Algorithms for off-line, retrospective data analysis are also in a developmental stage. Studies of novel automated "triage" software used to interpret hours of continuous noninvasive ECG data of monitored outpatients suggest that the software's diagnostic yield is not equal to a human's when it comes to arrhythmia detection [8], [9]." Asada 2003 at 29.

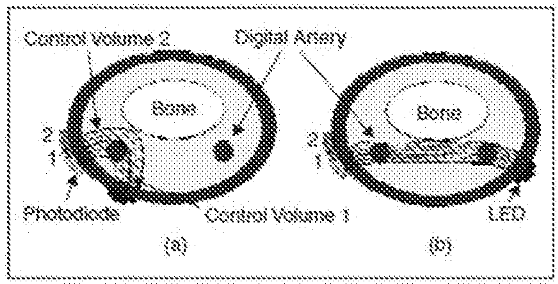
Asserted Claim of '533 Patent	Asada Combinations
	"The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "WBS, in conjunction with diagnostic algorithms and some specific response (which might be human or automated in nature), stand to ameliorate physiologic catastrophes occurring outside conventional clinical environments. For instance, WBS can play an important role in the wireless surveillance of people during hazardous operations (military, fire-fighting, etc.), or such sensors can be dispensed during a mass civilian casualty occurrence. In an overcrowded Emergency Department, patients who are in the waiting room for hours with an undifferentiated medical complaint will receive state-of-the-art physiologic monitoring. For hospital in-patients who require CV monitoring, current biosensor technology typically tethers patients in a tangle of cables. For convalescing patients in a hospital, or a rehabilitation center, there would no longer be a dichotomy between optimal bed-bound monitoring and optimal rehabilitation consisting of ambulation and a full scope of physical activities. Given the physical freedom when monitored by WBS, inpatients may experience less physical deconditioning, and these two factors together may impact the not insignificant problem of dangerous inpatient falls in the elderly (an incidence on the order of 1-5% per admission [32], [33])." Asada 2003 at 37. "AS THE population of aged people increases, vital sign monitoring is increasingly important for securing their independent lives. On-line, continuous monitoring allows us to detect emergencies and abrupt changes in the patient conditions. Especially for cardiac patients, on-line, long-term monitoring plays a pivotal role. It provides critical information for long-term assessment and preventive diagnosis for which long-term trends and signal patterns are of special importance. Such trends and patterns can hardly be identified by traditional examinations. Those cardiac problems that occur frequently during normal daily activities may disappear the moment the patient is hospitalized, causing diagnostic difficulties and consequently possible therapeutic errors. Continuous and ambulatory monitoring systems such as ambulatory electrocardiogram (EKG) are, therefore, needed to detect the trait….In general, long-term, ambulatory monitoring systems have not yet reached a technical level that is widely accepted by both clinicians and patients. Such long-term, ambulatory devices must be compact, lightweight, and comfortable to

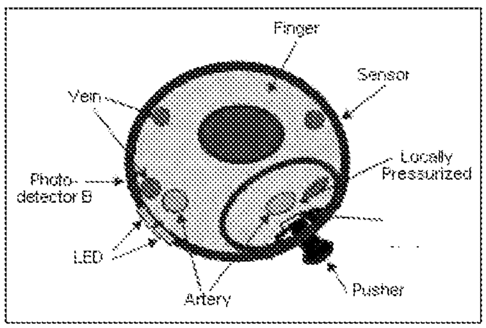
Asserted Claim of '533 Patent	Asada Combinations
	wear at all times. They must be designed for low power consumption for long-term use. Furthermore, they must be able to detect signals reliably and stably in the face of motion artifact and various disturbances. Unlike traditional monitoring systems, these devices are used under no supervision of clinicians. Data is collected from daily lives of patients in an unstructured environment. The goal of this paper is to develop technology for reducing motion artifact and obtaining reliable measurements of vital signs for long-term use." Asada 2001 at 795. "A prototype ring sensor has been designed, built, and tested. Experiments have verified that the ring sensor can detect beat-to-beat pulsation in the face of interfering force and acceleration acting on the ring body. With small battery cells, the ring sensor can continuously detect and transmit plethysmograph signals for 23.3 days, while the battery life can be extended to several months with an intermittent measurement schedule." Asada 2001 at 805. Asada 2010 Pages 26-31 Asada 2010 Page 35

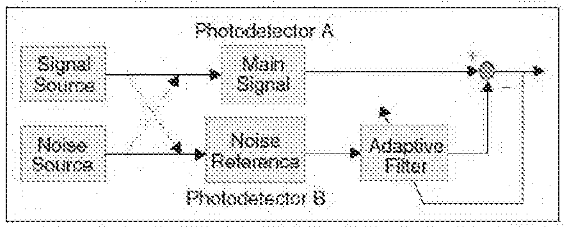
Asserted Claim of '533 Patent	Asada Combinations
	 Asada 2010 Page 37

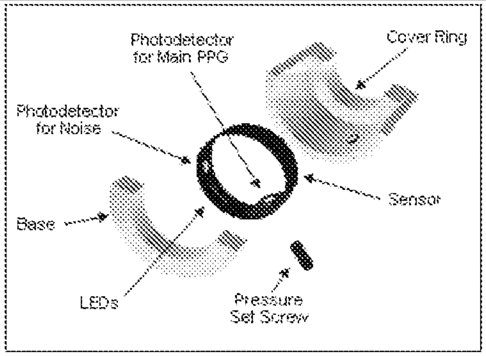
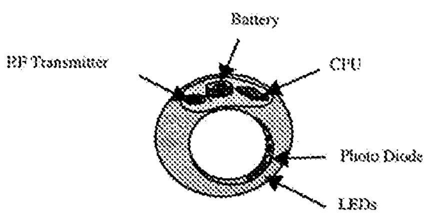
Asserted Claim of '533 Patent	Asada Combinations
	 Asada 2010 Page 66

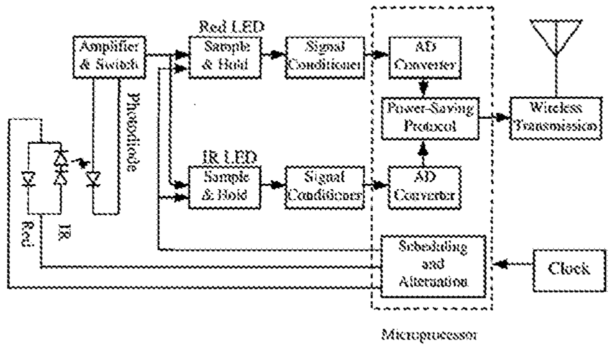
Asserted Claim of '533 Patent	Asada Combinations
	
[16] The system of claim 13, wherein the receiver is located a first distance from a first one of the plurality of light emitting diodes and a different, second distance from a second one of the plurality of light emitting diodes such that the receiver receives a first signal from the first light	The Asada Combinations disclose and/or render obvious "[t]he system of claim 13, wherein the receiver is located a first distance from a first one of the plurality of light emitting diodes and a different, second distance from a second one of the plurality of light emitting diodes such that the receiver receives a first signal from the first light emitting diode and a second signal from the second light emitting diode."

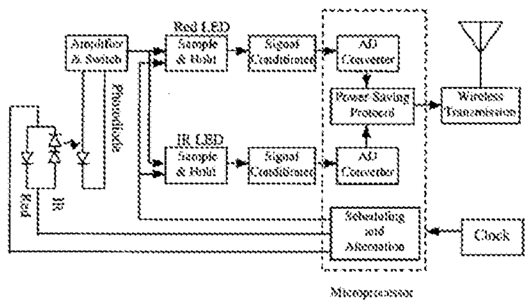
Asserted Claim of '533 Patent	Asada Combinations
emitting diode and a second signal from the second light emitting diode.	 Fig. 2. (a) For the reflective illumination method, movement of the photodiode relative to the LED (position 1 to position 2) leads to a photon path that no longer contains the digital artery. (b) For the transmittal illumination method, movement of the photodetector relative to the LED still contains photon paths that pass through the digital artery. "The location of the LEDs and a PD relative to the finger is an important design issue determining signal quality and robustness against motion artifact. Figure 2 shows a cross-sectional view of the finger with the ring sensor. The LEDs and PD are placed on the flanks of the finger rather than the dorsal and palmar sides." Asada 2003 at 30-31. "For these reasons, at least one optical device, either the PD or the LED, should be placed on one lateral face of the finger near the digital artery. The question is where to place the other device. Figure 2 shows two distinct cases. One case places both the PD and the LED on the same side of the finger-base, and the other places them on opposite sides of the finger. Placing both the PD and the LED on the same side creates a type of reflective PPG, while placing each of them on opposite sides makes a type of transmittal PPG. In the figure the average pathway of photons is shown for the two sensor arrangements. Although the exact photon path is difficult to obtain, due to the

Asserted Claim of '533 Patent	Asada Combinations
	heterogeneous nature of the finger tissue and blood, a banana-shaped arc connecting the LED and PD, as shown in the figure, can approximate its average path [19]." Asada 2003 at 31. "Reflective PPG needs more secure attachments of the LED and PD to the skin surface, when compared to transmittal PPG. Once an air gap is created between the skin surface and the optical components due to some disturbance, a direct optical path from the LED to the PD may be created. This direct path exposes the PD directly to the light source and consequently leads to saturation. To avoid this short circuit, the LED light beam must be focused only in the normal direction, and the PD must also have a strong directional property (i.e., polarity), so that it is sensitive to only the incoming light normal to the device surface. Such strong directional properties, however, work adversely when a disturbance pressure acts on the sensor bodies, since it deflects the direction of the LED and PD leading to fluctuations in the out- put signal. As a result, reflective PPG configurations are more susceptive to disturbances." Asada 2003 at 31. "Figure 3 shows an experimental comparison between transmittal and reflective PPGs. Two sets of PPG sensors, one reflective and one transmittal, were attached to the same finger. Both were at rest initially, and then shaken. The transmittal PPG was quite stable, while the reflective PPG was susceptive to the motion disturbances." Asada 2003 at 31. 

Asserted Claim of '533 Patent	Asada Combinations
	Fig. 6. The schematic of a locally pressurized sensor band  Fig. 8. Block diagram of adaptive noise cancellation using second PPG sensor as noise reference "The motion detector can be used not only for monitoring the presence of motion but also for canceling noise. By using PD-B as a noise reference, a noise cancellation filter can be built to eliminate the noise of PD-A that correlates with the noise reference signal. Assuming that the hemodynamic process observed by PPG is stationary and that the noise is additive, adaptive noise canceling methods, such as the classical Widrow method [29], can be applied in order to recover the true pulsation signal from corrupted waveforms. As shown in Figure 8, the noise-canceling filter combines two sensor signals; one is the main signal captured by PD-A and the other is the noise reference obtained by PD-B. The main signal mostly consists of the true pulsatile signal, but it does contain some noise. If we know the proportion of the noise contained in the main signal, we can generate the noise of the same magnitude by attenuating the noise reference signal and then subtract the noise from the main signal to recover the true pulsatile signal." Asada 2003 at 33. "See [30] for power budget and design details." Asada 2003 at 34.

Asserted Claim of '533 Patent	Asada Combinations
	 Fig. 15. The schematic of the Prototype C ring sensor. "The local pressurization and motion detection methods described previously have been implemented for further improvement. Figure 15 shows the schematic of the Prototype C ring sensor. Both transmittal (PD-A) and reflective (PD-B) PPGs were mounted on the sensor band. The former is placed on top of a locally pressurizing mechanism with an adjustable setscrew. The latter is mounted on the low-pressure side in order to detect motion." Asada 2003 at 36. Asada 2001 – Figure 1 

Asserted Claim of '533 Patent	Asada Combinations
	Fig. 1. Conceptual diagram of the ring sensor. Asada 2001 – Figure 4:  Fig. 4. Block diagram of electronic circuit. "Fig. 4 shows a block diagram of the ring sensor circuitry. The basic circuit configuration is a standard PPG circuit combined with a wireless transmitter. There are a single photodiode and LEDs of two different wavelengths, red and near infrared, involved in the circuit. The output from the photodiode is amplified and conditioned at the first stage operational amplifier. While the red and infrared LEDs are alternately turned on and off, the signal from the first stage op-amp is sampled by the two sample-and-hold circuits at different timings in order to obtain the reflected light intensity from each LED. Each channel of the signal is conditioned and converted to a digital signal with an AD converter. Using the standard RS-232 protocol, the two channels of digital signals are transmitted via a RF transmitter." Asada 2001 at 797.

Asserted Claim of '533 Patent	Asada Combinations
[17] The system of claim 16, wherein the output signal is generated in part by comparing the first and second signals.	The Asada Combinations disclose and/or render obvious "[t]he system of claim 5, wherein the output signal is generated in part by comparing the first and second signals." "The motion detector can be used not only for monitoring the presence of motion but also for canceling noise. By using PD-B as a noise reference, a noise cancellation filter can be built to eliminate the noise of PD-A that correlates with the noise reference signal. Assuming that the hemodynamic process observed by PPG is stationary and that the noise is additive, adaptive noise canceling methods, such as the classical Widrow method [29], can be applied in order to recover the true pulsation signal from corrupted waveforms. As shown in Figure 8, the noise-canceling filter combines two sensor signals; one is the main signal captured by PD-A and the other is the noise reference obtained by PD-B. The main signal mostly consists of the true pulsatile signal, but it does contain some noise. If we know the proportion of the noise contained in the main signal, we can generate the noise of the same magnitude by attenuating the noise reference signal and then subtract the noise from the main signal to recover the true pulsatile signal." Asada 2003 at 33. "See [30] for power budget and design details." Asada 2003 at 34. Asada 2001 -- Figure 4:  **Fig. 4. Block diagram of electronic circuit.**

Asserted Claim of '533 Patent	Asada Combinations
	"Fig. 4 shows a block diagram of the ring sensor circuitry. The basic circuit configuration is a standard PPG circuit combined with a wireless transmitter. There are a single photodiode and LEDs of two different wavelengths, red and near infrared, involved in the circuit. The output from the photodiode is amplified and conditioned at the first stage operational amplifier. While the red and infrared LEDs are alternately turned on and off, the signal from the first stage op-amp is sampled by the two sample-and-hold circuits at different timings in order to obtain the reflected light intensity from each LED. Each channel of the signal is conditioned and converted to a digital signal with an AD converter. Using the standard RS-232 protocol, the two channels of digital signals are transmitted via a RF transmitter." Asada 2001 at 797.

EXHIBIT CC-2

U.S. Patent No. 9,757,040 vs Asada Combinations

Publication Dates: July 2001, May/June 2003, 2010 Prior Art Status: § 103

To the extent Asada et al., "Mobile monitoring with wearable photoplethysmographic biosensors," IEEE Engineering in Medicine and Biology Magazine (May/June 2003) ("Asada 2003"), does not anticipate the asserted claims of U.S. Patent No. 9,757,040 ("the '040 Patent") or render those claims obvious alone and/or in view of at least any of the references identified in Apple's Obviousness Combinations Chart, the claims are obvious based on the combination of Asada 2003 with one or both of:

> Rhee et al., Artifact-Resistant Power-Efficient Design of Finger-Ring Plethsymographic Sensors," IEEE Transactions on Biomedical Engineering, Vol. 48, No. 7 (July 2001) ("Asada 2001");
>
> Asada, The MIT Ring: History, Technology, and Challenges of Wearable Health Monitoring, MIT Industrial Liason Program 2010 R&D Conference ("Asada 2010")

("Asada Combinations").

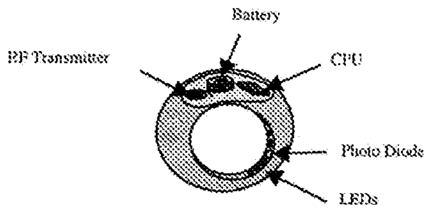
As set forth in Apple's Invalidity Contentions, the below contentions apply the prior art in part in accordance with Apple's assumption that Omni contends the claims are not invalid under 35 U.S.C. § 112. However, Apple's below contentions do not represent Apple's agreement or view as to the meaning, definiteness, written description support for, or enablement of any of the asserted claims. For each dependent claim, the disclosures cited for the claim from which it depends are incorporated by reference.

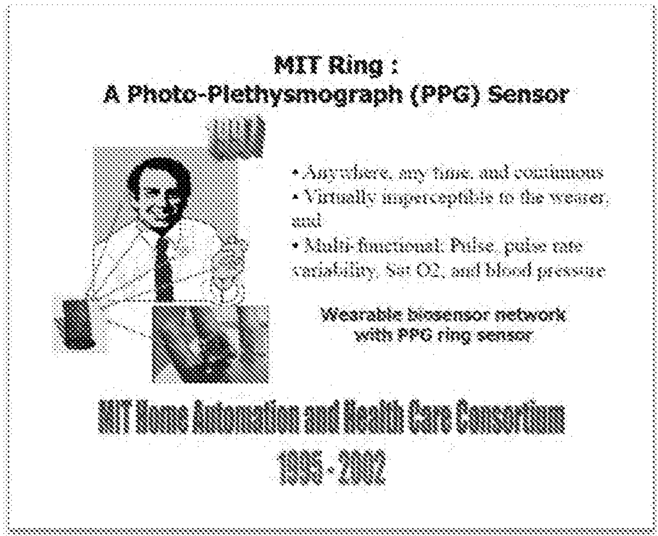
CHART TWO: U.S. Patent No. 9,757,040 vs Asada Combinations

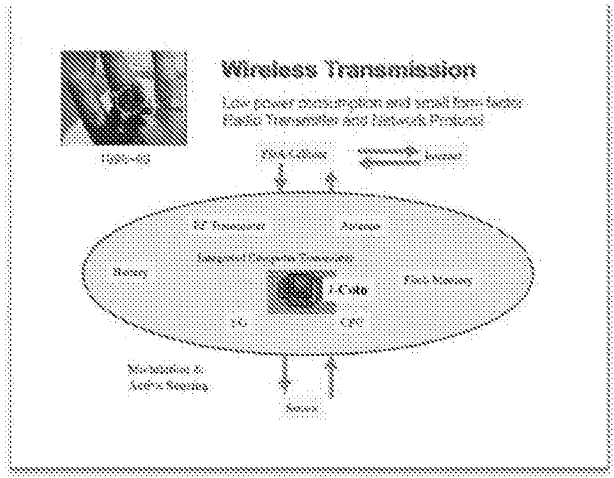
Asserted Claim of '040 Patent	Asada Combinations
[1] A wearable device for use with a smart phone or tablet, the wearable device comprising:	To the extent the preamble is limiting, The Asada Combinations disclose and/or render obvious "[a] wearable device for use with a smart phone or tablet." *See generally* Asada 2003 Figures 6, 9, 11, 15 and descriptions of Prototypes A, B, and C. "Wearable biosensors (WBS) will permit continuous cardiovascular (CV) monitoring in a number of novel settings. Benefits may be realized in the diagnosis and treatment of a number of major diseases. WBS, in conjunction with appropriate alarm algorithms, can increase surveillance capabilities for CV catastrophe for high-risk subjects. WBS could also play a role in the treatment of chronic diseases, by providing information that enables precise titration of therapy or detecting lapses in patient compliance. WBS could play an important role in the wireless surveillance of people during hazardous operations (military, fire-fighting, etc.), or such sensors could be dispensed during a mass civilian casualty occurrence. Given that CV physiologic parameters make up the "vital signs" that are the most important information in emergency medical situations, WBS might enable a wireless monitoring system for large numbers of at-risk subjects. This same approach may also have utility in monitoring the waiting room of today's overcrowded emergency departments. For hospital inpatients who require CV monitoring, current biosensor technology typically tethers patients in a tangle of cables, whereas wearable CV sensors could increase inpatient comfort and may even reduce the risk of tripping and falling, a perennial problem for hospital patients who are ill, medicated, and in an unfamiliar setting." Asada 2003 28. "In this article we will address both technical and clinical issues of WBS. First, design concepts of a WBS will be presented, with emphasis on the ring sensor developed by the author's group at MIT. The ring sensor is an ambulatory, telemetric, continuous health-monitoring device. This WBS combines miniaturized data acquisition features with advanced photoplethysmographic (PPG) techniques to acquire data related to the patient's cardiovascular state using a method that is far superior to existing fingertip PPG sensors [1]. In particular, the ring sensor is capable of reliably monitoring a patient's heart rate, oxygen saturation, and heart rate variability. Technical issues, including motion artifact, interference with blood circulation, and battery power issues,

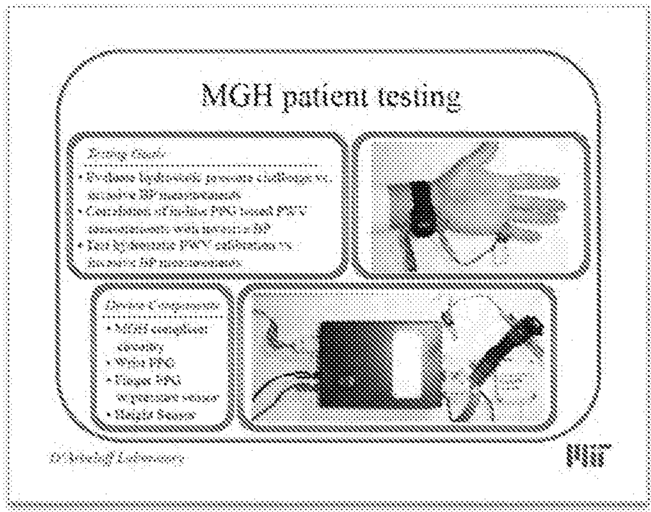
Asserted Claim of '040 Patent	Asada Combinations
	will be addressed, and effective engineering solutions to alleviate these problems will be presented. Second, based on the ring sensor technology the clinical potentials of WBS monitoring will be addressed." Asada 2003 at 28. "The WBS hardware solution must be adequate to make reliable physiologic measurements during activities of daily living or even more demanding circumstances such as fitness training or military battle. There must exist data processing and decision-making algorithms for the waveform data. These algorithms must prompt some action that improves health outcomes. Finally, the systems must be cost effective when compared with less expensive, lower technology alternatives." Asada 2003 at 28. "The monitoring environments for out-of-hospital, wearable devices demand a new paradigm in noninvasive sensor design. There are several design requirements central to such devices. Compactness, stability of signal, motion and other disturbance rejection, durability, data storage and transmission, and low power consumption comprise the major design considerations. Additionally, since WBS devices are to be worn without direct doctor supervision, it is imperative that they are simple to use and comfortable to wear for long periods of time. A challenge unique to wearable sensor design is the trade-off between patient comfort, or long-term wearability, and reliable sensor attachment. While it is nearly needless to say that WBS technology must be safe, it should be noted that there have been tragic reports of serious injury resulting from early home monitoring technology [2]." Asada 2003 28-29. "WBS solutions, in various stages of technologic maturity, exist for measuring established cardiopulmonary 'vital signs': heart rate, arterial blood pressure, arterial oxygen saturation, respiratory rate, temperature, and even cardiac output. In addition, there are numerous WBS modalities that can offer physiologic measurements not conventional in contemporary medical monitoring applications, including acoustic sensors, electrochemical sensors, optical sensors, electromyography and electroencephalography, and other bioanalytic sensors (to be sure, some of these sensors have well-established medical utility, but not for automated surveillance)." Asada 2003 at 29.

