補正　昭61.12.19

考案の名称を次のように補正する。

㊹考案の名称　　調光レンズ付き眼鏡またはヘルメット等の構造

実用新案登録請求の範囲、図面の簡単な説明を次のように補正する。

㊼実用新案登録請求の範囲

(1) 電極基板を有し、外部電圧の印加により色又は光透過度が変化するようになる素子や液晶分子の配向状態が変化して屈折率を変更する液晶レンズをレンズ部又はバイザー部に使用した自動二輪車用ヘルメットまたはサングラス等に於いて、素子の制御回路、外光を検出する光センサ、電源電池及び電源スイッチ等の全ての電子回路を眼鏡又はヘルメット等の本体に収容したことを特徴とする調光レンズ付き眼鏡またはヘルメット等の構造。

(2) 前記電子回路が、外部電圧の印加により色又は光透過度が変化するようになる素子を、特定の光量範囲または任意の光量範囲に切換又は可変する光感度切換機構を具備してなることを特徴とする実用新案登録請求の範囲第１項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(3) 前記外部電圧の印加により色又は光透過度が変化するようになる素子が、ゲストホスト型の液晶セルであることを特徴とする実用新案登録請求の範囲第１項及び第２項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(4) 前記外部電圧の印加により色又は光透過度が変化するようになる素子が、ツイストネマテイツク型の液晶セルであることを特徴とする実用新案登録請求の範囲第１項及び第２項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(5) 前記光感度切換機構がマイクロコンピュータによる自動制御機構に成ることを特徴とする実用新案登録請求の範囲第１項乃至第４項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(6) 前記光感度切換機構が信号増幅度を切り換え又は可変して、液晶素子を特定の光量範囲または任意の光量範囲に調整する構造になることを特徴とする実用新案登録請求の範囲第１項乃至第４項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(7) 前記光感度切換機構が出力インピーダンスを切り換え又は可変して、液晶素子を特定の光量範囲または任意の光量範囲に調整する構造になることを特徴とする実用新案登録請求の範囲第１項乃至第４項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(8) 前記光感度切換機構が光センサの光入射窓に、光透過度の異なるフイルタを配置し、該フイルタを切り換え又は可変して、液晶素子を特定の光量範囲または任意の光量範囲に調整する構造になることを特徴とする実用新案登録請求の範囲第１項乃至第４項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(9) 前記液晶素子が、円柱状又は球面状の曲率半径を有する２枚の合成樹脂透明板の間に収容された構造になることを特徴とする実用新案登録請求の範囲第１項乃至第８項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(10) 前記調光レンズに加えてヘルメット又は眼鏡等の一部に、距離センサによつて前方障害物との距離を検出し、特定の距離以下または任意の検出距離に切換又は可変する検出距離切換機構を介して該ヘルメット又は眼鏡等に設けたブザーを鈴鳴する障害物警告装置を具備して成ることを特徴とする実用新案登録請求の範囲第１項乃至第８項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(11) 前記距離センサが赤外線距離センサであることを特徴とする実用新案登録請求の範囲第10項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(12) 前記距離センサが超音波距離センサであることを特徴とする実用新案登録請求の範囲第10項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(13) 前記電子回路がフレキシブルプリント基板に構成されていることを特徴とする実用新案登録請求の範囲第１項乃至第12項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(14) 前記電源電池を除く電子回路がメガネフレームのブリッジ部に配置されていることを特徴と

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する実用新案登録請求の範囲第１項乃至第８項記載の調光レンズ付き眼鏡等の構造。

(15) 前記電子回路の電源電池がメガネフレームの智部分に配置されていることを特徴とする実用新案登録請求の範囲第１項乃至第８項記載の調光レンズ付き眼鏡等の構造。

図面の簡単な説明

第１図は本考案の一実施例を示す調光レンズ付きヘルメットの斜視図、第２図は第１図におけるⅡ－Ⅱ線断面図、第３図は液晶セルの構造と制御構造を示す説明図、第４図は第１図におけるⅣ－Ⅳ線断面図、第５図及び第６図はそれぞれ障害物警告機構の実施例を示すブロック線図、第７図は本考案の他の実施例を示すサングラスの斜視図、第８図は同電子回路収容部の拡大図、第９図は電源電池収容部の拡大図、第１０図は本考案の制御回路の基本的な実施例を示す回路図、第１１図乃至第１６図はそれぞれ光感度の切換機構の実施例を示す回路図、第１７図はCdSセルの光量－抵抗値特性の例を示すグラフ、第１８図は入力抵抗に光センサを使用した場合のCdSセルの抵抗値－出力電圧特性の例を示すグラフ、第１９図は直交ニコル間にツイストネマテイツク液晶セルを配置した場合の印加電圧－光透過度特性の例を示すグラフ、第２０図は外部光量－光透過度特性の例を示すグラフ、第２１図は帰還抵抗に光センサを使用した場合のCdSセルの抵抗値－出力電圧特性の例を示すグラフ、第２２図は平行ニコル間にツイストネマテイツク液晶セルを配置した場合の印加電圧－光透過度特性の例を示すグラフ、第２３図は出力抵抗と液晶セルの等価回路、第２４図は低域通過回路の周波数－電圧特性の例を示すグラフである。

１…ヘルメット本体、２…バイザー、４，５…合成樹脂透明板、１４…光センサ、１６，６５…光感度切換スイッチ、２０…障害物検出機構、２１…検出距離設定摘み、２２…投光素子、２３…受光素子、６１…眼鏡本体、６２…眼鏡フレーム、６４…光センサ、Ｌ…レンズ。

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⑲日本国特許庁（JP）　⑪実用新案出願公開

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⑤4考案の名称　調光レンズ付き眼鏡またはヘルメット等の構造

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１．考案の名称

調光レンズ付き眼鏡またはヘルメット等の構造

２．実用新案登録請求の範囲

（１）電極基板を有し、外部電圧の印加により色又は光透過度が変化するようになる素子をレンズ部又はバイザー部に使用した自動二輪車用ヘルメットまたはサングラス等に於いて、素子の制御回路、外光を検出する光センサ、電源電池及び電源スイッチ等の全ての電子回路を眼鏡又はヘルメット等の本体に収容したことを特徴とする調光レンズ付き眼鏡またはヘルメット等の構造。

（２）前記電子回路が、外部電圧の印加により色又は光透過度が変化するようになる素子を、特定の光量範囲または任意の光量範囲に切換又は可変する光感度切換機構を具備してなることを特徴とする実用新案登録請求の範囲第１項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（３）前記外部電圧の印加により色又は光透過度が変化するようになる素子が、ゲストホスト型の

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液晶セルであることを特徴とする実用新案登録請求の範囲第１項及び第２項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（４）前記外部電圧の印加により色又は光透過度が変化するようになる素子が、ツイストネマティック型の液晶セルであることを特徴とする実用新案登録請求の範囲第１項及び第２項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（５）前記光感度切換機構がマイクロコンピュータによる自動制御機構に成ることを特徴とする実用新案登録請求の範囲第１項乃至第４項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（６）前記光感度切換機構が信号増幅度を切り換え又は可変して、液晶素子を特定の光量範囲または任意の光量範囲に調整する構造になることを特徴とする実用新案登録請求の範囲第１項乃至第４項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（７）前記光感度切換機構が出力インピーダンスを切り換え又は可変して、液晶素子又はＥＣセル

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を特定の光量範囲または任意の光量範囲に調整する構造になることを特徴とする実用新案登録請求の範囲第１項乃至第４項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（８）前記光感度切換機構が光センサの光入射窓に、光透過度の異なるフィルタを配置し、該フィルタを切り換え又は可変して、液晶素子又はＥＣセルを特定の光量範囲または任意の光量範囲に調整する構造になることを特徴とする実用新案登録請求の範囲第１項乃至第４項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（９）前記液晶素子が、円柱状又は球面状の曲率半径を有する２枚の合成樹脂透明板の間に収容された構造になることを特徴とする実用新案登録請求の範囲第１項乃至第８項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（１０）前記調光レンズに加えてヘルメット又は眼鏡等の一部に、距離センサによって前方障害物との距離を検出し、特定の距離以下または任意の検出距離に切換又は可変する検出距離切換機構を

介して該ヘルメット又は眼鏡等に設けたブザーを鈴鳴する障害物警告装置を具備して成ることを特徴とする実用新案登録請求の範囲第１項乃至第８項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（１１）前記距離センサが赤外線距離センサであることを特徴とする実用新案登録請求の範囲第１０項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（１２）前記距離センサが超音波距離センサであることを特徴とする実用新案登録請求の範囲第１０項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（１３）前記電子回路がフレキシブルプリント基板に構成されていることを特徴とする実用新案登録請求の範囲第１項乃至第１２項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（１４）前記電源電池を除く電子回路がメガネフレームのブリッジ部に配置されていることを特徴とする実用新案登録請求の範囲第１項乃至第８項

記載の調光レンズ付き眼鏡等の構造。

（１５）前記電子回路の電源電池がメガネフレームの智部分に配置されていることを特徴とする実用新案登録請求の範囲第１項乃至第８項記載の調光レンズ付き眼鏡等の構造。

３．考案の詳細な説明

〔産業上の利用分野〕

本考案は自動二輪車又は軽二輪車或は乗用車，軽飛行機等各種移動体乗用時に着用する自動二輪車用ヘルメット、または一般時に着用するサングラス等の改良に係る調光レンズ付き眼鏡またはヘルメット等の構造に関するものである。

〔従来の技術〕

自動二輪車乗用時のヘルメット着用義務化に基づき種々の頭部防護用ヘルメットが使用されており、視野を確保するための開口部にサンバイザー兼用のウインドバイザーを設けたものも多用されているが、該サンバイザーを設けたヘルメットは、太陽光の強弱によって視度が異なり、殊にトンネルの出入りが多い道路での走行はトンネルに進入

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したときの視度が急に低下し、盲目状態になる欠点を有しており、これを解消するために色又は光透過度を異にする複数枚のサンバイザーを用意し、外光の状況に応じて交換使用するものが用いられていた。

これは一般時に使用するサングラスでも同様であり、外光の強弱によって眼鏡を掛け換える必要があった。

〔考案が解決しようとする問題点〕

従って、上記ヘルメットを着用している場合、トンネルへの出入りが多い道路では、トンネルへの進入時とトンネルからの進出時にその都度停止してサンバイザーの交換を行わなければならず、高速道路使用時等では道路上で停止することができないため使用不能であった。

殊にサングラス等の眼鏡の場合は、レンズ部に使用する液晶やＥＣ材を電気的に制御するための電子回路を眼鏡フレームの限られた場所に具備しなければならず、配置的に困難を極め具体化されない問題を有していた。

本考案は上記問題に鑑みて成されたもので、ヘルメットに設けたサンバイザー又はサングラス等の眼鏡のレンズの透光量を外部の照度に応じて切換調節又は自動調節する調光レンズ付き眼鏡またはヘルメット等の構造を提供すると共に、前方障害物を検知して警告信号を発する障害物警告機能を付加した調光レンズ付き眼鏡またはヘルメット等の構造を提供することを目的とするものである。加えてレンズ部に使用する液晶やＥＣ材を電気的に制御するための電子回路を眼鏡フレームの限られた場所に配置する技術を提供することを目的とするものである。

〔問題点を解決するための手段〕

本考案の調光レンズ付き眼鏡またはヘルメット等の構造は、電極基板を有し、外部電圧の印加により色又は光透過度が変化するようになる素子をレンズ部又はバイザー部に使用した自動二輪車用ヘルメットまたはサングラス等に於いて、素子の制御回路、外光を検出する光センサ、電源電池及び電源スイッチ等の全ての電子回路を眼鏡又はヘ

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ルメット等の本体に収容したことを要旨とするものである。

また上記電子回路が、外部電圧の印加により色又は光透過度が変化するようになる素子を、特定の光量範囲または任意の光量範囲に切換又は可変する光感度切換機構を具備せしめ外光の強弱に対応して使用する構造にした。

上記外部電圧の印加により色又は光透過度が変化するようになる液晶素子が、ゲストホスト型の液晶セル又はツイストネマティック型の液晶セルによって構成することができる。

また、光感度切換機構はマイクロコンピュータによって液晶素子に印加する外部電圧を自動制御する自動制御構造にすることができると共に、光感度切換機構を出力インピーダンスを切り換え又は可変するか、又は、光センサの光入射窓に、光透過度の異なるフィルタを配置し、該フィルタを切り換え又は可変する構成にし、液晶素子又はECセルを特定の光量範囲または任意の光量範囲に調整するようにしている。

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更に前記液晶素子又はＥＣセルを、円柱状又は球面状の曲率半径を有する２枚の合成樹脂透明板の間に収容することによってレンズに直接加わる外圧を解消している。

本考案の調光レンズ付き眼鏡またはヘルメット等の構造は、前記調光レンズに加えてヘルメット又は眼鏡等の一部に、距離センサによって前方障害物との距離を検出し、特定の距離以下または任意の検出距離に切換又は可変する検出距離切換機構を介して該ヘルメット又は眼鏡等に設けたブザーを鈴鳴する障害物警告装置を具備せしめたものであり、眼鏡に実施する場合はブザーに代えて直接着用者の皮膚を刺激する振動体を設けることもできる。

また、上記距離センサは赤外線距離センサ又は超音波距離センサで構成することができる。

加えて本考案の調光レンズ付き眼鏡またはヘルメット等の構造は、電子回路をフレキシブルプリント基板によって構成し、電源電池を除く電子回路をメガネフレームのブリッジ部に配置すると共

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に、電源電池をメガネフレームの智部分に配置することによって目的を達成することができるものである。

〔 作 用 〕

上記構成の調光レンズ付き眼鏡またはヘルメット等の構造は、光感度切換機構により調光バイザーまたはレンズの液晶セルに印加する電圧を切り換えて、光透過度を変更する調光作用によって昼間と夜間の使用、トンネル内外での使用等、外部光の強弱差がある場所で適正な透過光量を得ることができるため、バイザー又は眼鏡を交換する必要がない。

又、上記平板状の液晶セルを円柱状又は球面状の曲面を有する二枚の合成樹脂透明板の間隙に収容する構造にしたことにより該液晶セルを外部衝撃から保護し、衝撃に対する充分な強度を確保することができるものである。

更に、障害物検出機構が距離センサによってヘルメット前方の障害物を検出し、予めセットし又は調節した距離以下の場合にブザーを鈴鳴するよ

うになるため、車間距離警告器の作用をなす。

加えて、殊に眼鏡に構成したものでは、従来の眼鏡と殆ど外観を変更することなく実施できる制御回路部の小型化が図れるため、眼鏡の意匠性を損なうことなく実施できるものである。

〔実　施　例〕

以下、本考案の調光レンズ付き眼鏡またはヘルメット等の構造の実施例を図面に従って説明する。

第１図乃至第６図は自動二輪車用ヘルメットの一実施例を示すもので、第１図乃至第３図はその外観を示すものである。

符号１は使用者の頭部を覆うようになるヘルメット本体であり、前面に視野を確保するためのバイザー２を構成して成る。該バイザー２は第２図に示すようにスペーサ３を介して離間した円柱状又は球面状の曲率半径を有するプラスチック樹脂等の二枚の合成樹脂透明板４，５間に液晶セル収納枠６を介して平板状の液晶セルＬａ，ＬａからなるレンズＬ，Ｌを位置せしめたものであり、該液晶セルＬａがツイストネマチィック型の場合は合

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成樹脂透明板４の裏面に偏光フィルム８を貼着して成る。該液晶セルＬａは第４図に示すようにそれぞれ絶縁スペーサ１１を介して透明電極膜９を内面に形成したガラス板１０，１０を対置し、両透明電極膜９，９の微小間隙に液晶１２を充填した構造になるゲストホスト型Ａのものや、上記構成に偏光フィルム８を並設したツイストネマチック型Ｂによって構成して成る。該液晶セルＬａは、ヘルメット本体１内に装備した電池等の電源部１３によって駆動し、該ヘルメット本体１の額部前面に固設したＣｄＳ素子等の光センサ１４からの信号を入力して出力電圧を調整する制御手段１５からの出力電圧を両透明電極膜９，９に印加して成るもので、ヘルメット本体１に設けた光感度切換スイッチ１６によって光感度を切換可能とし、後述する制御回路によってレンズＬ，Ｌに対する印加電圧を制御する構造になる。

また符号２１はヘルメット本体１に構成した障害物検出機構２０の検出距離設定摘みであり、該障害物検出機構２０は第５図にブロック線図で示

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すようにヘルメット本体１の額部に固設したＬＥＤからなる投光素子２２とＰＳＤからなる受光素子２３を含む制御回路によって構成されている。該制御駆動回路は、受光レンズ２４を介して受光する受光素子２３のバイアス回路２４と２個のパルス電流変換アンプ２５，２６からの出力差によって駆動する差動アンプ２７の出力をサンプル・ホールド回路２８に入力し、該サンプル・ホールド回路２８の出力と前記検出距離設定摘み２１によって設定値を変更するようになる可変抵抗器２９を後段の比較器３０によって比較し、該比較出力によってブザー駆動回路３１を介してヘルメット本体１の内部に設けたブザー３２を鈴鳴駆動する。また上記サンプル・ホールド回路２８はタイミングジェネレータ３３と同期するようになり、該出力によってＬＥＤ駆動回路３４はＬＥＤからなる前記投光素子２２に通電し、投光レンズ３５を介してヘルメットの前方に位置する障害物に向かって赤外線を照射すると共に、該赤外線の反射光が受光素子２３に入力するようになる。

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次に第６図は超音波センサを使用した障害物検出機構２０のブロック線図を示すものであり、ヘルメット本体１の額部には前記実施例の投光素子２２と受光素子２３に代わって送波センサ４１と受波センサ４２を固設して成る。符号４３は受波センサ４２の感度調整ボリューム，４４は受波信号整形回路，４５は距離パルス発生回路，４６は距離係数回路であり、タイミングジェネレータ４９との比較によりブザー駆動回路４７を介してブザー５０を鈴鳴駆動する。また、上記タイミングジェネレータ４９はデジタルスイッチ回路によって構成される距離設定スイッチ５１からの入力値によって前記距離パルス発生回路５２及び送波センサ駆動回路４８に駆動信号を送達するようになり、該送波センサ駆動回路４８によって送波センサ４１から所定周波数の距離測定用高周波を発振する構造になる。

次に第７図乃至第９図はは本考案をサングラスに実施したものを示すものである。

眼鏡本体６１は眼鏡フレーム６２と、レンズＬ，

Ｌと眼鏡フレーム６２に形成した光センサ窓６４及び光感度切換スイッチ６５により構成されている。後述する電子回路及び電源電池は眼鏡フレーム６２の一部に内蔵されている。またレンズＬ，Ｌには液晶セルを使用しており、それぞれ電気的に透過光量を制御する構造になる。

第８図に示すように上記電子回路は、眼鏡フレーム６２のブリッジ部に構成されており、フレキシブルプリント基板６６上にＣｄＳセル６７，アナログＩＣ６８，電源スイッチ６９，チップコンデンサ７０，及びチップ抵抗７１を実装した後述の制御電子回路である。

上記制御電子回路は、従来技術であるチップマウンターマシンやリフローソルダーマシン等を使用して実装することにより、小型微細加工ができるため、上記眼鏡フレーム６２のブリッジ部に収容可能な高密度実装が可能である。

更にフレキシブルプリント基板６６は、フィルム状の基板であるため、凹凸のある場所や変形した場所でもその形状に沿って電気回路を形成する

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ことができるものである。

該制御電子回路とレンズＬ，Ｌの液晶セルとの接続は、導電性の接着剤等を介して符号７２で示す接続部で行われている。またフレキシブルプリント基板６６から延びた電源配線部７３は眼鏡フレーム６２のブリッジ部から智の部分まで配線され、第９図に示す電源電池７４の電極部に至っている。

以下に前記第一実施例に示した自動二輪車用ヘルメットの調光バイザーと第二実施例に示したサングラスのレンズＬ，Ｌに印加する電圧の制御回路を第１０図乃至第１６図について説明する。

第１０図の制御回路は本考案の基本的な実施例を示すものである。

本回路はアナログＩＣ６８にオペアンプを使用した実施例を示すもので、該アナログＩＣ６８，コンデンサＣ３，ＣｄＳセル６７，抵抗Ｒ３，Ｒ４でマルチバイブレータ回路を構成している。ＣｄＳセル６７は光を受けると抵抗値が低下する特性を持っているため、本回路では光量が多いと

きマルチバイブレータの発振周波数が高くなり、光量が少ないときには発振周波数が低くなる動作をする。こうして得られた信号を抵抗器Ｒ５を介してレンズＬ，Ｌの液晶セルＬａに印加する。

然るに液晶セルＬａは電気的特性上、容量性負荷Ｃを形成するため、第２３図の等価回路に示すようにＲ５とＣＬによってローパスフィルタを構成するようになる。従って液晶セルＬａの両端間の電圧Ｖ２は、高周波時には低電圧と成り、逆に低周波時には高電圧と成る。即ち光量が多いときには液晶セルＬａに印加する電圧が低く、レンズＬの光透過度を抑制し、光量が少ないときには液晶セルＬａに印加する電圧が高く、レンズＬの光透過度を高めるようになり、サングラスとしての外光に応じた遮光作用を発揮する。

次に光感度切換機構を装備した制御回路について説明する。第１１図乃至第１６図までの回路図において電源の接続は省略してある。電源の接続は使用する素子により適宜接続されるものであり、回路図は必要最小限を例示したものである。

第１１図及び第１２図は増幅度を切り換えて光感度を切り換える実施例の回路図を示すもので、Ａ１，Ｃ１，Ｒ１～Ｒ３でマルチバイブレータ回路を構成し、増幅器Ａ２にＡＣ信号を供給する。マルチバイブレータ回路の発振周波数はＣ１，Ｒ１によって決定され、該発振周波数ｆは次式（イ）により求めることができる。

$$f = \frac{1}{2 \cdot C1 \cdot R1} \quad (Hz) \quad \cdots (イ)$$

このマルチバイブレータ回路で使用するＡ１には、オペアンプＩＣやコンパレータＩＣ等が使用でき、またディスクリート部品を組合せた回路であってもよい。

第１１図において前記マルチバイブレータ回路で得られた信号は、光センサＲcds を介して増幅器Ａ２に供給される。該増幅器Ａ２には、帰還抵抗ＲflとＲfdが組み合わされており、これらを切り換えるためのスイッチ１６（６５）がある。

増幅器Ａ２の増幅度Ｇは次式（ロ）によって求められるため、スイッチ１６（６５）を切り換える

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ことにより増幅度Ｇを変更することが可能と成る。

$$\text{増幅度 } G = -\frac{\text{Rfl または Rfd}}{\text{Rcds}} \quad \cdots (ロ)$$

増幅器Ａ２で増幅された信号はレンズＬ，Ｌに供給される。該レンズＬ，Ｌは液晶セルＬａを偏光板Ｌｂ，Ｌｂ’で挟んだ構造と成っており、液晶セルＬａにはツイストネマティック型液晶セルを使用し、偏光板ＬｂとＬｂ’は、偏光軸を直交させた直交ニコルの状態にする。このように、ツイストネマティック型液晶セルを直交ニコルにした偏光板の間に配置すると、第１９図に示すように高電圧の信号を印加すると光透過度が低下し、逆に低電圧の信号を印加すると、光透過度を上げる作用をさせることができる。

また、本実施例では光センサRcds にＣｄＳセルを使用しており、ＣｄＳセルの光に対する特性は第１７図に示すように、光量が多い場合には抵抗値が小さく、光量が少ないときは抵抗値が大きくなるという特性を示す。

従って（ロ）式でわかるように、該光センサ

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Rcds が光を受けると抵抗値が小さくなり、増幅器Ａ２の増幅度が増し、レンズＬ，Ｌに高電圧の信号が印加され、該レンズＬ，Ｌの光透過度が下がる。また該光センサRcds の受光量が少ない場合は抵抗値が大きくなり、増幅器Ａ２の増幅度が低下し、レンズＬ，Ｌには低電圧の信号が印加されることになり、該レンズＬ，Ｌの光透過度が増す。このような動作をする回路に、RflとRfdという帰還抵抗を設け、これらを切り換えることにより光感度を切り換えることができる。

RflとRfdの抵抗値の関係をRfl＜Rfdとし、日中の外部光量の多いときにはRfl側を使用し、夜間（もしくは外部光量の少ないとき）はRfd側を使用する。即ち光量が多いときには、光センサRcds は低抵抗の範囲で作動するため、帰還抵抗Rflの抵抗値はRcds の変化分に合った低抵抗値にし、また光量が少ないときには、光センサRは高抵抗の範囲で作動するため、Rfdを高抵抗の値にすれば、光センサRcds の抵抗値と増幅器Ａ２の出力電圧の特性は第１８図に示したようになる。

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従って、光量とレンズの光透過度特性は第２０図に示したようになる。第２０図においてＤの特性曲線はＲfdを接続した場合、Ｌの特性曲線はＲflを接続した場合の特性例を示したものである。ＲflとＲfdの切換は切換スイッチ１６(６５)により行うことができる。

本実施例では帰還抵抗を２個としてあるが、用途に応じて２個以上としてもよく、この場合は切換スイッチ１６(６５)の接点数を帰還抵抗の個数に合った段数のものを使用すればよい。この切換スイッチ１６(６５)にはトグルスイッチやロータリースイッチ又はスライドスイッチなどを使用することができるもので、回路を切り換え得るものであれば足りる。

また、光感度を段階的ではなく無段階に可変するときには、ＲflやＲfdの代わりに可変抵抗器を帰還抵抗として使用すればよく、この場合切換スイッチ１６(６５)は不要となり、任意の光量範囲に設定できることになる。

第９図は、増幅器Ａ２の帰還抵抗に光センサ

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Ｒcds を使用し、入力抵抗Ｒsl，Ｒsdを切り換えることにより、光量に対する増幅器Ａ２の出力電圧を変え光感度を変えることができるようにした実施例の回路図を示したものである。

本実施例では、レンズＬ，Ｌに偏光軸を平行ニコルにした偏光板Ｌｂ，Ｌｂ’を用い、その間に液晶セルＬａ（ツイストネマティック液晶セル）を配置した実施例を示したものである。また、本実施例ではレンズＬ，Ｌにツイストネマティック液晶の他に、誘電異方性が正の液晶と染料分子の長軸方向に光を吸収する染料を混合したゲストホスト液晶を使用した液晶セルを用いることでもよい。ゲストホスト液晶を使用した液晶セルの場合、偏光板Ｌｂ，Ｌｂ’は全く使用しないかまたは、Ｌｂ，Ｌｂ’の偏光板どちらか一方を使用することでもよい。

レンズＬ，Ｌの印加電圧と光透過度特性を第２２図に示す。本実施例のように入力抵抗にＲsd及びＲslを使用した場合、増幅器Ａ２の増幅度Ｇは次式（ハ）により求めることができ、光センサ

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Ｒcds の光量に対する特性は第１７図に示した通りであり、光センサＲcds と増幅器Ａ２の出力電圧の特性は第２１図に示すようになる。

$$\text{増幅度 } G = -\frac{Rcds}{Rsd} \quad \text{又は} \quad G = -\frac{Rcds}{Rsl} \cdots (ハ)$$

従って、入力抵抗ＲsdとＲslをスイッチ１６（６５）で切り換えることにより、光量に対する増幅器Ａ２の出力電圧が変わり光感度を変えることができる。このときの光量とレンズの光透過度特性を第２０図に示す。第２０図においてＤの特性曲線は入力抵抗にＲsdを接続した場合、Ｌの特性曲線はＲslを接続した場合の特性例を示したものである。

本実施例では入力抵抗を２個としてあるが、用途に応じて２個以上としてもよく、この場合は切換スイッチ１６（６５）の接点数は、入力抵抗の個数に合った段数のものを使用すればよい。この切換スイッチ１６（６５）にはトグルスイッチやロータリースイッチ又はスライドスイッチなどを使用することができるもので、回路を切り換え得るも

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のであれば足りる。

また、光感度を段階的ではなく無段階に可変するときには、RslやRsdの代わりに可変抵抗器を入力抵抗として使用すればよい。この場合、切換スイッチ16(65)は不要となり、任意の光量範囲に光感度を設定できる。

第13図は出力インピーダンスを変えて光感度を切り換える一実施例の回路図を示したもので、A3, C2, R2, R3及びRcds でマルチバイブレータ回路を構成している。このマルチバイブレータ回路の発振周波数fは次式(ニ)によって求めることができる。

$$f = \frac{1}{2 \cdot C2 \cdot Rcds} \quad (Hz) \quad \cdots (ニ)$$

従って、光センサRcds の抵抗値は第17図に示したように光量によって変化するため、発振周波数fは光センサRcds の抵抗値の変化とともに、変化する。

液晶セルは電気的特性において容量性を示すため、第13図に示すような回路構成をした場合

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RolまたはRodを接続することにより、低域通過回路を構成することになる。従って、液晶セルの容量値をCとすると第２３図に示すような等価回路と成り、液晶セルに印加される電圧Ｖ２は次式（ホ）により求めることができる。第２３図においてＶ１はマルチバイブレータ回路の出力電圧、Ｖ２は液晶セルに印加される電圧、ＲはRol又はRodを示し、ＣはレンズＬ，Ｌの液晶セルの合成容量値を示す。

$$V2 = \frac{V1}{1 + j\omega CR} \qquad \cdots (ホ)$$

ただし、$\omega = 2\pi f$

（ホ）式で示されるように、Ｖ２は周波数が高い場合は低電圧に、また周波数が低い場合は高電圧と成り、その周波数特性は第２４図に示すように遮断周波数ｆｃ以上になると－６dB/オクターブの特性を示すことになる。この遮断周波数ｆｃは次式（へ）で求めることができる。

$$fc = \frac{1}{2\pi CR} \quad (Hz) \qquad \cdots (へ)$$

従って、（へ）式に示されるＲをRolやRodに

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変えることにより遮断周波数ｆｃを変えることができ、光量に対する感度を切り換えることが可能と成る。

本実施例に示すレンズＬ，Ｌには、偏光板Ｌｂ，Ｌｂ’を平行ニコルにしたツイストネマティック型の液晶セルや、偏光板Ｌｂ，Ｌｂ’のどちらか一方を使用するか又は偏光板を全く使用しないゲストホスト液晶を使用した液晶セルを用いることができる。このとき光量とレンズの光透過度特性は第２０図に示したようになる。第２０図においてＤの特性曲線はＲｏｄを接続した場合、Ｌの特性曲線はＲｏｌを接続した場合の特性例を示したものである。

また、本実施例では出力インピーダンスをＲｏｌとＲｏｄの２個としてあるが、用途に応じて２個以上としてもよく、この場合は切換スイッチ１６(６５)の接点数は、出力インピーダンスの数に合った段数のものを使用すればよい。この切換スイッチ１６(６５)にはトグルスイッチやロータリースイッチ又はスライドスイッチなどを使用するこ

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とができるもので、回路を切り換え得るものであれば足りる。

また、光感度を段階的ではなく無段階に可変するときには、RodやRolの代わりに可変抵抗器を出力インピーダンスとして使用すればよく、この場合は切換スイッチ16(65)は不要となり、任意の光量範囲に光感度を設定できることになる。

第14図乃至第16図は、光センサ受光窓に光透過度の異なるフィルタを配置し、該フィルタを切り換えることにより光感度を切り換える実施例の回路図を示したものである。フィルタf1は、光透過度の低い側Lと光透過度の高い側Dとがあり、これを切り換える。即ち、外部光量の多いときにはL側に設定し、外部光量をこのフィルタで低下させた状態で光センサRcds に当てる。また、外部光量の少ないときにはD側に設定する。フィルタのL側とD側の光透過度の差を、例えば昼夜の光量の差に設定すれば、フィルタを昼間は光量を低下させるL側にし、夜間は光量の低下しないD側に設定することにより光量差のある昼夜どち

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らでも同様の調光作用をさせることができる。

第１４図乃至第１６図の光透過度の異なるフィルタは２種類以上としてもよく、その場合は、光感度をフィルタの数だけ設定することができるようになる。また、光透過度が連続的に変化しているフィルタを使用すれば、段階的ではなく無段階に光感度を設定できることになる。更に、フィルタｆ１の形状は矩形板状のものや円盤状のものが考えられ、これらを摺動させたり回転させたりすることで光感度を切り換える（または可変にする）ことが可能となる。

第１４図の実施例のレンズＬ，Ｌには、ツイストネマティック液晶セルＬａを、偏光軸を平行ニコルにした偏光板Ｌｂ，Ｌｂ’で挟んだものや、誘電異方性が正の液晶と染料分子の長軸方向に光を吸収する染料を混合したゲストホスト液晶を使用した液晶セルＬａ等が使用できる。ゲストホスト液晶を使用した液晶セルの場合は偏光板Ｌｂ，Ｌｂ’を全く使用しないかまたは、Ｌｂ，Ｌｂ’の偏光板どちらか一方を使用することでもよい。

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尚、以上述べた実施例ではレンズL，Lにネマティック液晶セルを用いた場合について説明したが、該レンズL，Lにはコレステリック液晶やスメティック液晶、強誘電液晶等を用いた液晶セルを使用することでもよい。

〔考案の効果〕

以上述べたように本考案に係る調光レンズ付き眼鏡またはヘルメット等の構造は、光透過度を変更する調光作用によって昼間と夜間の使用、トンネル内外での使用等、外部光の強弱差がある場所で適正な透過光量を得ることができるため、バイザー又は眼鏡を交換する必要がないばかりでなく、障害物検出機構が距離センサによってヘルメット前方の障害物を検出し、予めセットし又は調節した距離以下の場合にブザーを鈴鳴するようになるため、車間距離警告器の作用をなすものである。

又、上記平板状の液晶セルを円柱状又は球面状の曲面を有する二枚の合成樹脂透明板の間隙に収容しているため、レンズを外部衝撃から保護し、衝撃に対する充分な強度を有するヘルメットを構

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成することができると共に、殊に眼鏡に構成したものでは、従来の眼鏡と殆ど外観を変更することなく実施できるため、眼鏡の意匠性を損なうことなく実施できる等の特徴を有するものであり、本考案実施後の実用的効果は極めて大きい。

4．図面の簡単な説明

第1図は本考案の一実施例を示す調光レンズ付きヘルメットの斜視図、第2図は第1図におけるII－II線断面図、第3図は液晶セルの構造と制御構造を示す説明図、第4図は第1図におけるIV－IV線断面図、第5図及び第6図はそれぞれ障害物警告機構の実施例を示すブロック線図、第7図は本考案の他の実施例を示すサングラスの斜視図、第8図は同電子回路収容部の拡大図、第9図は電源電池収容部の拡大図、第10図は本考案の制御回路の基本的な実施例を示す回路図、第11図乃至第16図はそれぞれ光感度の切換機構の実施例を示す回路図、第17図はCdSセルの光量－抵抗値特性の例を示すグラフ、第18図は入力抵抗に光センサを使用した場合のCdSセルの抵抗値

－出力電圧特性の例を示すグラフ、第１９図は直交ニコル間にツイストネマティック液晶セルを配置した場合の印加電圧－光透過度特性の例を示すグラフ、第２０図は外部光量－光透過度特性の例を示すグラフ、第２１図は帰還抵抗に光センサを使用した場合のＣｄＳセルの抵抗値－出力電圧特性の例を示すグラフ、第２２図は平行ニコル間にツイストネマティック液晶セルを配置した場合の印加電圧－光透過度特性の例を示すグラフ、第２３図は出力抵抗と液晶セルの等価回路、第２４図は低域通過回路の周波数－電圧特性の例を示すグラフである。

１…ヘルメット本体　　２…バイザー

４，５…合成樹脂透明板　１４…光センサ

１６，６５…光感度切換スイッチ

２０…障害物検出機構　２１…検出距離設定摘み

２２…投光素子　　２３…受光素子

６１…眼鏡本体　　６２…眼鏡フレーム

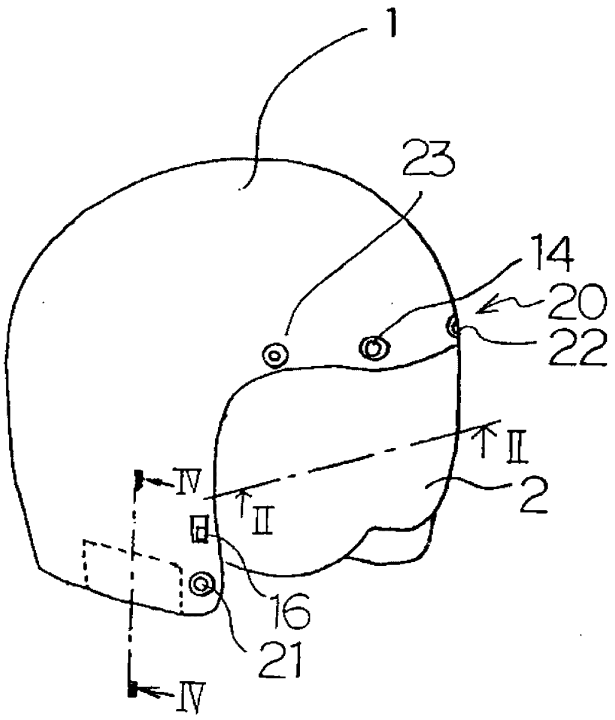
６４…光センサ　　Ｌ…レンズ

代理人　弁理士　畠　山　隆

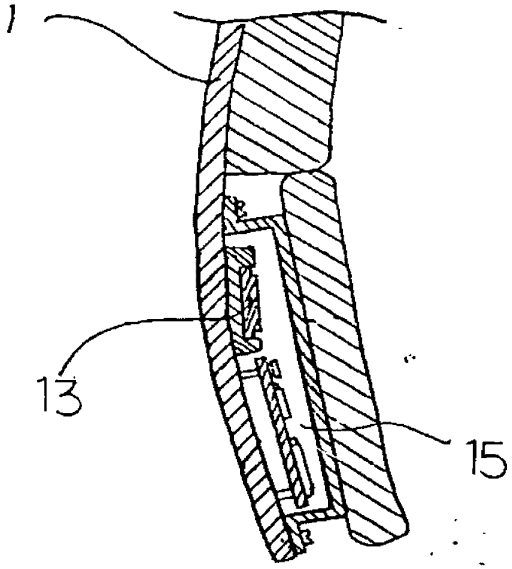
1383_PRIOR_ART_000421

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第１図



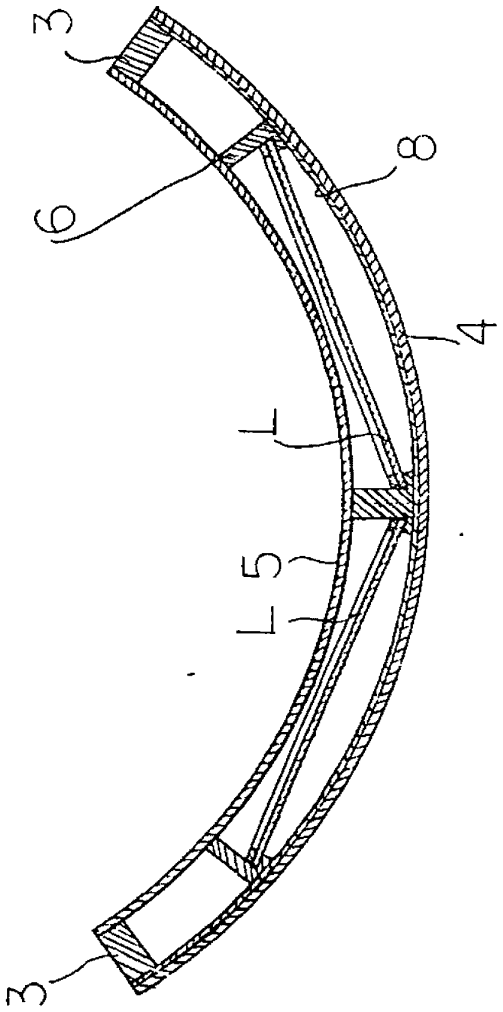
第４図



代理人 212
弁理士 畠 山 隆

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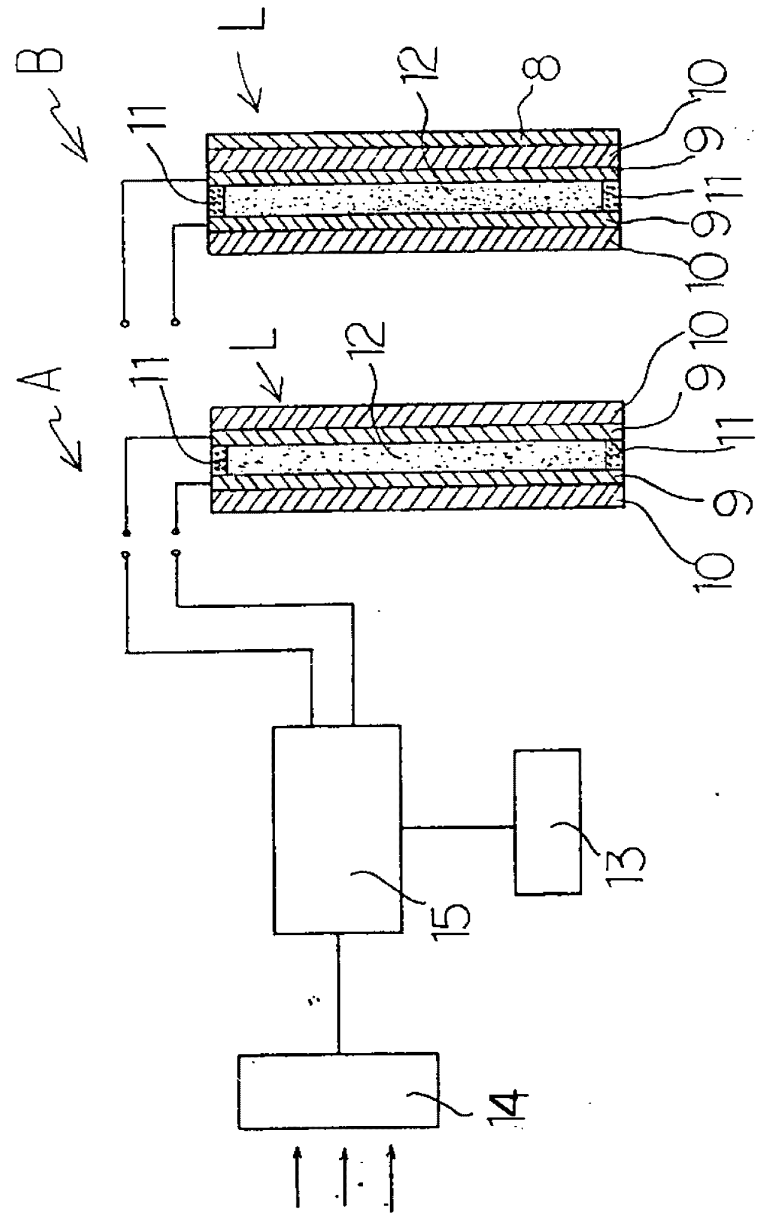


第2図

代理人 21
弁理士 畠 山

実開63-153221

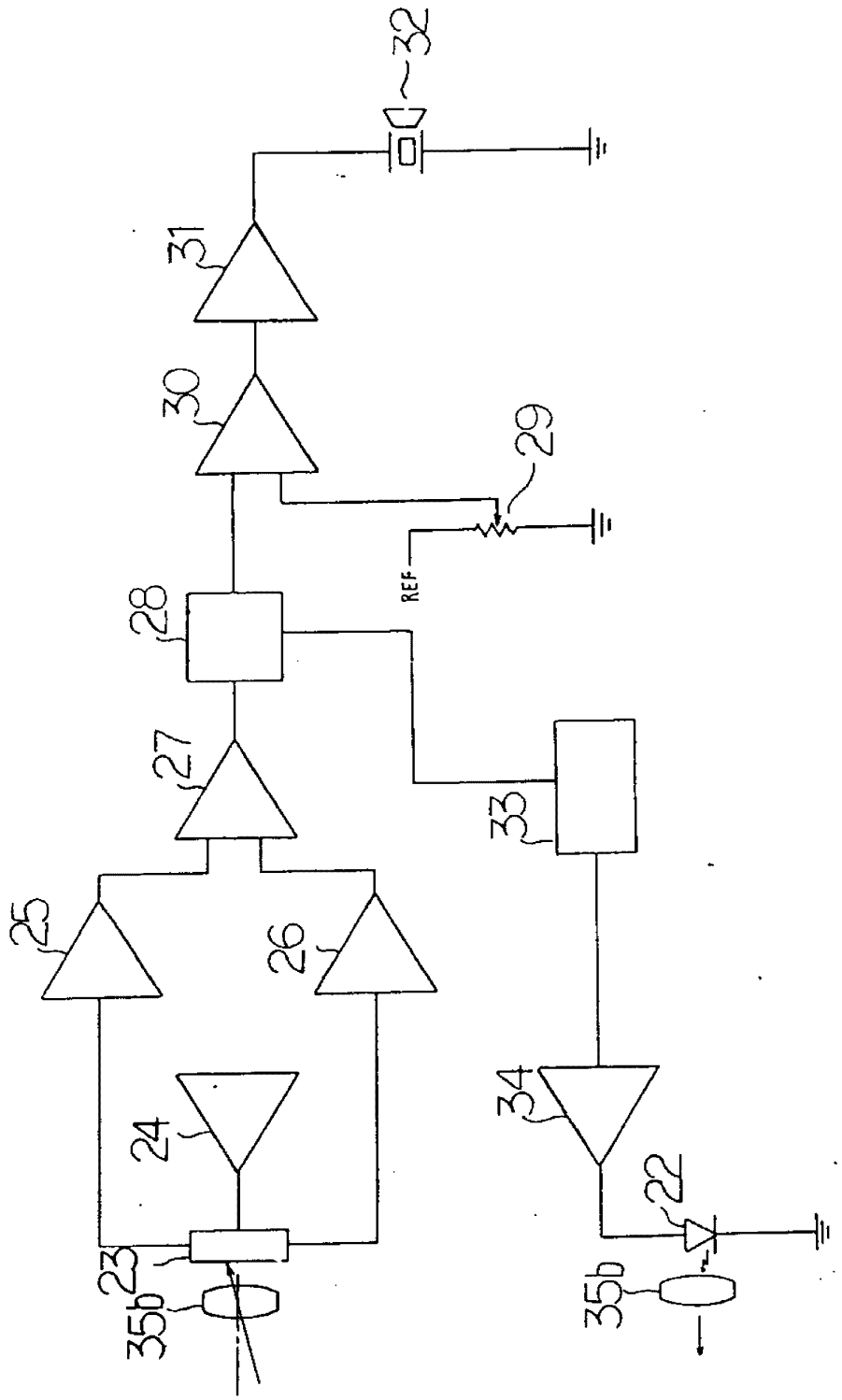
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第3図

代理人
弁理士 畠 山

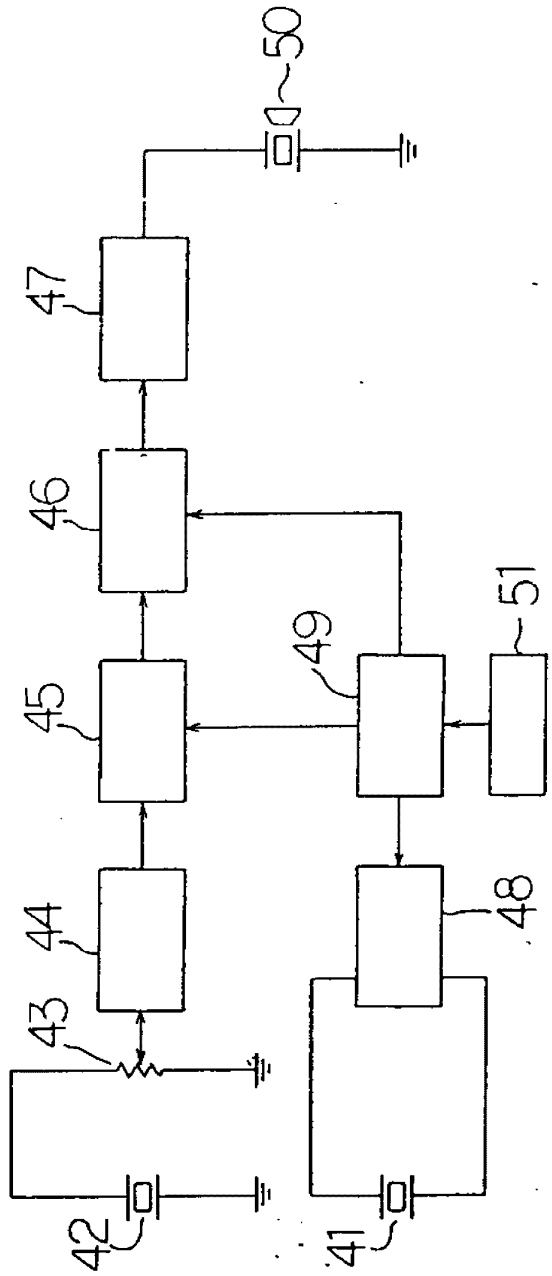
第5図



21

代理人
弁理士 畠 山

1383_PRIOR_ART_000425

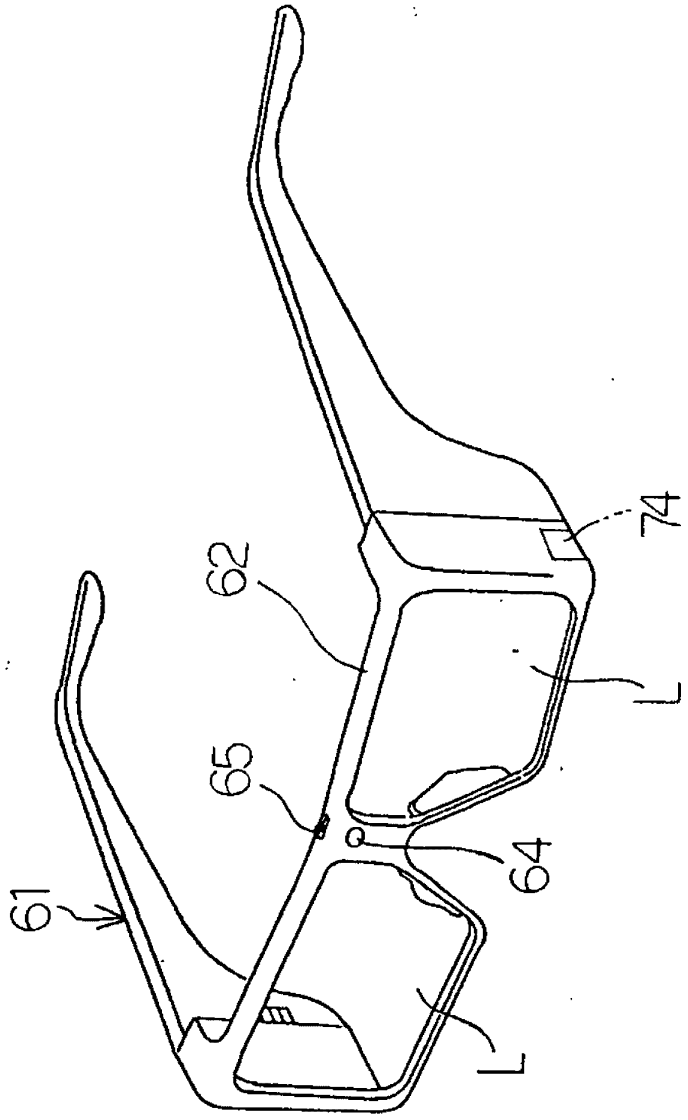


第6図

代理人 弁理士 畠山 隆 216

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第７図

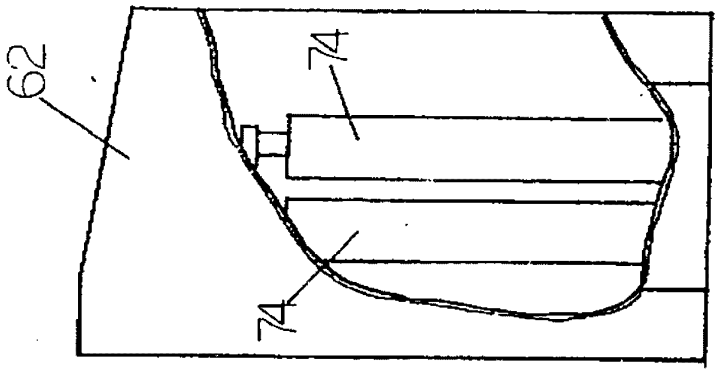


217

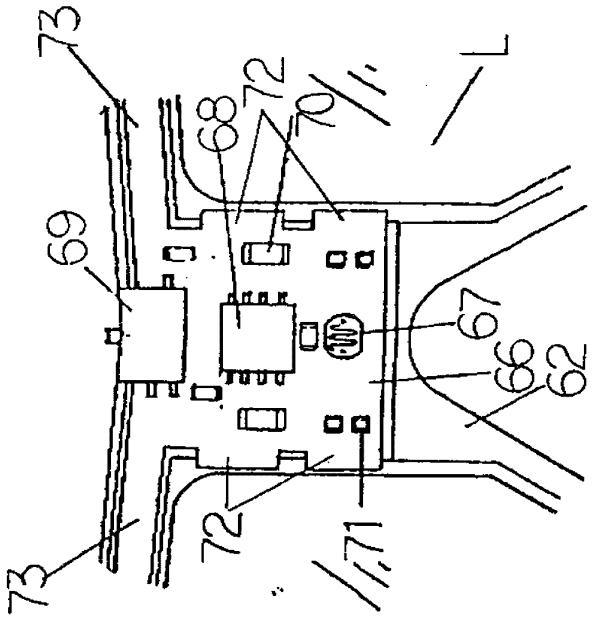
代理人 実開
弁理士 畠山 隆

1383_PRIOR_ART_000427

第9図

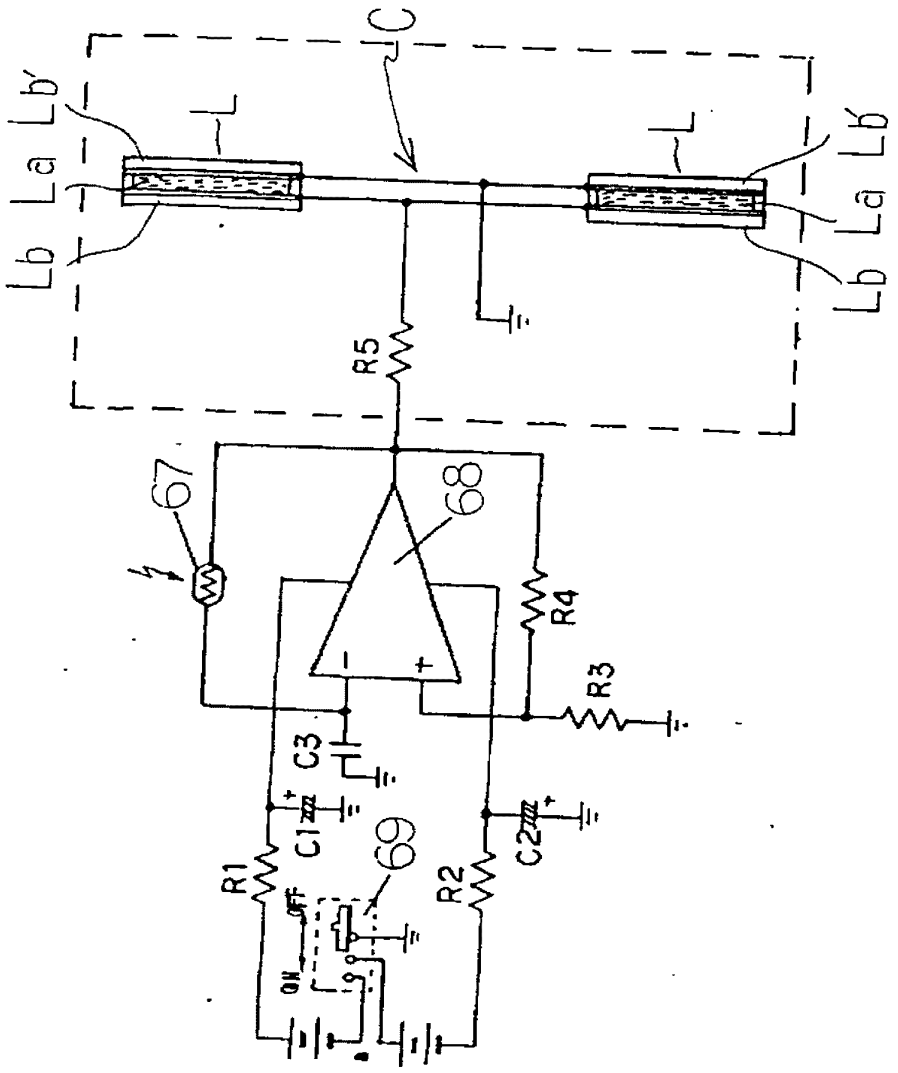


第8図



代理人
弁理士 畠 山

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第10図

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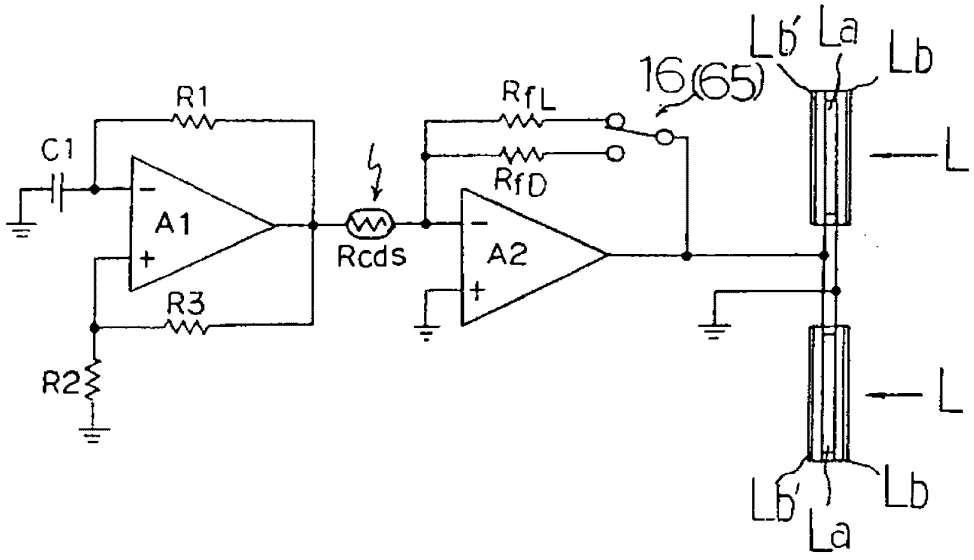
代理人

弁理士 畠山 隆

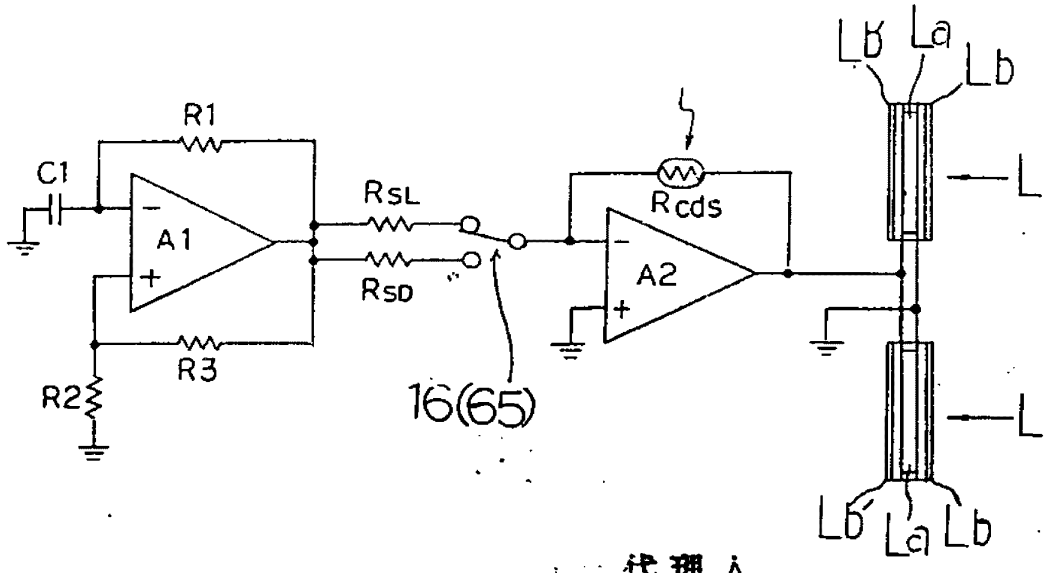
1383_PRIOR_ART_000429

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第11図



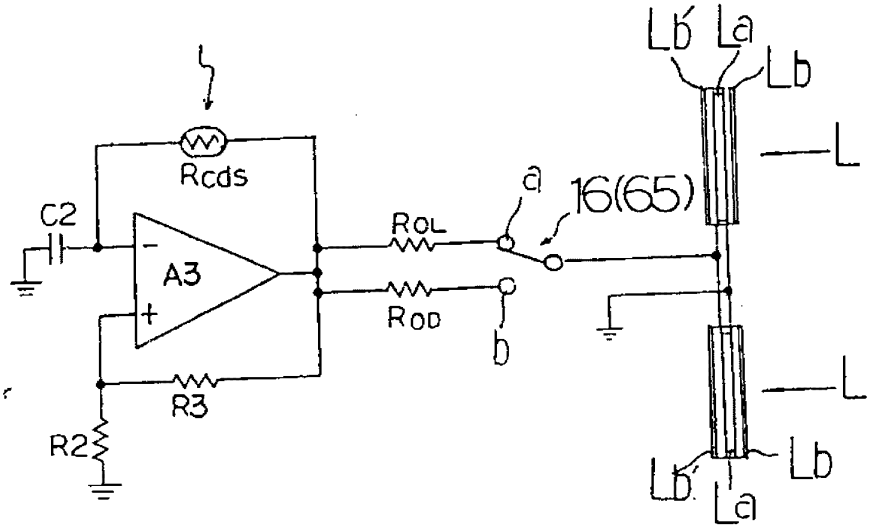
第12図



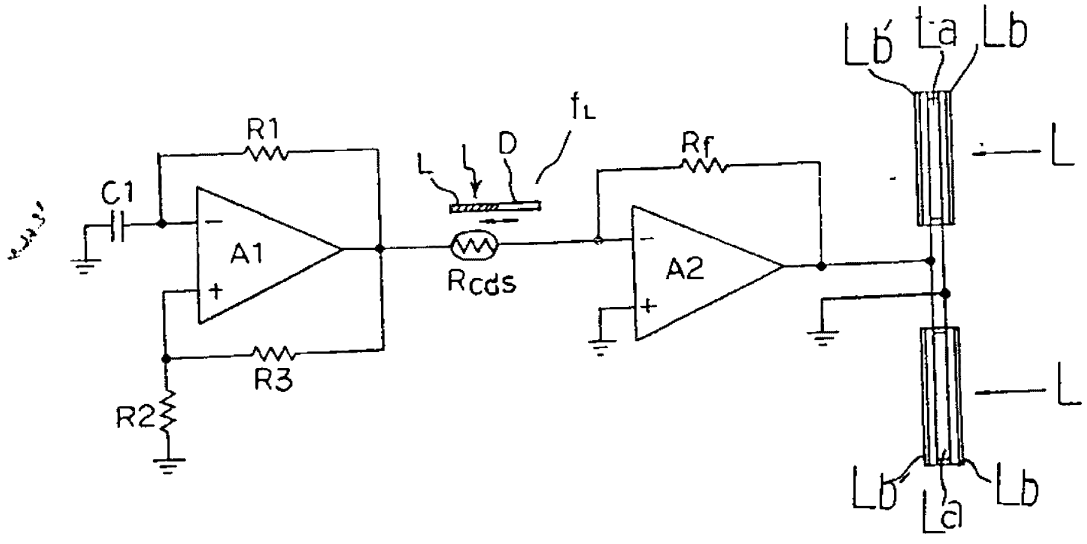
代理人
220 弁理士 畠山 隆

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第13図



第14図

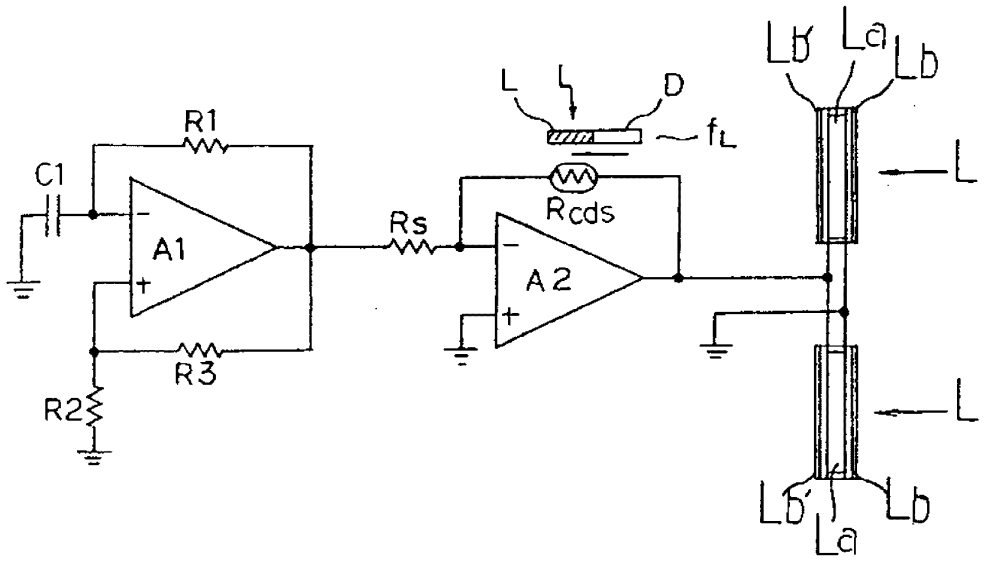


実開63-15321

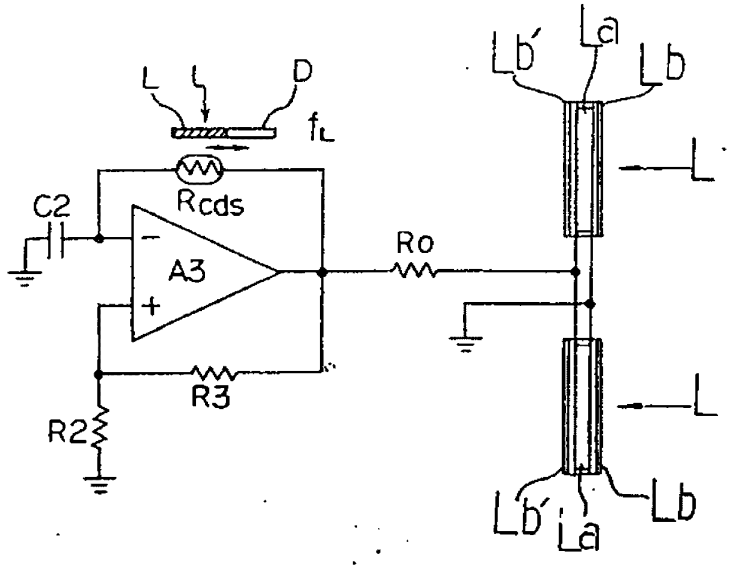
221 代理人 弁理士 畠山 隆

1383_PRIOR_ART_000431

第15図

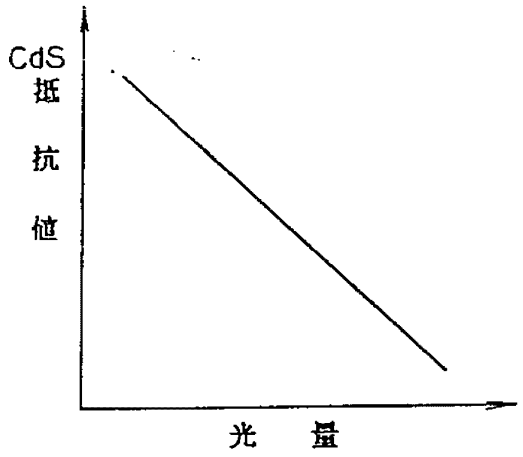


第16図

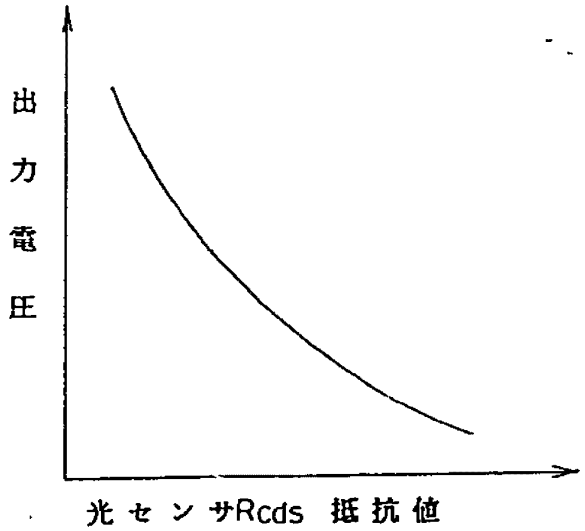


代理人
弁理士 畠 山 隆

実開63-153218
1383_PRIOR_ART_000432



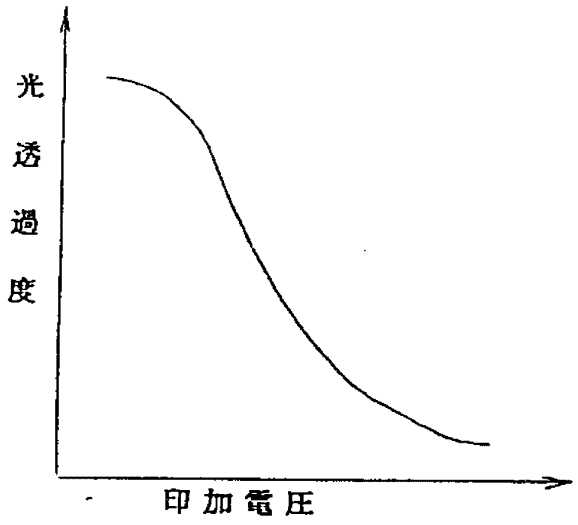
第17図



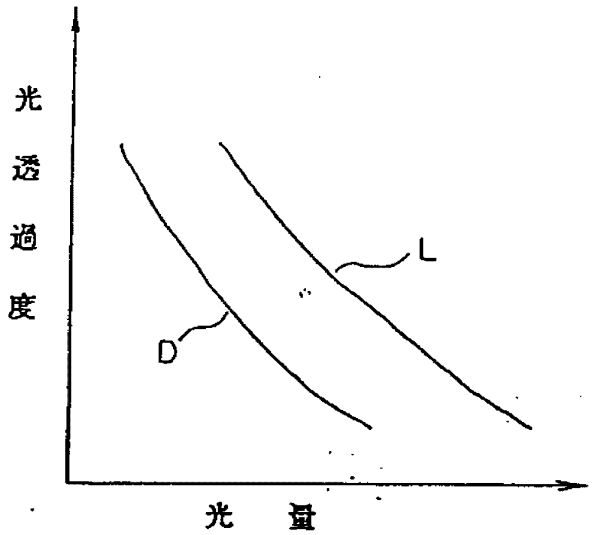
第18図

代理人
223 弁理士 畠 山 隆

実開63-
JP6301_PRIOR_ART_000433



第19図

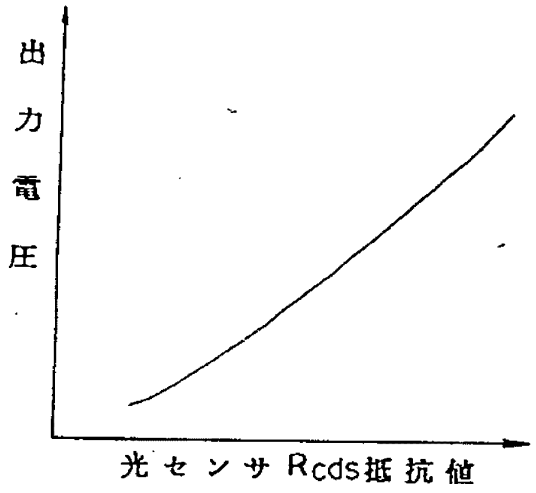


第20図

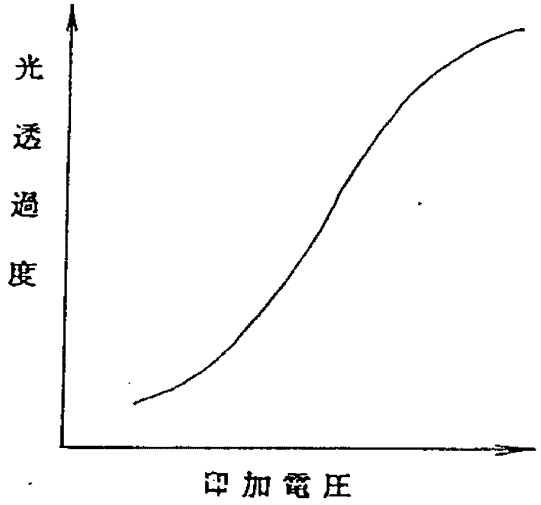
代理人
弁理士 畠 山

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第21図

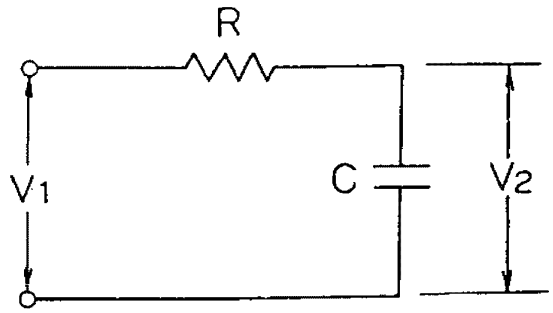


第22図

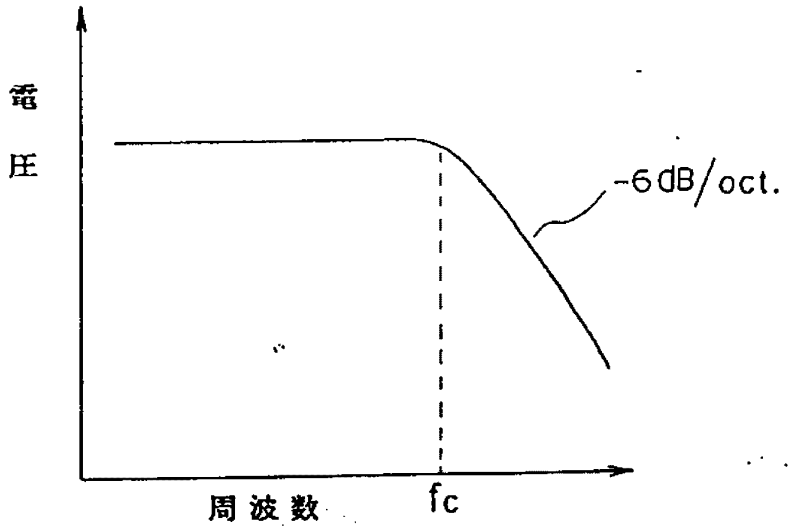
実開63-153

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1383_PRIOR_ART_000435



第23図



第24図

実開63-15321

代理人
226 弁理士 畠山 隆

1383_PRIOR_ART_000436

MACHINE TRANSLATION

Name of the device Structure of glasses or helmets, etc. with dimming lenses

priority claim
July 4, 1986 Japan (JP) Jissho 61-103330
October 4, 1986 Japan (JP) Jitsugyo 61-152899

Scope of Utility Model Registration Claims
(1) In helmets or sunglasses, etc. for motorcycles that have an electrode substrate and use an element in the lens section or visor section that causes the color or light transmittance to change by the application of an external voltage, all electronic circuits, including the control circuit of the element, a light sensor that detects external light, a power battery and a power switch, are contained in the body of the glasses or The structure of glasses or helmets, etc. with light-dimming lenses, characterized in that all electronic circuits such as control circuits of elements, light sensors to detect external light, power batteries and power switches are housed in the body of the helmet, etc.
(2) The structure of eyeglasses or helmets, etc. with light-dimming lenses as described in paragraph 1 of the utility model registration claims, characterized in that the electronic circuit is equipped with a light sensitivity switching mechanism that switches or varies the element that causes the color or light transmittance to change upon application of an external voltage to a specific light intensity range or any light intensity range.
(3) The structure of eyeglasses or helmets, etc. with a light-tuning lens as described in paragraphs 1 and 2 of the Utility Model Registration claims, characterized in that the element that causes the color or light transmittance to change upon application of an external voltage is a guest-host type liquid crystal cell.
(4) The structure of eyeglasses or helmets, etc. with a light-tuning lens as described in paragraphs 1 and 2 of the Utility Model Registration claims, characterized in that the element that causes the color or light transmittance to change by the application of an external voltage is a twisted nematic liquid crystal cell.
(5) The structure of eyeglasses or helmets, etc. with light-dimming lenses as described in paragraphs 1 to 4 of the Utility Model Registration Claims, characterized in that the light sensitivity switching mechanism comprises an automatic control mechanism by a microcomputer.
(6) A structure for eyeglasses or helmets, etc. with a light control lens as described in paragraphs 1 to 4 of the Utility Model Registration claims, characterized in that the light sensitivity switching mechanism switches or varies the signal amplification level to adjust the liquid crystal element to a specific light intensity range or any light intensity range.
(7) A structure for eyeglasses or helmets, etc. with light-dimming lenses as described in paragraphs 1 to 4 of the utility model registration claims, characterized in that the light sensitivity switching mechanism switches or varies the output impedance to adjust the liquid crystal element or EC cell to a specific light intensity range or any light intensity range.
(8) The light sensitivity switching mechanism is characterized by a structure in which a filter with a different light transmittance is placed in the light input window of the light sensor, and the filter is switched or varied to adjust the liquid crystal element or EC cell to a specific light intensity range or any light intensity range, as described in paragraphs 1 to 4 of the utility model registration claims. Structure of eyeglasses or helmets, etc. with lenses.
(9) The structure of glasses or helmets, etc. with a light-dimming lens as described in paragraphs 1 to 8 of the Utility Model Registration claims, characterized in that the liquid crystal element is housed between two synthetic resin transparent plates having a columnar or spherical radius of curvature.