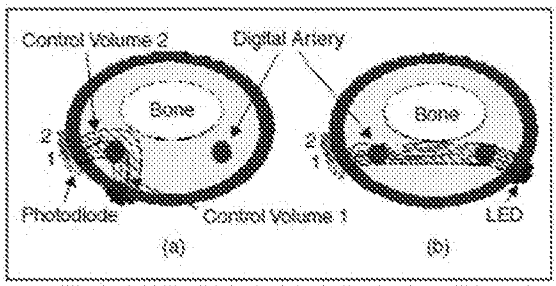
Asserted Claim of '040 Patent	Asada Combinations
	"This article focuses on a wearable ring pulse-oximeter solution, which measures the PPG as well as the arterial oxygen saturation. The PPG contains information about the vascular pressure wave-forms and compliances. Efforts to extract unique circulatory in- formation, especially an ABP surrogate, from the PPG waveform are discussed later in this article. The PPG provides an effective heart rate (measuring heart beats that generate identifiable forward-flow), useful for circulatory considerations though less useful for strict electrophysiologic considerations. For instance, the PPG signal may reveal heart rate variability, provided ectopic heart beats, which corrupt the association with autonomic tone, can be excluded." Asada 2003 at 29-30. "The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "The ring sensor is a miniaturized, telemetric, monitoring device worn by a patient as a finger ring. The ring encapsulates PPG, pulse oximetry combined with wireless communication and miniaturization technologies. This device optically captures the pulsation and oxygen saturation of the arterial blood flow, and transmits the signals to a host computer via a radio-frequency (RF) transmitter. Fig. 1 shows a conceptual diagram of the ring sensor [5], [6]. The ring sensor consists of optoelectronic components, a CPU, a RF transmitter, a battery, and a ring chassis. The optoelectronic components, i.e., micro photodiodes and LEDs, detect the blood-volume waveforms and oxygen-saturation level at the patient's digital artery. The CPU controls the LED lighting sequence as well as the data acquisition and transmission process. These signals are locally processed by the on-board CPU and transmitted to a host computer for diagnosis of the patient's cardiovascular conditions. The ring sensor is completely wireless and miniaturized so that the patient can wear the device comfortably 24 h/day." Asada 2001 at 796.

Asserted Claim of '040 Patent	Asada Combinations
	Asada 2001 – Figure 1  Fig. 1. Conceptual diagram of the ring sensor. Asada 2010 page 3

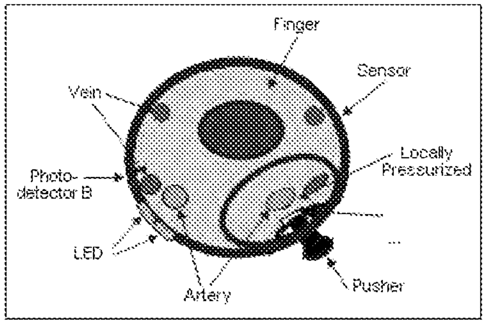
Asserted Claim of '040 Patent	Asada Combinations
	 Asada 2010 page 9

Asserted Claim of '040 Patent	Asada Combinations
	 Asada 2010 – Page 62

Asserted Claim of '040 Patent	Asada Combinations
	
[1A] a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters	The Asada Combinations disclose and/or render obvious "a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters." "Furthermore, wearable PPG sensors are exposed to diverse ambient lighting conditions, ranging from direct sunlight to flickering room light. In addition, wearable PPG sensors must be designed for reduced power consumption. Carrying a large battery pack is not acceptable for long-term applications. The whole sensor system must run continually using a small battery. Several ways to cope with these difficulties are:

Asserted Claim of '040 Patent	Asada Combinations
	➤ secure the LEDs and the photodetector (PD for short) at a location along the finger skin such that the dc component may be influenced less by the finger motion ➤ modulate the LEDs to attenuate the influence of uncorrelated ambient light as well as to reduce power consumption…" Asada 2003 at 30.  Fig. 2. (a) For the reflective illumination method, movement of the photodiode relative to the LED (position 1 to position 2) leads to a photon path that no longer contains the digital artery. (b) For the transmittal illumination method, movement of the photodetector relative to the LED still contains photon paths that pass through the digital artery. "The location of the LEDs and a PD relative to the finger is an important design issue determining signal quality and robustness against motion artifact. Figure 2 shows a cross-sectional view of the finger with the ring sensor. The LEDs and PD are placed on the flanks of the finger rather than the dorsal and palmar sides." Asada 2003 at 30-31. "For these reasons, at least one optical device, either the PD or the LED, should be placed on one lateral face of the finger near the digital artery. The question is where to place the other device. Figure 2 shows two distinct cases. One case places both the PD and the LED on the same side of

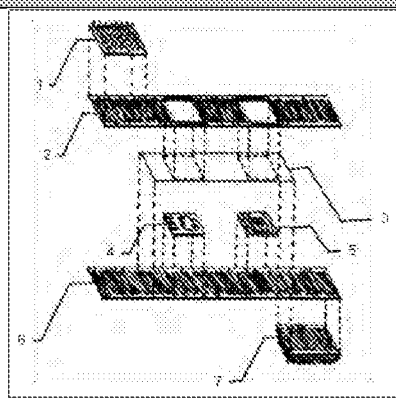
Asserted Claim of '040 Patent	Asada Combinations
	the finger-base, and the other places them on opposite sides of the finger. Placing both the PD and the LED on the same side creates a type of reflective PPG, while placing each of them on opposite sides makes a type of transmittal PPG. In the figure the average pathway of photons is shown for the two sensor arrangements. Although the exact photon path is difficult to obtain, due to the heterogeneous nature of the finger tissue and blood, a banana-shaped arc connecting the LED and PD, as shown in the figure, can approximate its average path [19]." Asada 2003 at 31. "Reflective PPG needs more secure attachments of the LED and PD to the skin surface, when compared to transmittal PPG. Once an air gap is created between the skin surface and the optical components due to some disturbance, a direct optical path from the LED to the PD may be created. This direct path exposes the PD directly to the light source and consequently leads to saturation. To avoid this short circuit, the LED light beam must be focused only in the normal direction, and the PD must also have a strong directional property (i.e., polarity), so that it is sensitive to only the incoming light normal to the device surface. Such strong directional properties, however, work adversely when a disturbance pressure acts on the sensor bodies, since it deflects the direction of the LED and PD leading to fluctuations in the out- put signal. As a result, reflective PPG configurations are more susceptive to disturbances." Asada 2003 at 31. "Furthermore, transmittal PPG is less sensitive to local disturbances acting on the finger, since the LED irradiates a larger volume of the finger. In the transmittal PPG configuration, the percentage of the measured signal does not significantly change although some peripheral capillary beds are collapsed. The percentage change is greater for reflective PPG, since this volume is smaller." Asada 2003 at 31. "Figure 3 shows an experimental comparison between transmittal and reflective PPGs. Two sets of PPG sensors, one reflective and one transmittal, were attached to the same finger. Both were at rest initially, and then shaken. The transmittal PPG was quite stable, while the reflective PPG was susceptive to the motion disturbances." Asada 2003 at 31.

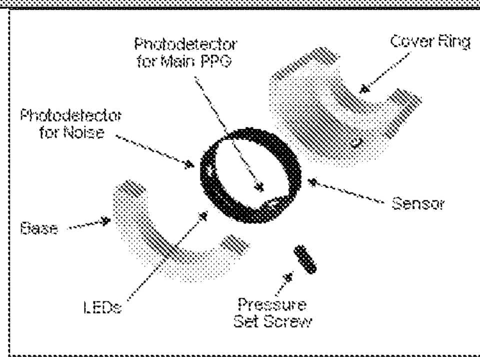
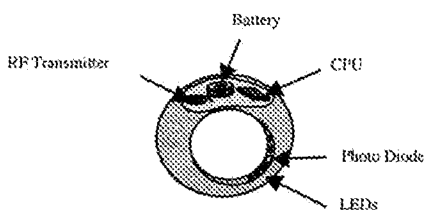
Asserted Claim of '040 Patent	Asada Combinations
	 **Fig. 6.** The schematic of a locally pressurized sensor band. 

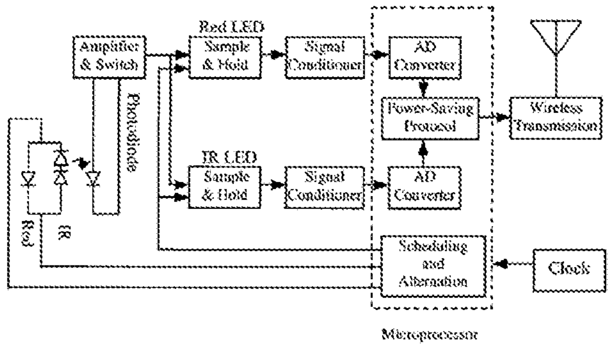
Omni MedSci, Inc. v. Apple Inc.
Case No. 2:18-cv-134-RWS (E.D. Tex.)

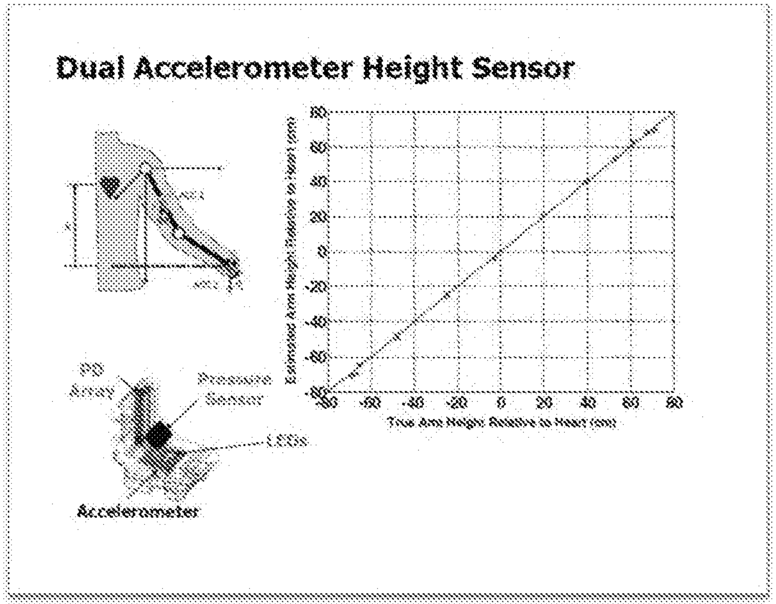
EXHIBIT CC-2, p. 11

Asserted Claim of '040 Patent	Asada Combinations
	Fig. 9. First prototype ring sensor with RF transmitter powered by a coin-size cell battery. "Figure 9 shows the first ring sensor prototype that contains an optical sensor unit, analog and digital processing units, and an RF transmitter, all of which are encapsulated in a compact body and powered by a tiny cell battery used for wristwatches. The ring has a PIC microcomputer performing all the device controls and low-level signal processing, including LED modulation, data acquisition, filtering, and bi-directional RF communication. The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz. The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "In this early development, the power consumption of the LEDs and the imbedded CPU clock were a major bottleneck limiting the design. The distance between the LEDs and PDs had to be shortened for power saving considerations, and the CPU clock was minimized in order to extend the battery life to a few weeks. See [30] for power budget and design details." Asada 2003 at 34.

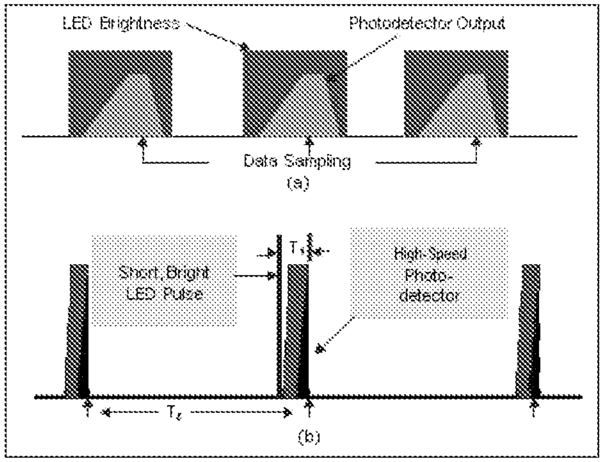
Asserted Claim of '040 Patent	Asada Combinations
	 Fig. 11. Redesigned sensor band that protects optical components from direct contact with skin and hides wires from outside environment. "To improve motion artifact resistance and accuracy, a transmittal PPG ring sensor, Prototype B, has been built and field-tested. Prototype B has high-speed optical devices enabling the lowering of the LED duty rate to 1/1,000. The LED used is 6.7 times brighter than that of Prototype A, while the resultant power consumption is 173 times smaller than before. The sensor band was redesigned with the use of bio-compatible elastic materials to better hold the LED's and PD's, maintain a proper level of pressure, optically shield the sensor unit, and secure the contact with the skin consistently in the face of finger motion (see Figure 11). As a result, the waveform of this transmittal PPG was quite stable. Figure 3 presented earlier is the experiment of Prototype B. Note that the transmittal PPG (Prototype B) signal did not collapse even when the hand was shaken. Additionally, the analog filtering circuit was optimized for quality of signal. These modifications greatly improved the ability of the device to measure traditionally difficult variables such as heart rate variability (Table 1, Figure 12)." Asada 2003 at 35.

Asserted Claim of '040 Patent	Asada Combinations
	 Fig. 15. The schematic of the Prototype C ring sensor. "The local pressurization and motion detection methods described previously have been implemented for further improvement. Figure 15 shows the schematic of the Prototype C ring sensor. Both transmittal (PD-A) and reflective (PD-B) PPGs were mounted on the sensor band. The former is placed on top of a locally pressurizing mechanism with an adjustable setscrew. The latter is mounted on the low-pressure side in order to detect motion." Asada 2003 at 36. Asada 2001 – Figure 1 

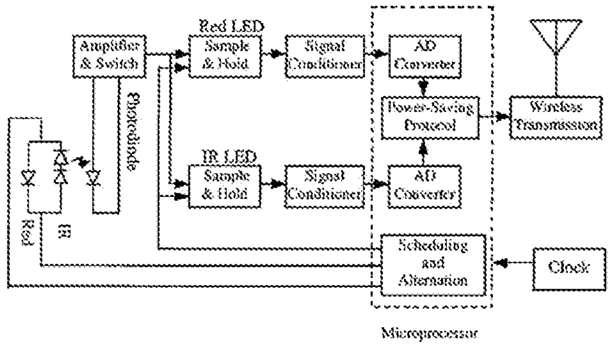
Asserted Claim of '040 Patent	Asada Combinations
	Fig. 1. Conceptual diagram of the ring sensor. Asada 2001 – Figure 4:  Fig. 4. Block diagram of electronic circuit. "Fig. 4 shows a block diagram of the ring sensor circuitry. The basic circuit configuration is a standard PPG circuit combined with a wireless transmitter. There are a single photodiode and LEDs of two different wavelengths, red and near infrared, involved in the circuit. The output from the photodiode is am- plified and conditioned at the first stage operational amplifier. While the red and infrared LEDs are alternately turned on and off, the signal from the first stage op-amp is sampled by the two sample-and-hold circuits at different timings in order to obtain the reflected light intensity from each LED. Each channel of the signal is conditioned and converted to a digital signal with an AD converter. Using the standard RS-232 protocol, the two channels of digital signals are transmitted via a RF transmitter." Asada 2001 at 797.

Asserted Claim of '040 Patent	Asada Combinations
	Asada 2010 – Page 50 
[1B] the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an input optical beam	The Asada Combinations disclose and/or render obvious "the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an input optical beam having one or more optical wavelengths."

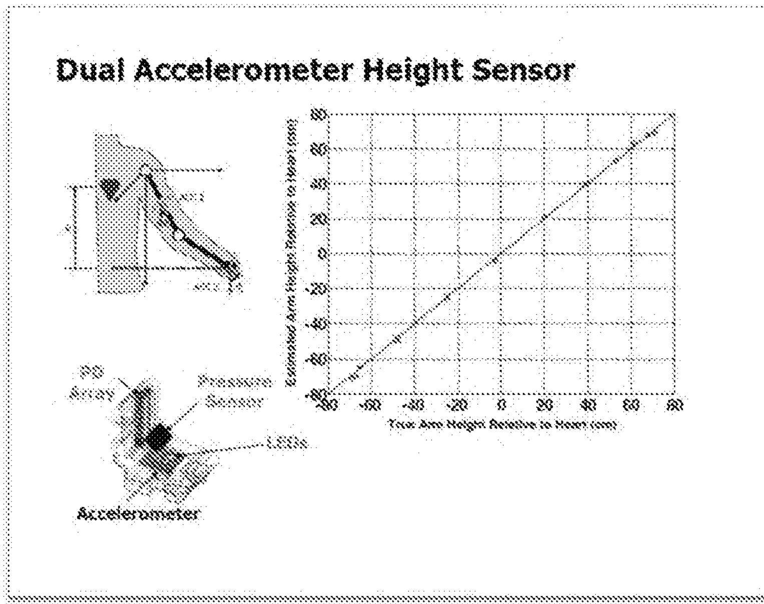
Asserted Claim of '040 Patent	Asada Combinations
having one or more optical wavelengths,	"Furthermore, wearable PPG sensors are exposed to diverse ambient lighting conditions, ranging from direct sunlight to flickering room light. In addition, wearable PPG sensors must be designed for reduced power consumption. Carrying a large battery pack is not acceptable for long-term applications. The whole sensor system must run continually using a small battery. Several ways to cope with these difficulties are: ➤ secure the LEDs and the photodetector (PD for short) at a location along the finger skin such that the dc component may be influenced less by the finger motion ➤ modulate the LEDs to attenuate the influence of uncorrelated ambient light as well as to reduce power consumption ➤ increase the amplitude of the ac component so that the signal-to-noise ratio may increase ➤ measure the finger motion with another sensor or a second PD and use it as a noise reference for verifying the signal as well as for canceling the disturbance and noise. In the following sections these methods will briefly be discussed, followed by specific sensor designs and performance tests." Asada 2003 at 30.

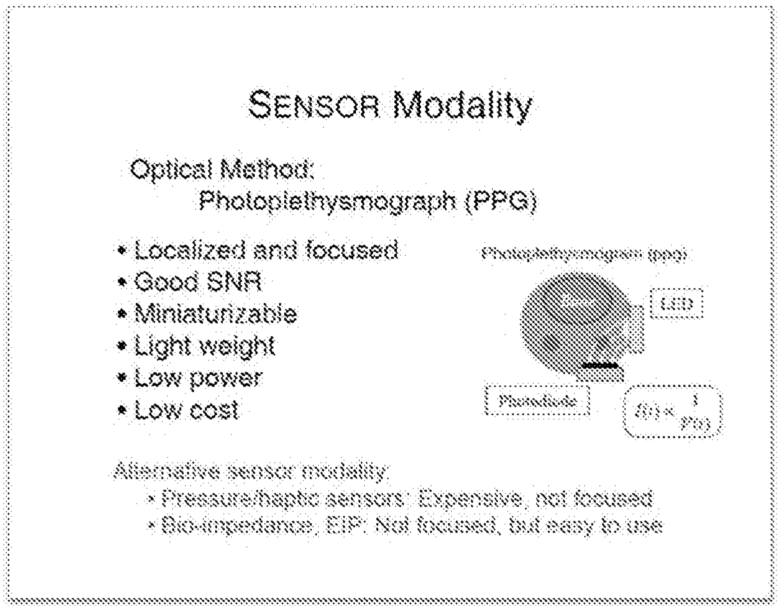
Asserted Claim of '040 Patent	Asada Combinations
	 **Fig. 4.** (a) The slow response time of the photodetector meant that the LED had to be modulated at lower frequencies for data sampling. (b) A faster photodetector response time makes it possible to increase the modulation frequency of the LED. "Transmittal PPG must have a powerful LED for transmitting light across the finger. This power consumption problem can be solved with a lighting modulation technique using high-speed devices. Instead of lighting the skin continually, the LED is turned on only for a short time, say 100 ~ 1000 ns, and the signal is sampled within this period. High-speed LEDs and PDs, which have become available at low cost in recent years, can be used for this purpose. Figure 4 shows a schematic of high-frequency, low-duty cycle modulation implemented to minimize LED power consumption. Utilizing fast rise-time optical detectors, it is possible to incorporate a modulation frequency of 1 kHz with a duty ratio of 0.1%, a theoretical power usage that is 1,000 times less than conventional full-cycle modulation methods [23]." Asada 2003 at 32.

Asserted Claim of '040 Patent	Asada Combinations
	"In addition to saving power, the modulation of LED lighting provides an effective means for reducing ambient light disturbances. Reading the PD output while the LED is turned off yields the baseline PPG level attributed to the ambient light alone. Subtracting this reading from the one acquired with the LED illuminated gives the net output correlated with the LED lighting. More sophisticated modulation schemes can be applied by controlling the LED brightness as a periodic time function. Computational power requirements often prohibit complex modulation, however. Design trade-offs must be considered to find the best modulation scheme." Asada 2003 at 32. "Figure 9 shows the first ring sensor prototype that contains an optical sensor unit, analog and digital processing units, and an RF transmitter, all of which are encapsulated in a compact body and powered by a tiny cell battery used for wristwatches. The ring has a PIC microcomputer performing all the device controls and low-level signal processing, including LED modulation, data acquisition, filtering, and bi-directional RF communication. The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz. The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "High-speed LEDs and PDs, which have become available at low cost in recent years, can be used for this purpose. Figure 4 shows a schematic of high-frequency, low-duty cycle modulation implemented to minimize LED power consumption. Utilizing fast rise-time optical detectors, it is possible to incorporate a modulation frequency of 1 kHz with a duty ratio of 0.1%, a theoretical power usage that is 1,000 times less than conventional full-cycle modulation methods [23]." Asada 2003 at 32. "In this early development, the power consumption of the LEDs and the imbedded CPU clock were a major bottleneck limiting the design. The distance between the LEDs and PDs had to be shortened for power saving considerations, and the CPU clock was minimized in order to extend the battery life to a few weeks. See [30] for power budget and design details." Asada 2003 at 34. "To improve motion artifact resistance and accuracy, a transmittal PPG ring sensor, Prototype B, has been built and field-tested. Prototype B has high-speed optical devices enabling the lowering

Asserted Claim of '040 Patent	Asada Combinations
	of the LED duty rate to 1/1,000. The LED used is 6.7 times brighter than that of Prototype A, while the resultant power consumption is 173 times smaller than before." Asada 2003 at 35. Asada 2001 – Figure 4:  Fig. 4. Block diagram of electronic circuit. "Fig. 4 shows a block diagram of the ring sensor circuitry. The basic circuit configuration is a standard PPG circuit combined with a wireless transmitter. There are a single photodiode and LEDs of two different wavelengths, red and near infrared, involved in the circuit. The output from the photodiode is amplified and conditioned at the first stage operational amplifier. While the red and infrared LEDs are alternately turned on and off, the signal from the first stage op-amp is sampled by the two sample-and-hold circuits at different timings in order to obtain the reflected light intensity from each LED. Each channel of the signal is conditioned and converted to a digital signal with an AD converter. Using the standard RS-232 protocol, the two channels of digital signals are transmitted via a RF transmitter." Asada 2001 at 797. "There are a number of existing techniques for dealing with artifact and disturbance rejection. The most common is signal processing, as reviewed by [11]. Another standard method is to identify

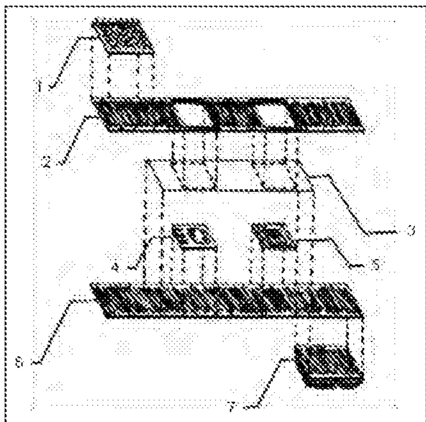
Asserted Claim of '040 Patent	Asada Combinations
	and reject corrupt signals by comparing pulse features with a predetermined template. Other methods use modulation by controlling the power level of multiple lighting sources [11].” Asada 2001 at 796. “*LED*: LEDs consume a large amount of power when emitting light continuously. Therefore they must be switched on only for a short interval when light must be emitted. Namely, the LEDs must be on only when the photodiode is detecting the reflected light for measuring the pulsation. Synchronizing the sampling of the photodetector with the LED switching reduces the duty ratio of the LEDs, and thereby reduces the power consumption. In the prototype system, this coordination is per- formed by the microprocessor. First, the LEDs are turned on; second, the photo detector signal is sampled at the next CPU cycle; the LEDs are switched off at the third CPU cycle. This sequence control is performed for both red and infrared LEDs.” Asada 2001 at 798. Asada 2010 – Page 50

Asserted Claim of '040 Patent	Asada Combinations
	 Asada 2010 Page 52

Asserted Claim of '040 Patent	Asada Combinations
	
[1C] wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers;	The Asada Combinations disclose and/or render obvious "wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers."