(10) In addition to said light-dimming lens, a part of the helmet or glasses is equipped with an obstacle warning device that detects a distance from a forward obstacle by a distance sensor and sounds a buzzer installed in said helmet or glasses via a detection distance switching mechanism that switches or changes the distance to a specific distance or less or to any detection distance. The structure of eyeglasses or helmets, etc. with light-dimming lenses as described in paragraphs 1 to 8 of the scope of claims for utility model registration, characterized in that
(11) The structure of eyeglasses or helmets, etc. with dimming lenses as described in paragraph 10 of the Utility Model Registration claims, characterized in that the distance sensor is an infrared distance sensor.
(12) The structure of eyeglasses or helmets, etc. with dimming lenses as described in paragraph 10 of the Utility Model Registration claims, characterized in that the distance sensor is an ultrasonic distance sensor.
(13) A structure for eyeglasses or helmets, etc. with a dimming lens as described in paragraphs 1 to 12 of the Utility Model Registration claims, characterized in that the electronic circuit is configured on a flexible blintz board.
(14) The structure of eyeglasses, etc. with dimming lenses as described in paragraphs 1 to 8 of the Utility Model Registration Claims, characterized in that the electronic circuit excluding the power supply battery is located in the bridge portion of the eyeglass frame.
(15) The structure of eyeglasses, etc. with light-dimming lenses as described in paragraphs 1 to 8 of the Utility Model Registration Claims, characterized in that the power supply battery for the electronic circuit is located in the wisdom portion of the eyeglass frame.

Brief Description of Drawings
Figure 1 shows a diagram of a helmet with a dimming lens, Figure 2 shows a cross-sectional view of the II-II line in Figure 1, Figure 3 shows the structure and control structure of a liquid crystal cell, Figure 4 shows a cross-sectional view of the IV-IV line in Figure 1, and Figure 5 and Figure 6 show block diagrams of an obstacle warning mechanism respectively Figures 7, 8, 9, 10, 11, 16, and 17 show the circuit diagram of a basic example of the control circuit of this idea, and the circuit diagram of the light sensitivity switching mechanism, respectively. The 17th figure shows an example of light intensity vs. resistance characteristics of a CdS cell, the 18th figure shows an example of resistance vs. output voltage characteristics of a CdS cell when an optical sensor is used as input resistance, the 19th figure shows an example of applied voltage vs. light transmittance characteristics when a twisted nematic liquid crystal cell is placed between orthogonal niches, and the 20th figure shows an example of external light intensity vs. light transmittance characteristics when a twisted nematic liquid crystal cell is placed between orthogonal niches. -Figure 21 shows an example of resistance value vs. output voltage characteristics of a CdS cell when an optical sensor is used as a feedback resistor; Figure 22 shows an example of applied voltage vs. optical transmittance characteristics when a twisted nematic liquid crystal cell is placed between parallel niches; Figure 23 shows the equivalent circuit of an output resistor and a liquid crystal Figure 24 is a graph showing an example of frequency-voltage characteristics of a low-pass circuit.

1...Helmet body, 2...Visor, 4, 5...Transparent synthetic resin plate, 14...Light sensor, 16, 65...Light sensitivity changeover switch, 20...Obstacle detection mechanism, 21. Obstacle detection mechanism, 21...Detection distance setting pick, 22...Light emitter, 23...Light receiver, 61...Glasses body, 62...Glasses frame, 64...Light sensor, L...lens.

Correction Dec. 19, 1961
The name of the device is amended as follows
Name of the device Structure of glasses or helmets, etc. with dimming lenses

The scope of claims and brief description of the drawings are amended as follows

Scope of Utility Model Registration Claims
(1) In helmets or sunglasses, etc. for motorcycles that have an electrode substrate and use an element that changes color or light transmittance by the application of an external voltage or a liquid crystal lens that changes its refractive index by changing the orientation state of liquid crystal molecules as a lens part or visor part, a control circuit for the element, an optical sensor that detects external light, The structure of glasses or helmets, etc. with light-dimming lenses, characterized in that all electronic circuits, such as power supply batteries and power switches, are housed in the body of the glasses or helmets, etc.
(2) A structure for eyeglasses or helmets, etc. with light-dimming lenses as described in paragraph 1 of the claims for utility model registration, characterized in that the electronic circuit is equipped with a light sensitivity switching mechanism that switches or varies the element that causes the color or light transmittance to change upon application of an external voltage to a specific light intensity range or any light intensity range.
(3) The structure of eyeglasses or helmets, etc. with a light-tuning lens as described in paragraphs 1 and 2 of the Utility Model Registration claims, characterized in that the element that causes the color or light transmittance to change upon application of an external voltage is a guest-host type liquid crystal cell.
(4) The structure of eyeglasses or helmets, etc. with a light-tuning lens as described in paragraphs 1 and 2 of the Utility Model Registration claims, characterized in that the element that causes the color or light transmittance to change by the application of an external voltage is a twisted nematic liquid crystal cell.
(5) The structure of eyeglasses or helmets, etc. with light-dimming lenses as described in paragraphs 1 to 4 of the Utility Model Registration Claims, characterized in that the light sensitivity switching mechanism comprises an automatic control mechanism by a microcomputer.
(6) A structure for eyeglasses or helmets, etc. with a light control lens as described in paragraphs 1 to 4 of the Utility Model Registration claims, characterized in that the light sensitivity switching mechanism switches or varies the signal amplification level to adjust the liquid crystal element to a specific light intensity range or any light intensity range.
(7) A structure for eyeglasses or helmets, etc. with light-dimming lenses as described in paragraphs 1 to 4 of the Utility Model Registration claims, characterized in that the light sensitivity switching mechanism switches or varies the output impedance to adjust the liquid crystal element to a specific light intensity range or any light intensity range.
(8) Glasses with a light control lens as described in paragraphs 1 to 4 of the Utility Model Registration Claims, characterized in that the light sensitivity switching mechanism comprises a structure in which a filter with a different light transmission level is placed in the light input window of the light sensor, and the filter is switched or varied to adjust the liquid crystal element to a specific light intensity range or any light intensity range. or structure of a helmet, etc. as described in paragraphs 1 to 4 of the utility model registration claims.
(9) The structure of glasses or helmets, etc. with a light-dimming lens as described in paragraphs 1 to 8 of the Utility Model Registration claims, characterized in that the liquid crystal element is housed between two synthetic resin transparent plates having a columnar or spherical radius of curvature.

(10) In addition to said light-dimming lens, a part of the helmet or glasses is equipped with an obstacle warning device that detects a distance from a forward obstacle by a distance sensor and sounds a buzzer installed in said helmet or glasses via a detection distance switching mechanism that switches or changes the distance to a specific distance or less or to any detection distance. The structure of eyeglasses or helmets, etc. with light-dimming lenses as described in paragraphs 1 to 8 of the scope of claims for utility model registration, characterized in that
(11) The structure of eyeglasses or helmets, etc. with dimming lenses as described in paragraph 10 of the Utility Model Registration claims, characterized in that the distance sensor is an infrared distance sensor.
(12) The structure of eyeglasses or helmets, etc. with dimming lenses as described in paragraph 10 of the Utility Model Registration claims, characterized in that the distance sensor is an ultrasonic distance sensor.
(13) A structure for eyeglasses or helmets, etc. with a dimming lens as described in paragraphs 1 to 12 of the Utility Model Registration claims, characterized in that the electronic circuit is configured on a flexible blintz board.
(14) The structure of eyeglasses, etc. with dimming lenses as described in paragraphs 1 to 8 of the Utility Model Registration Claims, characterized in that the electronic circuit excluding the power supply battery is located in the bridge portion of the eyeglass frame.
(l5) The structure of eyeglasses, etc. with dimming lenses as claimed in paragraphs 1 to 8 of the Utility Model Registration, characterized in that the power supply battery for the electronic circuit is located in the wisdom portion of the eyeglass frame.

Brief Description of Drawings
Figure 1 shows a diagram of a helmet with a dimming lens, Figure 2 shows a cross-sectional view of the II-II line in Figure 1, Figure 3 shows the structure and control structure of the liquid crystal cell, Figure 4 shows a cross-sectional view of the IV-IV line in Figure 1, Figure 5 and Figure 6 show examples of the obstacle warning mechanism, respectively. Fig. 4 shows the IV-IV cross section of Fig. 1; Fig. 5 and 6 show an example of the obstacle warning mechanism; Fig. 7 is a diagram of the sunglasses showing another example of this idea; Fig. 8 is an enlarged view of the electronic circuit housing; Fig. 9 is an enlarged view of the power battery housing; Fig. 10 is a circuit diagram showing a basic example of the control circuit of this idea; Fig. 11 to 16 show an example of the light sensitivity switching mechanism, respectively; Fig. 17 and 18 are circuit diagrams showing an example of the light sensitivity switching mechanism. The 17th figure is a graph showing an example of light intensity vs. resistance characteristics of a CdS cell, the 18th figure is a graph showing an example of resistance vs. output voltage characteristics of a CdS cell when an optical sensor is used as input resistance, the 19th figure is a graph showing an example of applied voltage vs. light transmission characteristics when a twisted nematic liquid crystal cell is placed between orthogonal niches Figure 20 shows an example of external light level - light transmittance characteristics; Figure 21 shows an example of resistance value - output voltage characteristics of a CdS cell when an optical sensor is used as a feedback resistor; and Figure 22 shows an example of applied voltage - light transmittance characteristics when a twisted nematic liquid crystal cell is placed between parallel niches, Figure 23 is an equivalent circuit of output resistance and liquid crystal cell, and Figure 24 is a graph showing an example of frequency-voltage characteristics of a low-pass circuit.

1...Helmet body, 2...Visor, 4, 5...Transparent synthetic resin plate, 1 4...Light sensor, 16, 65...Light sensitivity switching switch, 20...Obstacle detection mechanism, 21. Obstacle detection mechanism, 21...Detection distance setting knob, 22...Light emitter, 23...Light

receiver, 61...Eyeglass body, 62...Eyeglass frame, 64...Light sensor, L...Lens, 63...Light sensor, 64...Light sensor, 63...Light sensor, 64...Light sensor, 63...Light sensor, 64...Light sensor, 63...Light sensor sensor, L...lens.

Apple Inc. Exhibit 1015 Page 2555

specification

1. Name of the device

Structure of glasses or helmets, etc. with light-dimming lenses

2. Scope of claims for utility model registration

(1) In helmets or sunglasses, etc. for motorcycles that have an electrode substrate and use an element in the lens section or visor section that causes the color or light transmittance to change by the application of an external voltage, all electronic circuits, including the control circuit of the element, a light sensor that detects external light, a power battery and a power switch, are contained in the body of the glasses or The structure of glasses or helmets, etc. with light-dimming lenses, characterized in that all electronic circuits such as control circuits of elements, light sensors to detect external light, power batteries and power switches are housed in the body of the helmet, etc.

(2) The structure of eyeglasses or helmets, etc. with light-dimming lenses as described in paragraph 1 of the utility model registration claims, characterized in that the electronic circuit is equipped with a light sensitivity switching mechanism that switches or varies the element that causes the color or light transmittance to change upon application of an external voltage to a specific light intensity range or any light intensity range.

(3) The structure of eyeglasses or helmets, etc. with a light-tuning lens as described in paragraphs 1 and 2 of the Utility Model Registration claims, characterized in that the element that causes the color or light transmittance to change upon application of an external voltage is a guest-host type liquid crystal cell.

(4) The structure of eyeglasses or helmets, etc. with a light-tuning lens as described in paragraphs 1 and 2 of the Utility Model Registration claims, characterized in that the element that causes the color or light transmittance to change by the application of an external voltage is a twisted nematic liquid crystal cell.

(5) The structure of eyeglasses or helmets, etc. with light-dimming lenses as described in paragraphs 1 to 4 of the Utility Model Registration Claims, characterized in that the light sensitivity switching mechanism comprises an automatic control mechanism by a microcomputer.

(6) A structure for eyeglasses or helmets, etc. with a light control lens as described in paragraphs 1 to 4 of the Utility Model Registration claims, characterized in that the light sensitivity switching mechanism switches or varies the signal amplification level to adjust the liquid crystal element to a specific light intensity range or any light intensity range.

(7) A structure for eyeglasses or helmets, etc. with light-dimming lenses as described in paragraphs 1 to 4 of the utility model registration claims, characterized in that the light sensitivity switching mechanism switches or varies the output impedance to adjust the liquid crystal element or EC cell to a specific light intensity range or any light intensity range.

(8) The light sensitivity switching mechanism is characterized by a structure in which a filter with a different light transmittance is placed in the light input window of the light sensor, and the filter is switched or varied to adjust the liquid crystal element or EC cell to a specific light intensity range or any light intensity range, as described in paragraphs 1 to 4 of the utility model registration claims. Structure of eyeglasses or helmets, etc. with lenses.

(9) The structure of glasses or helmets, etc. with a light-dimming lens as described in paragraphs 1 to 8 of the Utility Model Registration claims, characterized in that the liquid crystal element is housed between two synthetic resin transparent plates having a columnar or spherical radius of curvature.

(10) In addition to said light-dimming lens, a part of the helmet or glasses is equipped with an obstacle warning device that detects a distance from a forward obstacle by a distance sensor and sounds a buzzer installed in said helmet or glasses via a detection distance switching mechanism that switches or changes the distance to a specific distance or less or to any

detection distance. The structure of eyeglasses or helmets, etc. with light-dimming lenses as described in paragraphs 1 to 8 of the scope of claims for utility model registration, characterized in that
(11) The structure of eyeglasses or helmets, etc. with dimming lenses as described in paragraph 10 of the Utility Model Registration claims, characterized in that the distance sensor is an infrared distance sensor.
(12) The structure of eyeglasses or helmets, etc. with dimming lenses as described in paragraph 10 of the Utility Model Registration claims, characterized in that the distance sensor is an ultrasonic distance sensor.
(13) A structure for eyeglasses or helmets, etc. with a dimming lens as described in paragraphs 1 to 12 of the Utility Model Registration claims, characterized in that the electronic circuit is configured on a flexible blintz board.
(14) The structure of eyeglasses, etc. with dimming lenses as described in paragraphs 1 to 8 of the Utility Model Registration Claims, characterized in that the electronic circuit excluding the power supply battery is located in the bridge portion of the eyeglass frame.
(15) The structure of eyeglasses, etc. with light-dimming lenses as described in paragraphs 1 to 8 of the Utility Model Registration Claims, characterized in that the power supply battery for the electronic circuit is located in the wisdom portion of the eyeglass frame.

3. Detailed description of the idea
(Industrial Applications)
This invention relates to the construction of a helmet for motorcycles, light motorcycles, passenger cars, light airplanes, and various other types of vehicles, and to the construction of glasses or helmets with light-controlling lenses for improving sunglasses, etc. worn during general riding.

(Conventional technology)
Various types of head protection helmets are in use in accordance with the mandatory wearing of helmets when riding motorcycles, and many of them are equipped with a wind visor that doubles as a sun visor in the opening to secure a field of vision. However, helmets with sun visors have the disadvantage that visibility varies depending on the intensity of sunlight, and especially when driving on roads with many tunnel entrances and exits, visibility suddenly drops when entering a tunnel, resulting in a blind state.

The same is true for sunglasses used in general, and it was necessary to change glasses depending on the intensity of outside light.

(Problem to be solved by the device)
Therefore, when wearing the above helmet, on roads with frequent tunnel entries and exits, the driver had to stop and change the sun visor each time when entering or exiting a tunnel, and it was impossible to use the helmet when using the highway because it was not possible to stop on the road.

In particular, in the case of eyeglasses such as sunglasses, the electronic circuit for electrically controlling the liquid crystal and EC material used in the lens section must be equipped in a limited location on the eyeglass frame, which has been extremely difficult to arrange and has not been embodied in practice.

The purpose of this invention is to provide a structure for glasses or helmets with light-controlling lenses that automatically adjusts or switches the translucent lenses of sun visors or

sunglasses installed on helmets according to the external illumination level, and also to provide a structure for glasses or helmets with light-controlling lenses that detect obstacles in front and issue warning signals to warn the wearer of obstacles in front. The purpose is to provide a structure for glasses or helmets with light-dimming lenses with an added function of detecting obstacles in front and issuing a warning signal. In addition, it is intended to provide a technology to place the electronic circuit for electrically controlling the liquid crystal and EC material used in the lens section in a limited location on the eyeglass frame.

(Means to solve the problem)
The structure of the proposed helmet or helmet, etc., with a light-dimming lens is a helmet or sunglasses, etc., for motorcycles, in which an element having an electrode substrate and in which the color or light transmittance is changed by the application of an external voltage is used in the lens part or visor part, wherein the control circuit of the element, light sensor to detect external light, power supply battery and a power switch are housed in the body of the glasses or helmet, etc.

The above electronic circuit is equipped with a light sensitivity switching mechanism that switches or varies the element, which changes color or light transmittance by the application of an external voltage, to a specific light intensity range or to an arbitrary light intensity range, and is used in response to the intensity of ambient light.

The liquid crystal element that causes the color or light transmittance to change upon application of the above external voltage can be composed of a guest host liquid crystal cell or a twisted nematic liquid crystal cell.

The light sensitivity switching mechanism can be an automatic control structure that automatically controls the external voltage applied to the liquid crystal element by a microcomputer, and the light sensitivity switching mechanism can be configured to switch or vary the output impedance, or to place a filter with different light transmittance in the light input window of the optical sensor and switch or vary the filter. The light sensitivity switching mechanism can be configured to switch or vary the output impedance, or to place a filter with a different light transmittance in the light input window of the light sensor and adjust the liquid crystal element or EC cell to a specific light intensity range or an arbitrary light intensity range.

Furthermore, the aforementioned liquid crystal element or EC cell is housed between two synthetic resin transparent plates with a columnar or spherical radius of curvature to eliminate external pressure directly applied to the lens.

The structure of glasses or helmets, etc., with light-dimming lenses is such that, in addition to the above-mentioned light-dimming lenses, a part of the helmet or glasses, etc., is equipped with an obstacle warning device that detects the distance from a forward obstacle by a distance sensor and switches or varies the detection distance to a specific distance or less or any detection distance through a detection distance switching mechanism, which is installed on the helmet or glasses, etc. The pusher can be used as a bell. In the case of glasses, a vibrating body that directly stimulates the wearer's skin can be provided instead of a pusher.

The above distance sensor can be composed of an infrared distance sensor or an ultrasonic distance sensor.

In addition, the structure of glasses or helmets, etc. with light-dimming lenses of the present invention can achieve the purpose by configuring the electronic circuit with a flexi ble printed circuit board and placing the electronic circuit excluding the power supply battery in the bridge part of the eyeglass frame and the power supply battery in the wisdom part of the eyeglass frame. The power supply battery is located in the bridge of the eyeglass frame.

(Action)
The structure of glasses or helmets, etc., with light-dimming lenses in the above configuration can obtain appropriate transmitted light presentation in places where there are differences in the intensity of external light, such as daytime and nighttime use, use inside or outside a tunnel, etc., by means of a light-dimming action that changes light transmission by switching the voltage applied to the liquid crystal cell of the light-dimming visor or lens by the light sensitivity switching mechanism. This allows the user to change the light transmittance without the need to replace the polarizers or lenses.

In addition, the above flat liquid cell is housed in the gap between two transparent synthetic resin plates with a cylindrical or spherical curved surface, which protects the liquid cell from external shocks and ensures sufficient strength against shocks.

Furthermore, the obstacle detection mechanism detects obstacles in front of the helmet with a distance sensor and sounds a buzzer when the distance is less than a preset or adjusted distance, thus acting as a distance warning device.

In addition, the control circuitry can be downsized without changing the appearance of conventional eyeglasses, so the design of eyeglasses can be implemented without compromising the design.

(Example)
The following is an example of the structure of glasses or helmets, etc. with light-dimming lenses of the present invention, which will be described in accordance with the drawings. Figures 1 to 6 show an example of a helmet for motorcycles, and Figures 1 to 3 show its appearance.

The sign 1 is the helmet body which covers the user's head and consists of a visor 2 for securing a field of vision in the front. As shown in the second figure, the visor 2 consists of lenses L, L consisting of flat liquid crystal cells La, La via a liquid crystal cell storage frame 6 between two synthetic resin transparent plates 4, 5 such as plastic resin having a cylindrical or spherical radius of curvature separated by a spacer 3, wherein the liquid crystal cells La are of the In the case of a twisted nematic type, a polarizing film 8 is attached to the back surface of a synthetic resin transparent plate 4. As shown in Figure 4, the liquid crystal cell La consists of glass plates 10 and 10 with transparent electrode films 9 formed on their inner surfaces through insulating spacers 11 and filled with liquid crystal 12 in the minute gaps between the transparent electrode films 9 and 9, respectively, as shown in Guest-host type A, and twisted-nematic type B. The liquid crystal cell La is composed of a helmets. The liquid crystal cell La is driven by a power supply unit 13 such as a battery equipped in the helmet body 1, and an output voltage is applied to both transparent electrode films 9 and 9 from a control means 15 that adjusts the output voltage by inputting a signal from an optical sensor 14 such as a CdS element fixed to the front face of the helmet body 1. The light sensitivity can be switched by the light sensitivity switching switch 16 installed in the main body 1, and the control circuit described below controls the applied voltage to the lense s L and L.

The obstacle detection mechanism 20 is composed of a control circuit including a light emitter 22 made of LED and a light receiver 23 made of PSD fixed on the forehead of the helmet body 1, as shown in the block diagram in Figure 5. . The control drive circuit inputs the output of the bias circuit 24 of the light-receiving element 23, which receives light through the light-receiving lens 24, and the output of the differential amplifier 27, which is driven by the difference in output from the two pulse crawling conversion amplifiers 25 and 26, to a sample and hold circuit 28, and the output of the sample and hold circuit 28 and the detection distance setting knob The output of the sample and hold circuit 28 is compared with the output of the variable resistor 29, the setting of which is changed by the detection distance setting knob 21, by the comparator 30 in the latter stage, and the comparative output drives the buzzer 32 installed inside the helmet body 1 via the buzzer drive circuit 31. The above sample-and-hold circuit 28 is synchronized with the timing generator 33, and the LED drive circuit 34 energizes the above light projector 22, which consists of LEDs, to emit infrared rays toward obstacles located in front of the helmet through the light projection lens 35, and the reflected light of the infrared rays is input to the light receiving element 23. The reflected light of the infrared ray is input to light receiving element 23.

Figure 6 shows a block diagram of the obstacle detection mechanism 20 using an ultrasonic sensor, which consists of a wave transmitter sensor 41 and a receiver sensor 42 fixed to the forehead of the helmet body 1, replacing the light emitter 22 and receiver 23 of the previous example. Sign 43 is the sensitivity adjustment volume of the receiver sensor 42, 44 is the receiver signal shaping circuit, 45 is the distance pulse generation circuit, 46 is the distance coefficient circuit, and the buzzer 50 is driven by comparison with the timing generator 49 via the buzzer drive circuit 47. The timing generator 49 sends a drive signal to the distance pulse generation circuit 52 and the wave sensor drive circuit 48 according to the input value from the distance setting switch 51, which is composed of a digital switch circuit, and the wave sensor drive circuit 48 oscillates a high frequency for distance measurement at a predetermined frequency from the wave sensor 41. The structure is designed to oscillate a high-frequency wave for distance measurement at a predetermined frequency from the wave transmitter sensor 41 by the wave transmitter sensor drive circuit 48.

Figures 7 through 9 show the implementation of this idea in sunglasses.

The main body 61 of the glasses consists of the eyeglass frame 62, the lenses L, L, and the light sensor window 64 and light sensitivity switching switch 65 formed on the eyeglass frame 62. The electronic circuit and power supply battery, which will be described later, are built into a part of the eyeglass frame 62. The lenses L, L use liquid crystal cells, each of which electrically controls the amount of transmitted light.

As shown in Figure 8, the above electronic circuit is configured in the bridge section of the eyeglass frame 62, and is the control electronic circuit described below with CdS cell 67, analog IC 68, power switch 69, chip capacitor 70, and chip resistor 71 mounted on flexible print substrate 66.

The above control electronic circuits can be mounted using conventional techniques such as chip mounter machines and reflow solder machines, which allow for compact microfabrication and high-density mounting that can be accommodated in the bridge section of the above eyeglass frame 62.

Furthermore, because the 66 flexible printed circuit board is a film-like substrate, it is capable of forming electric circuits that follow its shape even in uneven or deformed locations.

The connection between the control electronic circuit and the liquid crystal cell of the lens L, L is made at the connection indicated by the sign 72 via conductive adhesive or the like. The power supply wiring section 73 extending from the flexible printed circuit board 66 is wired from the bridge section of the eyeglass frame 62 to the wisdom section, leading to the electrode section of the power supply battery 74 shown in the 9th figure.

The control circuits for the voltage applied to the lenses L, L of the helmet's light modulating visor for motorcycles shown in the first example above and the sunglasses shown in the second example are described below in Figs. 10 through 16.

The control circuit in Figure 10 shows a basic example of this idea.

This circuit shows an example in which an operational amplifier is used as the analog IC68, and the analog IC68, capacitor C3, CdS cell 67, resistors R3 and R4 constitute a multivibrator circuit. Therefore, in this circuit, the oscillation frequency of the multivibrator is increased when the light level is high, and is decreased when the light level is low. The signal thus obtained is applied to the liquid crystal cell La of lens L, L via resistor R5.

However, since the liquid crystal cell La forms a capacitive load C in terms of electrical characteristics, R5 and CL constitute a low-pass filter as shown in the equivalent circuit in Figure 23. Therefore, the voltage V2 between the two ends of the liquid crystal cell La becomes low at high frequencies, and conversely becomes high at low frequencies. In other words, when the amount of light is high, the voltage applied to the liquid crystal cell La is low and the light transmittance of the lens L is suppressed, and when the amount of light is low, the voltage applied to the liquid crystal cell La is high and the light transmittance of the lens L is increased, thus demonstrating the light-shielding effect of sunglasses in response to external light.

Next, the control circuit equipped with the light sensitivity switching mechanism is described. The power supply connections are omitted from the circuit diagrams in Figures 11 through 16. The connection of the power supply is made as needed depending on the elements used, and the circuit diagrams are examples of the minimum necessary.

Figures 11 and 12 show the circuit diagram of an example in which the optical sensitivity is switched by switching the amplification level. The oscillation frequency of the multivibrator circuit is determined by C1 and R1, and the oscillation frequency f can be obtained by the following equation (a).

$$f = \frac{1}{2 \cdot C1 \cdot R1} \quad (Hz) \quad \cdots (1)$$

The Al used in this multivibrator circuit can be an operational amplifier IC, comparator IC, or a circuit combining discrete components.

In Figure 11, the signal obtained in the multivibrator circuit described above is supplied to amplifier A2 via optical sensor Rcds. The amplifier A2 has a combination of feedback resistors Rfl and Rfd, and a switch 16(65) to switch between them.

Since the amplification G of amplifier A2 is obtained by the following equation (mouth), it is possible to change the amplification G by switching the switch 16 (65).

$$\text{増幅度 } G = -\frac{Rfl \text{ または } Rfd}{Rcds} \quad \cdots (口)$$

The signal amplified by amplifier A2 is supplied to lenses L and L. The lenses L, L consist of a liquid crystal cell La sandwiched between polarizing plates Lb and Lb'. A twisted nematic liquid crystal cell is used for the liquid crystal cell La, and the polarizing plates Lb and Lb' are placed in an orthogonal niche with their polarization axes orthogonal to each other. When the twisted nematic liquid crystal cell is placed between the orthogonal-nicole polarizing plates, as shown in Figure 19, the optical transmittance decreases when a high-voltage signal is applied, while the optical transmittance increases when a low-voltage signal is applied.

In this example, a CdS cell is used for the light sensor Rcds, and the characteristics of the CdS cell with respect to light are shown in Figure 17, where the resistance value is low when the light level is high and high when the light level is low.

Therefore, as can be seen in equation (mouth), when the light sensor Rcds receives light, the resistance value becomes small, the amplification of amplifier A2 increases, a high voltage signal is applied to lenses L and L, and the light transmittance of lenses L and L decreases. When the amount of light received by the light sensor Rcds is low, the resistance value increases, the amplification of amplifier A2 decreases, a low voltage signal is applied to lenses L and L, and the light transmittance of lenses L and L increases. The circuit that operates in this way has two feedback resistors, Rfl and Rfd, and by switching these resistors, the light sensitivity can be switched.

The relationship between the resistance values of Rfl and Rfd is Rfl<Rfd, and the Rfl side is used during the day when external light intensity is high, and the Rfd side is used at night (or when external light intensity is low). In other words, when the light level is high, the light sensor Rcds operates in the low resistance range, so the resistance value of the feedback resistor Rfl should be set to a low resistance value that matches the change in Rcds. The characteristics of the output voltage of A2 will be as shown in Figure 18. Therefore, the light intensity and lens light transmittance characteristics will be as shown in the 20th figure. In the 20th figure, the characteristic curve of D shows an example of the characteristics when Rfd is connected, and the characteristic curve of L shows an example of the characteristics when Rfl is connected.

In this example, two feedback resistors are used, but more than two may be used depending on the application. In this case, the number of contacts of the changeover switch 16(65) should be the same number of steps as the number of feedback resistors. The 16(65) can be toggle switches, rotary switches, slide switches, or the like, as long as they are capable of switching the circuit.

When the light sensitivity is variable without steps, a variable resistor can be used as a feedback resistor instead of Rfl and Rfd. In this case, the switching switch 16(65) becomes unnecessary, and the light intensity can be set to any desired range.

Figure 9 shows a circuit diagram of an example in which an optical sensor Rcds is used as the feedback resistor of amplifier A2, and the output voltage of amplifier A2 with respect to the light level can be changed to change the light sensitivity by switching the input resistors Rs1 and Rsd.

This example shows a case in which polarizing plates Lb and Lb' with parallel-nickel polarization axes are used for lenses L and L, and a liquid crystal cell La (twisted nematic liquid crystal cell) is placed between them. In this example, in addition to the twisted nematic liquid crystal, a liquid crystal cell using a guest host liquid crystal, which is a mixture of a liquid crystal with positive dielectric anisotropy and a dye that absorbs light in the long axis direction of the dye molecules, may be used for the lenses L, L. In the case of a liquid crystal cell using guest host liquid crystal, polarizing plates Lb and Lb' may not be used at all, or either one of the polarizing plates Lb and Lb' may be used.

The applied voltage and light transmittance characteristics of lenses L and L are shown in Figure 22. When Rsd and Rsl are used as input resistors as in this example, the amplification G of amplifier A2 can be obtained by the following equation (c), and the characteristics of light sensor Rcds with respect to light intensity are as shown in Figure 17, and the characteristics of light sensor Rcds and output voltage of amplifier A2 are shown in Figure 21.

$$\text{増幅度 } G = -\frac{Rcds}{Rsd} \quad \text{又は} \quad G = -\frac{Rcds}{Rsl} \quad \cdots (ハ)$$

Therefore, by switching the input resistors Rsd and Rsl with switch 16(65), the output voltage of amplifier A2 with respect to the light intensity can be changed to change the light sensitivity. The light intensity and lens light transmittance characteristics at this time are shown in Figure 20. In Figure 20, the characteristic curve in D shows an example when Rsd is connected to the input resistor, and the characteristic curve in L shows an example when Rsl is connected.

In this example, two input resistors are used, but more than two may be used depending on the application. In this case, the number of contacts of the changeover switch 16(65) should be the same as the number of input resistors. In this case, the number of contacts of the changeover switch 16(65) should be the same number of steps as the number of input resistors.

When the light sensitivity is to be varied steplessly instead of stepwise, a variable resistor can be used as an input resistor instead of Rsl and Rsd. In this case, the changeover switch 16(65) becomes unnecessary, and the light sensitivity can be set to any light intensity range.

Figure 13 shows a circuit diagram of an example of switching optical sensitivity by changing the output impedance. A3, C2, R2, R3, and Rcds constitute a multivibrator circuit. The oscillation frequency f of this multivibrator circuit can be obtained by the following equation (d).

$$f = \frac{1}{2 \cdot C2 \cdot Rcds} \quad (Hz) \quad \cdots (二)$$

Therefore, since the resistance value of the optical sensor Rcds varies with the amount of light as shown in Figure 17, the oscillation frequency f varies with the change in the resistance value of the optical sensor Rcds.

Since the liquid crystal cell exhibits capacitive electrical characteristics, a low-pass circuit can be configured by connecting Rol or Rod in the circuit configuration shown in the 13th figure. Therefore, if the capacitance value of the liquid crystal cell is C, the equivalent circuit is as shown in the 23rd figure, and the voltage V2 applied to the liquid crystal cell can be obtained by the following formula (e). In the 23rd figure, V1 is the output voltage of the multivibrator circuit, V2 is the voltage applied to the liquid crystal cell, R represents Rol or Rod, and C represents the combined capacitance value of the liquid crystal cells of lenses L and L.

$$V2 = \frac{V1}{1 + j\omega CR} \quad \cdots (ホ)$$

ただし、$\omega = 2\pi f$

As shown in equation (e), V2 becomes a low voltage when the frequency is high and a high voltage when the frequency is low, and its frequency characteristic will show a characteristic of 1 6 dB/octave when the cutoff frequency fC or higher as shown in Figure 24. The cutoff frequency fC can be obtained by the following equation (He).

$$fc = \frac{1}{2\pi CR} \quad (Hz) \quad \cdots (ヘ)$$

Therefore, by changing R in equation (he) to Rol or Rod, the cutoff frequency fC can be changed, and the sensitivity to light intensity can be switched.

For the lenses L and L shown in this example, a twisted nematic liquid crystal cell with polarizers Lb and Lb' in parallel niche or a liquid crystal cell with guest host liquid crystal using either polarizers Lb and Lb' or no polarizer at all can be used. In this case, the light intensity and lens transmittance characteristics are as shown in Figure 20. In Figure 20, the characteristic curve in D shows an example when Rod is connected, and the characteristic curve in L shows an example when Rol is connected.

In this example, two output impedances, Rol and Rod, are used, but more than two may be used depending on the application. In this case, the number of contacts of the changeover switch 16(65) should be the number of steps appropriate for the number of output impedances. The changeover switch 16(65) can be a toggle switch, rotary switch, slide switch, or the like, as long as it is capable of switching the circuit.

When the light sensitivity is to be varied steplessly instead of stepwise, a variable resistor can be used as the output impedance instead of Rod and Rol. In this case, the changeover switch 16(65) is not needed, and the light sensitivity can be set to any light intensity range.

Figures 14 through 16 show the circuit diagram of an example in which a filter with different light transmittance is placed in the light receiving window of the light sensor, and the light sensitivity is switched by switching the filter. The filter fl has a side L with low light transmittance and a side D with high light transmittance, which is switched. That is, when the external light level is high, the filter is set to the L side, and the external light level is reduced by this filter and is applied to the light sensor Rcds. Also . When the external light level is low, it is set to the D side. If the difference in light transmittance between the L and D sides of the filter is set to the difference in light intensity between day and night, for example, the filter can be set to the L side, which reduces light intensity during the day, and to the D side, which does not reduce light intensity during the night, to provide the same light control effect for both day and night with a difference in light intensity.

Two or more filters with different light transmittance in Figures 14 through 16 may be used, in which case the light sensitivity can be set as many times as the number of filters. If filters with continuously varying light transmittance are used, the light sensitivity can be set steplessly instead of step by step. Furthermore, the shape of the fill evening f1 can be a rectangular plate or a disk, and the light sensitivity can be switched (or made variable) by sliding or rotating them.

For the lenses L, L in the example shown in Figure 14, a twisted nematic liquid crystal cell La sandwiched between polarizing plates Lb, Lb' with their polarization axes in parallel niche, or a liquid crystal cell La using a guest host liquid crystal mixed with a liquid crystal with positive dielectric anisotropy and a dye that absorbs light in the long axis direction of dye molecules, etc. can be used. In the case of liquid crystal cells using guest host liquid crystals, polarizing plates Lb and Lb' may not be used at all, or either one of the polarizing plates Lb and Lb' may be used.

In the above examples, the case in which nematic liquid crystal cells are used for the lenses L and L is described, but liquid crystal cells using cholesteric liquid crystal, smetic liquid crystal, ferroelectric liquid crystal, etc. may also be used for the lenses L and L.

(Effects of the device)
As described above, the structure of glasses or helmets, etc., with a light-transmitting lens of this invention can obtain the appropriate maximum transmitted light in places where there is a difference in the intensity of external light, such as use during the daytime and nighttime or use inside or outside a tunnel, by changing the degree of light transmission, so not only is it unnecessary to replace a visor or glasses, it is also possible to adjust the light transmission level of the lens to the desired level. In addition, the obstacle detection mechanism detect s obstacles in front of the helmet with a distance sensor and sounds a buzzer when the distance is less than a preset or adjusted distance, thus acting as a distance warning device.

In addition, since the above flat liquid crystal cell is housed in the gap between two synthetic resin transparent plates having a cylindrical or spherical curved surface, the lens can be protected from external impact force and a helmet with sufficient strength against impact can be constructed. In particular, when the helmet is used for eyeglasses, it can be implemented with almost no change in appearance from conventional eyeglasses, so the design of the eyeglasses can be implemented without losing any of its design.

4. brief description of the drawing

Figure 1 shows a diagram of a helmet with a dimming lens, Figure 2 shows a cross-sectional view of the II-II line in Figure 1, Figure 3 shows the structure and control structure of the liquid crystal cell, Figure 4 shows a cross-sectional view of the IV-IV line in Figure 1, Figure 5 and Figure 6 show examples of the obstacle warning mechanism, respectively. Fig. 4 shows the IV-IV cross section of Fig. 1; Fig. 5 and 6 show an example of the obstacle warning mechanism; Fig. 7 is a diagram of the sunglasses showing another example of this idea; Fig. 8 is an enlarged view of the electronic circuit housing; Fig. 9 is an enlarged view of the power battery housing; Fig. 10 is a circuit diagram showing a basic example of the control circuit of this idea; Fig. 11 to 16 show an example of the light sensitivity switching mechanism, respectively; Fig. 17 and 18 are circuit diagrams showing an example of the light sensitivity switching mechanism. The 17th figure is a graph showing an example of light intensity vs. resistance characteristics of a CdS cell, the 18th figure is a graph showing an example of resistance vs. output voltage characteristics of a CdS cell when an optical sensor is used as input resistance, the 19th figure is a graph showing an example of applied voltage vs. light transmission characteristics when a twisted nematic liquid crystal cell is placed between orthogonal niches Figure 20 shows an example of external light level - light transmittance characteristics; Figure 21 shows an example of resistance value - output voltage characteristics of a CdS cell when an optical sensor is used as a feedback resistor; and Figure 22 shows an example of applied voltage - light transmittance characteristics when a twisted nematic liquid crystal cell is placed between parallel niches, Figure 23 is an equivalent circuit of output resistance and liquid crystal cell, and Figure 24 is a graph showing an example of frequency-voltage characteristics of a low-pass circuit.

1...Helmet body, 2...Visor, 4, 5...Transparent synthetic resin plate, 1 4...Light sensor, 16, 65...Light sensitivity switching switch, 20...Obstacle detection mechanism, 21. Obstacle detection mechanism, 21...Detection distance setting knob, 22...Light emitter, 23...Light receiver, 61...Eyeglass body, 62...Eyeglass frame, 64...Light sensor, L...Lens, 63...Light sensor, 64...Light sensor, 63...Light sensor, 64...Light sensor, 63...Light sensor, 64...Light sensor, 63...Light sensor sensor, L...lens.

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(54) Title: APPARATUS AND METHOD FOR MEASURING BIOLOGIC PARAMETERS

(57) Abstract: Support structures for positioning sensors on a physiologic tunnel for measuring physical, chemical and biological parameters of the body and to produce an action according to the measured value of the parameters. The support structure includes a sensor fitted on the support structures using a special geometry for acquiring continuous and undisturbed data on the physiology of the body. Signals are transmitted to a remote station by wireless transmission such as by electromagnetic waves, radio waves, infrared, sound and the like or by being reported locally by audio or visual transmission. The physical and chemical parameters include brain function, metabolic function, hydrodynamic function, hydration status, levels of chemical compounds in the blood, and the like. The support structure includes patches, clips, eyeglasses, head mounted gear and the like, containing passive or active sensors positioned at the end of the tunnel with sensing systems positioned on and accessing a physiologic tunnel.

Apparatus and Method for Measuring Biologic Parameters

FIELD OF THE INVENTION

The present invention includes support and sensing structures positioned in a physiologic tunnel for measuring bodily functions and to manage abnormal conditions indicated by the measurements.

BACKGROUND OF THE INVENTION

Interfering constituents and variables can introduce significant source of errors that prevent measured biologic parameters from being of clinical value. In order to bypass said interfering constituents and achieve undisturbed signals invasive and semi-invasive techniques have been used. Such techniques have many drawbacks including difficulties in providing continuous monitoring for long periods of time. Non-invasive techniques also failed to deliver the clinical usefulness needed. The placement of a sensor on the skin characterized by the presence of interfering constituents do not allow obtaining clinically useful nor accurate signals due to the presence of said interfering constituents and background noise which greatly exceeds the signal related to the physiologic parameter being measured.

The most precise, accurate, and clinically useful way of evaluating thermal status of the body in humans and animals is by measuring brain temperature. Brain temperature measurement is the key and universal indicator of both disease and health equally, and is the only vital sign that cannot be artificially changed by emotional states. The other vital signs (heart rate, blood pressure, and respiratory rate) all can be

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influenced and artificially changed by emotional states or voluntary effort.

Body temperature is determined by the temperature of blood, which emits heat as far-infrared radiation. Adipose tissue (fat tissue) absorbs far-infrared and the body is virtually completely protected with a layer of adipose tissue adherent to the skin. Thus measurement of temperature using the skin does not achieve precision nor accuracy because previous techniques using sensors placed on skin included by the presence of adipose tissue.

Because it appeared to be impossible with current technology to non-invasively measure brain temperature, attempts were made to determine internal body temperature, also referred to as core temperature. An invasive, artificial, inconvenient, and costly process is currently used to measure internal (core) temperature consisting of inserting a catheter with a temperature sensor in the urinary canal, rectum or esophagus. But such methodology is not suitable for routine measurement, it is painful, and has potential fatal complications.

Semi-invasive techniques have also being tried. Abreu disclosed in U.S. Patent No. 6,120,460 apparatus and methods for measuring core temperature continuously using a contact lens in the eyelid pocket, but the contact lens is a semi-invasive device which requires prescription by a physician and sometimes it is not easy to place the contact lens in the eye of an infant or even in adults and many people are afraid of touching their eyes.

There are several drawbacks and limitations in the prior art for continuous and/or core measurement of temperature.

Measurement of temperature today is non-continuous, non-core and nurse dependent. Nurses have to stick a

thermometer in the patient's mouth, rectum or ear. To get core temperature nurses invasively place a tube inside the body which can cause infection and costly complications.

Measurement of core temperature on a routine basis in the hospital and/or continuously is very difficult and risky because it requires an invasive procedure with insertion of tubes inside the body or by ingesting a thermometer pill. The thermometer pill can cause diarrhea, measure temperature of the fluid/food ingested and not body temperature, and have fatal complications if the pill obstructs the pancreas or liver ducts. Placement of sensors on the skin do not provide clinically useful measurements because of the presence of many interfering constituents including fat tissue.

It is not possible to acquire precise and clinically useful measurements of not only brain temperature, but also metabolic parameters, physical parameters, chemical parameters, and the like by simply placing a sensor on the skin. One key element is the presence of fat tissue. Fat varies from person to person, fat varies with aging, fat content varies from time to time in the same person, fat attenuates a signal coming from a blood vessel, fat absorbs heat, fat prevents delivery of undisturbed far-infrared radiation, fat increases the distance traveled by the element being measured inside the body and an external sensor placed on the surface of the skin.

There is a need to identify a method and apparatus that can non-invasively, conveniently and continuously monitor brain temperature in a painless, simple, external and safe manner with sensors placed on the skin.

There is further a need to identify a method and apparatus that can conveniently, non-invasively, safely and precisely monitor biological parameters including

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metabolic parameters, physical parameters, chemical parameters, and the like.

There is a need to identify an apparatus and method capable of measuring biological parameters by positioning a sensor on a physiologic tunnel for the acquisition of undisturbed and continuous biological signals.

SUMMARY OF THE INVENTION

The present invention provides methods, apparatus and systems that effectively address the needs of the prior art.

In general, the invention provides a set of sensing systems and reporting means which may be used individually or in combination, which are designed to access a physiologic tunnel to measure biological, physical and chemical parameters. Anatomically and physiologically speaking, the tunnel discovered by the present invention is an anatomic path which conveys undisturbed physiologic signals to the exterior. The tunnel consists of a direct and undisturbed connection between the source of the function (signal) within the body and an external point at the end of the tunnel located on the skin. A physiologic tunnel conveys continuous and integral data on the physiology of the body. An undisturbed signal from within the body is delivered to an external point at the end of the tunnel. A sensor placed on the skin at the end of the tunnel allows optimal signal acquisition without interfering constituents and sources of error.

Included in the present invention are support structures for positioning a sensor on the skin at the end of the tunnel. The present invention discloses devices directed at measuring brain temperature, brain function, metabolic function, hydrodynamic function,

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hydration status, hemodynamic function, body chemistry and the like. The components include devices and methods for evaluating biological parameters using patches, clips, eyeglasses, head mounted gear and the like with sensing systems adapted to access physiologic tunnels to provide precise and clinically useful information about the physiologic status of the wearer and for enhancing the safety and performance of said wearer, and helping to enhance and preserve the life of said wearer by providing adequate reporting means and alert means relating to the biological parameter being monitored. Other components provide for producing direct or indirect actions, acting on another device, or adjusting another device or article of manufacture based on the biological parameter measured.

The search for a better way to measure biological parameters has resulted in long and careful research, which included the discovery of a Brain Temperature Tunnel (BTT) and other physiologic tunnels in humans and animals. The present invention was the first to recognize the physiologic tunnel in the body. The present invention was yet the first to recognize the end of the tunnel on the skin surface in which an optimal signal is acquired and measurements can be done without the presence of interfering constituents and background noise that exceeds the signal being measured. The present invention was also the first to recognize and precisely map the special geometry and location of the tunnel including the main entry point. The present invention was yet first to recognize the precise positioning of sensing systems at the main entry point for optimal signal acquisition. Careful studies have been undertaken including software development for characterizing infrared radiation to precisely determine the different aspects of the tunnel.

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This research has determined that the measurement of brain (core) temperature and other body parameters can be accomplished in a non-invasive and continuous manner in humans and animals with sensors positioned in a confined area of the skin at the end of a physiologic tunnel.

The key function and critical factor for life preservation and human performance is brain temperature. Brain tissue is the tissue in the body most susceptible to thermal damage, by both high and low temperature. Brain temperature is the most clinically relevant parameter to determine the thermal status of the body and the human brain is responsible for 18 to 20% of the heat produced in the body, which is an extraordinary fact considering that the brain represents only 2% of the body weight. The great amount of thermal energy generated in the brain is kept in a confined space and the scalp, skull, fat and CSF (cerebral spinal fluid) form an insulating layer. The recognition of the BTT by the present invention bypasses the insulating barriers and provides a direct connection to inside the brain physiology and physics.

Anatomically and physiologically speaking, a Brain Temperature Tunnel consists of a continuous, direct, and undisturbed connection between the heat source within the brain and an external point at the end of the tunnel. The physical and physiological events at one end of the tunnel inside the brain are reproduced at the opposite end on the skin. A BTT enables the integral and direct heat transfer through the tunnel without interference by heat absorbing elements, i.e., elements that can absorb far-infrared radiation transmitted as heat by blood within the brain. There are six characteristics needed to define a BTT. These characteristics are:

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1) area without heat absorbing elements, i.e., the area must not contain adipose tissue (fat tissue). This is a key and needed characteristic for defining a temperature tunnel,

2) area must have a terminal branch of a vessel in order to deliver the integral amount of heat,

3) terminal branch has to be a direct branch of a blood vessel from the brain,

4) terminal branch has to be superficially located to avoid heat absorption by deep structures such as muscles,

5) area must have a thin and negligible interface between a sensor and the source of thermal energy to achieve high heat flow, and

6) area must not have thermoregulatory arteriovenous shunts.

All six characteristics are present on the skin on the medial canthal area adjacent to the medial corner of the eye above the medial canthal tendon and in the medial third of the upper eyelid. In more detail the end of BTT area on the skin measures about 11 mm in diameter measured from the medial corner of the eye at the medial canthal tendon and extend superiorly for about 6 mm and then extends into the upper eyelid in a horn like projection for another 22 mm.

The BTT area is the only area in the body without adipose tissue, which is in addition supplied by a terminal branch, which has a superficial blood vessel coming from the brain vasculature, and which has a thin interface and no thermoregulatory shunts. The BTT area is supplied by a terminal branch of the superior ophthalmic vein which is a direct connection to the cavernous sinus, said cavernous sinus being an endothelium-lined system of

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venous channels inside the brain which collects and stores thermal energy. The blood vessel supplying the BTT area is void of thermoregulatory arteriovenous shunts and it ends on the skin adjacent to the medial corner of the eye and in the superior aspect of the medial canthal area right at the beginning of the upper eyelid. The blood vessels deliver undisturbed heat to the skin on the medial canthal area and upper eyelid as can be seen in the color as well as black and white photos of infrared images shown in FIGS. 1 and 2. The undisturbed thermal radiation from the brain is delivered to the surface of the skin at the end of the tunnel. The heat is delivered to an area of skin without fat located at the end of the tunnel. The blood vessel delivering heat is located just below the skin and thus there is no absorption of infrared radiation by deep structures.

If the blood vessel is located deep, other tissues and chemical substances would absorb the heat, and that can invalidate the clinical usefulness of the measurement. There is direct heat transfer and the skin in the BTT area is the thinnest skin in the body and is void of thermoregulatory arteriovenous shunts. A very important aspect for optimal measurement of temperature is no interference by fat tissue and direct heat transfer.

The absence of fat tissue in this particular and unique area in the body at the end of the tunnel allows the undisturbed acquisition of the signal. The combination of those six elements allows the undisturbed and integral emission of infrared radiation from the brain in the form of direct heat transfer at the BTT area location, which can be seen in the infrared image photographs (FIGS. 1 to 8). The BTT and physiologic

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tunnels are also referred in this description as the "Target Area".

From a physical standpoint, the BTT is the equivalent of a Brain Thermal Energy tunnel with high total radiant power and high heat flow. The temperature of the brain is determined by the balance between thermal energy produced due to metabolic rate plus the thermal energy delivered by the arterial supply to the brain minus the heat that is removed by cerebral blood flow. Convection of heat between tissue and capillaries is high and the temperature of the cerebral venous blood is in equilibrium with cerebral tissue. Accordingly, parenchymal temperature and thermal energy of the brain can be evaluated by measuring the temperature and thermal energy of the cerebral venous blood. The superior ophthalmic vein has a direct and undisturbed connection to the cavernous sinus and carries cerebral venous blood with a thermal energy capacity of 3.6 $J.ml^{-1}.(°C)^{-1}$ at hematocrit of 45%. Cerebral thermodynamic response, thermal energy, and brain temperature can be evaluated by placing a sensor to capture thermal energy conveyed by the cerebral venous blood at the end of the BTT.

The research concerning BTT and physiologic tunnels involved various activities and studies including: 1) In-vitro histologic analysis of mucosal and superficial body areas; 2) In-vivo studies with temperature evaluation of external areas in humans and animals; 3) In-vivo functional angiographic evaluation of heat source; 4) Morphologic studies of the histomorphometric features of the BTT area; 5) In-vivo evaluation of temperature in the BTT area using: thermocouples, thermistors, and far-infrared; 6) Comparison of the BTT area measurements with the internal eye anatomy and current standard most used (oral) for temperature measurement; 7) Cold and heat

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challenge to determine temperature stability of BTT; and 8) Infrared imaging and isotherm determination. Software for evaluating geometry of tunnel was also developed and used. Simultaneous measurement of a reference temperature and temperature in the BTT area were done using pre-equally calibrated thermistors. A specific circuit with multiple channels was designed for the experiments and data collection.

The measurement of temperature in the BTT area showed almost identical temperature signal between the BTT area and the internal conjunctival anatomy of the eye, which is a continuation of the central nervous system. Measurement of the temperature in the internal conjunctival anatomy of eye as used in the experiment was described by Abreu in U.S. Patents No. 6,120,460 and 6,312,393. The averaged temperature levels for BTT and internal eye were within 0.1 °C (0.18 °F) with an average normothermia value equivalent of 37.1°C (98.8 °F) for the BTT and 37°C (98.6 °F) for the internal eye. Comparison with the standard most used, oral temperature, was also performed. The temperature voltage signal of the BTT area showed an average higher temperature level in the BTT area of an equivalent of 0.3 °C (0.5 °F) when compared to oral.

Subjects underwent cold challenge and heat challenge through exercising and heat room. The lowering and rising of temperature in the BTT area was proportional to the lowering and rising in the oral cavity. However, the rate of temperature change was faster in the BTT area than for oral by about 1.2 minutes, and temperature at the BTT site was 0.5 °C (0.9 °F) higher on few occasions. Subjects of different race, gender, and age were evaluated to determine the precise location of the BTT area across a different population and identify any

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anatomic variation. The location of the BTT was present at the same location in all subjects with no significant anatomic variation, which can be seen in a sample of infrared imaging of different subjects.

The tunnel is located in a crowded anatomic area and thus the positioning of the sensor requires special geometry for optimal alignment with the end of the tunnel. The clinical usefulness of the tunnel can only be achieved with the special positioning of the sensor in relation to anatomic landmarks and the support structure. The tunnel is located in a unique position with distinctive anatomic landmarks that help define the external geometry and location of the end of the tunnel. The main entry point of the tunnel, which is the preferred location for positioning the sensor, requires the sensor to be preferably placed in the outer edge of a support structure. The preferred embodiment for the measurement of biological parameters by accessing a physiologic tunnel includes sensors positioned in a particular geometric position on the support structure.

The support structure includes patches containing sensors. For the purpose of the description any structure containing an adhesive as means to secure said structure to the skin at the end of the tunnel is referred to as a patch including strips with adhesive surfaces such as a "BAND-AID" adhesive bandage. It is understood that a variety of attachment means can be used including adhesives, designs incorporating spring tension pressure attachment, and designs based on other attachment methods such as elastic, rubber, jelly-pads and the like.

The patches are adapted to position sensors at the end of the tunnel for optimal acquisition of the signal. The patch is preferably secured to the area by having an adhesive backing which lays against the skin, although a

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combination of adhesive and other means for creating a stable apposition of the sensor to the tunnel can be used such as fastening or pressure.

Support structures also include clips or structures that are positioned at the end of the tunnel with or without adhesive and which are secured to the area by pressure means. Any structure that uses pressure means to secure said structure to the skin at the end of the tunnel is referred as a clip.

Head-mounted structures are structures mounted on the head or neck for positioning sensors on the end of the tunnel and include head bands with accessories that are adjacent to the tunnel, visors, helmets, headphone, structures wrapping around the ear and the like. For the purpose of this description TempAlert is referred herein as a system that measures temperature in the BTT area and has means to report the measured value and that can incorporate alarm means that are activated when certain levels are reached. Support structures yet include any article that has sensing means in which said sensing means are positioned at the end of the tunnel.

Support structures further include medial canthal pieces of eyeglasses. A medial canthal piece is also referred to herein as a medial canthal pad and includes a pad or a piece which positions sensing means on the skin at the medial canthal area on top of a tunnel, with said medial canthal piece being permanently attached to or mounted to an eyeglass. Any sensing means incorporated in an eyeglass (fixed or removable) for accessing a tunnel are referred to herein as EyEXT including means for sensing physical and chemical parameters. Any article of manufacture that has visual function, or ocular protection, or face protection with a part in contact with the tunnel is referred herein as eyeglasses and

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includes conventional eyeglasses, prescription eyeglasses, reading glasses, sunglasses, goggles of any type, masks (including gas masks, surgical masks, cloth masks, diving masks, eyemask for sleeping and the like) safety glasses, and the like.

For brain temperature evaluation the tunnel area consists of the medial canthal area and the superior aspect of the medial corner of the eye. For brain function evaluation the tunnel area consists of primarily the upper eyelid area. For metabolic function evaluation the tunnel area consists of an area adjacent to the medial corner of the eye and both the upper and lower eyelids.

The measurement of metabolic function, brain function, immunogenic function, physical parameters, physico-chemical parameters and the like includes a variety of support structures with sensors accessing the physiologic tunnels. The sensors are placed in apposition to the skin immediately adjacent to the medial corner of the eye preferably in the superior aspect of the medial canthal area. The sensor can also be positioned in the medial third of the upper eyelid. The sensor is most preferably located at the main entry point of the tunnel which is located on the skin 2.5 mm medial to the corner of the eye and about 3 mm above the medial corner of the eye. The diameter of the main entry point is about 6 to 7 mm. The positioning of the sensor at the main entry point of the tunnel provides the optimum site for measuring physical and chemical parameters of the body.

Besides a sensor that makes contact with the skin at the Target Area, it is understood that sensors which do not make contact with the skin can be equally used. For instance an infrared-based temperature measuring system can be used. The measurement is based on the Stefan-

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Boltzman law of physics in which the total radiation is proportional to the fourth power of the absolute temperature, and the Wien Displacement law in which the product of the peak wavelength and the temperature are constant. The field of view of the non-contact infrared apparatus of the invention is adapted to match the size and geometry of the BTT area on the skin.

A variety of lenses known in the art can be used for achieving the field of view needed for the application. For example, but not by way of limitation, a thermopile can be adapted and positioned in a manner to have a field of view aimed at the main entry point of the BTT area on the skin. The signal is then amplified, converted into a voltage output and digitized by a MCU (microcontroller).

This infrared-based system can be integrated into a support structure that is in contact with the body such as any of the support structures of the present invention. In addition, it is understood that the infrared-based system of the present invention can be integrated as a portable or hand-held unit completely disconnected from the body. The apparatus of the present invention can be held by an operator that aims said apparatus at the BTT area to perform the measurement. The apparatus further includes an extension shaped to be comfortably positioned at the BTT site for measuring biological parameters without discomfort to the subject. The extension in contact with the skin at the BTT is shaped in accordance with the anatomic landmarks and the geometry and size of the BTT site. The infrared radiation sensor is positioned in the extension in contact with the skin for receiving radiation emitted from the BTT site.

The present invention provides a method for measuring biological parameters including the steps of positioning sensing means on the skin area at the end of

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a tunnel, producing a signal corresponding to the biological parameter measured and reporting the value of the parameter measured.

It is also include a method to measure biological parameters by non-contact infrared thermometry comprising the steps of positioning an infrared detector at the BTT site with a field of view that encompasses the BTT site and producing a signal corresponding to the measured infrared radiation. The biological parameters include temperature, blood chemistry, metabolic function and the like.

Temperature and ability to do chemical analysis of blood components is proportional to blood perfusion. The present invention recognizes that the tunnel area, herein also referred as a Target Area, has the highest superficial blood perfusion in the head and has a direct communication with the brain, and that the blood vessels are direct branches of the cerebral vasculature and void of thermoregulatory arteriovenous shunts. It was also recognized that the Target Area has the highest temperature in the surface of the body as can be seen in the photographs of experiments measuring infrared emission from the body and the eye.

The Target Area discovered not only has the thinnest and most homogeneous skin in the whole body but is the only skin area without a fat layer. Since fat absorbs significant amounts of radiation, there is a significant reduction of signal. Furthermore other skin areas only provide imprecise and inaccurate signals because of the large variation of adipose tissue from person to person and also great variability of fat tissue according to age. This interference by a fat layer does not occur in the Target Area. Furthermore, the combined characteristics of the Target Area, contrary to the skin

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in the rest of the body, enable the acquisition of accurate signals and a good signal to noise ratio which far exceeds background noise. In addition, body temperature such as is found in the surface of the skin in other parts of the body is variable according to the environment.

Another important discovery of the present invention was the demonstration that the Target Area is not affected by changes in the environment (experiments included cold and heat challenge). The Target Area provides an optimum location for temperature measurement which has a stable temperature and which is resistant to ambient conditions. The Target Area discovered has a direct connection to the brain, is not affected by the environment and provides a natural, complete thermal seal and stable core temperature. The apparatus and methods of the present invention achieve precision and clinical usefulness needed with the non-invasive placement of a temperature sensor on the skin in direct contact with the heat source from the brain without the interference of heat absorbing elements.

The Target Area is extremely vascularized and is the only skin area in which a direct branch of the cerebral vasculature is superficially located and covered by a thin skin without a fat layer. The main trunk of the terminal branch of the ophthalmic vein is located right at the BTT area and just above the medial canthal tendon supplied by the medial palpebral artery and medial orbital vein. The BTT area on the skin supplied by a terminal and superficial blood vessel ending in a particular area without fat and void of thermoregulatory arteriovenous shunts provides a superficial source of undisturbed biological signals including brain

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temperature, metabolic function, physical signals, and body chemistry such as glucose level, and the like.

Infrared spectroscopy is a technique based on the absorption of infrared radiation by substances with the identification of said substances according to its unique molecular oscillatory pattern depicted as specific resonance absorption peaks in the infrared region of the electromagnetic spectrum. Each chemical substance absorbs infrared radiation in a unique manner and has its own unique absorption spectra depending on its atomic and molecular arrangement and vibrational and rotational oscillatory pattern. This unique absorption spectra allows each chemical substance to basically have its own infrared spectrum, also referred to as fingerprint or signature which can be used to identify each of such substances. Radiation containing various infrared wavelengths is emitted at the substance to be measured and the amount of absorption of radiation is dependent upon the concentration of said chemical substance being measured according to Beer-Lambert's Law.

Interfering constituents and variables such as fat, bone, muscle, ligaments and cartilage introduce significant source of errors which are particularly critical since the background noise greatly exceeds the signal of the substance of interest. Since those interfering constituents area not present on the skin at the BTT area, the sensing systems positioned at said BTT are can acquire optimal signal with minimal noise including spectroscopic-based measurements.

Spectroscopic means integrated into support structures disclosed in the present invention can precisely non-invasively measure blood components since the main sources of variation and error, such as fat tissue, are not present in the Target Area. In addition,

other key constituents which interfere with electromagnetic energy emission such as muscle, cartilage and bones, are not present in the Target Area either. The blood vessels delivering the infrared radiation are superficially located and the infrared radiation is delivered at the end of the tunnel without interacting with other structures. The only structure to be traversed by the infrared radiation is a very thin skin, which does not absorb the infrared wavelength. The present invention includes infrared spectroscopy means to provide a clinically useful measurement with the precise and accurate determination of the concentration of the blood components at the end of the tunnel.

In addition to spectroscopy in which electromagnetic energy is delivered to the Target Area, the present invention also discloses apparatus and methods for measuring substances of interest through far infrared thermal emission from the Target Area. Yet, besides near-infrared spectroscopy and thermal emission, other means are disclosed for measurement of substances of interest at the Target Area including electroosmosis as a flux enhancement by iontophoresis or reverse iontophoresis with increased passage of fluid through the skin through application of electrical energy. Yet, transcutaneous optical means can also be integrated into support structures including medial canthal pieces, modified nose pads, and the frame of eyeglasses, with said means positioned to access the tunnel.

It is understood that application of current, ultrasonic waves as well as chemical enhancers of flow, electroporation and other means can be used to increase permeation at the tunnel site such as for example increased flow of glucose with the use of alkali salts. In addition creating micro holes in the target area with

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a laser, or other means that penetrate the skin can be done with the subsequent placement of sensing means on the BTT site, with said means capable of measuring chemical compounds.

Furthermore, reservoirs mounted on or disposed within support structures, such as the frame and pads of eyeglasses, can deliver substances transdermally at the BTT site by various means including iontophoresis, sonophoresis, electrocompression, electroporation, chemical or physical permeation enhancers, hydrostatic pressure and the like.

In addition to measure the actual amount of oxygen in blood, the present invention also discloses means to measure oxygen saturation and the amount of oxygenated hemoglobin. In this embodiment the medial canthal piece of a support structure or the modified nose pads of eyeglasses contain LEDs emitting at two wave lengths around 940 and 660 nanometers. As the blood oxygenation changes, the ratio of the light transmitted by the two frequencies changes indicating the oxygen saturation. Since the blood level is measured at the end of a physiologic brain tunnel, the amount of oxygenated hemoglobin in the arterial blood of the brain is measured, which is the most valuable and key parameter for athletic purposes and health monitoring.

The present invention also provides a method for measuring biological parameters with said method including the steps of directing electromagnetic radiation at the BTT area on the skin, producing a signal corresponding to the resulting radiation and converting the signal into a value of the biological parameter measured.

Besides using passive radio transmission or communication by cable; active radio transmission with

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active transmitters containing a microminiature battery mounted in the support structure can also be used. Passive transmitters act from energy supplied to it from an external source. The transensor transmits signals to remote locations using different frequencies indicative of the levels of biological parameters. Ultrasonic micro-circuits can also be mounted in the support structure and modulated by sensors which are capable of detecting chemical and physical changes at the Target Area. The signal may be transmitted using modulated sound signals particularly under water because sound is less attenuated by water than are radio waves.

One preferred embodiment comprises a support structure including a patch adapted to be worn on or attached with adhesives to the tunnel and includes structural support, a sensor for measuring biological parameters, power source, microcontroller and transmitter. The parts can be incorporated into one system or work as individual units. The sensor is located preferably within 7 mm from the outer edge of the patch. The apparatus of the invention can include a temperature sensor located in the outer edge of the patch for sensing temperature. The transmitter, power source and other components can be of any size and can be placed in any part of the patch or can be connected to the patch as long as the sensing part is placed on the edge of the patch in accordance with the principles of the invention. The sensor in the patch is positioned on the skin adjacent to the medial canthal area (medial corner of the eye) and located about 2 mm from the medial canthal tendon. The sensor can preferably include electrically-based sensors, but non-electrical systems can be used such as chemicals that respond to changes in temperature including mylar.

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Besides patches, another preferred embodiment for measuring biological parameters at the physiologic tunnel includes a medial canthal pad. The medial canthal piece is a specialized structure containing sensors for accessing the tunnel and adapted to be worn on or attached to eyeglasses in apposition to the tunnel and includes structural support, a sensor for measuring biological parameters, power source, microcontroller and transmitter. The parts can be incorporated into one system or work as individual units. The sensors are positioned on the BTT area. The transmitter, power source, and other components can be placed in the medial canthal pad or in any part of the eyeglasses. A medial canthal piece or extension of nose pads of eyeglasses allow accessing the physiologic tunnel with sensing devices laying in apposition to the BTT area.

The apparatus of the invention include a temperature sensor located in the medial canthal pad. For temperature measurement the sensing system is located on a skin area that includes the medial canthal corner of the eye and upper eyelid. The sensor in the medial canthal pad is preferably positioned on the skin adjacent to the medial canthal area (medial corner of the eye). Although one of the preferred embodiments for measurement of brain temperature consists of medial canthal pads, it is understood that also included in the scope of the invention are nose pads of a geometry and size that reach the tunnel and that are equipped with temperature sensors preferably in the outer edge of said nose pads for measuring brain temperature and other functions. An oversized and modified nose pad containing sensors using a special geometry for adequate positioning at the BTT area is also included in the invention.

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With the disclosure of the present invention and by using anatomic landmarks in accordance with the invention the sensor can be precisely positioned on the skin at the end of the tunnel. However, since there is no external visible indication on the skin relating to the size or geometry of the tunnel, accessory means can be used to visualize, map or measure the end of the tunnel on the skin. These accessory means may be particularly useful for fitting medial canthal pads or modified nose pads of eyeglasses.

Accordingly, a infrared detector using thermocouple or thermopiles can be used as an accessory for identifying the point of maximum thermal emission and to map the area. An infrared imaging system or thermography means may be preferably used. In this instance, an optical store selling the eyeglasses can have a thermal imaging system. The optician, technician and the like take an infrared image picture or film the area, and in real time localize the tunnel of the particular user. The medial canthal pads or modified nose pads can then be adjusted to fit the particular user based on the thermal infrared imaging. The eyeglasses are fitted based on the thermal image created. This will allow customized fitting according to the individual needs of the user. Any thermography-based system can be used including some with great visual impact and resolution as a tri-dimensional color thermal wave imaging.

It is also a feature of the invention to provide a method to be used for example in optical stores for locating the tunnel including the steps of measuring thermal infrared emission, producing an image based on the infrared emission, and detecting the area with the highest amount of infrared emission. Another step that can be included is adjusting sensors in support

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structures to match the area of highest infrared emission.

One of said support structures includes the medial canthal pieces or nose pads of eyeglasses. The thermal imaging method can be used for fitting a patch, but said patch can be positioned at the tunnel by having an external indicator for lining up said indicator with a permanent anatomic landmark such as the medial corner of the eye. Although medial canthal pieces of eyeglasses can have an external indicator for precise positioning, since opticians are used to fit eyeglasses according to the anatomy of the user, the thermal imaging method can be a better fit for eyeglasses than an external indicator on the medial canthal pieces or modified nose pads of eyeglasses.

The source of the signal is key for the clinical usefulness of the measurement. The brain is the key and universal indicator of the health status of the body. The signal coming from the brain or brain area provides the most clinically useful data. In accordance with another embodiment, the measurement of biological parameters will be described. The amount of sodium and other elements in sweat is a key factor for safety and performance of athletes and military, as well as health monitoring.

For instance hyponatremia (decreased amount of sodium) can lead to reduced performance and even death. Hyponatremia can occur due to excess water intake, commonly occurring with intense physical activity and military training. Sweat can be considered as an ultrafiltrate of blood. The blood vessels supplying the skin on the head are branches of the central nervous system vasculature. The amount of chemical substances present in the sweat coming from those blood vessels is indicative of the amount of chemical substances present

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in the cerebral vasculature. For instance, sodium concentration of sweat from blood vessels in the head changes in relation to the rates of sweating. The apparatus and methods of the present invention can prevent death or harm due to water intoxication, by providing alert signals when the levels of sodium in sweat reach a certain threshold for that particular wearer. The presence of various chemical elements, gases, electrolytes and pH of sweat and the surface of the skin can be determined by the use of suitable electrodes and suitable sensors integrated in the eyeglasses and other support structures mounted on the head or fitted on the head or face. These electrodes, preferably microelectrodes, can be sensitized by several reacting chemicals which are in the sweat or the surface of the skin. The different chemicals and substances can diffuse through suitable permeable membranes sensitizing suitable sensors.

For example but not by way of limitation, electrochemical sensors can be used to measure various analytes such as glucose using a glucose oxidase sensor and the pilocarpine iontophoresis method can be used to measure electrolytes in sweat alone or in conjunction with microfluidics system. Besides the support structures of the present invention, it is also understood that other articles such as watches, clothing, footwear and the like can be adapted to measure concentration of substances such as electrolytes present in sweat, however there is reduced clinical relevance for evaluating metabolic state of an individual outside the central nervous system.

Body abnormalities may cause a change in the pH, osmolarity, and temperature of the sweat derived from brain and neck blood vessels as well as change in the

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concentration of substances such as acid-lactic, glucose, lipids, hormones, gases, markers, infectious agents, antigens, antibody, enzymes, electrolytes such as sodium, potassium and chloride, and the like. Eyeglasses and any head gear can be adapted to measure the concentration of substances in sweat. Microminiature glass electrodes mounted in the end portion of the temple of eyeglasses sitting behind the ear or alternatively mounted on the lens rim against the forehead can be used to detect divalent cations such as calcium, as well as sodium and potassium ion and pH. Chloride-ion detectors can be used to detect the salt concentration in the sweat and the surface of the skin.

Many agents including biological warfare agents and HIV virus are present in sweat and could be detected with the eyeglasses or support structure on the head or face using sensors coated with antibodies against the agent which can create a photochemical reaction with appearance of colorimetric reaction and/or potential shift with subsequent change in voltage or temperature that can be detected and transmitted to a monitoring station or reported locally by audio or visual means. Electrocatalytic antibodies also can generate an electrical signal when there is an antigen-antibody interaction. It is also understood that other articles such as watches, clothing, footwear, and the like or any article capturing sweat can be adapted to identify antigens, antibody, infectious agents, markers (cancer, heart, genetic, metabolic, drugs, and the like) in accordance with the present invention. However, identification of those elements away from the central nervous system is of reduced clinical relevance.

The different amounts of fluid encountered in sweat can be easily quantified and the concentration of

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substances calibrated according to the amount of fluid in sweat. The relationship between the concentration of chemical substances and molecules in the blood and the amount of said chemical substances in the sweat can be described mathematically and programmed in a computer.

The present invention also includes eyeglasses or support structures in which a radio frequency transensor capable of measuring the negative resistance of nerve fibers is mounted in the eyeglasses or support structure. By measuring the electrical resistance, the effects of microorganisms, drugs, and poisons can be detected. The system also comprises eyeglasses in which a microminiature radiation-sensitive transensor is mounted in said eyeglasses or support structure.

The brain has a rich vasculature and receives about 15% of the resting cardiac output and due to the absence of fat the tunnel offers an area for optimal signal acquisition for evaluating hemodynamics. Accordingly, change in the viscosity of blood can be evaluated from a change in damping on a vibrating quartz micro-crystal mounted in the eyeglasses or support structure and the invention can be adapted to measure blood pressure and to provide instantaneous and continuous monitoring of blood pressure through an intact wall of a blood vessel from the brain and to evaluate hemodynamics and hydrodynamics. Also, by providing a contact microphone, arterial pressure can be measured using sonic means.

Pressure can be applied to a blood vessel through a micro cuff mounted in the medial canthal pads, or alternatively by the temples of eyeglasses. Pressure can also be applied by a rigid structure, and the preferred end point is reached when sound related to blood turbulence is generated. The characteristic sound of systole (contraction of the heart) and diastole

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(relaxation of the heart) can be captured by the microphone. A microphone integrated into the medial canthal pad can be adapted to identify the heart sounds. Pressure transducers such as a capacitive pressure transducer with integral electronics for signal processing and a microphone can be incorporated in the same silicon structure and can be mounted in the medial canthal pad. Motion sensors and/or pressure sensors can be mounted in the medial canthal pad to measure pulse.

Reversible mechanical expansion methods, photometric, or electrochemical methods and electrodes can be mounted in the eyeglasses or support structures of the present invention and used to detect acidity, gases, analyte concentration, and the like. Oxygen gas can also be evaluated according to its magnetic properties or be analyzed by micro-polarographic sensors mounted in the eyeglasses or other support structure. A microminiature microphone mounted in the eyeglasses or other support structure can also be adapted to detect sounds from the heart, respiration, flow, vocal and the environment, which can be sensed and transmitted to a remote receiver or reported by local audio and visual means. The sensors are adapted and positioned to monitor the biological parameters at the end of the tunnel.

The eyeglasses or other support structures can also have elements which produce and radiate recognizable signals and this procedure could be used to locate and track individuals, particularly in military operations. A permanent magnet can also be mounted in the eyeglasses and used for tracking as described above. A fixed frequency transmitter can be mounted in the eyeglasses and used as a tracking device which utilizes a satellite tracking system by noting the frequency received from the fixed frequency transmitter to a passing satellite, or

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via Global Positioning Systems. Motion and deceleration can be detected by mounting an accelerometer in the eyeglasses. The use of eyeglasses as tracking means can be useful for locating a kidnapped individual or for rescue operations in the military, since eyeglasses are normally unsuspecting articles.

The use of integrated circuits and advances occurring in transducer, power source, and signal processing technology allow for extreme miniaturization of the components which permits several sensors to be mounted in one unit.

The present invention provides continuous automated brain temperature monitoring without the need for a nurse. The present invention can identify a spike in temperature. Thus, proper diagnosis is made and therapy started in a timely fashion. Time is critical for identifying the temperature spike and organism causing the infection. Delay in identifying spike and starting therapy for the infection can lead to demise of the patient. The invention timely and automatically identifies the temperature spike and prevents the occurrence of complications.

The present invention also alerts the user about overheating or hypothermia to allow:

1. Proper hydration;
2. Increased performance;
3. Increased safety; and
4. Feed back control in treadmills and other exercise machines for keeping proper hydration and performance.

Annually many athletes, construction workers, college students and the general public unnecessarily die due to heatstrokes. Once the brain reaches a certain temperature level such as 40° C, an almost irreversible

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process ensues. Because there are no specific symptoms and after a certain point there is rapid increase in brain temperature, heatstroke has one of the highest fatality rates. The more severe and more prolonged the episode, the worse the predicted outcome, especially when cooling is delayed. Without measuring core temperature and having an alert system when the temperature falls outside safe levels it is impossible to prevent hyperthermia and heatstroke. The present invention provides means for continuous monitoring of temperature with alert systems that can prevent dangerous levels to be reached and cooling measures applied if needed. The apparatus can be adapted to be used in an unobtrusive manner by athletes, military, workers and the general population.

All chemical reactions in the body are dependent on temperature. High temperature can lead to enzymatic changes and protein denaturation and low temperature can slow down vital chemical reactions. Hydration is dependent on brain temperature and loss of fluid leads to a rise in brain temperature. Minimal fluctuations in the body's temperature can adversely affect performance and increase risk of illness and of life threatening events. Therefore, it is essential that athletes, sports participants, military personnel, police officers, firefighters, forest rangers, factory workers, farmers, construction workers and other professionals have precise means to know exactly what is their brain temperature.

When the core temperature rises, the blood that would otherwise be available for the muscles is used for cooling via respiration and perspiration. The body will do this automatically as temperature moves out of the preferred narrow range. It is this blood shifting that ultimately impairs physical performance and thermal

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induced damage to brain tissue interferes with normal cognitive function. Intense exercise can increase heat production in muscles 20 fold. In order to prevent hyperthermia and death by heat stroke athletes drink water. Because the ingestion of water is done in a random fashion, many times there is water intoxication which can lead to death as occurs to many healthy people including marathon runners and military personnel. Both, excess of water (overhydration) or lack of water (dehydration) can lead to fatal events besides reducing performance. Therefore, it is essential that individuals have precise means to know exactly when and how much to drink. By monitoring brain temperature with the present invention proper hydration can be achieved and athletes and military will know precisely when and how much water to ingest.

Timely ingestion of fluids according to the core temperature allows optimization of cardiovascular function and avoidance of heat strain. Because there is a delay from the time of ingestion of fluid to absorption of said fluid by the body, the method of invention includes signaling the need for ingestion at a lower core temperature such as 38.5° C to account for that delay, and thus avoid the onset of exhaustion. The temperature threshold can be adjusted according to each individual, the physical activity, and the ambient temperature.

In addition, software can be produced based on data acquired at the BTT site for optimizing fitness, athletic performance, and safety. The upper temperature limit of a particular athlete for maintaining optimal performance can be identified, and the data used to create software to guide said athlete during a competition. For instance, the athlete can be informed on the need to drink cold fluid to prevent reaching a certain temperature level

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which was identified as reduced performance for said athlete. Brain temperature level for optimal performance identified can be used to guide the effort of an athlete during competition and training. Hyperthermia also affects mental performance and software based on data from the BTT can be produced to optimize mental and physical performance of firefighters in an individual manner. People can have different thresholds for deleterious effects of hyperthermia and thus setting one level for all users may lead to underutilization of one's capabilities and putting others at risk of reduced performance. Likewise, exercise endurance and mental performance is markedly reduced by hypothermia and the same settings can be applied for low temperature situations. Determinations of brain temperature, oxygen and lactic acid levels can also be used for endurance training of athletes, fitness training, and to monitor the effects of training. The system, method, and apparatus of the invention provides means for enhancing safety and optimizing fitness for athletes and recreational sports participants.

It is a feature of the invention to provide a method for the precise and timely intake of fluids including the steps of measuring brain temperature, reporting the signal measured, and ingesting an amount of fluid based on the signal measured. Other steps can be included such as reporting means using voice reproduction or visual means to instruct on what beverage to drink and how much to drink to reduce core temperature. It is understood that the method of the present invention can combine measurement of temperature associated with measurement of sodium in sweat or blood, in accordance with the principles of the invention.

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Children do not tolerate heat as well as adults because their bodies generate more heat relative to their size than adults do. Children are also not as quick to adjust to changes in temperatures. In addition, children have more skin surface relative to their body size which means they lose more water through evaporation from the skin. It is understood that different sizes, shapes, and designs of medial canthal pads including children size can be used in the present invention. Children eyeglasses equipped with sensors can have a booster radio transmitter that will transmit the signal to a remote receiver and alert parents about dangerous temperature levels. The eyeglasses can be incorporated with a detecting system to send a signal if the eyeglasses were removed or if the temperature sensor is not capturing signals in a proper manner. By way of illustration, but not of limitation, pressuse sensing means can be incorporated in the end of the temples to detect if the sunglasses are being worn, and an abrupt drop in the pressure signal indicates glasses were removed or misplacement of the sensor can also generate an identifiable signal. An adhesive, a double-sided adhesive tape, or other means for increasing grip can be used in the medial canthal pads to assure more stable position. It is understood that the eyeglasses can come equipped with sensors to detect ambient temperature and humidty, which allows for precisely alerting the wearer about any aspect affecting heat conditions.

In the current industrial, nuclear and military settings, personnel may be requied to wear protective clothing. Although the protective clothing prevent harm by hzaradous agents, the garments increase the rate of heat storage. It is understood that the present invention can be coupled with garments with adjustable permeability

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to automatically keep the core temperature within safe limits.

In addition, the present invention alerts an individual about risk of thermal damage (risk of wrinkles and cancer) at the beach or during outdoor activities. When one is at the beach, watching a game in a stadium, camping or being exposed to the sun, the radiant energy of the sun is absorbed and transformed into thermal energy. The combination of the different means of heat transfer to the body lead to an increase in body temperature, which is reflected by the brain temperature. Convection and conduction can also lead to an increase in body temperature through heat transfer in the absence of sun light. The absorption of heat from the environment leads to a rise in the average kinetic energy of the molecules with subsequent increase in core temperature.

The levels of core temperature is related to the risk of thermal damage to the skin. After certain levels of heat there is an increased risk of denaturing protein and breaking of collagen in the skin. This can be compared with changes that occur when frying an egg. After a certain amount of thermal radiation is delivered the egg white changes from fluidic and transparent to a hard and white structure. After the egg white reaches a certain level of temperature the structural change becomes permanent. After a certain level of increase in core temperature during sun exposure, such as a level of 37.7° Celsius to 37.9° Celsius at rest (e.g.; sun bathing), thermal damage may ensue and due to the disruption of proteins and collagen there is an increased risk for wrinkle formation. The increased brain temperature correlates to the amount of thermal radiation absorbed by the body, and the duration of exposure of the temperature level times the level of temperature is an

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indicator of the risk of thermal damage, wrinkle formation, and skin cancer.

The present invention provides an alarm system that can be set up to alert in real time when it is time to avoid sun exposure in order to prevent further absorption of thermal radiation and reduce the risk of dermatologic changes, as can occur during outdoor activities or at the beach. In addition, thermal damage to the skin prevents the skin from adequately cooling itself and can result in increasing the risk of dehydration which further increases the temperature. The present invention helps preserve the beauty and health of people exposed to sun light and during outdoor activities while allowing full enjoyment of the sun and the benefits of sun light.

By the present invention, a method for timing sun exposure includes the steps of measuring body temperature, reporting the value measured and avoiding sun exposure for a certain period of time based on the level measured.

Hypothermia is the number one killer in outdoor activities in the U.S. and Europe. Hypothermia also decreases athletic performance and leads to injuries. It is very difficult to detect hypothermia because the symptoms are completely vague such as loss of orientation and clumsiness which are indistinguishable from general behavior. Without measuring core temperature and having an alert system when the temperature falls outside safe levels it is impossible to prevent hypothermia due to the vague symptoms. The present invention can alert an individual about hypothermia during skiing, scuba diving, mountain climbing and hiking. The present invention provides means to precisely inform when certain temperature thresholds are met, either too high or too low temperature.

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The present invention continuously monitors the brain temperature and as soon as a temperature spike or fever occurs it activates diagnostics systems to detect the presence of infectious agents, which can be done locally in the BTT site, or the infectious agents can be identified in other parts of the body such as the blood stream or the eyelid pocket. The present invention can be also coupled to drug dispensing means for the automated delivery of medications in accordance with the signal produced at the BTT site including transcutaneous means, iontophoresis or by injection using a pump.

The invention also includes a tool for family planning. The system can detect spike and changes in basal temperature and identify moment of ovulation and phases of the menstrual cycle. This allows a woman to plan pregnancy or avoid pregnancy. This eliminates the need for invasive devices used for monitoring time for artificial insemination not only for humans but also animals. The invention can yet detect the start of uterine contractions (parturition) and allow a safer birth for animals. Support structures can be equally used in the BTT of animals.

The present invention also includes Automated Climate control according to the value measured at the BTT. The temperature of the user controls the temperature in the car. When the body starts to warm up, the signal from the apparatus of the invention automatically activates the air conditioner according to the user settings, alternatively it activates heat when the body is cold. This automation allows drivers to concentrate on the road and thus can reduce the risk for car crashes. It is understood that other articles that can affect body temperature can be controlled by the present invention including vehicle seats. Likewise, automated climate

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control at home, work, or any confined area can be achieved by activating the thermostat directly or via BlueTooth technology. Besides convenience and comfort, this automation allows saving energy since gross changes manually done in the thermostat leads to great energy expenditure.

It is understood that any body temperature measuring system can provide automated climate control or adjust temperature of articles in accordance with the principles of the present invention.

The present invention yet includes methods for reducing weight. It includes monitoring of temperature during programs for weight reduction based on increasing body heat to reduce said weight. The system alerts athletes on a weight losing program to prevent injury or death by overheating. The system can monitor temperature of people in sauna, steam rooms, spas and the like as part of weight reduction programs in order to prevent injuries and enhance results.

Yet, methods to enhance memory and performance besides preserving health by providing an automated mechanism to control ambient temperature and surrounding body temperature based on the brain temperature measured by the present invention. Human beings spent about one third of their lives sleeping. Many changes in body temperature occur during sleep. All of the metabolism and enzymatic reactions in the body are dependent on adequate level of temperature. The adequate control of ambient temperature which matches the needs of body temperature such as during sleeping have a key effect on metabolism. Adequate ambient temperature and surrounding temperature of objects which matches body temperature allow not only for people to sleep better, but also to achieve improved efficiency of enzymatic reactions which leads to improved

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mental ability and improved immune response. A variety of devices such as blankets, clothing, hats, mattress, pillows, or any article touching the body or in the vicinity of the body can be adapted to automatically increase or decrease temperature of said articles according to the temperature signal from the present invention.

The body naturally becomes cooler during the night and many people have restless sleep and turn continuously in bed because of that temperature effect. Since the tossing and turning occurs as involuntary movements and the person is not awake, said person cannot change the stimuli such as for instance increasing room temperature or increasing temperature of an electric blanket. The present invention automatically changes the ambient temperature or temperature of articles to match the temperature needs of the person. This is particularly useful for infants, elderly, diabetics, neuro- disorders, heart disease, and a variety of other conditions, since this population has reduced neurogenic response to changes in body temperature, and said population could suffer more during the night, have increased risk of complications besides decreased productivity due to sleep deprivation.

The invention also provides means and methods to be used with bio feedback activities. A brain temperature signal from the sensor at the BTT site produces a feedback signal as an audio tone or visual display indicating temperature and a series of tones or colors identify if the brain temperature is increasing (faster frequency and red) or decreasing (lower frequency and blue). The display means can be connected by wires to the support structure holding the sensor at the BTT site.

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Head cooling does not change brain temperature. Athletes, military, firefighters, construction workers and others are at risk of heatstroke despite pouring cold water on their head or using a fan. Medically speaking that is a dangerous situation because the cool feeling sensed in the head is interpreted as internal cooling and the physical activity is maintained, when in reality the brain remains at risk of thermal induced damage and heatstroke. Other medical challenges related to temperature disturbances concern response time. The brain has a slower recovery response to temperature changes than core temperature (internal temperature measured in rectum, bladder, esophagus, and other internal means). Thus, internal measurement may indicate stable temperature while the brain temperature remains outside safe levels, with risk of induced damage to cerebral tissue, either due to hypothermia or hyperthermia. The only medically acceptable way to prevent cerebral tissue damage due to temperature disturbances is by continuous monitoring brain temperature as provided by the present invention.

The present invention utilizes a plurality of active or passive sensors incorporated in support structures for accessing a physiologic tunnel for measuring biological parameters. The present invention preferably includes all functions in a miniature semiconductor chip, which as an integrated circuit, incorporates sensor, processing and transmitting units and control circuits.

The present invention includes means for collecting thermal radiation from a BTT site, means for positioning temperature sensitive devices to receive thermal radiation from the BTT site and means for converting said thermal radiation into the brain temperature. The present invention also provides methods for determining brain

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temperature with said methods including the steps of collecting the thermal emission from the BTT site, producing a signal corresponding to the thermal emission collected, processing the signal and reporting the temperature level. The invention also includes means and methods for proper positioning of the temperature sensor in a stable position at the BTT site.

It is also an object of the present invention to provide support structures adapted to position a sensor on the end of a tunnel on the skin to measure biological parameters.

It is an object of the present invention to provide apparatus and methods to measure brain (core) temperature including patches, adhesives strips, elastic means, clips and the like containing sensors positioned on a physiologic tunnel.

It is an object of the present invention to provide multipurpose eyeglasses equipped with medial canthal pads containing sensors positioned on a physiologic tunnel for measuring biological parameters

It is another object of the present invention to provide new methods and apparatus for measuring at least one of brain temperature, chemical function and physical function.

It is yet an object of the invention to provide apparatus that fit on both adults and children.

It is also an object of the invention to provide apparatus that report the signal produced at the tunnel by at least one of wired connection to reporting means, wireless transmission to reporting means and local reporting by audio, visual or tactile means such as by vibration incorporated in support structures.

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It is yet another object of the present invention to provide apparatus that allow the wearer to avoid dehydration or overhydration (water intoxication).

It is a further object of the present invention to provide methods and apparatus that allows athletes and sports participants to increase their performance and safety.

It is yet an object of the present invention to provide support structure positioned sensors on a tunnel which can be worn at least by one of athletes during practice and competition, military during training and combat, workers during labor and the general public during regular activities.

It is another object of the present invention to increase safety and comfort in vehicles by providing automated climate control and vehicle seat control based on the core temperature of the occupants of the vehicle.

It is an object of the present invention to provide methods and apparatus that act on a second device based on the level of the biological parameter measured.

It is another object of the invention to provide methods and apparatus to preserve skin health, reduce risk of wrinkles and reduce the risk of skin cancer by preventing sun damage by thermal radiation and alerting the wearer when the temperature has reached certain thresholds.

It is also an object of the invention to provide methods and apparatus for achieving controlled weight loss based on heat-based weight loss approach.

It is also an object of the invention to provide methods and apparatus to alert athletes in a weight losing program based on increasing body temperature to prevent injury or death by overheating.

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It is also an object of the invention to provide methods and apparatus that allow monitoring fever and spikes of temperature.

It is also an object of the invention to provide means for family planning by detecting time of ovulation.

It is a further object of the invention to provide methods and apparatus for the delivery of medications in accordance with the signal produced at the tunnel.

It is yet an object of the invention to provide methods and apparatus that enhance occupational safety by continually monitoring biological parameters.

It is also an object of the invention to provide an article of manufacture with a sensing apparatus positioned on a tunnel for monitoring biological parameters that can be fitted or mounted in at least one of the frame of eyeglasses, the nose pads of eyeglasses, the structure of a head mounted gear and clothing.

The invention also features transmitting the signal from the support structure to act on at least one of exercise equipment, bikes, sports gear, protective clothing, footwear and medical devices.

It is yet an object of the invention to provide support structures that transmit the signal produced at the tunnel to treadmills and other exercise machines for keeping proper hydration and preventing temperature disturbances of the user.

It is yet another object of the invention to provide apparatus and methods for monitoring biological parameters by accessing a physiologic tunnel using active or passive devices.

The invention yet features transmission of the signal from the support structures to watches, pagers, cell phones, computers, and the like.

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These and other objects of the invention, as well as many of the intended advantages thereof, will become more readily apparent when reference is made to the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a thermal infrared image of the human face showing the brain temperature tunnel.

FIG. 1B is a computer generated thermal infrared color image of the human face showing the brain temperature tunnel.

FIG. 2A is a schematic diagram showing a physiologic tunnel.

FIG. 2B is a cross-sectional schematic diagram of the human head showing the tunnel.

FIG. 2C is a coronal section schematic diagram showing the cavernous sinus of FIG. 2B.

FIG. 3A is a thermal infrared image of the human face showing the tunnel.

FIG. 3B is a schematic diagram of the image in FIG. 3A showing the geometry at the end of the tunnel.

FIG. 4A is a thermal infrared image of the side of the human face showing a general view of the main entry point of the brain temperature tunnel.

FIG. 4B is a schematic diagram of the image in FIG. 4A.

FIG. 5A is a thermal infrared image of the front of the human face showing the main entry point of the brain temperature tunnel.

FIG. 5B is a schematic diagram of the image in FIG. 5A.

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FIG. 5C is a thermal infrared image of the side of the human face in FIG. 5A showing the main entry point of the brain temperature tunnel.

FIG. 5D is a schematic view of the image in FIG. 5C.

FIG. 6 is a schematic view of the face showing the general area of the main entry point of the tunnel and peripheral parts.

FIG. 6A is a schematic diagram showing the brain temperature tunnel and the metabolic tunnel.

FIGS. 7A and 7B are thermal infrared images of the human face before and after cold challenge.

FIGS. 8A and 8B are thermal infrared images of the human face of different subjects showing the tunnel.

FIGS. 9A and 9B are thermal infrared images of animals showing a tunnel.

FIG. 10 is a perspective view of a preferred embodiment showing a person wearing a support structure comprised of a patch with a passive sensor positioned on the skin at the end of the tunnel in accordance with the present invention.

FIG. 11 is a perspective view of another preferred embodiment showing a person wearing a support structure comprised of a patch with a passive sensor positioned on the skin at the end of the tunnel in accordance with the present invention.

FIG. 12A is a front perspective view of a person wearing a support structure comprised of a patch with an active sensor positioned on the skin at the end of the tunnel in accordance with the present invention.

FIG. 12B is a side schematic view showing the flexible nature of the support structure shown in FIG. 12A.

FIG. 13 is a schematic block diagram of one preferred embodiment.

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FIG. 14 is a schematic diagram of one preferred embodiment of the invention interacting with devices and articles of manufacture.

FIGS. 15A to 15E are schematic views showing preferred embodiments of the invention using indicators.

FIGS. 16A to 16C are perspective views of a preferred embodiment showing a person wearing support structures incorporated as patches.

FIG. 17 is a perspective view of another preferred embodiment showing a person wearing a support structure incorporated as a clip with a sensor positioned on the skin at the end of the tunnel in accordance with the present invention.

FIG. 18 is a perspective view of another preferred embodiment showing a person wearing a support structure with a sensor positioned on the skin at the end of the tunnel and connected by a wire.

FIGS. 19A1, 19A2, 19B, 19C and 19D are schematic diagrams of preferred geometry and dimensions of support structures and sensing means

FIGS. 20A to 20C are schematic diagrams of preferred dimensions of the outer edge of support structures in relation to the outer edge of sensing means.

FIGS. 21A and 21B are schematic diagrams of preferred positions of sensing means.

FIGS. 22A to 22C are perspective views of preferred embodiments showing a person wearing a support structure incorporated as a medial canthal pad with a sensor positioned on the skin at the end of the tunnel in accordance with the present invention.

FIGS. 23A and 23B are perspective views of an alternative embodiment showing a support structure comprised of modified nose pads with a sensor positioned

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on the skin at the end of the tunnel in accordance with the present invention.

FIG. 24 is a perspective view of another preferred embodiment of support structure in accordance with the invention.

FIG. 25 is a perspective view of one preferred embodiment of support structure showing additional means for including a sensor.

FIG. 26A is a rear perspective view of one preferred embodiment of a support structure with display means.

FIG. 26B is a front perspective view of one preferred embodiment of a support structure with display means.

FIG. 27 is an exploded perspective view of another preferred embodiment showing a three piece support structure.

FIG. 28A is an exploded perspective view of one preferred embodiment of support structure showing a removable medial canthal piece.

FIG. 28B is a rear perspective view of the removable medial canthal piece of FIG. 28A.

FIG. 28C is a front perspective view of the removable medial canthal piece of FIG. 28B.

FIG. 29 is a rear perspective view of one preferred embodiment of a support structure incorporated as a clip-on for eyeglasses .

FIG. 30 is a perspective view of one alternative embodiment of a support structure with medial canthal pads that uses an adhesive backing for securing to another structure.

FIG. 31A is a top perspective view of one alternative embodiment of a support structure with holes for securing medial canthal pads.

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FIG. 31B is a magnified perspective view of part of the support structure of FIG. 31A.

FIG. 31C is a side perspective view of part of the support structure of FIG. 31B.

FIG. 31D is a side perspective view of a medial canthal piece secured at the support structure.

FIG. 32A is a perspective view of a person wearing a support structure comprised of medial canthal caps secured on top of a regular nose pad of eyeglasses.

FIG. 32B is a perspective view of the medial canthal cap of FIG. 32A.

FIG. 33A is an exploded perspective view of a medial canthal cap being secured to the nose pad.

FIG. 33B is a perspective view of the end result of the medial canthal cap secured to the nose pad.

FIG. 34 is a perspective view of a modified rotatable nose pad to position a sensor on the skin at the end of the tunnel in accordance with the present invention.

FIG. 35 is a schematic view of another preferred embodiment of the present invention using spectral reflectance.

FIG. 36 is a schematic view of a person showing another preferred embodiment in accordance with the present invention using spectral transmission.

FIG. 37 is a schematic cross-sectional view of another preferred embodiment of the present invention using thermal emission.

FIG. 38 is a side perspective view of an alternative embodiment using head mounted gear as a support structure.

FIG. 39 is a schematic diagram of a preferred embodiment for generating thermoelectric energy to power the sensing system.

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FIG. 40 is a perspective view of a preferred embodiment for animal use.

FIGS. 41A and 41B are perspective views of an alternative embodiment of a portable support structure with a sensor positioned at the tunnel.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In describing a preferred embodiment of the invention illustrated in the drawings, specific terminology will be resorted to for the sake of clarity. However, the invention is not intended to be limited to the specific terms so selected, and it is to be understood that each specific term includes all technical equivalents which operate in a similar manner to accomplish a similar purpose.

FIG. 1A shows a thermal infrared image of the human face showing a physiologic tunnel. The figure shows an image of the end of the brain temperature tunnel (BTT) depicted as white bright spots in the medial canthal area and the medial half of the upper eyelid. The end of the BTT on the skin has special geometry, borders, and internal areas and the main entry point is located on the supero-medial aspect of the medial canthal area diametrically in position with the inferior portion of the upper eyelid and 4 mm medial to the medial corner of the eye. From there the boundary goes down in the medial canthal area diametrically in position with the medial corner of the eye and within 5 mm down from the medial corner of the eye, and proceeding up to the upper eyelid with the lateral boundary beginning at the mid-part of the upper eyelid as a narrow area and extending laterally in a fan-like shape with the superior boundary beginning in the mid-half of the upper eyelid.

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The scale indicates the range of temperature found in the human face. The hottest spots are indicated by the brightest white spots and the coldest areas are black, temperature between the hottest and coldest areas are seen in different hues in a gray scale. The nose is cold (seen as black) since it is primarily composed of cartilage and bones, and consequently has a lower blood volume. That is the reason why frostbite is most common in the nose.

The surrounding periocular area of the upper and lower eyelids (seen as gray) is hotter because of high vascularization and the reduced amount of adipose tissue. The skin underneath the eyelids is very thin and does not have adipose tissue either. However, the other conditions necessary to define a brain temperature tunnel are not present in this area.

The BTT requirements also include the presence of a terminal branch to deliver the total amount of heat, a terminal branch that is a direct branch from a vessel from the brain, a terminal branch that is superficially located to avoid far-infrared radiation absorption by other structures, and no thermoregulatory arteriovenous shunts. Thus, the BTT, i.e., the skin area in the medial corner of the eye and upper eyelid, is the unique location that can access a brain temperature tunnel. The skin around the eyelids delivers undisturbed signals for chemical measurements using spectroscopy and is defined as a metabolic tunnel with optimal acquisition of signals for chemical evaluation, but not for evaluation of the total radiant power of the brain.

FIG. 1B is a computer generated thermal infrared color plot image of the human face showing in detail the geometry and different areas of the brain temperature tunnel and surrounding areas. Only few creatures such as

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some beetles and rattle snakes can see this type of radiation, but not humans. The infrared images make the invisible into visible. Thus the geometry and size of the tunnel can be better quantified. The color plot of the isothermal lines show the peripheral area of the tunnel in red and the central area in yellow-white with the main entry point at the end of the BTT located in the supero-medial aspect of the medial canthal area above the medial canthal tendon.

The main entry point is the area of most optimal signal acquisition. The image also shows the symmetry of thermal energy between the two BTT sites. Since other areas including the forehead do not have the aforementioned six characteristics needed to define a BTT, said areas have lower total radiant power seen as light and dark green. Thus the forehead is not suitable to measure total radiant power. The whole nose has very little radiant power seen as blue and purple areas, and the tip of the nose seen as brown has the lowest temperature of the face. Thus, the nose area is not suitable for measuring biological parameters.

FIG. 2A is a schematic diagram of a physiologic tunnel, more particularly a Brain Temperature Tunnel. From a physical standpoint, the BTT is a brain thermal energy tunnel characterized by a high total radiant power and high heat flow and can be characterized as a Brain Thermal Energy tunnel. The tunnel stores thermal energy and provides an undisturbed path for conveying thermal energy from one end of the tunnel in the cavernous sinus inside of the brain to the opposite end on the skin with the thermal energy transferred to the surface of the skin at the end of the tunnel in the form of far-infrared radiation. High heat flow occurs at the end of tunnel which is characterized by a thin interface, and the heat

flow is inversely proportional to the thickness of the interface.

The total radiated power (P) at the end of the tunnel is defined by $P = \sigma * e * A * T^4$, where σ is the Stefan-Boltzman constant with a value $\sigma = 5.67 \times 10^{-8}$ $W.m^{-2}.K^{-4}$ and e is the emissivity of the area. Since the end of the tunnel provides an optimal area for radiation, the total power radiated grows rapidly as the temperature of the brain increases because of the T^4 term in the equation. As demonstrated in the experiments in the present invention mentioned, the radiated power in the BTT occurred at a faster rate than the radiated power in the tongue and oral cavity.

The BTT site on the skin is a very small area measuring only less than 0.5% of the body surface area. However, this very small skin region of the body provides the area for the optimal signal acquisition for measuring both physical and chemical parameters.

FIG. 2A shows the brain 10 with the thermal energy 12 stored in its body. The BTT 20 include the brain 10, the thermal energy stored in the brain 12, the thermal energy stored in the tunnel 14 and the thermal energy 16 transferred to the exterior at the end of the tunnel. The thermal energy 12, 14, 16 is represented by dark arrows of same size and shape. The arrows have the same size indicating undisturbed thermal energy from one end of the tunnel to the other and characterized by equivalent temperature within the tunnel.

Thermal energy from the sinus cavernous in the brain 10 is transferred to the end of the tunnel 16 and a rapid rate of heat transfer occurs through the unimpeded cerebral venous blood path. The tunnel also has a wall 18 representing the wall of the vasculature storing the thermal energy with equivalent temperature and serving as

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a conduit from the inside of the body 10 to the exterior (skin surface) 19 which ends as a terminal vessel 17 transferring the total amount of thermal energy to said skin 19.

The skin 19 is very thin and allows high heat flow. The thickness of skin 19 is negligible compared to the skin 39, 49 in non-tunnel areas 30 and 40 respectively. Due to the characteristics of skin 19, high heat flow occurs and thermal equilibrium is achieved rapidly when a sensor is placed on the skin 19 at the end of the BTT 20.

In other areas of skin in the face and in the body in general, and in the exemplary non-tunnel areas 30 and 40 of FIG. 2 several interfering phenomena occur besides the lack of direct vasculature connection to the brain, and includes self-absorption and thermal gradient. 1. Self-absorption: This relates to the phenomena that deep layers of tissue selectively absorb wavelengths of infrared energy prior to emission at the surface. The amount and type of infrared energy self-absorbed is unknown. At the surface those preferred emissions are weak due to self-absorption by the other layers deriving disordered thermal emission and insignificant spectral characteristic of the substance being analyzed being illustratively represented by the various size, shapes and orientations of arrows 34a to 36g and 44a to 46g of FIG.2. Self-absorption in non-tunnel areas thus naturally prevents useful thermal emission for measurement to be delivered at the surface. 2. Thermal gradient: there is a thermal gradient with the deeper layers being warmer than the superficial layers, illustratively represented by thicker arrows 36d and 46d in the deeper layers compared to thinner arrows 36e and 46e located more superficially. There is excessive and highly variable scattering of photons when passing through various layers such as fat

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and other tissues such as muscles leading to thermal loss.

Contrary to that, the tunnel area 20 is homogeneous with no absorption of infrared energy and the blood vessels are located on the surface. This allows undisturbed delivery of infrared energy to the surface of the skin 19 and to a temperature detector such as an infrared detector placed in apposition to said skin 19. In the BTT area there is no thermal gradient since there is only a thin layer of tissue 19 with terminal blood vessel 17 directly underneath said thin interface skin 19. The thermal energy 16 generated by the terminal blood vessel 17 exiting to the surface skin 19 corresponds to the undisturbed brain (true core) temperature of the body. The preferred path for achieving thermal equilibrium with brain tissue temperature is through the central venous system which exits the brain and enters the orbit as the superior ophthalmic vein. The arterial blood is 0.2 to 0.3 degrees Celsius lower when compared to the central venous blood, and said arterial blood is not the actual equivalent of the brain temperature. Thus although arterial blood may be of interest in certain occasions, the venous system is the preferred carrier of thermal energy for measurement of brain temperature. Arterial blood temperature may be of interest to determine possible brain cooling by the arterial blood in certain circumstances.

Non-tunnel areas 30 and 40 are characterized by the presence of heat absorbing elements. The non-tunnel areas 30 and 40 are defined by broken lines characterizing the vulnerability of interference by heat absorbing constituents and by the disorganized transferring of heat in said non-tunnel areas 30 and 40. Various layers and other constituents in non-tunnel areas 30 and 40

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selectively absorb infrared energy emitted by the deeper layers before said energy reaches the surface of skin, and the different thermal energy and the different areas are represented by the different shapes and sizes of arrows and arrows heads.

Non-tunnel area 30 can be representative of measuring temperature with a sensor on top of the skin anatomically located above the heart 32. White arrows 34 represent the thermal energy in the heart 32. Non-tunnel area 30 includes the heart 32 and the various blood vessels and its branches 36a, 36b, 36c, 36d storing thermal energy.

Different amounts of heat are transferred and different temperatures measured depending on the location and anatomy of blood vessels 36a, 36b, 36c. The blood vessels branch out extensively from the main trunk 34a.The non-tunnel area 30 also includes heat absorbing structures 37 such as bone and muscles which thermal energy 34 from the heart 32 need to be traversed to reach the skin 39. The non-tunnel area 30 also includes a variable layer of fat tissue 38 which further absorbs thermal energy. The reduced amount of thermal energy reaching the skin surface 39 due to the presence of fat 38 is represented by the arrows 36d and 36e, in which arrow 36d has higher temperature than arrow 36e. Non-tunnel area 30 also includes a thick skin 39 with low heat flow represented by arrows 36f.

The thick skin 39 corresponds to the skin in the chest area and fat layer 38 corresponds to the variable amount of fat present in the chest area. Arrows 36g represent the disordered and reduced total radiant power delivered after said thermal energy traverses the interfering constituents in the non-tunnel area including a thick interface and heat absorbing structures. In

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addition, BTT 20 has no fat layer as found in non-tunnel areas 30 and 40. Lack of a thick interface such as thick skin and fat, lack of thermal barriers such as fat, and lack of heat absorbing elements such as muscles allows undisturbed emission of radiation at the end of the BTT. Lack of a thick interface such as thick skin and fat, lack of thermal barriers such as fat, and lack of heat absorbing elements such as muscles allowed undisturbed emission of radiation at the end of the BTT.

Yet referring to FIG. 2, non-tunnel area 40 can be representative of measuring temperature with a sensor on top of the skin in the arm 42. The heat transfer in non-tunnel area 40 has some similarity with non-tunnel area 30 in which the end result is a disordered and reduced total radiant power not representative of the temperature at the opposite end internally. The blood vessels branch out extensively from the main trunk 44a. Thermal energy and temperature in blood vessels 46a, 46b, 46c is different than in areas 36a, 36b, 36c. The structures that thermal energy 44 needs to traverse to reach the skin are also different compared to non-tunnel 30. The amount of heat absorbing structures 47 is different and thus the end temperature at non-tunnel 40 is also different when compared to non-tunnel area 30. The amount of fat 48 also varies which changes the energy in areas area 46d and 46e, wherein 46d is deeper than area 46e. Thick skin 49 also reduces heat flow and the temperature of the area 46f. Reduction of radiant power indicated by arrow 46g when compared to radiant power 36g is usually quite different, so different skin temperature is measured depending on the area of the body. This applies to the whole skin surface of the body, with the exception of the skin at the end of the BTT.

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Measurements of internal temperature such as rectal do not have the same clinical relevance as measurement in the brain. Selective brain cooling has been demonstrated in a number of mammalian species under laboratory conditions and the same process could occur in humans. For instance the temperature in bladder and rectum may be quite different than the brain. High or low temperature in the brain may not be reflected in the temperature measured in other internal organs.

FIG. 2B is a cross-sectional schematic diagram of the human head 9 showing the brain 10, spinal cord 10a, the tunnel 20 represented by the superior ophthalmic vein, the cavernous sinus 1, which is the thermal energy storage compartment for the brain, and the various insulating barriers 2, 2a, 3, 4, 4a, 4b, 5 that keep the brain as a completely thermally insulated structure. Insulating barriers include skin 2 corresponding to the scalp, skin 2a corresponding to the skin covering the face, fat 3 covering the whole surface of the skull and face, skull bone 4, spinal bone 4a surrounding spinal cord 10a, facial bone 4b covering the face, and cerebral spinal fluid (CSF) 5. The combined thickness of barriers 2,3,4,5 insulating the brain can reach 1.5 cm to 2.0 cm, which is a notable thickness and the largest single barrier against the environment in the whole body. Due to this completely confined environment the brain cannot remove heat efficiently and heat loss occurs at a very lower rate. Skin 2 corresponds to the scalp which is the skin and associated structure covering the skull and which has low thermal conductivity and works as an insulator. Fat tissue 3 absorbs the majority of the far-infrared wavelength and works as a thermal buffer. Skull bone 4 has low thermal conductivity and the CSF works as a physical buffer and has zero heat production.

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The heat generated by metabolic rate in the brain corresponds to 20% of the total heat produced by the body and this enormous amount of heat is kept in a confined and thermally sealed space. Brain tissue is the most susceptible tissue to thermal energy induced damage, both high and low levels of thermal energy. Because of the thermal insulation and physical inability of the brain to gain heat or lose heat, both hypothermic (cold) and hyperthermic (hot) states can lead to brain damage and death can rapidly ensue, as occur to thousands of healthy people annually besides seizures and death due to high fever in sick people. Unless appropriate and timely warning is provided by continuously monitoring brain temperature anyone affected by cold or hot disturbances is at risk of thermal induced damage to the brain.

FIG. 2B also shows a notably small entry point 20a measuring less than 0.5% of the body surface which corresponds to the end of the tunnel 20 on the skin 2b. The skin 2b is extremely thin with a thickness of 1 mm or less compared to the skin 2 and 2a which are five fold or more, thicker than skin 2b.

The tunnel 20 starts at the cavernous sinus 1 which is a conduit for venous drainage for the brain and for heat transfer at the end of the tunnel 20 as a radiant energy. Tunnel 20 provides an obstructed passage to the cavernous sinus 1, a structure located in the middle of the brain, and which is in direct contact with the two sources of heat to the brain: 1) thermal energy produced due to metabolic rate by the brain and carried by the venous system; and 2) thermal energy delivered by the arterial supply from the rest of the body to the brain. This direct contact arrangement is showed in detail in FIG. 2C, which is a coronal section of FIG. 2B corresponding to the line marked "A".

FIG. 2C is a coronal section through the cavernous sinus 1 which is a cavity-like structure with multiple spaces 1a filled with venous blood from the veins 9 and from the superior ophthalmic vein 6. Cavernous sinus 1 collects thermal energy from brain tissue 7, from arterial blood of the right and left internal carotid arteries 8a, 8b, and from venous blood from vein 9. All of the structures 7, 8a, 8b, 9 are disposed along and in intimate contact with the cavernous sinus 1. A particular feature that makes the cavernous sinus 1 of the tunnel a very useful gauge for temperature disturbances is the intimate association with the carotid arteries 8a, 8b. The carotid arteries carry the blood from the body, and the amount of thermal energy delivered to the brain by said vessels can lead to a state of hypothermia or hyperthermia. For instance during exposure to cold, the body is cold and cold blood from the body is carried to the brain by internal carotid arteries 8a, 8b, and the cavernous sinus 1 is the entry point of those vessels 8a, 8b to the brain.

As soon as cold blood reaches the cavernous sinus 1 the corresponding thermal energy state is transferred to the tunnel and to the skin surface at the end of the tunnel, providing therefore an immediate alert even before the cold blood is distributed throughout the brain. The same applies to hot blood for instance generated during exercise which can lead to a 20 fold heat production compared to baseline. This heat carried by vessels 8a, 8b is transferred to the cavernous sinus 1 and can be measured at the end of the tunnel. In addition, the thermal energy generated by the brain is carried by cerebral venous blood and the cavernous sinus 1 is a structure filled with venous blood.

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FIG. 3A is a thermal infrared image of the human face in which the geometry of the end of the tunnel on the skin can be visualized. The white bright spots define the central area of the tunnel. FIG. 3B is a schematic diagram of an exemplary geometry on the skin surface at the end of the tunnel. The medial aspect 52 of the tunnel 50 has a round shape. The lateral aspect 54 borders the upper lid margin 58 and caruncle 56 of the eye 60. The tunnel extends from the medial canthal area 52 into the upper eyelid 62 in a horn like projection.

The internal areas of the tunnel 50 include the general area for the main entry point and the main entry point as shown in FIGS. 4A to 5D. FIG. 4A is a thermal infrared image of the side of the human face showing a general view of the main entry point of the brain temperature tunnel, seen as white bright points located medial and above the medial canthal corner. FIG. 4B is a diagram showing the general area 70 of the main entry point and its relationship to the eye 60, medial canthal corner 61, eyebrow 64, and nose 66.The general area 70 of the main entry point provides an area with more faithful reproduction of the brain temperature since the area 70 has less interfering elements than the peripheral area of the tunnel.

FIG. 5A is a thermal infrared image of the front of the human face with the right eye closed showing the main entry point of the brain temperature tunnel seen as white bright spots above and medial to the medial canthal corner. With closed eyes it is easy to observe that the radiant power is coming solely from the skin at the end of BTT.

FIG. 5B is a diagram showing the main entry point 80 and its relationship to the medial canthal corner 61 of closed eye 60 and eyelids 62. The main entry point 80 of

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the tunnel provides the area with the most faithful reproduction of the brain temperature since the area 80 has the least amount of interfering elements and is universally present in all human beings at an equivalent anatomical position. The main entry point 80 has the highest total radiant power and has a surface with high emissivity. The main entry point 80 is located on the skin in the superior aspect of the medial canthal area 63, in the supero-medial aspect of the medial canthal corner 61.

FIG. 5C is a thermal infrared image of the side of the human face in FIG. 5A with the left eye closed showing a side view of the main entry point of the brain temperature tunnel, seen as bright white spots. It can be observed with closed eyes that the radiant power is coming solely from the skin at the end of BTT.

FIG. 5D shows the main entry point 80 in the superior aspect of the medial canthal area above the medial canthal corner 61, and also shows the position of main entry point 80 in relation to the eye 60, eyebrow 64 and nose 66. Support structures can precisely position sensing means on top of the main entry point of the tunnel because the main entry point is completely demarcated by anatomic landmarks. In general the sensor is positioned on the medial canthal skin area above the medial canthal corner and adjacent to the eye. Although indicators can be placed on support structures to better guide the positioning of the sensor, the universal presence of the various permanent anatomic landmarks allows the precise positioning by any non-technical person.

The main entry point is the preferred location for the positioning of the sensor by the support structure, but the placement of a sensor in any part of the end of

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the tunnel including the general entry point area and peripheral area provides clinically useful measurements depending on the application. The degree of precision needed for the measurement will determine the positioning of the sensor. In cases of neurosurgery, cardiovascular surgery, or other surgical procedure in which the patient is at high risk of hypothermia or malignant hyperthermia, the preferred position of the sensor is at the main entry point. For recreational or professional sports, military, workers, fever detection at home, wrinkle protection in sunlight, and the like, positioning the sensor in any part of the end of the tunnel area provides the precision needed for clinical usefulness.

In accordance with the present invention, FIG. 6 is a schematic view of the face showing the general area of the main entry point of the tunnel 90 and the overall area of the end of the tunnel and its relationship to the medial canthal tendon 67. The end of the tunnel includes the general main entry point area 90 and the upper eyelid area 94. The area 90 has a peripheral portion 92. Both medial canthal areas have a medial canthal tendon and the left eye is used to facilitate the illustration. The medial canthal tendon 67 arises at the medial canthal corner 61 of eye 60. The left medial canthal tendon 67 is diametrically opposed to the right medial canthal tendon as shown by broken lines 61a which begins at the medial corner of the eye 61. Although the main entry point is above the medial canthal tendon 67, some of the peripheral area 92 of the tunnel is located below tendon 67.

Fig. 6A is a schematic diagram showing two physiologic tunnels. The upper figure shows the area corresponding to the BTT 10. The lower figure shows an area corresponding to a metabolic tunnel 13 which

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includes the upper eyelid area 13a and lower eyelid area 13b seen as light blue areas in FIG. 1B. For measuring the concentration of chemical substances the total radiant power is not mandatory. The key aspect for clinical useful spectroscopic measurements is signal coming from the cerebral area and the reduction or elimination of interfering constituents, and the main interfering constituent is adipose tissue. By removing adipose tissue and receiving spectral information carried by a vasculature from the brain, precise and clinical measurements can be achieved. The sensors supported by support structure are adapted to have a field of view that matches in total or in part the metabolic tunnel 13 for capturing thermal radiation from said tunnel 13.

To determine the thermal stability of the tunnel area in relation to environmental changes, cold and heat challenge tests were performed. FIGS. 7A and 7B are thermal infrared images of an exemplary experiment showing the human face before and after cold challenge. In FIG. 7A the face has a lighter appearance when compared to FIG. 7B which is darker indicating a lower temperature. The nose in FIG. 7A has an overall whitish appearance as compared to the nose in FIG. 7B which has an overall darker appearance. Since the areas outside the tunnel have thermoregulatory arteriovenous shunts and interfering constituents including fat, the changes in the temperature of the environment are reflected in said areas. Thus measurements in those non-tunnel areas of the face reflect the environment instead of the actual body temperature. The non-tunnel areas of the skin in the face and body can change with the changes in ambient temperature. The radiant power of the tunnel area remains stable and there is no change in the amount of thermal energy demonstrating the stability of the thermal

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emission of the area. Changes of thermal radiation at the tunnel area only occur when the brain temperature changes, which provides the most reliable measurement of the thermal status of the body.

FIGS. 8A and 8B are thermal infrared images of the human face of different subjects showing the tunnel seen as bright white spots in the medial canthal area. The physiologic tunnel is universally present in all individuals despite anatomic variations and ethnic differences. FIGS. 9A and 9B are thermal infrared image showing that the tunnel seen as bright white spots are equally present in animals, illustrated here by a cat (FIG. 9A) and a dog (FIG. 9B).

A preferred embodiment includes a temperature sensor with measurement processing electronics housed in a patch-like support structure which positions a passive sensor directly in contact with the skin over the brain temperature tunnel site. Accordingly, FIG. 10 is a perspective view of a preferred embodiment showing a person 100 wearing a support structure comprised of a patch 72 with a passive sensor 74 positioned on the skin at the end of the tunnel. Person 100 is laying on a mattress 76 which contains antenna 78. Wire 82 extends from antenna 78 to controller unit 84 with said controller 84 communicating with device 88 by communication line 86. Exemplary device 88 includes a decoding and display unit at the bedside or at the nursing station. It is understood that controller unit 84 besides communicating by cable 86, can also contain wireless transmission means to wirelessly transmit the signal acquired to a remote station. This inductive radio frequency powered telemetry system can use the same antenna 78 to transfer energy and to receive the signal.

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The antenna 78 can be secured to a mattress, pillow, frame of a bed, and the like in a removable or permanent manner. The preferred embodiment includes a thin flat antenna encapsulated by a flexible polymer that is secured to a mattress and is not visible to the user. Alternatively an antenna can be placed in any area surrounding the patient, such as on a night stand.

The antenna 78 and controller unit 84 works as a receiver/interrogator. A receiver/interrogator antenna 78 causes RF energy to radiate to the microcircuit in the patch 72. This energy would be stored and converted for use in the temperature measurement process and in the transmission of the data from the patch 72 to the antenna 78. Once sufficient energy has been transferred, the microcircuit makes the measurement and transmits that data to the receiver/interrogator antenna 78 with said data being processed at controller 84 and further communicated to device 88 for display or further transmission. The switching elements involved in the acquisition of the sensor data (measurement of the energy) is done in a sequence so that the quantized answer is available and stored prior to the activation of the noise-rich transmission signal. Thus the two inherently incompatible processes successfully coexist because they are not active simultaneously.

The capability of the RF link to communicate in the presence of noise is accomplished by "spreading" the spectral content of the transmitted energy in a way that would inherently add redundancy to the transmission while reducing the probability that the transmission can ever be interpreted by the receiver/interrogator 78 as another transmission or noise that would cause the receiver/interrogator 78 to transmit and display incorrect information. This wireless transmission scheme

can be implemented with very few active elements. The modulation purposely spreads the transmission energy across the spectrum and thus provides noise immunity and the system can be ultimately be produced via batch processing and thus at a very low cost.

Since the energy to operate sensor 74 in patch 72 comes from the antenna 78, the microcircuit in said patch 72 can be very small and ultra-thin. Size of the patch 72 would be further minimized to extremely small dimensions by the design approach that places all the processing function of the RF link in the controller unit 84 working as a receiver. RF messaging protocol and the control of the sensor 74 resides in the receiver/interrogator controller 84 powered by commercially available batteries or by AC current. Thus the RF messaging protocol and the control of the sensor 74 is directly controlled by the MCU of controller 84. The circuit resident in the patch 72 is preferably completely self-contained. The sensing system 74 in the patch 72 is preferably a silicon microcircuit containing the circuits needed to support the sensor, quantatize the data from the sensor, encode the data for radio frequency transmission, and transmit the data, besides power conditioning circuits and digital state control. Sensor, support circuitry, RF power and communications are all deposited on a micro-chip die allowing the circuit to be built in large quantities and at very low cost. This scheme is preferably used for both passive and active devices.

The operational process can consist of two modes, manual or automated. In the manual mode, an operator such as a nurse activates the system and RF energy radiated to the microcircuit in the patch 72 would be stored and converted for use in the temperature measurement process and in the transmission of the data from the end of the

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BTT to the antenna 78. Once sufficient energy has been transferred (less than 1 second) the microcircuit would make the measurement and transmit the data to the antenna 78 receiver and controller 84 to be displayed for example on a back-lit LCD display at the nursing station. An audio "beep" will signal that the data had been received and is ready for view. In the automated mode, the process is done automatically and continuously by interrogation at preset frequency and an alarm being activated when the reading is outside the specified range. A tri-dimensional antenna can also be used and the controller 84 set up to search the three dimensions of the antenna to assure continued and proper connection between antenna 78 and sensing means 74. It is also understood that the sensor can modulate reflected RF energy. Accordingly, the energy will trigger the unit to acquire a temperature measurement, and then the unit will modulate the reflected energy. This reflected energy and information will be received at the interrogator and displayed as above.

The present invention also provides a method for monitoring biological parameters, which comprises the steps of: securing a passive sensor to the body; generating electromagnetic radiation from a device secured to at least one of a mattress, a pillow and the frame of a bed; generating a signal from said passive sensor; receiving said signal by a device secured to at least one of a mattress, a pillow and the frame of a bed; and determining the value of the biological parameter based on said signal.

It is understood that a variety of external power sources such as electromagnetic coupling can be used including an ultra-capacitor charged externally through electromagnetic induction coupling and cells that can be

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recharged by an external oscillator. It is also understood that the sensing system can be remotely driven by ultrasonic waves.

FIG. 11 is a perspective view of another preferred embodiment showing in closer detail a person 100 wearing a support structure comprised of patch 72 with a sensor 74, transmitter 71, and digital converter and control 73 positioned on the skin at the end of the tunnel. Person 100 is wearing a necklace which works as antenna 78 and a pendant in the necklace works as the controller unit and transmitting unit 79. Solar cells and/or specialized batteries power unit 79. Patients are used to carrying Holter monitoring and cards with cords around their necks and this embodiment can fit well with those currently used systems. It is understood that, besides a necklace, a variety of articles including clothing and electric devices can be used as a receiver/interrogator and this capability can be easily incorporated into cell phones, note book computers, hand held computers, internet appliances for connecting to the internet, and the like, so a patient could use his/her cell phone or computer means to monitor his/her brain temperature.

The preferred embodiments shown in FIGS. 10 and 11 can preferably provide continuous monitoring of fever or temperature spikes for any surgery, for any patient admitted to a hospital, for nursing home patients, in ambulances, and to prevent death or harm by hospital infection. Hospital infection is an infection acquired during a hospital stay. Hospital infection is the fourth cause of death in the US and kills more than 100,000 patients annually and occurs primarily due to lack of early identification of fever or temperature spikes. The present invention provides timely identification and therapy of an infection due to 24 hour automated

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monitoring of temperature. If there is a spike in temperature an alarm can be activated. This will allow timely identification and treatment of an infection and thus prevent death or costly complications such as septic shock that can occur due to delay in treating infectious processes. Besides, said preferred embodiments provide means for continuous fever monitoring at home including during sleeping for both children and adults.

FIG. 12A is a front perspective view of a preferred embodiment showing a person 100 wearing a support structure comprised of a patch 109 with indicator lines 111 and containing an active sensor 102 positioned on the skin at the end of the tunnel. The preferred embodiment shown in FIG. 12 provides transmitting means 104, processing means 106, AD converter 107 and sensing means 102 connected by flexible circuit 110 to power source 108. For example the transmitting module can include RF, sound or light. FIG. 12B is a side schematic view showing the flexible nature of the support structure in FIG. 12A with flexible circuit 110 connecting microelectronic package 103 which contains transmitting means, processing means and sensing means in the right side of the patch 109 to the power source 108 in the left side of said patch 109. Exemplary embodiments will be described.

In accordance with this exemplary embodiment for temperature measurement, the thermal energy emitted by the BTT is sensed by the temperature sensor 102 such as a miniature thermistor which produces a signal representing the thermal energy sensed. The signal is then converted to digital information and processed by processor 106 using standard processing for determining the temperature. An exemplary sonic-based system for brain temperature measurement comprises a temperature sensor, input coupling circuit, signal processing circuit, output

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coupling circuit and output display circuit. A temperature sensor 102 (e.g., thermistor) in a patch 109 placed on the surface of the skin at the medial canthal area responds to variations in brain temperature which is manifested as a DC voltage signal.

This signal, coupled to a Signal Processor Circuit via an Input Coupling Circuit is used to modulate the output of an oscillator, e.g., a multivibrator circuit, piezoelectric systems operating in or just above the audio frequency range. The oscillator is a primary component of the Signal Processor Circuit. The output of the oscillator is input to an amplifier, which is the second primary component of the Signal Processor.

The amplifier increases the output level from the oscillator so that the output of the Signal Processor is sufficient to drive an Output Display Circuit. Depending on the nature of the Output Display Circuit, e.g., an audio speaker, a visual LED display, or other possible display embodiment, an Output Coupling Circuit is utilized to match the signal from the Signal Processor Circuit to the Output Display Circuit. For an Output Display Circuit that requires a digital input signal, the Output Coupling Circuit might include an analog to digital (A/D) converter circuit. A DC power supply circuit is the remaining primary component in the Signal Processor Module. The DC power supply is required to support the operation of the oscillator and the amplifier in the Signal Processing Circuit. Embodiments of the DC power supply can include ultra miniature DC batteries, a light sensitive DC power source, or some combination of the two. The micro transducers, signal processing electronics, transmitters and power source can be preferably constructed as an Application Specific Integrated Circuit or as a hybrid circuit alone or in

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combination with MEMS (micro electrical mechanical systems) technology.

The thermistor voltage is input to a microcontroller unit, i.e., a single chip microprocessor, which is pre-programmed to process the thermistor voltage into a digital signal which corresponds to the patient's measured temperature in degrees C (or degrees F) at the BTT site. It is understood that different programming and schemes can be used. For example, the sensor voltage can be directly fed into to the microcontroller for conversion to a temperature value and then displayed on a screen as a temperature value, e.g., 98.6° F. On the other hand the voltage can be processed through an analog to digital converter (ADC) before it is input to the microcontroller.

The microcontroller output, after additional signal conditioning, serves as the driver for a piezoelectric audio frequency (ultrasonic) transmitter. The piezoelectric transmitter wirelessly sends digital pulses that can be recognized by software in a clock radio sized receiver module consisting of a microphone, low-pass audio filter, amplifier, microcontroller unit, local temperature display and pre-selected temperature level alert mechanism. The signal processing software is pre-programmed into the microcontroller unit of the receiver. Although the present invention provides means for RF transmission in the presence of noise, this particular embodiment using a microphone as the receiving unit may offer additional advantages in the hospital setting since there is zero RF interference with the many other RF devices usually present in said setting. The microcontroller unit drives a temperature display for each patient being monitored. Each transmitter is tagged with its own ID. Thus one receiver module can be used for

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various patients. A watch, cell phone, and the like adapted with a microphone can also work as the receiver module.

In another embodiment the output of the microcontroller is used to drive a piezo-electric buzzer. The microcontroller output drives the piezo-electric buzzer to alert the user of the health threatening situation. In this design the output of the microcontroller may be fed into a digital-to-analog converter (DAC) that transforms the digital data signal from the microcontroller to an equivalent analog signal which is used to drive the buzzer.

In yet another embodiment the output from the (DAC) is used to drive a speech synthesizer chip programmed to output an appropriate audio warning to the user, for instance an athlete at risk of heatstroke. For a sensed temperature above 39 degrees Celsius the message might be: "Your Body temperature is High. Seek shade. Drink cold liquid. Rest." For temperature below 36 degrees Celsius the message might be: "Your Body temperature is Low. Seek shelter from the Cold. Drink warm liquid. Warm up."

In another embodiment the output is used to drive a light transmitter programmed to output an appropriate light signal. The transmitter consists of an infrared light that is activated when the temperature reaches a certain level. The light signal will work as a remote control unit that activates a remote unit that sounds an alarm. This embodiment for instance can alert the parents during the night when the child is sleeping and has a temperature spike.

An exemplary embodiment of the platform for local reporting consists of three electronic modules mechanically housed in a fabric or plastic holder such as

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patch 100, which contain a sensor 102 positioned on the skin at the BTT site. The modules are: Temperature Sensor Module, Microcontroller Module, and Output Display Module in addition to a battery. An electronic interface is used between each module for the overall device to properly function. The configuration of this system consists of a strip such as patch 100 attached to the BTT area by a self-adhesive pad. A thermistor coupled to a microcontroller drives an audio frequency piezoelectric transmitter or LED. The system provides local reporting of temperature without a receiver. An audio tone or light will alert the user when certain thresholds are met. The tone can work as a chime or reproduction of human voice.

Another exemplary embodiment for remote reporting consists of four electronic modules: Sensor Module, Microcontroller Module, Output Transmitter Module and Receiver/Monitor Module. From a mechanical viewpoint the first three modules are virtually identical to the first embodiment. Electronically the Temperature Sensor and Microprocessor Modules are identical to the previous embodiment. In this embodiment an Output Transmitter Module replaces the previous local Output Display Module. Output Transmitter Module is designed to transmit wirelessly the temperature results determined by the Microprocessor Module to a remotely located Receiver/Monitor Module. An electronic interface is used between each module for proper function. This device can be utilized by patients in a hospital or home setting. On a continuous basis temperature levels can be obtained by accessing data provided by the Receiver/Monitor Module.

A variety of temperature sensing elements can be used as a temperature sensor including a thermistor, thermocouple, or RTD (Resistance Temperature Detector), platinum wire, surface mounted sensors, semiconductors,

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thermoelectric systems which measure surface temperature, optic fiber which fluoresces, bimetallic devices, liquid expansion devices, and change-of-state devices, heat flux sensor, crystal thermometry and reversible temperature indicators including liquid crystal Mylar sheets. Two preferred temperature sensors are thermistor models ET-503 and 104JT available from Semitec of Japan.

FIG. 13 shows a block diagram of a preferred embodiment of the present invention linking transmitter 120 to receiver 130. Transmitter 120 preferably includes a chip 112 incorporating a microcontroller (MCU) 114, a radio frequency transmitter (RF) 116 and a A/D converter 118 in addition to a power source 122, amplifier (A) 124, sensor 126, and antenna 128, preferably built-in in the chip. Exemplary chips include: (1) rfPIC12F675F, (available from Microchip Corporation, Arizona, USA) this is a MCU + ADC + 433Mhz Transmitter (2) CC1010, available from Chipcon Corporation of Norway.

Receiver 130 preferably includes a chip RF transceiver 132 (e.g., CC1000 available from Chipcon Corporation), a microcontroller unit (MCU) 134, amplifier and filtering units (A/F) 136, display 138, clock 140, keypad 142, LED 144, speaker 146, in addition to a power source 150 and input/output units (I/O) 148 and associated modem 152, optical transceiver 154 and communication ports 156.