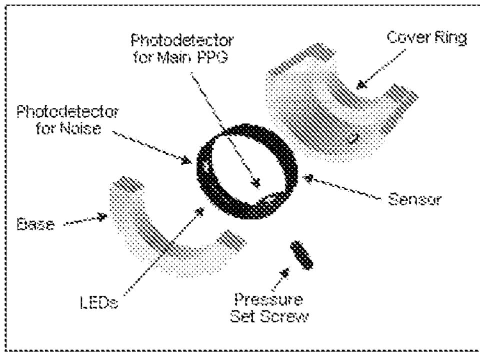
Asserted Claim of '040 Patent	Asada Combinations
	"Figure 9 shows the first ring sensor prototype that contains an optical sensor unit, analog and digital processing units, and an RF transmitter, all of which are encapsulated in a compact body and powered by a tiny cell battery used for wristwatches. The ring has a PIC microcomputer performing all the device controls and low-level signal processing, including LED modulation, data acquisition, filtering, and bi-directional RF communication. The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz. The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "High-speed LEDs and PDs, which have become available at low cost in recent years, can be used for this purpose. Figure 4 shows a schematic of high-frequency, low-duty cycle modulation implemented to minimize LED power consumption. Utilizing fast rise-time optical detectors, it is possible to incorporate a modulation frequency of 1 kHz with a duty ratio of 0.1%, a theoretical power usage that is 1,000 times less than conventional full-cycle modulation methods [23]." Asada 2003 at 32. "See [30] for power budget and design details." Asada 2003 at 34. "To improve motion artifact resistance and accuracy, a transmittal PPG ring sensor, Prototype B, has been built and field-tested. Prototype B has high-speed optical devices enabling the lowering of the LED duty rate to 1/1,000. The LED used is 6.7 times brighter than that of Prototype A, while the resultant power consumption is 173 times smaller than before." Asada 2003 at 35. "*LEDs and Photodiode*: One red LED and two infrared LEDs are used as the light sources. The peak wavelength of the red LED is 660 nm, and that of the infrared LEDs is 940 nm. The photodiode has the peak wavelength of 940 nm and the spectral sensitivity ranges from 500 nm to 1000 nm, which meets our needs. The voltage drop across the red LED is 1.6 V and that of the infrared LEDs is 1.2 V, and two infra-red LEDs are connected in serial. These LEDs are in a die form with a size of 0.3 mm x 0.3 mm." Asada 2001 at 800.

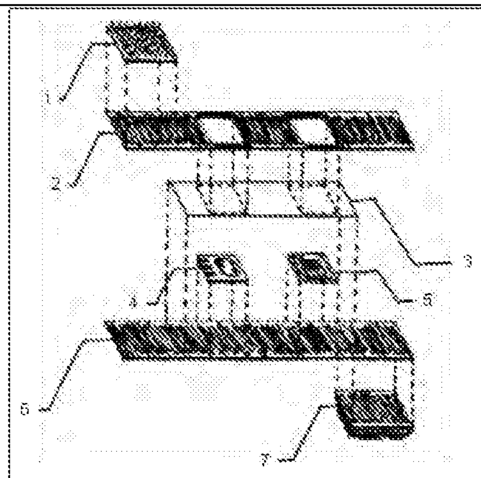
Asserted Claim of '040 Patent	Asada Combinations
[1D] the measurement device comprising one or more lenses configured to receive and to deliver a portion of the input optical beam to tissue, wherein the tissue reflects at least a portion of the input optical beam delivered to the tissue;	The Asada Combinations disclose and/or render obvious "the measurement device comprising one or more lenses configured to receive and to deliver a portion of the input optical beam to tissue, wherein the tissue reflects at least a portion of the input optical beam delivered to the tissue;" "Reflective PPG needs more secure attachments of the LED and PD to the skin surface, when compared to transmittal PPG. Once an air gap is created between the skin surface and the optical components due to some disturbance, a direct optical path from the LED to the PD may be created. This direct path exposes the PD directly to the light source and consequently leads to saturation. To avoid this short circuit, the LED light beam must be focused only in the normal direction, and the PD must also have a strong directional property (i.e., polarity), so that it is sensitive to only the incoming light normal to the device surface." Asada 2003 at 31.  Fig. 9. First prototype ring sensor with RF transmitter powered by a coin-size cell battery.

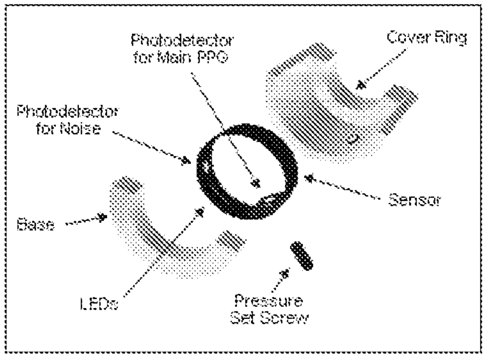
Asserted Claim of '040 Patent	Asada Combinations
	"Figure 9 shows the first ring sensor prototype that contains an optical sensor unit, analog and digital processing units, and an RF transmitter, all of which are encapsulated in a compact body and powered by a tiny cell battery used for wristwatches. The ring has a PIC microcomputer performing all the device controls and low-level signal processing, including LED modulation, data acquisition, filtering, and bi-directional RF communication. The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz. The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "See [30] for power budget and design details." Asada 2003 at 34.  Fig. 11. Redesigned sensor band that protects optical components from direct contact with skin and hides wires from outside environment. "To improve motion artifact resistance and accuracy, a transmittal PPG ring sensor, Prototype B, has been built and field-tested. Prototype B has high-speed optical devices enabling the lowering

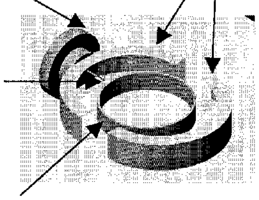
Omni MedSci, Inc. v. Apple Inc.
Case No. 2:18-cv-134-RWS (E.D. Tex.)

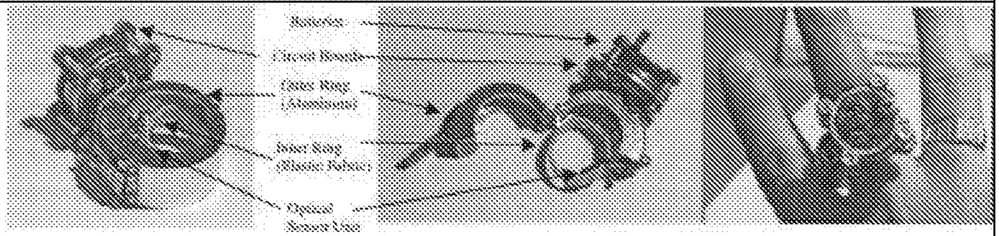
EXHIBIT CC-2, p. 26

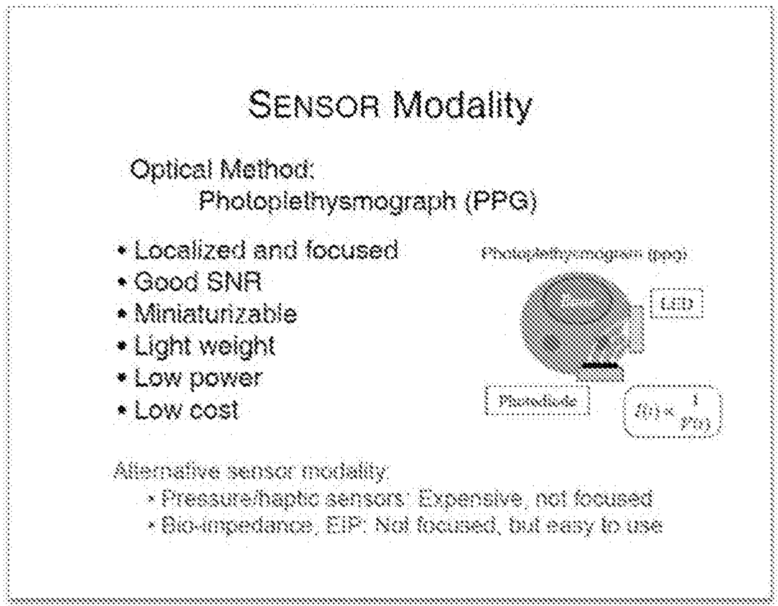
Asserted Claim of '040 Patent	Asada Combinations
	of the LED duty rate to 1/1,000. The LED used is 6.7 times brighter than that of Prototype A, while the resultant power consumption is 173 times smaller than before. The sensor band was redesigned with the use of bio-compatible elastic materials to better hold the LED's and PD's, maintain a proper level of pressure, optically shield the sensor unit, and secure the contact with the skin consistently in the face of finger motion (see Figure 11). As a result, the waveform of this transmittal PPG was quite stable. Figure 3 presented earlier is the experiment of Prototype B. Note that the transmittal PPG (Prototype B) signal did not collapse even when the hand was shaken. Additionally, the analog filtering circuit was optimized for quality of signal. These modifications greatly improved the ability of the device to measure traditionally difficult variables such as heart rate variability (Table 1, Figure 12)." Asada 2003 at 35.  Fig. 15. The schematic of the Prototype C ring sensor. "The local pressurization and motion detection methods described previously have been implemented for further improvement. Figure 15 shows the schematic of the Prototype C ring sensor. Both transmittal (PD-A) and reflective (PD-B) PPGs were mounted on the sensor band.

Asserted Claim of '040 Patent	Asada Combinations
	The former is placed on top of a locally pressurizing mechanism with an adjustable setscrew. The latter is mounted on the low-pressure side in order to detect motion." Asada 2003 at 36.
[1E] the measurement device further comprising a reflective surface configured to receive and redirect at least a portion of light reflected from the tissue;	 Fig. 11. Redesigned sensor band that protects optical components from direct contact with skin and hides wires from outside environment. "To improve motion artifact resistance and accuracy, a transmittal PPG ring sensor, Prototype B, has been built and field-tested. Prototype B has high-speed optical devices enabling the lowering of the LED duty rate to 1/1,000. The LED used is 6.7 times brighter than that of Prototype A, while the resultant power consumption is 173 times smaller than before. The sensor band was redesigned with the use of bio-compatible elastic materials to better hold the LED's and PD's, maintain a proper level of pressure, optically shield the sensor unit, and secure the contact with the

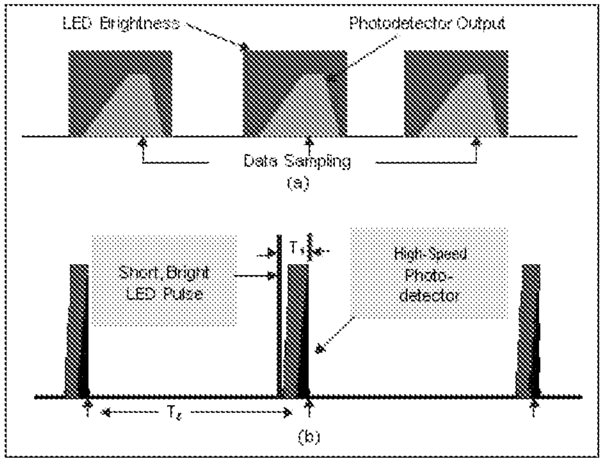
Asserted Claim of '040 Patent	Asada Combinations
	skin consistently in the face of finger motion (see Figure 11). As a result, the waveform of this transmittal PPG was quite stable. Figure 3 presented earlier is the experiment of Prototype B. Note that the transmittal PPG (Prototype B) signal did not collapse even when the hand was shaken. Additionally, the analog filtering circuit was optimized for quality of signal. These modifications greatly improved the ability of the device to measure traditionally difficult variables such as heart rate variability (Table 1, Figure 12)." Asada 2003 at 35.  Fig. 15. The schematic of the Prototype C ring sensor. "The local pressurization and motion detection methods described previously have been implemented for further improvement. Figure 15 shows the schematic of the Prototype C ring sensor. Both transmittal (PD-A) and reflective (PD-B) PPGs were mounted on the sensor band. The former is placed on top of a locally pressurizing mechanism with an adjustable setscrew. The latter is mounted on the low-pressure side in order to detect motion." Asada 2003 at 36. "See [30] for power budget and design details." Asada 2003 at 34.

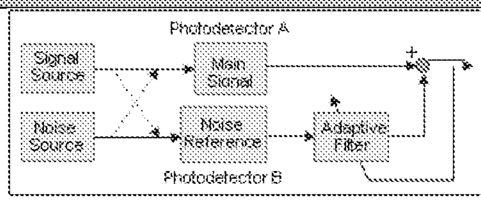
Asserted Claim of '040 Patent	Asada Combinations
	Asada 2001 – Figure 3  Fig. 3. Construction of isolating ring. "Reducing the influence of the ambient lighting: The outer ring shields the sensor unit and thereby reduces optical disturbances from the ambient lighting. The isolating ring structure provides the sensor unit with an optical shield." Asada 2001 at 797. Asada 2001 – Figure 5

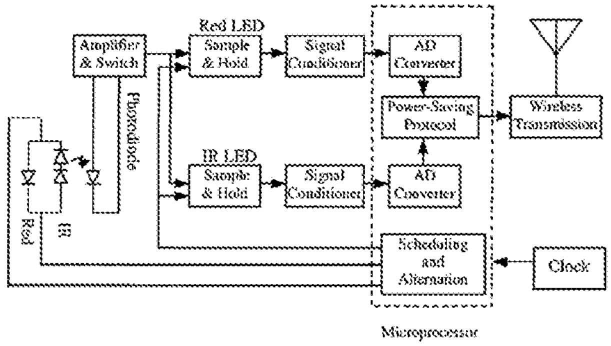
Asserted Claim of '040 Patent	Asada Combinations
	 Fig. 5. Isolating ring sensor designed for motion artifact minimization. "The outer ring is made of aluminum; a block of aluminum was machined to a hollow ring as shown in Fig. 3, and all the parts other than the sensor unit were fixed to the outer ring." Asada 2001 at 799. Asada 2010 Page 52

Asserted Claim of '040 Patent	Asada Combinations
	
[1F] the measurement device further comprising a receiver configured to: capture light while the LEDs are off and convert the captured light into a first signal and capture light while at least one of the LEDs is on and convert the	The Asada Combinations disclose and/or render obvious "the measurement device further comprising a receiver configured to: capture light while the LEDs are off and convert the captured light into a first signal and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the input optical beam reflected from the tissue." "Furthermore, wearable PPG sensors are exposed to diverse ambient lighting conditions, ranging from direct sunlight to flickering room light. In addition, wearable PPG sensors must be designed for reduced power consumption. Carrying a large battery pack is not acceptable for long-term

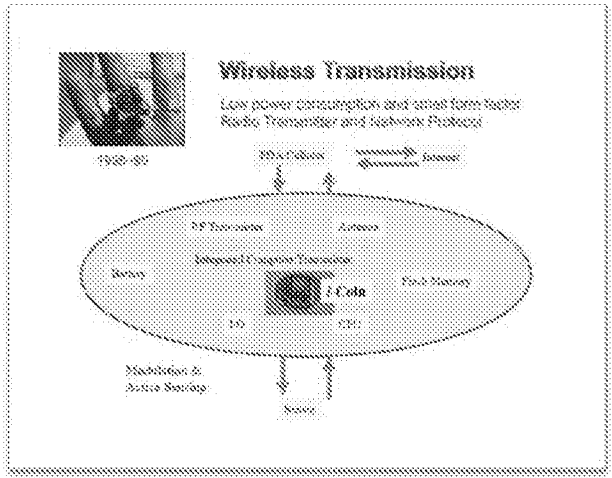
Asserted Claim of '040 Patent	Asada Combinations
captured light into a second signal, the captured light including at least a portion of the input optical beam reflected from the tissue;	applications. The whole sensor system must run continually using a small battery. Several ways to cope with these difficulties are: ➤ secure the LEDs and the photodetector (PD for short) at a location along the finger skin such that the dc component may be influenced less by the finger motion ➤ modulate the LEDs to attenuate the influence of uncorrelated ambient light as well as to reduce power consumption ➤ increase the amplitude of the ac component so that the signal-to-noise ratio may increase ➤ measure the finger motion with another sensor or a second PD and use it as a noise reference for verifying the signal as well as for canceling the disturbance and noise. In the following sections these methods will briefly be discussed, followed by specific sensor designs and performance tests." Asada 2003 at 30.

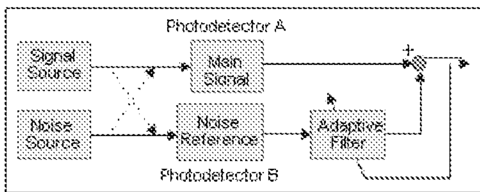
Asserted Claim of '040 Patent	Asada Combinations
	 Fig. 4. (a) The slow response time of the photodetector meant that the LED had to be modulated at lower frequencies for data sampling. (b) A faster photodetector response time makes it possible to increase the modulation frequency of the LED. "In addition to saving power, the modulation of LED lighting provides an effective means for reducing ambient light disturbances. Reading the PD output while the LED is turned off yields the baseline PPG level attributed to the ambient light alone. Subtracting this reading from the one acquired with the LED illuminated gives the net output correlated with the LED lighting. More sophisticated modulation schemes can be applied by controlling the LED brightness as a periodic time function. Computational power requirements often prohibit complex modulation, however. Design trade-offs must be considered to find the best modulation scheme." Asada 2003 at 32.

Asserted Claim of '040 Patent	Asada Combinations
	 Fig. 8. Block diagram of adaptive noise cancellation using second PPG sensor as noise reference. "The motion detector can be used not only for monitoring the presence of motion but also for canceling noise. By using PD-B as a noise reference, a noise cancellation filter can be built to eliminate the noise of PD-A that correlates with the noise reference signal. Assuming that the hemodynamic process observed by PPG is stationary and that the noise is additive, adaptive noise canceling methods, such as the classical Widrow method [29], can be applied in order to recover the true pulsation signal from corrupted waveforms. As shown in Figure 8, the noise-canceling filter combines two sensor signals; one is the main signal captured by PD-A and the other is the noise reference obtained by PD-B. The main signal mostly consists of the true pulsatile signal, but it does contain some noise. If we know the proportion of the noise contained in the main signal, we can generate the noise of the same magnitude by attenuating the noise reference signal and then subtract the noise from the main signal to recover the true pulsatile signal. If the noise magnitude is not known a priori, it must be determined adaptively during the measurement. Various algorithms for adaptive filtering can be applied to tune the filter in real time." Asada 2003 at 33. "See [30] for power budget and design details." Asada 2003 at 34. Asada 2001 – Figure 4:

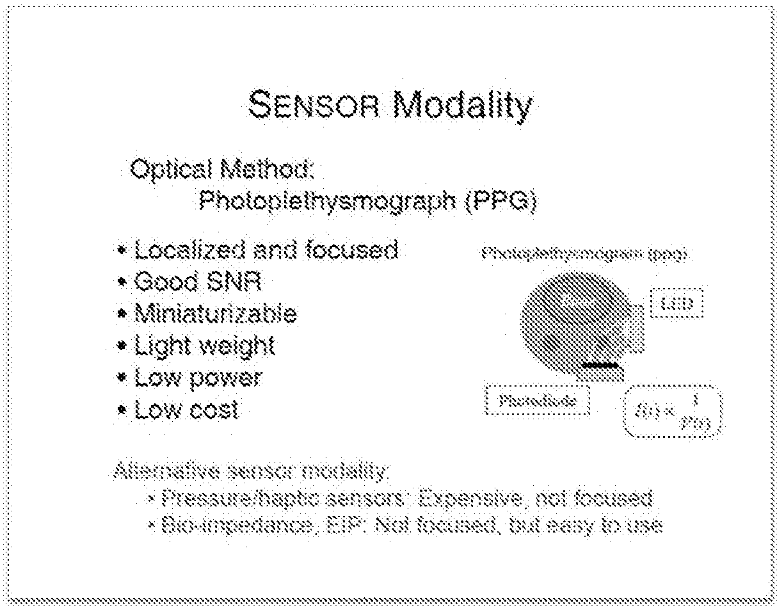
Asserted Claim of '040 Patent	Asada Combinations
	 Fig. 4. Block diagram of electronic circuit. "Fig. 4 shows a block diagram of the ring sensor circuitry. The basic circuit configuration is a standard PPG circuit combined with a wireless transmitter. There are a single photodiode and LEDs of two different wavelengths, red and near infrared, involved in the circuit. The output from the photodiode is amplified and conditioned at the first stage operational amplifier. While the red and infrared LEDs are alternately turned on and off, the signal from the first stage op-amp is sampled by the two sample-and-hold circuits at different timings in order to obtain the reflected light intensity from each LED. Each channel of the signal is conditioned and converted to a digital signal with an AD converter. Using the standard RS-232 protocol, the two channels of digital signals are transmitted via a RF transmitter." Asada 2001 at 797.