A variety of means can be used for the transmission scheme besides the commercially available RF transmitter chips previously mentioned. One simple transmission means include an apparatus with a single channel transmitter in the 916.48 MHz band that sends the temperature readings to a bed side receiver as a frequency proportional to the reading. The thermistor's resistance would control the frequency of an oscillator feeding the RF transmitter

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data input. If the duty cycle is less than 1%, the 318 MHz band would be usable. Rather than frequency, a period measurement technique can be used. The model uses a simple radio frequency carrier as the information transport and modulating that carrier with the brain temperature information derived from a transduction device capable of changing its electrical characteristics as a function of temperature (e.g.; thermistor). Either frequency or amplitude of the carrier would be modulated by the temperature information so that a receiver tuned to that frequency could demodulate the changing carrier and recover the slowly moving temperature data.

Another transmission technique suitable to transmit the signal from a sensor in a support structure is a chirp device. This means that when activated, the transmitter outputs a carrier that starts at a lower frequency in the ISM band and smoothly increases frequency with time until a maximum frequency is reached. The brain temperature information is used to modify the rate of change of frequency of the chirp. The receiver is designed to measure the chirp input very accurately by looking for two or more specific frequencies. When the first of the frequencies is detected, a clock measures the elapsed time until the second frequency is received. Accordingly, a third, fourth, etc., frequency could be added to aid in the rejection of noise. Since virtually all the direct sequence spread spectrum transmitters and frequency hopping transmitters are spread randomly throughout their part of the ISM band, the probability of them actually producing the "right" sequence of frequencies at exactly the right time is remote.

Once the receiver measured the timing between the target frequencies, that time is the value that would represent the brain temperature. If the expected second,

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third, or fourth frequency is not received by the receiver within a "known" time window, the receiver rejects the initial inputs as noise. This provides a spread spectrum system by using a wide spectrum for transmitting the information while encoding the information in a way that is unlike the expected noise from other users of the ISM band. The chirp transmitter is low cost and simple to build and the brain temperature transducer is one of the active elements that controls the rate of change of frequency.

Other preferred embodiments for local reporting include a sensor, an operational amplifier (LM358 available from National Semicondutor Corporation) and a LED in addition to a power source. It is understood that the operational amplifier (Op Amp) can be substituted by a MCU and the LED substituted by a piezoelectric component.

FIG. 14 is a schematic diagram showing the support structure 160 with a sensor 158, and MCU 164 controlling and/or adjusting unit 162. Communication between MCU 164 and unit 162 is achieved by wires 168 or wirelessly 166. By way of example, but not by limitation, exemplary units 162 include climate control units in cars, thermostats, vehicle seats, furniture, exercise machines, clothing, footwear, medical devices, drug pumps, and the like. For example, MCU 164 is programmed with transmit the temperature level to receiver unit 162 in the exercise machine. MCU in the exercising machine unit 162 is programmed to adjust speed or other settings in accordance with the signal generated by MCU 164.

The preferred embodiment allows precise positioning of the sensing apparatus by the support structure on the BTT site. The support structure is designed to conform to the anatomical landmarks of the BTT area which assures

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proper placement of the sensor at all times. The corner of the eye is considered a permanent anatomic landmark, i.e., it is present in the same location in all human beings. The BTT area is also a permanent anatomic landmark as demonstrated by the present invention. To facilitate consistent placement at the BTT site, an indicator in the support structure can be used as shown in FIGS. 15A to 15E.

FIG. 15A shows a Guiding Line 170 placed on the outside surface of the support structure 172. The Guiding Line 170 is lined up with the medial corner of the eye 174. The sensor 176 is located above the Guiding Line 170 and on the outer edge of the support structure 172, so once the Guiding Line 170 of the support structure 172 is lined up with the medial corner of the eye 174, the sensor 176 is positioned on the main entry point of the tunnel. Thus the support structure 172 can be precisely and consistently applied in a way to allow the sensor 176 to cover the BTT area at all times.

FIG. 15B shows a different design of the patch 172 but with the same Guiding Line 170 lined up with the medial corner of the eye 174, thus allowing consistent placement of sensor 176 at the BTT site despite the difference in design.

FIG. 15C is another preferred embodiment showing the senor 176 lined up with medial corner 174. Thus in this embodiment a Guiding Line is not required and the sensor 176 itself guides the positioning.

In FIG. 15D the MCU 175 and cell 177 of patch 172 are located outside of the BTT site while sensor 176 is precisely positioned at the BTT site. It is understood that any type of indicator on the support structure can be used to allow proper placement in the BTT area including external marks, leaflets, cuts in the support

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structure, different geometry that lines up with the corner of the eye, and the like.

FIG. 15E is another preferred embodiment showing the superior edge 176a of sensor 176 lined up with medial corner 174 and located in the inferior aspect of the medial canthal area while microchip controller 175 is located in the superior aspect of the medial canthal area. Support structure 172 has a geometric indicator 179 comprised of a small recess on the support structure 172. It is understood that a strip working as support structure like a band-aid can have the side opposite to the sensor and hardware made with tear off pieces. The sensor side is first attached to the skin and any excess strip can be easily torn off. Two sizes, adult and children cover all potential users.

The material for the support structure working as a patch can be soft and have insulating properties such as are found in polyethylene. Depending on the application a multilayer structure of the patch can include from the external side to the skin side the following: thinsulate layer; double foam adhesive (polyethylene); sensor (thermistor); and a Mylar sheet. The sensor surface can be covered by the Mylar sheet, which in turn is surrounded by the adhesive side of the foam. Any soft thin material with high thermal resistance and low thermal conductivity can be preferably used as an interface between the sensor and the exterior, such as polyurethane foam (K =0.02 W/m.C). Any support structure can incorporate the preferred insulation material.

A preferred power source for the patch includes natural thermoelectrics as disclosed by the present invention. In addition, standard lightweight thin plastic batteries using a combination of plastics such as fluorophenylthiophenes as electrodes can be used, and are

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flexible allowing better conformation with the anatomy of the BTT site. Another exemplary suitable power source includes a light weight ultra-thin solid state lithium battery comprised of a semisolid plastic electrolyte which are about 300 microns thick.

The system can have two modes: at room temperature the system is quiet and at body temperature the system is activated. The system can also have an on/off switch by creating a circuit using skin resistance, so only when the sensor is placed on the skin is the system activated. The patch can also have a built-in switch in which peeling off a conductive backing opens the circuit (pads) and turn the system on. In addition, when removed from the body, the patch can be placed in a case containing a magnet. The magnet in the case acts as an off switch and transmission is terminated when said patch is in the case.

FIG. 16A to 16C are perspective views of preferred embodiments showing a person 100 wearing support structures 180 incorporated as patches. In a preferred embodiment shown in FIG 16A, the support structure 180 contains LED 184, cell 186, and sensor 182. Sensor 182 is positioned at a main entry point on the superior aspect of the medial canthal area adjacent to the medial corner of the eye 25. LED 184 is activated when signal reaches certain thresholds and in accordance with the principles of the invention. FIG. 16B is another preferred embodiment showing a person 100 wearing support structure 180 with sensor 182 positioned at the general area of the main entry point of the tunnel with the superior edge 181 of support structure 180 being lined up with the corner of the eye 25. Support structure 180 contains an extension that rests on the cheek area 189 and houses transmitting means 183 for wireless transmission,

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processing means 185 and power source 187. FIG 16C is an exemplary preferred embodiment showing person 100 wearing a two piece structure 180a comprised of support structure 180b and housing structure 180c connected by wires 192, preferably a flexible circuit. Support structure 180b contains the sensor 182 which is positioned at the BTT site. Housing structure 180c which can comprise an adhesive strip on the forehead 21 houses processing means 183a, transmitting means 183b and power source 187 for transmitting the signal to unit 194, for example a cell phone.

FIG. 17 is a schematic view of another preferred embodiment showing the support structure 180 with sensor 182 being held at the nose 191 by a clip 196. Support structure 180 extends superiorly to the forehead 193. Housing 195 of support structure 180 contains pressure attachment means such as clip 196. Housing 197 on the forehead contains the transmitting means and power source. Clip 196 uses a spring based structure 196a to apply gentle pressure to secure support structure 180 and sensor 182 in a stable position. Housing 197 can also have a LCD display 19. The LCD 19 can have an inverted image to be viewed in a mirror by the user, besides LCD 19 can have a hinge or be foldable to allow proper positioning to allow the user to easily view the numerical value displayed.

FIG. 18 is a perspective view of another preferred embodiment showing a person 100 wearing a support structure 180 comprised of a patch with sensor 182 positioned on the skin at the end of the tunnel and connected by a wire 199 to a decoding and display unit 200. Support structure 180 has a visible indicator 170 lined up with the medial corner of the eye 174. Wire 199 includes an adhesive tape 201 within its first 20 cm, and

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most preferably adhesive tape connected to wire 199 is in the first 10 cm of wire from sensor 182.

FIGS. 19A1 to 19D are schematic views of preferred geometry and dimensions of support structures 180 and sensing means 182. Special geometry and dimension of sensors and support structure is necessary for the optimal functioning of the present invention. The dimensions and design for the support structure 180 are made in order to optimize function and in accordance with the geometry and dimensions of the different parts of the tunnel.

FIG. 19A1 shows support structure 180 working as a patch. The patch 180 contains sensor 182. The patch 180 may contain other hardware or solely the sensor 182. Exemplary sensor 182 is a flat thermistor or surface mount thermistor. The preferred longest dimension for the patch referred to as "z" is equal or less than 12 mm, preferably equal or less than 8 mm, and most preferably equal or less than 5 mm. The shortest distance from the outer edge of the sensor 182 to the outer edge of the patch 180 is referred to as "x". "x" is equal or less than 11 mm, preferably equal or less than 6 mm and most preferably equal or less than 2.5 mm. For illustrative purposes the sensor 182 has unequal sides, and distance "y" corresponds to the longest distance from outer edge of the sensor to outer edge of the patch 180. Despite having unequal sides, the shortest distance "x" is the determining factor for the preferred embodiment. It is understood that the whole surface of the sensor 182 can be covered with an adhesive and thus there is no distance between the sensor and an outer edge of a support structure.

An exemplary embodiment for that includes a sensor in which the surface touching the skin at the BTT site is

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made with Mylar. The Mylar surface, which comprises the sensor itself, can have an adhesive in the surface that touches the skin.

As shown in FIG. 19A2, the sensor 182 has adhesive in its surface, to be secured to skin 11. The sensor then can be applied to the BTT site in accordance with the principles of the invention. The preferred distance "x" equal or less than 2.5 mm allows precise pinpoint placement of sensor 182 at the main entry site of the tunnel and thus allows the most optimal signal acquisition, and it should be used for applications that require greatest precision of measurements such as during monitoring surgical procedures. Although a patch was used as support structure for the description of the preferred dimensions, it is understood that the same dimensions can be applied to any support structure in accordance with the principle of the invention including clips, medial canthal pads, head mounted gear, and the like.

FIG. 19B is an exemplary embodiment of a round patch 180 with a flat sensor 182. Preferred dimensions "x" and "z" apply equally as for FIG. 19A1. FIG. 19C is an exemplary embodiment of a patch 180 with a bead-type sensor 182. Preferred dimensions "x" and "z" apply equally as for FIG. 19A1. FIG. 19D is an exemplary embodiment of a support structure 180 with a sensor-chip 15. Sensor chip 15 comprises a sensor that is integrated as part of a chip, such as an Application Specific Integrated Circuit (ASIC). For example sensor chip 15 includes sensor 15a, processor 15b, and transmitter 15c. Preferred dimension "x" apply equally as for FIG. 19A1. Other hardware such as power source 27 may be housed in the support structure 180 which can have a long dimension referred to as "d" that does not affect performance as long as the dimension "x" is preserved.

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The support structure and sensor are adapted to match the geometry and dimensions of the tunnel, for either contact measurements or non-contact measurements, in which the sensor does not touch the skin at the BTT site.

FIGS. 20A to 20C show the preferred dimensions "x" for any support structure in accordance with the present invention. The distance from the outer edge 180a of the support structure to outer edges of sensor 182a is 11 mm, as shown in FIG. 20A. Preferably, the distance from the outer edge 180a of support structure to outer edges of sensor 182a is 6 mm, as shown in FIG. 20B. Most preferably, the distance from the outer edge 180a of the support structure to outer edges of sensor 182a, is 2.5 mm, as shown in FIG. 20C.

Preferred positions of sensors 182 in relation to the medial corner of the eye 184 are shown in FIGs. 21A and 21B. Support structure 180 positions sensor 182 lined up with medial corner 184 (FIG. 21B). Preferably, as shown in FIG. 21A, support structure 180 positions the sensor 182 above the medial corner 184.

The preferred embodiments of support structures incorporated as patches and clips are preferably used in the hospital setting and in the health care field including continuous monitoring of fever or temperature spikes. Support structures incorporated as medial canthal pads or head mounted gear are preferred for monitoring hyperthermia, hypothermia and hydration status of recreational athletes, professional athletes, military, firefighters, construction workers and other physically intensive occupations, occupational safety, and for preventing wrinkle formation due to thermal damage by sun light.

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FIGS. 22A to 22C are perspective views of preferred embodiments showing a person 100 wearing support structures incorporated as a medial canthal pad 204 of eyeglasses 206. In a preferred embodiment shown in FIG. 22A, the medial canthal pad 204 contains sensor 202. Connecting arm 208 connects medial canthal pad 204 to eyeglasses frame 206 next to regular nose pads 212. Sensor 202 is positioned on the superior aspect of the medial canthal area adjacent to the medial corner of the eye 210.

FIG. 22B is an exemplary preferred embodiment showing person 100 wearing support structure incorporated as medial canthal pads 204 with sensor 202 integrated into specially constructed eyeglasses frame 216 and containing LEDs 228, 230. Connecting piece 220 which connects the left lens rim 222 and right lens rim 224 is constructed and positioned at a higher position than customary eyeglasses construction in relation to the lens rim 222, 224. Due to the higher position of connecting piece 220 and the special construction of frame 216, the upper edge 222a of left lens rim 222 is positioned slightly above the eyebrow 226. This construction allows medial canthal pad 204 to be positioned at the BTT site while LEDs 228,230 are lined up with the visual axis. Arm 232 of medial canthal pad 204 can be flexible and adjustable for proper positioning of sensor 202 on the skin at the BTT site and for moving away from the BTT site when measurement is not required. The LED 228 is green and LED 230 is red, and said LEDs 228, 230 are activated when signal reaches certain thresholds.

FIG. 22C is an exemplary preferred embodiment showing person 100 wearing support structure incorporated as medial canthal pads 204 with sensor 202. Signal from sensor 202 is transmitted wirelessly from transmitter 234

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housed in the temple of eyeglasses 236. Receiving unit 238 receives a signal from transmitter 234 for processing and displaying. Exemplary receiving units 238 include watch, cell phone, pagers, hand held computers, and the like.

FIGS. 23A to 23B are perspective views of alternative embodiments showing support structures incorporated as a modified nose pad 242 of eyeglasses 244. FIG. 23A is a perspective view showing eyeglasses 244 containing a modified nose pad 242 with sensor 240 and processor 241, sweat sensor 246 and power source 248 supported by temple 250, and transmitter 252 supported by temple 254, all of which are electrically connected. Modified nose pads 242 are comprised of oversized nose pads with a horn like extension 243 superiorly which positions sensor 240 on top of the end of the tunnel.

FIG. 23B is a perspective view showing eyeglasses 256 containing an oversized modified nose pad 258 with sensor 240, sweat sensor 260 supported by temple 262, and transmitter 264 supported by temple 266. Modified oversized nose pad 258 measures preferably 12 mm or more in its superior aspect 258a and contains sensor 240 in its outer edge in accordance with the dimensions and principles of the present invention.

Another preferred embodiment of the invention, shown in FIG. 24, provides goggles 268 supporting medial canthal pads 260 adapted to position sensor 262, 264 at the tunnel site on the skin. As shown, goggles 268 also support transmitting means 261, power source 263, local reporting means 265 such as LED and an antenna 267 for remote reporting. Antenna 267 is preferably integrated as part of the lens rim 269 of goggles 268.

As shown in FIG. 25, additional means related to the signal generated by sensor 270 in medial canthal pad 272

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include power switch 274, set switch 276 which denotes a mode selector, transmitter 278 for wireless transmission of signals, a speaker 282, piezoelectric device 283, input means 284 and processing means 286. The means 274, 276, 278, 282, 284, and 286 are preferably supported by any portion of the frame of eyeglasses 280. It is understood that a variety of means, switches and controlling means to allow storage of data, time and other multiple functions switches can be incorporated in the apparatus in addition to wires for wired transmission of signals.

FIG. 26A is a rear perspective view of one preferred embodiment showing sensors 299, 300 supported by medial canthal pads 290, 289 of eyeglasses 292 and includes lens rim 297 and display 298 in addition to transmitter 288, sweat sensor 294 and wires 296 disposed within temple 295 and lens rim 293 of said eyeglasses 292 and connected to display means 296.

FIG. 26B is a front perspective view of eyeglasses 292 including sweat sensor 294, transmitter 288 and wires 296 disposed within temple 295 and lens rim 293 of eyeglasses 292 and connected to display means. In this embodiment sweat sensor 294 produces a signal indicating the concentration of substances in sweat (e.g., sodium of 9 mmol/L) which is displayed on left side display 296 and sensor 300 supported by medial canthal pad 290 produces a signal indicative of, for example, brain temperature of 98 degrees F which is displayed on the right side display 298. Sweat sensor can be porous or microporous in order to optimize fluid passage to sensors when measuring chemical components.

A variety of display means and associated lenses for proper focusing can be used including liquid crystal display, LEDs, fiber optic, micro-projection, plasma

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means, and the like. It is understood that display means can be attached directly to the lens or be an integral part of the lens. It is also understood that display means can include a separate portion contained in the lens rim or outside of the lens rim. Further, the two lenses and display 296, 298 held within the lens rims 293, 297 can be replaced with a single unit which can be attached directly to the frame of eyeglasses 292 with or without the use of lens rim 293, 297.

FIG. 27 is a perspective view of another preferred embodiment showing a three piece support structure 304 and preferably providing a medial canthal pad connecting piece 303 adapted as an interchangeable connecting piece. This embodiment comprises three pieces. Piece 301 comprises left lens rim 301a and left temple 301b. Piece 302 comprises right lens rim 302a and right temple 302b. Piece 303 called the medial canthal piece connector comprises the connecting bridge of eyeglasses 303a and the pad structure 303b of eyeglasses. Pad piece 303 is particularly adapted to provide medial canthal pads 306 for positioning a sensor 308 at the BTT site. In reference to this embodiment, the user can buy three piece eyeglasses in accordance with the invention in which the connector 303 has no sensing capabilities, and it is thus a lower cost. However, the three piece eyeglasses 304 offers the versatility of replacing the non-sensing connector 303 by a connector 303 with sensing capabilities. As shown in FIG. 27 connector 303 with medial canthal pads 306 and sensor 308 includes also radio frequency transmitter 310 and cell 312. Therefore, connector 303 provides all the necessary hardware including means for sensing, transmitting, and reporting the signal. Any means for attachment known in the art can

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be used including pressure means, sliding means, pins, and the like.

Another preferred embodiment, as shown in FIG. 28A, provides a removable medial canthal piece 314 supporting sensor 316. As shown, connecting bridge 320 of eyeglasses 318 are attached to medial canthal piece 314 in a releasable manner. Eyeglasses 318 further includes sweat sensor 322, 324 supported by front part 311 and transmitting means 326 supported by temple 313. Front part 311 of eyeglasses 318 defines a front brow portion and extends across the forehead of the wearer and contains sweat sensor 322, 324. Sweat fluid goes through membranes in the sensor 322, 324 and reaches an electrode with generation of current proportional to the amount of analyte found in the sweat fluid.

FIG. 28B is a rear perspective view of the removable medial canthal piece 314 showing visual reporting means 323, 325 such as a green LED and a red LED in left arm 328 and sensor 316 adapted to be positioned at the end of the tunnel, and wire 326 for electrically connecting right arm 329 and left arm 328 of medial canthal piece 314. FIG. 28C is a front perspective view of the removable medial canthal piece 314 showing power source 330, transmitter 332 and sensor 316 in right arm 329 and wire 326 for electrically connecting right arm 329 and left arm 328 of medial canthal piece 314. Medial canthal piece 314 can be replaced by a non-sensing regular nose pad which would have the same size and dimension as medial canthal piece 314 for adequate fitting with connecting bridge 320 of eyeglasses 318 of FIG. 28A. The removable medial canthal piece can have, besides LED, a built-in LCD display for displaying a numerical value and/or RF transmitter. Therefore, the removable medial

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canthal piece can have one or various reporting means integrated as a single sensing and reporting unit.

FIG. 29 is a rear perspective view of one preferred embodiment of a support structure incorporated as a clip-on 340 for eyeglasses and includes attachment means 338 such as a hook or a magnet, transmitting means 342, processing means 344, power source 346, medial canthal pad 348 mounted on a three axis rotatable structure 349 for proper positioning at the BTT site, and sensor 350. Clip-on 340 is adapted to be mounted on regular eyeglasses and to fit the medial canthal pad 348 above the regular nose pads of eyeglasses.

Sensing medial canthal pads can be preferably connected to attachment structure such as eyeglasses independent of the presence of specialized connecting or attachment means mounted in said eyeglasses such as grooves, pins, and the like. This embodiment provides means for the universal use of sensing medial canthal pads in any type or brand of attachment structure. FIG. 30 shows a front perspective view of medial canthal pads 352 comprising an adhesive backing 354 for securing pad 352 to an attachment structure such as eyeglasses or another support structure. Adhesive surface 354 is adapted to match an area of eyeglasses that allow securing medial canthal pad 352 to said eyeglasses, such as for instance the area corresponding to regular nose pads of eyeglasses. Medial canthal pad 352 works as a completely independent unit and contains sensor 356, power source 358 and reporting means 360 electrically connected by wire 361,362. Reporting means 360 include local reporting with visual means (e.g., LED), audio means (e.g., piezoelectric, voice chip or speaker) and remote reporting with wireless transmission.

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FIG. 31A is a top perspective view of one alternative embodiment of a support structure incorporated as eyeglasses 380 with holes 364, 365 in regular nose pads 366, 376 for securing specialized medial canthal pads. Eyeglasses 380 includes wire 368 disposed within the right lens rim 371 of the frame of eyeglasses 380 with said wire 368 connecting transmitter 370 housed inside the right temple 369 to nose pad 366. Eyeglasses 380 further includes wire 363 mounted on top of left lens rim 365 with said wire 363 connecting transmitter 372 mounted on top of the left temple 374 to nose pad 376. FIG. 31B is a magnified perspective view of part of the support structure 380 with hole 365 in regular nose pad 376. FIG. 31C is a side perspective view of regular nose pad 366 with hole 364. FIG. 31D is a side perspective view of a medial canthal piece 382 secured to hole 364 of regular nose pad 366.

FIG. 32A is a perspective view of a person 100 wearing a support structure comprised of medial canthal caps 390 secured on top of a regular nose pad 392 of eyeglasses 394. FIG. 32B is a perspective rear view of the medial canthal cap 390 showing sensor 396, transmitter chip 398 and opening 397 for securing cap 390 to nose pads.

FIG. 33A is a perspective view of a medial canthal cap 390 being secured to the nose pad 392. Medial canthal cap 390 contains sensor 396, transmitter chip 398 and opening 397. FIG. 33B is a perspective view showing the end result of the medial canthal cap 390 secured to the nose pad 392.

Special nose pads are provided by the present invention for proper positioning a sensor at the BTT site. FIG. 34 is a perspective view of a modified left side rotatable nose pad 400 adapted to position a sensor

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on the skin at the end of the tunnel and includes nose pad 402 with sensor 401, arm 404, house 406 which houses a gear that allows rotation of a nose pad as a dial for positioning sensor 401 on different regions of the tunnel identified as 1 and 2. Position 1 places the sensor in line with the medial canthal corner and reaches the general area of the main entry point of the tunnel and position 2 places the sensor above the medial canthal corner right at the main entry point of the tunnel. This embodiment allows automated activation of the sensing system and takes advantage of the fact that the nose bridge is cold as seen in FIG. 1 (nose is dark) and FIG. 2 (nose is purple and blue). When the pad is in its resting position ("zero"), the sensor 401 rests in a cold place with temperature of 35.7° C corresponding to the regular position of nose pads on the nose. In position "zero" the sensor is in Sleep Mode (temperature of 35.8° C or less). Changing the sensor to a hot region such as the general area (position 1) or the main entry point (position 2) automatically activates the sensor which goes into Active Mode and start sensing function.

It is understood that numerous special nose pads and medial canthal pads can be used in accordance with the principles of the invention including a pivotal hinge that allows pads to be foldable in total or in part, self-adjusting pads using a spring, pivoting, sliding in a groove, and the like as well as self-adjusting mechanisms which are adaptable to anatomic variations found in different races. It is understood that the modified nose pads are preferably positioned high in the frame, most preferably by connecting to the upper part of the lens rim or within 6 mm from the upper edge of the lens rim.

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A variety of materials can be used including materials with super-adherent properties to allow intimate apposition of sensing means to the BTT site. A variety of metallic wires exhibiting super-elastic properties can be used as the hinge assembly mechanism for allowing proper positioning of sensing means to the BTT site. Medial canthal pads can be made of a flexible synthetic resin material such as a silicon rubber, conductive plastic, conductive elastomeric material, metal, pliable material, and the like so that appropriate apposition to the BTT site at the medial canthal area and proper functioning is achieved. It is also understood that the medial canthal pads can exhibit elastic and moldable properties and include material which when stressed is able to remain in the stressed shape upon removal of the stress. Any type of rubber, silicone, and the like with shape memory can also be used in the medial canthal pads and modified nose pad.

By greatly reducing or eliminating the interfering constituents and providing a high signal to noise ratio with a sensor adapted to capture thermal radiation from the BTT, the present invention provide the means needed for accurate and precise measurement of biological parameters including chemical components in vivo using optical means such as infrared spectroscopy. Moreover, the apparatus and methods of the present invention by enhancing the signal allows clinical useful readings to be obtained with various techniques and using different types of electromagnetic radiation. Besides near-infrared spectroscopy, the present invention provides superior results and higher signal to noise ratio when using other forms of electromagnetic radiation such as for example mid-infrared radiation, radio wave impedance, photoacoustic spectroscopy, Raman spectroscopy, visible

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spectroscopy, ultraviolet spectroscopy, fluorescent spectroscopy, scattering spectroscopy and optical rotation of polarized light as well as other techniques such as fluorescent (including Maillard reaction, light induced fluorescence and induction of glucose fluorescence by ultraviolet light), colorimetric, refractive index, light reflection, thermal gradient, Attenuated Total Internal Reflection, molecular imprinting, and the like. A sensor adapted to capture thermal energy at the BTE (Brain Thermal Energy) tunnel site provides optimal means for measurement of biological parameters using electromagnetic means. The BTE tunnel is the physical equivalent to the physiologic BTT and is used herein to characterize the physics of the tunnel. The geometry and dimension on the skin surface are the same for the BTT and BTE tunnel.

The following characteristics of the BTE tunnel allow optimal signal acquisition. Skin at the end of the BTE tunnel is thin. With a thick skin radiation may fail to penetrate and reach the substance to be measured. Skin at the BTE tunnel is homogenous with constant thickness along its entire surface. Random thickness of skin as occurs in other skin areas prevent achieving the precision needed. The BTE tunnel has no fat. The intensity of the reflected or transmitted signal can vary drastically from patient to patient depending on the individual physical characteristics such as the amount of fat. A blood vessel in the end of the BTE is superficial, terminal and void of thermoregulatory shunts. In other parts of the skin the deep blood vessels are located deep and vary greatly in position and depth from person to person. The BTE tunnel has no light scattering elements covering its end such as bone, cartilage and the like. Thermal radiation does not have to go through cartilage

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or bone to reach the substance to be measured. The end of the BTE tunnel on the skin has a special but fixed geometry and is well demarcated by permanent anatomic landmarks. In other skin surfaces of the body, inconsistency in the location of the source and detector can be an important source of error and variability.

Far-infrared radiation spectroscopy measures natural thermal emissions after said emissions interact and are absorbed by the substance being measured. The present invention provides a thermally stable medium, insignificant number of interfering constituents, and a thin skin is the only structure to be traversed by the thermal emissions from the BTE tunnel before reaching the detector. Thus there is high accuracy and precision when converting the thermal energy emitted by the BTE tunnel into concentration of the substance being measured.

The natural spectral emission by BTE tunnel changes according to the presence and concentration of chemical substances. The far-infrared thermal radiation emitted follow Planck's Law and the predicted amount of thermal radiation can be calculated. Reference intensity is calculated by measuring thermal energy absorption outside the substance of interest band. The thermal energy absorption in the band of substance of interest can be determined via spectroscopic means by comparing the measured and predicted values at the BTE tunnel site. The signal is then converted to concentration of the substance measured according to the amount of thermal energy absorbed.

A sensor adapted to view the BTE tunnel provides means for measuring a substance of interest using natural brain far-infrared emissions emitted at the BTE tunnel site and for applying Beer-Lambert's law in-vivo. Spectral radiation of infrared energy from the surface of

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the BTE tunnel site corresponds to spectral information of chemical substances. These thermal emissions irradiated at 38 degrees Celsius can include the 4,000 to 14,000 nm wavelength range. For example, glucose strongly absorbs light around the 9,400 nm band. When far-infrared thermal radiation is emitted at the BTE tunnel site, glucose will absorb part of the radiation corresponding to its band of absorption. Absorption of the thermal energy by glucose bands is related in a linear fashion to blood glucose concentration in the thermally sealed and thermally stable environment present in the BTE tunnel.

The support structure includes at least one radiation source from infrared to visible light which interacts with the substance being measured at the BTE tunnel and a detector for collecting the resulting radiation.

The present invention provides method for measuring biological parameters comprising the steps of measuring infrared thermal radiation at the BTE tunnel site, producing output electrical signals representative of the intensity of the radiation, converting the resulting input, and sending the converted input to a processor. The processor is adapted to provide the necessary analysis of the signal to determine the concentration of the substance measured and for displaying the results.

The present invention includes means for directing preferably near-infrared energy into the surface of the skin at the end of the BTE tunnel, means for analyzing and converting the reflectance or back scattered spectrun into the concentration of the substance measured and support means for positioning the light source and detector means adjacent to the surface of the skin at the BTE tunnel site.

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The present invention also provides methods for determining the concentration of a substance with said methods including the steps of directing electromagnetic radiation such as near-infrared at the skin at the BTE tunnel site, detecting the near-infrared energy radiated from said skin at the BTE tunnel site, taking the resulting spectra and providing an electrical signal upon detection, processing the signal and reporting concentration of the substance of interest according to said signal. The invention also includes means and methods for positioning the light sources and detectors in stable position and with stable pressure and temperature in relation to the surface to which radiation is directed to and received from.

The present invention further includes means for directing infrared energy through the nose using medial canthal pads, means for positioning radiation source and detector diametrically opposed to each other, and means for analyzing and converting the transmitted resulting spectrum into the concentration of the substance measured. The present invention also provides methods for measuring biological parameters with said methods including the steps of directing electromagnetic radiation such as near-infrared through the nose using medial canthal pads, collecting the near-infrared energy radiated from said nose, taking the resulting spectra and providing an electrical signal upon detection, processing the signal and reporting concentration of the substance measured according to said signal. The invention also includes means and methods for positioning the radiation sources and detectors in a stable position and with stable pressure and temperature in relation to the surface to which radiation is directed through.

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The present invention yet includes means for collecting natural far-infrared thermal radiation from the BTE tunnel, means for positioning a radiation collector to receive said radiation, and means for converting the collected radiation from the BTE tunnel into the concentration of the substance measured. The present invention also provides methods for measuring biological parameters with said methods including the steps of using the natural far-infrared thermal emission from the BTE tunnel as the resulting radiation for measuring the substance of interest, collecting the resulting radiation spectra, providing an electrical signal upon detection, processing the signal and reporting the concentration of the substance measured according to said signal.

A drug dispensing system including an infusion pump can be activated according to the level of the substance measured at the BTE tunnel, for example insulin can be injected automatically as needed to normalize glucose levels as an artificial pancreas.

Any substance present in blood which is capable of being analyzed by electromagnetic means can be measured at the BTE tunnel. For example but not by way of limitation such substances can include exogenous chemicals such as drugs and alcohol as well as endogenous chemicals such as glucose, oxygen, lactic acid, cholesterol, bicarbonate, hormones, glutamate, urea, fatty acids, triglycerides, proteins, creatinine, aminoacids and the like. Values such as pH can also be calculated as pH can be related to light absorption using reflectance spectroscopy.

In accordance with FIG. 35 a schematic view of one preferred reflectance measuring apparatus of the present invention is shown. FIG. 35 shows a light source 420 such

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as an infrared LED and a photodetector 422 located side-by-side and disposed within support structure 426 such as a medial canthal pad or modified nose pads of eyeglasses directing radiation 424 at the BTE tunnel 430 with said light source 420 laying in apposition to the skin 428 at the BTE tunnel 430. The light source 420 delivers the radiation 424 to the skin 428 at the BTE tunnel which is partially absorbed according to the interaction with the substance 432 being measured resulting in attenuated radiation 425. Part of the radiation 424 is then absorbed by the substance 432 and the resulting radiation 425 emitted from BTE tunnel 430 is collected by the photodetector 422 and converted by a processor into the blood concentration of the substance 432. Thin skin 428 is the only tissue interposed between radiation 424, 425 and the substance 432 being measured. The concentration of the substance 432 is accomplished by detecting the magnitude of light attenuation collected which is caused by the absorption signature of the substance being measured.

Infrared LEDs (wavelength-specific LEDs) are the preferred light source for this embodiment because they can emit light of known intensity and wavelength, are very small in size, low-cost, and the light can be precisely delivered to the site. The light source 420 emits preferably at least one near-infrared wavelength, but alternatively a plurality of different wavelengths can be used. The light source emits radiation 424, preferably between 750 and 3000 nm, including a wavelength typical of the absorption spectrum for the substance 432 being measured. The preferred photodetector includes a semiconductor photodiode with a 400 micron diameter photosensitive area coupled to an amplifier as an integrated circuit.

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FIG. 36 shows a schematic view of a person 100 wearing a support structure 434 and light source 436 and detector 438 adapted to measure biological parameters using spectral transmission means. The light source 436 and photodetector 438 are positioned diametrically opposed to each other so that the output of the radiation source 436 goes through the nasal interface 442 containing the substance 440 being measured before being received by the detector 438. Photodetector 438 collects the resulting transmitted radiation which was directed through the nasal interface 442. A variety of LEDs and optical fibers disposed within the support structure 434 such as the medial canthal pads, nose pads and frames of eyeglasses are preferably used as a light delivery for the light source 436 and the light detector 438.

Arms of support structures 434 such as medial canthal pads are moveable and can be adjusted into different positions for creating fixed or changeable optical path. Preferred substances measured include oxygen and glucose. The brain maintains constant blood flow, whereas flow in extremities change according to cardiac output and ambient conditions. The oxygen levels found in the physiologic tunnel reflects central oxygenation. The oxygen monitoring in a physiologic tunnel is representative of the general hemodynamic state of the body. Many critical conditions such as sepsis (disseminated infection) or heart problems which alter perfusion in most of the body can be monitored. Oxygen in the BTE tunnel can continuously monitor perfusion and detect early hemodynamic changes.

FIG. 37 is a schematic cross-sectional view of another preferred embodiment of the present invention using thermal emission from the BTE tunnel. FIG 37 shows a support structure 450 housing a thermal infrared

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detector 444 which has a filter 446 and a sensing element 448 with said sensing element 448 being preferably a thermopile and responding to thermal infrared radiation 452 naturally emitted by the BTE tunnel 454. The support structure 450 is adapted to have sensing means 448 with a field of view that corresponds to the geometry and dimension of the skin 462 at the end of the BTE tunnel 454. Support structure 450 provides walls 456, 458 which are in contact with the skin 462 with said walls creating a cavity 460 which contains thermal radiation 453 which has already passed through thin skin 462.

For example in the thermally sealed and thermally stable environment in the BTE tunnel 454, at 38° Celsius spectral radiation 453 emitted as 9,400 nm band is absorbed by glucose in a linear fashion according to the amount of the concentration of glucose due to the carbon-oxygen-carbon bond in the pyrane ring present in the glucose molecule. The resulting radiation 453 is the thermal emission 452 minus the absorbed radiation by the substance 464. The resulting radiation 453 enters the infrared detector 444 which generates an electrical signal corresponding to the spectral characteristic and intensity of said resulting radiation 453. The resulting radiation 453 is then converted into the concentration of the substance 464 according to the amount of thermal energy absorbed in relation to the reference intensity absorption outside the substance 464 band.

The same principles disclosed in the present invention can be used for near-infrared transmission measurements as well as for continuous wave tissue oximeters, evaluation of hematocrit, blood cells and other blood components. The substance measured can be endogenous such as glucose or exogenous such as alcohol and drugs including photosensitizing drugs.

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Numerous support structures can position sensors at the BTT site for measuring biological parameters. Accordingly, FIG. 38 is a side perspective view of an alternative embodiment showing a person 100 using head mounted gear 470 as a support structure positioning with wires 478 and sensor 476 on the skin at the BTT site. A microelectronic package 472 containing transmitting means, processing means, and power source is disposed within or mounted on head band 470, with said head band 470 providing wire 478 from microelectronic package 472 for connection with sensing means 476 on the skin at the BTT site.

It is understood that the sensing means can be an integral part of the support structure or be connected to any support structures such as using conventional fasteners including screw, pins, a clip, a tongue-groove relationship, interlocking pieces, direct attachment, adhesives, mechanical joining, and the like; and said support structures include patches, clips, eyeglasses, head mounted gear, and the like.

Various means to provide electrical energy to the sensing system were disclosed. The BTE tunnel offers yet a new way for natural generation of electrical energy. Accordingly, FIG. 39 is a schematic diagram of a preferred embodiment for generating thermoelectric energy from the BTE tunnel to power the sensing system. The generator of the invention converts heat from the tunnel into electricity needed to power the system. A thermoelectric module is integrated into the support structure to power the sensing system. The thermoelectric module preferably includes a thermopile or a thermocouple which comprises dissimilar metallic wires forming a junction. As heat moves from the tunnel through the thermoelectric module an electric current is generated.

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Since the BTE tunnel is surrounded by cold regions, the Seebeck effect can provide means for generating power by inducing electromotive force (emf) in the presence of a temperature gradient due to distribution of electric charges at the surface and interface of the thermoelectric circuit generated by the temperature at the BTE tunnel.

Accordingly, FIG. 39 shows the junctions T1 and T2 of metallic wire A 470 and metallic wire B 472 kept at different temperatures by placing junction T1 at the main entry point of the tunnel and junction T2 in a cold area such as the nose bridge (denoted in blue or purple in FIG. 1B, and referred herein as blue-purple nose). Metallic wires A 470 and B 472 are made of different materials and electric current flows from the hot to the cold region due to the thermal gradient with a magnitude given by the ratio of the thermoelectric potential. The potential U is given by $U = (Q_a - Q_b)*(T_1 - T_2)$, where Q_a and Q_b denote the Seebeck coefficient (thermoelectric power) of metal A and metal B_2 and T_1 denotes temperature at the entry point of the BTE tunnel and T_2 denotes temperature at the blue-purple nose. The thermoelectric potential generated can power the sensing system and a capacitor 474 inserted into the system can be used to collect and store the energy and MCU 476 is adapted to controls the delivery of energy as needed for measuring, processing and transmitting the signal.

It is understood that other means to convert thermal energy from the BTE tunnel into electricity can be used. It is also understood that the surface of the eye and caruncle in the eye can provide a thermal gradient and Seebeck effect, however it is much less desirable than using the skin at the end of the BTE tunnel since hardware and wires touching the surface of the eye and/or

coming out of the eye can be quite uncomfortable and cause infection.

Contrary to that numerous support structures disclosed in the present invention including eyeglasses can easily be adapted to provide in an unobtrusive manner the power generating system of the invention, for example by using a support structure such as eyeglasses for positioning the hot junction at the BTE site using medial canthal pads and positioning the cold junction on the nose using regular nose pads of eyeglasses. It is also understood that although the power generating system using Brain Thermal Energy was designed for powering the sensing system of the present invention, any other electrical device could be adapted to be supplied with energy derived from the Brain Thermal Energy tunnel.

Additional embodiments include support structures to position the sensor at the BTT site of animals. Many useful applications can be achieved, including enhancing artificial insemination for mammalian species by detecting moment of ovulation, monitoring herd health by continuous monitoring of brain temperature, detection of parturition and the like.

Accordingly, FIG. 40 is a perspective view of a preferred embodiment showing an animal 101 with sensor 480 positioned at the BTT site with wire 482 connecting sensor 480 with a microelectronic package 484 containing transmitting means, processing means, and power source in the eyelid pocket 486 of animal 101. Signal from microelectronic package 484 is preferably transmitted as radio waves 489. The signal from the transmitter in package 484 can be conveyed to a GPS collar allowing the identification of the animal having a high temperature associated with the localization of said animal by GPS means. Whenever there is an increase in brain temperature

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identified by the sensing means 480, the signal of high temperature activates the GPS collar to provide the localization of the affected animal. Alternatively the remote radio station receiving waves 489 activate the GPS system when the abnormal signal is received. In this case, the transmitter in package 484 only sends the signal to the remote station, but not to the GPS collar.

FIG. 41A is a perspective view of a portable support structure 490 positioning sensor 492 in contact with the skin 494 at the BTT site for measuring biological parameters. Support structure 490 incorporated as a thermometer with a contact sensor 492 is held by a second person 17 for positioning the sensor 492 on the skin 494 and performing the measurement. FIG. 41B is a perspective view of a portable support structure 496 with walls 500 positioning non-contact sensor 498 such as a thermopile with a field of view that matches in total or in part the geometry and dimension of the skin area at the end of the BTT. Support structure 496 incorporated as an infrared thermometer is held by a second person 105 for positioning the sensor 498 and measuring biological parameters. Although it is understood that pointing an infrared detector to the BTT site can be used in accordance with the invention, the temperature measured is not as clinically useful because of the ambient temperature. Therefore, the support structure 496 contains walls 500 that create a confined environment for thermal radiation to reach sensor 498 from the skin over the tunnel. Walls 500 of the support structure are adapted to match the geometry of the tunnel and to provide a cavity 499 with the boundaries consisting of the sensor surface 492 and the skin area 493 viewed by said sensor 498, in a similar manner as described for FIG. 37.

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It is also understood that many variations are evident to one of ordinary skill in the art and are within the scope of the invention. For instance, one can place a sensor on the skin at the BTT site and subsequently place an adhesive tape on top of said sensor to secure the sensor in position at the BTT site. Thus in this embodiment the sensor does not need to have an adhesive surface nor a support structure permanently connected to said sensor.

It is understood that any electrochemical sensor, thermoelectric sensor, acoustic sensor, piezoelectric sensor, optical sensor, and the like can be supported by the support structure for measuring biological parameters in accordance with the principles of the invention. It is understood that sensors using amperometric, potentiometric, conductometric, gravimetric, impedimetric, systems, and the like can be used in the apparatus of the invention for the measurement of biological parameters. It is also understood that other forms for biosensing can be used such as changes in ionic conductance, enthalpy, and mass as well as immunobiointeractions and the like.

The foregoing description should be considered as illustrative only of the principles of the invention. Since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and, accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the invention.

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CLAIMS

I claim:

1. A support structure for placement on the skin at an end of a brain tunnel, said support structure comprising

a housing for placement on the skin at the end of the brain tunnel, and

a sensor contained in the housing for measuring signals produced on said skin at the end of the brain tunnel,

said sensor being located adjacent to an edge of said housing.

2. The support structure as claimed in claim 1, wherein said sensor is positioned eccentrically in the housing.

3. The support structure as claimed in claim 1, wherein a distance form an outer edge of said housing to an outer edge of said sensor is equal to or less than 11 mm.

4. The support structure as claimed in claim 3, wherein the distance is equal to or less than 6 mm.

5. The support structure as claimed in claim 4, wherein the distance is equal to or less than 3 mm.

6. The support structure as claimed in claim 1, wherein said housing includes of at least one of a patch, a clip, a medial canthal pad of eyeglasses, a modified nose pad of eyeglasses and head mounted gear.

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7. The support structure as claimed in claim 6, wherein said patch measures less than 11 mm at its greatest dimension.

8. The support structure as claimed in claim 1, wherein said housing includes a power source.

9. The support structure as claimed in claim 1, wherein said housing includes a microprocessor.

10. The support structure as claimed in claim 1, wherein said housing includes a wireless transmitter.

11. The support structure as claimed in claim 10, wherein said wireless transmitter transmits a signal by at least one of a radio frequency, light, sound and electromagnetic energy.

12. The support structure as claimed in claim 1, wherein said housing includes a local reporting device for local reporting of the signal.

13. The support structure as claimed in claim 10, wherein said local reporting device reports the signal by at least one of a visual, audio and tactile transmission.

14. The support structure as claimed in claim 1, wherein said sensor is passive.

15. The support structure as claimed in claim 13, wherein said passive sensor is powered by an antenna.

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16. The support structure as claimed in claim 1, wherein said sensor is active.

17. The support structure as claimed in claim 1, wherein said sensor measures brain temperature.

18. The support structure as claimed in claim 1, wherein said sensor measures glucose levels.

19. The support structure as claimed in claim 1, wherein said sensor measures oxygen levels.

20. The support structure as claimed in claim 1, wherein said sensor measures electrolyte levels.

21. The support structure as claimed in claim 1, wherein said sensor measures pulse.

22. The support structure as claimed in claim 1, wherein said sensor measures blood pressure.

23. The support structure as claimed in claim 1, wherein said housing includes a transmitter for controlling an article of manufacture.

24. The support structure as claimed in claim 23, wherein said article of manufacture includes at least one of a medical device, exercise equipment, a bicycle, clothing, footwear, a climate control system, an electric blanket, a vehicle seat, furniture, sports equipment and military gear.

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25. The support structure as claimed in claim 1, wherein said support structure includes a wired transmitter.

26. The support structure as claimed in claim 25, wherein said wired transmitter is connected by a wire to a display unit.

27. The support structure as claimed in claim 10, wherein a receiver for said wireless transmitter includes at least one of a watch, a cellular phone, a computer, an internet appliance and a pager.

28. A support structure for placement adjacent to the skin at an end of a brain tunnel, said support structure comprising

a housing for placement adjacent to the skin at the end of the brain tunnel, and

a sensor contained in the housing being spaced by said housing so as to project a field of view of said sensor on the brain tunnel.

29. The support structure as claimed in claim 28, wherein said sensor detects infrared radiation.

30. The support structure as claimed in claim 28, wherein said sensor measures at least one of brain temperature and concentration of substances in blood.

31. The support structure as claimed in claim 28, wherein said housing includes at least one of a patch, a clip, a medial canthal pad, a modified nose pad, head mounted gear and a portable hand held device.

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32. The support structure as claimed in claim 31, wherein said medial canthal pad is releasably secured to eyeglasses.

33. Eyeglasses for measuring biological parameters, said eyeglasses comprising

a right lens rim and right temple assembly,

a left lens rim and left temple assembly, and

a medial connector piece including a support bridge and nose pad portions, said support bridge releasably connecting said right lens and right temple assembly and said left lens rim and left temple assembly.

34. The eyeglasses claimed in claim 33, wherein said medial connector piece contains a sensor located adjacent to an edge of at least one of the nose pad portions.

35. A head mounted support structure for measuring biological parameters in a brain tunnel, said head mounted support structure comprising

a housing to be worn on the head, and

a sweat sensor contained in the housing being operable to receive sweat fluid from the head and produce a signal corresponding to a concentration of a substance present in said sweat fluid.

36. The head mounted support structure as claimed in claim 35, wherein said housing includes at least one of eyeglasses, a head band and a wrap around ear device.

37. A support structure for measuring biological parameters in a brain tunnel, said support structure comprising

eyeglasses to be worn on the face, and

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a medial canthal piece releasably connected to said eyeglasses,

said medial canthal piece containing a sensor.

38. A medial canthal pad for measuring biological parameters in a brain tunnel, said medical canthal pad comprising

a housing,

a sensor in said housing,

a power source, and

a reporting device,

whereby said sensor, said power source and said reporting device are electrically connected to produce and report a signal.

38. The medial canthal pad as claimed in claim 37, wherein said housing is secured to a pair of eyeglasses.

39. The medical canthal pad as claimed in claim 37, wherein said reporting device includes at least one of audio reporting, visual reporting and wireless reporting to a remote unit.

38. The medial canthal pad as claimed in claim 37, wherein said housing includes an adhesive area.

40. A support structure for measuring biological parameters in a brain tunnel, aid support structure comprising

eyeglasses to be worn on the face,

a nose pad of the eyeglasses containing a hole for securing a medial canthal pad having a sensor to the eyeglasses, and

1383_PRIOR_ART_000110

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an electrical connector for connecting said nose pad to a reporting device.

41. A support structure for measuring biological parameters in a brain tunnel, said support structure comprising

a medical canthal cap to be secured to a nose pad portion of eyeglasses, and

a sensor contained in the medical canthal cap,

whereby said sensor measures biological parameters.

42. The support structure as claimed in claim 41, wherein said medial canthal cap includes a power source and a reporting device.

43. A nose pad of a support structure for measuring biological parameters in a brain tunnel, said nose pad comprising:

a housing,

a sensor contained in the housing, and

a rotatable gear connected to the sensor positioning the sensor at different locations by rotating said housing.

44. A support structure for measuring biological parameters, said support structure comprising

eyeglasses to be worn in contact with the skin of the face,

a source of electromagnetic radiation contained in the eyeglasses for irradiating said skin,

a photodetector contained in the eyeglasses for detecting an intensity of electromagnetic radiation emitted by said skin, and

1383_PRIOR_ART_000111

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whereby said photodetector detects spectral changes representative of a concentration of the biological parameters being measured.

45. The support structure as claimed in claim 44, wherein a light source and the photodetector are located side-by-side in the eyeglasses.

46. The support structure as claimed in claim 44, wherein a light source and the photodetector are located opposed to each other in the eyeglasses.

47. A support structure for placement on the skin at an end of a brain tunnel, said support structure comprising

a housing for placement on the skin at the end of the brain tunnel,

a sensor contained in the housing for measuring signals produced on said skin at the end of the brain tunnel,

said sensor being located adjacent to an edge of said housing, and

an electrical device for connecting said sensor to a processing device and a reporting device.

48. A support structure for measuring biological parameters in a brain tunnel, said support structure comprising

a detecting device for receiving infrared energy from the brain tunnel and for measuring infrared absorption of at least one substance present in said brain tunnel based upon infrared energy generated in the brain tunnel and a processing device for determining a

1383_PRIOR_ART_000112

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concentration of at least one substance based upon the measured infrared absorption.

49. A support structure for placement on the skin at an end of a brain tunnel, said support structure comprising

a thermoelectric device having dissimilar wires for converting thermal energy from the brain tunnel into electric power,

a medial canthal pad positioned on the brain tunnel containing a hot junction of the thermoelectric device,

a nose pad positioned on the nose containing a cold junction of the thermoelectric device,

a sensor powered by the thermoelectric device, and

a capacitor to store energy generated by thermoelectric device.

50. A method for measuring biological parameters, said method comprising the steps of

positioning a sensor on the skin at an end of a brain tunnel,

producing a signal corresponding to a biological parameter measured by the sensor, and

reporting a value of said signal to a display device.

51. A method for measuring biological parameters in a brain tunnel, said method comprising the steps of

receiving infrared energy from the brain tunnel,

producing a signal representative of an amount of infrared energy received from said brain tunnel,

processing said signal for determining a value of a biological parameter, and

reporting said value.

1383_PRIOR_ART_000113

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52. The method as claimed in claim 51, further comprising measuring infrared absorption of at least one substance in said tunnel for determining a concentration of said substance.

53. The method as claimed in claim 51, wherein the biological parameter measured includes at least one of brain temperature, metabolic function and blood concentration of substances.

54. A method for measuring biological parameters in a brain tunnel, said method comprising the steps of

directing infrared energy to the brain tunnel,

producing a signal representative of an amount of infrared energy received from said brain tunnel,

processing said signal for determining a value of a biological parameter, and

reporting said value.

55. A method for fitting eyeglasses, said method comprising the steps of

measuring infrared emission from the face,

producing an infrared image from said face, and

adjusting eyeglasses according to the produced infrared image.

56. A method of warning for thermal damage by thermal radiation in an individual exposed to said thermal radiation, said method comprising the steps of

measuring temperature of said individual,

analyzing the measured temperature to determine whether the measured temperature fits a predetermined criteria for a condition of developing thermal damage, and

1383_PRIOR_ART_000114

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notifying said individual of said condition.

57. A method of enhancing safety and performance of an individual during physical activity, said method comprising the steps of

measuring body temperature and determining a type, amount and time of fluid intake according to a predetermined criteria based on said measured body temperature so as to enhance safety and performance during said physical activity.

58. A physical activity management device comprising

a temperature sensor measuring a user's brain temperature,

a processor determining a thermal state of the body of said user from said user's brain temperature, and

a reporting device reporting to said user when said thermal state is outside a predetermined value.

1383_PRIOR_ART_000115

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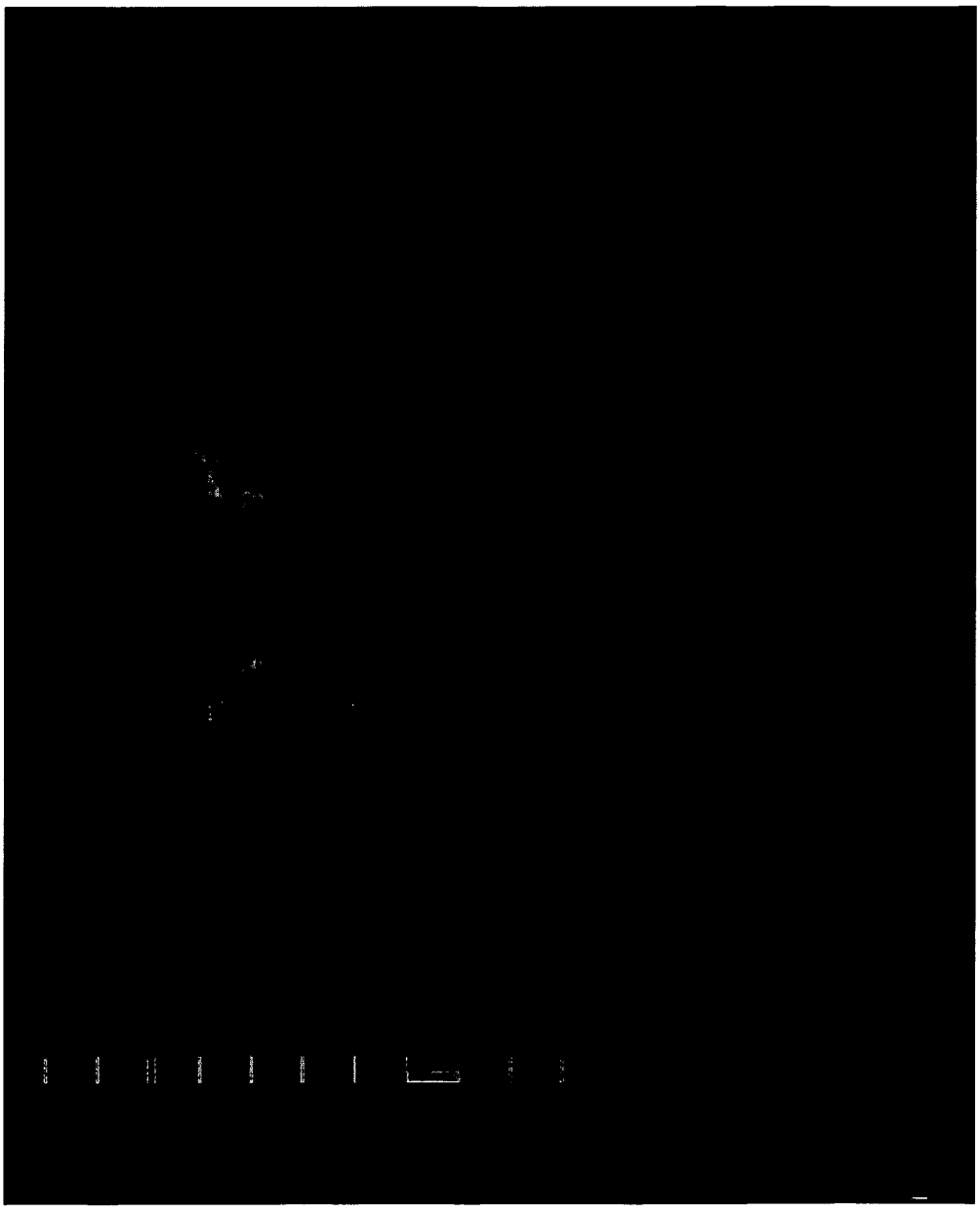


FIG. 1A

1383_PRIOR_ART_000116

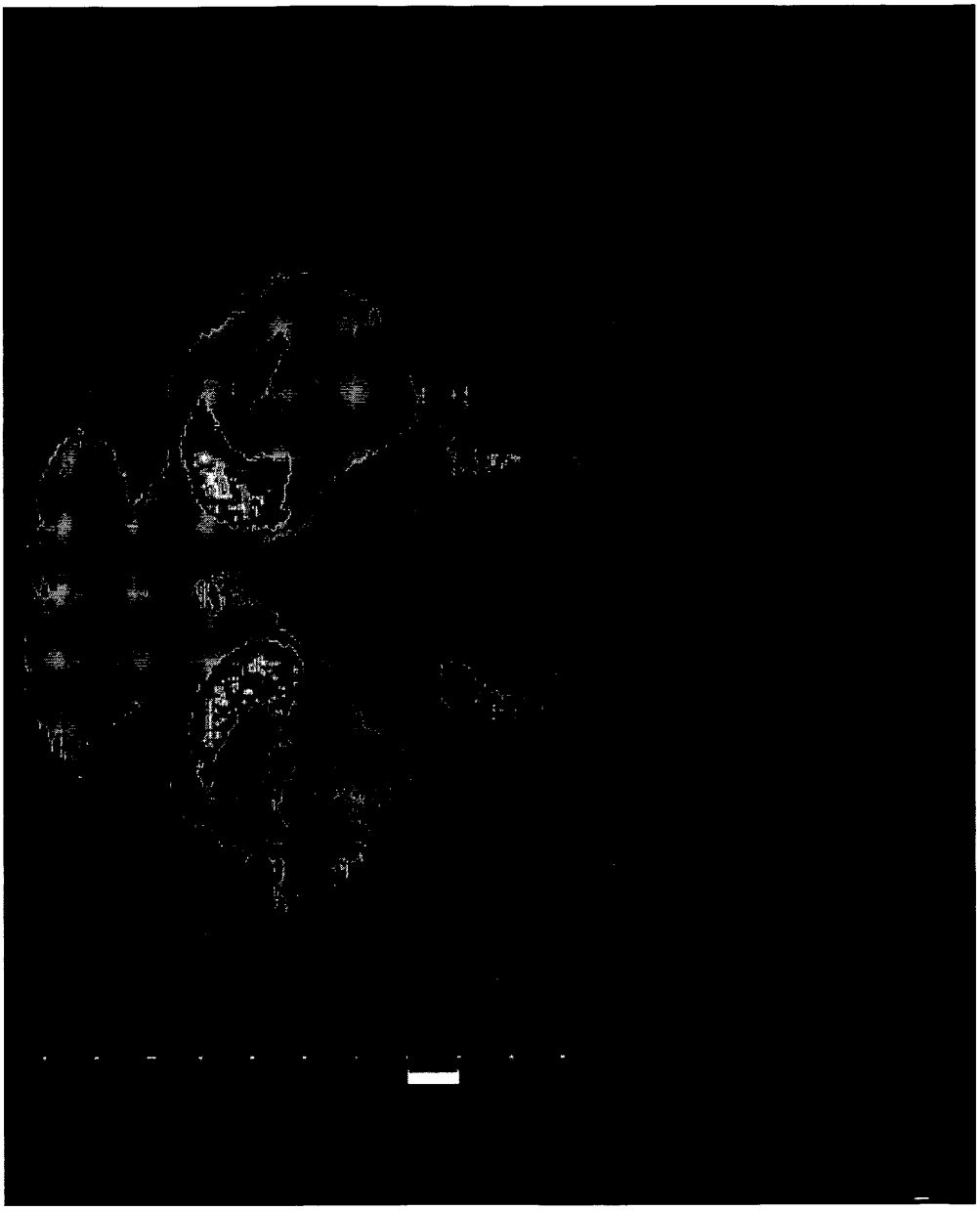


FIG. 1B

1383_PRIOR_ART_000117

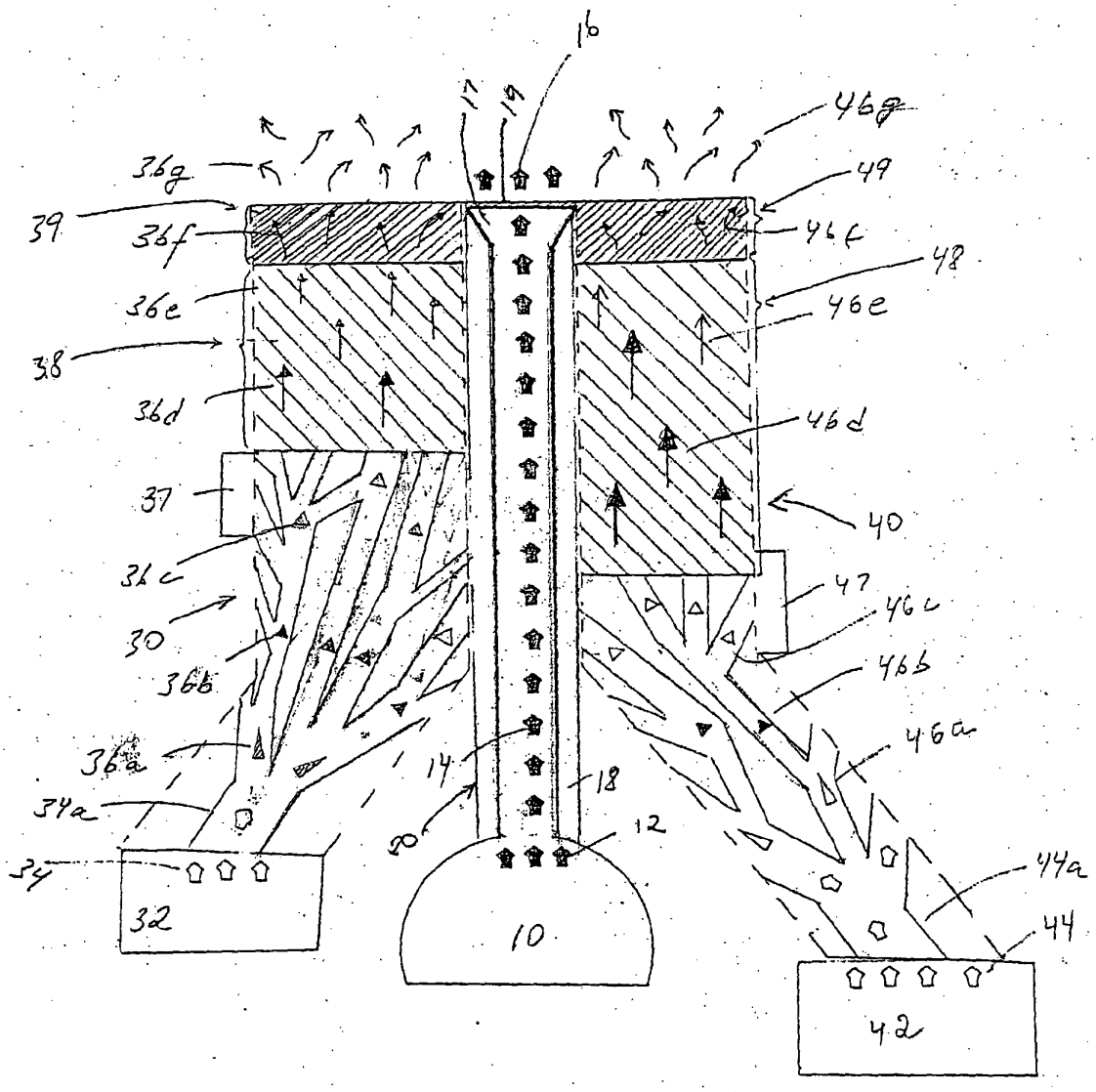


Fig. 2A

1383_PRIOR_ART_000118

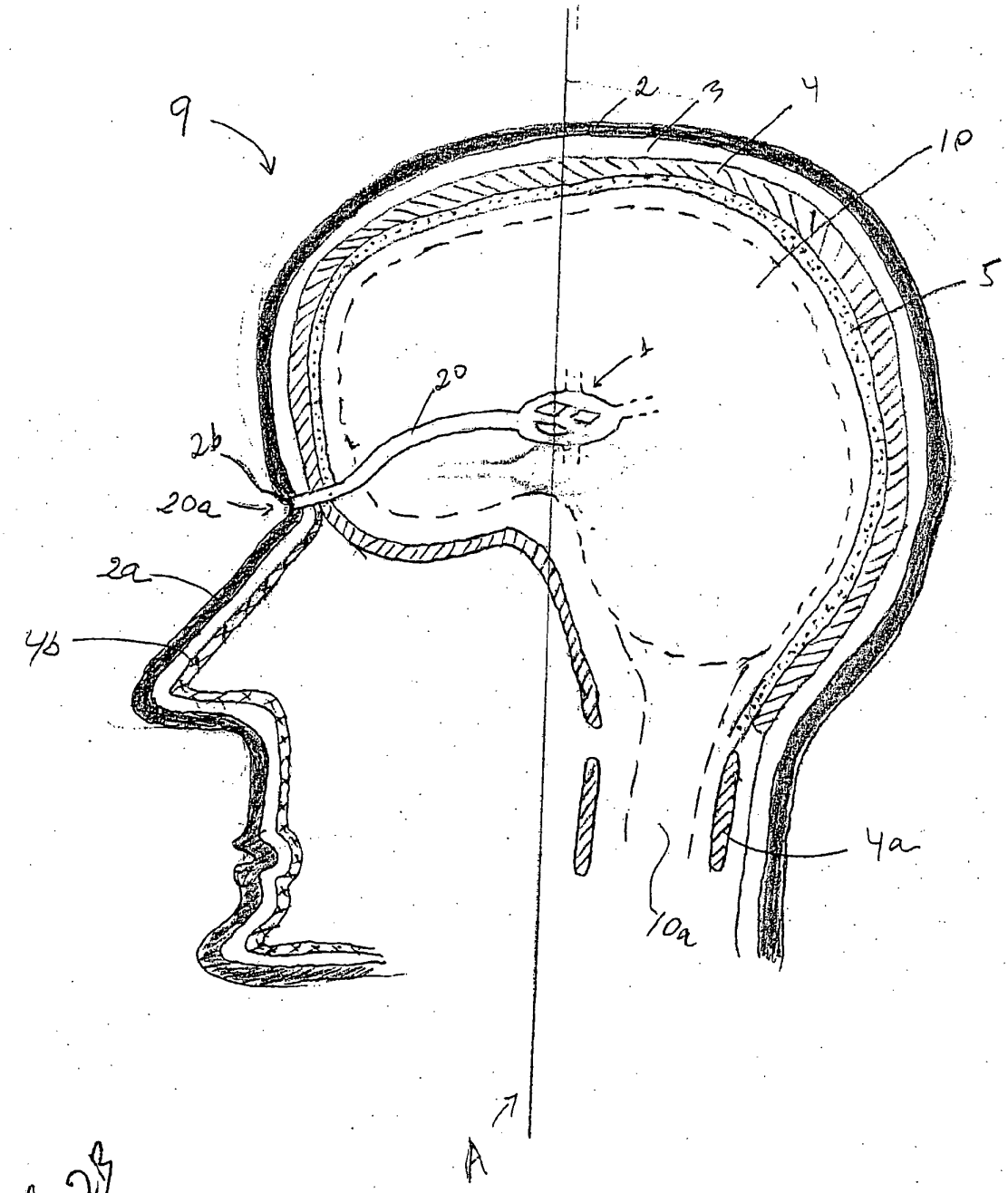
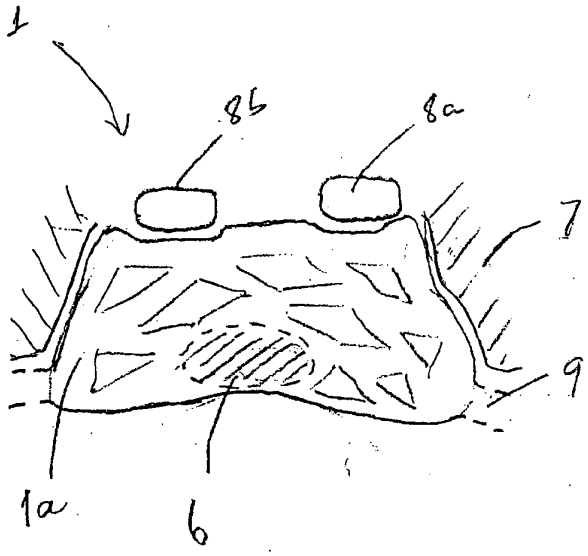


Fig 2B

1383_PRIOR_ART_000119

Fig 2C



1383_PRIOR_ART_000120

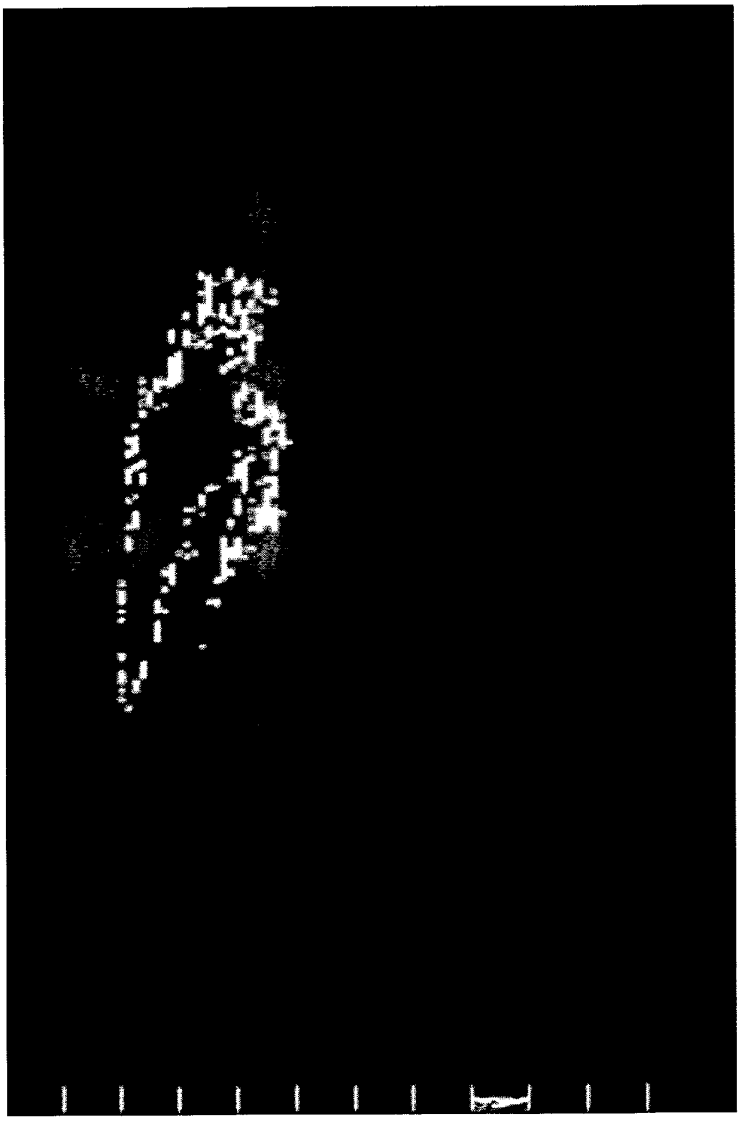
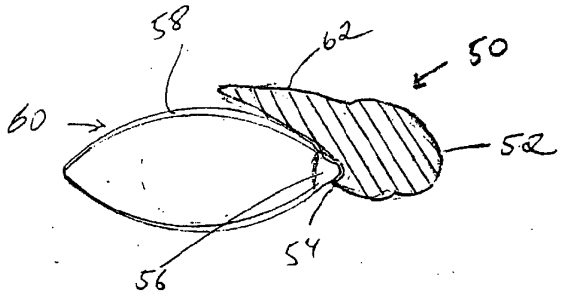


FIG. 3A

1383_PRIOR_ART_000121

Fig 3B



1383_PRIOR_ART_000122

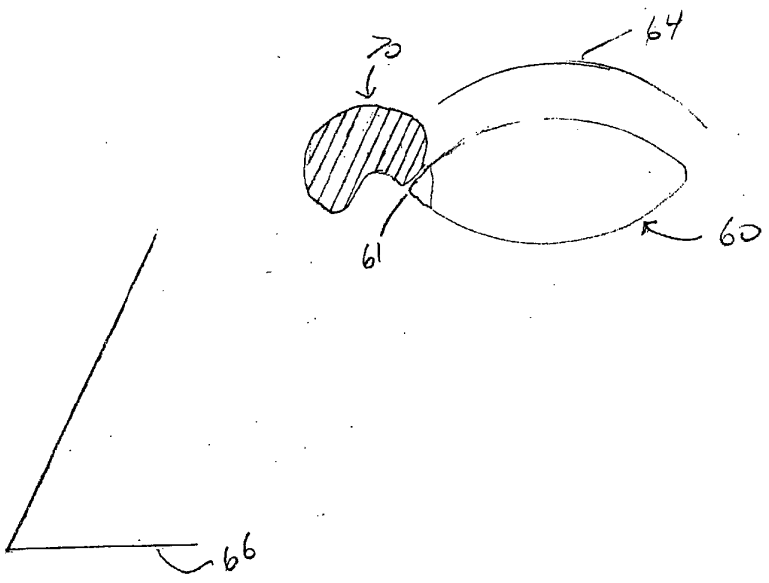
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FIG. 4A

1383_PRIOR_ART_000123

Fig 4B



1383_PRIOR_ART_000124

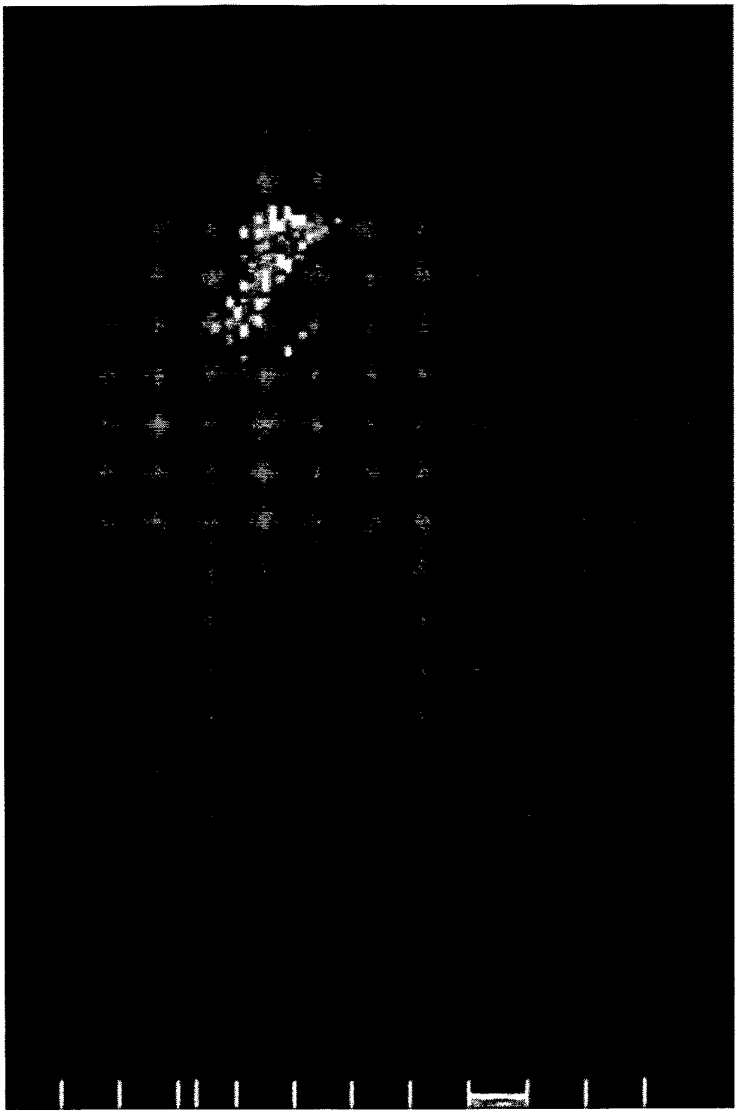
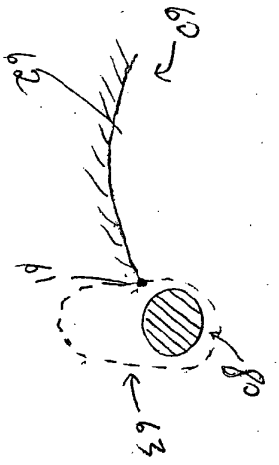


FIG. 5A

1383_PRIOR_ART_000125

Fig. 5B



1383_PRIOR_ART_000126

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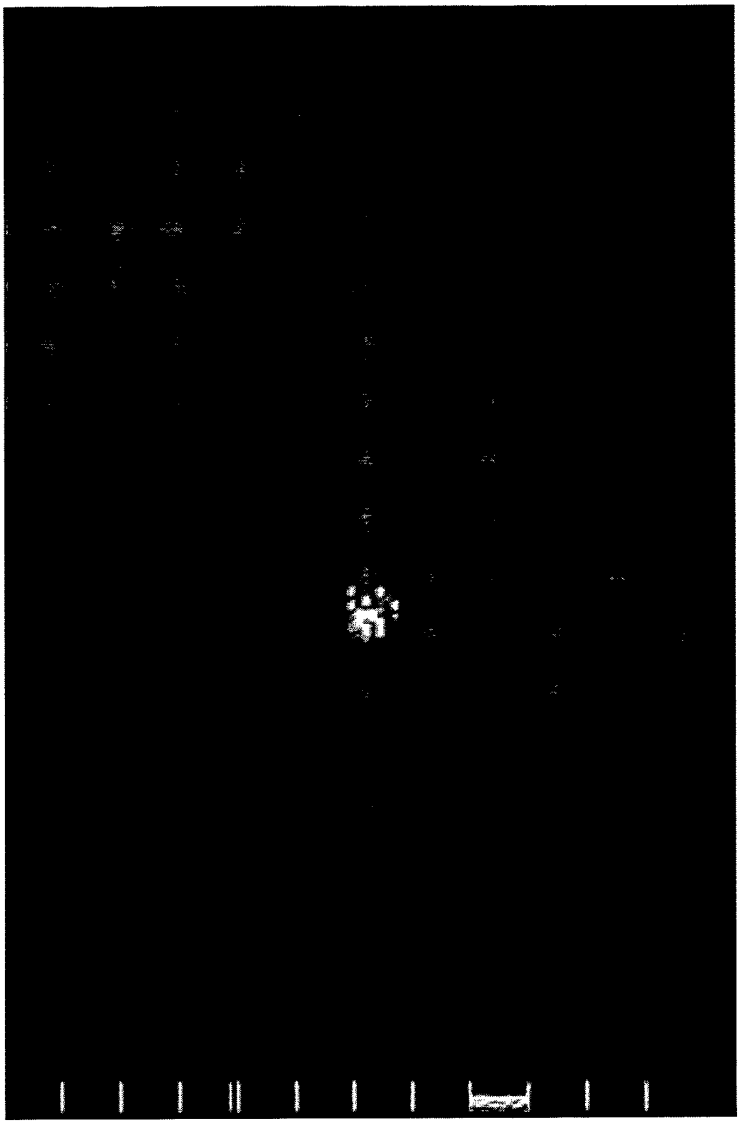
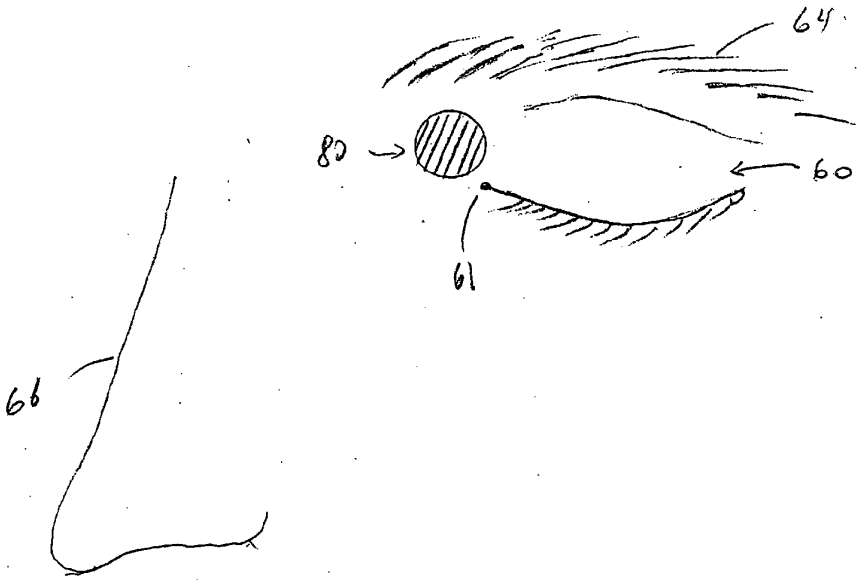


FIG. 5C

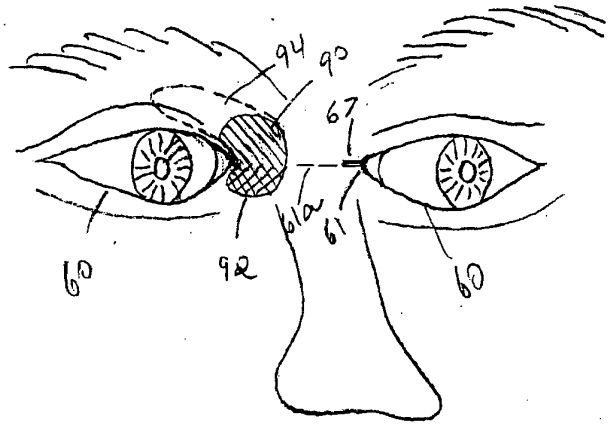
1383_PRIOR_ART_000127

Fig 5D



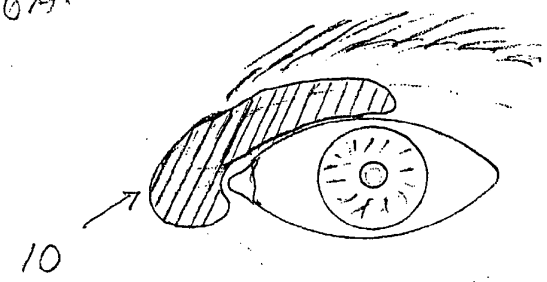
1383_PRIOR_ART_000128

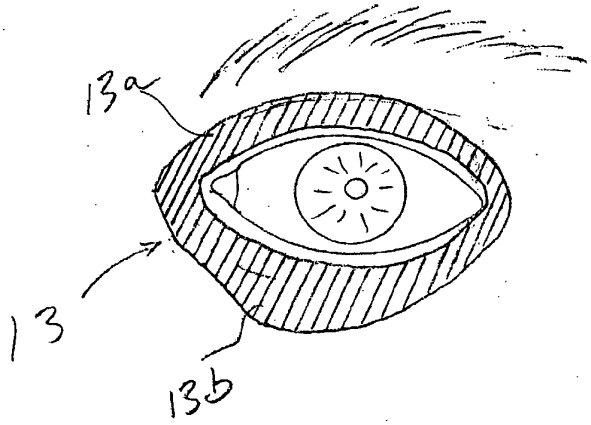
Fig 6



1383_PRIOR_ART_000129

Fig 6A.





1383_PRIOR_ART_000130

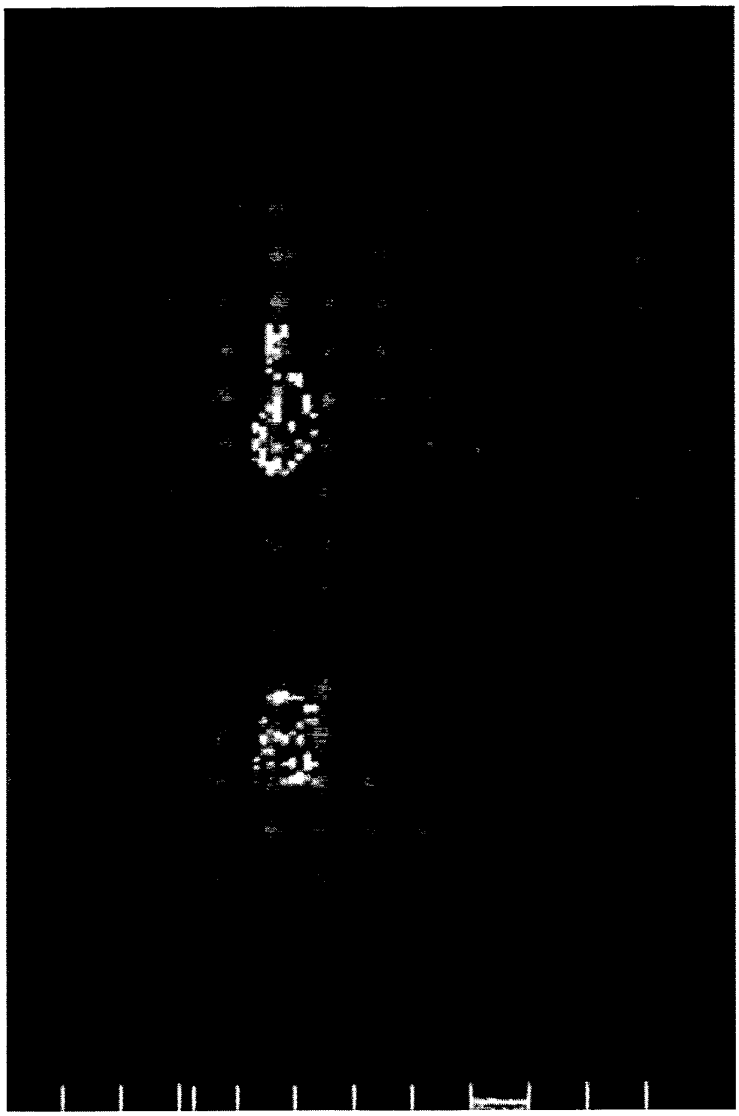


FIG. 7A

1383_PRIOR_ART_000131

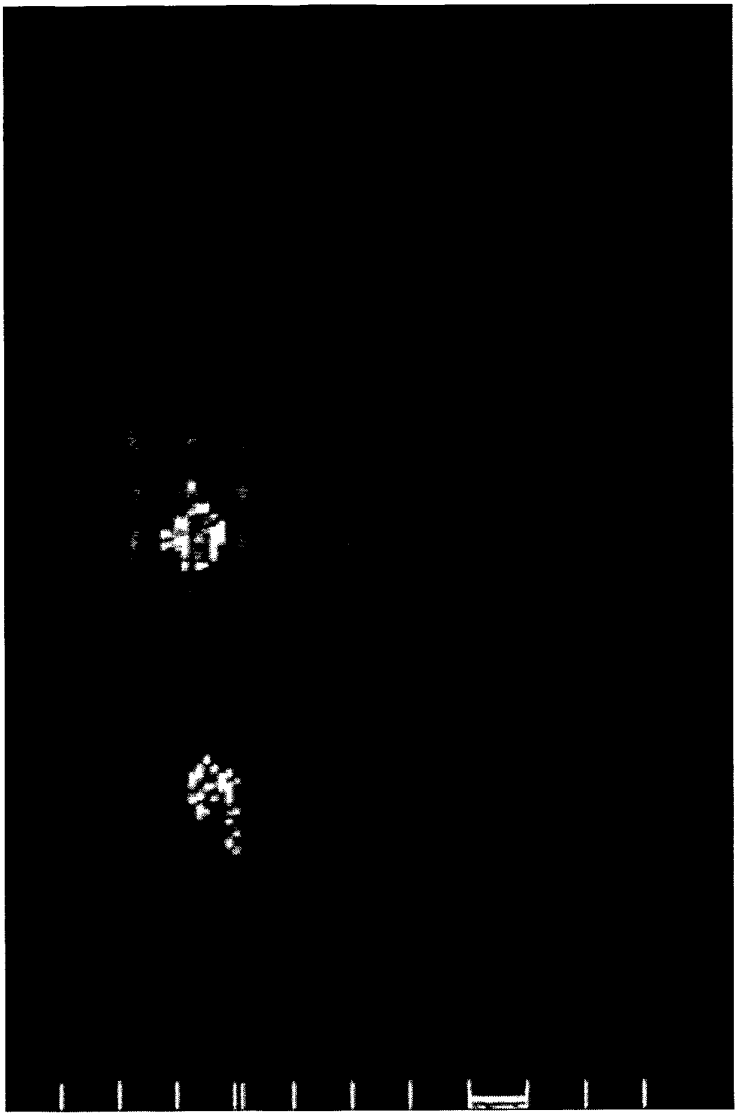


FIG. 7B

1383_PRIOR_ART_000132

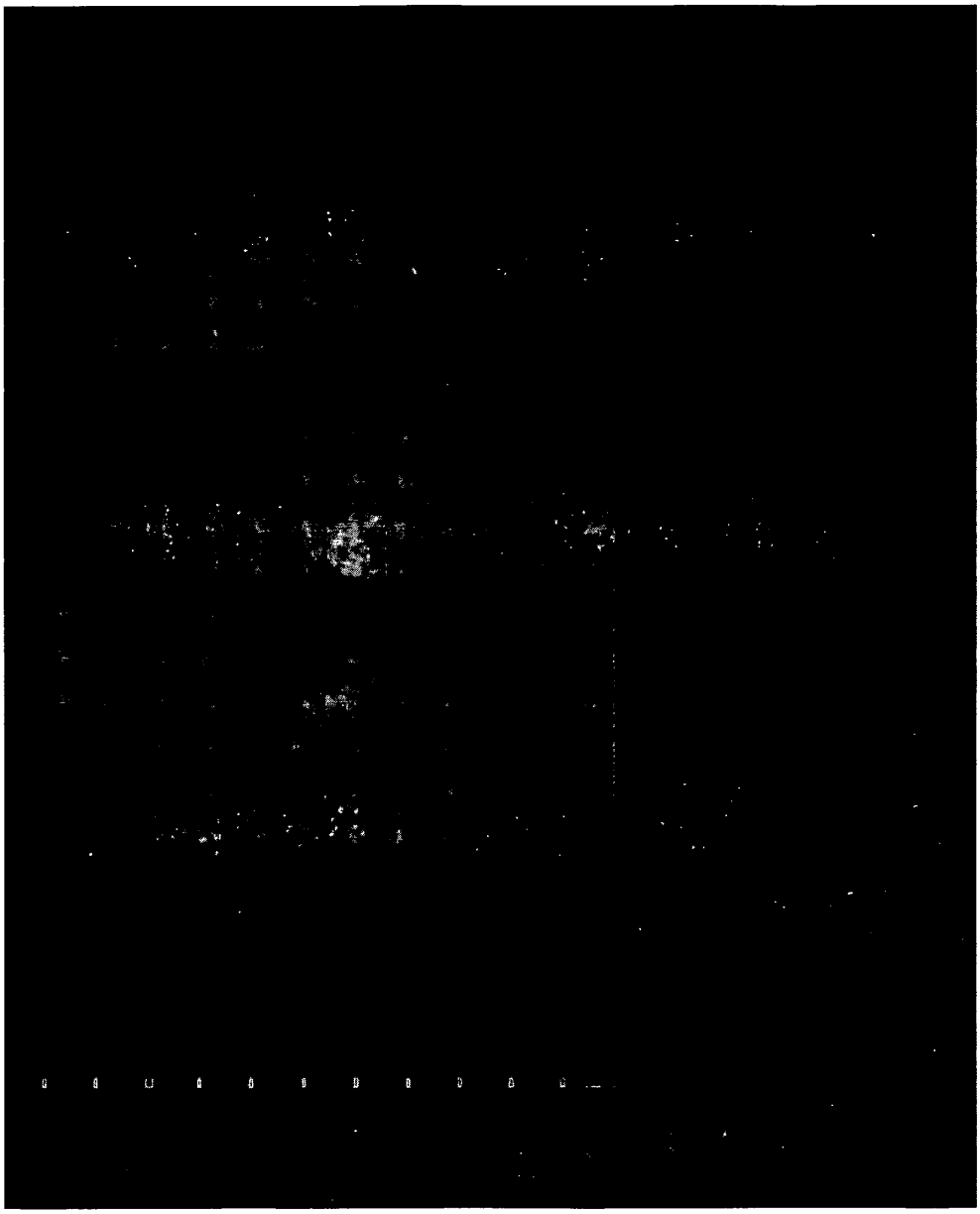


FIG. 8A

1383_PRIOR_ART_000133

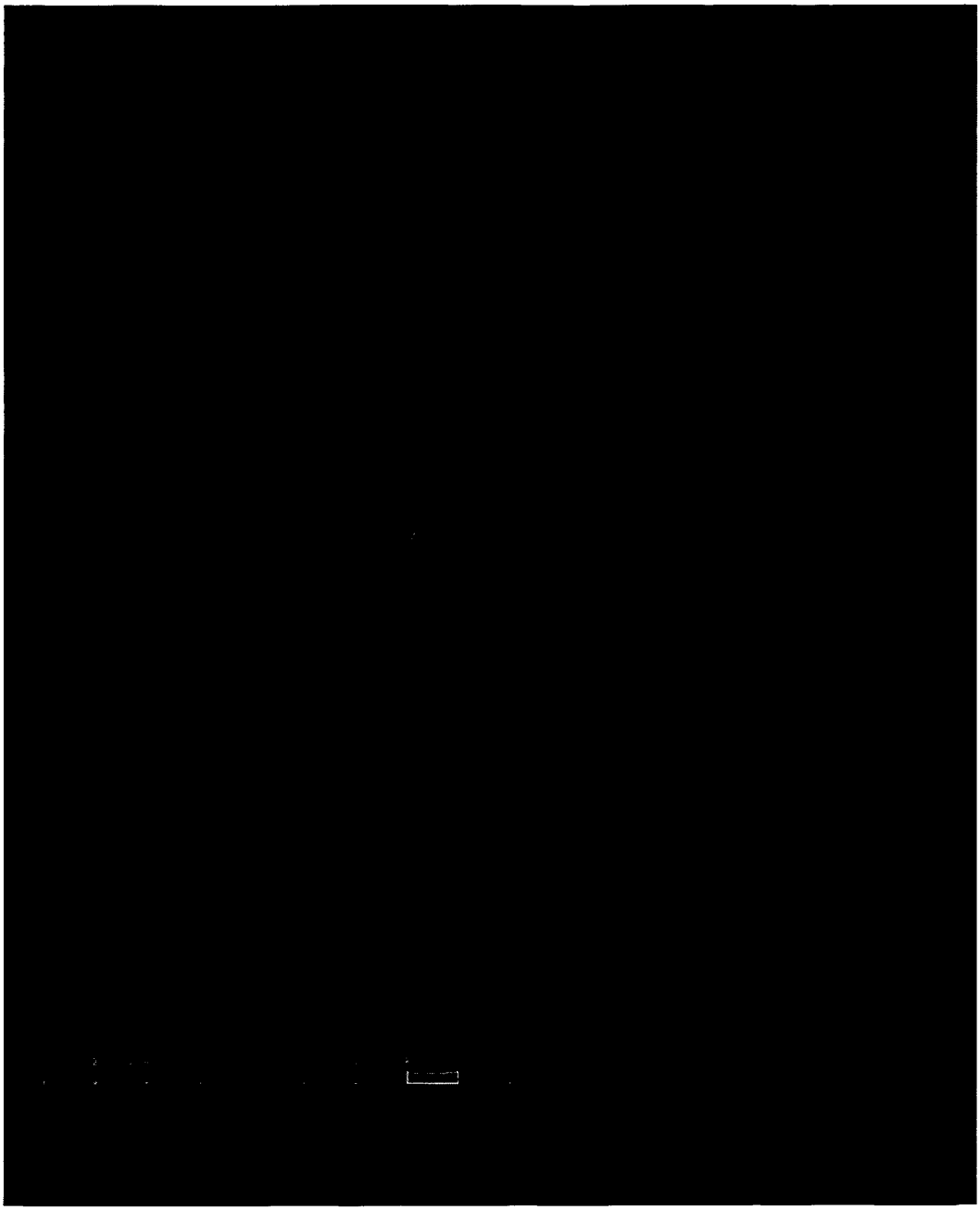


FIG. 8B

1383_PRIOR_ART_000134

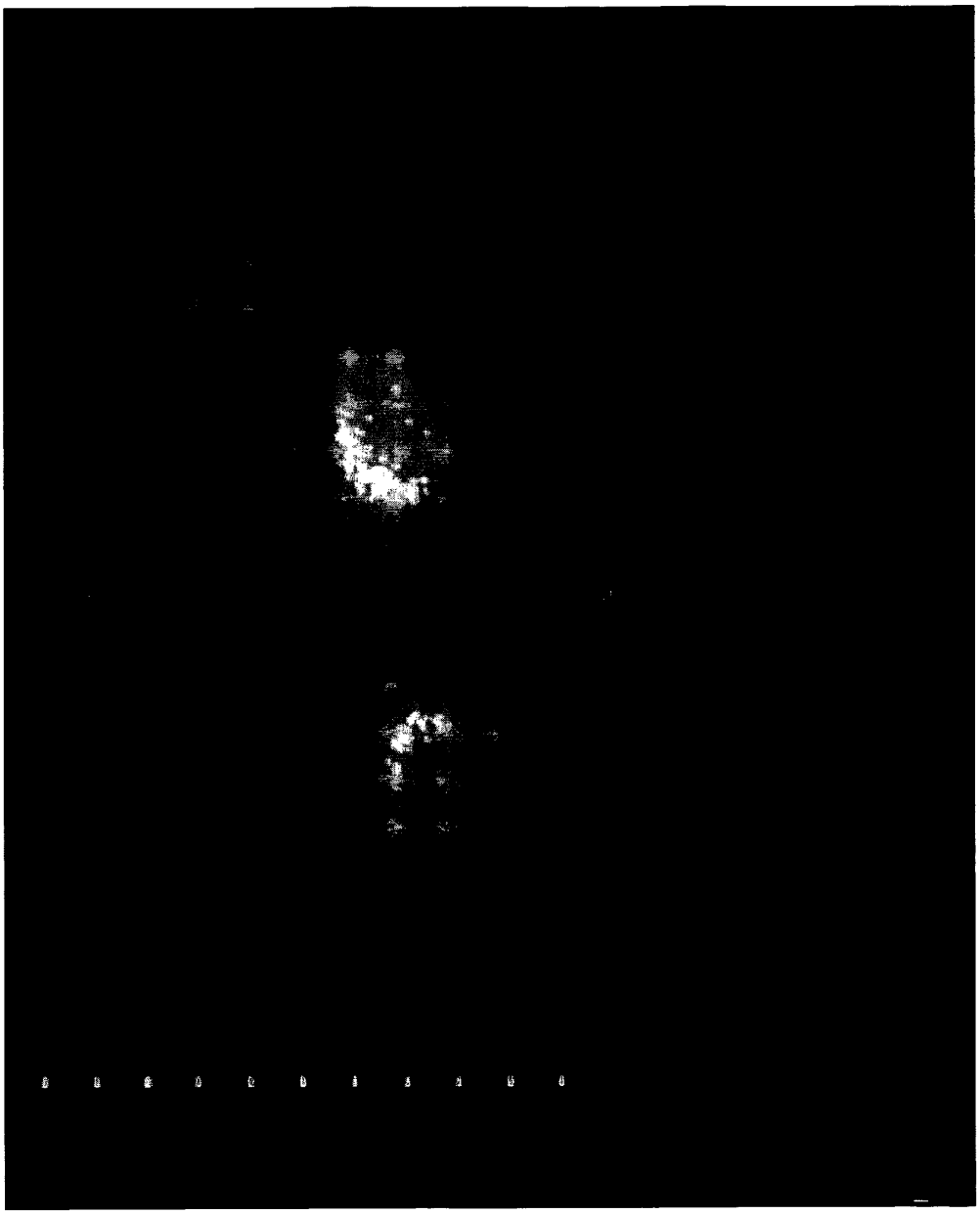


FIG. 9A

1383_PRIOR_ART_000135

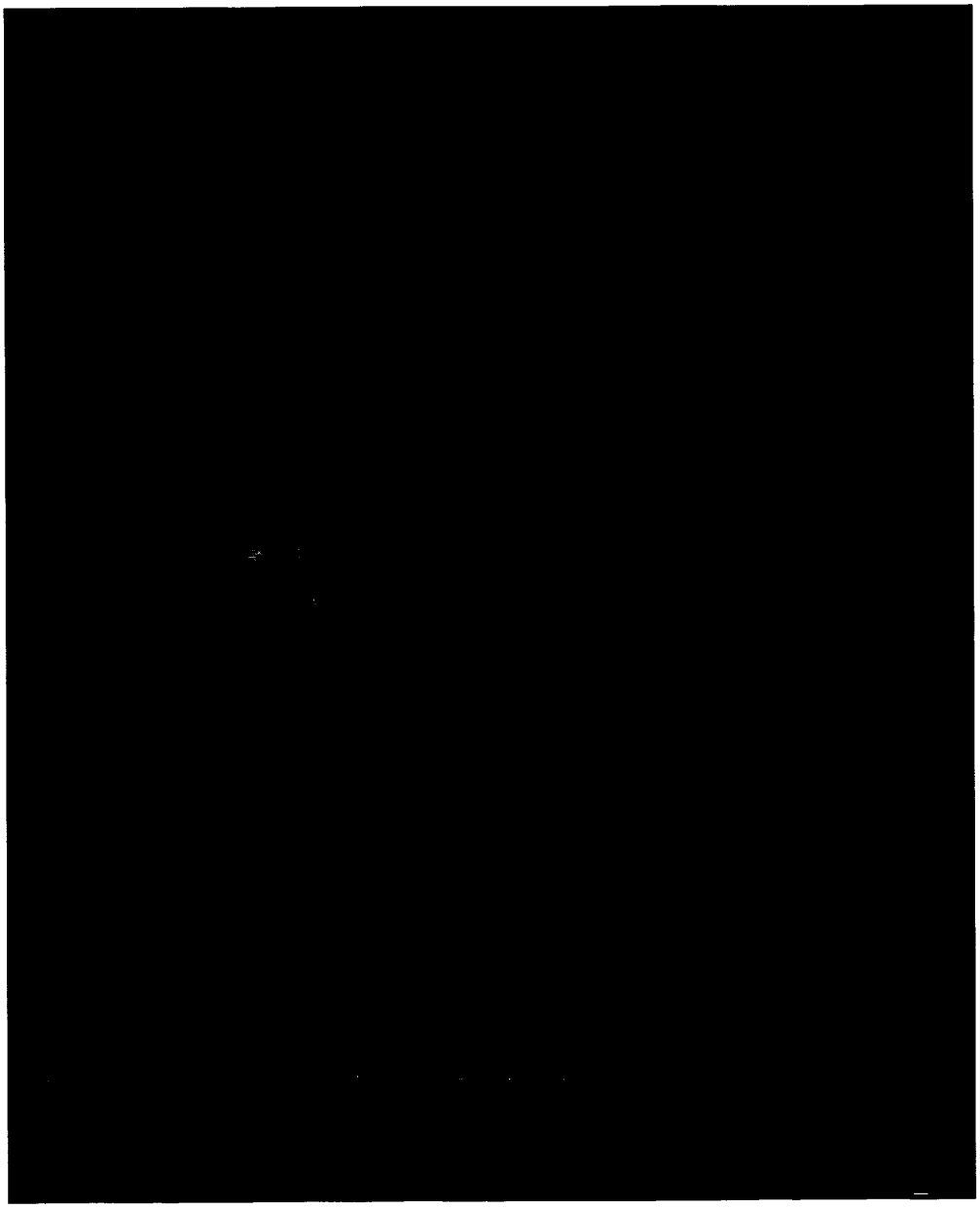


FIG. 9B

1383_PRIOR_ART_000136

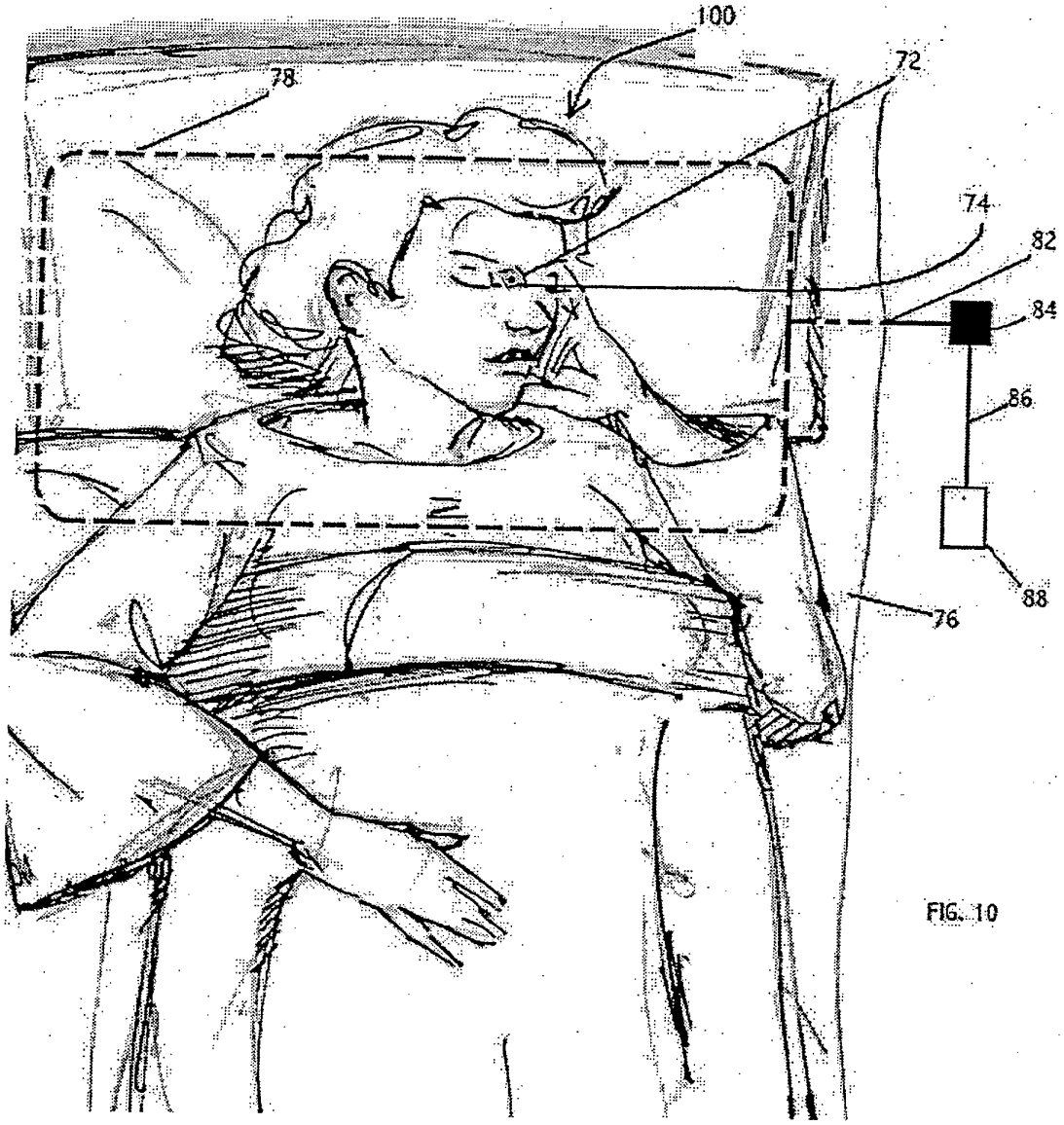


FIG. 10

1383_PRIOR_ART_000137



FIG. 11

1383_PRIOR_ART_000138

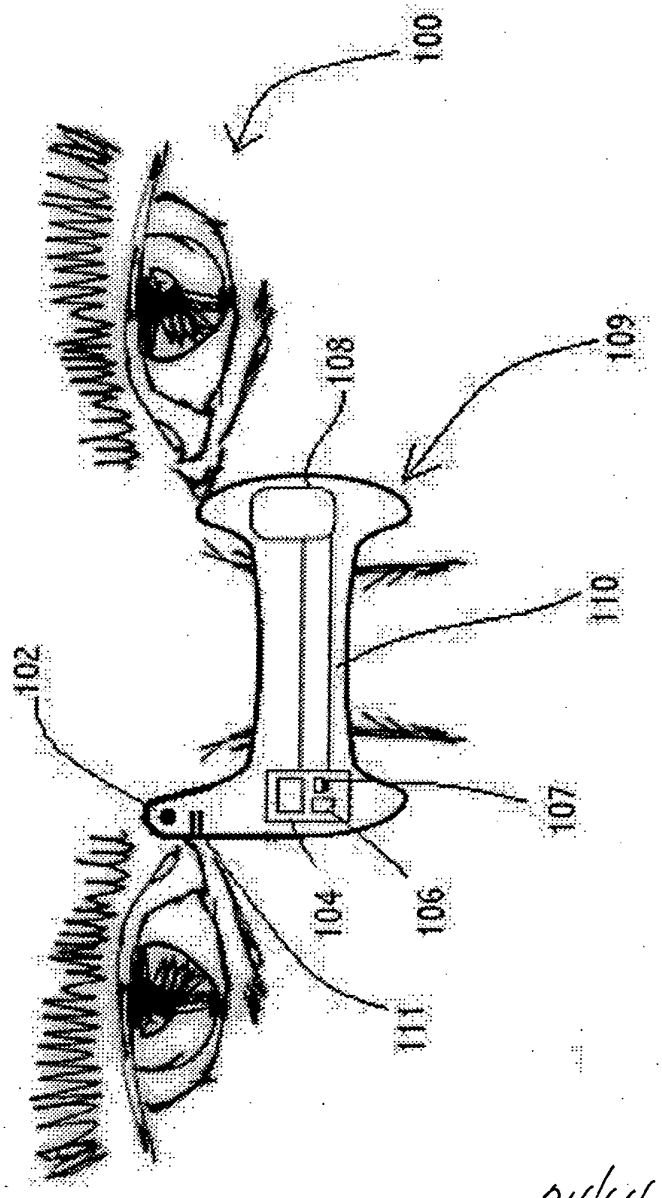


FIG. 12A

1383_PRIOR_ART_000139

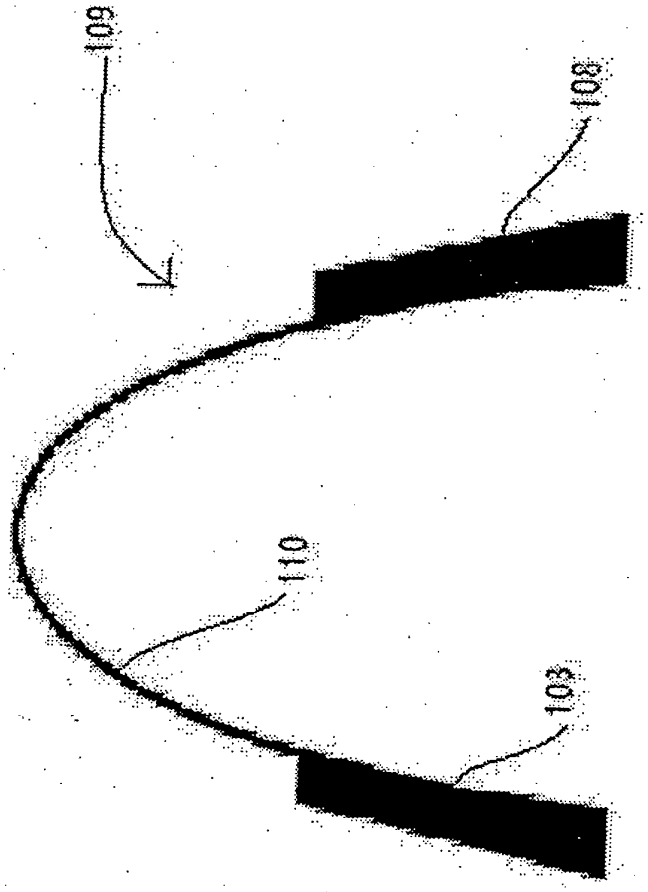
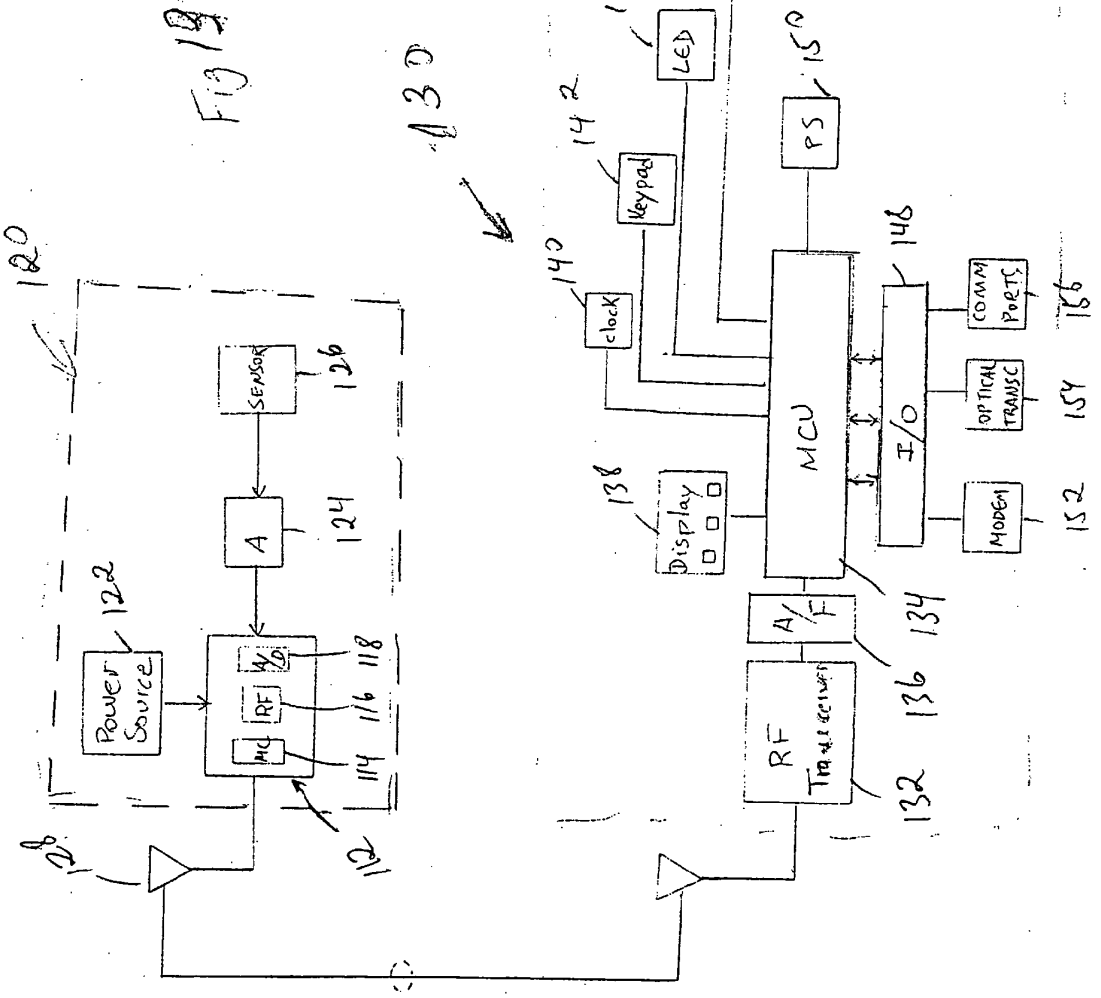


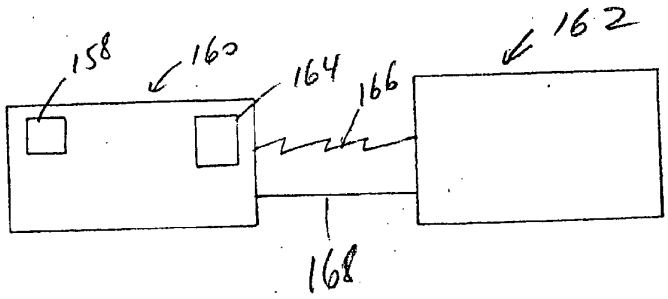
FIG. 12B

1383_PRIOR_ART_000140



1383_PRIOR_ART_000141

Fig. 14



1383_PRIOR_ART_000142

Fig 15A

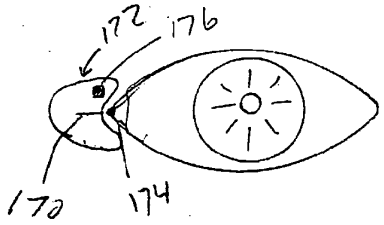


Fig 15B

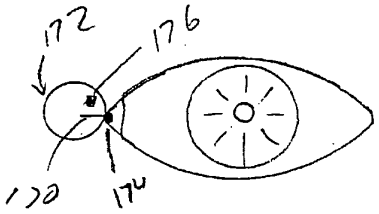


Fig 15C

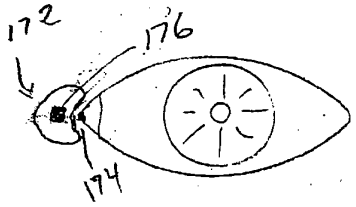


Fig 15D

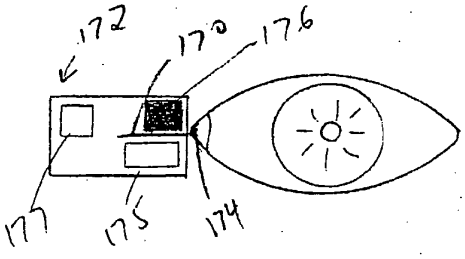
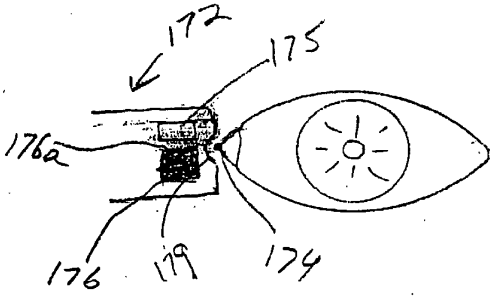


Fig 15E



1383_PRIOR_ART_000143

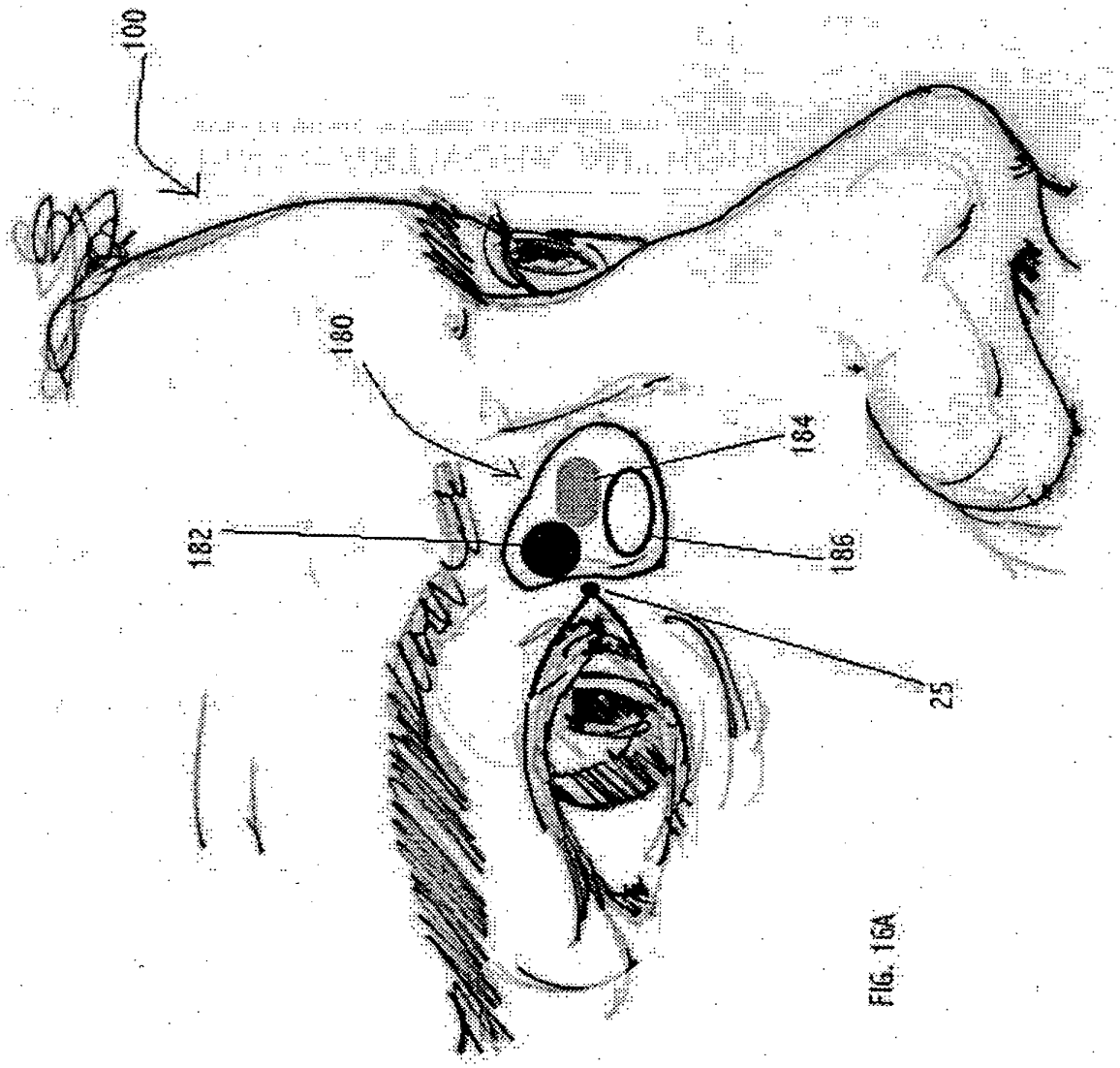
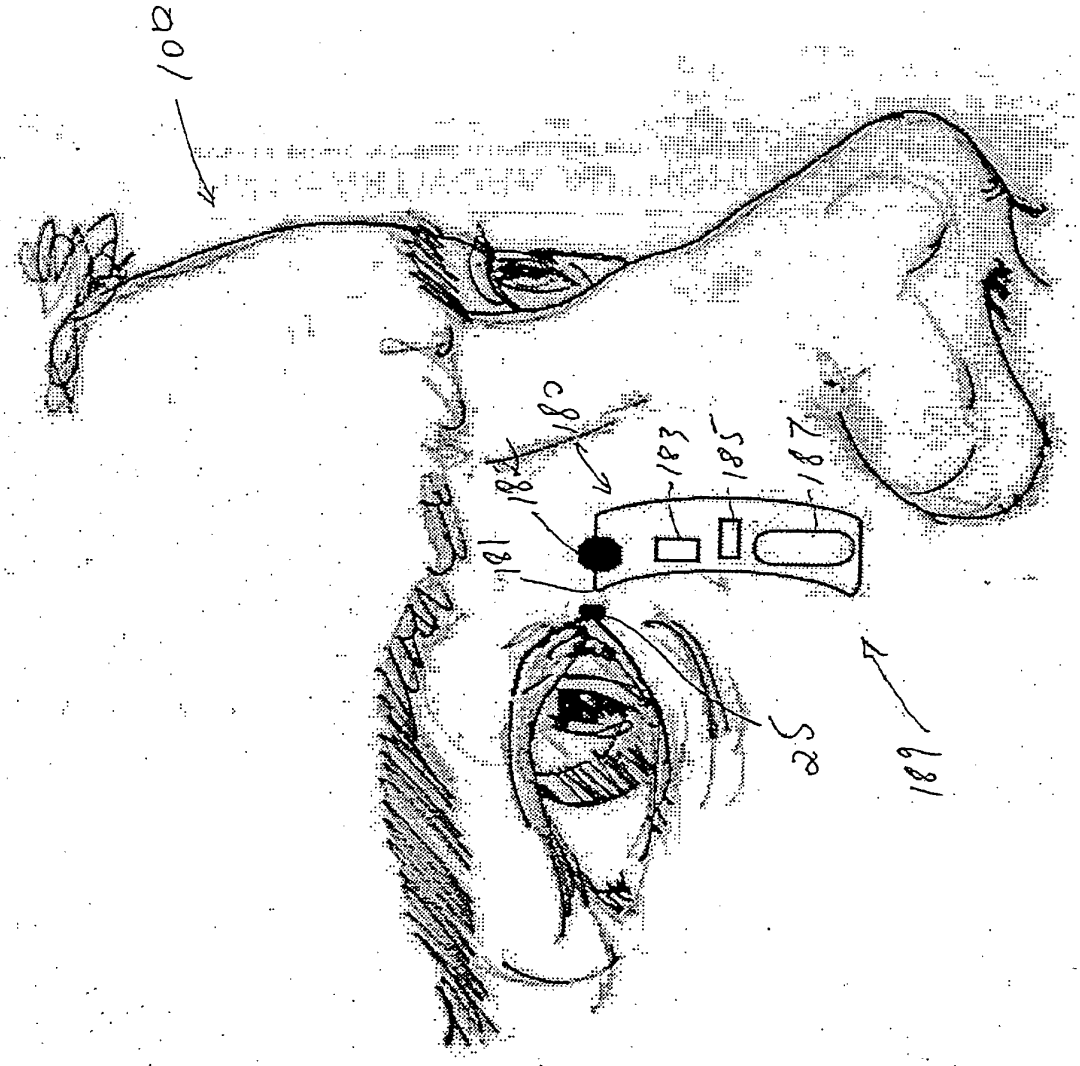


FIG. 16A

1383_PRIOR_ART_000144

Fig 18B



1383_PRIOR_ART_000145

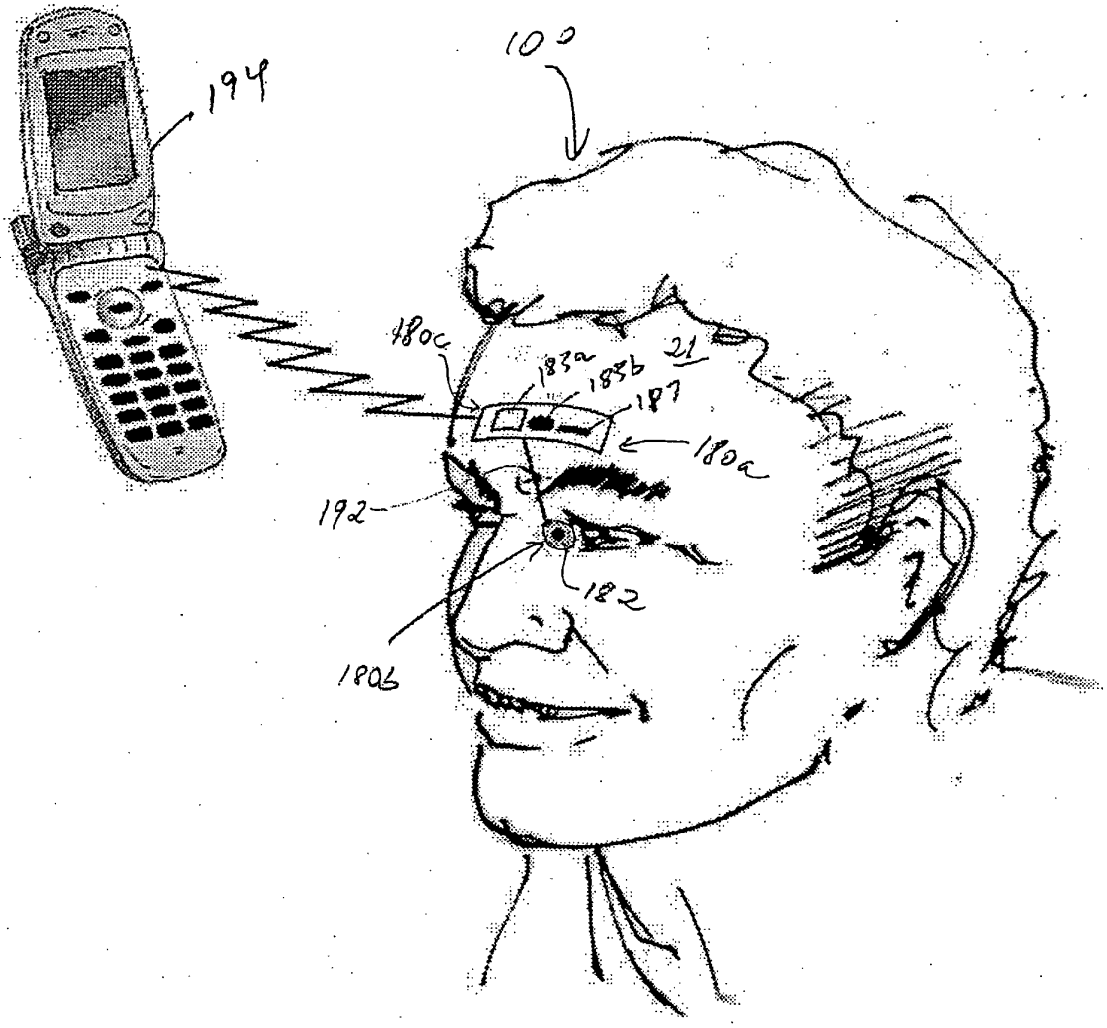


Fig 16C

1383_PRIOR_ART_000146

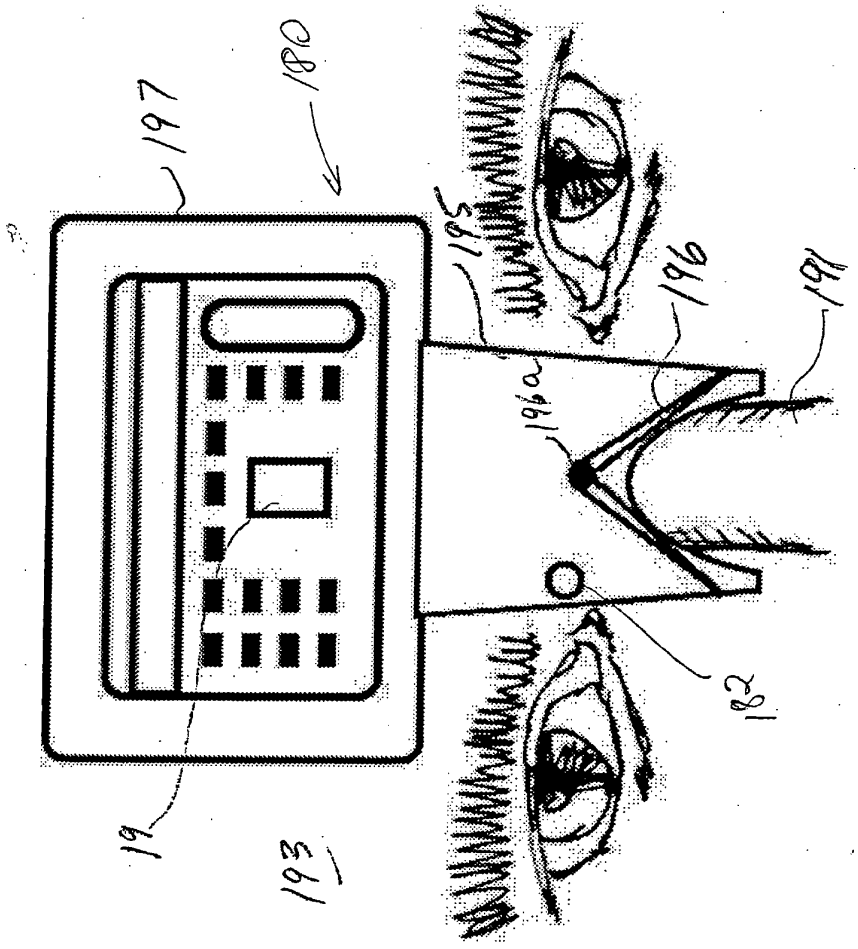


Fig. 17

1383_PRIOR_ART_000147

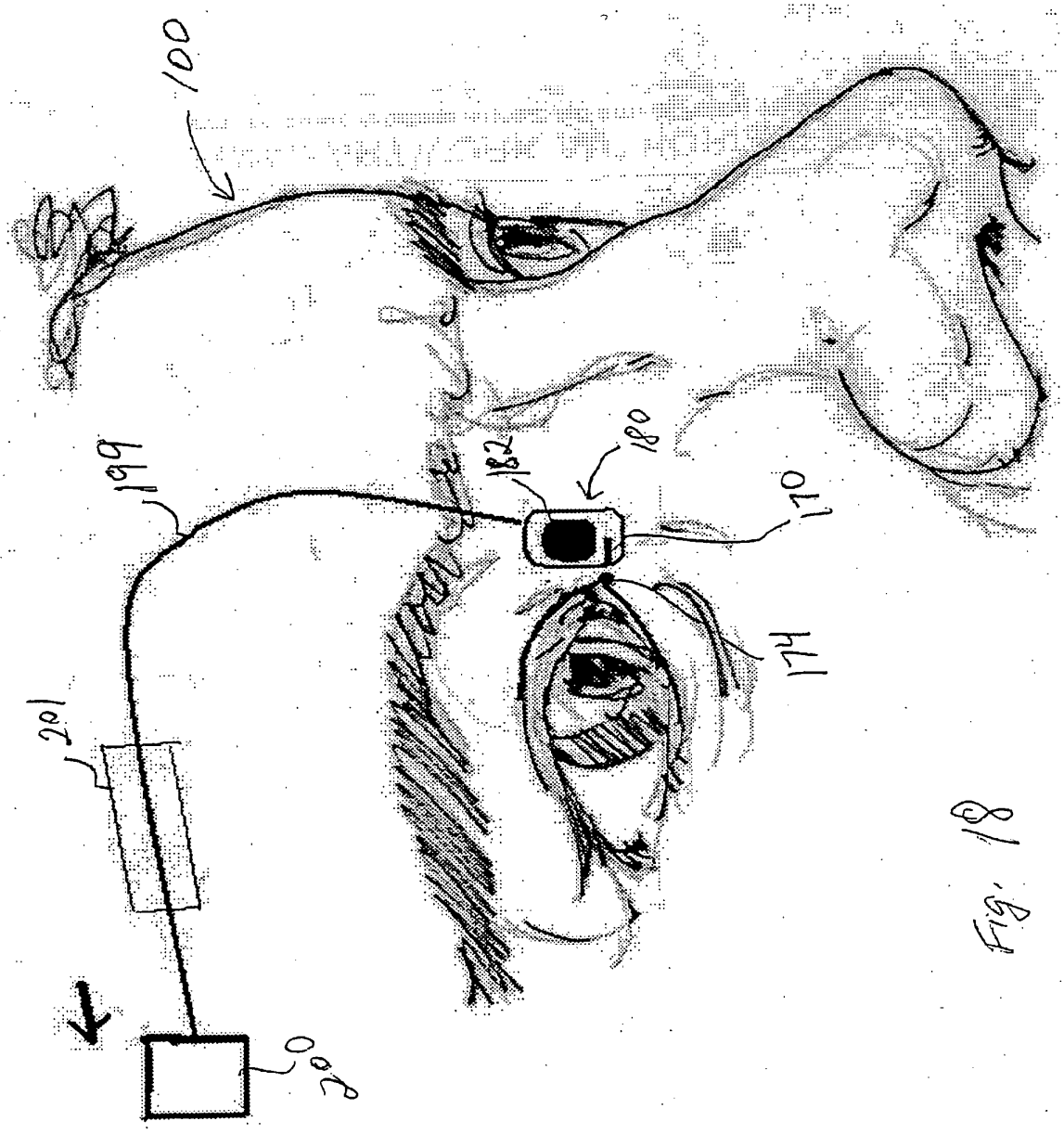


Fig. 8A

1383_PRIOR_ART_000148

Fig 19A1

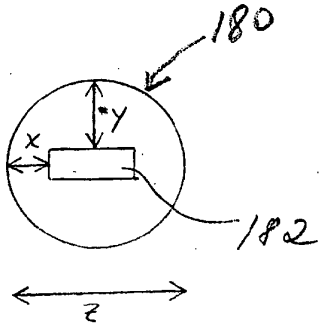


Fig 19A2

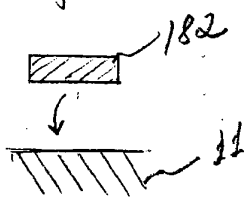


Fig 19B

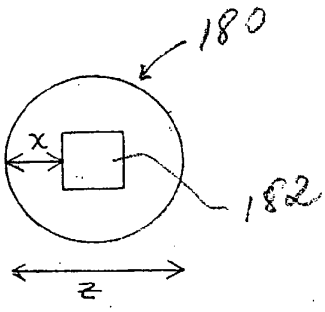


Fig 19C

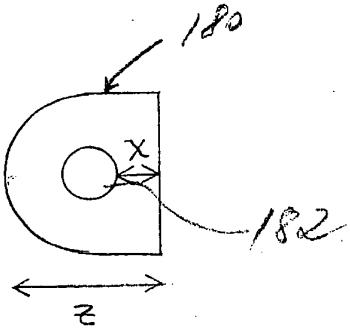
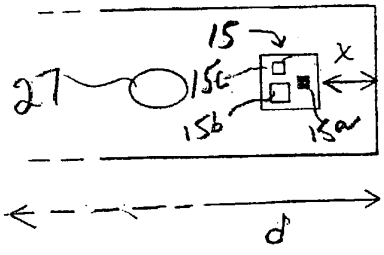