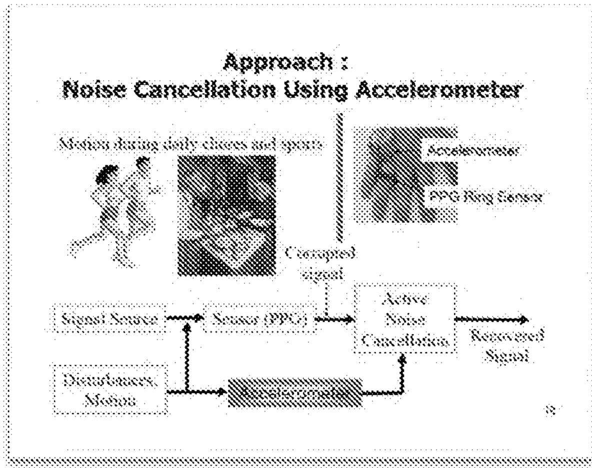
Asserted Claim of '040 Patent	Asada Combinations
	"*LED*: LEDs consume a large amount of power when emitting light continuously. Therefore they must be switched on only for a short interval when light must be emitted. Namely, the LEDs must be on only when the photodiode is detecting the reflected light for measuring the pulsation. Synchronizing the sampling of the photodetector with the LED switching reduces the duty ratio of the LEDs, and thereby reduces the power consumption. In the prototype system, this coordination is performed by the microprocessor. First, the LEDs are turned on; second, the photo detector signal is sampled at the next CPU cycle; the LEDs are switched off at the third CPU cycle. This sequence control is performed for both red and infrared LEDs." Asada 2001 at 798. "The other electronic components of the ring sensor include multiple op-amps, switches, sample-and-hold, and filters." Asada 2001 at 800. "*CPU*: The on-board CPU controls all the operations of the ring sensor, ranging from the sequence control of LED lighting and data acquisition to the conversion of analogue data to digital signals in the RS-232 format for wireless transmission. A PIC16C711 microprocessor from Microchip was selected be- cause of its unique design for low power consumption. It consumes less than 25 A for 32-kHz clock frequency in the normal operation mode and almost no power consumption in the sleep mode. This CPU has 4 channels of embedded A/D converter, 13 channels of digital input–output line. It has 1 KB of EPROM that is good enough to store the whole code needed for computation. The resolution of the A/D converters are all 8-bits. In case that higher resolution is necessary, other CPUs such as PIC16C773 which has 12-bit A/D converters can be used." Asada 2001 at 800. Asada 2010 Page 9

Asserted Claim of '040 Patent	Asada Combinations
	
[1G] the measurement device configured to improve a signal-to-noise ratio of the input optical beam reflected from the tissue by differencing the first signal and the second signal;	The Asada Combinations disclose and/or render obvious "the measurement device configured to improve a signal-to-noise ratio of the input optical beam reflected from the tissue by differencing the first signal and the second signal." "Furthermore, wearable PPG sensors are exposed to diverse ambient lighting conditions, ranging from direct sunlight to flickering room light. In addition, wearable PPG sensors must be designed for reduced power consumption. Carrying a large battery pack is not acceptable for long-term applications. The whole sensor system must run continually using a small battery. Several ways to cope with these difficulties are: ➤ secure the LEDs and the photodetector (PD for short) at a location along the finger skin such that the dc component may be influenced less by the finger motion

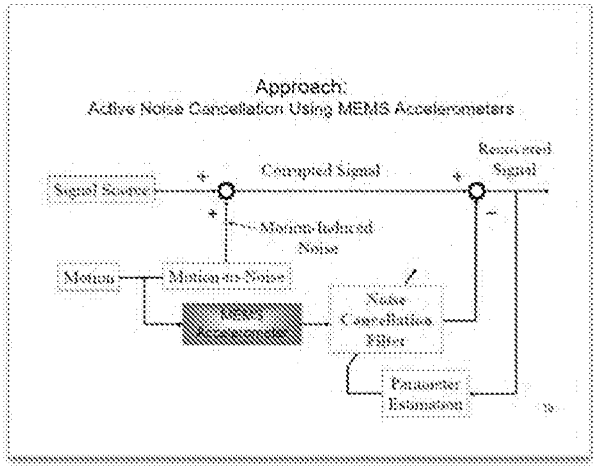
Asserted Claim of '040 Patent	Asada Combinations
	➤ modulate the LEDs to attenuate the influence of uncorrelated ambient light as well as to reduce power consumption ➤ increase the amplitude of the ac component so that the signal-to-noise ratio may increase ➤ measure the finger motion with another sensor or a second PD and use it as a noise reference for verifying the signal as well as for canceling the disturbance and noise. In the following sections these methods will briefly be discussed, followed by specific sensor designs and performance tests." Asada 2003 at 30. "In addition to saving power, the modulation of LED lighting provides an effective means for reducing ambient light disturbances. Reading the PD output while the LED is turned off yields the baseline PPG level attributed to the ambient light alone. Subtracting this reading from the one acquired with the LED illuminated gives the net output correlated with the LED lighting. More sophisticated modulation schemes can be applied by controlling the LED brightness as a periodic time function. Computational power requirements often prohibit complex modulation, however. Design trade-offs must be considered to find the best modulation scheme." Asada 2003 at 32.  Fig. 8. Block diagram of adaptive noise cancellation using second PPG sensor as noise reference. "The motion detector can be used not only for monitoring the presence of motion but also for canceling noise. By using PD-B as a noise reference, a noise cancellation filter can be built to eliminate the noise of PD-A that correlates with the noise reference signal. Assuming that the hemodynamic process observed by PPG is stationary and that the noise is additive, adaptive noise canceling methods, such as the classical Widrow method [29], can be applied in order to recover

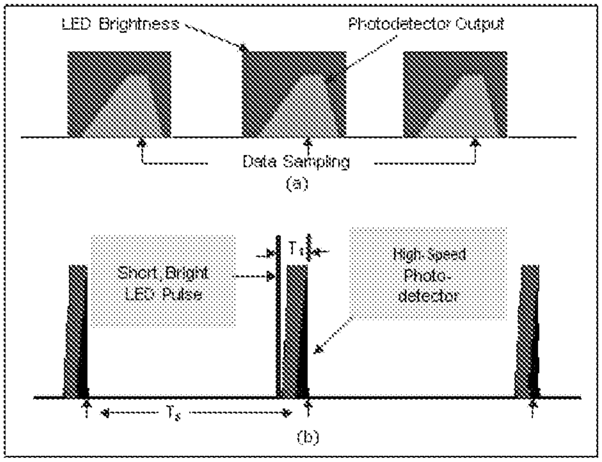
Asserted Claim of '040 Patent	Asada Combinations
	the true pulsation signal from corrupted waveforms. As shown in Figure 8, the noise-canceling filter combines two sensor signals; one is the main signal captured by PD-A and the other is the noise reference obtained by PD-B. The main signal mostly consists of the true pulsatile signal, but it does contain some noise. If we know the proportion of the noise contained in the main signal, we can generate the noise of the same magnitude by attenuating the noise reference signal and then subtract the noise from the main signal to recover the true pulsatile signal. If the noise magnitude is not known a priori, it must be determined adaptively during the measurement. Various algorithms for adaptive filtering can be applied to tune the filter in real time." Asada 2003 at 33. "See [30] for power budget and design details." Asada 2003 at 34. "There are a number of existing techniques for dealing with artifact and disturbance rejection. The most common is signal processing, as reviewed by [11]. Another standard method is to identify and reject corrupt signals by comparing pulse features with a predetermined template. Other methods use modulation by controlling the power level of multiple lighting sources [11]." Asada 2001 at 796. Asada 2010 Page 52

Asserted Claim of '040 Patent	Asada Combinations
	 Asada 2010 Pages 18 and 19

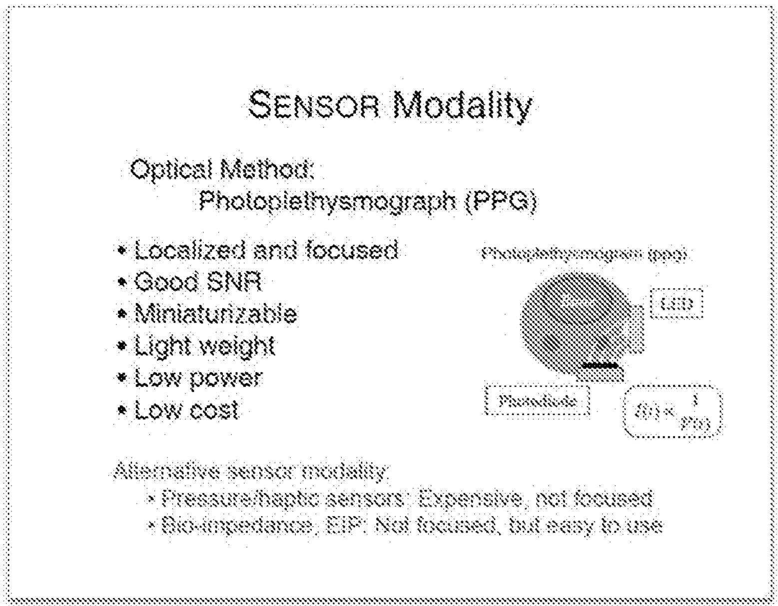
	

Approach :
Noise Cancellation Using Accelerometer
Motion during daily chores and sports
Accelerometer
PPG Ring Sensor
Corrupted signal
Signal Source
Sensor (PPG)
Active Noise Cancellation
Recovered Signal
Disturbances, Motion

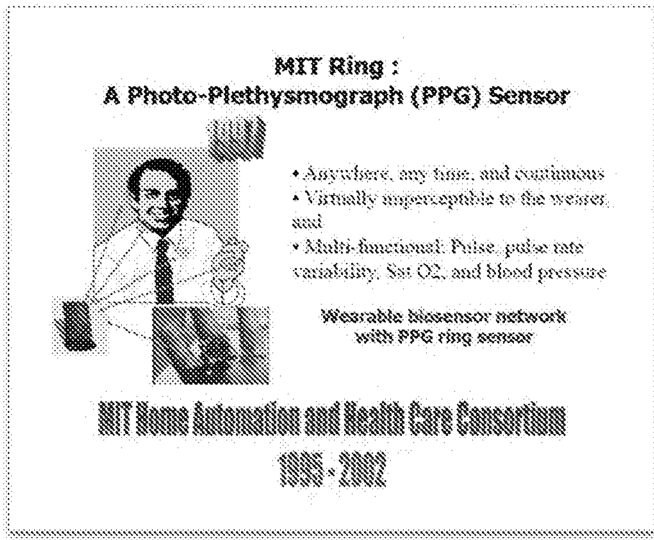
Asserted Claim of '040 Patent	Asada Combinations
	
[1H] the light source configured to further improve the signal-to-noise ratio of the input optical beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs;	The Asada Combinations disclose and/or render obvious "the light source configured to further improve the signal-to-noise ratio of the input optical beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs." "Furthermore, wearable PPG sensors are exposed to diverse ambient lighting conditions, ranging from direct sunlight to flickering room light. In addition, wearable PPG sensors must be designed for reduced power consumption. Carrying a large battery pack is not acceptable for long-term applications. The whole sensor system must run continually using a small battery. Several ways to cope with these difficulties are: ➤ secure the LEDs and the photodetector (PD for short) at a location along the finger skin such that the dc component may be influenced less by the finger motion

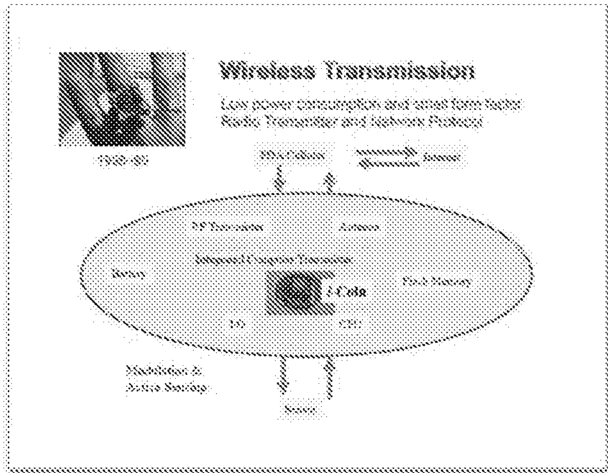
Asserted Claim of '040 Patent	Asada Combinations
	➤ modulate the LEDs to attenuate the influence of uncorrelated ambient light as well as to reduce power consumption ➤ increase the amplitude of the ac component so that the signal-to-noise ratio may increase ➤ measure the finger motion with another sensor or a second PD and use it as a noise reference for verifying the signal as well as for canceling the disturbance and noise. In the following sections these methods will briefly be discussed, followed by specific sensor designs and performance tests." Asada 2003 at 30.  **Fig. 4.** (a) The slow response time of the photodetector meant that the LED had to be modulated at lower frequencies for data sampling. (b) A faster photodetector response time makes it possible to increase the modulation frequency of the LED.

Asserted Claim of '040 Patent	Asada Combinations
	"In addition to saving power, the modulation of LED lighting provides an effective means for reducing ambient light disturbances. Reading the PD output while the LED is turned off yields the baseline PPG level attributed to the ambient light alone. Subtracting this reading from the one acquired with the LED illuminated gives the net output correlated with the LED lighting. More sophisticated modulation schemes can be applied by controlling the LED brightness as a periodic time function. Computational power requirements often prohibit complex modulation, however. Design trade-offs must be considered to find the best modulation scheme." Asada 2003 at 32. Asada 2003 explains that "according to the Lambert-Beer law, the brightness decreases exponentially as the distance from the light source increases." In order to improve the signal-to-noise ratio, brightness of the light is increased by "application of an external pressure on the tissue surrounding the artery" in order to increase the detected amplitude of arterial pulsations. Asada 2003 at 32. "Figure 5 shows the pulsatile amplitude of a finger base PPG for varied pressures generated by a finger cuff. As the cuff pressure increases, the PPG amplitude increases until it reaches a maximum." Asada 2003 at 32. "See [30] for power budget and design details." Asada 2003 at 34. "There are a number of existing techniques for dealing with artifact and disturbance rejection. The most common is signal processing, as reviewed by [11]. Another standard method is to identify and reject corrupt signals by comparing pulse features with a predetermined template. Other methods use modulation by controlling the power level of multiple lighting sources [11]." Asada 2001 at 796. Asada 2010 Page 52

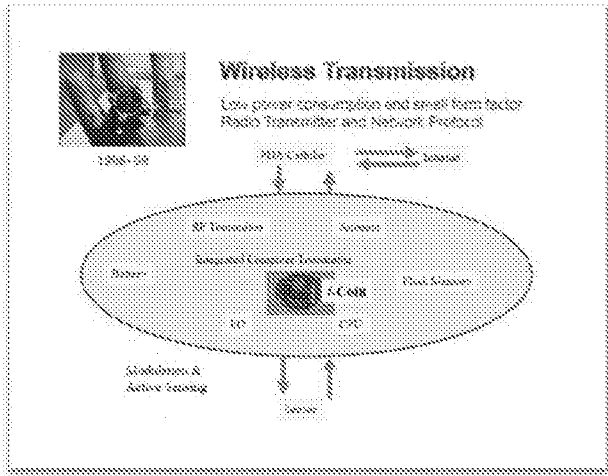
Asserted Claim of '040 Patent	Asada Combinations
	
[1I] the measurement device further configured to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue; and	The Asada Combinations disclose and/or render obvious "the measurement device further configured to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue." "In this article we will address both technical and clinical is- sues of WBS. First, design concepts of a WBS will be presented, with emphasis on the ring sensor developed by the author's group at MIT. The ring sensor is an ambulatory, tele- metric, continuous health-monitoring device. This WBS com- bines miniaturized data acquisition features with advanced photoplethysmographic (PPG) techniques to acquire data related to the patient's cardiovascular state using a method that is

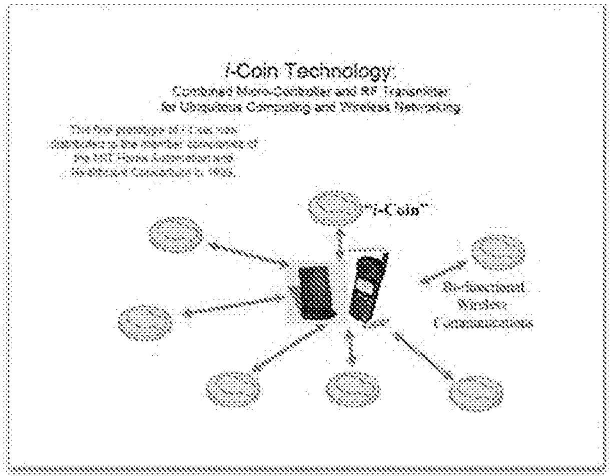
Asserted Claim of '040 Patent	Asada Combinations
	far superior to existing fingertip PPG sensors [1]. In particular, the ring sensor is capable of reliably monitoring a patient's heart rate, oxygen saturation, and heart rate variability. Technical issues, including motion artifact, interference with blood circulation, and battery power issues, will be addressed, and effective engineering solutions to alleviate these problems will be presented. Second, based on the ring sensor technology the clinical potentials of WBS monitoring will be addressed." Asada 2003 at 28. *See generally* Asada 2003 Prototypes A, B, and C. "The ring sensor is a miniaturized, telemetric, monitoring de- vice worn by a patient as a finger ring. The ring encapsulates PPG, pulse oximetry combined with wireless communication and miniaturization technologies. This device optically captures the pulsation and oxygen saturation of the arterial blood flow, and transmits the signals to a host computer via a radio-frequency (RF) transmitter. Fig. 1 shows a conceptual diagram of the ring sensor [5], [6]. The ring sensor consists of optoelectronic components, a CPU, a RF transmitter, a battery, and a ring chassis. The optoelectronic components, i.e., micro photodiodes and LEDs, detect the blood-volume waveforms and oxygen-saturation level at the patient's digital artery. The CPU controls the LED lighting sequence as well as the data acquisition and transmission process. These signals are locally processed by the on-board CPU and transmitted to a host computer for diagnosis of the patient's cardiovascular conditions. The ring sensor is completely wireless and miniaturized so that the patient can wear the device comfortably 24 h/day." Asada 2001 at 796. Asada 2010 Page 3

Asserted Claim of '040 Patent	Asada Combinations
	 Asada 2010 Page 9

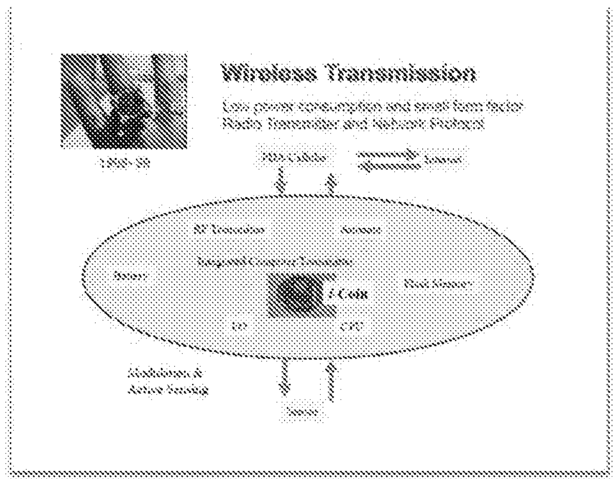
Asserted Claim of '040 Patent	Asada Combinations
	
[1J] the wearable device configured to communicate with the smart phone or tablet, the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a voice input module, a speaker, and a touch screen, the smart phone or tablet configured to receive and to process at least a portion of the output signal,	The Asada Combinations disclose and/or render obvious "the wearable device configured to communicate with the smart phone or tablet, the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a voice input module, a speaker, and a touch screen, the smart phone or tablet configured to receive and to process at least a portion of the output signal." "WBS could play an important role in the wireless surveillance of people during hazardous operations (military, fire-fighting, etc.), or such sensors could be dispensed during a mass civilian casualty occurrence. Given that CV physiologic parameters make up the 'vital signs' that are the most important information in emergency medical situations, WBS might enable a wireless monitoring system for large numbers of at-risk subjects." Asada 2003 at 28. "At the same time, the physiologic information generated by WBS technology must trigger some appropriate system action to improve health outcomes. Abnormal states must be efficiently recognized while false alarms are minimized. This requires carefully designed WBS devices, as

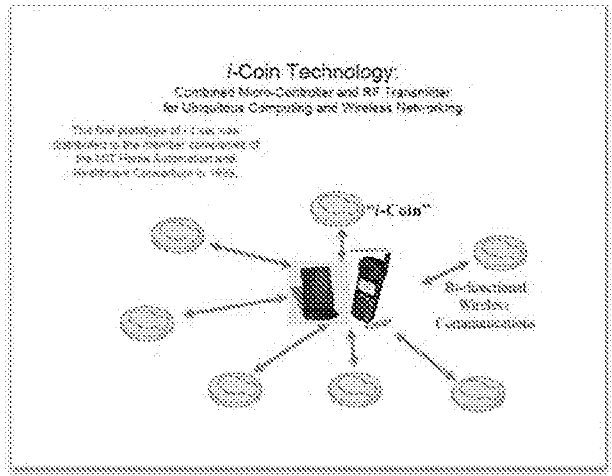
Asserted Claim of '040 Patent	Asada Combinations
	well as innovative postprocessing and intelligent data interpretation. Post-processing of sensor data can improve usability, as illustrated by recent improvements in pulse oximetry technology [3]-[5]. Data interpretation can occur in real time (as is necessary for detecting cardiovascular-related catastrophes) or offline (as is the standard-of-care for arrhythmia surveillance using Holter and related monitoring). Real-time alarm "algorithms" using simple thresholds for measured parameters, like heart rate and oxygen saturation, have demonstrated high rates of false alarms [6], [7]. Algorithms for off-line, retrospective data analysis are also in a developmental stage. Studies of novel automated "triage" software used to interpret hours of continuous noninvasive ECG data of monitored outpatients suggest that the software's diagnostic yield is not equal to a human's when it comes to arrhythmia detection [8], [9]." Asada 2003 at 29. "The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "WBS, in conjunction with diagnostic algorithms and some specific response (which might be human or automated in nature), stand to ameliorate physiologic catastrophes occurring outside conventional clinical environments. For instance, WBS can play an important role in the wireless surveillance of people during hazardous operations (military, fire-fighting, etc.), or such sensors can be dispensed during a mass civilian casualty occurrence. In an overcrowded Emergency Department, patients who are in the waiting room for hours with an undifferentiated medical complaint will receive state-of-the-art physiologic monitoring. For hospital in-patients who require CV monitoring, current biosensor technology typically tethers patients in a tangle of cables. For convalescing patients in a hospital, or a rehabilitation center, there would no longer be a dichotomy between optimal bed-bound monitoring and optimal rehabilitation consisting of ambulation and a full scope of physical activities. Given the physical freedom when monitored by WBS, inpatients may experience less physical deconditioning, and these two factors together may impact the not insignificant problem of dangerous inpatient falls in the elderly (an incidence on the order of 1-5% per admission [32], [33])." Asada 2003 at 37.

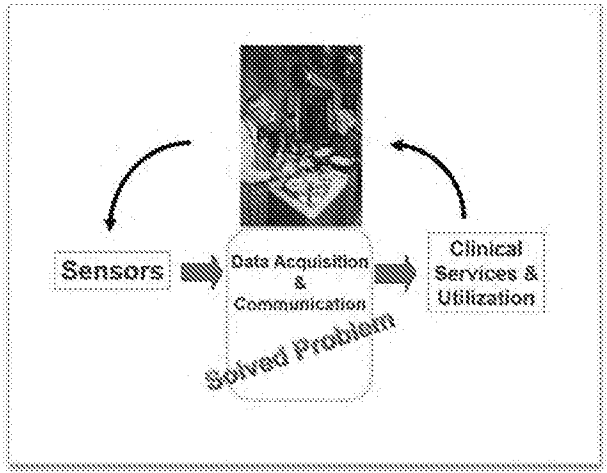
Asserted Claim of '040 Patent	Asada Combinations
	"WBS measuring circulation could also be used to monitor geriatric subjects living alone, offering an automatic 911 call in the event of a catastrophe and peace of mind for the subject and concerned family the rest of the time." Asada 2003 at 37. "See [30] for power budget and design details." Asada 2003 at 34. Asada 2010 Page 9  Asada 2010 Page 10

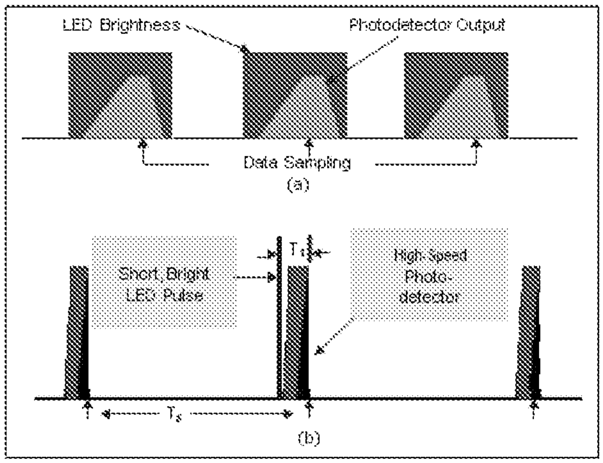
Asserted Claim of '040 Patent	Asada Combinations
	
[1K] wherein the smart phone or tablet is configured to store and display the processed output signal, wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link.	The Asada Combinations disclose and/or render obvious "wherein the smart phone or tablet is configured to store and display the processed output signal, wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link." "However, healthcare providers have only intermittent values of blood pressure on which to base therapy decisions; it is possible that continuous blood pressure monitoring would permit enhanced titration of therapy and reductions in mortality. Similarly, WBS would be able to log the physiologic signature of a patient's exercise efforts (manifested as changes in heart rate and blood pressure), permitting the patient and healthcare provider to assess compliance with a regimen proven to improve health outcomes." Asada 2003 at 28. "The monitoring environments for out-of-hospital, wearable devices demand a new paradigm in noninvasive sensor design. There are several design requirements central to such devices.