Fig 19D



1383_PRIOR_ART_000149

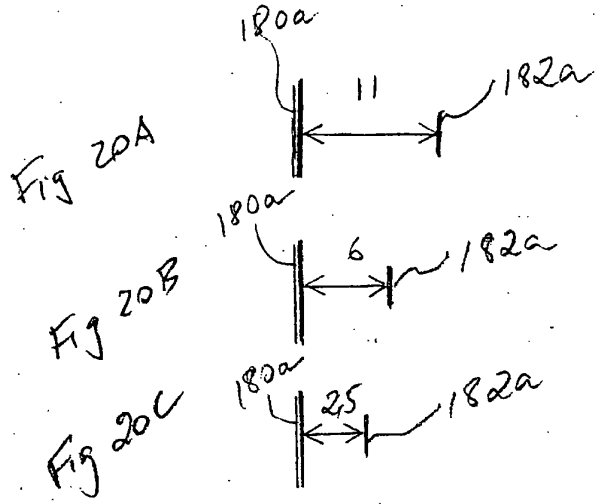


Fig 20A

Fig 20B

Fig 20C

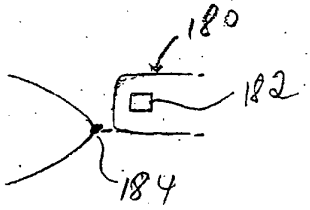


Fig 21A

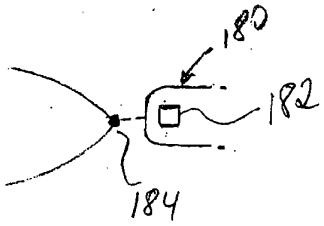


Fig 21B

1383_PRIOR_ART_000150



Fig 22A

1383_PRIOR_ART_000151

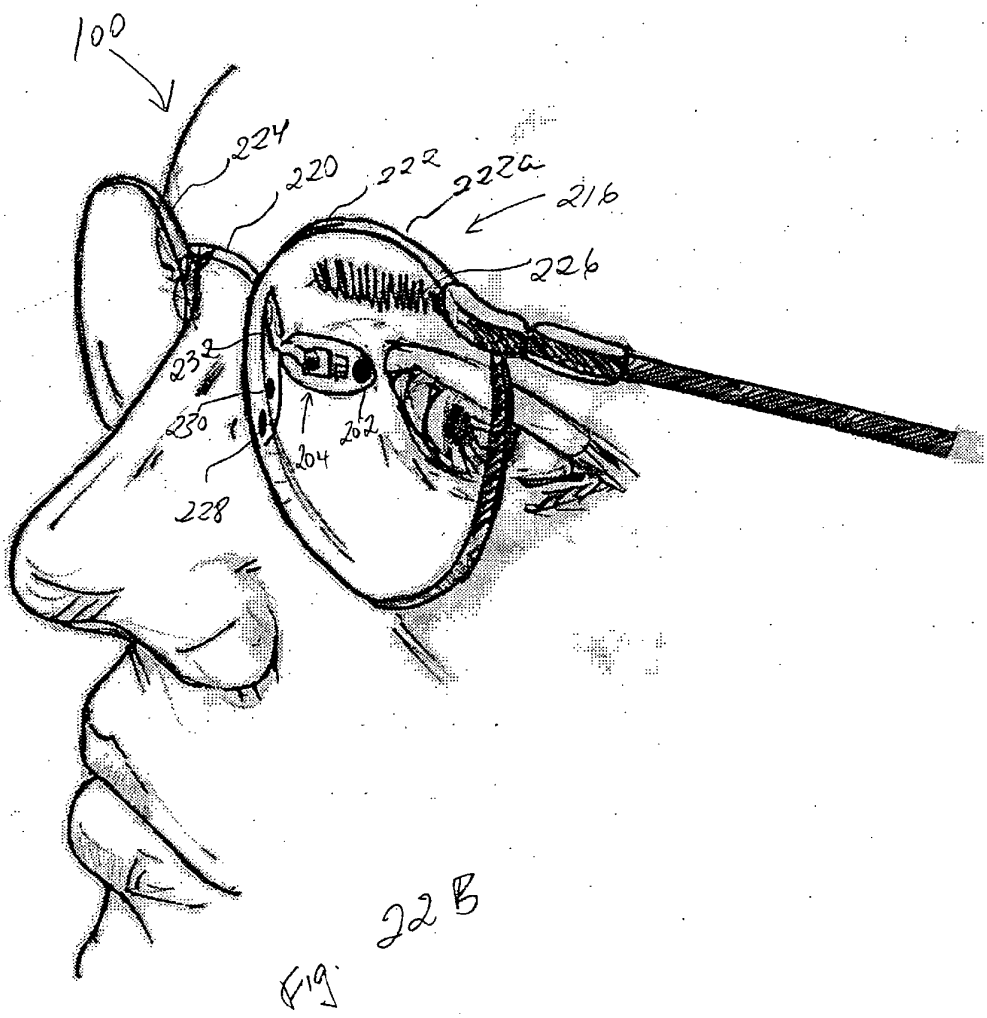


Fig. 22B

1383_PRIOR_ART_000152

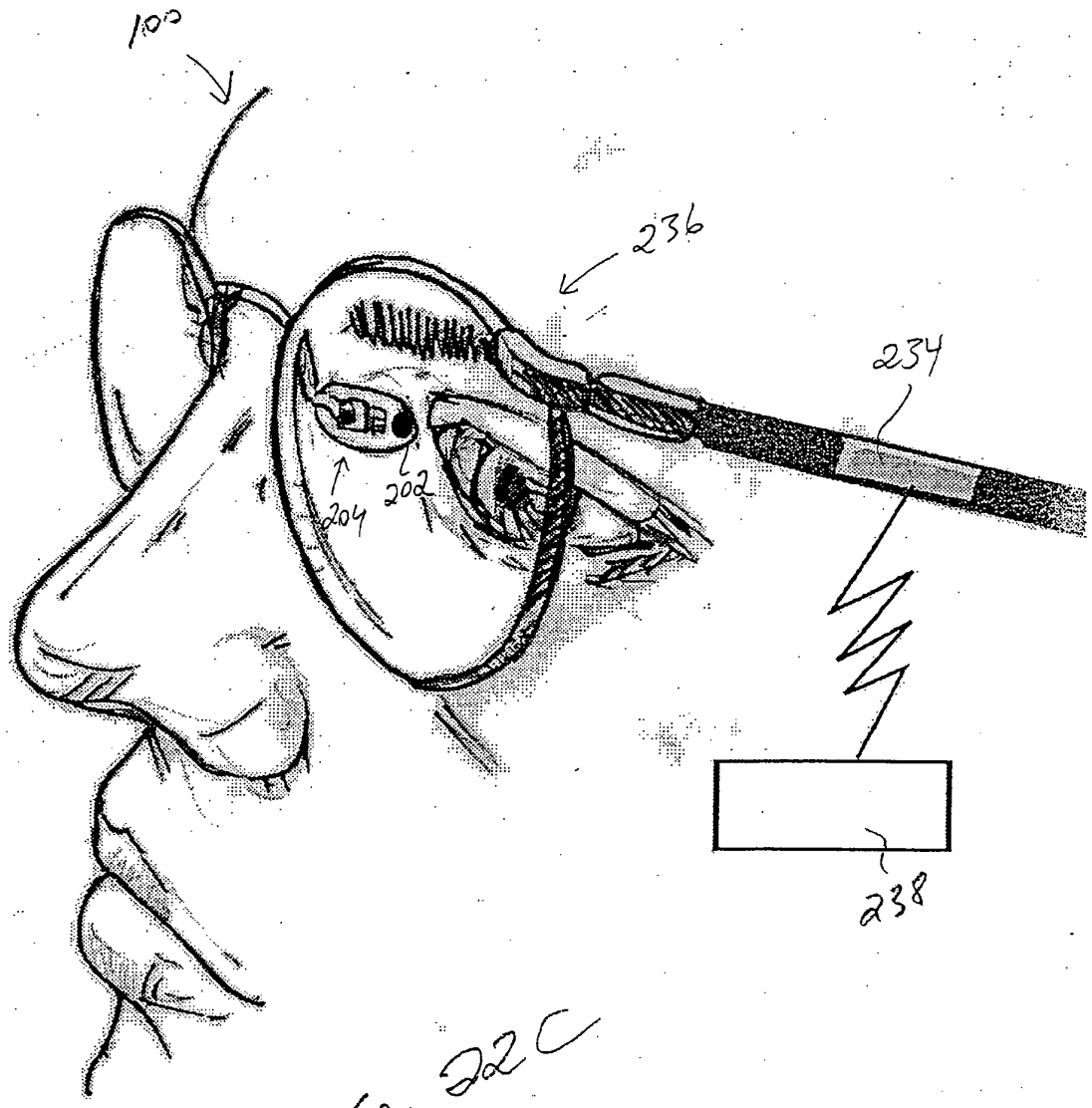


Fig. 22C

1383_PRIOR_ART_000153

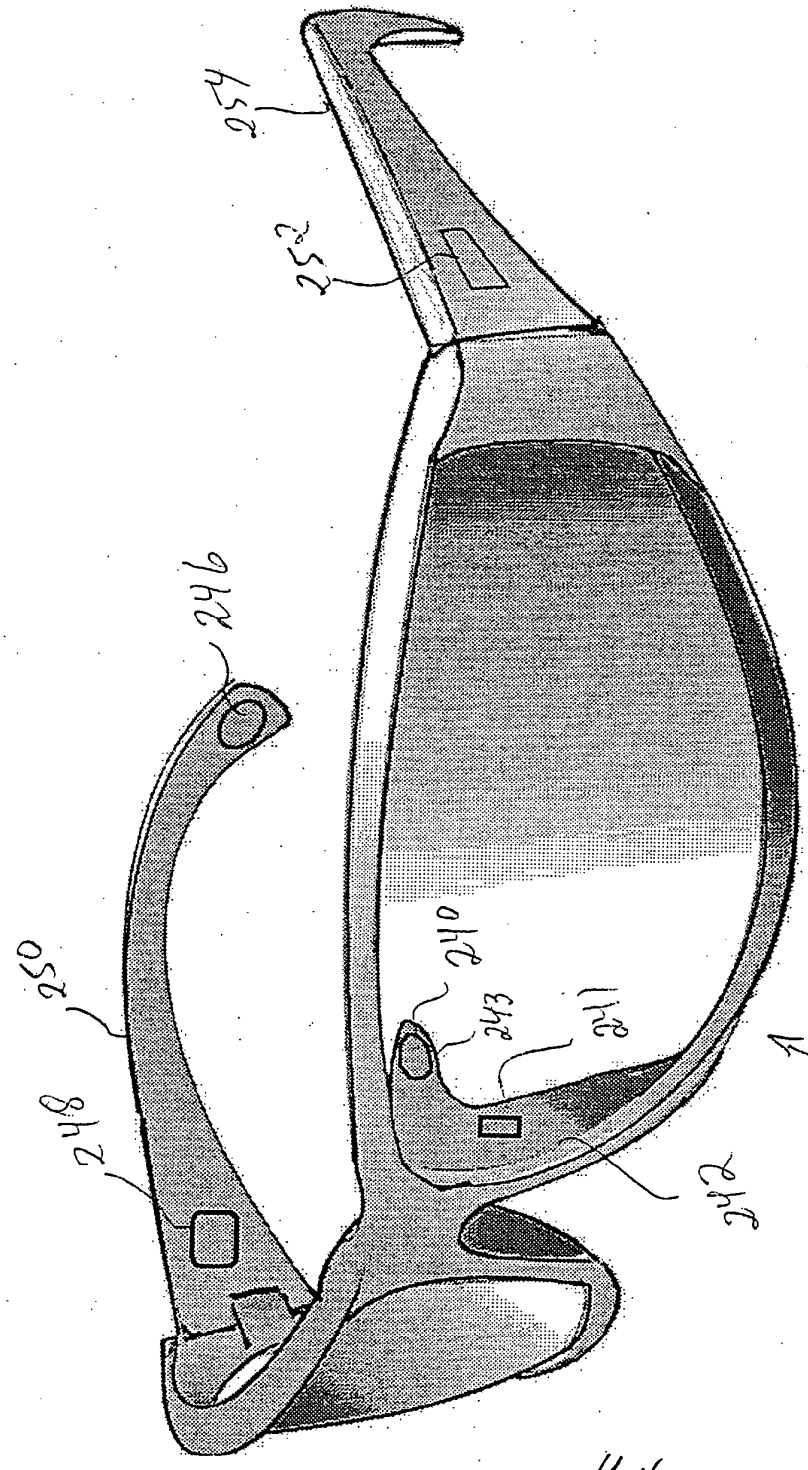


Fig. 23A

1383_PRIOR_ART_000154

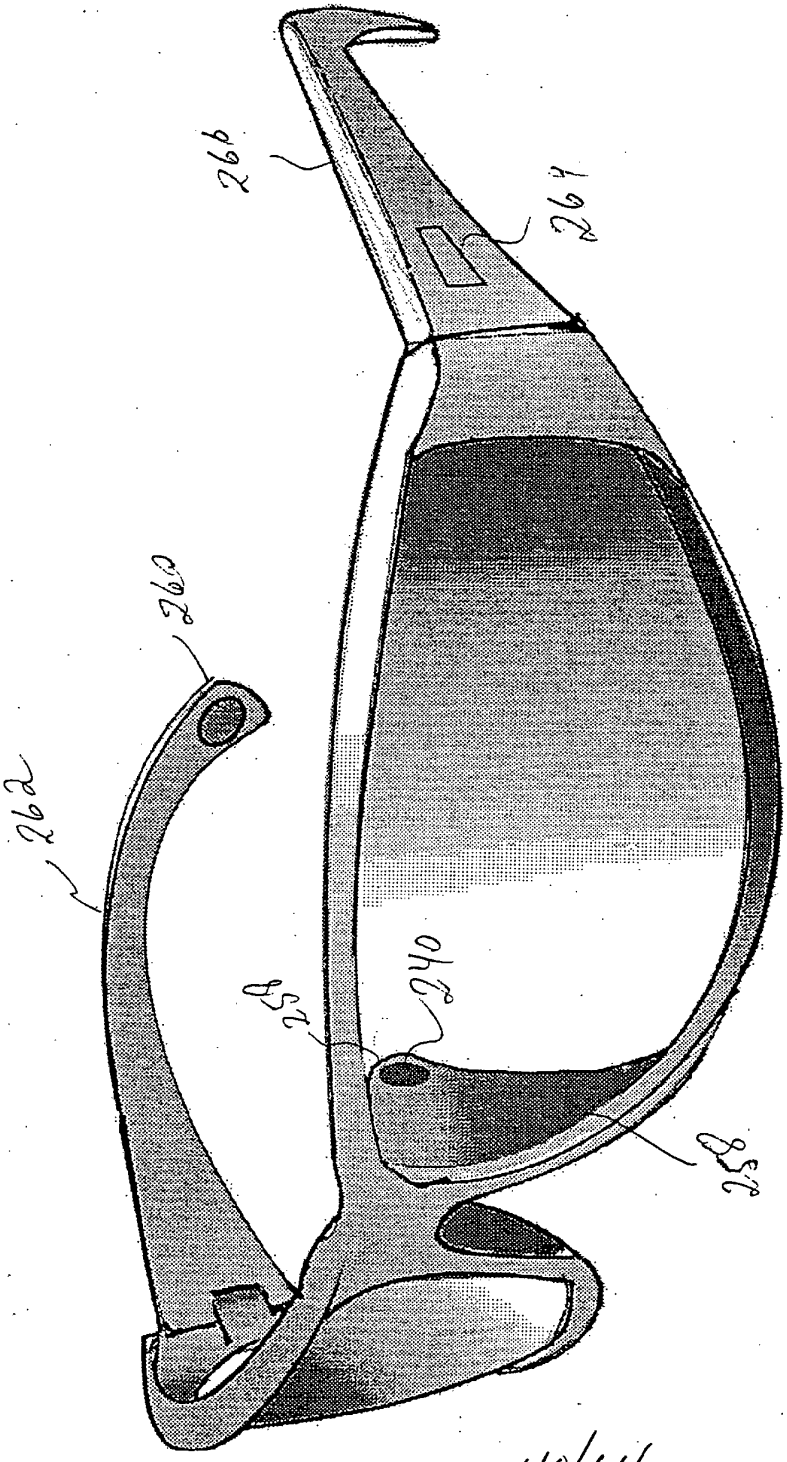


Fig. 23B

1383_PRIOR_ART_000155

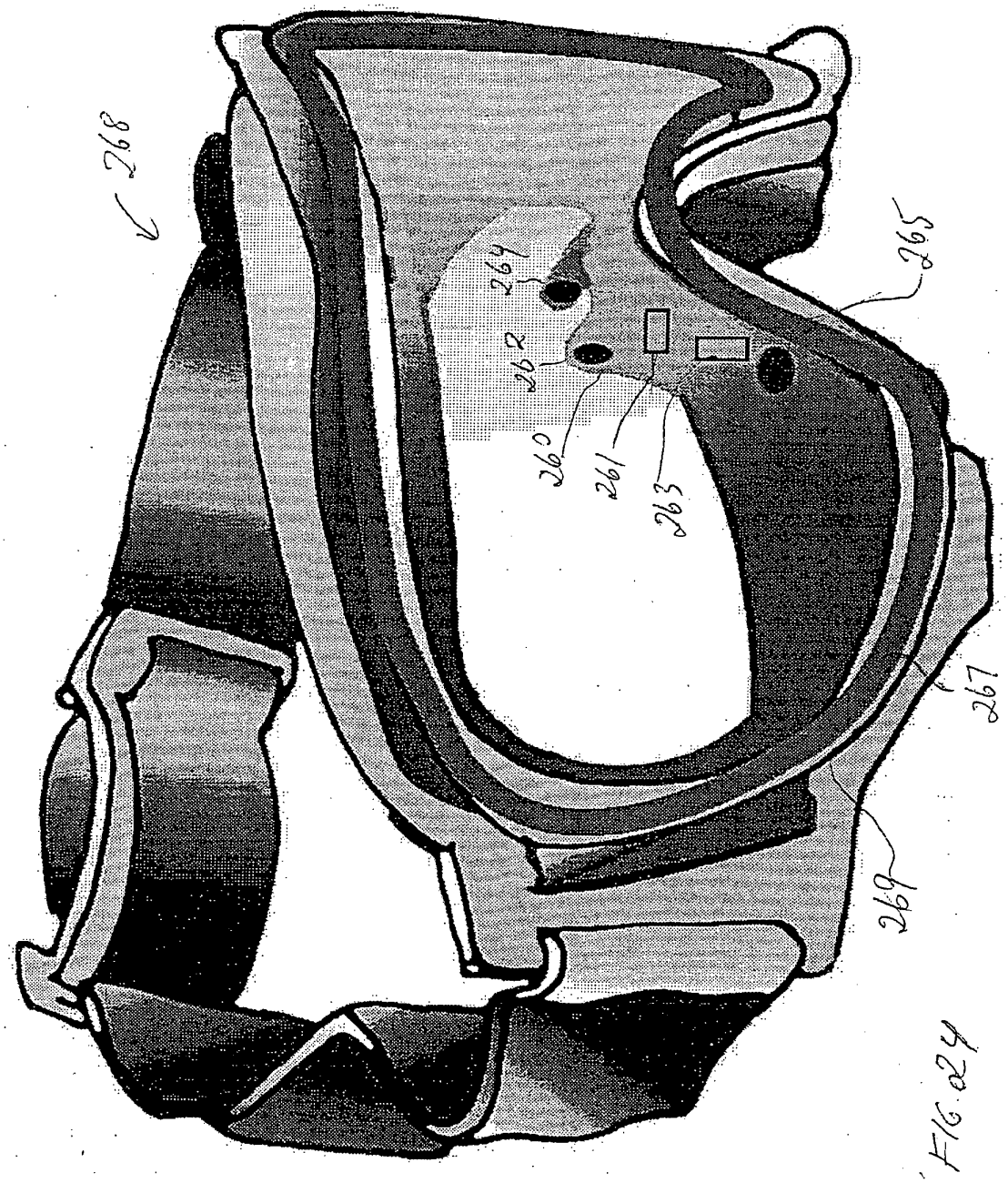


FIG. 24

1383_PRIOR_ART_000156

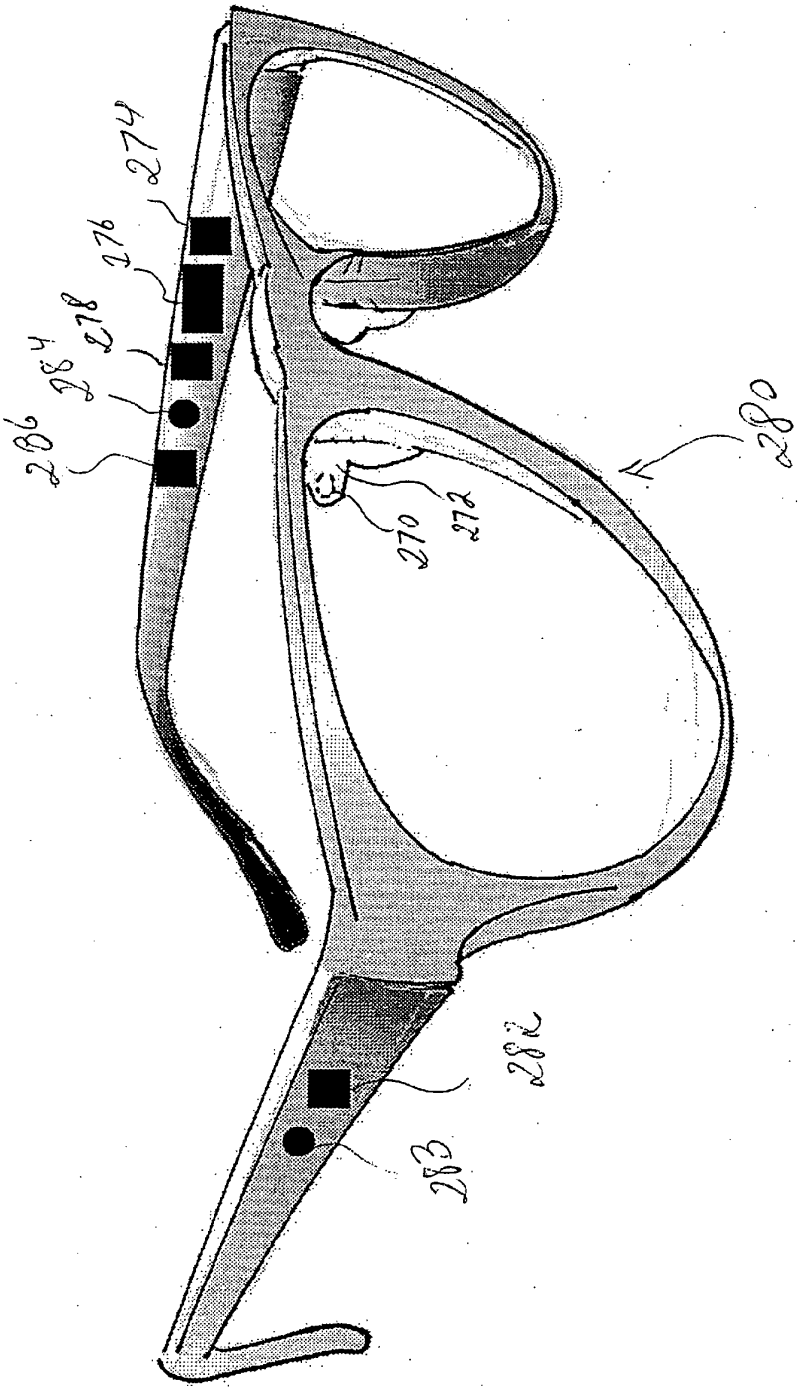


FIG. 25

1383_PRIOR_ART_000157

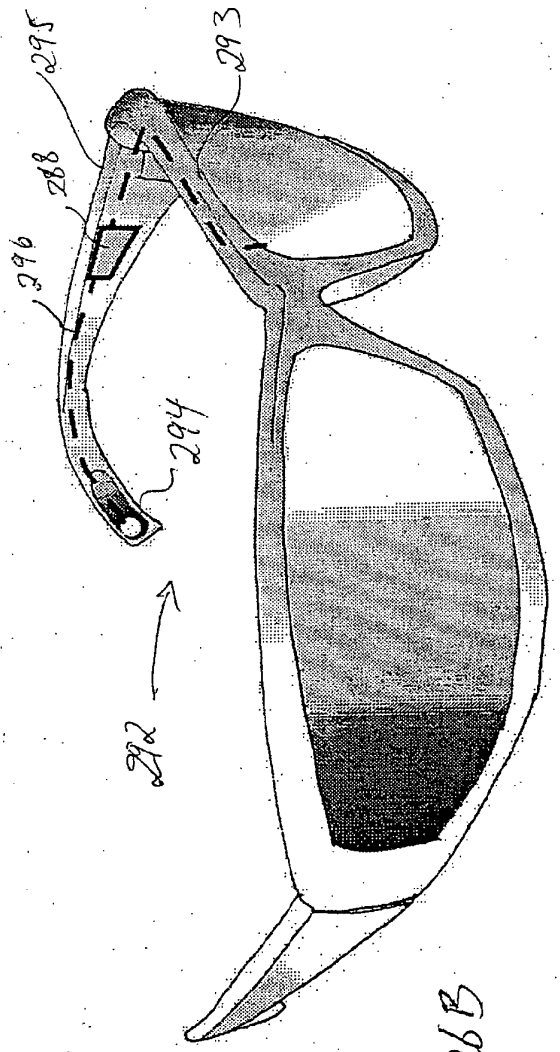


Fig. 26B

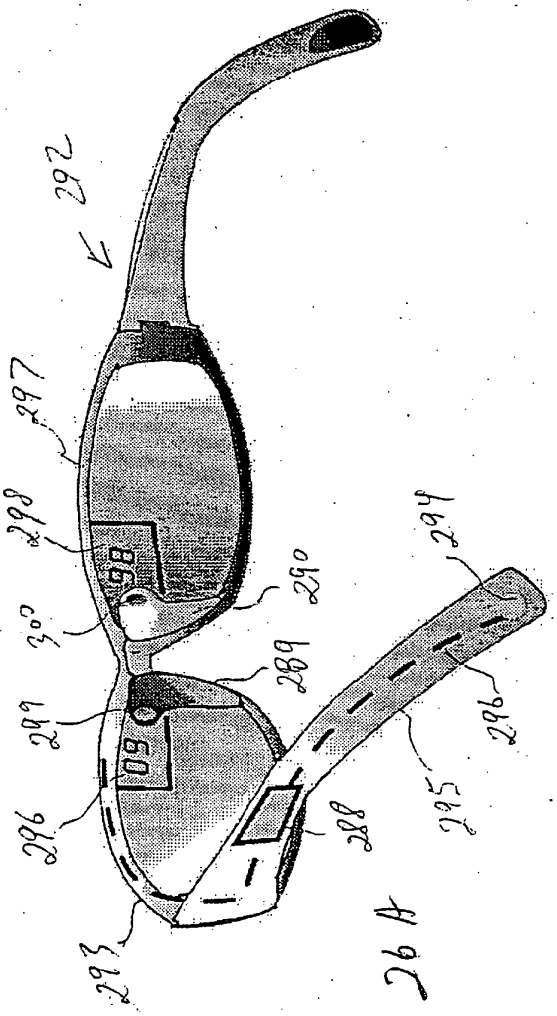


Fig. 26A

1383_PRIOR_ART_000158

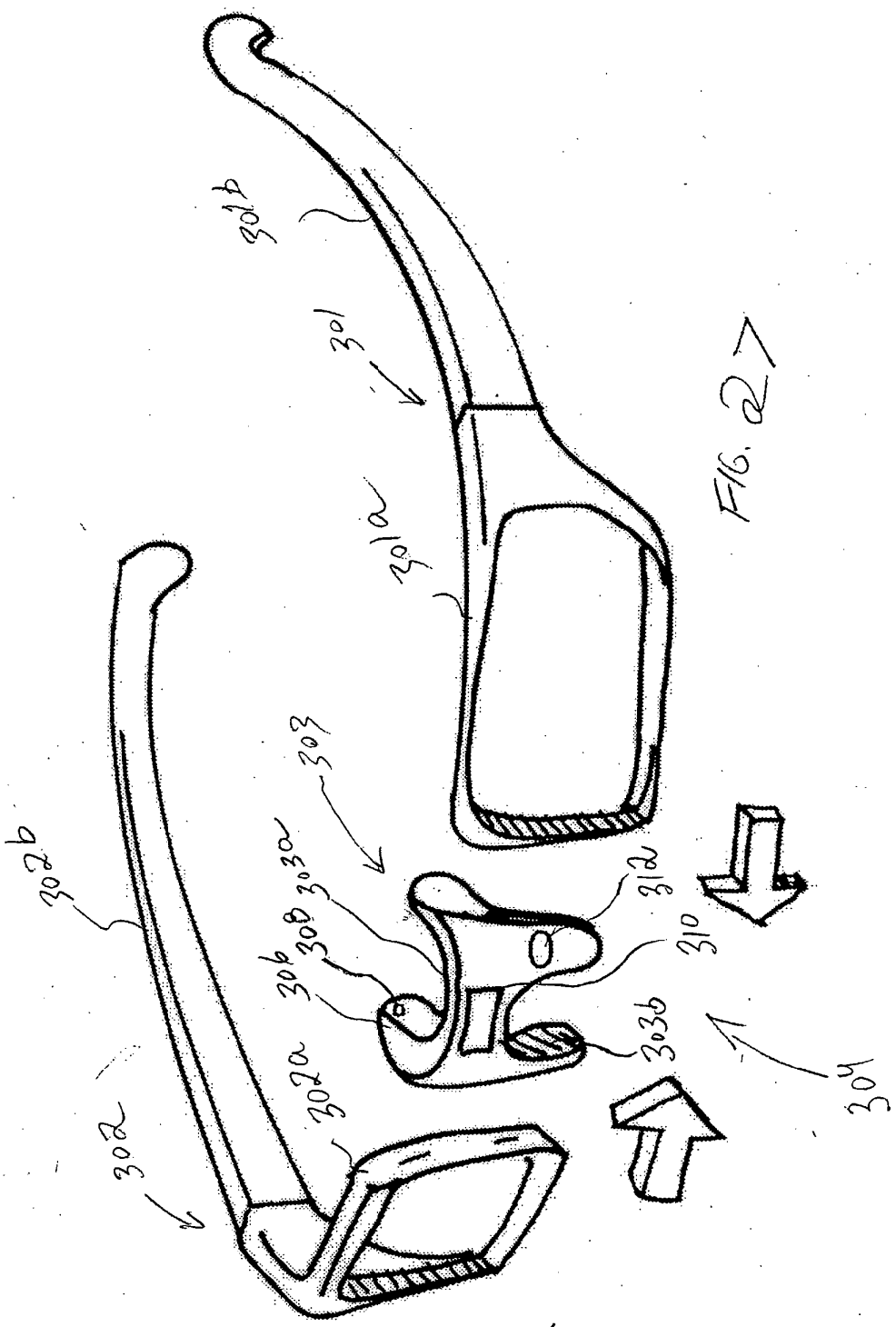


FIG. 27

1383_PRIOR_ART_000159

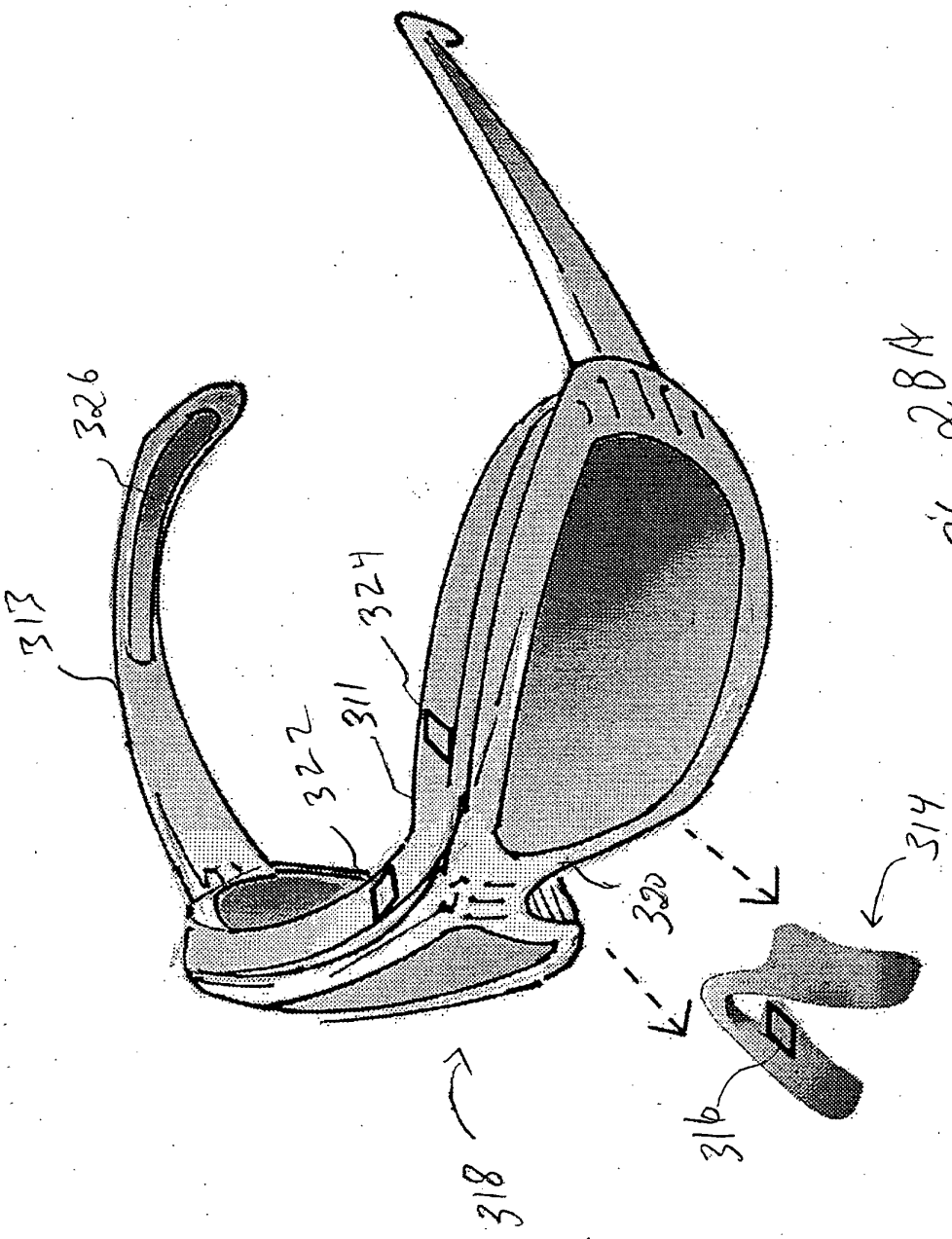


Fig. 28A

1383_PRIOR_ART_000160

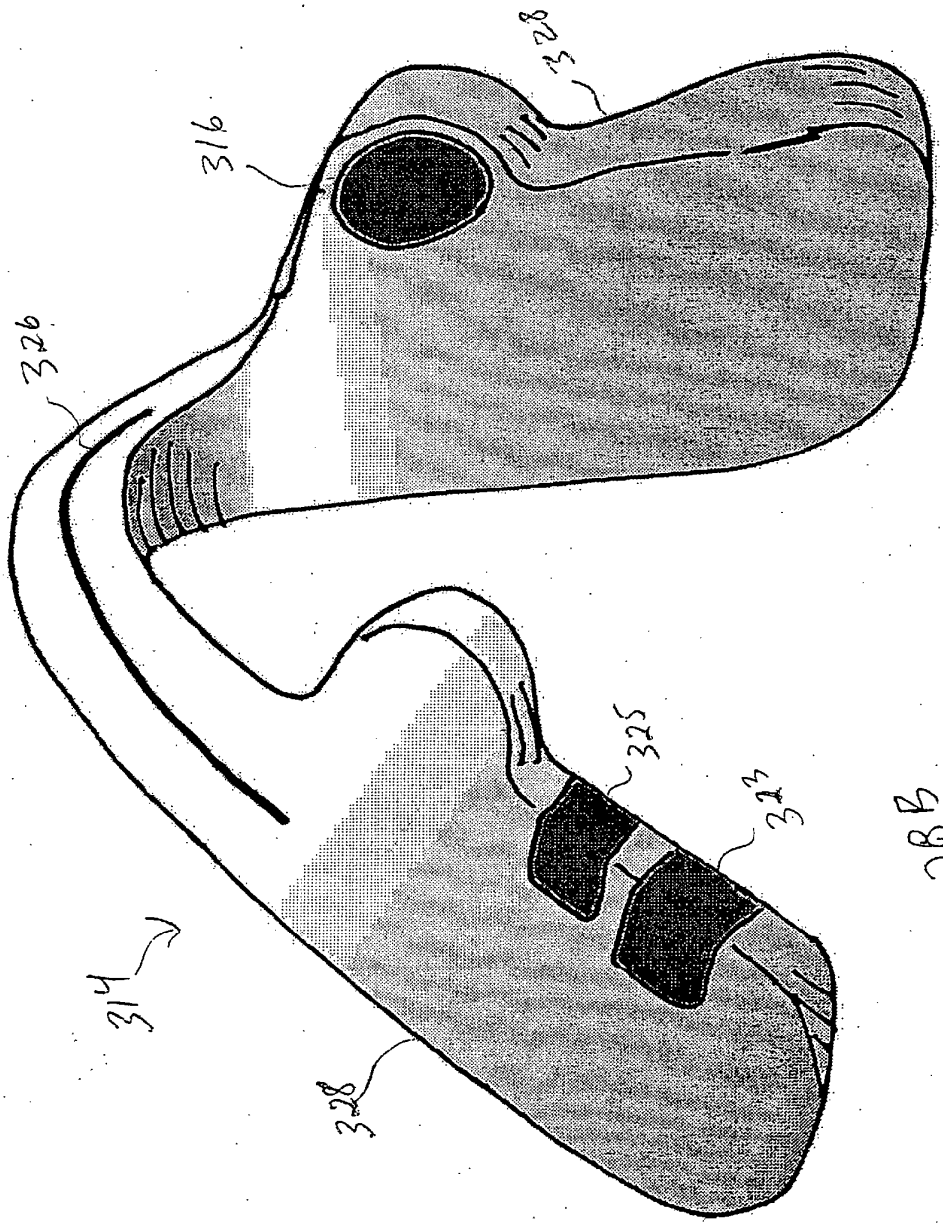


FIG. 28B

1383_PRIOR_ART_000161

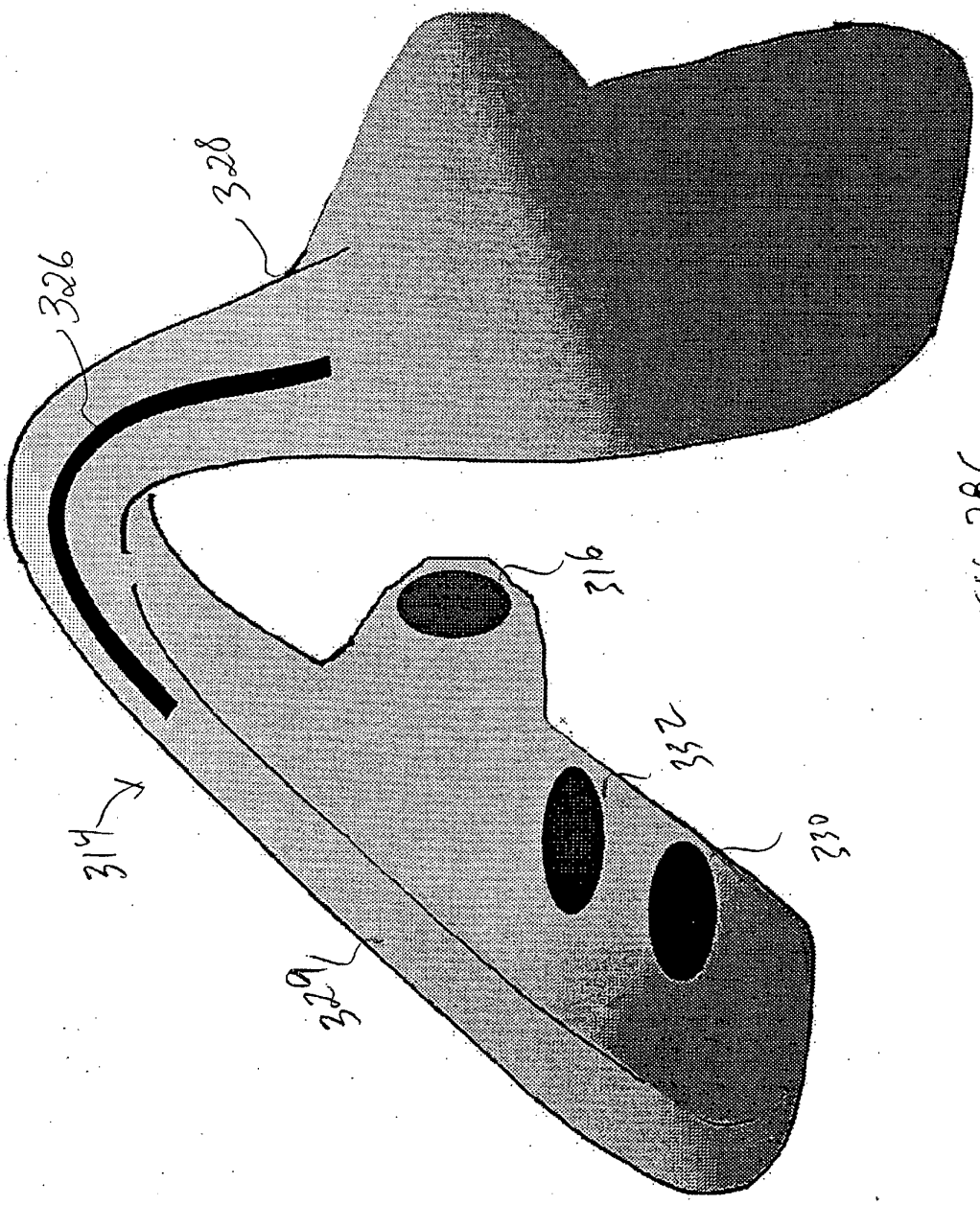


FIG. 28C

1383_PRIOR_ART_000162

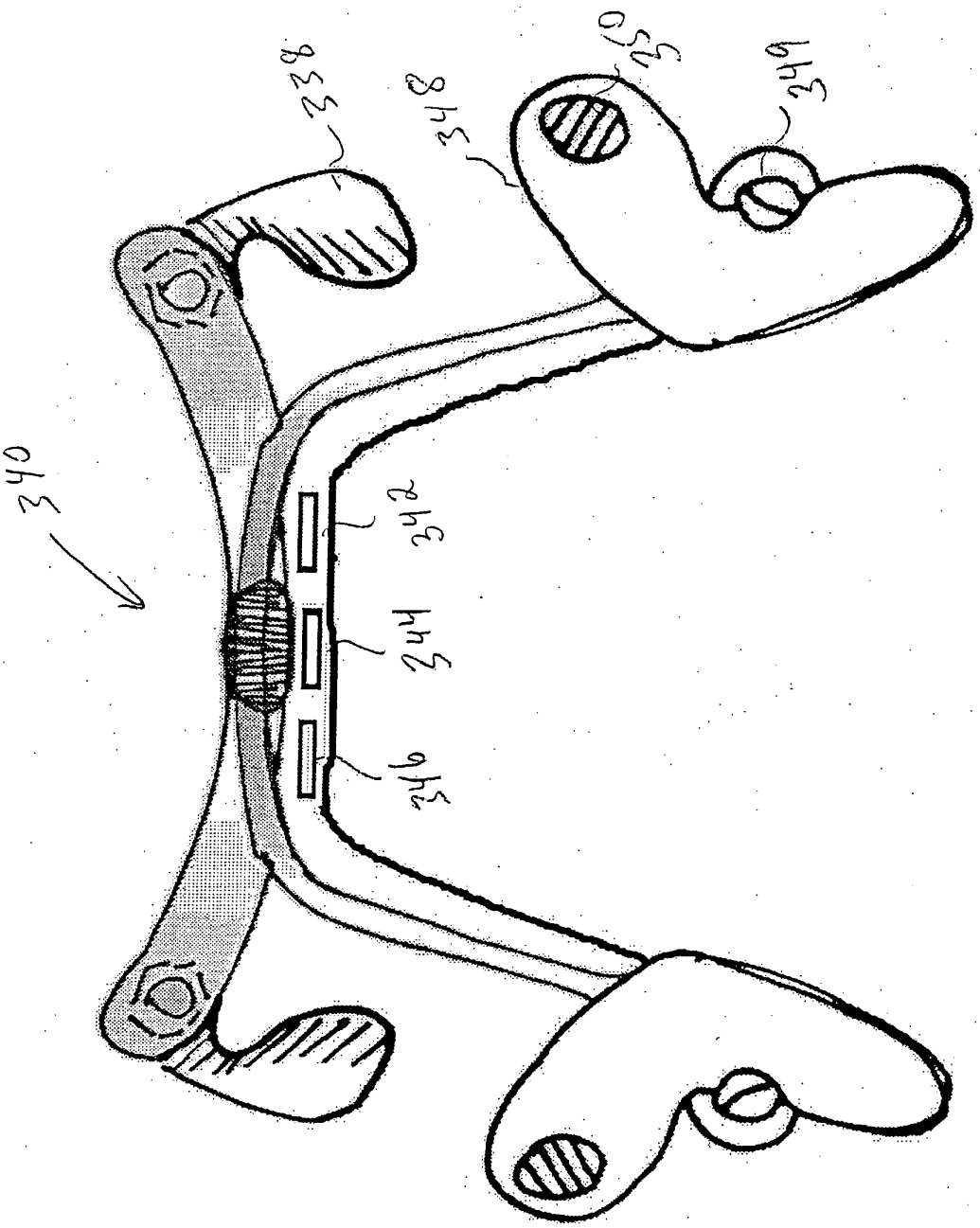


FIG. 29

1383_PRIOR_ART_000163

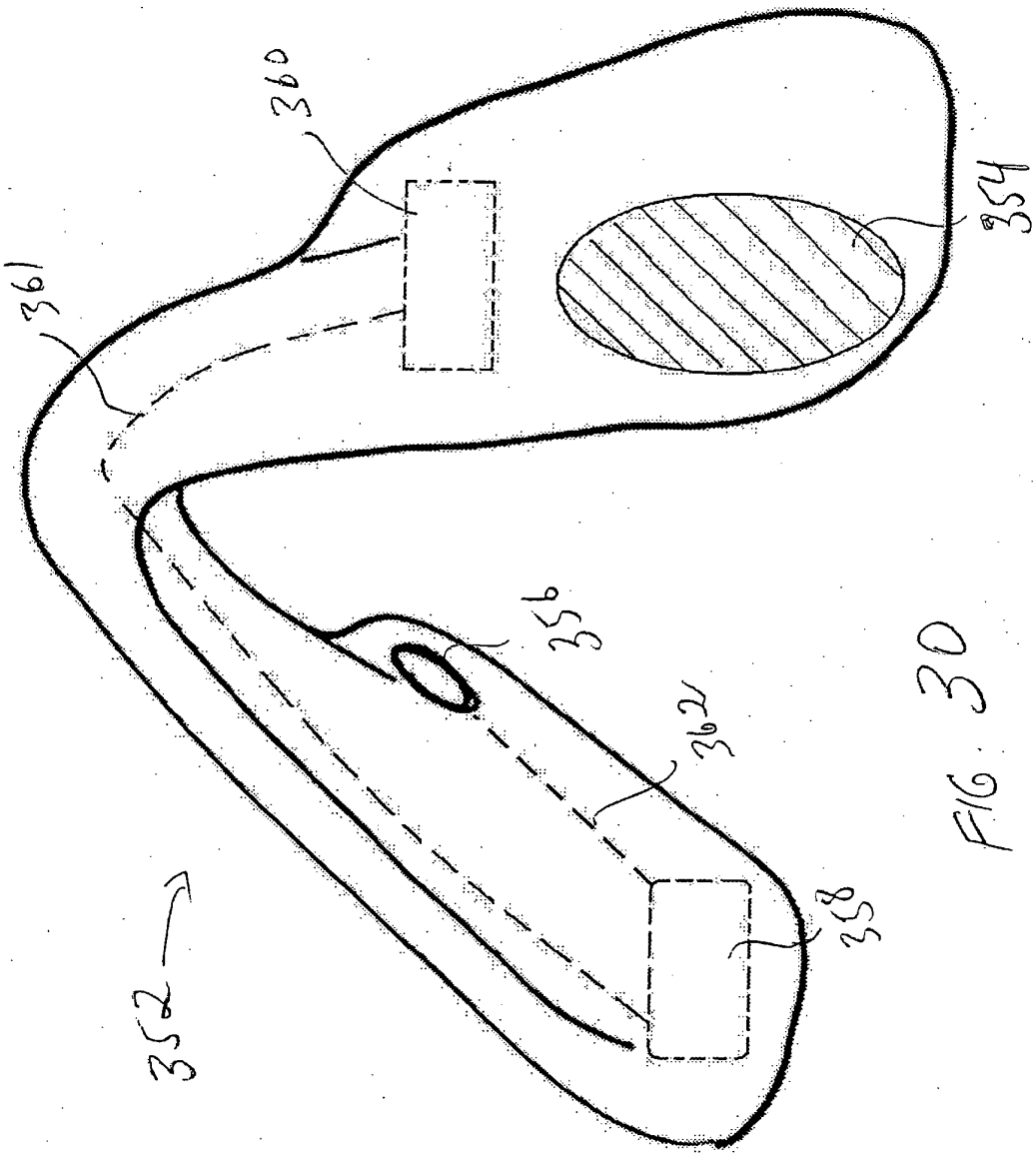


FIG. 30

1383_PRIOR_ART_000164

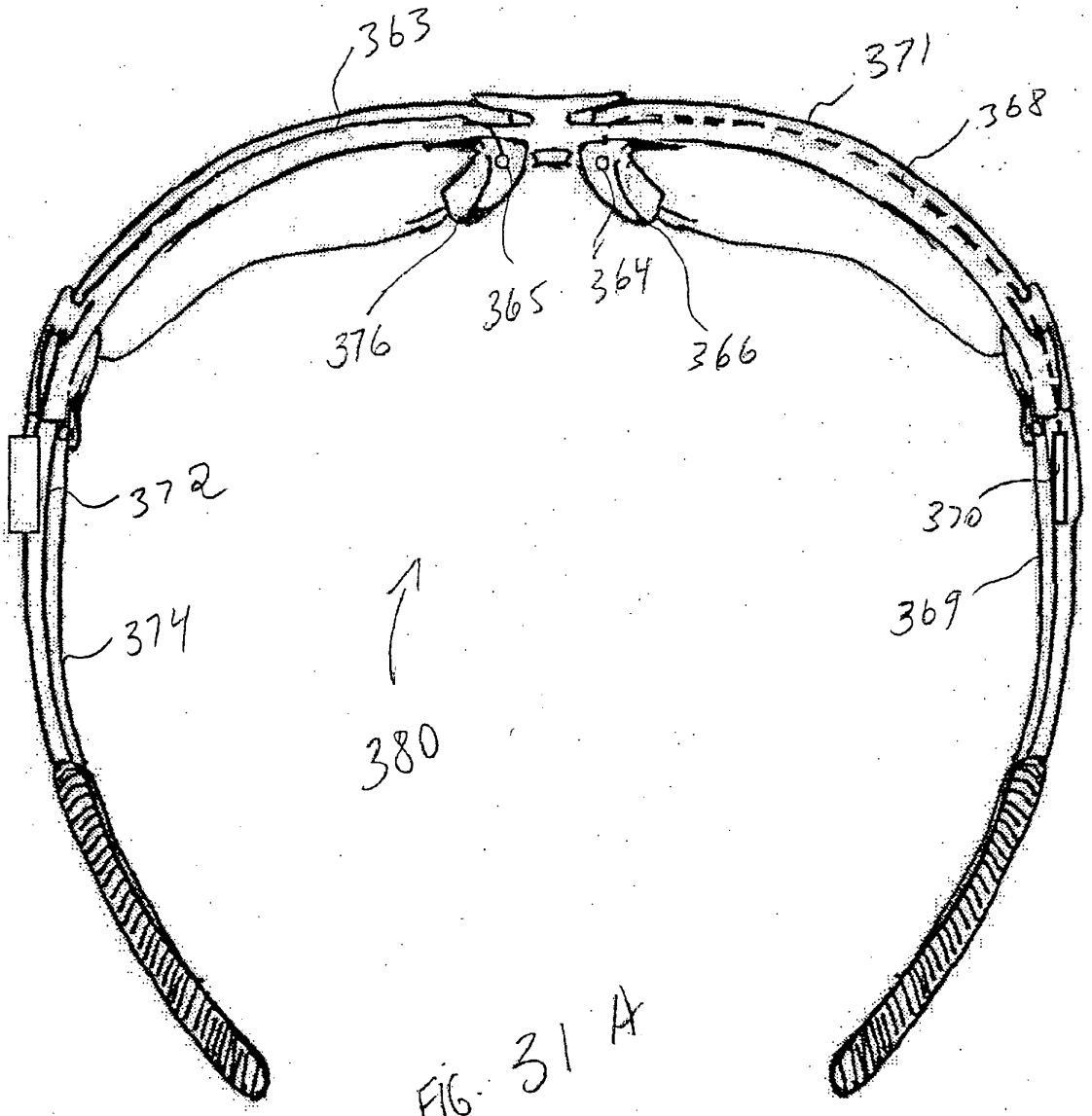


FIG. 31A

1383_PRIOR_ART_000165

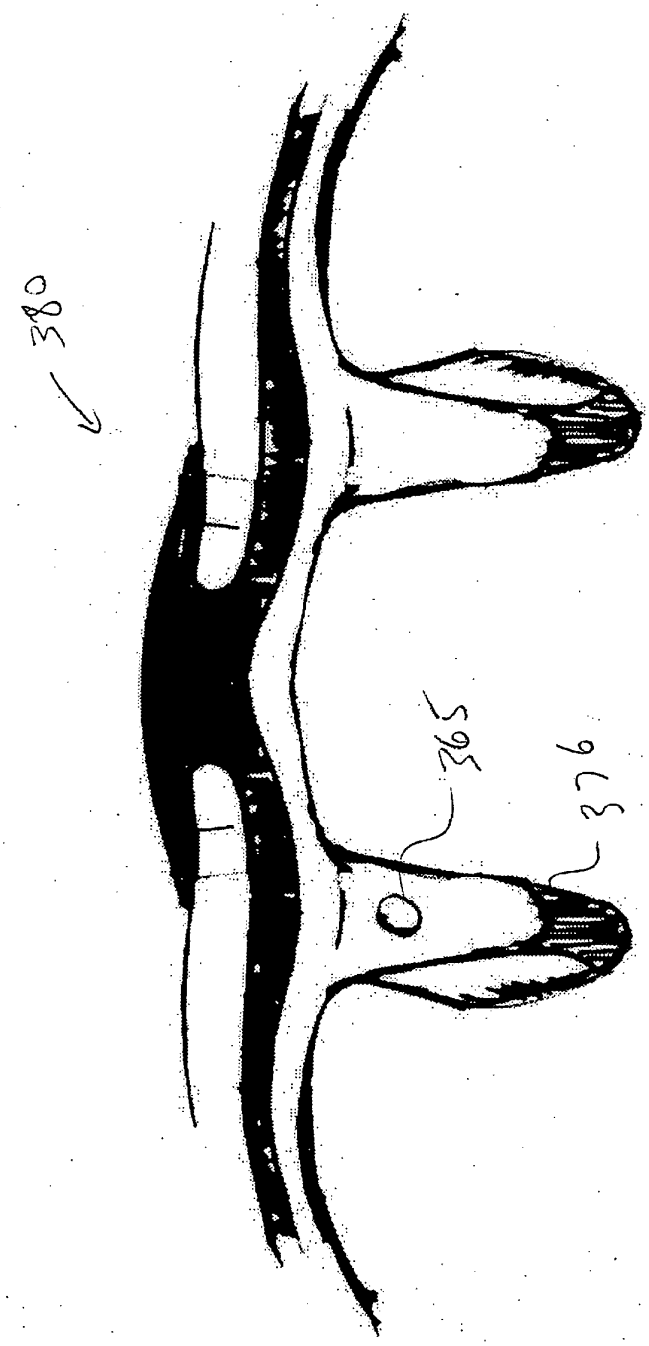


FIG. 31B

1383_PRIOR_ART_000166

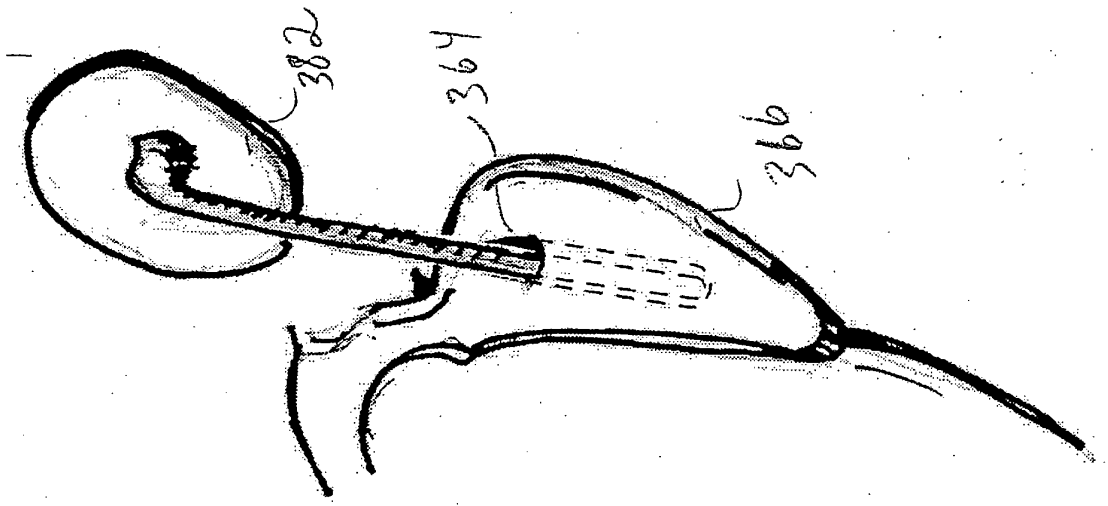


Fig 31D

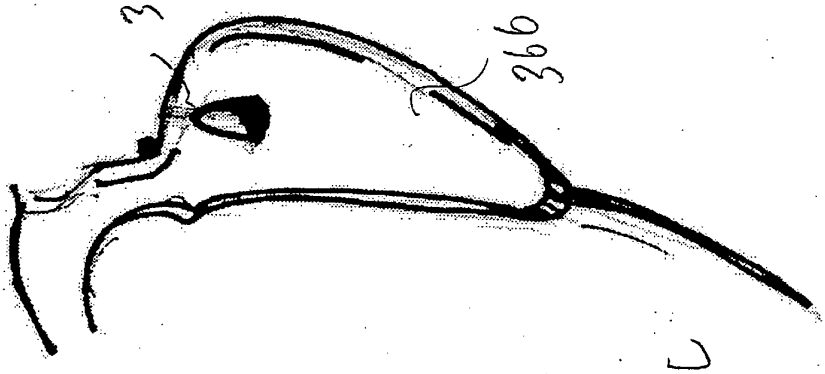


Fig 31C

1383_PRIOR_ART_000167



FIG 32A

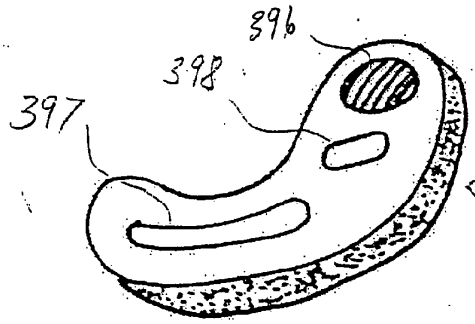
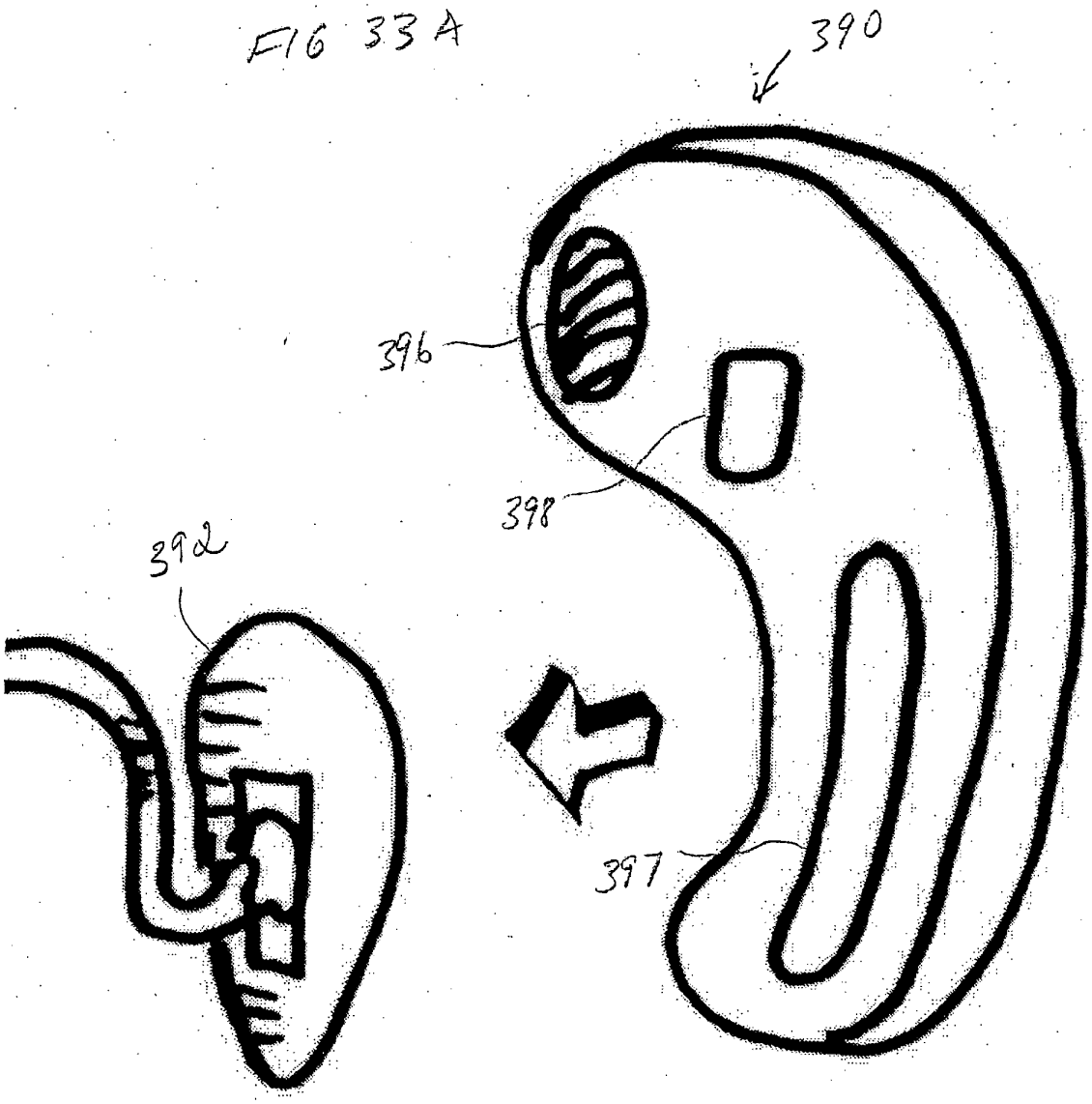


FIG 32B

1383_PRIOR_ART_000168

FIG 33A



1383_PRIOR_ART_000169

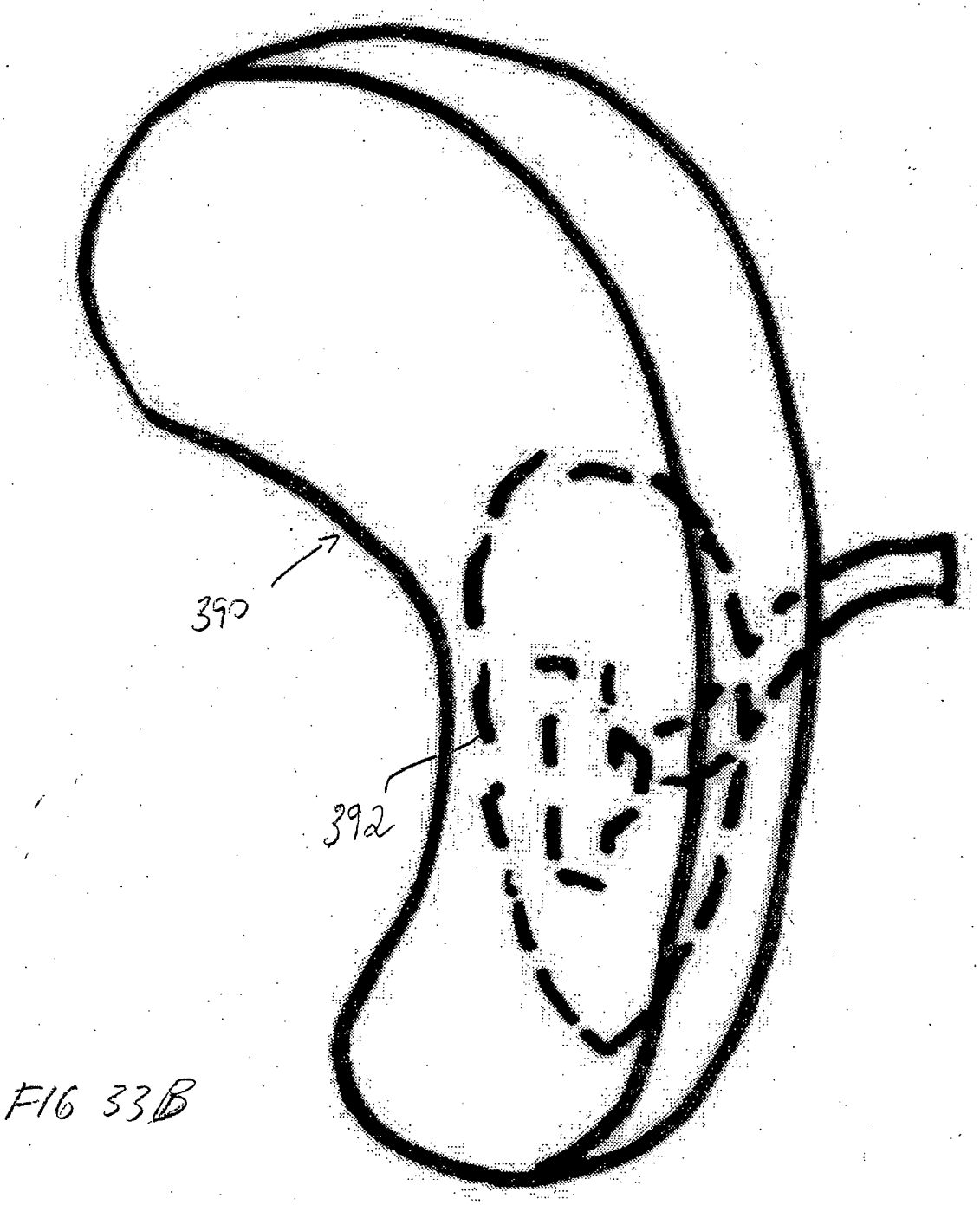


FIG 33B

1383_PRIOR_ART_000170

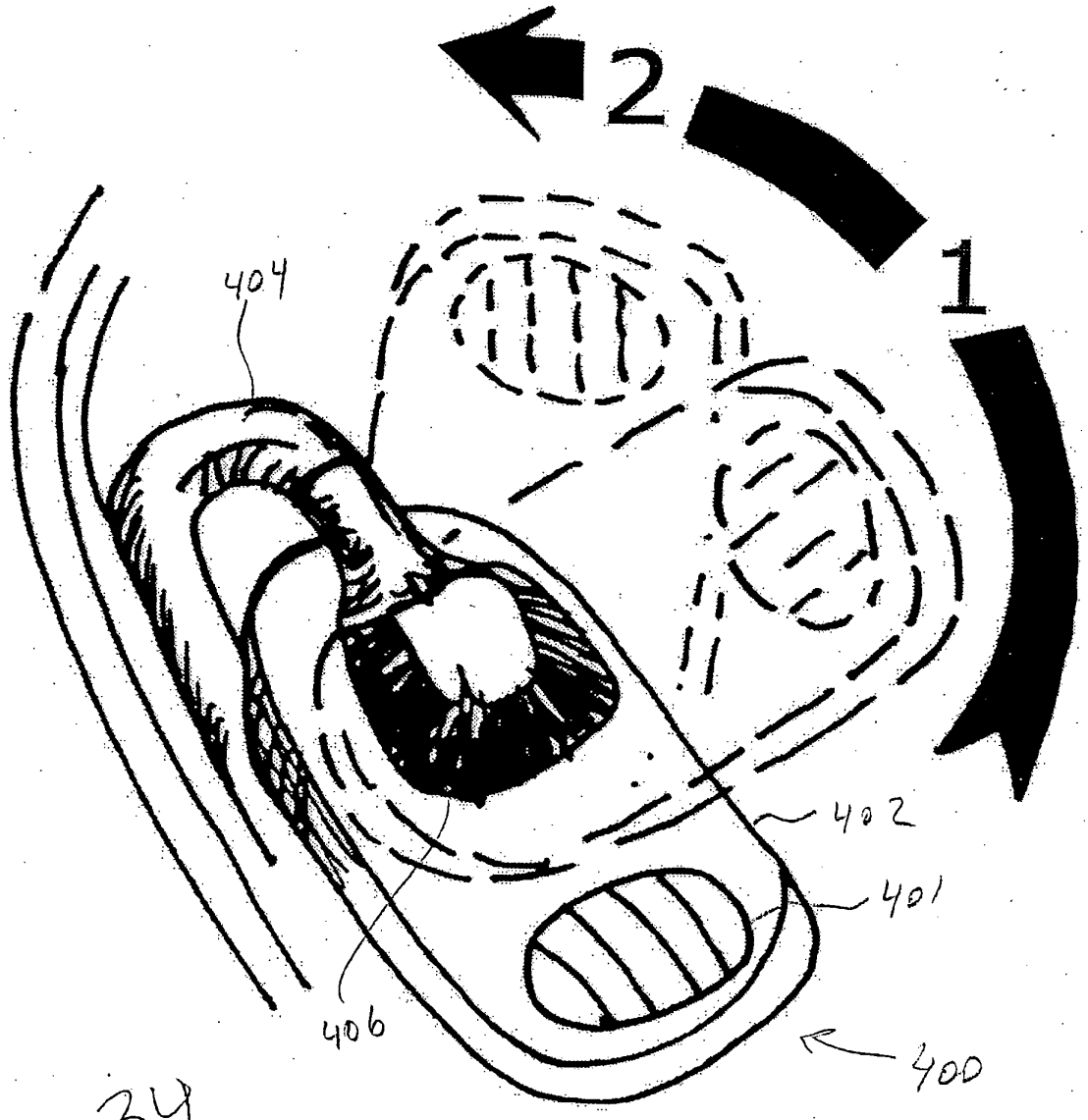


FIG. 34

1383_PRIOR_ART_000171

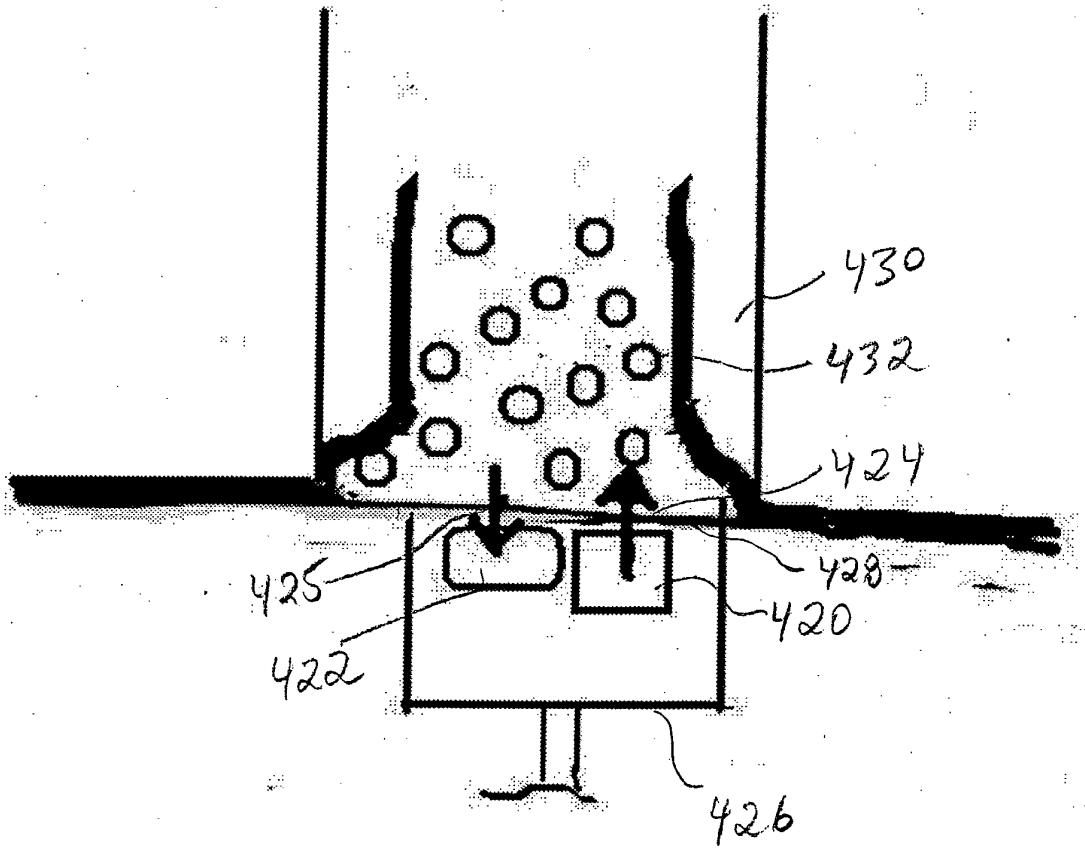


FIG. 35

1383_PRIOR_ART_000172

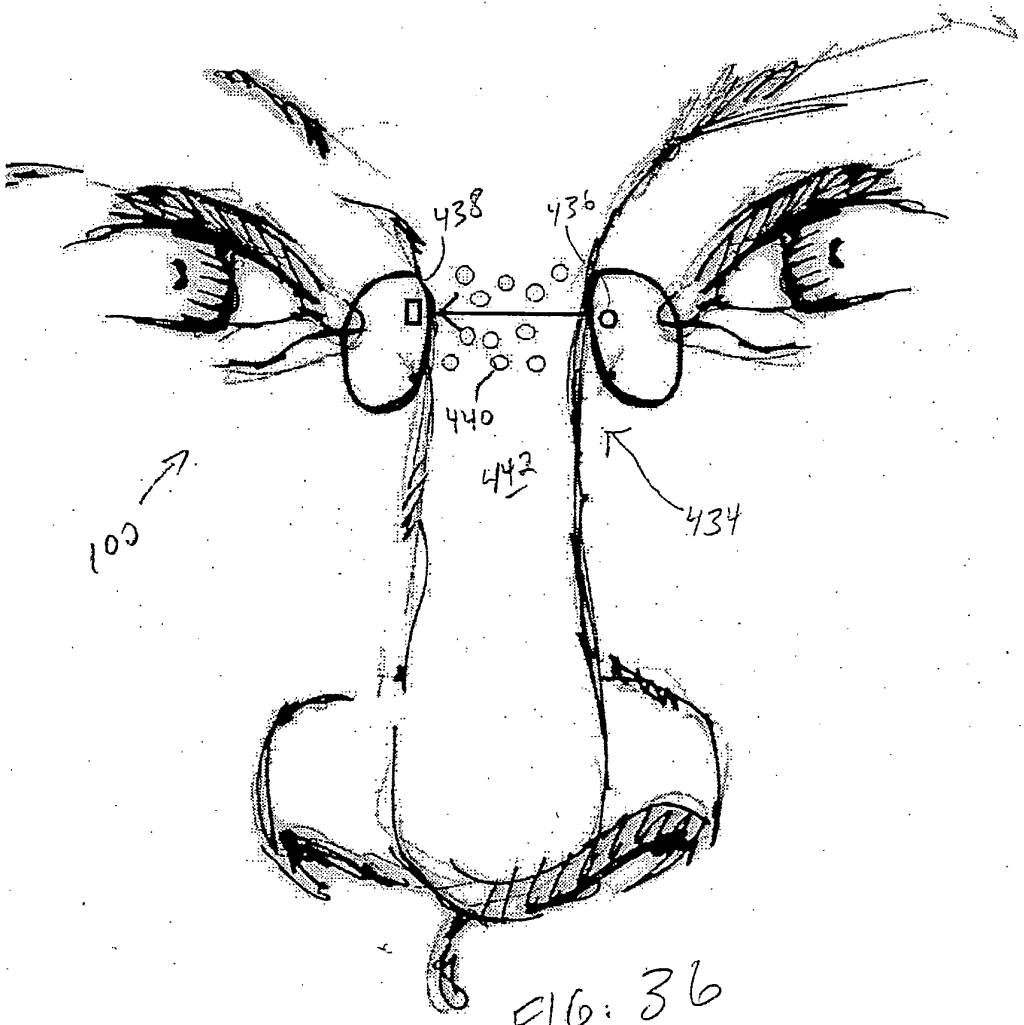


FIG. 36

1383_PRIOR_ART_000173

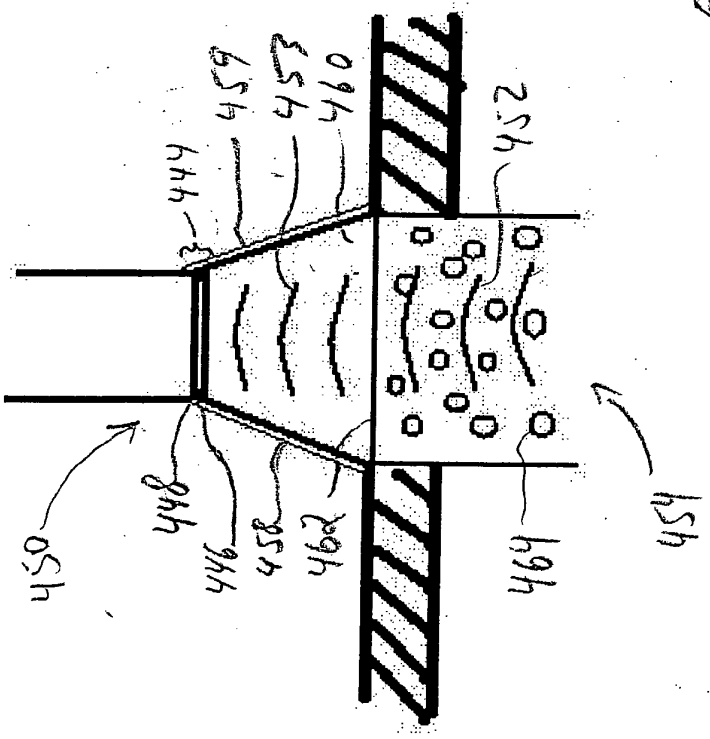


FIG. 37

1383_PRIOR_ART_000174

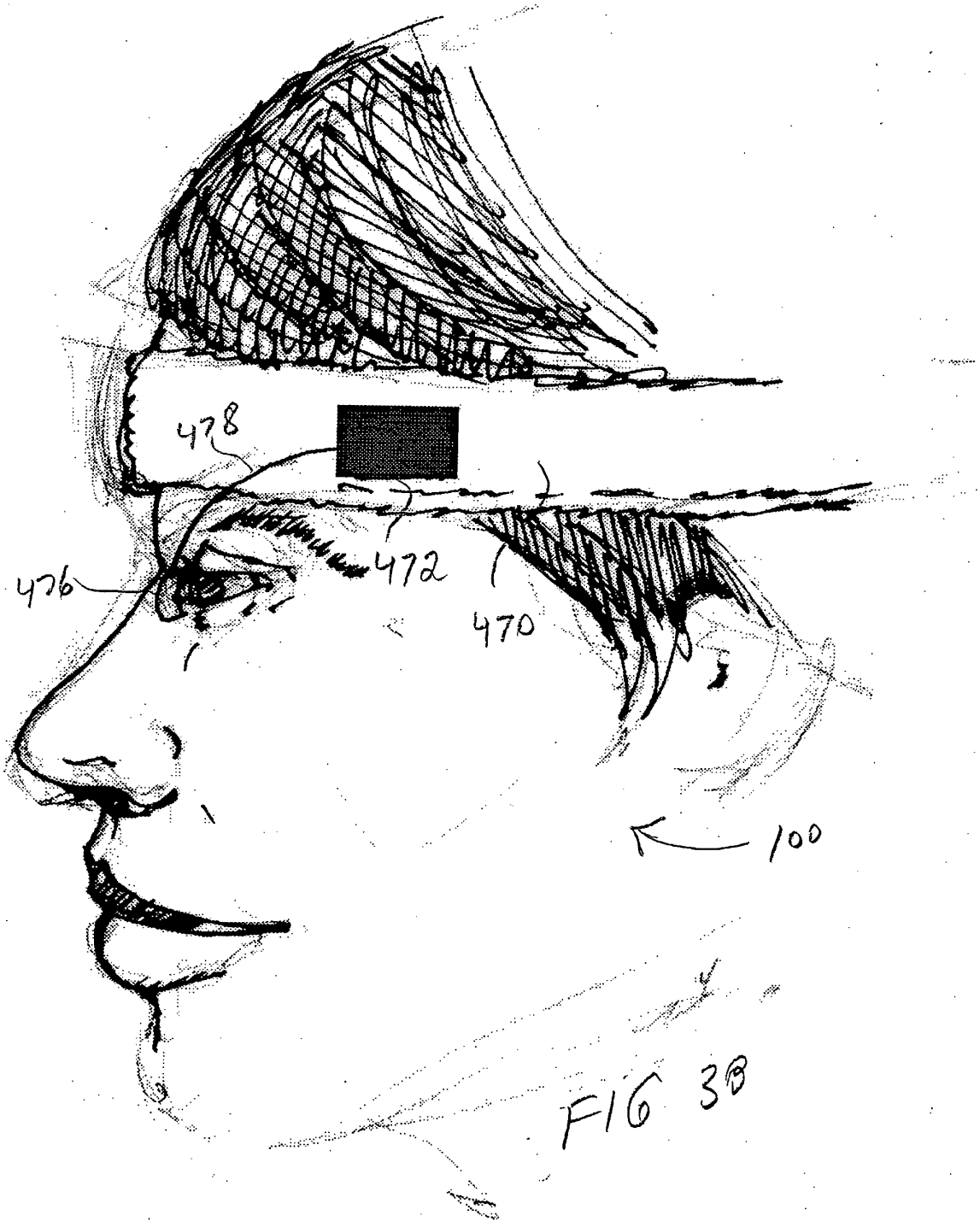


FIG 3B

1383_PRIOR_ART_000175

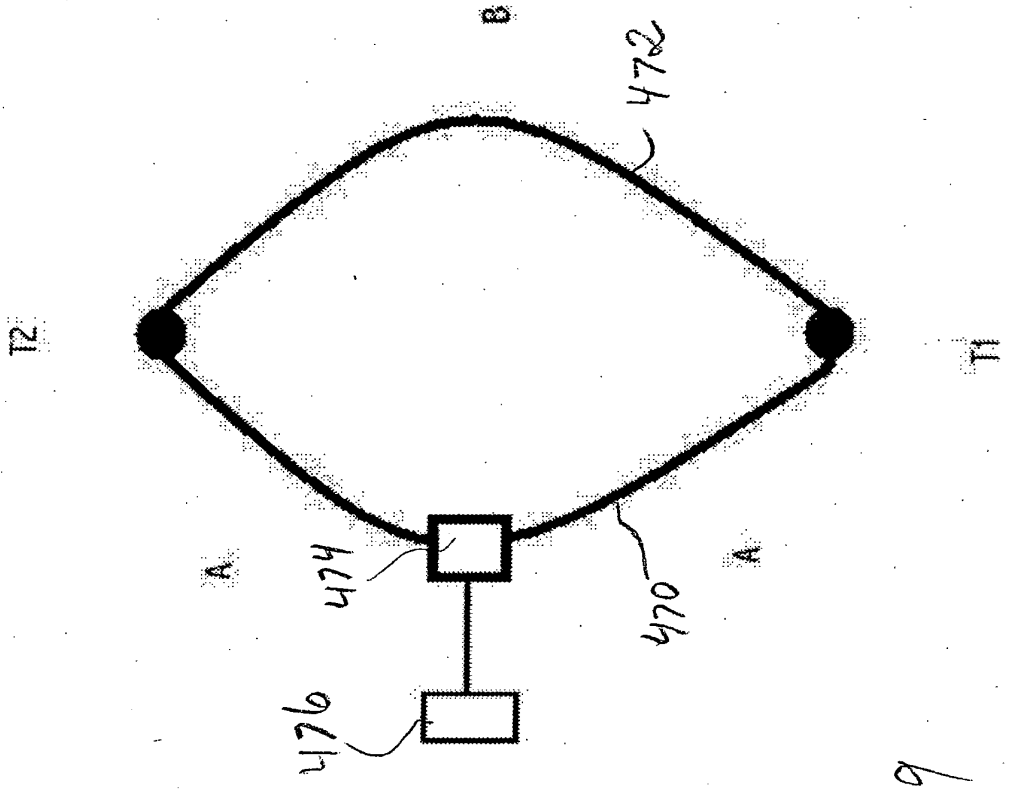
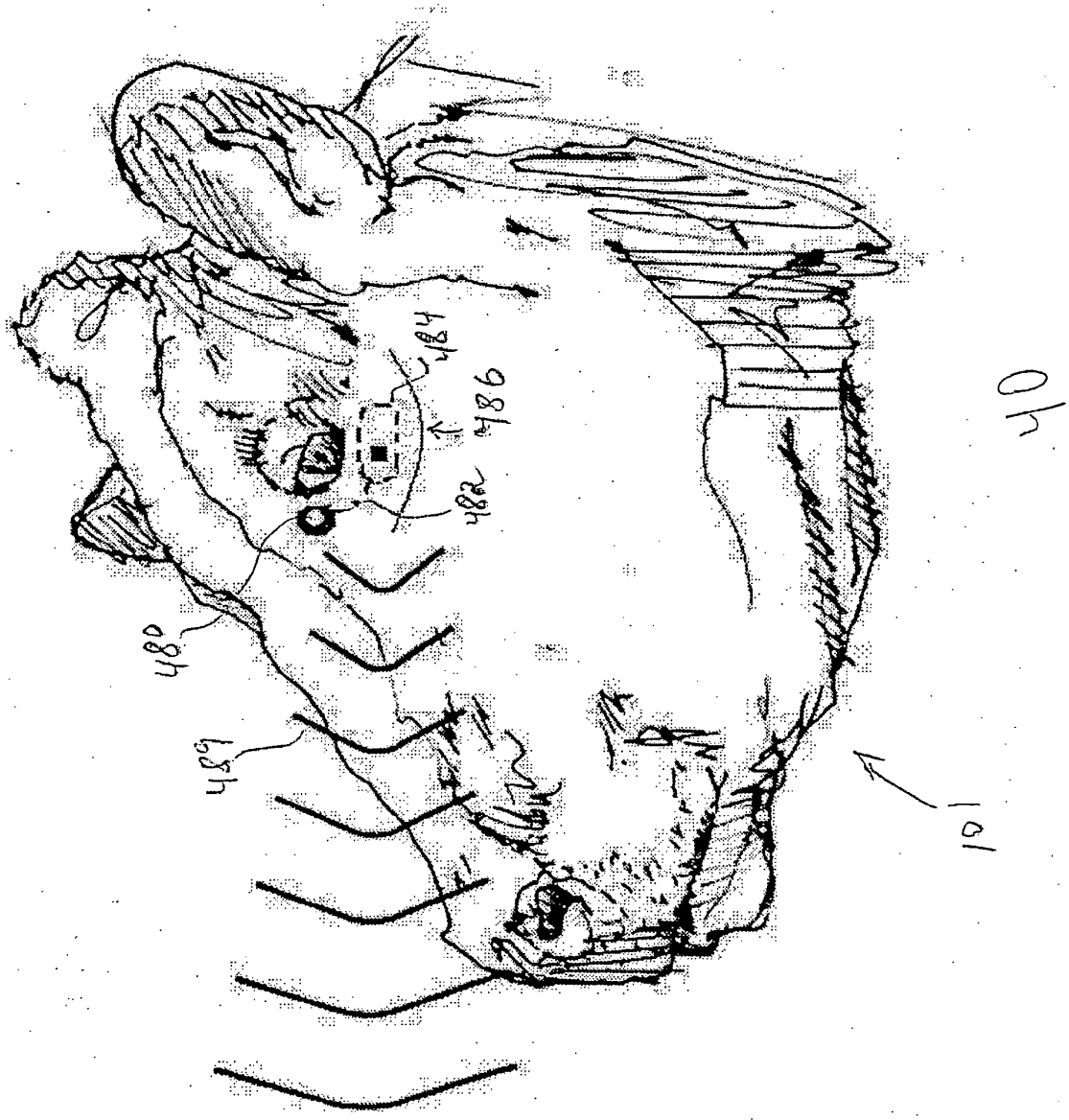


Fig 39

1383_PRIOR_ART_000176



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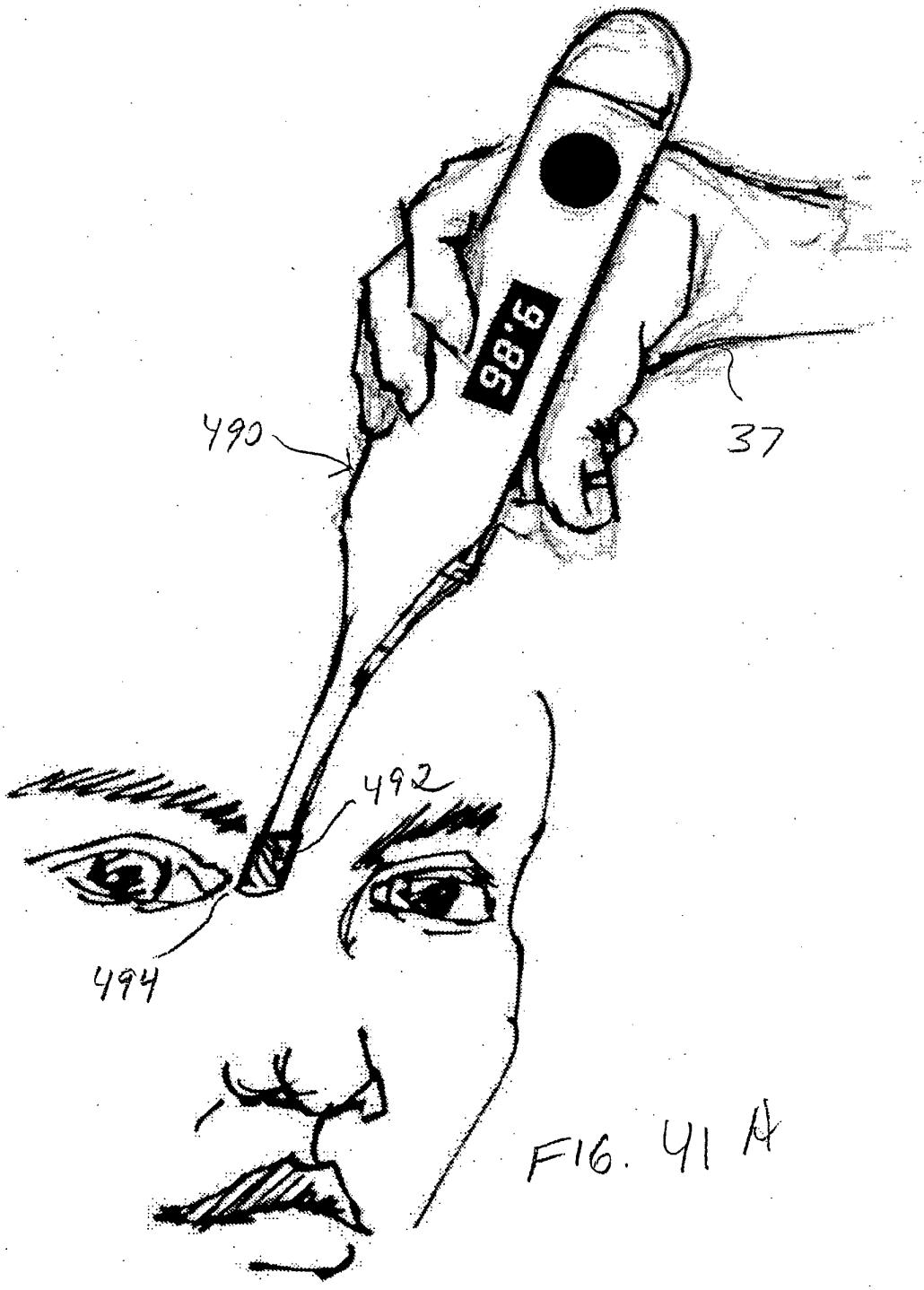


FIG. 41A

1383_PRIOR_ART_000178

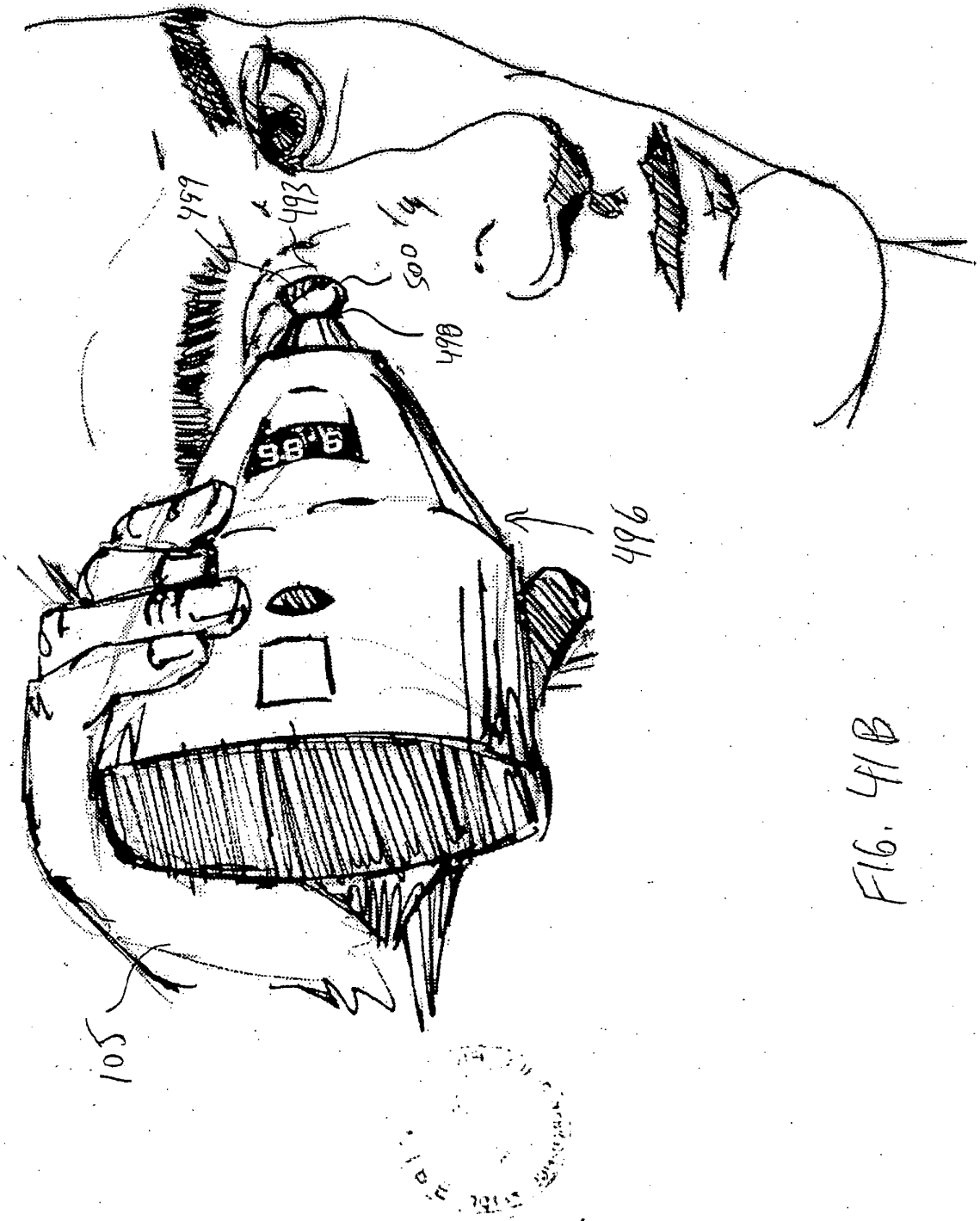


FIG. 41B

1383_PRIOR_ART_000179

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(54)【発明の名称】移動無線デバイスと通信するための組み込まれた音響通信システムを有する眼鏡フレーム、及び対応する方法

(57)【特許請求の範囲】

【請求項１】

音響通信のためのシステムであって、

１つ又は複数の音声信号をキャプチャするための複数の方向依存のマイクロホンを含む眼鏡フレームと、

１つ又は複数の外部電子デバイスにキャプチャされた該１つ又は複数の音声信号を含むデータを伝送するように構成される送信機と、

該複数の方向依存のマイクロホンのうちの少なくとも１つの第２の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号に基づき、該複数の方向依存のマイクロホンのうちの少なくとも１つの第１の方向依存のマイクロホンの方向依存性を調整するための制御モジュールとを備え、

該第２の方向依存のマイクロホンは、身体的振動音響信号をキャプチャするために該眼鏡フレームの耳係合部分に配置された、音響通信のためのシステム。

【請求項２】

請求項１に記載の音響通信のためのシステムにおいて、

該第２の方向依存のマイクロホンは、接触マイクロホンである音響通信のためのシステム。

【請求項３】

請求項１に記載の音響通信のためのシステムにおいて、

該第１の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号

は、第３の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号に基づき該制御モジュールによって濾波されることが可能である音響通信のためのシステム。

【請求項４】

請求項１に記載の音響通信のためのシステムにおいて、

第３の方向依存のマイクロホンによってキャプチャされた１つ又は複数の音声信号を使用して制御可能な増幅器を備えた音響通信のためのシステム。

【請求項５】

請求項１に記載の音響通信のためのシステムにおいて、

少なくとも１つの方向依存のマイクロホンは、マイクロホン・アレイである音響通信のためのシステム。

【請求項６】

請求項５に記載の音響通信のためのシステムにおいて、

少なくとも１つのマイクロホン・アレイは、ＭＥＭＳ技術で実施される音響通信のためのシステム。

【請求項７】

請求項１に記載の音響通信のためのシステムにおいて、

該１つ又は複数の外部デバイスは、移動無線デバイスを含む音響通信のためのシステム。

【請求項８】

請求項１に記載の音響通信のためのシステムにおいて、

該眼鏡フレームは、網膜走査表示のための手段を含む音響通信のためのシステム。

【請求項９】

請求項８に記載の音響通信のためのシステムにおいて、

該眼鏡フレームは、視線方向をキャプチャするように構成された方向モジュールを含む音響通信のためのシステム。

【請求項１０】

請求項１に記載の音響通信のためのシステムにおいて、

少なくとも１つの方向依存のマイクロホンを使用して口頭のコマンドをキャプチャするように構成された音声認識モジュールを含む音響通信のためのシステム。

【請求項１１】

請求項１に記載の音響通信のためのシステムにおいて、

Ｂｌｕｅｔｏｏｔｈインタフェース、ＺｉｇＢｅｅインタフェース、ＧＳＭインタフェース、及びＵＭＴＳインタフェースのうちの少なくとも１つを含む音響通信のためのシステム。

【請求項１２】

請求項１に記載の音響通信のためのシステムにおいて、

眼鏡フレームが、電力を供給するように構成された光電池を含む音響通信のためのシステム。

【請求項１３】

請求項１に記載の音響通信のためのシステムにおいて、

該制御モジュールは、該第１の方向依存のマイクロホン及び該複数の方向依存のマイクロホンのうちの少なくとも１つの第２の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号に基づき、少なくとも１つの該第１の方向依存のマイクロホンの位置を調整する音響通信のためのシステム。

【請求項１４】

音響通信のための方法であって、

１つ又は複数の音声信号を複数の方向依存のマイクロホンによってキャプチャするステップと、

キャプチャされた該１つ又は複数の音声信号を含むデータを、１つ又は複数の外部デバ

イスに伝送するステップと、
該複数の方向依存のマイクロホンのうちの少なくとも１つの第２の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号に基づき、制御モジュールを使用して、該複数の方向依存のマイクロホンのうちの少なくとも１つの第１の方向依存のマイクロホンの方向依存性を調整するステップとを含み、
該第２の方向依存のマイクロホンは身体的振動音響信号をキャプチャすることができる位置に配置される、音響通信のための方法。
【請求項１５】
請求項１４に記載の音響通信のための方法において、
該第２の方向依存のマイクロホンは、接触マイクロホンである音響通信のための方法。
【請求項１６】
請求項１４に記載の音響通信のための方法において、
該第１の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号を、第３の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号に基づいて濾波するステップを含む音響通信のための方法。
【請求項１７】
請求項１４に記載の音響通信のための方法において、
第３の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号を使用して増幅器を制御するステップを含む音響通信のための方法。
【請求項１８】
請求項１４に記載の音響通信のための方法において、
該少なくとも１つの方向依存のマイクロホンは、マイクロホン・アレイである音響通信のための方法。
【請求項１９】
請求項１８に記載の音響通信のための方法において、
該少なくとも１つのマイクロホン・アレイは、ＭＥＭＳ技術によって実装される音響通信のための方法。
【請求項２０】
請求項１４に記載の音響通信のための方法において、
該キャプチャされた１つ又は複数の音声信号を、移動無線デバイスに伝送するステップを含む音響通信のための方法。
【請求項２１】
請求項１４に記載の音響通信のための方法において、
網膜走査ディスプレイを使用して網膜上にイメージ・データを投射するステップを含む音響通信のための方法。
【請求項２２】
請求項２１に記載の音響通信のための方法において、
ユーザの視線方向を、モジュールを使用してキャプチャするステップを含む音響通信のための方法。
【請求項２３】
請求項１４に記載の音響通信のための方法において、
口頭のコマンドを、音声認識モジュールを使用してキャプチャするステップを含む音響通信のための方法。
【請求項２４】
請求項１４に記載の音響通信のための方法において、
該１つ又は複数のキャプチャされた信号を、Ｂｌｕｅｔｏｏｔｈインタフェース、ＺｉｇＢｅｅインタフェース、ＧＳＭインタフェース、及びＵＭＴＳインタフェースのうちの少なくとも１つを介して該１つ又は複数の外部デバイスに伝送するステップを含む音響通信のための方法。
【請求項２５】

請求項１４に記載の音響通信のための方法において、
光電池を介して電源を提供するステップを含む音響通信のための方法。
【請求項２６】
音響通信のためのシステムにおいて、
１つ又は複数の音声信号をキャプチャするための複数の記録手段を含む眼鏡フレームと、
１つ又は複数の外部電子デバイスにキャプチャされた該１つ又は複数の音声信号を含むデータを伝送するための通信手段と、
該複数の記録手段のうちの少なくとも１つの第２の記録手段によってキャプチャされた該１つ又は複数の音声信号に基づき、該複数の記録手段のうちの少なくとも１つの第１の記録手段の方向依存性を調整するための制御手段と、
身体的振動音響信号をキャプチャするために該第２の記録手段を保持する耳係合手段とを備える音響通信のためのシステム。
【請求項２７】
音響通信のためのシステムであって、
１つ又は複数の音声信号をキャプチャするための複数の方向依存のマイクロホンと、
１つ又は複数の外部電子デバイスにキャプチャされた該１つ又は複数のキャプチャされた音声信号を含むデータを伝送するように構成された送信機と、
該複数の方向依存のマイクロホンのうちの少なくとも１つの第２の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号に基づき、該複数の方向依存のマイクロホンのうちの少なくとも１つの第１の方向依存のマイクロホンの方向依存性を調整するための制御モジュールとを備え、
該第２の方向依存のマイクロホンは身体的振動音響信号をキャプチャすることができる位置に配置される、音響通信のためのシステム。
【請求項２８】
請求項２７に記載の音響通信のためのシステムにおいて、
該第２の方向依存のマイクロホンは、接触マイクロホンである音響通信のためのシステム。
【請求項２９】
請求項２７に記載の音響通信のためのシステムにおいて、
該第１の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号は、第３の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号に基づき該制御モジュールによって濾波されることが可能である音響通信のためのシステム。
【請求項３０】
請求項２７に記載の音響通信のためのシステムにおいて、
第３の方向依存のマイクロホンによってキャプチャされた１つ又は複数の音声信号を使用して制御可能な増幅器を備えた音響通信のためのシステム。
【請求項３１】
請求項２７に記載の音響通信のためのシステムにおいて、
少なくとも１つの方向依存のマイクロホンは、マイクロホン・アレイである音響通信のためのシステム。
【請求項３２】
請求項３１に記載の音響通信のためのシステムにおいて、
少なくとも１つのマイクロホン・アレイは、ＭＥＭＳ技術で実施される音響通信のためのシステム。
【請求項３３】
請求項２７に記載の音響通信のためのシステムにおいて、
該１つ又は複数の外部デバイスは、移動無線デバイスを含む音響通信のためのシステム。

【請求項３４】
請求項２７に記載の音響通信のためのシステムにおいて、
少なくとも１つの方向依存のマイクロホンを使用して複数の口頭のコマンドをキャプチャするように構成された音声認識モジュールを含む音響通信のためのシステム。
【請求項３５】
請求項２７に記載の音響通信のためのシステムにおいて、
Ｂｌｕｅｔｏｏｔｈインタフェース、ＺｉｇＢｅｅインタフェース、ＧＳＭインタフェース、及びＵＭＴＳインタフェースのうちの少なくとも１つを含む音響通信のためのシステム。
【発明の詳細な説明】
【技術分野】
【０００１】
本発明は、眼鏡フレームが、ユーザの音声信号をキャプチャするための少なくとも１つの方向依存のマイクロホン、ならびに外部電子デバイスに信号送信するための通信手段を含む、音響通信のための方法及びシステムに関する。詳細には、本発明は、少なくとも１つのマイクロホンの方向依存性が、動的な形でユーザ固有に調整可能である通信システムに関する。
【背景技術】
【０００２】
移動通信端末装置は、今日、ますます重要な役割を果たしている。より新型の移動通信端末装置は、近頃は、単純な音声通信又はデータ通信に応えるだけでなく、複雑なマルチメディア・デバイスにますます変容しており、そのデバイスを使用して、オーディオ・ブロードキャスト又はビデオ・ブロードキャストが受信されることが可能である、例えば、ゲームが行われることが可能である、又はインターネットもしくは移動無線ネットワークなどのネットワーク内で、情報にアクセスが行われることが可能である。それらの複雑な移動通信端末装置の制御、特に、利用可能なデータ及び／又はデータ・セット、あるいは動作モードの選択、ならびにデータの入力及び／又はコマンドの入力には、しばしば、キーボード、スタイラス、トラックボール、タッチスクリーン、その他などの、高価で、扱いにくい補助デバイスの使用が関わることになり、しばしば、そのようなデバイスの使用を必然的に伴うことになる。これに関連して、それぞれの事例において、移動通信デバイスを自分の手に持つことも不可欠であり、最新の通信端末装置のハンズフリーの便利な使用が、極度に制限される。
【０００３】
音声認識に基づく問題解決法が、技術の現状において既に知られている。音声認識又は自動音声認識は、口頭の言語を認識する、又は口頭の言語を文字列に変換すること、及び処理することをそれぞれ行うコンピュータなどの、マシンを可能にする方法の研究及び開発を扱う。その一方で、音声認識は、例えば、例として、時刻表問い合わせなどの、自動ダイアログ・システムにも技術的応用を見出している。自動音声認識は、限られたボキャブラリだけが使用されている場所ではどこでも実施されている。しかし、自動化された音声認識では、音響受信の品質が、決定的な役割を果たし、したがって、受信品質が可能な限り向上させられて、認識の大幅により高い精度が実現されることが可能であるようになることが不可欠である。
【０００４】
刊行物、国際公開第０３／０６２９０６号及び国際公開第０２／０８６５９９号が、例えば、マイクロホン及び小型スピーカが眼鏡フレーム上に配置されたデバイスを説明している。次いで、眼鏡フレームは、ケーブル接続を介して外部電子デバイスに接続される。しかし、この提案されるデバイスの抱える問題は、ユーザ固有のサウンド及びオーディオの記録のために許容できる雑音除去を実現すること、特に、ユーザの口頭のコマンドを、近辺に位置する他の人々の音声と区別することの困難である。
【０００５】

刊行物、欧州特許第０　２１９　０２６　Ｂ１号において説明されているのが、補聴器をどのように眼鏡フレームに組み込むことができるかである。眼鏡フレーム上のいくつかのマイクロホンの、特定の空間的分布を介して、聴覚障害者が、音響イベントと関連して空間的向きを得ることができるようにするはずである、方向効果及び位置特定効果が実現されることが可能である。すべての音響コンポーネント及び電子コンポーネントが、眼鏡に収容される。外部電子デバイスに対する送信接続及び／又は受信接続は、提供されない。

【０００６】

米国特許出願公開第２００２／０１９７９６１　Ａ１号において開示されているのが、マイクロホン、小型スピーカ、電源供給装置（アキュムレータ）、及び移動無線デバイス、又は他の外部電子デバイスに信号を送信するための送信機又は相当する受信機が実装された、眼鏡フレームである。代替として、前記コンポーネントは、眼鏡フレームに取り付けられ、再び取り外されることが可能な、又は帽子、もしくは頭部に着用されることが可能な類似の物品上の、クリップの中に収容されることも可能である。また、マイクロホンは、調整可能なアーム上に取り付けられることも可能である。大きい、一定でないスタティック・ノイズを有する環境における前述した構成の使用では、それでもやはり、所望される信号が、十分なレベルでマイクロホンに印加されることは保証されない。

国際出願ＷＯ２００４／０１６０３７号が、音声の分かりやすさを向上させるための方法、及び対応するデバイスを説明している。この出願には、マイクロホン・アレイと、スピーカと、信号処理デバイスとを含む眼鏡フレームが関わる。この信号処理デバイスは、マイクロホン・アレイの信号を受け取り、干渉する背景信号の量を減らし、このように処理された信号をスピーカ又は外部電子デバイスに伝送する。また、眼鏡フレームは、マイクロホンの方向を調節して、より良好な信号品質が実現されることが可能であるようにすることができるマイクロホン・コントロールも含む。様々な方法及びアルゴリズム、特に、いわゆるＡＮＣ（アクティブ雑音制御）技術が、信号処理のために使用されることが可能である。それでも、説明されているビーム形式方法は、周囲雑音及び周囲干渉をすべての状況において効率的な形で除去するのに適していない。

【先行技術文献】

【特許文献】

【０００７】

【特許文献１】国際公開第０３／０６２９０６号
【特許文献２】国際公開第０２／０８６５９９号
【特許文献３】欧州特許第０　２１９　０２６　Ｂ１号
【特許文献４】米国特許出願公開第２００２／０１９７９６１　Ａ１号
【特許文献５】国際出願ＷＯ２００４／０１６０３７号

【発明の概要】

【発明が解決しようとする課題】

【０００８】

本発明の目的は、技術の現状の前述した諸問題を有さない音響通信のための新たなシステム、及び新たな方法を提案することである。特に、システムは、移動無線デバイスの便利な、ハンズフリーの使用を可能にするとともに、雑音のある環境においてＩＶＲシステム（対話型音声応答）に関連して、口頭のコマンドの信頼できる便利な入力、及び対話型音声制御を可能にしなければならない。

【課題を解決するための手段】

【０００９】

以上の諸目的は、特に、独立請求項の要素を介して、本発明に従って実現される。それに加えて、さらに有利な諸実施形態が、従属請求項及び本明細書からもたらされる。

特に、以上の諸目的は、眼鏡フレームが、ユーザの音声信号をキャプチャするための少なくとも１つの方向依存のマイクロホンと、外部電子デバイスに信号を送信するための通信手段とを含み、少なくとも１つのマイクロホンの方向依存性は、制御モジュールによっ

て動的な形でユーザ固有に調整可能であり、制御モジュールは、少なくとも１つの第２の方向依存のマイクロホンによってキャプチャされた音声信号に基づき、少なくとも１つの第１の方向依存のマイクロホンの方向依存性の、適応的なユーザ固有の調整を行うための手段を含むという点で、本発明を介して実現される。この実施形態変種の利点は、とりわけ、効果的な雑音除去であり、そのため、各個人ユーザに関して、キャプチャされる音声信号の大幅により高い品質が可能であることである。これは、特に、ユーザの口頭のコマンドの認識のために、必要な前提条件である可能性がある。さらなる利点は、口頭の命令のハンズフリーの入力、ならびに入力デバイスが、眼鏡フレームに組み込まれるために、ほとんど目立たないことである。

【００１０】

さらに、この実施形態変種は、とりわけ、方向依存のマイクロホンの方向依存性の調整が、他のマイクロホンによってキャプチャされる信号の関数として実行されることが可能であるという利点を有する。そのため、さらに良好なユーザ固有の適合が実現されることが可能であり、高いレベルの干渉雑音を有する環境において、本発明によるシステム及び方法の応用に関して、より高い音声品質、及びより良好な前提条件がもたらされる。

【００１１】

さらなる実施形態変種において、少なくとも１つの第２の方向依存のマイクロホンは、接触マイクロホンである。この実施形態変種は、とりわけ、話すユーザによって送られる音声信号が、空気中における伝播後だけでなく、ユーザの身体における伝播後にもキャプチャされることが可能であるという利点を有する。これにより、対応する取り扱い及び処理の後、雑音の除去のさらなる改良が、実現されることが可能である。詳細には、接触マイクロホンを使用して、ユーザが、ちょうど今、話しているか否かが、非常に容易に判定されることが可能であり、近辺で話しているさらなるユーザとの可能な混乱が、実質的に解消されることが可能である。さらに、接触マイクロホンによってキャプチャされる信号は、他の方向依存のマイクロホンの方向依存性の、適応的なユーザ固有の調整を行うための制御モジュールによって使用されるのに、非常によく適している。

【００１２】

さらに別の実施形態変種では、第１の方向依存のマイクロホンによってキャプチャされる信号は、第３のマイクロホンによってキャプチャされる信号を使用して濾波される。この実施形態変種は、とりわけ、別のマイクロホンによってキャプチャされる周囲雑音が、第１の方向依存のマイクロホンによってキャプチャされる信号の濾波及び信号品質向上のために使用されることが可能であるという利点を有する。そのため、方向依存のマイクロホンの肯定的な諸特徴が、濾波を介する雑音除去の肯定的な諸特徴と最適な形で組み合わせられて、さらに良好な音声品質がもたらされる。

【００１３】

さらなる実施形態変種では、少なくとも１つの方向依存のマイクロホンは、マイクロホン・アレイとして実施される。少なくとも１つのマイクロホン・アレイは、有利には、例えば、ＭＥＭＳ技術で実施されることが可能である。その結果、この実施形態変種は、とりわけ、特別に効果的で、強力な方向効果が実現されることが可能であるという利点を有する。また、マイクロホン・グループの使用を介して、音波の多くの空間的特徴も利用されることが可能であり、それらの特徴は、単一のマイクロホンでは、利用されることが可能でない。この実施形態変種のさらなる利点は、はるかに低い製造費用、及び高い一体化の割合であり、これにより、特に小さく、コンパクトな構成が、実現されることが可能である。

【００１４】

別の実施形態変種では、外部デバイスは、移動無線デバイスを含む。その結果、移動無線デバイスは、例えば、眼鏡フレームに組み込まれることも、自己完結型のデバイスとして存在することも可能である。この実施形態変種は、とりわけ、本発明によるシステム、及び本発明による方法が、移動無線ネットワークを介する音声通信のために使用されることが可能であるという利点を有する。このため、その眼鏡の着用者は、眼鏡フレームを介

して、移動無線ネットワークに接続された１つ又は複数のサーバと通信すること、又は音響命令を入力することもできる。したがって、眼鏡の着用者は、補足のハンズフリー・デバイスを全く使用する必要がなく、そのため、大幅により低い費用で、より便利に通信することができる。

【００１５】

別の実施形態変種では、眼鏡フレームは、網膜走査ディスプレイのための手段を含む。網膜走査ディスプレイは、光線が、目の網膜上に直接に投射されるディスプレイ・デバイスである。光線の対応する光変調、及び迅速な分解を介して、ピクチャ全体が示されることが可能である。眼鏡フレームは、視線方向をキャプチャするためのさらなる手段を含むことが可能である。その結果、この実施形態変種は、とりわけ、ユーザが、外部出力デバイスに依存することなしに、情報を直接に見ること、及び情報を直接に聞くことを可能にする、複雑なシステムが構成されることが可能であるという利点を有する。同時に、視線キャプチャにより、データ入力のさらなる可能性が、システムに組み込まれることが可能である。

【００１６】

さらなる実施形態変種では、システムは、少なくとも１つの方向依存のマイクロホンを使用して口頭のコマンドをキャプチャするための音声認識モジュールを含む。この実施形態変種は、データが、口頭のコマンドを使用して、ユーザによって単純な形で制御され、かつ／又は選択されることが可能であるという利点を有する。さらなる利点は、すべてのデバイスが、同一のフレーム内で一体化されるため、より低い電力消費である。

【００１７】

さらなる実施形態変種では、通信システムは、Ｂｌｕｅｔｏｏｔｈ（登録商標）インタフェース及び／又はＺｉｇＢｅｅ（登録商標）インタフェース及び／又はＧＳＭ（登録商標）インタフェース及び／又はＵＭＴＳインタフェース及び／又はＷＬＡＮインタフェースを含む。以上のインタフェースは、例えば、通信端末装置、及び／又は眼鏡フレームの通信手段の中に組み込まれることが可能である。これは、とりわけ、現在の業界標準に、通信システムを使用してアクセスが行われることが可能であるという利点を有する。

【００１８】

ここで、本発明によるシステムに加えて、本発明は、音響通信のための方法にも関することを述べておかなければならない。

本発明の実施形態変種を、実施例に関連して以下に説明する。諸実施形態の実施例は、以下の添付された図によって示される。

【図面の簡単な説明】

【００１９】

【図１】本発明による音響通信のためのシステム及び方法を概略で示すブロック図である。

【図２】図１による本発明のシステム及び方法を実行するために使用されることが可能な眼鏡フレームの側面図である。

【図３】音響通信のための本発明によるシステム及び方法の別の実施形態を概略で示すブロック図である。

【図４】図１による音響通信のための本発明のシステムの構造を概略で示すブロック図である。

【図５】図３による音響通信のための本発明のシステムの別の実施形態の構造を概略で示すブロック図である。

【図６】本発明によるシステム及び方法を実施するために使用されることが可能な、着用されている眼鏡フレームのおおよその通常の位置が示されている、人間の頭蓋の骨を示す分解図である。

【発明を実施するための最良の形態】

【００２０】

図１で、符号１０は、眼鏡フレームを指し、例えば、近視の、又は遠視の個人によって

着用される、矯正レンズを有する眼鏡フレーム、又は日よけレンズを有するサングラスのためのフレームを指す。眼鏡フレーム１０は、ユーザ２０の口から出る音波２１がキャプチャされることが可能な位置において、少なくとも１つの方向依存の音響センサ１６を含む。センサ１６の方向依存性を介して、伝播の直線上の、ユーザ２０の口から出る音波２２が、特によくキャプチャされることが可能である。方向依存の音響センサ１６は、例えば、単純なマイクロホンであることが可能であるが、マイクロホンのグループとして、つまり、いわゆるマイクロホン・アレイとして実施されることも可能である。マイクロホン・アレイの使用を介して、音場の空間的特徴が、利用されることが可能であり、キャプチャされる信号の品質、又は、それぞれ、分かりやすさが、その結果、相当に向上させられることが可能である。複数のそのようなマイクロホン又はマイクロホン・アレイ１６が、同様に、眼鏡フレーム１０上に、例えば、眼鏡フレーム１０の両側上に対称的に実装されることも可能である。

【００２１】

やはり、図１又は図２に示されるとおり、眼鏡フレーム１０は、１つ又は複数の方向依存の音響センサ１５をさらに含むことが可能である。さらなる方向依存の音響センサ１５が、その方向依存の音響センサ１５によって、ユーザの身体的振動音響信号が、よくキャプチャされることが可能な位置に実装される。身体的振動音響信号は、音波が、ユーザの喉頭において、話す際に生じさせられ、その音波が、次いで、ユーザの身体によって伝播させられるという点で生じる。身体的振動音響信号を受信し、キャプチャするために特に好適な位置は、図６に示されるとおり、人間の頭蓋６０の両側部上に位置する側頭骨６６である。眼鏡フレーム１０のアームが、普通、側頭骨に接して着用され、そのことが、キャプチャされる身体的振動音波の、より高い品質に寄与することが可能である。方向依存の音響センサ１５は、同様に、単純なマイクロホンとして実施されることも、又はマイクロホンのグループとして、つまり、いわゆるマイクロホン・アレイとして実施されることも可能である。

【００２２】

図１及び図２で、符号１３は、１つ又は複数のさらなる方向依存の音響センサ１３を指す。１つ又は複数のさらなる方向依存の音響センサ１３は、ユーザの環境から来る周囲サウンドが、特によくキャプチャされることが可能な、眼鏡フレーム１０上の位置に実装される。方向依存の音響センサ１３は、同様に、単純なマイクロホンとして実施されることも、又はキャプチャされる信号のより良好な品質のために、マイクロホン・アレイとして実施されることも可能であり、周囲サウンドに対して揃えられた複数の方向依存のマイクロホン又は方向依存のマイクロホン・アレイ１３も、眼鏡フレーム１０上に実装されることが可能である。

【００２３】

マイクロホン、又は、それぞれ、マイクロホン・アレイ１３、１５、１６は、特に、いわゆるＭＥＭＳ技術（ＭｉｃｒｏＥｌｅｃｔｒｏＭｅｃｈａｎｉｃａｌ　Ｓｙｓｔｅｍｓ）で実施されることが可能である。ＭＥＭＳによって理解されるのは、ある論理と、少なくとも一部の可動部品とを有する極小チップである。したがって、ＭＥＭＳは、通例、データを収集することができるとともに、それらのデータからもたらされるタスクを実行することもできる、機械的部品を有するプロセッサである。このため、さらに良好なサウンド品質を、同時に小さい全体的サイズで実現することができる、ＭＥＭＳ技術の使用を介して製造されることが可能な、非常に小さいマイクロホン又はマイクロホン・アレイであり、それらのマイクロホン又はマイクロホン・アレイが、眼鏡フレーム１０内に実装するのに、特によく適するようになる。

【００２４】

図１で、符号１１は、制御モジュールを指す。制御モジュールは、方向依存の音響センサ１３、１５、１６から信号を獲得し、評価することができる。また、制御モジュール１１は、方向依存の音響センサ１３、１５、１６と通信して、センサ１３、１５、１６を制御することもできる。特に、ＭＥＭＳ技術の使用を介して、方向依存の音響センサ１３、

１５、１６は、特に単純な形で、あまり労力をかけずに制御されることが可能である。その結果、方向依存の音響センサ１３、１５、１６の位置、感度、及び／又は方向依存性に影響が与えられることが可能である。例えば、ある方向依存の音響センサ１３、１５、１６によってキャプチャされた音声信号に基づき、制御モジュール１１は、別の方向依存の音響センサ１３、１５、１６を制御することができる。信号処理、信号増幅、及びその他の信号取り扱いに必要とされるすべてのコンポーネントが、例えば、増幅器４６、４８、５１、調整要素４３、制御回路４４、５４、又は遅延要素４７が、眼鏡フレーム１０内に、特に、制御モジュール１１内に収容されることが可能である。

【００２５】

本発明による問題解決法の実施形態変種では、例えば、身体的振動音波が、話しているユーザの喉頭内で生じさせられ、身体によって伝播させられる。また、それらの身体的振動音波、又は、それぞれ、音声信号は、頭蓋骨及び側頭骨にも伝播させられ、頭蓋骨及び側頭骨において、音声信号は、方向依存の音響センサ１５によってキャプチャされる。キャプチャされた音声信号は、制御モジュール１１によって解釈され、評価されて、方向依存の音響センサ１６が、その評価に基づき、ユーザ固有に調整される。特に、制御モジュール１１は、ＭＥＭＳ技術で実施された方向依存の音響センサ１６の位置を変更して、それらのセンサ１６が、ユーザの顔つきをよりよく考慮に入れるようにすることができる。制御モジュール１１は、同様に、方向依存の音響センサ１６の感度をユーザ固有の形で変更して、それらのセンサ１６が、側頭骨上に身体的振動音波が当たっている間に、ユーザ２０の口から出る音声信号に特に高い感度で反応するようにすることもできる。

【００２６】

本発明による問題解決法の別の実施形態変種では、話しているユーザからの身体的振動音波が、方向依存の音響センサ１３によってキャプチャされるだけでなく、環境から来る周囲サウンドもキャプチャされる。第１の方向依存の音響センサ１５によってキャプチャされた身体的振動音波と、第２の方向依存の音響センサ１３によってキャプチャされた周囲雑音信号とが、制御モジュール１１によって解釈され、評価されて、方向依存の音響センサ１６が、その評価に基づき、ユーザ固有に調整される。特に、一定のままである周囲サウンドでは、方向依存の音響センサ１６の方向依存性の適応的な、つまり動的なユーザ固有調整が、必要になることが生じる可能性がある。すなわち、ユーザは、内々の性質を有し、近辺に位置する人々によって気付かれるべきでない話題を切り出したために、突然、より穏やかに話す可能性がある。このため、適応型のユーザ固有の調整によって理解されるのは、マイクロホンの方向依存性が、例えば、ＭＥＭＳマイクロホンを使用して、最適な値に動的な形で適合させられる動的調整である。

【００２７】

特に、眼鏡フレーム１０は、物理的ネットワーク・インタフェース１２も備え、インタフェース１２を使用して、口頭の情報及び／又はデータの形態の情報が、通信チャネル１７を介して、眼鏡フレーム１０と移動通信端末装置３０の間で交換されることが可能である。ネットワーク・インタフェース１２は、複数の異なるネットワーク標準、例えば、Ｂｌｕｅｔｏｏｔｈ又はＺｉｇＢｅｅという名前で知られているローカル無線ネットワーク標準だけでなく、ＧＳＭ（Ｇｌｏｂａｌ Ｓｙｓｔｅｍ ｆｏｒ Ｍｏｂｉｌｅ Ｃｏｍｍｕｎｉｃａｔｉｏｎ）、ＧＰＲＳ（Ｇｅｎｅｒａｌｉｚｅｄ Ｐａｃｋｅｔ Ｒａｄｉｏ Ｓｅｒｖｉｃｅ）、ＵＭＴＳ（Ｕｎｉｖｅｒｓａｌ Ｍｏｂｉｌｅ Ｔｅｌｅｃｏｍｍｕｎｉｃａｔｉｏｎｓ Ｓｙｓｔｅｍ）、ＷＬＡＮ（無線ローカル・エリア・ネットワーク）８０２．１１、赤外線通信技術、又は他の任意の非接触通信技術もサポートすることができる。しかし、原則として、ネットワーク・インタフェース１２は、任意の接触インタフェースであること、例えば、ＵＳＢインタフェース又はＦｉｒｅｗｉｒｅ（登録商標）インタフェース、あるいはイーサネット（登録商標）、トークンリング、又は他の任意の有線ＬＡＮ（ローカル・エリア・ネットワーク）に対するインタフェースであることも可能である。インタフェースは、もちろん、例えば、イーサネット又はトークンリングなどのネットワーク・プロトコルを直接に使用するので、パケット交換インタフェースだ

けでなく、例えば、ＰＰＰ（ポイントツーポイント・プロトコル）、ＳＬＩＰ（シリアル・ライン・インターネット・プロトコル）又はＧＰＲＳ（Ｇｅｎｅｒａｌｉｚｅｄ　Ｐａｃｋｅｔ　Ｒａｄｉｏ　Ｓｅｒｖｉｃｅ）などのプロトコルによって使用されることが可能な、回線交換インタフェース、すなわち、例えば、ＭＡＣアドレス又はＤＬＣアドレスなどのネットワーク・アドレスを全く有さないインタフェースも「含む」ことが可能である。原則として、本発明によるシステム及び／又は方法は、本発明による諸特徴が存在する限り、特定のネットワーク標準に限定されず、代わりに、１つ又は複数の所望されるネットワークで実現されることが可能であり、特に、異なる通信技術の間でトランスペアレントに切り替えられる、又はルーティングされる音声伝送及び／又はデータ伝送によっても実現されることが可能であることが、強調されなければならない。それに加えて、さらなる要求されるコンポーネント、例えば、スピーカ及び電源供給装置が、眼鏡フレーム１０内に収容されることも可能である。

【００２８】

図１の符号３０は、移動通信端末装置、又は任意の所望される、いわゆる顧客宅内機器（ＣＰＥ）を指す。移動通信端末装置３０は、任意の移動無線ネットワークの任意の移動無線デバイスであることが可能であり、移動無線デバイスは、例えば、ＧＳＭ移動無線ネットワークのＧＳＭデバイス、又はＵＭＴＳネットワークのＵＭＴＳデバイス、又はサテライト・ネットワークのサテライト・デバイスであることが可能である。しかし、移動通信端末装置３０は、原則として、標準のパーソナル・コンピュータ（ＰＣ）、ポータブルＰＣ、固定ネット電話機、移動無線デバイスのための充電デバイス、プレイステーション、あるいは電子的にネットワーク化されたコンポーネントを有する他の任意のデバイスであることも可能である。移動通信端末装置３０は、例えば、データ要素を入力するための入力ユニット３２を含む。移動通信端末装置３０は、例えば、数字キー及びコントロール・キーから成る、移動無線電話機のタイプに応じた、標準のキーボード、又は類似の入力デバイスを有することが可能であり、数字キーは、例えば、文字の入力に切り替えられることが可能である。例えば、遠隔通信における料金の登録のケースにおいて、許可及び認証の目的で、移動通信端末装置３０は、通例、取り外し可能な識別モジュール、例えば、ＳＩＭ（加入者ＩＤモジュール）カード３４を含み、カード３４は、この図では、端末装置３０の下に示され、動作の際、移動通信端末装置内部の接触子と接触する。移動通信端末装置３０は、データ要素を表示するためのディスプレイ・デバイス３１をさらに含むことが可能である。アンテナ３５が、遠隔通信ネットワークを介するデータの伝送のために、知られている形で役割を果たし、ネットワークは、通例、移動無線ネットワーク、例えば、ＧＳＭ（Ｇｌｏｂａｌ　Ｓｙｓｔｅｍ　ｆｏｒ　Ｍｏｂｉｌｅ　Ｃｏｍｍｕｎｉｃａｔｉｏｎ）ネットワーク、ＵＭＴＳ（Ｕｎｉｖｅｒｓａｌ　Ｍｏｂｉｌｅ　Ｔｅｌｅｃｏｍｍｕｎｉｃａｔｉｏｎ　Ｓｙｓｔｅｍ）ネットワーク、又はＷＬＡＮ（無線ローカル・エリア・ネットワーク）ネットワークである。移動通信端末装置３０に実装されているのが、非接触インタフェース３３であり、例えば、そのインタフェース３３を介して、眼鏡フレーム１０の非接触インタフェース１２からのデータ及びコマンドが、送受信されることが可能である。

【００２９】

本発明によるシステム、及び本発明による方法の実施形態変種の構造が、図４に示されている。第１の方向依存の音響センサ１６によって受信されるのが、とりわけ、ユーザ２２の口の領域からの音声信号であるのに対して、第２の方向依存の音響センサ１３は、とりわけ、近辺から来る周囲サウンドに向けられる。第３の方向依存の音響センサ１５が、とりわけ、ユーザの身体的振動サウンドからの音声信号をキャプチャすることができるようにセットアップされ、位置付けられる。第１の方向依存の音響センサ１６、及び第２の方向依存の音響センサ１３によってキャプチャされる音声信号は、信号調整モジュール４３及び制御回路４４によって、差動増幅器４６の出力において最小周囲雑音に調整される。第３の方向依存の音響センサ１５によってキャプチャされる音声信号は、「身体的振動サウンドがない」ケースにおいて、第１の方向依存の音響センサ１６によってキャプチャ

される音声信号の増幅が、あまりにも増幅され過ぎないように、増幅器コントローラ４８によって使用される。しかし、「身体的振動サウンドが存在する」ケースでは、増幅器は、第１の方向依存の音響センサ１６によってキャプチャされた音声信号が、第２の方向依存の音響センサ１３によってキャプチャされた音声信号に対して増幅されるように設定される。実行時間に起因して歪みが全く生じないように、信号遅延モジュール４７が、備えられることが可能である。

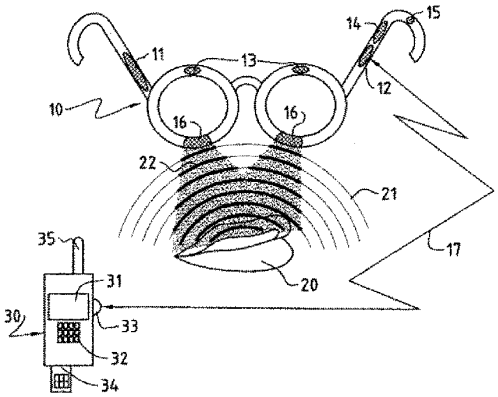
【００３０】

図３に示されているのが、本発明によるシステム、及び本発明による方法の別の実施形態変種である。符号１０は、この場合も、１つ又は複数の方向依存の音響センサ１５を含む眼鏡フレームに関し、センサ１５は、ユーザの身体的振動音響信号が、その方向依存の音響センサ１５によってよくキャプチャされることが可能な位置に実装される。方向依存の音響センサ１５は、同様に、単純なマイクロホンとして、又はマイクロホンのグループ、つまり、いわゆるマイクロホン・アレイとして、かつ／又はＭＥＭＳ技術で実施されることが可能である。少なくとも１つの方向依存の音響センサ１５、５０によってキャプチャされた音声信号は、制御モジュール１１に伝送される。図５に示されるとおり、方向依存の音響センサ１５によってキャプチャされた音声信号は、制御モジュール１１内の増幅器５１によって増幅され、信号処理モジュール５２によって、レベル及び周波数に関して処理され、その後、基準－制御回路５４によって処理されて、キャプチャされたマイクロホン信号が、特性において、通常のマイクロホンによってキャプチャされる音声信号に対応するようにされる。次いで、音声信号は、移動通信端末装置３０のオーディオ・パス５３に追加される。基準－制御回路５４に関する基準が、各ユーザに関して、移動通信端末装置３０の中に、例えば、デバイスのマイクロホンによって記録される。信号処理モジュール５２、ならびに基準－制御回路５４はともに、眼鏡フレーム１０内にも、移動通信端末装置内にも配置されることが可能である。

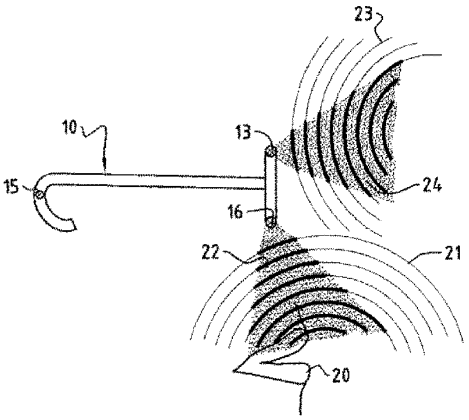
【００３１】

電子システムに給電するための、電源供給装置１４に対するエネルギー源は、特に、光電池（図示せず）を介して実施されることが可能であり、この光電池は、眼鏡レンズ上に真空蒸着させられる。さらに、エネルギー源は、眼鏡フレーム１０に組み込まれた、又はフレーム１０に接続された一般的なバッテリを使用して実施されることも可能である。

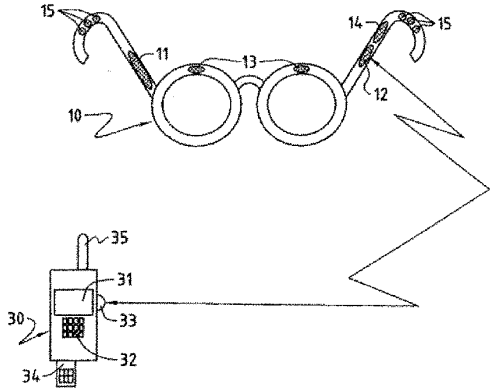
【図１】



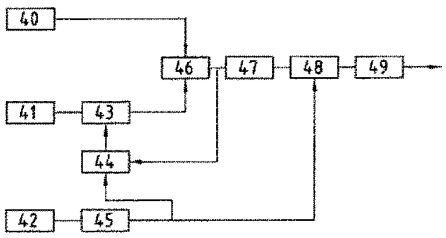
【図２】



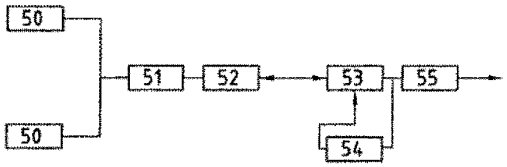
【図３】



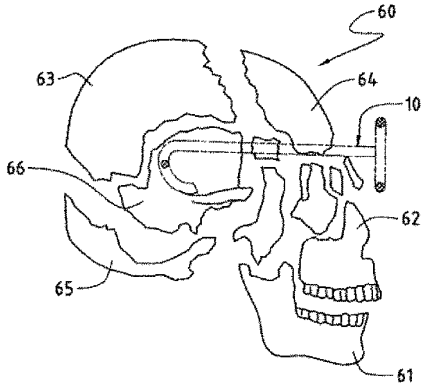
【図４】



【図５】



【図６】



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特開２０００－１６５９８３（ＪＰ，Ａ）
特開平１－１９５４９９（ＪＰ，Ａ）

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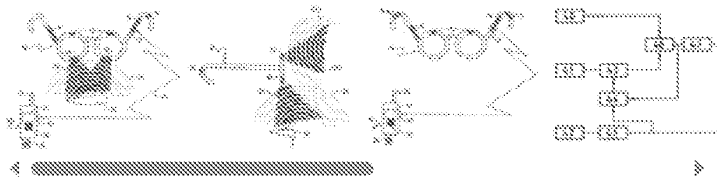
Patents JP6275987B2

Eyeglass frame with integrated acoustic communication system for communicating with a mobile wireless device and corresponding method

Abstract

A system and method for acoustical communication, in which an eyeglass frame includes at least one directionally dependent microphone for capturing voice signals of a user and a communication device for signal transmission to external electronic devices, so that the directional dependence of the at least one microphone is user-specifically adjustable in an adaptive way. The directionally dependent microphones can be implemented as microphone arrays and/or in MEMS technology, and contact microphones can be used.

Images (6)



Classifications

- H04M1/725 Cordless telephones

View 10 more classifications

JP6275987B2

Japan

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Other languages: Japanese

Inventor: リッター, ルドルフ, ラウアー, エリック

Current Assignee : Swisscom AG

Worldwide applications

2005 US AT EP WO RU CN HR JP PW BA 2013 JP

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Status Active

2025-03-29 Anticipated expiration

Info: Patent citations (26), Cited by (30), Legal events, Similar documents, Priority and Related Applications

External links: Espacenet, Global Dossier, Discuss

Claims (35)

Hide Dependent
translated from Japanese

A system for acoustic communication,
A spectacle frame including a plurality of direction-dependent microphones for capturing one or more audio signals;
A transmitter configured to transmit data including the one or more audio signals captured by one or more external electronic devices;
Based on even without least one said 1 captured by one second directionally dependent microphone or audio signals of the plurality of direction-dependent microphones of the plurality of direction-dependent microphones least one A control module for adjusting the direction dependency of the first direction dependent microphone;
The system for acoustic communication, wherein the second direction-dependent microphone is disposed at an ear engaging portion of the spectacle frame to capture a body vibration acoustic signal.
The system for acoustic communication according to claim 1,
The system for acoustic communication, wherein the second direction-dependent microphone is a contact microphone.
The system for acoustic communication according to claim 1,
The one or more audio signals captured by the first direction-dependent microphone are filtered by the control module based on the one or more audio signals captured by a third direction-dependent microphone. A system for acoustic communication that is possible.
The system for acoustic communication according to claim 1,
A system for acoustic communication comprising an amplifier controllable using one or more audio signals captured by a third direction dependent microphone.
The system for acoustic communication according to claim 1,
The system for acoustic communication, wherein the at least one direction dependent microphone is a microphone array.
The system for acoustic communication according to claim 5 ,
At least one microphone array is a system for acoustic communication implemented in MEMS technology.
The system for acoustic communication according to claim 1,
The system for acoustic communication, wherein the one or more external devices include a mobile wireless device.
The system for acoustic communication according to claim 1,
The eyeglass frame is a system for acoustic communication including means for retinal scanning display.
The system for acoustic communication according to claim 8 ,
The system for acoustic communication, wherein the eyeglass frame includes a direction module configured to capture a gaze direction.
The system for acoustic communication according to claim 1,
A system for acoustic communication including a speech recognition module configured to capture verbal commands using at least one direction-dependent microphone.
The system for acoustic communication according to claim 1,
A system for acoustic communication including at least one of a Bluetooth interface, a ZigBee interface, a GSM interface, and a UMTS interface.
The system for acoustic communication according to claim 1,

Apple Inc. Exhibit 1015 Page 2760

A system for acoustic communication wherein a spectacle frame includes a photovoltaic cell configured to provide power.
The system for acoustic communication according to claim 1,
The control module is based on the one or more audio signals captured by the first direction-dependent microphone and at least one second direction-dependent microphone of the plurality of direction-dependent microphones, and at least A system for acoustic communication that adjusts the position of one of the first direction-dependent microphones.
A method for acoustic communication comprising:
Capturing one or more audio signals with a plurality of direction-dependent microphones;
Transmitting the captured data including the one or more audio signals to one or more external devices;
Based on even without least one said 1 captured by one second directionally dependent microphone or audio signals of the plurality of direction-dependent microphones, using a control module, the plurality of direction-dependent Adjusting the direction dependency of a first direction dependent microphone of at least one of the microphones;
A method for acoustic communication, wherein the second direction-dependent microphone is located at a location where a physical vibration acoustic signal can be captured.
The method for acoustic communication according to claim 14 .
The method for acoustic communication, wherein the second direction-dependent microphone is a contact microphone.
The method for acoustic communication according to claim 14 ,
Acoustics including filtering the one or more audio signals captured by the first direction-dependent microphone based on the one or more audio signals captured by a third direction-dependent microphone Method for communication.
The method for acoustic communication according to claim 14 ,
A method for acoustic communication comprising controlling an amplifier using the one or more audio signals captured by a third direction dependent microphone.
The method for acoustic communication according to claim 14 ,
The method for acoustic communication, wherein the at least one direction-dependent microphone is a microphone array.
The method for acoustic communication according to claim 18 ,
The method for acoustic communication, wherein the at least one microphone array is implemented by MEMS technology.
The method for acoustic communication according to claim 14 ,
A method for acoustic communication comprising transmitting the captured one or more audio signals to a mobile wireless device.
The method for acoustic communication according to claim 14 ,
A method for acoustic communication comprising projecting image data onto a retina using a retinal scanning display.
The method for acoustic communication according to claim 21 .
A method for acoustic communication comprising capturing a user's gaze direction using a module.
The method for acoustic communication according to claim 14 ,
A method for acoustic communication comprising the step of capturing verbal commands using a speech recognition module.
The method for acoustic communication according to claim 14 ,
Transmitting the one or more captured signals to the one or more external devices via at least one of a Bluetooth interface, a ZigBee interface, a GSM interface, and a UMTS interface; Way for
The method for acoustic communication according to claim 14 ,
A method for acoustic communication comprising providing a power source via a photovoltaic cell.
In a system for acoustic communication,
A spectacle frame including a plurality of recording means for capturing one or more audio signals;
Communication means for transmitting data comprising the one or more audio signals captured by one or more external electronic devices;
Based on even without least one said 1 captured by one of the second recording means or a plurality of audio signals of the plurality of recording means, the at least one first recording means of the plurality of recording means Control means for adjusting the direction dependence;
A system for acoustic communication comprising ear engagement means for holding the second recording means for capturing a body vibration acoustic signal.
A system for acoustic communication,
A plurality of direction-dependent microphones for capturing one or more audio signals;
A transmitter configured to transmit data including the one or more captured audio signals captured by one or more external electronic devices;
Based on even without least one said 1 captured by one second directionally dependent microphone or audio signals of the plurality of direction-dependent microphones of the plurality of direction-dependent microphones least one A control module for adjusting the direction dependency of the first direction dependent microphone;
A system for acoustic communication, wherein the second direction-dependent microphone is located at a location where a physical vibration acoustic signal can be captured.
28. The system for acoustic communication according to claim 27 .
The system for acoustic communication, wherein the second direction-dependent microphone is a contact microphone.
28. The system for acoustic communication according to claim 27 .
The one or more audio signals captured by the first direction-dependent microphone are filtered by the control module based on the one or more audio signals captured by a third direction-dependent microphone. A system for acoustic communication that is possible.
28. The system for acoustic communication according to claim 27 .
A system for acoustic communication comprising an amplifier controllable using one or more audio signals captured by a third direction dependent microphone.
28. The system for acoustic communication according to claim 27 .
The system for acoustic communication, wherein the at least one direction dependent microphone is a microphone array.
The system for acoustic communication according to claim 31 ,
At least one microphone array is a system for acoustic communication implemented in MEMS technology.
28. The system for acoustic communication according to claim 27 .
The system for acoustic communication, wherein the one or more external devices include a mobile wireless device.
28. The system for acoustic communication according to claim 27 .
A system for acoustic communication including a speech recognition module configured to capture a plurality of verbal commands using at least one direction-dependent microphone.
28. The system for acoustic communication according to claim 27 .
A system for acoustic communication including at least one of a Bluetooth interface, a ZigBee interface, a GSM interface, and a UMTS interface.