Asserted Claim of '040 Patent	Asada Combinations
	Compactness, stability of signal, motion and other disturbance rejection, durability, data storage and transmission, and low power consumption comprise the major design considerations." Asada 2003 at 28. "At the same time, the physiologic information generated by WBS technology must trigger some appropriate system action to improve health outcomes. Abnormal states must be efficiently recognized while false alarms are minimized. This requires carefully designed WBS devices, as well as innovative postprocessing and intelligent data interpretation. Post-processing of sensor data can improve usability, as illustrated by recent improvements in pulse oximetry technology [3]-[5]. Data interpretation can occur in real time (as is necessary for detecting cardiovascular-related catastrophes) or offline (as is the standard-of-care for arrhythmia surveillance using Holter and related monitoring). Real-time alarm "algorithms" using simple thresholds for measured parameters, like heart rate and oxygen saturation, have demonstrated high rates of false alarms [6], [7]. Algorithms for off-line, retrospective data analysis are also in a developmental stage. Studies of novel automated "triage" software used to interpret hours of continuous noninvasive ECG data of monitored outpatients suggest that the software's diagnostic yield is not equal to a human's when it comes to arrhythmia detection [8], [9]." Asada 2003 at 29. "The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "WBS, in conjunction with diagnostic algorithms and some specific response (which might be human or automated in nature), stand to ameliorate physiologic catastrophes occurring outside conventional clinical environments. For instance, WBS can play an important role in the wireless surveillance of people during hazardous operations (military, fire-fighting, etc.), or such sensors can be dispensed during a mass civilian casualty occurrence. In an overcrowded Emergency Department, patients who are in the waiting room for hours with an undifferentiated medical complaint will receive state-of-the-art physiologic monitoring. For hospital in-patients who require CV monitoring, current biosensor technology typically tethers patients in a tangle of cables. For convalescing patients in a hospital, or a rehabilitation center, there would no longer be a dichotomy between optimal bed-bound monitoring and optimal rehabilitation consisting of

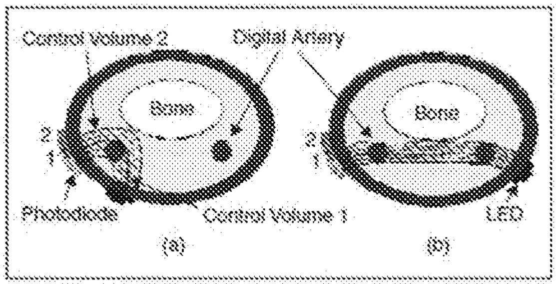
Asserted Claim of '040 Patent	Asada Combinations
	ambulation and a full scope of physical activities. Given the physical freedom when monitored by WBS, inpatients may experience less physical deconditioning, and these two factors together may impact the not insignificant problem of dangerous inpatient falls in the elderly (an incidence on the order of 1-5% per admission [32], [33])." Asada 2003 at 37. "WBS measuring circulation could also be used to monitor geriatric subjects living alone, offering an automatic 911 call in the event of a catastrophe and peace of mind for the subject and concerned family the rest of the time." Asada 2003 at 37. "See [30] for power budget and design details." Asada 2003 at 34. Asada 2010 Page 9  Asada 2010 Page 10

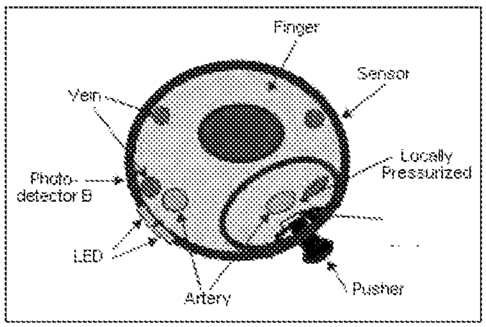
Asserted Claim of '040 Patent	Asada Combinations
	 Asada 2010 Page 13

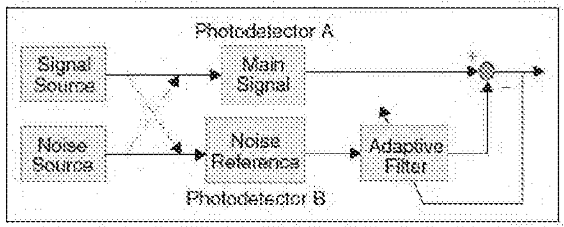
Asserted Claim of '040 Patent	Asada Combinations
	
[2] The wearable device of claim 1, wherein the receiver is configured to be synchronized to the modulation of the at least one of the LEDs.	The Asada Combinations disclose and/or render obvious "wherein the receiver is configured to be synchronized to the modulation of the at least one of the LEDs." "Furthermore, wearable PPG sensors are exposed to diverse ambient lighting conditions, ranging from direct sunlight to flickering room light. In addition, wearable PPG sensors must be designed for reduced power consumption. Carrying a large battery pack is not acceptable for long-term applications. The whole sensor system must run continually using a small battery. Several ways to cope with these difficulties are: ➤ secure the LEDs and the photodetector (PD for short) at a location along the finger skin such that the dc component may be influenced less by the finger motion

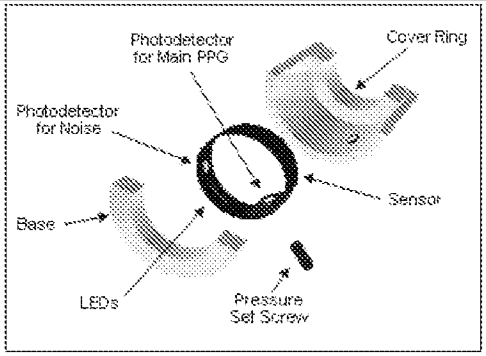
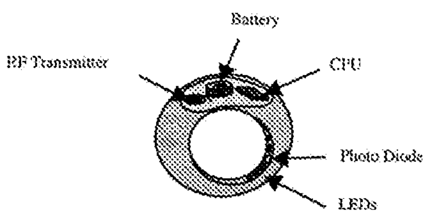
Asserted Claim of '040 Patent	Asada Combinations
	➤ modulate the LEDs to attenuate the influence of uncorrelated ambient light as well as to reduce power consumption ➤ increase the amplitude of the ac component so that the signal-to-noise ratio may increase ➤ measure the finger motion with another sensor or a second PD and use it as a noise reference for verifying the signal as well as for canceling the disturbance and noise. In the following sections these methods will briefly be discussed, followed by specific sensor designs and performance tests." Asada 2003 at 30.  **Fig. 4.** (a) The slow response time of the photodetector meant that the LED had to be modulated at lower frequencies for data sampling. (b) A faster photodetector response time makes it possible to increase the modulation frequency of the LED.

Asserted Claim of '040 Patent	Asada Combinations
	"In addition to saving power, the modulation of LED lighting provides an effective means for reducing ambient light disturbances. Reading the PD output while the LED is turned off yields the baseline PPG level attributed to the ambient light alone. Subtracting this reading from the one acquired with the LED illuminated gives the net output correlated with the LED lighting. More sophisticated modulation schemes can be applied by controlling the LED brightness as a periodic time function. Computational power requirements often prohibit complex modulation, however. Design trade-offs must be considered to find the best modulation scheme." Asada 2003 at 32. "See [30] for power budget and design details." Asada 2003 at 34. "*LED*: LEDs consume a large amount of power when emitting light continuously. Therefore they must be switched on only for a short interval when light must be emitted. Namely, the LEDs must be on only when the photodiode is detecting the reflected light for measuring the pulsation. Synchronizing the sampling of the photodetector with the LED switching reduces the duty ratio of the LEDs, and thereby reduces the power consumption. In the prototype system, this coordination is per- formed by the microprocessor. First, the LEDs are turned on; second, the photo detector signal is sampled at the next CPU cycle; the LEDs are switched off at the third CPU cycle. This sequence control is performed for both red and infrared LEDs." Asada 2001 at 798. "For the prototype ring sensor, the sample-and-hold frequency was set to f = 1000 Hz. The choice of this frequency depends on applications. A lower sampling frequency can be used when required accuracy is lower." Asada 2001 at 800.
[4] The wearable device of claim 1, wherein the receiver is located a first distance from a first one of the LEDs and a different distance from a second one of the LEDs such that the receiver can capture a third signal from the first LED and a fourth signal from the second LED, and wherein the	The Asada Combinations disclose and/or render obvious "[t]he wearable device of claim 1, wherein the receiver is located a first distance from a first one of the LEDs and a different distance from a second one of the LEDs such that the receiver can capture a third signal from the first LED and a fourth signal from the second LED, and wherein the output signal is generated in part by comparing the third and fourth signals."

Asserted Claim of '040 Patent	Asada Combinations
output signal is generated in part by comparing the third and fourth signals.	 Fig. 2. (a) For the reflective illumination method, movement of the photodiode relative to the LED (position 1 to position 2) leads to a photon path that no longer contains the digital artery. (b) For the transmittal illumination method, movement of the photodetector relative to the LED still contains photon paths that pass through the digital artery. "The location of the LEDs and a PD relative to the finger is an important design issue determining signal quality and robustness against motion artifact. Figure 2 shows a cross-sectional view of the finger with the ring sensor. The LEDs and PD are placed on the flanks of the finger rather than the dorsal and palmar sides." Asada 2003 at 30-31. "For these reasons, at least one optical device, either the PD or the LED, should be placed on one lateral face of the finger near the digital artery. The question is where to place the other device. Figure 2 shows two distinct cases. One case places both the PD and the LED on the same side of the finger-base, and the other places them on opposite sides of the finger. Placing both the PD and the LED on the same side creates a type of reflective PPG, while placing each of them on opposite sides makes a type of transmittal PPG. In the figure the average pathway of photons is shown for the two sensor arrangements. Although the exact photon path is difficult to obtain, due to the

Asserted Claim of '040 Patent	Asada Combinations
	heterogeneous nature of the finger tissue and blood, a banana-shaped arc connecting the LED and PD, as shown in the figure, can approximate its average path [19]." Asada 2003 at 31. "Reflective PPG needs more secure attachments of the LED and PD to the skin surface, when compared to transmittal PPG. Once an air gap is created between the skin surface and the optical components due to some disturbance, a direct optical path from the LED to the PD may be created. This direct path exposes the PD directly to the light source and consequently leads to saturation. To avoid this short circuit, the LED light beam must be focused only in the normal direction, and the PD must also have a strong directional property (i.e., polarity), so that it is sensitive to only the incoming light normal to the device surface. Such strong directional properties, however, work adversely when a disturbance pressure acts on the sensor bodies, since it deflects the direction of the LED and PD leading to fluctuations in the out- put signal. As a result, reflective PPG configurations are more susceptive to disturbances." Asada 2003 at 31. "Figure 3 shows an experimental comparison between transmittal and reflective PPGs. Two sets of PPG sensors, one reflective and one transmittal, were attached to the same finger. Both were at rest initially, and then shaken. The transmittal PPG was quite stable, while the reflective PPG was susceptive to the motion disturbances." Asada 2003 at 31. 

Asserted Claim of '040 Patent	Asada Combinations
	Fig. 6. The schematic of a locally pressurized sensor band  Fig. 8. Block diagram of adaptive noise cancellation using second PPG sensor as noise reference "The motion detector can be used not only for monitoring the presence of motion but also for canceling noise. By using PD-B as a noise reference, a noise cancellation filter can be built to eliminate the noise of PD-A that correlates with the noise reference signal. Assuming that the hemodynamic process observed by PPG is stationary and that the noise is additive, adaptive noise canceling methods, such as the classical Widrow method [29], can be applied in order to recover the true pulsation signal from corrupted waveforms. As shown in Figure 8, the noise-canceling filter combines two sensor signals; one is the main signal captured by PD-A and the other is the noise reference obtained by PD-B. The main signal mostly consists of the true pulsatile signal, but it does contain some noise. If we know the proportion of the noise contained in the main signal, we can generate the noise of the same magnitude by attenuating the noise reference signal and then subtract the noise from the main signal to recover the true pulsatile signal." Asada 2003 at 33. "See [30] for power budget and design details." Asada 2003 at 34.

Asserted Claim of '040 Patent	Asada Combinations
	 **Fig. 15.** The schematic of the Prototype C ring sensor. "The local pressurization and motion detection methods described previously have been implemented for further improvement. Figure 15 shows the schematic of the Prototype C ring sensor. Both transmittal (PD-A) and reflective (PD-B) PPGs were mounted on the sensor band. The former is placed on top of a locally pressurizing mechanism with an adjustable setscrew. The latter is mounted on the low-pressure side in order to detect motion." Asada 2003 at 36. Asada 2001 – Figure 1 

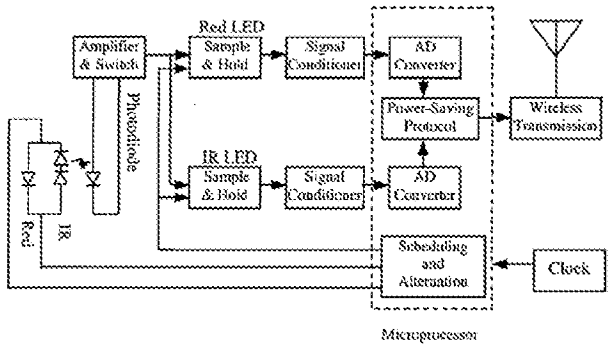
Asserted Claim of '040 Patent	Asada Combinations
	Fig. 1. Conceptual diagram of the ring sensor. Asada 2001 – Figure 4:  Fig. 4. Block diagram of electronic circuit. "Fig. 4 shows a block diagram of the ring sensor circuitry. The basic circuit configuration is a standard PPG circuit combined with a wireless transmitter. There are a single photodiode and LEDs of two different wavelengths, red and near infrared, involved in the circuit. The output from the photodiode is amplified and conditioned at the first stage operational amplifier. While the red and infrared LEDs are alternately turned on and off, the signal from the first stage op-amp is sampled by the two sample-and-hold circuits at different timings in order to obtain the reflected light intensity from each LED. Each channel of the signal is conditioned and converted to a digital signal with an AD converter. Using the standard RS-232 protocol, the two channels of digital signals are transmitted via a RF transmitter." Asada 2001 at 797.

EXHIBIT CC-3

U.S. Patent No. 9,861,286 vs Asada Combinations

Publication Dates: July 2001, May/June 2003, 2010 Prior Art Status: § 103

To the extent Asada et al., "Mobile monitoring with wearable photoplethysmographic biosensors," IEEE Engineering in Medicine and Biology Magazine (May/June 2003) ("Asada 2003"), does not anticipate the asserted claims of U.S. Patent No 9,861,286 ("the '286 Patent") or render those claims obvious alone and/or in view of at least any of the references identified in Apple's Obviousness Combinations Chart, the claims are obvious based on the combination of Asada 2003 with one or both of:

> Rhee et al., Artifact-Resistant Power-Efficient Design of Finger-Ring Plethsymographic Sensors," IEEE Transactions on Biomedical Engineering, Vol. 48, No. 7 (July 2001) ("Asada 2001");
>
> Asada, The MIT Ring: History, Technology, and Challenges of Wearable Health Monitoring, MIT Industrial Liason Program 2010 R&D Conference ("Asada 2010")

("Asada Combinations").

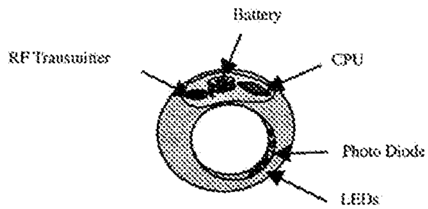
As set forth in Apple's Invalidity Contentions, the below contentions apply the prior art in part in accordance with Apple's assumption that Omni contends the claims are not invalid under 35 U.S.C. § 112. However, Apple's below contentions do not represent Apple's agreement or view as to the meaning, definiteness, written description support for, or enablement of any of the asserted claims. For each dependent claim, the disclosures cited for the claim from which it depends are incorporated by reference.

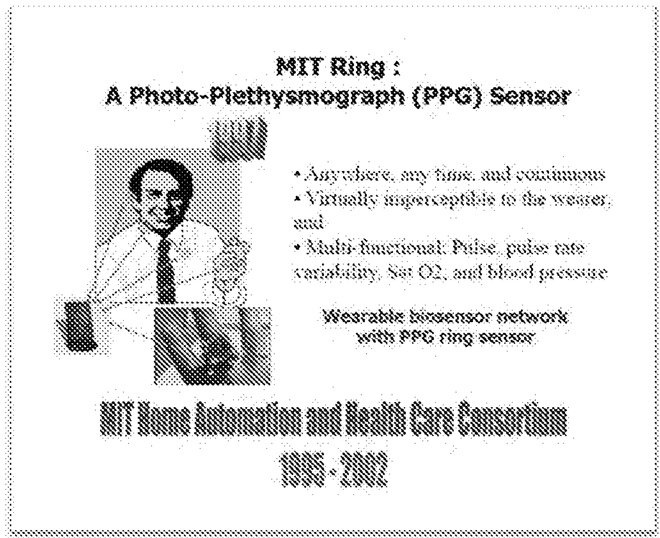
CHART THREE: U.S. Patent No. 9,861,286 vs Asada Combinations

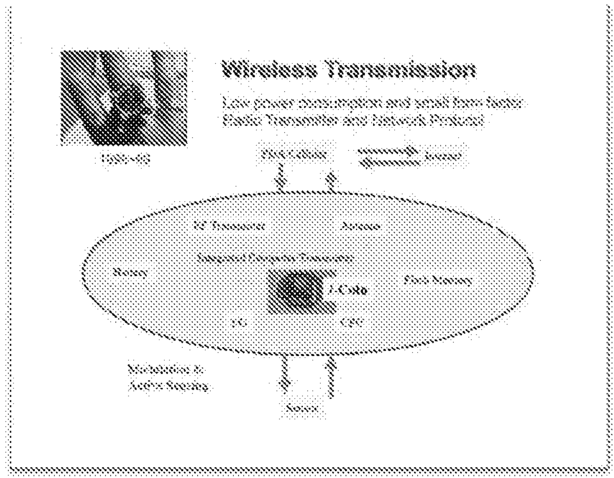
Asserted Claim of '286 Patent	Asada Combinations
[16] A wearable device for use with a smart phone or tablet, the wearable device comprising:	To the extent the preamble is limiting, The Asada Combinations disclose and/or render obvious "[a] wearable device for use with a smart phone or tablet." *See generally* Asada 2003 Figures 6, 9, 11, 15 and descriptions of Prototypes A, B, and C. "Wearable biosensors (WBS) will permit continuous cardiovascular (CV) monitoring in a number of novel settings. Benefits may be realized in the diagnosis and treatment of a number of major diseases. WBS, in conjunction with appropriate alarm algorithms, can increase surveillance capabilities for CV catastrophe for high-risk subjects. WBS could also play a role in the treatment of chronic diseases, by providing information that enables precise titration of therapy or detecting lapses in patient compliance. WBS could play an important role in the wireless surveillance of people during hazardous operations (military, fire-fighting, etc.), or such sensors could be dispensed during a mass civilian casualty occurrence. Given that CV physiologic parameters make up the "vital signs" that are the most important information in emergency medical situations, WBS might enable a wireless monitoring system for large numbers of at-risk subjects. This same approach may also have utility in monitoring the waiting room of today's overcrowded emergency departments. For hospital inpatients who require CV monitoring, current biosensor technology typically tethers patients in a tangle of cables, whereas wearable CV sensors could increase inpatient comfort and may even reduce the risk of tripping and falling, a perennial problem for hospital patients who are ill, medicated, and in an unfamiliar setting." Asada 2003 28. "In this article we will address both technical and clinical issues of WBS. First, design concepts of a WBS will be presented, with emphasis on the ring sensor developed by the author's group at MIT. The ring sensor is an ambulatory, telemetric, continuous health-monitoring device. This WBS combines miniaturized data acquisition features with advanced photoplethysmographic (PPG) techniques to acquire data related to the patient's cardiovascular state using a method that is far superior to existing fingertip PPG sensors [1]. In particular, the ring sensor is capable of reliably monitoring a patient's heart rate, oxygen saturation, and heart rate variability. Technical issues, including motion artifact, interference with blood circulation, and battery power issues,

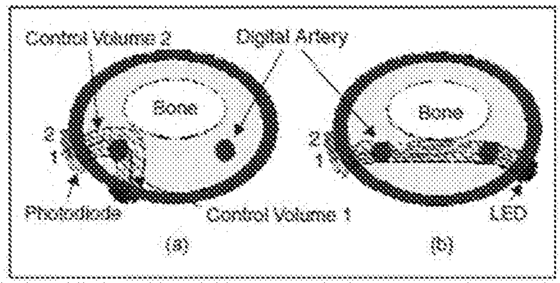
Asserted Claim of '286 Patent	Asada Combinations
	will be addressed, and effective engineering solutions to alleviate these problems will be presented. Second, based on the ring sensor technology the clinical potentials of WBS monitoring will be addressed." Asada 2003 at 28. "The WBS hardware solution must be adequate to make reliable physiologic measurements during activities of daily living or even more demanding circumstances such as fitness training or military battle. There must exist data processing and decision-making algorithms for the waveform data. These algorithms must prompt some action that improves health outcomes. Finally, the systems must be cost effective when compared with less expensive, lower technology alternatives." Asada 2003 at 28. "The monitoring environments for out-of-hospital, wearable devices demand a new paradigm in noninvasive sensor design. There are several design requirements central to such devices. Compactness, stability of signal, motion and other disturbance rejection, durability, data storage and transmission, and low power consumption comprise the major design considerations. Additionally, since WBS devices are to be worn without direct doctor supervision, it is imperative that they are simple to use and comfortable to wear for long periods of time. A challenge unique to wearable sensor design is the trade-off between patient comfort, or long-term wearability, and reliable sensor attachment. While it is nearly needless to say that WBS technology must be safe, it should be noted that there have been tragic reports of serious injury resulting from early home monitoring technology [2]." Asada 2003 28-29. "WBS solutions, in various stages of technologic maturity, exist for measuring established cardiopulmonary 'vital signs': heart rate, arterial blood pressure, arterial oxygen saturation, respiratory rate, temperature, and even cardiac output. In addition, there are numerous WBS modalities that can offer physiologic measurements not conventional in contemporary medical monitoring applications, including acoustic sensors, electrochemical sensors, optical sensors, electromyography and electroencephalography, and other bioanalytic sensors (to be sure, some of these sensors have well-established medical utility, but not for automated surveillance)." Asada 2003 at 29.

Asserted Claim of '286 Patent	Asada Combinations
	"This article focuses on a wearable ring pulse-oximeter solution, which measures the PPG as well as the arterial oxygen saturation. The PPG contains information about the vascular pressure wave-forms and compliances. Efforts to extract unique circulatory in- formation, especially an ABP surrogate, from the PPG waveform are discussed later in this article. The PPG provides an effective heart rate (measuring heart beats that generate identifiable forward-flow), useful for circulatory considerations though less useful for strict electrophysiologic considerations. For instance, the PPG signal may reveal heart rate variability, provided ectopic heart beats, which corrupt the association with autonomic tone, can be excluded." Asada 2003 at 29-30. "The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "The ring sensor is a miniaturized, telemetric, monitoring device worn by a patient as a finger ring. The ring encapsulates PPG, pulse oximetry combined with wireless communication and miniaturization technologies. This device optically captures the pulsation and oxygen saturation of the arterial blood flow, and transmits the signals to a host computer via a radio-frequency (RF) transmitter. Fig. 1 shows a conceptual diagram of the ring sensor [5], [6]. The ring sensor consists of optoelectronic components, a CPU, a RF transmitter, a battery, and a ring chassis. The optoelectronic components, i.e., micro photodiodes and LEDs, detect the blood-volume waveforms and oxygen-saturation level at the patient's digital artery. The CPU controls the LED lighting sequence as well as the data acquisition and transmission process. These signals are locally processed by the on-board CPU and transmitted to a host computer for diagnosis of the patient's cardiovascular conditions. The ring sensor is completely wireless and miniaturized so that the patient can wear the device comfortably 24 h/day." Asada 2001 at 796.