Description

translated from Japanese

The present invention relates to a method and system for acoustic communication, in which a spectacle frame includes at least one direction-dependent microphone for capturing a user's audio signal and communication means for transmitting a signal to an external electronic device. In particular, the present invention relates to a communication system in which the direction dependence of at least one microphone can be adjusted in a dynamic manner, in a user-specific manner.

Mobile communication terminal equipment plays an increasingly important role today. Newer mobile communication terminals are not only responding to simple voice or data communications, but are increasingly transforming into complex multimedia devices that can be used for audio broadcast or A video broadcast can be received,

for example, a game can be played, or information can be accessed in a network such as the Internet or a mobile wireless network. The control of these complex mobile communication terminals, in particular the selection of available data and / or data sets, or operating modes, and the entry of data and / or commands, are often keyboards, styluses, tracks This involves the use of expensive and cumbersome auxiliary devices such as balls, touch screens, etc., and often entails the use of such devices. In this connection, in each case, it is also essential to have a mobile communication device in his hand, which limits the hand-free and convenient use of the latest communication terminal devices.

Problem solving methods based on speech recognition are already known in the state of the art. Speech recognition or automatic speech recognition deals with research and development of methods that enable machines, such as computers that recognize verbal languages or convert verbal languages into strings and process them respectively. . On the other hand, voice recognition has also found technical application in automatic dialog systems such as, for example, timetable queries. Automatic speech recognition is performed everywhere where only a limited vocabulary is used. However, in automated speech recognition, the quality of acoustic reception plays a decisive role, and therefore the reception quality can be improved as much as possible to achieve a much higher accuracy of recognition. It is essential that

Publications WO 03/062906 and WO 02/086599 describe, for example, devices in which a microphone and a small speaker are arranged on a spectacle frame. The spectacle frame is then connected to the external electronic device via a cable connection. However, the problem with this proposed device is that it achieves acceptable noise removal for user-specific sound and audio recording, in particular, the user's verbal command, the voice of other people in the vicinity. Difficult to distinguish

As described in the publication EP 0 219 026 B1, it is how a hearing aid can be incorporated into a spectacle frame. Directional effects and localization, which should allow deaf people to gain spatial orientation in relation to acoustic events, through a specific spatial distribution of several microphones on the spectacle frame An effect can be realized. All acoustic and electronic components are housed in eyeglasses. Send connections and / or receive connections to external electronic devices are not provided.

US 2002/0197961 A1 discloses a microphone, a small speaker, a power supply (accumulator), and a transmitter for transmitting signals to a mobile radio device or other external electronic device Or it is a spectacles frame in which a corresponding receiver is mounted. Alternatively, the component may be housed in a clip on a similar article that can be attached to the spectacle frame and removed again, or worn on a hat or head. Is possible. The microphone can also be mounted on an adjustable arm. The use of the above-described arrangement in an environment with large, non-constant static noise still does not guarantee that the desired signal is applied to the microphone at a sufficient level.
International application WO 2004/016037 describes a method and corresponding device for improving the comprehension of speech. This application involves a spectacle frame including a microphone array, a speaker, and a signal processing device. The signal processing device receives the microphone array signal, reduces the amount of interfering background signals, and transmits the processed signal to a speaker or external electronic device. The eyeglass frame also includes a microphone control that can adjust the direction of the microphone so that better signal quality can be achieved. Various methods and algorithms, in particular so-called ANC (active noise control) techniques, can be used for signal processing. Nevertheless, the beamform method described is not suitable for removing ambient noise and interference in an efficient manner in all situations.

International Publication No. 03/062906 International Publication No. 02/086599 European Patent 0 219 026 B1 US Patent Application Publication No. 2002/0197961 A1 International application WO2004 / 016037

The object of the present invention is to propose a new system and a new method for acoustic communication that do not have the above-mentioned problems of the state of the art. In particular, the system allows for convenient, hands-free use of mobile radio devices and provides reliable and convenient input of verbal commands in connection with IVR systems (interactive voice response) in noisy environments, And interactive voice control must be enabled.

The above objects are achieved according to the invention in particular through the elements of the independent claims. In addition, further advantageous embodiments result from the dependent claims and the present description.
In particular, the above objects are such that the spectacle frame includes at least one direction-dependent microphone for capturing a user's audio signal and a communication means for transmitting the signal to an external electronic device, the at least one microphone. The direction dependence of the can be adjusted in a user-specific manner in a dynamic manner by the control module, which is based on the audio signal captured by the at least one second direction-dependent microphone. This is achieved through the present invention in that it includes means for performing an adaptive user-specific adjustment of the direction dependence of the direction-dependent microphone. The advantage of this embodiment variant is inter alia effective denoising, so that for each individual user a much higher quality of the captured audio signal is possible. This may be a necessary prerequisite, especially for recognition of the user's verbal commands. A further advantage is that hands-free input of verbal instructions, as well as the input device is almost inconspicuous because it is incorporated into the spectacle frame.

Furthermore, this embodiment variant has the advantage, inter alia, that the direction-dependent adjustment of direction-dependent microphones can be performed as a function of the signals captured by other microphones. Therefore, better user specific adaptations can be realized, higher voice quality and better preconditions for application of the system and method according to the invention in an environment with a high level of interference noise is brought about

In a further embodiment variant, the at least one second direction-dependent microphone is a contact microphone. This embodiment variant has the advantage, inter alia, that the audio signal sent by the speaking user can be captured not only after propagation in the air but also after propagation in the user's body. Thereby, further improvements in noise removal can be realized after corresponding handling and processing. In particular, using a contact microphone, it can be very easily determined whether the user is speaking right now, and there is possible confusion with additional users speaking in the vicinity. Can be substantially eliminated. Furthermore, the signal captured by the contact microphone is very well suited for use by the control module to make an adaptive user-specific adjustment of the direction dependence of other direction dependent microphones.

In yet another embodiment variant, the signal captured by the first direction-dependent microphone is filtered using the signal captured by the third microphone. This embodiment variant has the advantage that, inter alia, ambient noise captured by another microphone can be used for filtering and signal quality enhancement of the signal captured by the first direction-dependent microphone. Have Thus, the positive features of direction-dependent microphones are optimally combined with the positive features of noise removal via filtering, resulting in better voice quality.

In a further embodiment variant, the at least one direction-dependent microphone is implemented as a microphone array. The at least one microphone array can advantageously be implemented, for example, in MEMS technology. As a result, this embodiment variant has the advantage that, inter alia, a particularly effective and powerful directional effect can be realized. Also, through the use of microphone groups, many spatial features of sound waves can be exploited, and those features cannot be exploited with a single microphone. A further advantage of this embodiment variant is a much lower manufacturing cost and a high integration rate, whereby a particularly small and compact configuration can be realized.

In another embodiment variant, the external device comprises a mobile wireless device. As a result, the mobile wireless device can be incorporated into a spectacle frame, for example, or can exist as a self-contained device. This embodiment variant has, inter alia, the advantage that the system according to the invention and the method according to the invention can be used for voice communication over mobile radio networks. For this reason, the wearer of the glasses can communicate with

one or more servers connected to the mobile radio network or input an acoustic command via the glasses frame. Thus, the wearer of glasses does not need to use any supplementary hands-free device and can therefore communicate more conveniently at a significantly lower cost.

In another embodiment variant, the spectacle frame includes means for a retinal scanning display. A retinal scanning display is a display device in which light rays are projected directly onto the retina of the eye. Through corresponding light modulation of the rays and rapid decomposition, the entire picture can be shown. The spectacle frame may include additional means for capturing the gaze direction. As a result, this embodiment variant constitutes, among other things, a complex system that allows users to directly view and listen to information without relying on external output devices. Has the advantage that it is possible. At the same time, with line-of-sight capture, further possibilities of data input can be incorporated into the system.

In a further embodiment variant, the system includes a speech recognition module for capturing verbal commands using at least one direction-dependent microphone. This embodiment variant has the advantage that the data can be controlled and / or selected in a simple manner by the user using verbal commands. A further advantage is lower power consumption since all devices are integrated in the same frame.

In a further embodiment variant, the communication system comprises a Bluetooth (R) interface and / or a ZigBee (R) interface and / or a GSM (R) interface and / or a UMTS interface and / or a WLAN interface. The above interface can be incorporated into, for example, a communication terminal device and / or a communication unit of a spectacle frame. This has the advantage, among other things, that current industry standards can be accessed using a communication system.

It has to be mentioned here that, in addition to the system according to the invention, the invention also relates to a method for acoustic communication. Embodiment variants of the invention are described below in connection with the examples. Examples of embodiments are illustrated by the accompanying figures below.

1 is a block diagram schematically illustrating a system and method for acoustic communication according to the present invention. 2 is a side view of a spectacle frame that can be used to carry out the system and method of the present invention according to FIG. FIG. 6 is a block diagram schematically illustrating another embodiment of a system and method according to the present invention for acoustic communication. FIG. 2 is a block diagram schematically showing the structure of the system of the present invention for acoustic communication according to FIG. 1 Fig. 4 is a block diagram schematically showing the structure of another embodiment of the system of the present invention for acoustic communication according to Fig. 3; FIG. 2 is an exploded view of a human skull bone showing the approximate normal position of a worn spectacle frame that can be used to implement the system and method according to the present invention.

In FIG. 1, reference numeral 10 refers to a spectacle frame, for example a spectacle frame with a corrective lens or a frame for sunglasses with a sunshade lens, worn by a myopic or hyperopic individual. The spectacle frame 10 includes at least one direction-dependent acoustic sensor 16 at a position where sound waves 21 emanating from the mouth of the user 20 can be captured. Through the direction dependence of the sensor 16, the sound wave 22 emanating from the mouth of the user 20 on the straight line of propagation can be captured particularly well. The direction-dependent acoustic sensor 16 can be, for example, a simple microphone, but can also be implemented as a group of microphones, ie a so-called microphone array. Through the use of a microphone array, the spatial characteristics of the sound field can be exploited, and the quality of the captured signal or, respectively, the intelligibility is consequently improved considerably. It is possible. A plurality of such microphones or microphone arrays 16 can likewise be mounted symmetrically on the spectacle frame 10, for example on both sides of the spectacle frame 10.

Again, as shown in FIG. 1 or 2, the spectacle frame 10 may further include one or more direction-dependent acoustic sensors 15. A further direction-dependent acoustic sensor 15 is implemented by the direction-dependent acoustic sensor 15 at a location where the user's physical vibrational acoustic signal can be well captured. The physical vibration acoustic signal is generated in that sound waves are generated in the user's larynx as they speak and that sound waves are then propagated by the user's body. A particularly suitable location for receiving and capturing physical vibroacoustic signals is the temporal bone 66 located on both sides of the human skull 60, as shown in FIG. The arm of the spectacle frame 10 is usually worn against the temporal bone, which can contribute to the higher quality of the captured physical vibration sound waves. The direction-dependent acoustic sensor 15 can likewise be implemented as a simple microphone or as a group of microphones, ie as a so-called microphone array.

1 and 2, reference numeral 13 refers to one or more additional direction-dependent acoustic sensors 13. One or more further direction-dependent acoustic sensors 13 are implemented at a position on the spectacle frame 10 where ambient sounds coming from the user's environment can be particularly well captured. The direction-dependent acoustic sensor 13 can likewise be implemented as a simple microphone, or as a microphone array, for better quality of the signal being captured, A plurality of direction-dependent microphones or direction-dependent microphone arrays 13 aligned with respect to can also be mounted on the spectacle frame 10.

The microphones or the microphone arrays 13, 15, 16, respectively, can be implemented in particular with so-called MEMS technology (MicroElectroMechanical Systems). Understood by MEMS is a microchip with some logic and at least some moving parts. Thus, a MEMS is typically a processor with mechanical parts that can collect data and also perform the tasks that result from that data. This is a very small microphone or microphone array that can be manufactured through the use of MEMS technology, which can achieve better sound quality at the same time with a small overall size. A microphone or microphone array will be particularly well suited for mounting in the spectacle frame 10.

In FIG. 1, reference numeral 11 indicates a control module. The control module can acquire and evaluate signals from direction-dependent acoustic sensors 13, 15, 16. The control module 11 can also communicate with the direction-dependent acoustic sensors 13, 15, 16 to control the sensors 13, 15, 16. In particular, through the use of MEMS technology, the direction-dependent acoustic sensors 13, 15, 16 can be controlled in a particularly simple manner and with little effort. As a result, the position, sensitivity, and / or direction dependency of the direction-dependent acoustic sensors 13, 15, 16 can be influenced. For example, based on the audio signal captured by one direction-dependent acoustic sensor 13, 15, 16, the control module 11 can control another direction-dependent acoustic sensor 13, 15, 16. All components required for signal processing, signal amplification, and other signal handling are, for example, amplifiers 46, 48, 51, adjustment elements 43, control circuits 44, 54, or delay elements 47 in the spectacle frame 10, in particular, it can be accommodated in the control module 11.

In an embodiment variant of the problem-solving according to the invention, for example, physical vibration sound waves are generated in the larynx of the talking user and propagated by the body. In addition, the physical vibration sound wave or the audio signal is propagated to the skull and the temporal bone, and the audio signal is captured by the direction-dependent acoustic sensor 15 in the skull and the temporal bone. The captured audio signal is interpreted and evaluated by the control module 11, and the direction-dependent acoustic sensor 16 is tailored to the user based on the evaluation. In particular, the control module 11 can change the position of the direction-dependent acoustic sensors 16 implemented with MEMS technology so that the sensors 16 better take into account the user's facial appearance. The control module 11 similarly changes the sensitivity of the direction-dependent acoustic sensors 16 in a user-specific manner so that while the sensors 16 are experiencing physical vibrational sound waves on the temporal bone, it is also possible to react with a particularly high sensitivity to an audio signal coming out of the mouth.

In another embodiment variant of the problem-solving according to the invention, not only the physical vibration sound waves from the speaking user are captured by the direction-dependent acoustic sensor 13, but also ambient sounds coming from the environment. The body vibration sound wave captured by the first direction-dependent acoustic sensor 15 and the ambient noise signal captured by the second direction-dependent acoustic sensor 13 are interpreted and evaluated by the control module 11 to determine the direction. The dependent acoustic sensor 16 is tailored to the user based on the evaluation. In particular, ambient sounds that remain constant may require an adaptive or dynamic user-specific adjustment of the direction dependence of the direction-dependent acoustic sensor 16. That is, the user may suddenly speak more gently because he or she has cut out a topic that has a secret nature and should not be noticed by nearby people. Thus, what is understood by

adaptive user-specific adjustment is a dynamic adjustment in which the direction dependence of the microphone is dynamically adapted to an optimal value, for example using a MEMS microphone. .

In particular, the spectacle frame 10 also comprises a physical network interface 12 using which the verbal information and / or information in the form of data can be communicated with the spectacle frame 10 and the mobile communication terminal via the communication channel 17. It can be exchanged between devices 30. The network interface 12 is not only a local wireless network standard known by the name of Bluetooth or ZigBee, but also GSM (Global System for Mobile Communication), GPRS (Generalized Packet Radio Service), UTS. (Universal Mobile Telecommunication Systems), WLAN (Wireless Local Area Network) 802.11, infrared communication technology, or any other contactless communication technology can also be supported. However, in principle, the network interface 12 may be any contact interface, for example, USB interface or Firewire (R) interface or an Ethernet (registered trademark), Token Ring, or any other wired LAN, (local. It can also be an interface to an area network. The interface, of course, directly uses a network protocol such as, for example, Ethernet or Token Ring, so that not only packet switched interfaces, but also PPP (Point to Point Protocol), SLIP (Serial Line internet Protocol, for example)) Or a circuit-switched interface that can be used by a protocol such as GPRS (Generalized Packet Radio Service), ie, an interface that has no network address such as a MAC address or a DLC address, for example. Is possible. In principle, the system and / or method according to the present invention is not limited to a particular network standard, as long as the features according to the present invention exist, but instead may be implemented in one or more desired networks. It has to be emphasized that it is possible, and in particular can also be realized by voice transmission and / or data transmission switched transparently or routed between different communication technologies. In addition, further required components such as speakers and power supply devices can be accommodated in the spectacle frame 10.

Reference numeral 30 in FIG. 1 refers to a mobile communication terminal device or any desired so-called customer premises equipment (CPE). The mobile communication terminal 30 can be any mobile radio device of any mobile radio network, for example a GSM device of a GSM mobile radio network, or a UMTS device of a UMTS network, or a satellite. It can be a network satellite device. However, the mobile communication terminal 30 in principle has a standard personal computer (PC), portable PC, fixed net telephone, charging device for mobile wireless devices, PlayStation, or electronic networked components. It can be any other device. The mobile communication terminal device 30 includes, for example, an input unit 32 for inputting data elements. The mobile communication terminal 30 can have a standard keyboard or similar input device, for example consisting of numeric keys and control keys, depending on the type of mobile radiotelephone. It is possible to switch to character input. For example, in the case of fee registration in telecommunications, for the purposes of authorization and authentication, the mobile communication terminal device 30 typically includes a removable identification module, for example a SIM (Subscriber ID Module) card 34, is shown under the terminal device 30 in this figure, and contacts the contact inside the mobile communication terminal device during operation. The mobile communication terminal device 30 may further include a display device 31 for displaying data elements. An antenna 35 plays a role in a known manner for the transmission of data over a telecommunications network, which is typically a mobile radio network, for example a GSM (Global System for Mobile Communication) network, a UMTS (Universal). It is a Mobile Telecommunication System (WLAN) network or a WLAN (Wireless Local Area Network) network. Mounted on the mobile communication terminal device 30 is a non-contact interface 33. For example, data and commands from the non-contact interface 12 of the spectacle frame 10 can be transmitted and received via the interface 33. It is.

The structure of an embodiment variant of the system according to the invention and the method according to the invention is shown in FIG. What is received by the first direction-dependent acoustic sensor 16 is, inter alia, an audio signal from the mouth area of the user 22, whereas the second direction-dependent acoustic sensor 13 is notably from the vicinity. Directed to the incoming ambient sound. A third direction-dependent acoustic sensor 15 is set up and positioned so that, inter alia, an audio signal from the user's physical vibration sound can be captured. The audio signals captured by the first direction-dependent acoustic sensor 16 and the second direction-dependent acoustic sensor 13 are adjusted to the minimum ambient noise at the output of the differential amplifier 46 by the signal conditioning module 43 and the control circuit 44. Is done. The audio signal captured by the third direction-dependent acoustic sensor 15 is too amplified in the case of "no physical vibration sound" when the audio signal captured by the first direction-dependent acoustic sensor 16 is amplified. It is used by the amplifier controller 48 so that it is not overdoed. However, in the "physical vibration sound is present" case, the amplifier causes the audio signal captured by the first direction-dependent acoustic sensor 16 to be converted into an audio signal captured by the second direction-dependent acoustic sensor 13. Set to be amplified. A signal delay module 47 can be provided so that no distortion occurs due to the execution time.

Shown in FIG. 3 is another embodiment variant of the system according to the invention and the method according to the invention. Reference numeral 10 again relates to a spectacle frame that includes one or more direction-dependent acoustic sensors 15, where the user's physical vibrational acoustic signal is well captured by the direction-dependent acoustic sensor 15. Can be implemented at a possible position. The direction-dependent acoustic sensor 15 can likewise be implemented as a simple microphone or as a group of microphones, ie a so-called microphone array, and / or in MEMS technology. The audio signal captured by the at least one direction-dependent acoustic sensor 15, 50 is transmitted to the control module 11. As shown in FIG. 5, the audio signal captured by the direction-dependent acoustic sensor 15 is amplified by an amplifier 51 in the control module 11 and processed in terms of level and frequency by a signal processing module 52, after which reference-control is performed. Processed by the circuit 54, the captured microphone signal is made to correspond in character to the audio signal captured by the normal microphone. Next, the audio signal is added to the audio path 53 of the mobile communication terminal device 30. The criteria for the reference-control circuit 54 are recorded in the mobile communication terminal 30 for each user, for example by means of a device microphone. Both the signal processing module 52 and the reference-control circuit 54 can be arranged in the spectacle frame 10 or in the mobile communication terminal device.

The energy source for the power supply 14 for powering the electronic system can in particular be implemented via a photovoltaic cell (not shown), which is vacuum deposited on the spectacle lens. Furthermore, the energy source can be implemented using a general battery built into or connected to the spectacle frame 10.

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Priority And Related Applications

Parent Applications (1)

Application	Priority date	Filing date	Relation	Title
JP2007505555A	2004-03-31	2005-03-29	Division	Method and system for acoustic communication

Applications Claiming Priority (2)

Application	Filing date	Title
EP04101327	2004-03-31	
EP04101327.7	2004-03-31	

Legal Events

Date	Code	Title	Description
2014-07-10	A977	Report on retrieval	**Free format text**: JAPANESE INTERMEDIATE CODE: A971007 **Effective date**: 20140709
2014-07-16	A131	Notification of reasons for refusal	**Free format text**: JAPANESE INTERMEDIATE CODE: A131 **Effective date**: 20140715
2014-10-16	A601	Written request for extension of time	**Free format text**: JAPANESE INTERMEDIATE CODE: A601 **Effective date**: 20141015
2014-10-21	A602	Written permission of extension of time	**Free format text**: JAPANESE INTERMEDIATE CODE: A602 **Effective date**: 20141020
2015-01-15	A521	Request for written amendment filed	**Free format text**: JAPANESE INTERMEDIATE CODE: A523 **Effective date**: 20150115
2015-04-15	A131	Notification of reasons for refusal	**Free format text**: JAPANESE INTERMEDIATE CODE: A131 **Effective date**: 20150414
2015-07-14	A601	Written request for extension of time	**Free format text**: JAPANESE INTERMEDIATE CODE: A601 **Effective date**: 20150714
2015-08-14	A601	Written request for extension of time	**Free format text**: JAPANESE INTERMEDIATE CODE: A601 **Effective date**: 20150814
2015-08-31	A521	Request for written amendment filed	**Free format text**: JAPANESE INTERMEDIATE CODE: A523 **Effective date**: 20150831
2016-02-03	A02	Decision of refusal	**Free format text**: JAPANESE INTERMEDIATE CODE: A02 **Effective date**: 20160202
2017-07-27	A601	Written request for extension of time	**Free format text**: JAPANESE INTERMEDIATE CODE: A601 **Effective date**: 20170727
2017-10-26	A521	Request for written amendment filed	**Free format text**: JAPANESE INTERMEDIATE CODE: A523 **Effective date**: 20171026
2018-01-16	A61	First payment of annual fees (during grant procedure)	**Free format text**: JAPANESE INTERMEDIATE CODE: A61 **Effective date**: 20180111

2018-01-19	R150	Certificate of patent or registration of utility model	**Ref document number**: 6275987 **Country of ref document**: JP **Free format text**: JAPANESE INTERMEDIATE CODE: R150
2021-01-14	R250	Receipt of annual fees	**Free format text**: JAPANESE INTERMEDIATE CODE: R250
2022-01-13	R250	Receipt of annual fees	**Free format text**: JAPANESE INTERMEDIATE CODE: R250
2023-01-12	R250	Receipt of annual fees	**Free format text**: JAPANESE INTERMEDIATE CODE: R250
2024-01-12	R250	Receipt of annual fees	**Free format text**: JAPANESE INTERMEDIATE CODE: R250

Concepts

machine-extracted

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Name	Image	Sections	Count	Query match
communication		title,claims,abstract,description	94	0.000
method		title,claims,abstract,description	44	0.000
dependent effect		claims,abstract,description	95	0.000
engineering process		claims,abstract,description	13	0.000
sound signal		claims,description	44	0.000
vocal effect		claims,description	12	0.000
retinal effect		claims,description	4	0.000
filtration		claims,description	3	0.000
retina		claims,description	2	0.000
adaptive effect		abstract,description	5	0.000
array		abstract,description	4	0.000
signal transmission		abstract	1	0.000

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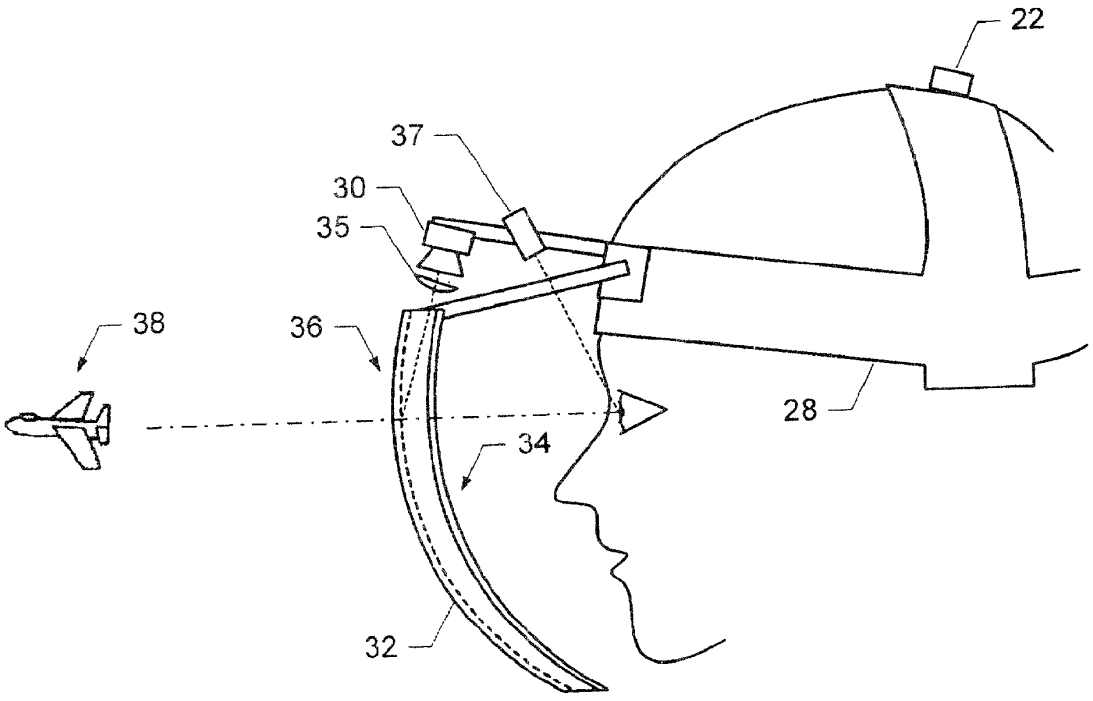
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(54) Titre : SYSTEME DE SUIVI DU REGARD, ENSEMBLE DE SUIVI DU REGARD ET METHODE D'ETALONNAGE ASSOCIEE

(54) Title: GAZE TRACKING SYSTEM, EYE-TRACKING ASSEMBLY AND AN ASSOCIATED METHOD OF CALIBRATION



(57) Abrégé/Abstract:
A system for tracking a gaze of an operator includes a head-mounted eye tracking assembly, a head-mounted head tracking assembly and a processing element. The head-mounted eye tracking assembly comprises a visor having an arcuate shape

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(13) C

(57) Abrégé(suite)/Abstract(continued):
including a concave surface and an opposed convex surface. The visor is capable of being disposed such that at least a portion of the visor is located outside a field of view of the operator. The head-mounted head tracking sensor is capable of repeatedly determining a position of the head to thereby track movement of the head. In this regard, each position of the head is associated with a position of the at least one eye. Thus, the processing element can repeatedly determine the gaze of the operator, based upon each position of the head and the associated position of the eyes, thereby tracking the gaze of the operator.

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GAZE TRACKING SYSTEM, EYE-TRACKING ASSEMBLY AND AN ASSOCIATED METHOD OF CALIBRATION

ABSTRACT OF THE DISCLOSURE

A system for tracking a gaze of an operator includes a head-mounted eye tracking assembly, a head-mounted head tracking assembly and a processing element. The head-mounted eye tracking assembly comprises a visor having an arcuate shape including a concave surface and an opposed convex surface. The visor is capable of being disposed such that at least a portion of the visor is located outside a field of view of the operator. The head-mounted head tracking sensor is capable of repeatedly determining a position of the head to thereby track movement of the head. In this regard, each position of the head is associated with a position of the at least one eye. Thus, the processing element can repeatedly determine the gaze of the operator, based upon each position of the head and the associated position of the eyes, thereby tracking the gaze of the operator.

GAZE TRACKING SYSTEM, EYE-TRACKING ASSEMBLY AND AN ASSOCIATED METHOD OF CALIBRATION

FIELD OF THE INVENTION

The present invention relates generally to head/eye tracking systems for visual display systems and, more particularly, to head/eye tracking systems including an eye tracking device having a curved visor.

BACKGROUND OF THE INVENTION

Visual display systems, such as flight simulation systems, are commonly employed to train military and commercial pilots. Conventional visual display systems include one or more screens onto which a video image is projected by one or more projectors containing image sources, such as cathode ray tubes (CRTs). The operator of the visual display system is also generally provided with a control panel and, in some instances, a joystick for providing input to the visual display system in response to the displayed video image. In this regard, the control panel and joystick are often designed to duplicate the controls and displays found in an aircraft. Thus, the operator can simulate the flight of an aircraft, for example, and can respond to the environment as depicted by the visual display.

In order to provide a relatively large display for the operator, the video image produced by the projector of a conventional flight simulation system is generally expanded and displayed upon a screen having a much larger surface area than the surface of the image source. For example, each optical line pair of a conventional projector generally defines a projection angle of 7 to 12 arcminutes. Thus, while a relatively large image is displayed for the operator, the resolution of the image is somewhat diminished by the expansion of the video image.

To improve the effective resolution of the projected video image, systems and methods have been developed to inset a high resolution video image into the displayed video image or background image. The high resolution inset image is generally relatively small and is, for example, positioned at an area of interest, such as the portion of the screen that the operator is currently viewing. The high resolution inset image generally has a small relative size, taking advantage of the human visual system's limited ability to see clear images outside a small area surrounding the line

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of sight. The small region surrounding the line of sight corresponds to the foveal region of the human eye and, therefore, the corresponding ability to see high detail in the region surrounding the line of sight is typically referred to as foveal vision. This high resolution inset image, which is positioned to generally follow the operator's line of sight, is typically referred to as the Area of Interest (AOI) display. The line of sight including the foveal vision of the operator is generally defined by (1) the direction the operator's head faces, and (2) the direction the operator's eyes face relative to the position of the operator's head.

An area of interest **8** is typically determined by a head/eye tracking device, as shown in FIG. 1. As shown, to track the operator's head position, the head/eye tracking device **10** includes a head tracker sensor **12** mounted above the operator's head by means of a headband **14**, helmet, or other securing device worn on the operator's head so that the position of the head/eye tracking device is held fixed in position and orientation relative to the operator's head. To track the position of the operator's eyes, the head/eye tracking device includes a video camera **16** mounted above and forward of the operator's head by means of the headband or other head-mounted securing device. The image capture device tracks the position of the operator's eyes by imaging the pupils of the operator's eyes through a partially reflective/partially transmissive flat mirror **18**, which is mounted in front of the operator's eyes. By imaging the operator's pupils through the mirror, the image capture device can be mounted in a position out of the operator's visual field of view. In operation, before the head/eye tracking device **10** can track position of the operator's head and eyes, the head/eye tracking device must be calibrated with the screen upon which the video image produced by the projector is displayed. According to one conventional method of calibrating the head/eye tracking device, a plurality of calibration points are displayed upon the screen, such as nine calibration points displayed in a 3x3 matrix. Then, to calibrate the head tracker sensor **12** of the head/eye tracking device, the operator moves his head and, thus, the head tracker sensor such that one of the calibration points is in line with a fixed reference point attached to the head/eye tracker. A data point is then recorded based upon the position of the head tracker sensor. The operator then repeats the process for each of the calibration points displayed upon the screen, with a data point recorded at each calibration point. Once a data point has been recorded for all calibration points, a head tracking calibration function is calculated based upon the recorded data points.

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Either before or after calibrating the head tracker sensor, the image capture device of the head/eye tracker must be calibrated with the screen so that the head/eye tracking device can accurately track the position of the operator's eyes relative to the head tracker sensor. To calibrate the image capture device, the calibration points are again displayed upon the screen. The operator then orients his head and, thus the head tracker sensor, in a fixed position, preferably such that the operator's line of sight intersects a center point of the screen. Holding his head in the fixed position, the operator moves his eyes such that the operator's line of sight intersects one of the calibration points. A data point is then recorded for the calibration point based upon an image of the operator's pupils taken by the image capture device. In this regard, the data point can include information such as pupil position in both the X and Y directions, as well as corneal reflection in both the X and Y directions. Also as before, the operator repeats the process of moving his eyes to each calibration point and recording a data point for each calibration point, all while holding his head in the fixed position. And after the data points have been recorded for all of the calibration points, an eye tracking calibration function is calculated based upon the recorded data points, e.g., (eye pitch, eye yaw) = f(input data from tracker).

After calculating the calibration functions, the head/eye tracking device tracks the position of the operator's head based upon the position of the operator's head as determined by the head tracker sensor, and based upon the head tracking calibration function. Similarly, the head/eye tracking device tracks the position of the operator's eyes as determined by the image capture device, and based upon the eye tracking calibration function. And based upon the position of the operator's head and pupils at any given time, the area of interest is selected relative to the screen and thereafter displayed, such as in line with the operator's line of sight. The high resolution inset image can then be projected within the area of interest to thereby be within the operator's foveal vision.

Whereas conventional head/eye tracking devices are adequate in tracking the head and eye position of the operator, such conventional tracking devices have drawbacks. The partially reflective/partially transmissive flat mirror **18**, which is mounted in front of the operator's eyes, is visually distracting for the operator. In this regard, the mirror is an unnatural obstruction in the operator's visual field of view, limiting the operator's feeling of visual immersion in a virtual reality application, such as that found in flight simulation systems.

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In addition to the structural drawback of the partially reflective/partially transmissive flat mirror **18**, the method by which conventional head/eye tracking devices are calibrated also has drawbacks. As stated before, either the operator's eyes or head must remain in a fixed position for a period of time during various stages of calibrating the head/eye tracking device. In this regard, the calibration method is prone to errors caused by inadvertent movement of either the operator's eyes or head during a time in which the eyes or head must remain in a fixed position for complete accuracy. Due to the time period the operator is required to keep either his eyes or head in the fixed position, the operator can have a tendency to fatigue, which can cause the operator's eyes or head to inadvertently move.

SUMMARY OF THE INVENTION

In accordance with one aspect of the invention there is provided a head-mounted eye tracking assembly for tracking movement of at least one eye of an operator. The eye tracking assembly includes a visor having an arcuate shape including a concave surface and an opposed convex surface, wherein the visor is capable of being disposed such that the at least one eye is located proximate the concave surface, wherein the visor is at least partially reflective such that the visor is capable of reflecting an image of the at least one eye, and wherein the visor is capable of being disposed such that at least a portion of the visor is located outside a field of view of the operator. The eye tracking assembly further includes an image capture device disposed proximate the concave surface of the visor, wherein the image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by the visor.

The concave surface of the visor may include a reflective coating.

The head-mounted eye tracking assembly may further include an illuminator capable of illuminating the at least one eye.

The illuminator may be capable of illuminating the at least one eye with infrared light.

The head-mounted eye tracking assembly may further include a lens disposed in an optical path of the image capture device, wherein an effective focus of the image capture device is based upon an optical power of the visor and an optical power of the lens.

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The image capture device may be located outside the field of view of the operator.

In accordance with another aspect of the invention, there is provided a system for tracking a gaze of an operator. The gaze tracking system includes a head-mounted eye tracking assembly. The head-mounted eye tracking assembly further includes a visor having an arcuate shape including a concave surface and an opposed convex surface, wherein the visor is capable of being disposed such that at least one eye is located proximate the concave side, wherein the visor is at least partially reflective such that the visor is capable of reflecting an image of the at least one eye, wherein the visor is capable of being disposed such that at least a portion of the visor is located outside a field of view of the operator, and wherein the head-mounted eye tracking assembly is capable of repeatedly determining a position of the at least one eye based upon the image of the at least one eye reflected by the visor to thereby track movement of the at least one eye. The head-mounted eye tracking assembly further includes a head-mounted head tracking sensor capable of repeatedly determining a position of the head to thereby track movement of the head, wherein each position of the head is associated with a position of the at least one eye. The head-mounted eye tracking assembly further includes a processing element capable of repeatedly determining the gaze of the operator to thereby track the gaze of the operator, wherein the processing element repeatedly determines the gaze of the operator based upon each position of the head and the associated position of the at least one eye.

The concave surface of the visor of the head-mounted eye tracking assembly may include a reflective coating.

The head-mounted eye tracking assembly may further include an illuminator capable of illuminating the at least one eye.

The illuminator may be capable of illuminating the at least one eye with infrared light.

The head-mounted eye tracking assembly may further include an image capture device disposed proximate the concave surface of the visor, and wherein the image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by the visor.

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The head-mounted eye tracking assembly may further include a lens disposed in an optical path of the image capture device, wherein an effective focus of the image capture device is based upon an optical power of the visor and an optical power of the lens.

The image capture device may be located outside the field of view of the operator.

In accordance with another aspect of the invention, there is provided a visual display system. The visual display system includes a background image projector having a predetermined field of view, the background image projector generating a background image having a predetermined size and resolution that at least partially fills the field of view. The visual display system further includes at least one inset image projector for generating an area of interest (AOI) image having a smaller size and a higher resolution than the background image, the inset image projector having a predetermined field of view that is capable of being movably disposed at least partially within the field of view of the background image projector. The visual display system further includes a gaze tracking system capable of directing the movement of the field of view of the inset image projector based upon the direction in which an operator is looking. The gaze tracking system includes a head-mounted eye tracking assembly. The head-mounted eye tracking assembly includes a visor having an arcuate shape including a concave surface and an opposed convex surface, wherein the visor is capable of being disposed such that at least one eye is located proximate the concave surface, wherein the visor is at least partially reflective such that the visor is capable of reflecting an image of the at least one eye, and wherein the visor is capable of being disposed such that at least a portion of the visor is located outside a field of view of an operator. The head-mounted eye tracking assembly further includes an image capture device disposed proximate the concave surface of the visor, wherein the image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by the visor.

The gaze tracking system may further include a head-mounted head tracking sensor capable of repeatedly determining a position of the head to thereby track movement of the head, wherein each position of the head is associated with a position of the at least one eye. The gaze tracking system may further include a processing element capable of repeatedly determining a gaze of the operator to thereby track the gaze of the operator, wherein the processing element repeatedly determines the gaze

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of the operator based upon each position of the head and the associated position of the at least one eye.

The concave surface of the visor of the head-mounted eye tracking assembly may include a reflective coating.

The head-mounted eye tracking assembly may further include an illuminator capable of illuminating the at least one eye.

The head-mounted eye tracking assembly may further include a lens disposed in an optical path of the image capture device, wherein an effective focus of the image capture device is based upon an optical power of the visor and an optical power of the lens.

In accordance with another aspect of the invention, there is provided a head-mounted eye tracking assembly for tracking movement of at least one eye of an operator. The eye tracking assembly includes a visor having an arcuate shape including a concave surface and an opposed convex surface, wherein the visor is capable of being disposed such that the at least one eye is located proximate the concave surface, wherein the visor is at least partially reflective such that the visor is capable of reflecting an image of the at least one eye, and wherein the visor is capable of being disposed such that at least a portion of the visor is located outside a field of view of the operator. The eye tracking assembly further includes an image capture device disposed proximate the concave surface of the visor, wherein the image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by the visor. The eye tracking assembly further includes a lens disposed in an optical path of the image capture device wherein an effective focus of the image capture device is based upon an optical power of the visor and an optical power of the lens.

The concave surface of the visor may include a reflective coating.

The head-mounted eye tracking assembly may further include an illuminator capable of illuminating the at least one eye.

The illuminator may be capable of illuminating the at least one eye with infrared light.

The image capture device may be located outside the field of view of the operator.

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The visor may be capable of reflecting an image of a pupil of at least one eye, and wherein the image capture device is capable of tracking movement of the at least one eye based upon the image of the pupil of the at least one eye.

In accordance with another aspect of the invention, there is provided a system for tracking a gaze of an operator. The gaze tracking system includes a head-mounted eye tracking assembly. The head-mounted tracking assembly includes a visor having an arcuate shape including a concave surface and opposed an convex surface, wherein the visor is capable of being disposed such that the at least one eye is located proximate the concave side, wherein the visor is at least partially reflective such that the visor is capable of reflecting an image of the at least one eye, wherein the visor is capable of being disposed such that at least a portion of the visor is located outside a field of view of the operator, and wherein the head-mounted eye tracking assembly is capable of repeatedly determining a position of the at least one eye based upon the image of the at least one eye reflected by the visor to thereby track movement of the at least one eye. The head-mounted tracking assembly further includes an image capture device disposed proximate the concave surface of the visor, wherein the image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by the visor. The head-mounted tracking assembly further includes a lens disposed in an optical path of the image capture device, wherein an effective focus of the image capture device is based upon an optical power of the visor and an optical power of the lens. The gaze tracking system further includes a head-mounted head tracking sensor capable of repeatedly determining a position of the head to thereby track movement of the head, wherein each position of the head associated with a position of the at least one eye. The gaze tracking system further includes a processing element capable of repeatedly determining the gaze of the operator to thereby track the gaze of the operator, wherein the processing element repeatedly determines the gaze of the operator based upon each position of the head and the associated position of the at least one eye. The concave surface of the visor of the head-mounted eye tracking assembly may include a reflective coating.

The head-mounted eye tracking assembly may further include an illuminator capable of illuminating the at least one eye.

The illuminator may be capable of illuminating the at least one eye with infrared light.

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The image capture device may be located outside the field of view of the operator.

The visor may be capable of reflecting an image of a pupil of at least one eye, and wherein the head-mounted eye tracking assembly is capable of repeatedly determining a position of the at least one eye based upon the image of the pupil of the at least one eye.

In accordance with another aspect of the invention, there is provided a visual display system. The visual display system includes a background image projector having a predetermined field of view, the background image projector generating a background image having a predetermined size an resolution that at least partially fills the field of view. The visual display system further includes at least one inset image projector for generating an area of interest (AOI) image having a smaller size and a higher resolution than the background image, the inset image projector having a predetermined field of view that is capable of being movably disposed at least partially within the field of view of the background image projector. The visual display system further includes a gaze tracking system capable of directing the movement of the field of view of the inset image projector based upon the direction in which an operator is looking. The gaze tracking system includes a head-mounted eye tracking assembly. The head-mounted eye tracking assembly includes a visor having an arcuate shape including a concave surface and an opposed convex surface, wherein the visor is capable of being disposed such that the at least one eye is located proximate the concave surface, wherein the visor is at least partially reflective such that the visor is capable of reflecting an image of the at east one eye, and wherein the visor is capable of being disposed such that at least a portion of the visor is located outside a field of view of the operator. The head-mounted eye tracking assembly further includes an image capture device disposed proximate the concave surface of the visor, wherein the image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by the visor. The head-mounted eye tracking assembly further includes a lens disposed in an optical path of the image capture device, wherein an effective focus of the image capture device is based upon an optical power of the visor and an optical power of the lens.

The gaze tracking system may further include a head-mounted head tracking sensor capable of repeatedly determining a position of the head to thereby track movement of the head, wherein each position of the head is associated with a position

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of the at least one eye. The gaze tracking system may further include a processing element capable of repeatedly determining the gaze of the operator to thereby track the gaze of the operator, wherein the processing element repeatedly determines the gaze of the operator based upon each position of the head and the associated position of the at least one eye.

The concave surface of the visor of the head-mounted eye tracking assembly may include a reflective coating.

The head-mounted eye tracking assembly may further include an illuminator capable of illuminating the at least one eye.

The head-mounted eye tracking assembly may further include a lens disposed in an optical path of the image capture device, wherein an effective focus of the image capture device is based upon an optical power of the visor and an optical power of the lens.

The visor may be capable of reflecting an image of a pupil of at least one eye, and wherein the image capture device is capable of tracking movement of the at least one eye based upon the image of the pupil of the at least one eye.

The inset image projector may have a predetermined field of view that is capable of being movably disposed based upon electronic raster deflection.

BRIEF DESCRIPTION OF THE DRAWINGS

Having thus described the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

FIG. 1 is a schematic illustration of portions of a conventional gaze tracking system;

FIG. 2 is a schematic illustration of portions of a gaze tracking system according to one embodiment of the present invention;

FIG. 3 is a block diagram of a gaze tracking system according to one embodiment of the present invention;

FIGS. 4A and 4B are schematic illustrations illustrating various movements in a method for calibrating the gaze tracking system according to one embodiment of the present invention;

FIG. 5 is a flow chart illustrating various steps in a method of calibrating a gaze tracking system according to one embodiment of the present invention; and

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FIG. 6 is a perspective view illustrating a visual display system incorporating the gaze tracking system of one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

Referring to FIGS. 2 and 3, a gaze tracking system **20** according to one embodiment of the present invention is shown. The system includes a head-mounted head tracking sensor **22**, a head-mounted eye tracking assembly **24**, and a processing element **26**. The head tracking sensor and eye tracking assembly are mounted to an operator's head by means of a headband **28**, helmet or other head-mounted securing device. The head tracking sensor is mounted to the operator's head out of the field of vision of the operator so as to not impede the operator's vision. The head tracking sensor is capable of repeatedly determining a position of the operator's head to thereby track the movement of the head. In this regard, the head tracking sensor can comprise any of a number of known sensors capable of determining the position of the operator's head. For example, the head tracker sensor can comprise an InsideTrak™ model head tracking sensor or a FasTrak™ model head tracking sensor, both manufactured by Polhemus Incorporated of Colchester, VT. Alternatively, the head tracker sensor can comprise any of a number of other head tracking sensors that operate based on magnetic, acoustic, optical or other technologies, as such are known to those skilled in the art.

The eye tracking assembly comprises an image capture device **30** and a visor **32**. The visor is secured to the headband **28** such that, when the headband is mounted to the operator's head, the visor is disposed in front of the operator's head. The visor is preferably at least partially reflective for light of a predetermined wavelength or range of wavelengths. For example, the visor may be made from a partially reflective material, such as Lexan® brand polycarbonate (manufactured by the General Electric Company of Pittsfield, MA) coated with a reflective film, so that the operator's field

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of view can extend through the visor while an image of the operator's eyes, or more particularly the operator's pupils, reflects off of the visor into the optical path of the image capture device. Advantageously, the visor is designed to provide an environment for the operator that is typically found in many applications employing the system, such as flight simulation applications. In this regard, the visor is designed to not present any visually obstructive edges with the operator's field of view. Thus, the visor has an arcuate or curved shape including a concave surface **34** and an opposed convex surface **36**, one of which may support an at least partially reflective coating. The visor is secured to the headband such that, when the headband is

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mounted to the operator's head, the concave surface is disposed proximate the operator's eyes. Further, the visor is secured to the headband such that, when the headband is mounted to the operator's head, at least a portion of the visor is located outside the operator's field of view.

Like the head tracking sensor **22**, the image capture device **30** is mounted outside the field of view of the operator so as to not impede the operator's vision. In this regard, the image capture device is preferably mounted on a front portion of the headband **28** such that the image capture device is located at a position peripheral to the operator's head out of the operator's field of view. The image capture device is capable of repeatedly determining a position of the operator's eyes by imaging the pupil of one or both of the operator's eyes. Because the image capture device is mounted on the headband outside the field of view of the operator, the image capture device images the operator's pupils by imaging a reflection of the pupils from the visor of the eye tracking assembly. Thus, the image capture device can comprise any of a number of devices capable of repeatedly determining the position of the operator's eyes to thereby track the movement of the operator's eyes. According to one embodiment, for example, the image capture device comprises a camera, such as is included within ETL-500 model eye tracking system manufactured by ISCAN, Inc. of Burlington, MA.

Advantageously, the image capture device **30** can comprise a camera, such as is used in a conventional head/eye tracking device including a partially reflective/partially transmissive flat mirror **18**, as shown in FIG. 1. But it will be appreciated that the visor **32** of the present invention will typically have a different optical power than the flat mirror of the conventional head/eye tracking device. In this regard, lenses have a characteristic power that is typically measured in diopters and equals the inverse of the focal length of the lens in meters, as such is known to those skilled in the art. It will also be appreciated that, in using a camera such as is used in a conventional head/eye tracking device, the effective focus of the camera will differ from the desired effective focus due to the difference in optical power between the visor and the conventional flat mirror. Thus, in embodiments where the image capture device comprises a camera such as is used in a conventional head/eye tracking device, the system preferably compensates for the change effective focus due to the difference in optical power so as to bring the effective focus to a desired value, or the

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value of the effective focus of the camera as used in the conventional head/eye tracking device.

The system **20** can compensate for the optical power of the visor **32** in any of a number of different manners. For example, the aperture of the camera lens can be reduced to thereby increase the depth-of-field of the camera. And by increasing the depth-of-field of the camera, the system can compensate for the change in effective focus of the camera. Additionally or alternatively, the system can include a lens **35** disposed in the optical path of the camera to compensate for the optical power of the visor. In this regard, if the aperture of the camera lens is not reduced, the lens can be selected such that the optical power of the lens plus the optical power of the visor equals the optical power of a flat mirror as would be included in a conventional head/eye tracking device including the camera.

As previously stated, the image capture device **30** images the operator's pupils by receiving light reflected off of the pupils and thereafter off of the visor **32** into the optical path of the image capture device. To facilitate tracking the eyes, the system **20** can include an illuminator **37** capable of illuminating the eyes such that more light reflects off of the eyes and, thus, the visor. However, to avoid visual distractions, the illuminator is preferably an infrared illuminator, such as an infrared light emitting diode, capable of illuminating infrared light to the eyes. The infrared light, thus, reflects off of the front and rear surfaces of the corneas and the lenses of the eyes, and thereafter reflects off of the visor into the optical path of the camera. It will be appreciated that such images are commonly referred to as Purkinje images by those skilled in the art. It will also be appreciated that as the light in this embodiment comprises infrared light, the image capture device of this embodiment is preferably infrared sensitive, such as an infrared sensitive camera. Additionally, the predetermined wavelength or range of wavelengths that the visor is capable of reflecting advantageously includes infrared light in this embodiment.

To track the gaze of the operator based upon a position of the operator's eyes and head, the system **20** also includes a processing element **26**. The processing element can comprise any of a number of different devices, such as a personal computer or other high level processor. As shown in FIG. 3, and as already stated, the eye-tracking assembly is capable of determining a position of the operator's eyes. Similarly, the head tracking sensor **22** is capable of determining a position of the operator's head. The processing element **26**, in turn, is capable of receiving the

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position of the operator's eyes from the eye-tracking assembly and the position of the operator's head from the head tracking sensor. Based upon the position of the operator's eyes and operator's head, the processing element can determine the operator's gaze. Repeatedly receiving the position of the operator's eyes and head, the processing element can therefore track the operator's gaze, as will be appreciated by those skilled in the art. And based upon the gaze of the operator the processing element can define an area of interest **38** (shown in FIG. 2) relative to an external device, such as a display.

Before the system can track the gaze of the operator, the system **20** is preferably calibrated to the external device, such as a display. As previously indicated, the difficulty in calibrating conventional eye trackers is that any head movement during calibration will cause an error in the calibration. Thus, embodiments of the present invention provide a method of calibrating a gaze tracking system, such as the gaze tracking system described above, using data from the head tracking sensor **22**. By using data from the head tracking sensor, then, the calibration can compensate for any head movement, and the true gaze angle can be determined more accurately.

Advantageously, embodiments of the method of the present invention also uses movement of the head tracking sensor during calibration to collect eye data. In this regard, conventional eye tracker calibration methods commonly calibrate the eye tracker based upon a set of calibration points that typically numbers less than ten. Conventional calibration methods, then, are typically limited to a small number of data points (i.e., input parameters) by which to approximate a calibration function for the eye tracker. As such, the more data points that are recorded, and the more distributed the data points, the better the final calibration of the eye tracker. Whereas any of a number of different techniques can be employed to collect data points, embodiments of the present invention provide are capable of collecting a large number of data points during calibration, as described below.

Referring now to FIGS. 4A, 4B and 5, the method of calibrating the gaze tracking system begins with initializing calibration of the gaze tracking system, as shown in block **40** of FIG. 5. Initialization can be accomplished according to any of a number of different manners but, according to one embodiment, calibration of the system is initialized by initiating a calibration routine within the processing element **26**. Once calibration of the system has been initialized, the processing element can

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drive a display to present a first reference point **42**, or target, within the operator's field of view, as shown in FIGS. 4A, 4B and block **44** of FIG. 5.

Once the target **42** has been presented to the operator, the operator aligns the operator's line of sight **46** with the displayed target, as shown in block **48** of FIG. 5. The operator then begins the calibration process, such as by actuating the processing element **26** to begin calibration of the system. In this regard, when the operator actuates the processing element, the processing element drives the eye tracking assembly to measure the position of the operator's eyes, which measurement the processing element will then associate with the target, as shown in block **50**. At the same time, the processing element drives the head tracking sensor **22** to measure the angle of the operator's head as well as translations of the position of the operator's head, as shown in block **52**. The measured angle and translations are then set by the processing element to be a second reference position.

After the position of the operator's eyes and head have been measured by the gaze tracking system **20**, while keeping the operator's line of sight **46** aligned with the target **42**, the operator moves the operator's head and, thus, the head tracking sensor **22**, to a position offset from the second reference position, as shown in FIGS. 4A and 4B, and block **54** of FIG. 5. In keeping the operator's line of sight aligned with the target while the operator moves the operator's head, the operator's eyes generally move opposite of the head to maintain alignment of the line of sight with the target. Once at the offset position, then, the gaze tracking system measures the position of the eyes and an angle offset of the line of sight of the eyes relative to the first reference point, as shown in block **56**. Similarly, the gaze tracking system measures the position of the head tracking sensor or, more particularly, the angle of the operator's head and translations of the position of the operator's head relative to the second reference position, as shown in block **58**. Next, the processing element **26** records the positions, such as in a memory location. Also, the processing element can determine the direction of the operator's eyes relative to the operator's head from the measurements, and record the direction along with the measurements.

After the processing element **26** has recorded the measurements and the direction of the operator's eyes, the operator then moves the operator's head to another offset position, again keeping the line of sight **46** aligned with the target **42**. The gaze tracking system again measures the position of the eyes and head tracking sensor **22**, and records the measurements along with the direction of the operator's

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eyes. The process continues for N (e.g., 300) movements of the operator's head such that the processing records N data points consisting of the recorded measurements and directions of the operator's eyes relative to the operator's head, as shown in blocks **60** and **62** of FIG. 5. Advantageously, the operator can move the operator's head to different offset positions, and the processing element can correspondingly record measurements, at a high rate, such as 60 times a second. As such, large amounts of data can be collected in a short amount of time. For example, recording measurements at a rate of 60 times a second, the processing element can record 300 measurements in five seconds. In comparison, it would require roughly ten second to collect data from a nine point grid of calibration points using conventional methods.

Allowing the operator to move the operator's head freely while aligning the line of sight **46** with the target **42** allows a large amount of data to be collected in a short amount of time. But such a method typically gives very little control over what data is collected. For example, since the operator can move his head in any way the operator chooses, the recorded data can become concentrated in a small area, such as around the target. For most calibration functions, the more distributed the data, the better the resulting calibration. Thus, to allow for more control over the data that is collected, the processing element **26** can be capable of moving the target to one or more different positions. And after moving the target to each position ,the operator again aligns the line of sight and moves the head tracking sensor **22** to different offset positions, with the processing element collecting data at each position. Whereas the processing element can move the target to any one of a number of different points, the processing element preferably moves the target to areas on a reference plane (e.g., display screen) for which the processing element has fewer recorded measurements.

With the data points, then, the processing element **26** determines a calibration function to thereby calibrate the gaze tracking system **20**. The processing element can determine the calibration function according to any one of a number of different methods. For example, the processing element can determine the calibration function according to an interpolation method using an interpolation function, such as akima interpolation, b-spline interpolation, bi-cubic interpolation, linear interpolation quadratic interpolation, or the like. In such functions, the set of data points are used as reference points and intermediate points, between the data points, are determined, or interpolated, based on the surrounding data points.

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According to one advantageous embodiment, the processing element determines the calibration function utilizing an artificial neural network, as illustrated in block **64** of FIG. 5. As is known to those skilled in the art, artificial neural networks are modeled upon the human brain's interconnected system of neurons. Based upon this premise, the artificial neural network allows the processing element to imitate the brain's ability to sort out patterns and learn from trial and error, discerning and extracting the relationships that underlie the input data. The network learns when the input data (with known results) is presented to processing element. Factors associated with the known results are then adjusted to bring the calibration output closer to the known result (e.g., position relative to the target).

In addition to the above identified methods of determining the calibration function, the processing element can use known physical properties of the optics of the eye tracking assembly **24** of the gaze tracking system **20**, and/or the physical properties of the operator's eyes (e.g., curvature of the eyes), to determine the calibration function. In this regard, the above methods of determining the calibration function allow for any unknown distortion to be present in the input data. For example, due to the curvature of the visor **32**, the image capture device **30** may receive and/or record an image of the pupils of the operator's eyes that has some degree of radial distortion. Embodiments of the calibration method of the present invention can at least partially compensate for the distortion by estimating the calibration function for the data. However, using the known physical properties of the optics, the processing element can further compensate for any optical distortion. For example, the processing element can further compensate for optical distortion by computing the light path through the system and mapping out any irregularities according to any of a number of known techniques.

Referring now to FIG. 6, a visual display system **70**, such as a flight simulation system, that would benefit from the gaze tracking system of the present invention is illustrated. The visual display system generally includes a plurality of display screens **72**. For example, the visual display system can include an out-the-window flight simulation system such as the Visual Integrated Display System manufactured by The Boeing Company, the assignee of the present application. As also illustrated in FIG. 6, the image displayed on the display screens **72** includes a background image having a predetermined size and resolution. The background image is generally generated by a background image projector. The background

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image projector can, and preferably does, include a plurality of background image projectors, at least one of which is associated with each display screen. For full color background images, the background image projectors are generally RGB projector.

In order to display a relatively large background image for the operator, the individual pixels are projected, and thereby expanded, for display on the associated display screen **72**. For example, each pair of video lines typically defines a projection angle of 7 to 12 arcminutes. Therefore, the resulting background image displayed on the display screens has a relatively low resolution. As illustrated in FIG. 6, an inset image **74** can also be displayed on the display screen and is generally generated by an inset image projector. As shown, the inset image can include other aircraft in an area of interest (AOI) **76** of the operator. Each inset image (i.e., AOI image) preferably has a smaller size and a higher resolution than the background image in order to provide the operator with additional detail in this particular AOI. The AOI is defined by the gaze of the operator and, as such, the visual display system includes a gaze tracking system, such as a gaze tracking system **20** in accordance with the present invention (shown in FIGS. 2 – 4), to track the gaze of the operator. For more information on such a display system, see U.S. Patent No. 5,487,665 or U.S. Patent No. 5,746,599.

Therefore, the present invention provides an improved eye-tracking assembly, gaze tracking system and method of calibration. In this regard, by including a visor, at least a portion of which is capable of being located outside the field of view of the operator, the operator can utilize the eye-tracking assembly without distractions associated with conventional eye-tracking assemblies. As such, the visor of the eye-tracking assembly can provide a more native environment to an operator, particularly in instances in which the operator would typically wear a visor that encompasses the operator's field of view. Also, the present invention provides an improved method of calibrating a gaze tracking system. The method of calibration includes movement of the head tracking sensor with the operator's eyes aligned in a particular direction, as opposed to fixing the head in position and aligning the operator's line of sight with several reference points. As such, the method provides a more accurate technique for calibrating the gaze tracking system. Further, the method can utilize an artificial neural network to calibrate the system based upon input data from an eye-tracking

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assembly and head tracking sensor, which allows the neural network to adaptively learn from previous movements.

Many modifications and other embodiments of the invention will come to mind to one skilled in the art to which this invention pertains having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the invention is not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

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THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A head-mounted eye tracking assembly for tracking movement of at least one eye of an operator, said eye tracking assembly comprising:

a visor having an arcuate shape including a concave surface and an opposed convex surface, wherein said visor is capable of being disposed such that the at least one eye is located proximate the concave surface, wherein said visor is at least partially reflective such that said visor is capable of reflecting an image of the at least one eye, and wherein said visor is capable of being disposed such that at least a portion of said visor is located outside a field of view of the operator; and

an image capture device disposed proximate the concave surface of said visor, wherein said image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by said visor.

2. A head-mounted eye tracking assembly according to Claim **1**, wherein the concave surface of said visor includes a reflective coating.

3. A head-mounted eye tracking assembly according to Claims **1** or **2**, further comprising an illuminator capable of illuminating the at least one eye.

4. A head-mounted eye tracking assembly according to Claim **3**, wherein said illuminator is capable of illuminating the at least one eye with infrared light.

5. A head-mounted eye tracking assembly according to any one of Claims **1** to **4** further comprising a lens disposed in an optical path of said image capture device, wherein an effective focus of said image capture device is based upon an optical power of said visor and an optical power of said lens.

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6. A head-mounted eye tracking assembly according to any one of Claims **1** to **5**, wherein said image capture device is located outside the field of view of the operator.

7. A system for tracking a gaze of an operator, said gaze tracking system comprising:

a head-mounted eye tracking assembly comprising:

a visor having an arcuate shape including a concave surface and an opposed convex surface, wherein said visor is capable of being disposed such that at least one eye is located proximate the concave side, wherein said visor is at least partially reflective such that said visor is capable of reflecting an image of the at least one eye, wherein said visor is capable of being disposed such that at least a portion of said visor is located outside a field of view of the operator, and wherein the head-mounted eye tracking assembly is capable of repeatedly determining a position of the at least one eye based upon the image of the at least one eye reflected by said visor to thereby track movement of the at least one eye;

a head-mounted head tracking sensor capable of repeatedly determining a position of the head to thereby track movement of the head, wherein each position of the head is associated with a position of the at least one eye; and

a processing element capable of repeatedly determining the gaze of the operator to thereby track the gaze of the operator, wherein said processing element repeatedly determines the gaze of the operator based upon each position of the head and the associated position of the at least one eye.

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8. A system according to Claim **7**, wherein the concave surface of the visor of said head-mounted eye tracking assembly includes a reflective coating.

9. A system according to Claims **7** or **8**, wherein said head-mounted eye tracking assembly further comprises an illuminator capable of illuminating the at least one eye.

10. A system according to Claim **9**, wherein the illuminator is capable of illuminating the at least one eye with infrared light.

11. A system according to any one of Claims **7** to **10**, wherein said head-mounted eye tracking assembly further comprises an image capture device disposed proximate the concave surface of said visor, and wherein the image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by said visor.

12. A system according to Claim **11**, wherein said head-mounted eye tracking assembly further comprises a lens disposed in an optical path of the image capture device, wherein an effective focus of the image capture device is based upon an optical power of the visor and an optical power of the lens.

13. A system according to Claims **11** or **12**, wherein the image capture device is located outside the field of view of the operator.

14. A visual display system comprising:

a background image projector having a predetermined field of view, said background image projector generating a background image having a predetermined size and resolution that at least partially fills the field of view;

at least one inset image projector for generating an area of interest (AOI) image having a smaller size and a higher resolution than the

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background image, said inset image projector having a predetermined field of view that is capable of being movably disposed at least partially within the field of view of said background image projector; and

a gaze tracking system capable of directing the movement of the field of view of said inset image projector based upon the direction in which an operator is looking, said gaze tracking system comprising a head-mounted eye tracking assembly comprising:

a visor having an arcuate shape including a concave surface and an opposed convex surface, wherein said visor is capable of being disposed such that at least one eye is located proximate the concave surface, wherein said visor is at least partially reflective such that said visor is capable of reflecting an image of the at least one eye, and wherein said visor is capable of being disposed such that at least a portion of said visor is located outside a field of view of an operator; and

an image capture device disposed proximate the concave surface of said visor, wherein said image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by said visor.

15. A visual display system according to Claim **14**, wherein said gaze tracking system further comprises:

a head-mounted head tracking sensor capable of repeatedly determining a position of the head to thereby track movement of the head, wherein each position of the head is associated with a position of the at least one eye; and

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a processing element capable of repeatedly determining a gaze of the operator to thereby track the gaze of the operator, wherein said processing element repeatedly determines the gaze of the operator based upon each position of the head and the associated position of the at least one eye.

16. A visual display system according to Claims **14** or **15**, wherein the concave surface of the visor of said head-mounted eye tracking assembly includes a reflective coating.

17. A visual display system according to any one of Claims **14** to **16**, wherein said head-mounted eye tracking assembly further comprises an illuminator capable of illuminating the at least one eye.

18. A visual display system according to any one of Claims **14** to **17**, wherein said head-mounted eye tracking assembly further comprises a lens disposed in an optical path of said image capture device, wherein an effective focus of said image capture device is based upon an optical power of said visor and an optical power of said lens.

19. A head-mounted eye tracking assembly for tracking movement of at least one eye of an operator, said eye tracking assembly comprising:

a visor having an arcuate shape including a concave surface and an opposed convex surface, wherein said visor is capable of being disposed such that the at least one eye is located proximate the concave surface, wherein said visor is at least partially reflective such that said visor is capable of reflecting an image of the at least one eye, and wherein said visor is capable of being disposed such that at least a portion of said visor is located outside a field of view of the operator;

an image capture device disposed proximate the concave surface of said visor, wherein said image capture device is capable of tracking

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movement of the at least one eye based upon the image of the at least one eye reflected by said visor; and

a lens disposed in an optical path of said image capture device wherein an effective focus of said image capture device is based upon an optical power of said visor and an optical power of said lens.

20. A head-mounted eye tracking assembly according to claim **19**, wherein the concave surface of said visor includes a reflective coating.

21. A head-mounted eye tracking assembly according to claim **19**, further comprising an illuminator capable of illuminating the at least one eye.

22. A head-mounted eye tracking assembly according to claim **21**, wherein said illuminator is capable of illuminating the at least one eye with infrared light.

23. A head-mounted eye tracking assembly according to claim **19**, wherein said image capture device is located outside the field of view of the operator.

24. A head-mounted eye tracking assembly according to claim **19**, wherein said visor is capable of reflecting an image of a pupil of at least one eye, and wherein said image capture device is capable of tracking movement of the at least one eye based upon the image of the pupil of the at least one eye.

25. A system for tracking a gaze of an operator, said gaze tracking system comprising:

a head-mounted eye tracking assembly comprising:

a visor having an arcuate shape including a concave surface and opposed an convex surface, wherein said visor is capable of being disposed such that the at least one eye is located proximate the concave side, wherein said visor is at least

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partially reflective such that said visor is capable of reflecting an image of the at least one eye, wherein said visor is capable of being disposed such that at least a portion of said visor is located outside a field of view of the operator, and wherein the head-mounted eye tracking assembly is capable of repeatedly determining a position of the at least one eye based upon the image of the at least one eye reflected by said visor to thereby track movement of the at least one eye;

an image capture device disposed proximate the concave surface of said visor, wherein the image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by said visor; and

a lens disposed in an optical path of the image capture device, wherein an effective focus of the image capture device is based upon an optical power of the visor and an optical power of the lens;

a head-mounted head tracking sensor capable of repeatedly determining a position of the head to thereby track movement of the head, wherein each position of the head associated with a position of the at least one eye; and

a processing element capable of repeatedly determining the gaze of the operator to thereby track the gaze of the operator, wherein said processing element repeatedly determines the gaze of the operator based upon each position of the head and the associated position of the at least one eye.

26. A system according to claim **25**, wherein the concave surface of the visor of said head-mounted eye tracking assembly includes a reflective coating.

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27. A system according to claim **25**, wherein said head-mounted eye tracking assembly further comprises an illuminator capable of illuminating the at least one eye.

28. A system according to claim **27**, wherein the illuminator is capable of illuminating the at least one eye with infrared light.

29. A system according to claim **25**, wherein the image capture device located outside the field of view of the operator.

30. A system according to claim **25**, wherein said visor is capable of reflecting an image of a pupil of at least one eye, and wherein the head-mounted eye tracking assembly is capable of repeatedly determining a position of the at least one eye based upon the image of the pupil of the at least one eye.

31. A visual display system comprising:

a background image projector having a predetermined field of view, said background image projector generating a background image having a predetermined size an resolution that at least partially fills the field of view;

at least one inset image projector for generating an area of interest (AOI) image having a smaller size and a higher resolution than the background image, said inset image projector having a predetermined field of view that is capable of being movably disposed at least partially within the field of view of said background image projector; and

a gaze tracking system capable of directing the movement of the field of view of said inset image projector based upon the direction in which an operator is looking, said gaze tracking system comprising a head-mounted eye tracking assembly comprising:

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a visor having an arcuate shape including a concave surface and an opposed convex surface, wherein said visor is capable of being disposed such that the at least one eye is located proximate the concave surface, wherein said visor is at least partially reflective such that said visor is capable of reflecting an image of the at east one eye, and wherein said visor is capable of being disposed such that at least a portion of said visor is located outside a field of view of the operator;

an image capture device disposed proximate the concave surface of said visor, wherein said image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by said visor;

a lens disposed in an optical path of said image capture device, wherein an effective focus of said image capture device is based upon an optical power of said visor and an optical power of said lens.

32. A visual display system according to claim **31**, wherein said gaze tracking system further comprises:

a head-mounted head tracking sensor capable of repeatedly determining a position of the head to thereby track movement of the head, wherein each position of the head is associated with a position of the at least one eye; and

a processing element capable of repeatedly determining the gaze of the operator to thereby track the gaze of the operator, wherein said processing element repeatedly determines the gaze of the operator based upon each position of the head and the associated position of the at least one eye.

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