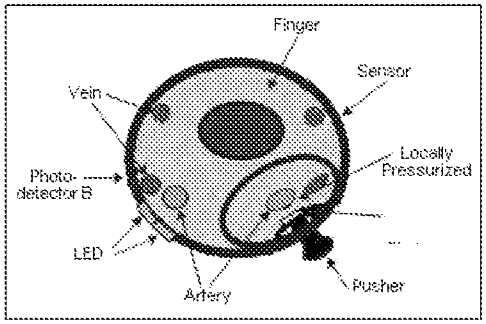
Asserted Claim of '286 Patent	Asada Combinations
	Asada 2001 – Figure 1  Fig. 1. Conceptual diagram of the ring sensor. Asada 2010 page 3

Asserted Claim of '286 Patent	Asada Combinations
	 Asada 2010 page 9

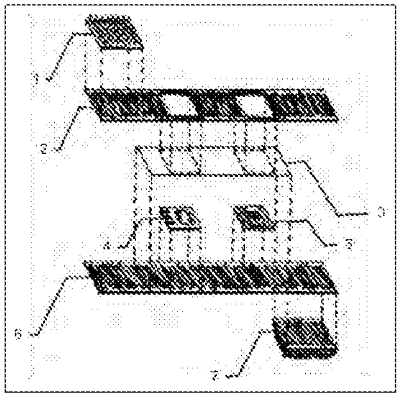
Asserted Claim of '286 Patent	Asada Combinations
	
[16A] a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters,	The Asada Combinations disclose and/or render obvious "a measurement device including a light source comprising a plurality of light emitting diodes (LEDs) for measuring one or more physiological parameters." "Furthermore, wearable PPG sensors are exposed to diverse ambient lighting conditions, ranging from direct sunlight to flickering room light. In addition, wearable PPG sensors must be designed for reduced power consumption. Carrying a large battery pack is not acceptable for long-term

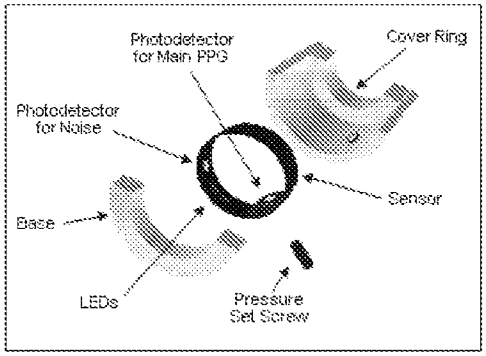
Asserted Claim of '286 Patent	Asada Combinations
	applications. The whole sensor system must run continually using a small battery. Several ways to cope with these difficulties are: ➤ secure the LEDs and the photodetector (PD for short) at a location along the finger skin such that the dc component may be influenced less by the finger motion ➤ modulate the LEDs to attenuate the influence of uncorrelated ambient light as well as to reduce power consumption…" Asada 2003 at 30.  Fig. 2. (a) For the reflective illumination method, movement of the photodiode relative to the LED (position 1 to position 2) leads to a photon path that no longer contains the digital artery. (b) For the transmittal illumination method, movement of the photodetector relative to the LED still contains photon paths that pass through the digital artery. "The location of the LEDs and a PD relative to the finger is an important design issue determining signal quality and robustness against motion artifact. Figure 2 shows a cross-sectional view of the finger with the ring sensor. The LEDs and PD are placed on the flanks of the finger rather than the dorsal and palmar sides." Asada 2003 at 30-31.

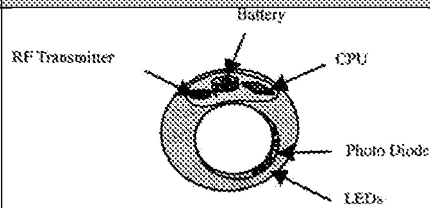
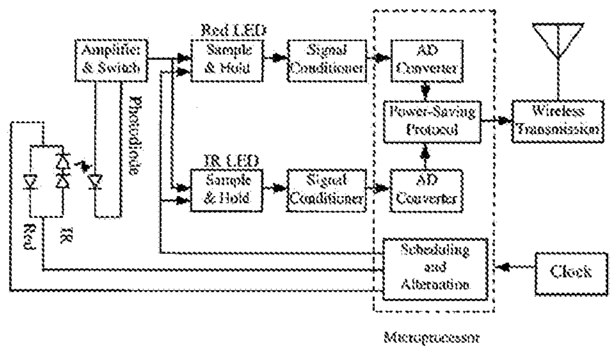
Asserted Claim of '286 Patent	Asada Combinations
	"For these reasons, at least one optical device, either the PD or the LED, should be placed on one lateral face of the finger near the digital artery. The question is where to place the other device. Figure 2 shows two distinct cases. One case places both the PD and the LED on the same side of the finger-base, and the other places them on opposite sides of the finger. Placing both the PD and the LED on the same side creates a type of reflective PPG, while placing each of them on opposite sides makes a type of transmittal PPG. In the figure the average pathway of photons is shown for the two sensor arrangements. Although the exact photon path is difficult to obtain, due to the heterogeneous nature of the finger tissue and blood, a banana-shaped arc connecting the LED and PD, as shown in the figure, can approximate its average path [19]." Asada 2003 at 31. "Reflective PPG needs more secure attachments of the LED and PD to the skin surface, when compared to transmittal PPG. Once an air gap is created between the skin surface and the optical components due to some disturbance, a direct optical path from the LED to the PD may be created. This direct path exposes the PD directly to the light source and consequently leads to saturation. To avoid this short circuit, the LED light beam must be focused only in the normal direction, and the PD must also have a strong directional property (i.e., polarity), so that it is sensitive to only the incoming light normal to the device surface. Such strong directional properties, however, work adversely when a disturbance pressure acts on the sensor bodies, since it deflects the direction of the LED and PD leading to fluctuations in the out- put signal. As a result, reflective PPG configurations are more susceptive to disturbances." Asada 2003 at 31. "Furthermore, transmittal PPG is less sensitive to local disturbances acting on the finger, since the LED irradiates a larger volume of the finger. In the transmittal PPG configuration, the percentage of the measured signal does not significantly change although some peripheral capillary beds are collapsed. The percentage change is greater for reflective PPG, since this volume is smaller." Asada 2003 at 31. "Figure 3 shows an experimental comparison between transmittal and reflective PPGs. Two sets of PPG sensors, one reflective and one transmittal, were attached to the same finger. Both were at rest initially, and then shaken. The transmittal PPG was quite stable, while the reflective PPG was susceptive to the motion disturbances." Asada 2003 at 31.

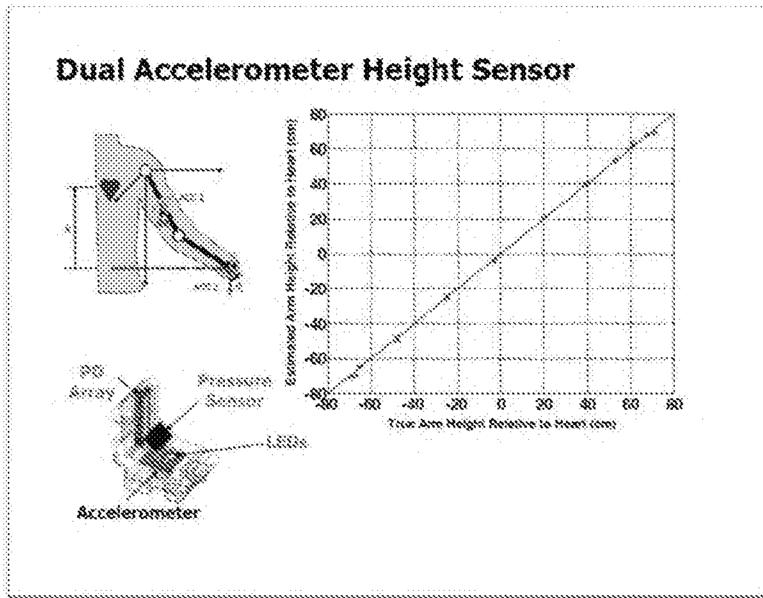
Asserted Claim of '286 Patent	Asada Combinations
	 Fig. 6. The schematic of a locally pressurized sensor band.

Asserted Claim of '286 Patent	Asada Combinations
	 Fig. 9. First prototype ring sensor with RF transmitter powered by a coin-size cell battery. "Figure 9 shows the first ring sensor prototype that contains an optical sensor unit, analog and digital processing units, and an RF transmitter, all of which are encapsulated in a compact body and powered by a tiny cell battery used for wristwatches. The ring has a PIC microcomputer performing all the device controls and low-level signal processing, including LED modulation, data acquisition, filtering, and bi-directional RF communication. The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz. The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34.

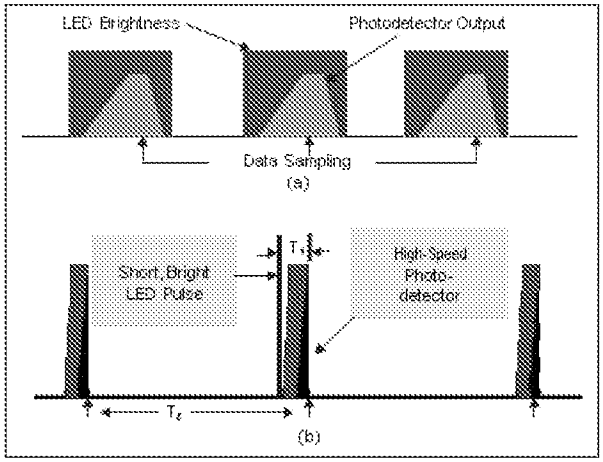
Asserted Claim of '286 Patent	Asada Combinations
	"In this early development, the power consumption of the LEDs and the imbedded CPU clock were a major bottleneck limiting the design. The distance between the LEDs and PDs had to be shortened for power saving considerations, and the CPU clock was minimized in order to extend the battery life to a few weeks. See [30] for power budget and design details." Asada 2003 at 34.  Fig. 11. Redesigned sensor band that protects optical components from direct contact with skin and hides wires from outside environment. "To improve motion artifact resistance and accuracy, a transmittal PPG ring sensor, Prototype B, has been built and field-tested. Prototype B has high-speed optical devices enabling the lowering of the LED duty rate to 1/1,000. The LED used is 6.7 times brighter than that of Prototype A, while the resultant power consumption is 173 times smaller than before. The sensor band was redesigned with the use of bio-compatible elastic materials to better hold the LED's and PD's, maintain a proper level of pressure, optically shield the sensor unit, and secure the contact with the skin consistently in the face of finger motion (see Figure 11). As a result, the waveform of this transmittal PPG was quite stable. Figure 3 presented earlier is the experiment of Prototype B. Note that the transmittal PPG (Prototype B) signal did not collapse even when the hand was shaken.

Asserted Claim of '286 Patent	Asada Combinations
	Additionally, the analog filtering circuit was optimized for quality of signal. These modifications greatly improved the ability of the device to measure traditionally difficult variables such as heart rate variability (Table 1, Figure 12)." Asada 2003 at 35.  Fig. 15. The schematic of the Prototype C ring sensor. "The local pressurization and motion detection methods described previously have been implemented for further improvement. Figure 15 shows the schematic of the Prototype C ring sensor. Both transmittal (PD-A) and reflective (PD-B) PPGs were mounted on the sensor band. The former is placed on top of a locally pressurizing mechanism with an adjustable setscrew. The latter is mounted on the low-pressure side in order to detect motion." Asada 2003 at 36. Asada 2001 – Figure 1

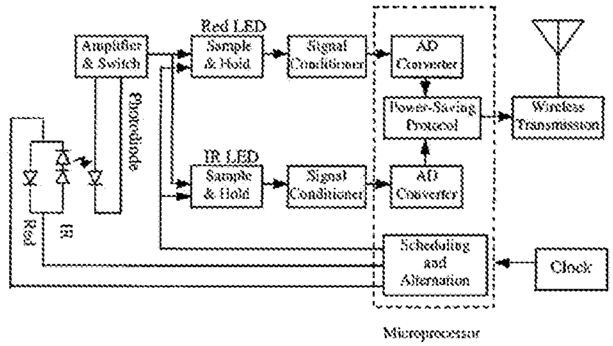
Asserted Claim of '286 Patent	Asada Combinations
	 Fig. 1. Conceptual diagram of the ring sensor. Asada 2001 – Figure 4:  Fig. 4. Block diagram of electronic circuit. "Fig. 4 shows a block diagram of the ring sensor circuitry. The basic circuit configuration is a standard PPG circuit combined with a wireless transmitter. There are a single photodiode and LEDs of two different wavelengths, red and near infrared, involved in the circuit. The output from the photodiode is am- plified and conditioned at the first stage operational amplifier. While the red and infrared LEDs are alternately turned on and off, the signal from the first stage op-amp

Asserted Claim of '286 Patent	Asada Combinations
	is sampled by the two sample-and-hold circuits at different timings in order to obtain the reflected light intensity from each LED. Each channel of the signal is conditioned and converted to a digital signal with an AD converter. Using the standard RS-232 protocol, the two channels of digital signals are transmitted via a RF transmitter." Asada 2001 at 797. Asada 2010 – Page 50 

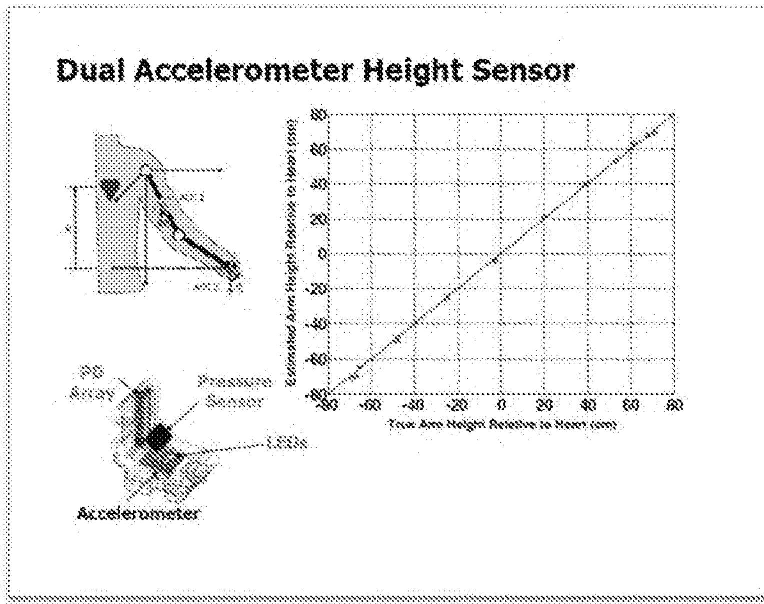
Asserted Claim of '286 Patent	Asada Combinations
[16B] the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an optical beam having a plurality of optical wavelengths,	The Asada Combinations disclose and/or render obvious "the measurement device configured to generate, by modulating at least one of the LEDs having an initial light intensity, an optical beam having a plurality of optical wavelengths." "Furthermore, wearable PPG sensors are exposed to diverse ambient lighting conditions, ranging from direct sunlight to flickering room light. In addition, wearable PPG sensors must be designed for reduced power consumption. Carrying a large battery pack is not acceptable for long-term applications. The whole sensor system must run continually using a small battery. Several ways to cope with these difficulties are: ➤ secure the LEDs and the photodetector (PD for short) at a location along the finger skin such that the dc component may be influenced less by the finger motion ➤ modulate the LEDs to attenuate the influence of uncorrelated ambient light as well as to reduce power consumption ➤ increase the amplitude of the ac component so that the signal-to-noise ratio may increase ➤ measure the finger motion with another sensor or a second PD and use it as a noise reference for verifying the signal as well as for canceling the disturbance and noise. In the following sections these methods will briefly be discussed, followed by specific sensor designs and performance tests." Asada 2003 at 30.

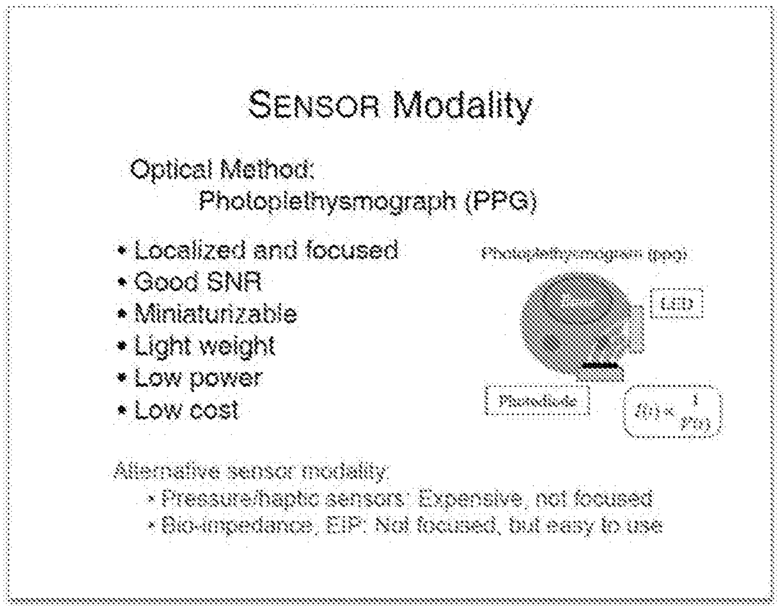
Asserted Claim of '286 Patent	Asada Combinations
	 **Fig. 4.** (a) The slow response time of the photodetector meant that the LED had to be modulated at lower frequencies for data sampling. (b) A faster photodetector response time makes it possible to increase the modulation frequency of the LED. "Transmittal PPG must have a powerful LED for transmitting light across the finger. This power consumption problem can be solved with a lighting modulation technique using high-speed devices. Instead of lighting the skin continually, the LED is turned on only for a short time, say 100 ~ 1000 ns, and the signal is sampled within this period. High-speed LEDs and PDs, which have become available at low cost in recent years, can be used for this purpose. Figure 4 shows a schematic of high-frequency, low-duty cycle modulation implemented to minimize LED power consumption. Utilizing fast rise-time optical detectors, it is possible to incorporate a modulation frequency of 1 kHz with a duty ratio of 0.1%, a theoretical power usage that is 1,000 times less than conventional full-cycle modulation methods [23]." Asada 2003 at 32.

Asserted Claim of '286 Patent	Asada Combinations
	"In addition to saving power, the modulation of LED lighting provides an effective means for reducing ambient light disturbances. Reading the PD output while the LED is turned off yields the baseline PPG level attributed to the ambient light alone. Subtracting this reading from the one acquired with the LED illuminated gives the net output correlated with the LED lighting. More sophisticated modulation schemes can be applied by controlling the LED brightness as a periodic time function. Computational power requirements often prohibit complex modulation, however. Design trade-offs must be considered to find the best modulation scheme." Asada 2003 at 32. "High-speed LEDs and PDs, which have become available at low cost in recent years, can be used for this purpose. Figure 4 shows a schematic of high-frequency, low-duty cycle modulation implemented to minimize LED power consumption. Utilizing fast rise-time optical detectors, it is possible to incorporate a modulation frequency of 1 kHz with a duty ratio of 0.1%, a theoretical power usage that is 1,000 times less than conventional full-cycle modulation methods [23]." Asada 2003 at 32. "Figure 9 shows the first ring sensor prototype that contains an optical sensor unit, analog and digital processing units, and an RF transmitter, all of which are encapsulated in a compact body and powered by a tiny cell battery used for wristwatches. The ring has a PIC microcomputer performing all the device controls and low-level signal processing, including LED modulation, data acquisition, filtering, and bi-directional RF communication. The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz. The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "See [30] for power budget and design details." Asada 2003 at 34. "To improve motion artifact resistance and accuracy, a transmittal PPG ring sensor, Prototype B, has been built and field-tested. Prototype B has high-speed optical devices enabling the lowering

Asserted Claim of '286 Patent	Asada Combinations
	of the LED duty rate to 1/1,000. The LED used is 6.7 times brighter than that of Prototype A, while the resultant power consumption is 173 times smaller than before." Asada 2003 at 35. Asada 2001 – Figure 4:  Fig. 4. Block diagram of electronic circuit. "Fig. 4 shows a block diagram of the ring sensor circuitry. The basic circuit configuration is a standard PPG circuit combined with a wireless transmitter. There are a single photodiode and LEDs of two different wavelengths, red and near infrared, involved in the circuit. The output from the photodiode is amplified and conditioned at the first stage operational amplifier. While the red and infrared LEDs are alternately turned on and off, the signal from the first stage op-amp is sampled by the two sample-and-hold circuits at different timings in order to obtain the reflected light intensity from each LED. Each channel of the signal is conditioned and converted to a digital signal with an AD converter. Using the standard RS-232 protocol, the two channels of digital signals are transmitted via a RF transmitter." Asada 2001 at 797. "There are a number of existing techniques for dealing with artifact and disturbance rejection. The most common is signal processing, as reviewed by [11]. Another standard method is to identify

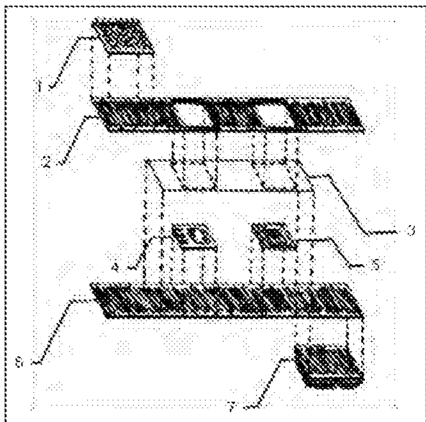
Asserted Claim of '286 Patent	Asada Combinations
	and reject corrupt signals by comparing pulse features with a predetermined template. Other methods use modulation by controlling the power level of multiple lighting sources [11]." Asada 2001 at 796. "*LED*: LEDs consume a large amount of power when emitting light continuously. Therefore they must be switched on only for a short interval when light must be emitted. Namely, the LEDs must be on only when the photodiode is detecting the reflected light for measuring the pulsation. Synchronizing the sampling of the photodetector with the LED switching reduces the duty ratio of the LEDs, and thereby reduces the power consumption. In the prototype system, this coordination is performed by the microprocessor. First, the LEDs are turned on; second, the photo detector signal is sampled at the next CPU cycle; the LEDs are switched off at the third CPU cycle. This sequence control is performed for both red and infrared LEDs." Asada 2001 at 798. Asada 2010 – Page 50

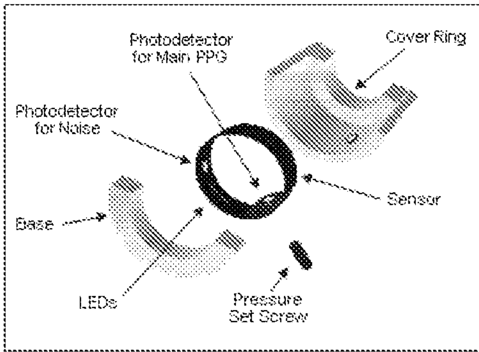
Asserted Claim of '286 Patent	Asada Combinations
	 Asada 2010 Page 52

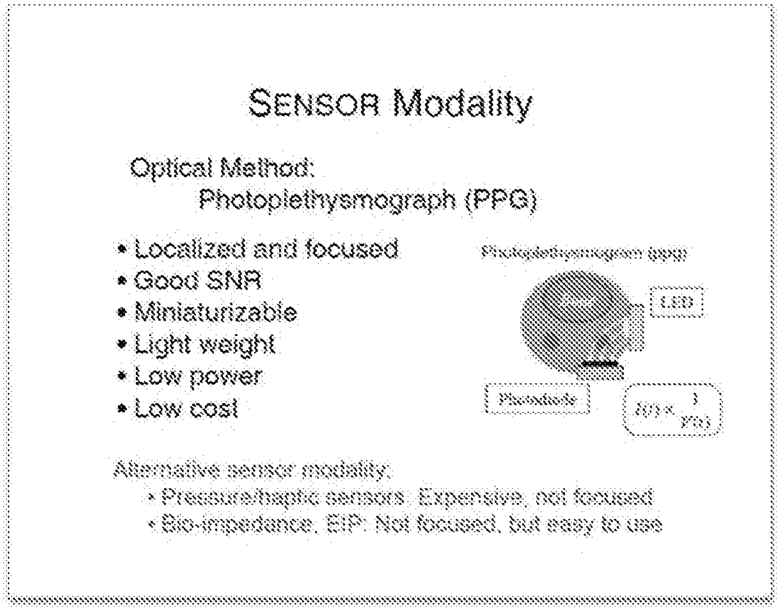
Asserted Claim of '286 Patent	Asada Combinations
	
[16C] wherein at least a portion of the plurality of optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers;	The Asada Combinations disclose and/or render obvious "wherein at least a portion of the plurality of optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers."

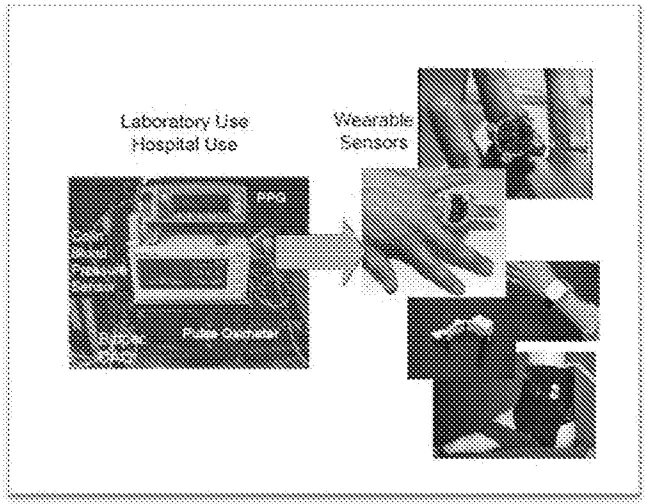
Asserted Claim of '286 Patent	Asada Combinations
	"Figure 9 shows the first ring sensor prototype that contains an optical sensor unit, analog and digital processing units, and an RF transmitter, all of which are encapsulated in a compact body and powered by a tiny cell battery used for wristwatches. The ring has a PIC microcomputer performing all the device controls and low-level signal processing, including LED modulation, data acquisition, filtering, and bi-directional RF communication. The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz. The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "High-speed LEDs and PDs, which have become available at low cost in recent years, can be used for this purpose. Figure 4 shows a schematic of high-frequency, low-duty cycle modulation implemented to minimize LED power consumption. Utilizing fast rise-time optical detectors, it is possible to incorporate a modulation frequency of 1 kHz with a duty ratio of 0.1%, a theoretical power usage that is 1,000 times less than conventional full-cycle modulation methods [23]." Asada 2003 at 32. "See [30] for power budget and design details." Asada 2003 at 34. "To improve motion artifact resistance and accuracy, a transmittal PPG ring sensor, Prototype B, has been built and field-tested. Prototype B has high-speed optical devices enabling the lowering of the LED duty rate to 1/1,000. The LED used is 6.7 times brighter than that of Prototype A, while the resultant power consumption is 173 times smaller than before." Asada 2003 at 35. "*LEDs and Photodiode*: One red LED and two infrared LEDs are used as the light sources. The peak wavelength of the red LED is 660 nm, and that of the infrared LEDs is 940 nm. The photodiode has the peak wavelength of 940 nm and the spectral sensitivity ranges from 500 nm to 1000 nm, which meets our needs. The voltage drop across the red LED is 1.6 V and that of the infrared LEDs is 1.2 V, and two infra-red LEDs are connected in serial. These LEDs are in a die form with a size of 0.3 mm x 0.3 mm." Asada 2001 at 800.

Asserted Claim of '286 Patent	Asada Combinations
[16D] the measurement device comprising one or more lenses configured to receive and to deliver a portion of the optical beam to tissue, wherein the tissue reflects at least a portion of the optical beam delivered to the tissue, and	The Asada Combinations disclose and/or render obvious "the measurement device comprising one or more lenses configured to receive and to deliver a portion of the optical beam to tissue, wherein the tissue reflects at least a portion of the optical beam delivered to the tissue." "Reflective PPG needs more secure attachments of the LED and PD to the skin surface, when compared to transmittal PPG. Once an air gap is created between the skin surface and the optical components due to some disturbance, a direct optical path from the LED to the PD may be created. This direct path exposes the PD directly to the light source and consequently leads to saturation. To avoid this short circuit, the LED light beam must be focused only in the normal direction, and the PD must also have a strong directional property (i.e., polarity), so that it is sensitive to only the incoming light normal to the device surface." Asada 2003 at 31.  **Fig. 9.** First prototype ring sensor with RF transmitter powered by a coin-size cell battery.

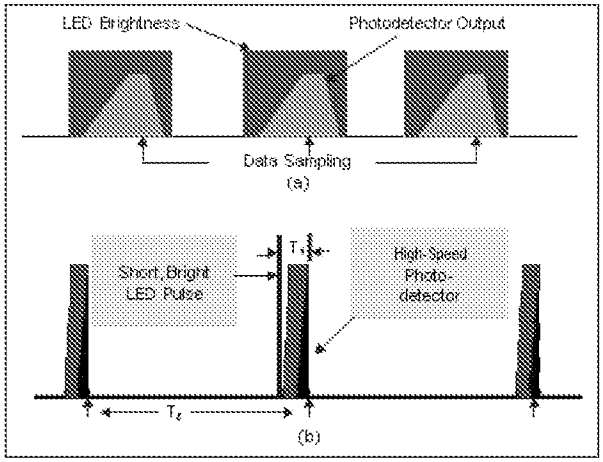
Asserted Claim of '286 Patent	Asada Combinations
	"Figure 9 shows the first ring sensor prototype that contains an optical sensor unit, analog and digital processing units, and an RF transmitter, all of which are encapsulated in a compact body and powered by a tiny cell battery used for wristwatches. The ring has a PIC microcomputer performing all the device controls and low-level signal processing, including LED modulation, data acquisition, filtering, and bi-directional RF communication. The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz. The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "See [30] for power budget and design details." Asada 2003 at 34.  **Fig. 11.** Redesigned sensor band that protects optical components from direct contact with skin and hides wires from outside environment. "To improve motion artifact resistance and accuracy, a transmittal PPG ring sensor, Prototype B, has been built and field-tested. Prototype B has high-speed optical devices enabling the lowering

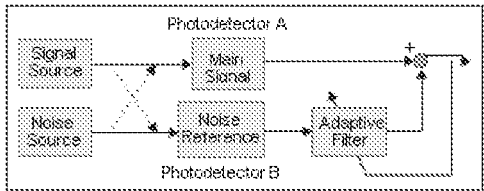
Asserted Claim of '286 Patent	Asada Combinations
	of the LED duty rate to 1/1,000. The LED used is 6.7 times brighter than that of Prototype A, while the resultant power consumption is 173 times smaller than before. The sensor band was redesigned with the use of bio-compatible elastic materials to better hold the LED's and PD's, maintain a proper level of pressure, optically shield the sensor unit, and secure the contact with the skin consistently in the face of finger motion (see Figure 11). As a result, the waveform of this transmittal PPG was quite stable. Figure 3 presented earlier is the experiment of Prototype B. Note that the transmittal PPG (Prototype B) signal did not collapse even when the hand was shaken. Additionally, the analog filtering circuit was optimized for quality of signal. These modifications greatly improved the ability of the device to measure traditionally difficult variables such as heart rate variability (Table 1, Figure 12)." Asada 2003 at 35.  Fig. 15. The schematic of the Prototype C ring sensor. "The local pressurization and motion detection methods described previously have been implemented for further improvement. Figure 15 shows the schematic of the Prototype C ring sensor. Both transmittal (PD-A) and reflective (PD-B) PPGs were mounted on the sensor band.

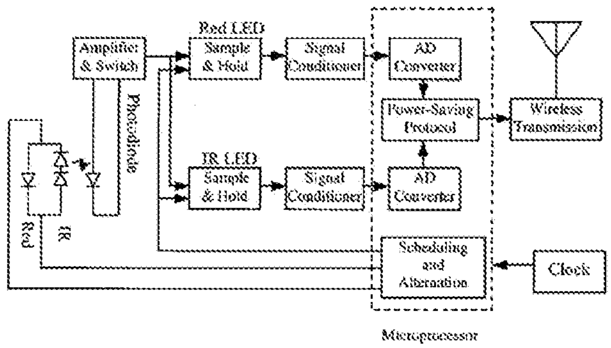
Asserted Claim of '286 Patent	Asada Combinations
	The former is placed on top of a locally pressurizing mechanism with an adjustable setscrew. The latter is mounted on the low-pressure side in order to detect motion." Asada 2003 at 36. Asada 2010 Page 52 
[16E] wherein the measurement device is adapted to be placed on a wrist or an ear of a user;	The Asada Combinations disclose and/or render obvious "wherein the measurement device is adapted to be placed on a wrist or an ear of a user." "The technology encumbers a finger and the wrist of the subject." Asada 2003 at 29.

Asserted Claim of '286 Patent	Asada Combinations
	"See [30] for power budget and design details." Asada 2003 at 34. "On the other hand, wristwatch-type pulse oximetry and blood pressure sensors have been developed and commercialized by several companies including Casio (BP-100 and JP200W-1V) and Omron (HEM-608 and HEM-609)." Asada 2001 at 795. Asada 2010 Page 8 
[16F] the measurement device further comprising a receiver configured to:	The Asada Combinations disclose and/or render obvious "the measurement device further comprising a receiver configured to: capture light while the LEDs are off and convert the captured light into a first signal and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the optical beam reflected from the tissue."

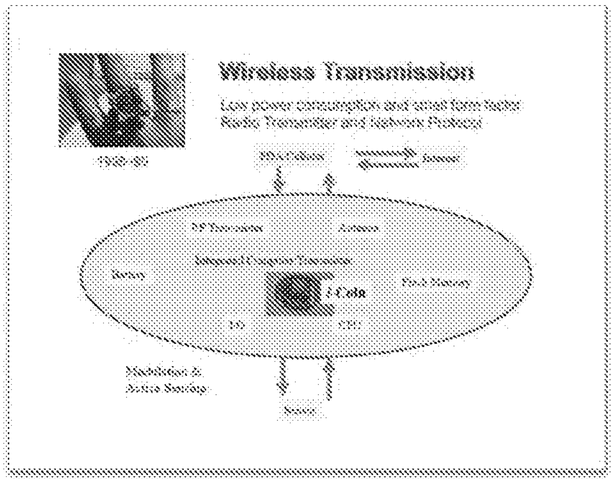
Asserted Claim of '286 Patent	Asada Combinations
capture light while the LEDs are off and convert the captured light into a first signal and capture light while at least one of the LEDs is on and convert the captured light into a second signal, the captured light including at least a portion of the optical beam reflected from the tissue;	"Furthermore, wearable PPG sensors are exposed to diverse ambient lighting conditions, ranging from direct sunlight to flickering room light. In addition, wearable PPG sensors must be designed for reduced power consumption. Carrying a large battery pack is not acceptable for long-term applications. The whole sensor system must run continually using a small battery. Several ways to cope with these difficulties are: ➤ secure the LEDs and the photodetector (PD for short) at a location along the finger skin such that the dc component may be influenced less by the finger motion ➤ modulate the LEDs to attenuate the influence of uncorrelated ambient light as well as to reduce power consumption ➤ increase the amplitude of the ac component so that the signal-to-noise ratio may increase ➤ measure the finger motion with another sensor or a second PD and use it as a noise reference for verifying the signal as well as for canceling the disturbance and noise. In the following sections these methods will briefly be discussed, followed by specific sensor designs and performance tests." Asada 2003 at 30.

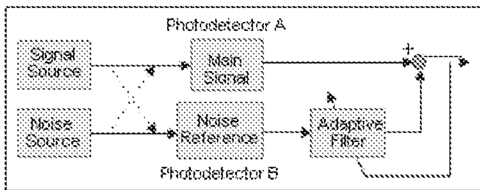
Asserted Claim of '286 Patent	Asada Combinations
	 **Fig. 4.** (a) The slow response time of the photodetector meant that the LED had to be modulated at lower frequencies for data sampling. (b) A faster photodetector response time makes it possible to increase the modulation frequency of the LED. "**Transmittal PPG must have a powerful LED for transmitting light across the finger. This power consumption problem can be solved with a lighting modulation technique using high-speed devices. Instead of lighting the skin continually, the LED is turned on only for a short time, say 100 ~ 1000 ns, and the signal is sampled within this period.** High-speed LEDs and PDs, which have become available at low cost in recent years, can be used for this purpose. Figure 4 shows a schematic of high-frequency, low-duty cycle modulation implemented to minimize LED power consumption. Utilizing fast rise-time optical detectors, it is possible to incorporate a modulation frequency of 1 kHz with a duty ratio of 0.1%, a theoretical power usage that is 1,000 times less than conventional full-cycle modulation methods [23]." Asada 2003 at 32.

Asserted Claim of '286 Patent	Asada Combinations
	"In addition to saving power, the modulation of LED lighting provides an effective means for reducing ambient light disturbances. Reading the PD output while the LED is turned off yields the baseline PPG level attributed to the ambient light alone. Subtracting this reading from the one acquired with the LED illuminated gives the net output correlated with the LED lighting. More sophisticated modulation schemes can be applied by controlling the LED brightness as a periodic time function. Computational power requirements often prohibit complex modulation, however. Design trade-offs must be considered to find the best modulation scheme." Asada 2003 at 32.  Fig. 8. Block diagram of adaptive noise cancellation using second PPG sensor as noise reference. "The motion detector can be used not only for monitoring the presence of motion but also for canceling noise. By using PD-B as a noise reference, a noise cancellation filter can be built to eliminate the noise of PD-A that correlates with the noise reference signal. Assuming that the hemodynamic process observed by PPG is stationary and that the noise is additive, adaptive noise canceling methods, such as the classical Widrow method [29], can be applied in order to recover the true pulsation signal from corrupted waveforms. As shown in Figure 8, the noise-canceling filter combines two sensor signals; one is the main signal captured by PD-A and the other is the noise reference obtained by PD-B. The main signal mostly consists of the true pulsatile signal, but it does contain some noise. If we know the proportion of the noise contained in the main signal, we can generate the noise of the same magnitude by attenuating the noise reference signal and then subtract the noise from the main signal to recover the true pulsatile signal. If the noise magnitude is not known a priori, it must be determined adaptively during the measurement.

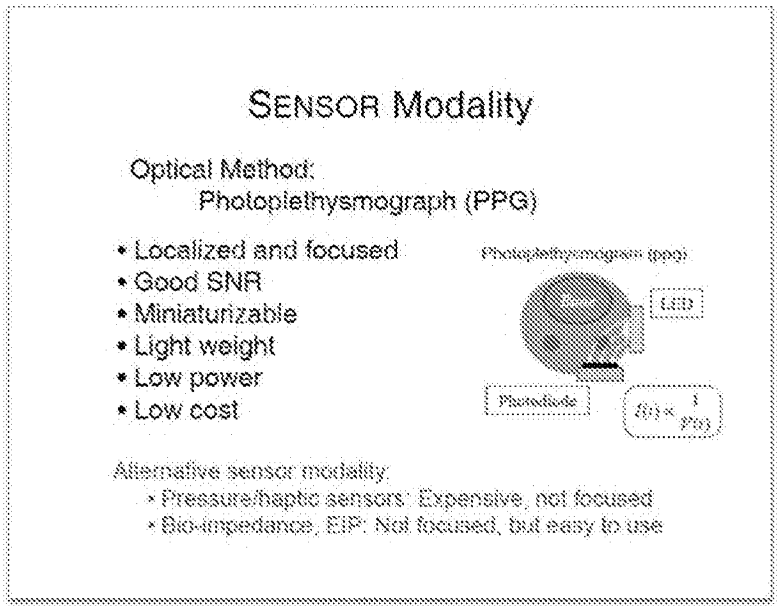
Asserted Claim of '286 Patent	Asada Combinations
	Various algorithms for adaptive filtering can be applied to tune the filter in real time." Asada 2003 at 33. "See [30] for power budget and design details." Asada 2003 at 34. Asada 2001 -- Figure 4:  Fig. 4. Block diagram of electronic circuit. "Fig. 4 shows a block diagram of the ring sensor circuitry. The basic circuit configuration is a standard PPG circuit combined with a wireless transmitter. There are a single photodiode and LEDs of two different wavelengths, red and near infrared, involved in the circuit. The output from the photodiode is amplified and conditioned at the first stage operational amplifier. While the red and infrared LEDs are alternately turned on and off, the signal from the first stage op-amp is sampled by the two sample-and-hold circuits at different timings in order to obtain the reflected light intensity from each LED. Each channel of the signal is conditioned and converted to a digital signal with an AD converter. Using the standard RS-232 protocol, the two channels of digital signals are transmitted via a RF transmitter." Asada 2001 at 797.

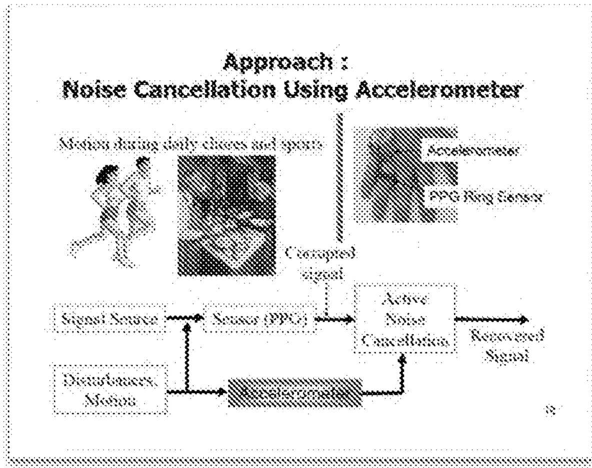
Asserted Claim of '286 Patent	Asada Combinations
	"*LED*: LEDs consume a large amount of power when emitting light continuously. Therefore they must be switched on only for a short interval when light must be emitted. Namely, the LEDs must be on only when the photodiode is detecting the reflected light for measuring the pulsation. Synchronizing the sampling of the photodetector with the LED switching reduces the duty ratio of the LEDs, and thereby reduces the power consumption. In the prototype system, this coordination is performed by the microprocessor. First, the LEDs are turned on; second, the photo detector signal is sampled at the next CPU cycle; the LEDs are switched off at the third CPU cycle. This sequence control is performed for both red and infrared LEDs." Asada 2001 at 798. "The other electronic components of the ring sensor include multiple op-amps, switches, sample-and-hold, and filters." Asada 2001 at 800. "*CPU*: The on-board CPU controls all the operations of the ring sensor, ranging from the sequence control of LED lighting and data acquisition to the conversion of analogue data to digital signals in the RS-232 format for wireless transmission. A PIC16C711 microprocessor from Microchip was selected be- cause of its unique design for low power consumption. It consumes less than 25 A for 32-kHz clock frequency in the normal operation mode and almost no power consumption in the sleep mode. This CPU has 4 channels of embedded A/D converter, 13 channels of digital input–output line. It has 1 KB of EPROM that is good enough to store the whole code needed for computation. The resolution of the A/D converters are all 8-bits. In case that higher resolution is necessary, other CPUs such as PIC16C773 which has 12-bit A/D converters can be used." Asada 2001 at 800. Asada 2010 Page 9

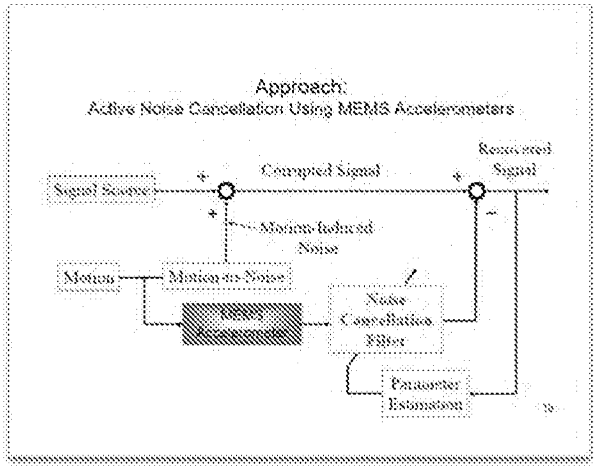
Asserted Claim of '286 Patent	Asada Combinations
	
[16G] the measurement device configured to improve a signal-to-noise ratio of the optical beam reflected from the tissue by differencing the first signal and the second signal;	The Asada Combinations disclose and/or render obvious "the measurement device configured to improve a signal-to-noise ratio of the optical beam reflected from the tissue by differencing the first signal and the second signal." "Furthermore, wearable PPG sensors are exposed to diverse ambient lighting conditions, ranging from direct sunlight to flickering room light. In addition, wearable PPG sensors must be designed for reduced power consumption. Carrying a large battery pack is not acceptable for long-term applications. The whole sensor system must run continually using a small battery. Several ways to cope with these difficulties are: ➤ secure the LEDs and the photodetector (PD for short) at a location along the finger skin such that the dc component may be influenced less by the finger motion

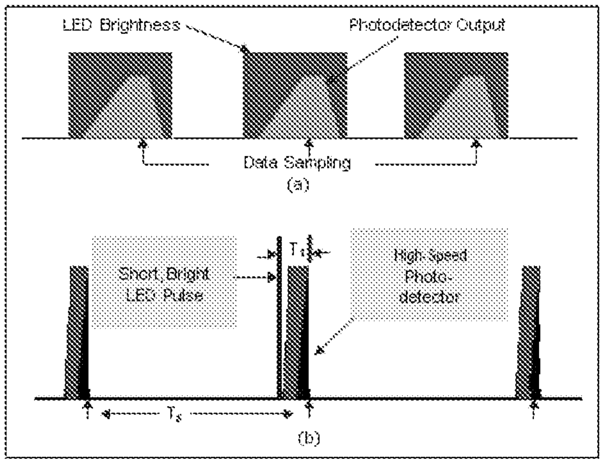
Asserted Claim of '286 Patent	Asada Combinations
	➤ modulate the LEDs to attenuate the influence of uncorrelated ambient light as well as to reduce power consumption ➤ increase the amplitude of the ac component so that the signal-to-noise ratio may increase ➤ measure the finger motion with another sensor or a second PD and use it as a noise reference for verifying the signal as well as for canceling the disturbance and noise. In the following sections these methods will briefly be discussed, followed by specific sensor designs and performance tests." Asada 2003 at 30. "In addition to saving power, the modulation of LED lighting provides an effective means for reducing ambient light disturbances. Reading the PD output while the LED is turned off yields the baseline PPG level attributed to the ambient light alone. Subtracting this reading from the one acquired with the LED illuminated gives the net output correlated with the LED lighting. More sophisticated modulation schemes can be applied by controlling the LED brightness as a periodic time function. Computational power requirements often prohibit complex modulation, however. Design trade-offs must be considered to find the best modulation scheme." Asada 2003 at 32.  Fig. 8. Block diagram of adaptive noise cancellation using second PPG sensor as noise reference. "The motion detector can be used not only for monitoring the presence of motion but also for canceling noise. By using PD-B as a noise reference, a noise cancellation filter can be built to eliminate the noise of PD-A that correlates with the noise reference signal. Assuming that the hemodynamic process observed by PPG is stationary and that the noise is additive, adaptive noise canceling methods, such as the classical Widrow method [29], can be applied in order to recover

Asserted Claim of '286 Patent	Asada Combinations
	the true pulsation signal from corrupted waveforms. As shown in Figure 8, the noise-canceling filter combines two sensor signals; one is the main signal captured by PD-A and the other is the noise reference obtained by PD-B. The main signal mostly consists of the true pulsatile signal, but it does contain some noise. If we know the proportion of the noise contained in the main signal, we can generate the noise of the same magnitude by attenuating the noise reference signal and then subtract the noise from the main signal to recover the true pulsatile signal. If the noise magnitude is not known a priori, it must be determined adaptively during the measurement. Various algorithms for adaptive filtering can be applied to tune the filter in real time." Asada 2003 at 33. "See [30] for power budget and design details." Asada 2003 at 34. "There are a number of existing techniques for dealing with artifact and disturbance rejection. The most common is signal processing, as reviewed by [11]. Another standard method is to identify and reject corrupt signals by comparing pulse features with a predetermined template. Other methods use modulation by controlling the power level of multiple lighting sources [11]." Asada 2001 at 796. Asada 2010 Page 52

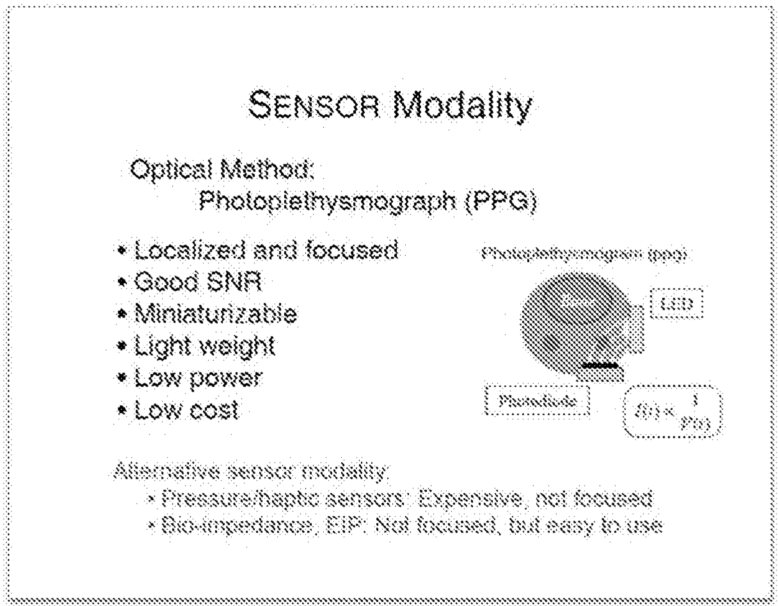
Asserted Claim of '286 Patent	Asada Combinations
	 Asada 2010 Pages 18 and 19

	Approach : Noise Cancellation Using Accelerometer Motion during daily chores and sports Accelerometer PPG Ring Sensor Corrupted signal Signal Source Sensor (PPG) Active Noise Cancellation Recovered Signal Disturbances, Motion

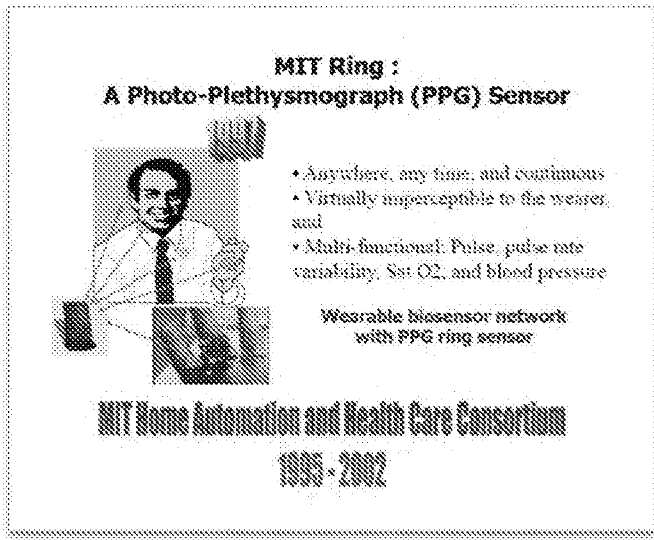
Asserted Claim of '286 Patent	Asada Combinations
	
[16H] the light source configured to further improve the signal-to-noise ratio of the optical beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs;	The Asada Combinations disclose and/or render obvious "the light source configured to further improve the signal-to-noise ratio of the optical beam reflected from the tissue by increasing the light intensity relative to the initial light intensity from at least one of the LEDs." "Furthermore, wearable PPG sensors are exposed to diverse ambient lighting conditions, ranging from direct sunlight to flickering room light. In addition, wearable PPG sensors must be designed for reduced power consumption. Carrying a large battery pack is not acceptable for long-term applications. The whole sensor system must run continually using a small battery. Several ways to cope with these difficulties are: ➤ secure the LEDs and the photodetector (PD for short) at a location along the finger skin such that the dc component may be influenced less by the finger motion

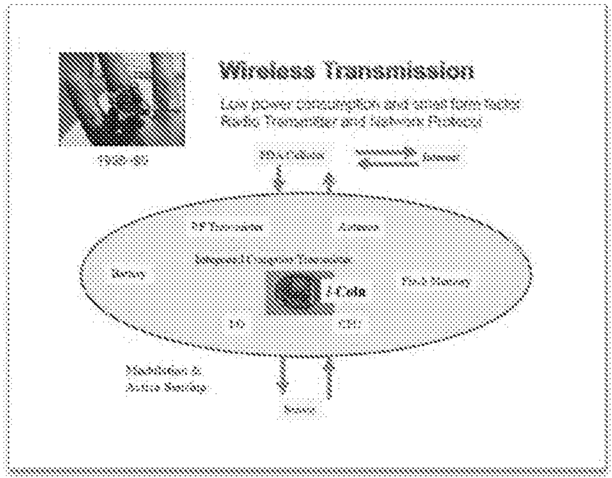
Asserted Claim of '286 Patent	Asada Combinations
	➤ modulate the LEDs to attenuate the influence of uncorrelated ambient light as well as to reduce power consumption ➤ increase the amplitude of the ac component so that the signal-to-noise ratio may increase ➤ measure the finger motion with another sensor or a second PD and use it as a noise reference for verifying the signal as well as for canceling the disturbance and noise. In the following sections these methods will briefly be discussed, followed by specific sensor designs and performance tests." Asada 2003 at 30.  **Fig. 4.** (a) The slow response time of the photodetector meant that the LED had to be modulated at lower frequencies for data sampling. (b) A faster photodetector response time makes it possible to increase the modulation frequency of the LED.

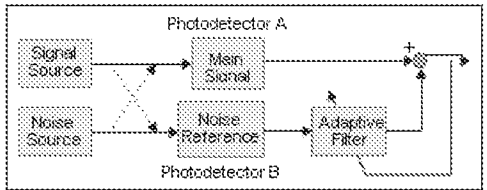
Asserted Claim of '286 Patent	Asada Combinations
	"In addition to saving power, the modulation of LED lighting provides an effective means for reducing ambient light disturbances. Reading the PD output while the LED is turned off yields the baseline PPG level attributed to the ambient light alone. Subtracting this reading from the one acquired with the LED illuminated gives the net output correlated with the LED lighting. More sophisticated modulation schemes can be applied by controlling the LED brightness as a periodic time function. Computational power requirements often prohibit complex modulation, however. Design trade-offs must be considered to find the best modulation scheme." Asada 2003 at 32. Asada 2003 explains that "according to the Lambert-Beer law, the brightness decreases exponentially as the distance from the light source increases." In order to improve the signal-to-noise ratio, brightness of the light is increased by "application of an external pressure on the tissue surrounding the artery" in order to increase the detected amplitude of arterial pulsations. Asada 2003 at 32. "Figure 5 shows the pulsatile amplitude of a finger base PPG for varied pressures generated by a finger cuff. As the cuff pressure increases, the PPG amplitude increases until it reaches a maximum." Asada 2003 at 32. "See [30] for power budget and design details." Asada 2003 at 34. "There are a number of existing techniques for dealing with artifact and disturbance rejection. The most common is signal processing, as reviewed by [11]. Another standard method is to identify and reject corrupt signals by comparing pulse features with a predetermined template. Other methods use modulation by controlling the power level of multiple lighting sources [11]." Asada 2001 at 796. Asada 2010 Page 52

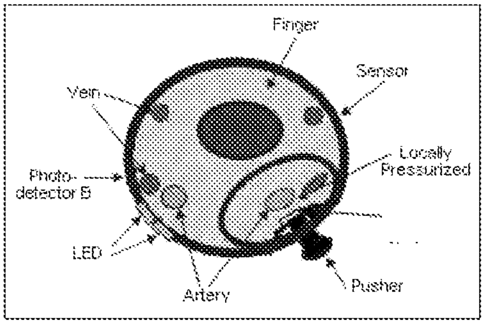
Asserted Claim of '286 Patent	Asada Combinations
	
[16I] the measurement device further configured to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue; and	The Asada Combinations disclose and/or render obvious "the measurement device further configured to generate an output signal representing at least in part a non-invasive measurement on blood contained within the tissue." "In this article we will address both technical and clinical is- sues of WBS. First, design concepts of a WBS will be presented, with emphasis on the ring sensor developed by the author's group at MIT. The ring sensor is an ambulatory, tele- metric, continuous health-monitoring device. This WBS com- bines miniaturized data acquisition features with advanced photoplethysmographic (PPG) techniques to acquire data related to the patient's cardiovascular state using a method that is

Asserted Claim of '286 Patent	Asada Combinations
	far superior to existing fingertip PPG sensors [1]. In particular, the ring sensor is capable of reliably monitoring a patient's heart rate, oxygen saturation, and heart rate variability. Technical issues, including motion artifact, interference with blood circulation, and battery power issues, will be addressed, and effective engineering solutions to alleviate these problems will be presented. Second, based on the ring sensor technology the clinical potentials of WBS monitoring will be addressed." Asada 2003 at 28. *See generally* Asada 2003 Prototypes A, B, and C. "The ring sensor is a miniaturized, telemetric, monitoring de- vice worn by a patient as a finger ring. The ring encapsulates PPG, pulse oximetry combined with wireless communication and miniaturization technologies. This device optically captures the pulsation and oxygen saturation of the arterial blood flow, and transmits the signals to a host computer via a radio-frequency (RF) transmitter. Fig. 1 shows a conceptual diagram of the ring sensor [5], [6]. The ring sensor consists of optoelectronic components, a CPU, a RF transmitter, a battery, and a ring chassis. The optoelectronic components, i.e., micro photodiodes and LEDs, detect the blood-volume waveforms and oxygen-saturation level at the patient's digital artery. The CPU controls the LED lighting sequence as well as the data acquisition and transmission process. These signals are locally processed by the on-board CPU and transmitted to a host computer for diagnosis of the patient's cardiovascular conditions. The ring sensor is completely wireless and miniaturized so that the patient can wear the device comfortably 24 h/day." Asada 2001 at 796. Asada 2010 Page 3

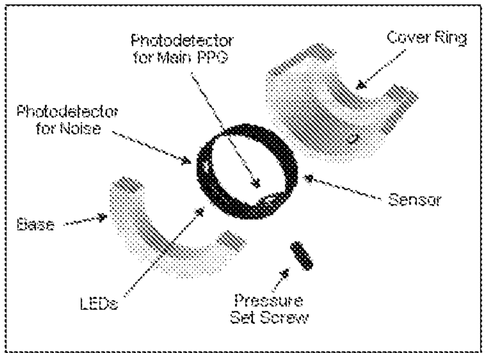
Asserted Claim of '286 Patent	Asada Combinations
	 Asada 2010 Page 9

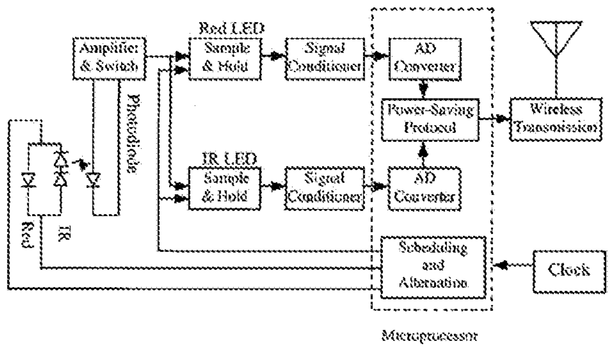
Asserted Claim of '286 Patent	Asada Combinations
	
[16J] wherein the receiver includes a plurality of spatially separated detectors,	The Asada Combinations disclose and/or render obvious "a receiver configured to receive and process at least a portion of the analysis output beam reflected or transmitted from the sample and to generate an output signal." "Figure 2 shows two distinct cases. One case places both the PD and the LED on the same side of the finger-base, and the other places them on opposite sides of the finger. Placing both the PD and the LED on the same side of the finger-base, and the other places them on opposite sides of the finger. Placing both the PD and the LED on the same side creates a type of reflective PPG, while placing each of them on opposite sides makes a type of transmittal PPG. In the figure the average pathway of photons is shown for the two sensor arrangements. Although the exact photon path is difficult to obtain, due to the heterogeneous nature of the finger tissue and blood, a banana-shaped

Asserted Claim of '286 Patent	Asada Combinations
	arc connecting the LED and PD, as shown in the figure, can approximate its average path [19]." Asada 2003 at 31. "Figure 3 shows an experimental comparison between transmittal and reflective PPGs. Two sets of PPG sensors, one reflective and one transmittal, were attached to the same finger. Both were at rest initially, and then shaken. The transmittal PPG was quite stable, while the reflective PPG was susceptive to the motion disturbances." Asada 2003 at 31.  Fig. 8. Block diagram of adaptive noise cancellation using second PPG sensor as noise reference. "The motion detector can be used not only for monitoring the presence of motion but also for canceling noise. By using PD-B as a noise reference, a noise cancellation filter can be built to eliminate the noise of PD-A that correlates with the noise reference signal. Assuming that the hemo-dynamic process observed by PPG is stationary and that the noise is additive, adaptive noise canceling methods, such as the classical Widrow method [29], can be applied in order to recover the true pulsation signal from corrupted wave- forms. As shown in Figure 8, the noise-canceling filter combines two sensor signals; one is the main signal captured by PD-A and the other is the noise reference obtained by PD-B. The main signal mostly consists of the true pulsatile signal, but it does contain some noise. If we know the proportion of the noise contained in the main signal, we can generate the noise of the same magnitude by attenuating the noise reference signal and then subtract the noise from the main signal to recover the true pulsatile signal. If the noise magnitude is not known a priori, it must be determined adaptively during the measurement. Various algorithms for adaptive filtering can be applied to tune the filter in real time. Some can determine optimal filter gains and parameters based on the evaluation of the recovered signal, as shown in Figure 8 by the feedback from the output to the adaptive filter block. Details of this

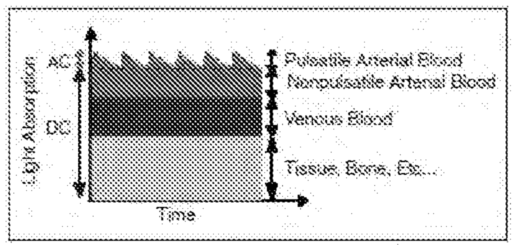
Asserted Claim of '286 Patent	Asada Combinations
	adaptive filtering method are beyond the scope of this article. The dual photodetector design shown in Figure 6 provides both main signal and noise reference that are distinct. This allows us to implement noise-canceling filters effectively despite complex motion artifact." Asada 2003 at 33-34.  **Fig. 6.** The schematic of a locally pressurized sensor band.

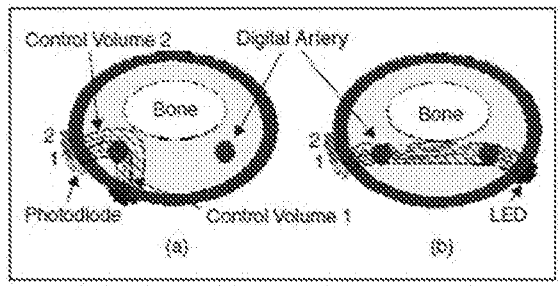
Asserted Claim of '286 Patent	Asada Combinations
	 Fig. 9. First prototype ring sensor with RF transmitter powered by a coin-size cell battery. "Figure 9 shows the first ring sensor prototype that contains an optical sensor unit, analog and digital processing units, and an RF transmitter, all of which are encapsulated in a compact body and powered by a tiny cell battery used for wristwatches. The ring has a PIC microcomputer performing all the device controls and low-level signal processing, including LED modulation, data acquisition, filtering, and bi-directional RF communication. The acquired waveforms, sampled at 100 Hz, are transmitted to a PDA or a cellular phone carried by the patient through an RF link of 105 kbps at a carrier frequency of 915 MHz. The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada 2003 at 34. "In this early development, the power consumption of the LEDs and the imbedded CPU clock were a major bottleneck limiting the design. The distance between the LEDs and PDs had to be shortened for power saving considerations, and the CPU clock was minimized in order to extend the battery life to a few weeks. See [30] for power budget and design details." Asada 2003 at 34.

Asserted Claim of '286 Patent	Asada Combinations
	"To improve motion artifact resistance and accuracy, a transmittal PPG ring sensor, Prototype B, has been built and field-tested. Prototype B has high-speed optical devices enabling the lowering of the LED duty rate to 1/1,000. The LED used is 6.7 times brighter than that of Prototype A, while the resultant power consumption is 173 times smaller than before. The sensor band was redesigned with the use of bio-compatible elastic materials to better hold the LED's and PD's, maintain a proper level of pressure, optically shield the sensor unit, and secure the contact with the skin consistently in the face of finger motion (see Figure 11). As a result, the waveform of this transmittal PPG was quite stable. Figure 3 presented earlier is the experiment of Prototype B. Note that the transmittal PPG (Prototype B) signal did not collapse even when the hand was shaken. Additionally, the analog filtering circuit was optimized for quality of signal. These modifications greatly improved the ability of the device to measure traditionally difficult variables such as heart rate variability (Table 1, Figure 12)." Asada 2003 at 35.  Fig. 15. The schematic of the Prototype C ring sensor.

Asserted Claim of '286 Patent	Asada Combinations
	"The local pressurization and motion detection methods described previously have been implemented for further improvement. Figure 15 shows the schematic of the Prototype C ring sensor. Both transmittal (PD-A) and reflective (PD-B) PPGs were mounted on the sensor band. The former is placed on top of a locally pressurizing mechanism with an adjustable setscrew. The latter is mounted on the low-pressure side in order to detect motion." Asada 2003 at 36.
[16K] wherein at least one analog to digital converter is coupled to the spatially separated detectors.	The Asada Combinations disclose and/or render obvious "wherein at least one analog to digital converter is coupled to the spatially separated detectors." "Fig. 9 shows the first ring sensor prototype that contains an optical sensor unit, analog and digital processing units, and an RF transmitter, all of which are encapsulated in a compact body and powered by a tiny cell battery used for wristwatches." Asada 2003 at 34. "See [30] for power budget and design details." Asada 2003 at 34. Asada 2001 – Figure 4:  Fig. 4. Block diagram of electronic circuit.

Omni MedSci, Inc. v. Apple Inc.
Case No. 2:18-cv-134-RWS (E.D. Tex.)

Asserted Claim of '286 Patent	Asada Combinations
	"Fig. 4 shows a block diagram of the ring sensor circuitry. The basic circuit configuration is a standard PPG circuit combined with a wireless transmitter. There are a single photodiode and LEDs of two different wavelengths, red and near infrared, involved in the circuit. The output from the photodiode is amplified and conditioned at the first stage operational amplifier. While the red and infrared LEDs are alternately turned on and off, the signal from the first stage op-amp is sampled by the two sample-and-hold circuits at different timings in order to obtain the reflected light intensity from each LED. Each channel of the signal is conditioned and converted to a digital signal with an AD converter. Using the standard RS-232 protocol, the two channels of digital signals are transmitted via a RF transmitter." Asada 2001 at 797.
[17] The wearable device of claim 16, wherein at least one LED emits at a first wavelength and at least another LED emits at a second wavelength, and wherein the first wavelength has a first penetration depth into the tissue and wherein the second wavelength has a second penetration depth into the tissue different from the first penetration depth.	The Asada Combinations disclose and/or render obvious "[t]he wearable device of claim 16, wherein at least one LED emits at a first wavelength and at least another LED emits at a second wavelength, and wherein the first wavelength has a first penetration depth into the tissue and wherein the second wavelength has a second penetration depth into the tissue different from the first penetration depth."  Fig. 1. Illustrative representation of the relative photon absorbance for various sections of the finger; the dc component is significantly larger than the ac component. "Figure 1 shows the typical waveform of a photoplethysmograph signal obtained from a human subject *at rest.* The signal comprises a large segment of dc signal and a small-amplitude ac signal. The dc component of photon absorption results from light passing through various nonpulsatile media, including tissue, bones, venous blood, and nonpulsatile arterial blood." Asada 2003 at 30.

Asserted Claim of '286 Patent	Asada Combinations
	 Fig. 2. (a) For the reflective illumination method, movement of the photodiode relative to the LED (position 1 to position 2) leads to a photon path that no longer contains the digital artery. (b) For the transmittal illumination method, movement of the photodetector relative to the LED still contains photon paths that pass through the digital artery. "The location of the LEDs and a PD relative to the finger is an important design issue determining signal quality and robustness against motion artifact. Figure 2 shows a cross-sectional view of the finger with the ring sensor. The LEDs and PD are placed on the flanks of the finger rather than the dorsal and palmar sides." Asada 2003 at 30-31. "For these reasons, at least one optical device, either the PD or the LED, should be placed on one lateral face of the finger near the digital artery. The question is where to place the other device. Figure 2 shows two distinct cases. One case places both the PD and the LED on the same side of the finger-base, and the other places them on opposite sides of the finger. Placing both the PD and the LED on the same side creates a type of reflective PPG, while placing each of them on opposite sides makes a type of transmittal PPG. In the figure the average pathway of photons is shown for the two sensor arrangements. Although the exact photon path is difficult to obtain, due to the

Asserted Claim of '286 Patent	Asada Combinations
	heterogeneous nature of the finger tissue and blood, a banana-shaped arc connecting the LED and PD, as shown in the figure, can approximate its average path [19]." Asada 2003 at 31. "The motion detector can be used not only for monitoring the presence of motion but also for canceling noise. By using PD-B as a noise reference, a noise cancellation filter can be built to eliminate the noise of PD-A that correlates with the noise reference signal. Assuming that the hemodynamic process observed by PPG is stationary and that the noise is additive, adaptive noise canceling methods, such as the classical Widrow method [29], can be applied in order to recover the true pulsation signal from corrupted waveforms. As shown in Figure 8, the noise-canceling filter combines two sensor signals; one is the main signal captured by PD-A and the other is the noise reference obtained by PD-B. The main signal mostly consists of the true pulsatile signal, but it does contain some noise. If we know the proportion of the noise contained in the main signal, we can generate the noise of the same magnitude by attenuating the noise reference signal and then subtract the noise from the main signal to recover the true pulsatile signal. If the noise magnitude is not known a priori, it must be determined adaptively during the measurement. Various algorithms for adaptive filtering can be applied to tune the filter in real time. Some can determine optimal filter gains and parameters based on the evaluation of the recovered signal, as shown in Figure 8 by the feedback from the output to the adaptive filter block. Details of this adaptive filtering method are beyond the scope of this article. The dual photodetector design shown in Figure 6 provides both main signal and noise reference that are distinct. This allows us to implement noise-canceling filters effectively despite complex motion artifact." Asada 2003 at 33-34. "See [30] for power budget and design details." Asada 2003 at 34. Asada 2001 – Figure 4: