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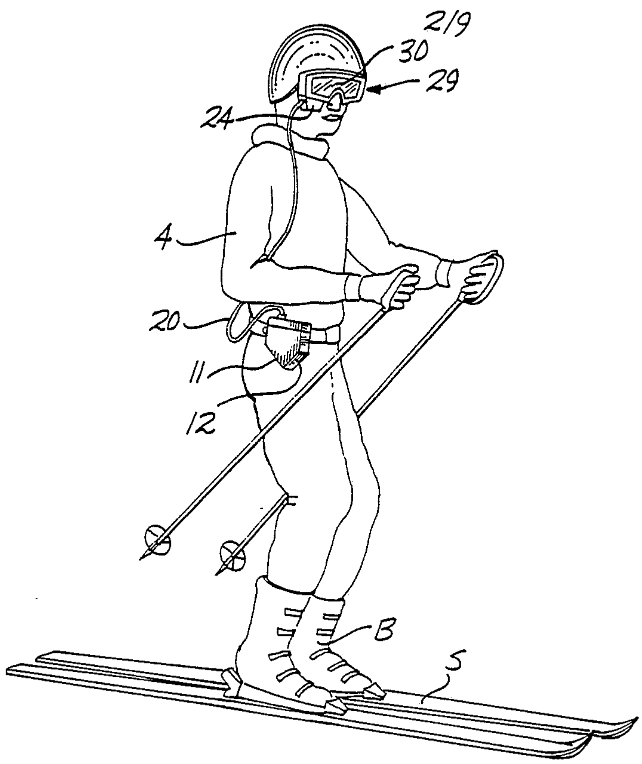
(54) Title: SPEED SENSOR AND HEAD-MOUNTED DATA DISPLAY

(57) Abstract

A transmitter unit (11) is mounted for movement with a skier or other self-propelled sportsman (U) and transmits ultrasonic or electromagnetic waves toward the stationary medium over which the skier or sportsman (U) is moving. An element of the same transmitter unit (11) detects waves reflected from the stationary medium. A computer calculates the speed of the skier or sportsman (U) from the Doppler shift of the reflected waves and actuates a readout unit (24, 29) to indicate the speed to the skier or sportsman. The readout system has a head-mounted display including a character generator and a semitransparent reflector in which the character generator is viewed so that the speed indication appears superposed over the normal background in the viewing direction.



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Description

Speed Sensor and Head-Mounted Data Display

Technical Field

This invention relates to speedometers and odometers and to data display systems. More specifically, this invention relates to a speedometer-odometer for a skier or other moving sportsman and to a head-mounted display for the speed-distance information. The display also can be used for other types of data of interest to the wearer.

Background Art

Moll U.S. Patent No. 3,505,878, issued April 14, 1970, discloses a "Speed and Distance Indicator for a Ski Device". Jander et al. U.S. Patent No. 4,262,537, issued April 21, 1981, discloses a "Speedometer and/or Odometer for Skiers". Cameron U.S. Patent No. 4,546,650, issued October 15, 1985, discloses a "Speed and Distance Calculator for Skis". Each of the devices described in these patents uses one or more wheels mounted on the ski for rotation about a horizontal axis and rotated by contact with the medium over which the ski is traveling, namely, the snow or water, and a speed indicator or display incorporated in the ski-mounted unit.

Disclosure of the Invention

In accordance with the present invention, wave-transmitting and echo or backscatter wave-receiving mechanism are mounted substantially stationarily relative to a sportsman moving relative to a supporting medium, and mechanism is provided for measuring the difference between the frequency of transmitted waves and waves reflected from the medium for calculating the speed of the sportsman relative to the supporting medium in accordance with the Doppler effect. A computer processes a signal generated by the receiving mechanism and can actuate a display of current speed on a readout unit. The computer can have an internal clock and be programmed to calculate information on the distance traveled as well as speed information.

A data display system can be driven by the computer or other data generator and preferably includes a head-mounted reflector in which the desired data is viewed by the user. The reflector can be semitransparent so that the data as viewed in the reflector appears superimposed on the background in the viewing direction. Preferably, the apparent optical distance of projection of the data characters beyond the reflector is great for easy focusing on the data characters and background simultaneously or almost simultaneously.

The preferred speedometer-odometer is of simple, inexpensive, yet sturdy and reliable construction for use in connection with a sportsman, such as a skier, moving relative to the surrounding surface or medium. The system conveniently displays the speed-distance information or other data of interest to the sportsman or another user of the display system.

Brief Description of the Drawings

Figure 1 is a very diagrammatic, fragmentary, top perspective of a snow ski having components of a speed sensor in accordance with the present invention.

Figure 2 is an enlarged diagrammatic side elevation of a portion of the ski of Figure 1, with parts shown in section.

Figure 3 is a diagrammatic side elevation corresponding to Figure 2 illustrating an alternative embodiment of a speed sensor in accordance with the present invention.

Figure 4 is a diagrammatic perspective of a skier having another embodiment of a speed sensor and also a head-mounted data display in accordance with the present invention.

Figure 5 is a somewhat diagrammatic top perspective of the speed sensor component of the invention as shown in Figure 4.

Figure 6 is a block circuit diagram of the speed sensor in accordance with the present invention.

Figure 7 is a block circuit diagram of a modified form of speed sensor in accordance with the present invention.

Figure 8 is a block circuit diagram of a further modified form of speed sensor in accordance with the present invention.

Figure 9 is a diagrammatic side elevation illustrating components of the head-mounted data display of the embodiment of the invention shown in Figure 4.

Figures 10 and 11 are corresponding perspectives of different embodiments of head-mounted data displays in accordance with the present invention such as would be incorporated in goggles for a skier.

Figure 12 is a diagrammatic rear perspective of another embodiment of head-mounted data display as incorporated in a mask such as would be used by a scuba diver.

Figure 13 is a diagrammatic rear perspective of another embodiment of head-mounted data display in accordance with the present invention as incorporated in eye wear for a sportsman or other user.

Figure 14 is a diagrammatic top plan of another embodiment of head-mounted data display in accordance with the present invention utilizing a segment of a parabolic reflector; and Figure 15 is a diagrammatic perspective of the reflector used in the embodiment of Figure 14, illustrating the surface of revolution of which such reflector is a segment.

Figure 16 is a diagrammatic rear perspective of still another embodiment of a head-mounted data display in accordance with the present invention; and Figure 17 is a very diagrammatic side elevation of components of the display of Figure 16 with parts deleted.

Best Modes for Carrying Out the Invention

In the embodiment shown in Figures 1 and 2, the speed sensor in accordance with the present invention includes a block 1 mounted on the top surface of a snow ski S having the usual bindings for a ski boot B. As best seen in Figure 2, the block 1 mounts a transducer 2 stationarily relative to the ski S for transmitting ultrasonic waves of a known, preferably constant, frequency downward through the block and also through the ski itself. In the illustrated embodiment, the ultrasound waves are transmitted downward and forward at a small acute angle to vertical.

A receiving transducer 3 is mounted rearward from the transmitting transducer 2 in the block 1. Ultrasonic waves reflected from the medium over which the ski is traveling impinge on the flat bottom face 4 of the receiving transducer 3 which generates a corresponding electrical signal. Preferably, the flat bottom face 4 of the receiving transducer 3 is positioned perpendicular to waves reflected at the bottom of the ski. As illustrated in broken lines in Figure 2, waves perpendicular to the transducer faces at their opposite side edges intersect, respectively, precisely at the bottom of the ski. In the arrangement shown, the receiving transducer is inclined more sharply than the transmitting transducer.

Given the known angles of the transmitting and receiving transducers 2 and 3 and the known constant frequency of the transmitted ultrasound waves, the speed of the ski relative to the stationary supporting medium can be calculated once the frequency of reflected waves is detected. Preferably, the calculation is performed by a computer 5 having a readout or display 6 and mounted on the ski. Optionally, the computer can be mounted on the ski boot and have a conveniently detachable cable connectible to the transducer block 1. The computer also could be carried by the skier, in which case the readout could be a separate unit mounted, for example, on a wrist band or in the skier's helmet or goggles. The transducers and the detecting-calculating mechanism can be similar to that used in medical Doppler blood flowmeters.

The computer is programmed to calculate the speed of the ski relative to the supporting medium and display it on the readout 6. Preferably the computer has an internal clock so that optionally or additionally distance traveled also can be displayed. The computer can be provided with memory and programmed to display current speed, average speed, maximum speed, current acceleration, maximum acceleration, trip distance, cumulative distance, trip time, total or cumulative time, air time (i.e., the time for which the ski bottom was not in contact with the supporting medium) or time of day.

In the alternative embodiment shown in Figure 3, a single transducer 7 is mounted in a cavity 8 in the ski S'. Such transducer is of the "pulsed-Doppler" type, alternately transmitting ultrasonic waves and receiving reflected waves. Its transmitting-receiving face 9 is angled downward and forward. The bottom portion of the cavity can be filled with a suitable medium 10 for conducting ultrasonic waves such that the form shown in Figure 3 is particularly adapted to a ski of a type which will not otherwise transmit ultrasonic waves. The computer 5' with readout 6' controls the transducer and performs the calculations as in the previously described embodiment.

While the embodiments shown in Figures 1, 2 and 3 use ultrasound transducers, the alternative embodiment shown in Figures 4 and 5 utilizes an electromagnetic wave transceiver which is portable and mounted in a small casing 11. The casing, in turn, is mountable on a ski S, a ski boot B or on the skier or other user U. As seen in Figure 4, the casing can be carried by a belt for attachment to the skier approximately waist high. The position of the casing 11 should be substantially constant.

The transceiver preferably includes an oscillator transmitting waves in the superhigh or extremely high frequency range, such as between 3 gigahertz and 100 gigahertz. In a representative embodiment, the oscillator can be a negative resistance diode oscillator of the general type described in the article titled "Modulation Schemes in Low-Cost Microwave Field Sensors" beginning at page 613 of IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, VOL. MTT-31, NO. 8, AUGUST 1983, available from the Institute of Electrical and Electronics Engineers. See also the references to that article listed at page 623. Such article and references are expressly incorporated by reference herein.

The casing 11 contains a lower leading edge portion 12 from which waves are transmitted downward and forward through the air. As represented in Figure 6, such waves can be transmitted by the transceiver 14 through the wave guide antenna 13, which is also shown diagrammatically in broken lines in Figure 5, at a range of angles relative to horizontal for which the median angle is perpendicular to the casing end edge 12. In the preferred embodiment, the median transmission angle is 45 degrees. Waves backscattered from the ground pass through the wave guide antenna to impinge on the diode which can serve as both the oscillator of the transmitter and as a mixer in the receiver. A "Doppler shift signal" indicative of the difference between the transmission frequency and the frequency of the received backscattered waves is fed to a low-pass amplifier 15. In a representative embodiment utilizing a transmission frequency of 24.125 gigahertz, the Doppler shift signal fed to the low-pass amplifier will have a median frequency of about 50 hertz times the actual speed of the skier relative to the ground in miles per hour.

The cutoff frequency of the low-pass amplifier 15 is selected to eliminate high-frequency noise, such as noise of a frequency higher than the maximum possible speed of the skier.

The signal from the low-pass amplifier 15 is fed to an analog to digital converter 16 for processing by a microprocessor 17. Representative of the conventional microprocessor which can be used is the Intel 80C51. The microprocessor is programmed for frequency analysis of the digitized input signal. For example, the microprocessor can be programmed to apply a fast Fourier transform frequency analysis of the digitized input signal frequencies to calculate the energy of discrete frequency components. The backscattered received waves are composed of signal energies coming from different angles and, consequently, result in a nonmonochromatic Doppler shift signal, just as the angles of transmitted waves relative to the skier and the ground encompass a range of angles. Nevertheless, the median-transmitted angle is known, namely, 45 degrees in the preferred embodiment, and the microprocessor is programmed to calculate the median "shifted" frequency of the incoming digital signal from the converter 16, that is, the frequency for which one-half of the total incoming energy results from components of higher frequencies and one-half results from components of lower frequencies. Such median shifted frequency is used to calculate an approximation of the actual speed in accordance with Doppler techniques. The microprocessor then actuates a display 18 which can be, for example, an LCD or LED display carried by the casing 11 as seen in Figure 5.

A switch 19 represented in Figure 6 can be provided for selecting different modes of the microprocessor for displaying other information such as distance traveled, elapsed time, average speed, time of day and so on. Power can be supplied by batteries carried in a cavity 27 of the casing 11 accessible by opening a door 27'.

Speed, distance and related information is of interest to sportsmen other than Alpine skiers, and modifications in the microprocessor programming can adapt the speed sensor in accordance with the present invention for other sportsmen. For a Nordic or cross-country skier with a speed sensor of the general type represented in Figure 6 but mounted on the skier's boot or ski, there would be some rearward motion in addition to forward motion. The microprocessor can be programmed in conjunction with an inertia switch or direction sensitive Doppler elements to calculate and display aggregate forward distance by subtracting the reverse motion component and, similarly, can be programmed to display average forward speed over a desired period. A runner or hiker may be as interested in distance and average speed rather than instantaneous speed and the microprocessor can be programmed to calculate that information and actuate the display on demand.

In the speed sensor embodiment shown in Figure 6, the microprocessor is programmed to calculate the approximate forward velocity of the speed sensor unit 11 relative to the surrounding medium by assuming a known, substantially constant, median transmission angle _a_. In practice, it may be difficult to position the speed sensor casing 11 so as to have a median angle of transmission precisely equal to the angle assumed by the microprocessor. In some applications, the actual median angle of transmission may change as the user assumes different postures. Consequently, for a more accurate determination of the actual forward velocity, the speed sensor unit can be modified to compute the actual velocity taking into consideration changes in the median transmission angle a.

For example, in the modified form for which the circuit is shown diagrammatically in Figure 7, the casing 11' accommodates two identical Doppler transceivers 14' each having its own waveguide antenna 13'. The transceivers and their antennas are mounted stationarily relative to the casing 11'. Consequently, the difference in transmission angles is known and constant. In the embodiment shown in Figure 7, one assembly of transceiver and waveguide antenna is positioned for transmitting waves downward and forward at a median transmission angle a of 45 degrees when the casing 11' is maintained in the precise position shown. With the casing in such position, the other assembly of Doppler transceiver and waveguide antenna transmits waves at a median transmission angle a' of 45 degrees downward and rearward, i.e., 90 degrees minus the other angle a. If the casing 11' is maintained precisely in the position shown, the amount of frequency shift detected by one assembly will be the same as the amount of frequency shift detected by the other assembly. In one instance the detected backscattered waves will have a higher frequency than the transmission frequency, and in the other instance the detected backscattered waves will have a frequency lower than the transmission frequency.

If, however, the casing is canted such that the median transmission angles a and a' of the two assemblies are different, the detected frequency shift will be different for the two transceiver assemblies. The actual forward velocity along the supporting medium is, of course, always the same for each assembly, and since the difference in transmission angles is known ($a' = 90° - a$) the actual forward velocity can be calculated by analyzing the separate Doppler shift signals fed, respectively, to the separate low-pass amplifiers 15' and analog-to-digital converters 16' before being fed to the microprocessor 17 for analysis and calculation of the actual velocity which is shown on the display 18.

In the further modified form of speed sensor for which the circuit diagram is shown diagrammatically in Figure 8, a single Doppler transceiver 14" transmits waves through the separate, oppositely inclined waveguide antennas 13' and detects reflected waves. A single diode or diode assembly can be used for wave transmission and detection. The single Doppler shift signal fed to the computer contains information on the higher and lower frequency shifted components received through the different waveguide antennas which, after filtering and analog to digital conversion, is analyzed by the microprocessor 17 for comparison and calculation of the actual speed.

Preferably, the microprocessor 17 updates the display 18 periodically, such as once each second. Also, in the preferred embodiment, operation of the Doppler transceiver or transceivers is not constant. Rather, the transceiver or transceivers are actuated for short but uniform periods separated by much longer, uniform intervals. In a representative embodiment, the transceiver or transceivers can be actuated for approximately 50 milliseconds twice each second. During each such period of actuation, the microprocessor computes essentially the instantaneous speed with reference to the detected Doppler shift. When the display is updated, the value shown preferably is the average of the last several calculated speeds, such as the average of the last three speeds detected during the previous three short, uniformly spaced, sampling periods. Consequently, the display always shows an average of a plurality of substantially instantaneous speeds detected during short, discrete time periods separated by longer intervals. During the much longer periods of nonactuation of the transceiver or transceivers, little power is used which greatly increases the battery life.

With reference to Figures 4 and 5, in lieu of or in addition to the unit-mounted display 18, the microprocessor can supply the data signal to a remote display such as through a cable 20 to goggles 29 shown in Figure 4. With reference to Figures 7 and 8, alternately the data signal can be transmitted, such as by an antenna 20', to a user-mounted display or to a stationary display or receiving device 29' which could be positioned adjacent to a race course, for example. Nevertheless, in accordance with the present invention, preferably the remote display is incorporated in eye wear or headgear, such as the goggles 29, so as to be movable with the viewer's head. The basic components carried by the eye wear or headgear of a representative system are best seen in Figure 9. In such system there is a transmissive, white, diffusing filter 21 exposed to ambient light and adjacent to a conventional internal backing 22 for a liquid crystal plate 23. Preferably, such plate is in transmissive mode so that, when driven, data characters are transparent on a dark background. Ambient light then acts as an auto-contrast control because the brighter the ambient light, the brighter the characters will appear. Alternatively, the filter, backing and liquid crystal plate can be replaced by active elements such as light-emitting diodes, but a liquid crystal display in transmissive mode is preferred.

Elements 21, 22 and 23 are carried by the eye wear or headgear out of the field of vision of the user such as in a lower goggle extension 24 shown in Figure 4. The image of the display is viewable in a flat reflector 25 located above the user's eye outside the usual forward or forward and downward direct line of vision but within the peripheral field of view and easily seen. The head-mounted construction is extremely convenient because it allows data to be viewed without movement of the head and with at most only momentary distraction from the desired direct line of sight. There can be a complication because of the necessarily close positioning of the reflector 25 to the eye such that the eye does not easily change focus from the background to the closer displayed characters and back again. Preferably there is an optical element such as a lens 26 to increase the apparent optical distance of the characters from the eye to at least several times the actual physical distance of the path from the eye to the reflector to the display. The apparent optical distance to the characters should be at least 10 inches to 12 inches (25.40 cm 30.48 cm) but less than infinity in front of the eye. The projection of the characters to such distance makes focusing much easier and quicker and less tiring to the eye. Placing the characters at a great distance allows viewing the characters with little focal adjustment of the eye.

In addition, preferably the reflector is semitransparent such as a half-silvered mirror or a pellicle of the type used for beam splitting. The result is that the reflected display characters are clearly visible, but the background is not completely obscured. When used in the preferred method of incorporation into eye wear having a darkened or polarized or tinted front lens 30, the data characters appear to be projected onto the background.

The embodiment illustrated in Figure 10 corresponds to the embodiment shown in Figure 4 where the character-generating elements of the display are carried in the goggle extension 24. The semitransparent planar reflector 25 is mounted toward the top of the goggles 29, inside the outer lens 30, slightly higher than the eye. The elements for measuring the optical distance can be mounted at approximately the junction of the bottom edge of the goggles 29 and the top edge of the extension 24. Button 31 can be used to actuate the microprocessor to change to a desired mode.

In the embodiment shown in Figure 11, all of the display elements are mounted inside the wider goggles 29'. Dial 32 is usable to select the mode and the display characters are viewed on the planar half-silvered mirror or pellicle 25.

Figure 12 illustrates a display in accordance with the present invention as incorporated in a mask 50 of the type used by scuba divers. As in the embodiment shown in Figure 10, there is a bottom housing 24' containing the character-generating mechanism which, in the case of the embodiment of Figure 12, includes a dial 28 for adjusting the angle of the LCD or LED plate. Data to be displayed can be generated by a remote microprocessor and can including information on the depth or pressure or time of remaining air supply, for example.

Figure 13 illustrates another embodiment more closely resembling a pair of sunglasses than a skier's or sportsman's goggles. The light diffusing filter 21 is positioned at the forward end of one sidepiece 33 of the frame 34. The LCD character generator controlled by the cable 20 from the computer is located immediately adjacent to the filter 21 inside the sidepiece 33. By using several internal planar reflectors 35, 35' and 35", the length of the path from the character generator to the viewing reflector 25' is increased substantially, as indicated in broken lines. Light enters through the bottom front of the sidepiece 33 and through the transmission LCD plate. From the plate, the passed light travels rearward the full length of the sidepiece to a pair of cooperating planar reflectors 35, then back forward to a central pair 35' positioned to offset the light beams upward. The light proceeds forward and to an additional planar reflector 35" positioned toward the top of the sidepiece 33 at its front to direct the light substantially horizontally inward. In the embodiment shown in Figure 11, the viewing reflector 25', which still is preferably semitransparent, can be shaped to magnify the image of the display characters for more convenient viewing.

The optical distance from the image of the display generator to the eye also can be increased by using a reflector of complex shape. In the embodiment shown diagrammatically in Figure 14, a horizontal section of the reflector 25" is a segment of a paraboloid for which an axial section, if more fully complete, would continue along the broken line path 40. The full reflector surface preferably is a three-dimensional concave segment of the paraboloid formed by rotation of the parabola 40 about the horizontal axis 41 as best seen in Figure 15. Such axis intersects or is closely adjacent to the character generator such as the liquid crystal plate 42 carried on a sidepiece 33' of eye wear 34'. Preferably, the axis 41 of the paraboloid of which the reflector 25" is a segment intersects the character generator or is closely adjacent to it, and the parabolic focus 43 is close to the character generator but opposite it from the imaginary apex of the paraboloid, in which case the optical distance at which the eye E will focus will be very long, i.e., at least several times the actual length of the patch from the eye to the reflector and then to the character generator.

The reflector can be a short strip positioned slightly above the eye, as in the previously described embodiments, or can completely cover the normal field of view. In the embodiment shown in Figure 14 the entire field of view is covered by reflector 25" so that viewing of the background is necessarily through the semitransparent reflector regardless of whether or not the line of sight is directly at the reflection of the displayed characters. When the entire field of view is covered by the reflector, corresponding reflectors can be placed at both sides of the eye wear even if only one of them is used for character display. The embodiment shown in Figures 14 and 15 is particularly effective in creating the illusion of projection of the data onto the surrounding background.

In the modified embodiment shown in Figures 16 and 17, the character generator is a liquid crystal plate 42 carried in a frame 49 extending inward at the top of one side portion of the eyewear 50. Such eyewear includes side pieces 51 connected to the compensating front lens 52 such as a lens darkened or polarized or tinted. The LCD plate is in transmissive mode such that the data characters are transparent and viewed by passage of ambient light through the plate. Substantially directly below the frame 49 carrying the LCD plate, the lens 52 has an inward-projecting parabolic bottom portion 53 which preferably is semireflective and semitransparent. The desired data is viewed in the reflector superimposed on the background.

The geometry of the eyewear 50 is best seen in Figure 17. The inward-projecting bottom portion 53 of the lens 52 preferably is a segment of a paraboloid having the axis 54 and focus 55. Preferably such axis 54 intersects approximately the center of the LCD plate 42 and is approximately parallel to the path 56 from the eye to about the center of the bottom lens portion or segment 53. The focus 55 is close to the LCD plate 42 but opposite such plate from the imaginary apex of the paraboloid. Also, preferably the LCD plate 42 is mounted approximately perpendicular to the axis 54 which requires that it be canted downward from the upper portion of the lens 52 toward the eye at a small acute angle. The overall result is that the LCD display is magnified but appears at a long distance from the eye for easy focusing and is projected on the peripheral field of view.

The visibility of the characters can be increased by the use of color-compensating filter material which can be incorporated in the lens 52 or otherwise such as sheet 44 shown in Figure 17 located at the opposite side of the reflector from the eye. The visual effect is to enhance or remove color components of the background differently from the reflected characters. Preferably, color components of light transmitted through the LCD plate are not filtered so that the display characters are as bright as possible, in which case all color compensation for increasing the visibility of the reflected data is by color filtering elements disposed opposite the semitransparent reflector from the eye.

The form of the invention represented in Figure 17 will provide a bright, easily viewable image of the LCD display in the reflector 53 when ambient light is primarily directed downward from above the eyewear. In a situation where a substantial or major portion of ambient light is generated and directed or reflected from below, light passing through the reflector from below may reduce the contrast of the data characters reflected from above. For such situation it may be desirable to use a totally reflective reflector, which will obscure a portion of the peripheral field of view. Another alternative is to provide a totally reflective mirror 60, shown in broken lines in Figure 17, positioned above the LCD plate 42. The amount of light passing upward through the LCD plate and reflected back down by the mirror 60 will be approximately the same or greater than the light passing upward through the partially transmissive reflector 53 so that approximately the same contrast is maintained for different lighting conditions.

Claims

1. A speedometer for a self-propelled sportsman moving by his or her own force or momentum along a stationary medium comprising means mounted for movement with the sportsman for transmitting waves toward the stationary medium and for detecting such waves reflected from the stationary medium, means mounted for movement with the sportsman for measuring the difference in frequency between the transmitted and reflected waves in accordance with the Doppler effect, means mounted for movement with the sportsman for calculating the speed of the sportsman from such frequency difference, and means mounted for movement with the sportsman for indicating such speed.

2. The speedometer defined in claim 1, in which the wave-transmitting means includes means for transmitting electromagnetic waves through the air toward the stationary medium at a range of angles relative to horizontal but centered about a median angle and means for detecting waves reflected from the stationary medium through a corresponding range of angles, and in which the calculating means includes means for performing a frequency analysis to determine the median frequency of detected reflected waves and for using such median frequency to calculate an approximation of the forward speed of the sportsman taking into consideration the median angle of transmission of the waves.

3. The speedometer defined in claim 1, in which the wave-transmitting means includes first means for transmitting electromagnetic waves through the air toward the stationary medium at a range of angles relative to horizontal but centered about a first median angle and second means for transmitting

electromagnetic waves through the air toward the stationary medium at a range of angles relative to horizontal but centered about a second median angle different from the first median angle, said first and second median angles differing by a constant amount, and means for detecting for waves reflected from the stationary median, the calculating means including means for performing a frequency analysis to determine the forward speed of the sportsman taking into consideration said first and second median angles of transmission of the waves.

4. The speedometer defined in claim 1, in which the indicating means is remote from the calculating means and includes a head-mounted display.

5. The speedometer defined in claim 4, in which the head-mounted display includes a liquid crystal plate in transmission mode and a reflector disposed within the peripheral field of view of the sportsman and positioned for viewing the image of said liquid crystal plate in said reflector, said reflector being substantially in the shape of a segment of a paraboloid.

6. A speedometer for a skier supported on skis for movement along a stationary supporting medium comprising means mounted for movement with the skier for transmitting waves toward the stationary medium and for detecting such waves reflected from the stationary medium, means for measuring the difference in frequency between the transmitted and reflected waves in accordance with the Doppler effect, and means for calculating and indicating the speed of the skier from such frequency difference.

7. A data system for viewing by a user comprising means for generating the data, means

movable with the head of the user for displaying the data, and a viewing reflector mounted within the field of view of the user for movement with the user's head, said reflector being positioned for viewing of the displaying means by reflection in said reflector.

8. The system defined in claim 7, in which the reflector is semitransparent so that the remote background can be seen through the reflector, the reflector in cross section being a segment of a parabola having an axis intersecting the displaying means and a focus close to the displaying means but opposite the displaying means from the apex of the parabola for increasing the optical distance of the displaying means from the eye to a distance much greater than the physical distance of the path from the eye to the reflector to the displaying means.

9. The system defined in claim 7, in which the displaying means includes a liquid crystal plate in transmission mode.

10. The system defined in claim 9, including a color-filtering element for enhancing or removing color components of the remote background differently from light transmitted through the liquid crystal plate.

Fig. 1

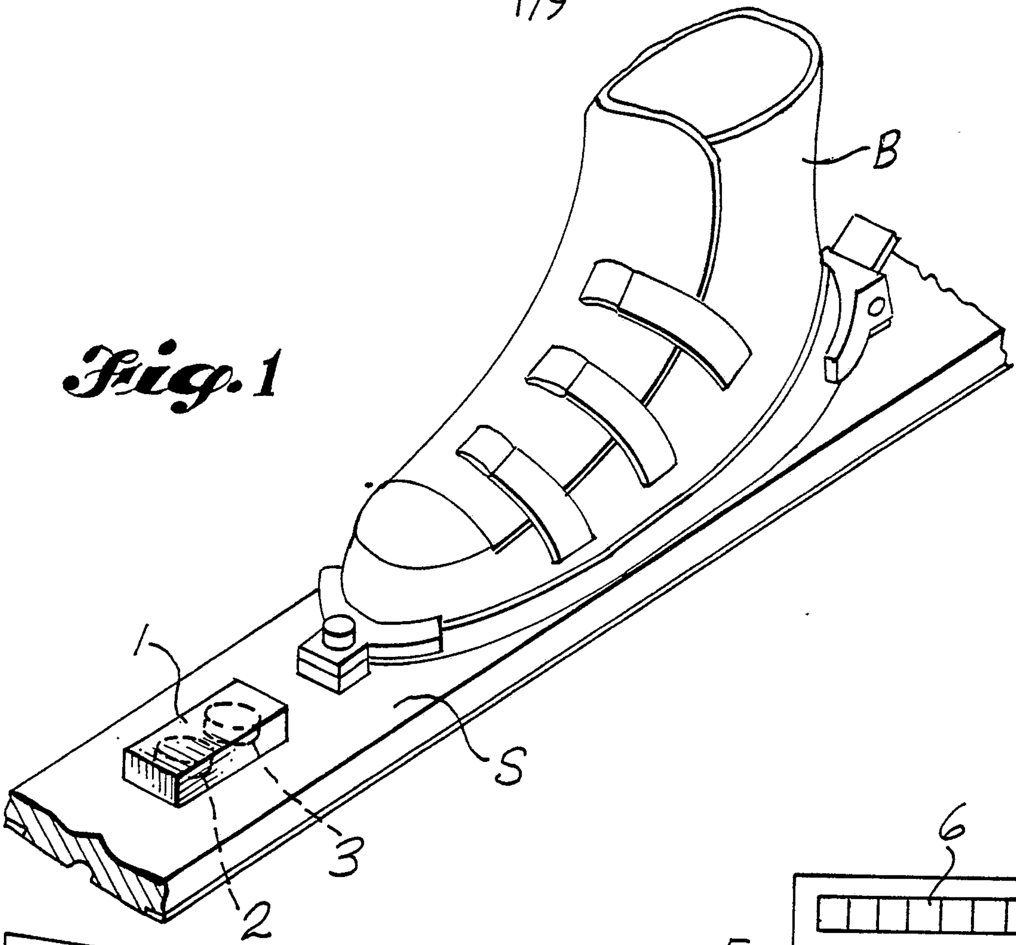
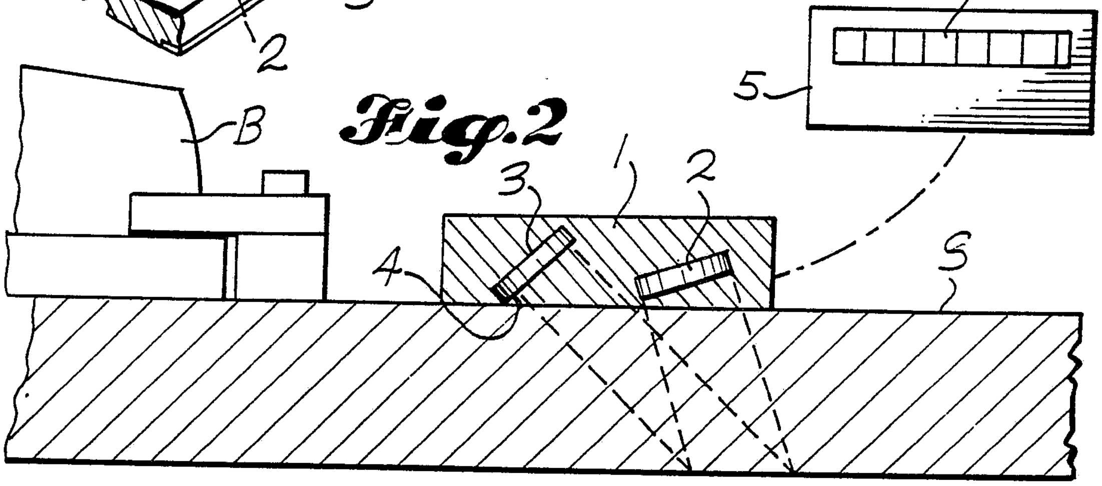


Fig. 2



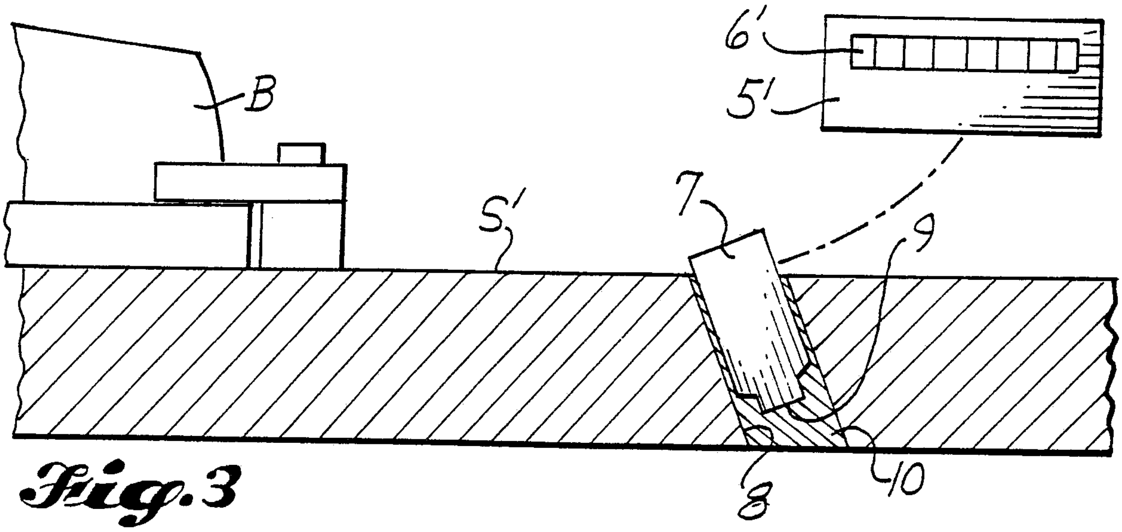


Fig. 3

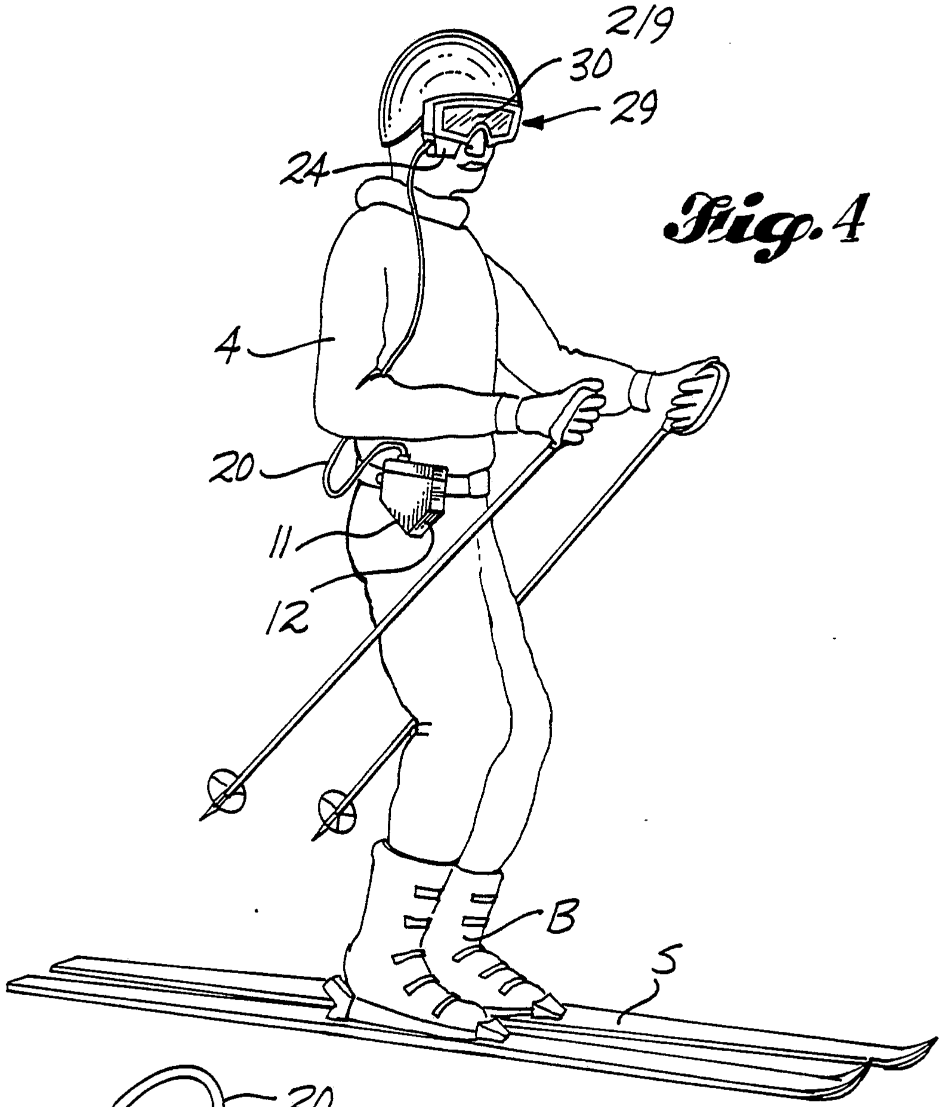


Fig. 4

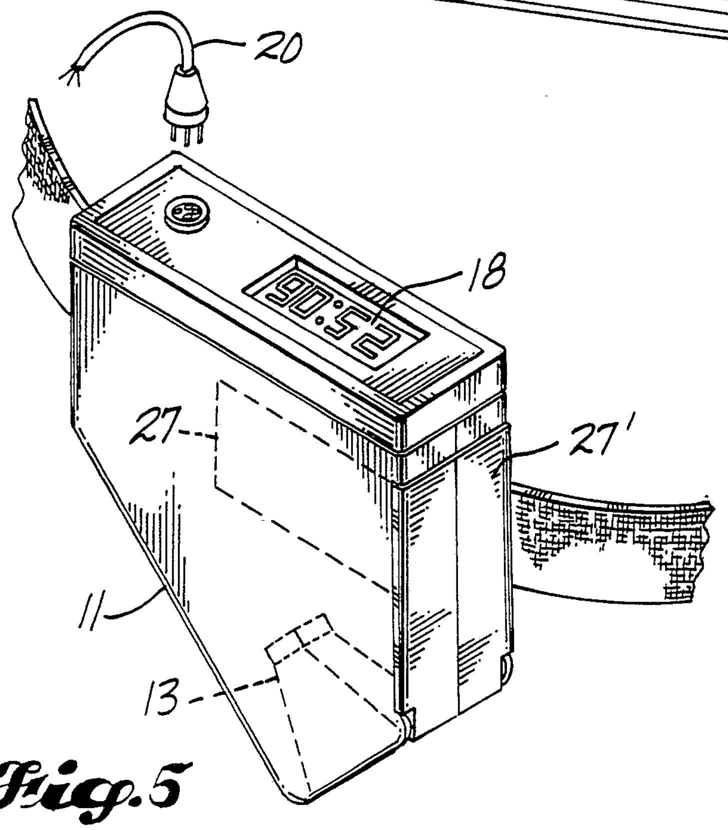


Fig. 5

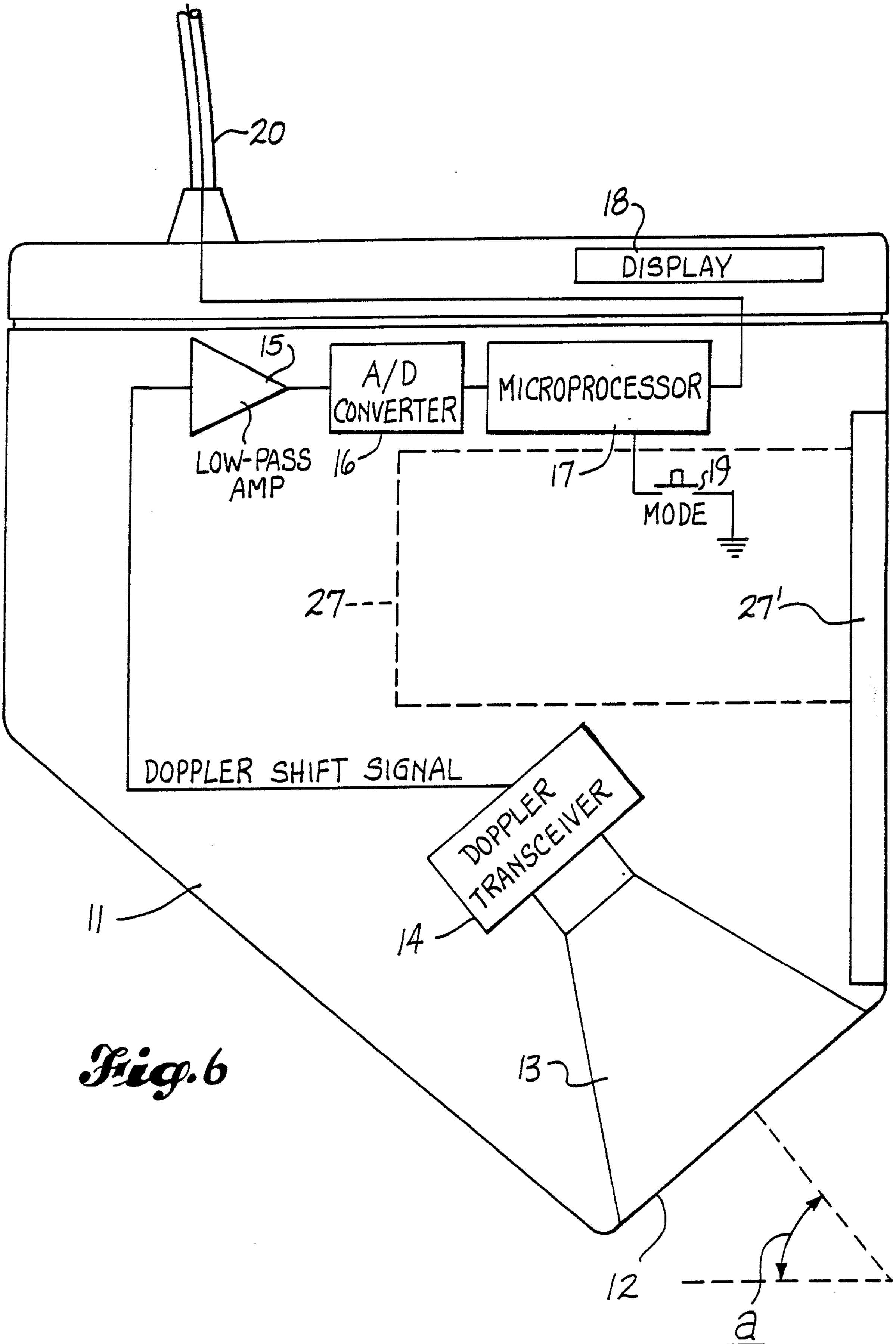
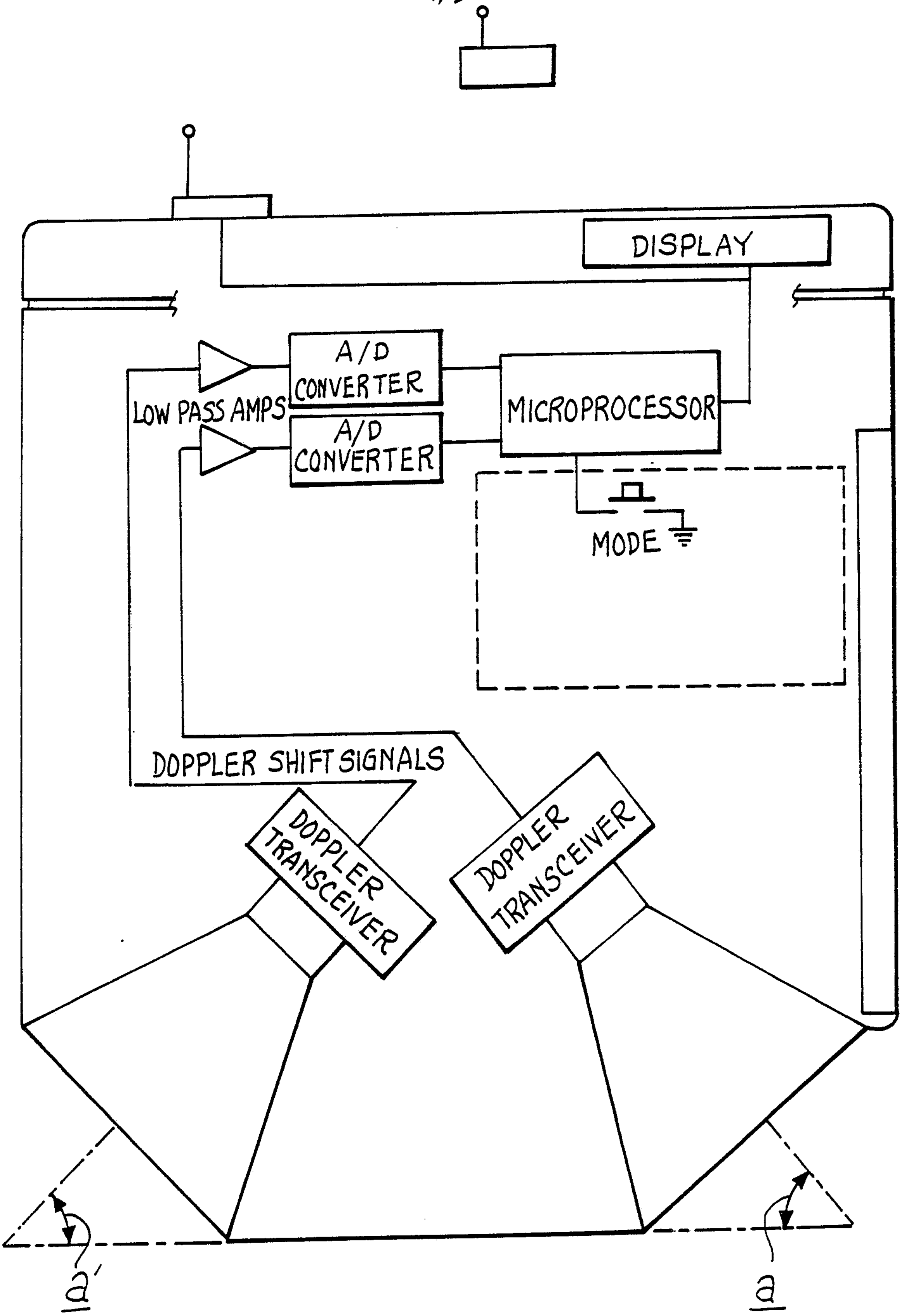

20
18
DISPLAY
15
A/D CONVERTER
MICROPROCESSOR
LOW-PASS AMP
16
17
19
MODE
27
27'
DOPPLER SHIFT SIGNAL
DOPPLER TRANSCEIVER
11
14
13
12
a

Fig.6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A/D CONVERTER
A/D CONVERTER
LOW PASS AMPS
MICROPROCESSOR
MODE
DOPPLER SHIFT SIGNALS
DOPPLER TRANSCEIVER
DOPPLER TRANSCEIVER
a'
a

Fig. 7

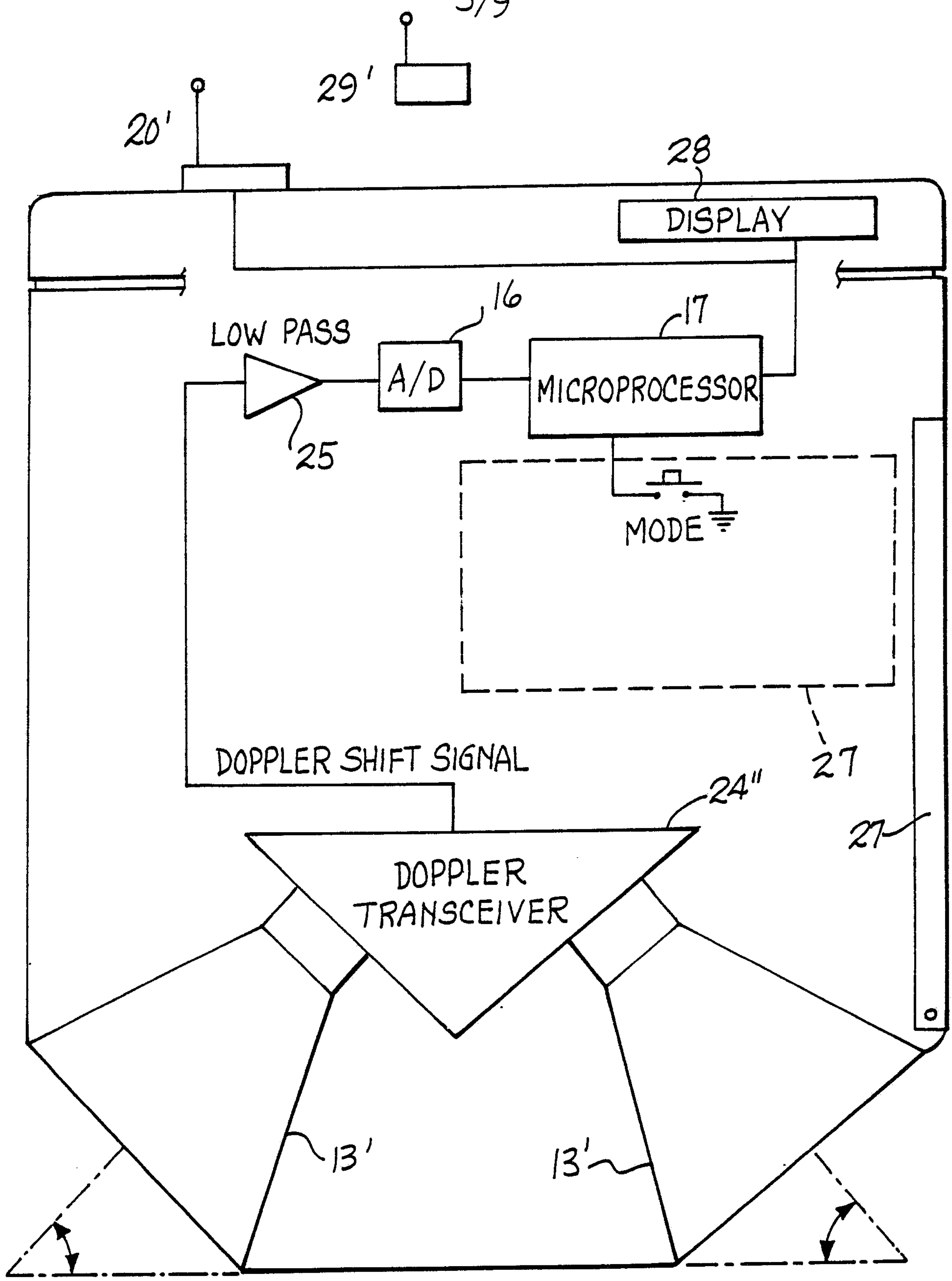

29'
20'
28
DISPLAY
16
17
LOW PASS
A/D
MICROPROCESSOR
25
MODE
27
DOPPLER SHIFT SIGNAL
24"
27
DOPPLER
TRANSCEIVER
13'
13'

Fig. 8

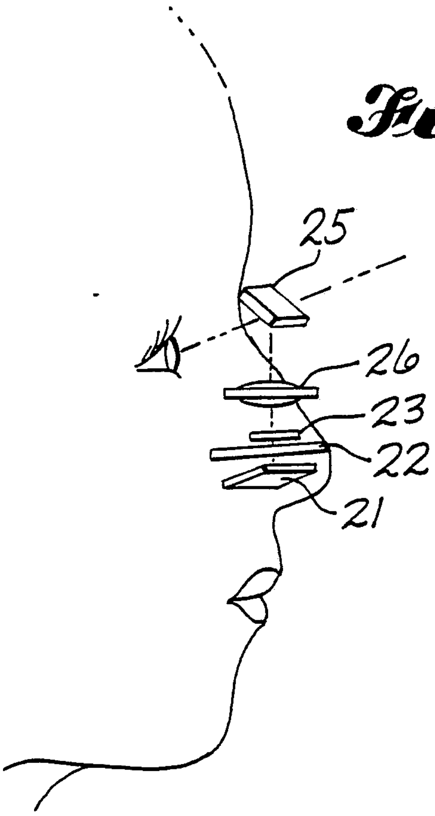
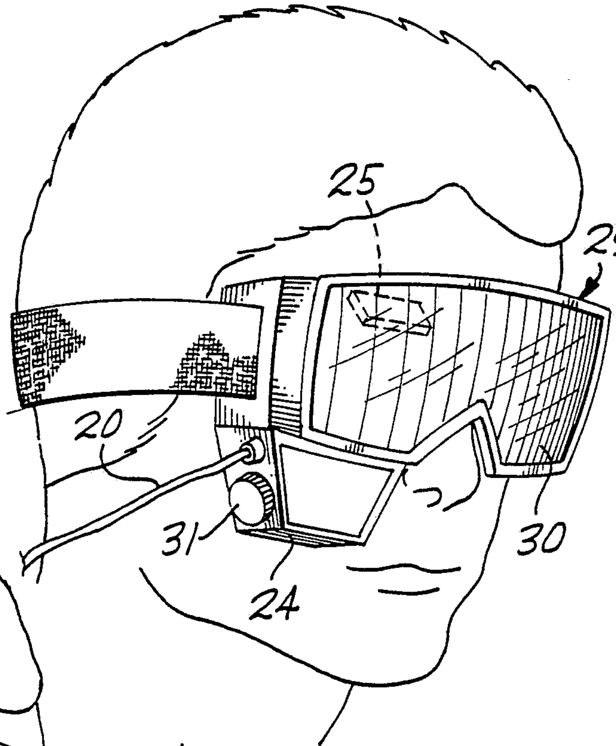


Fig. 9

Fig. 10



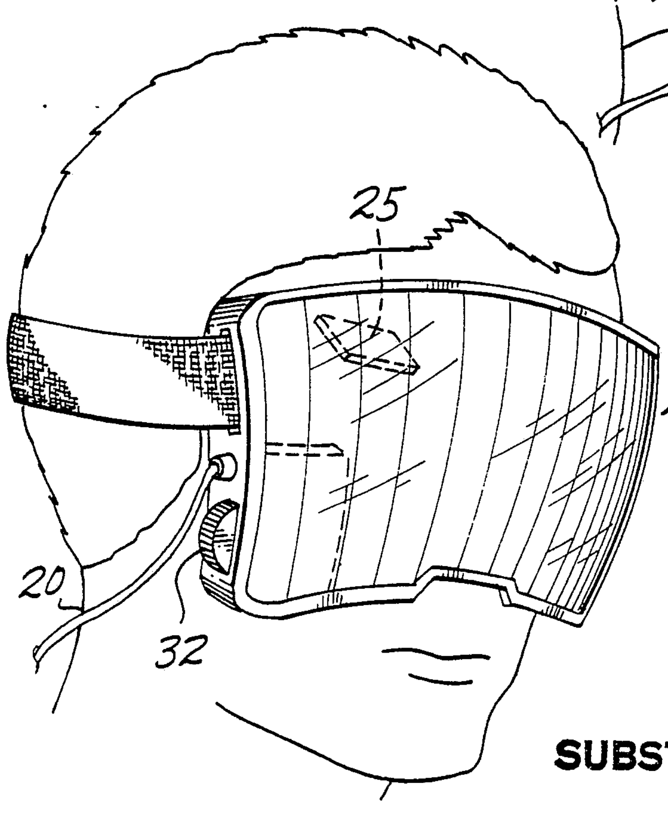


Fig. 11

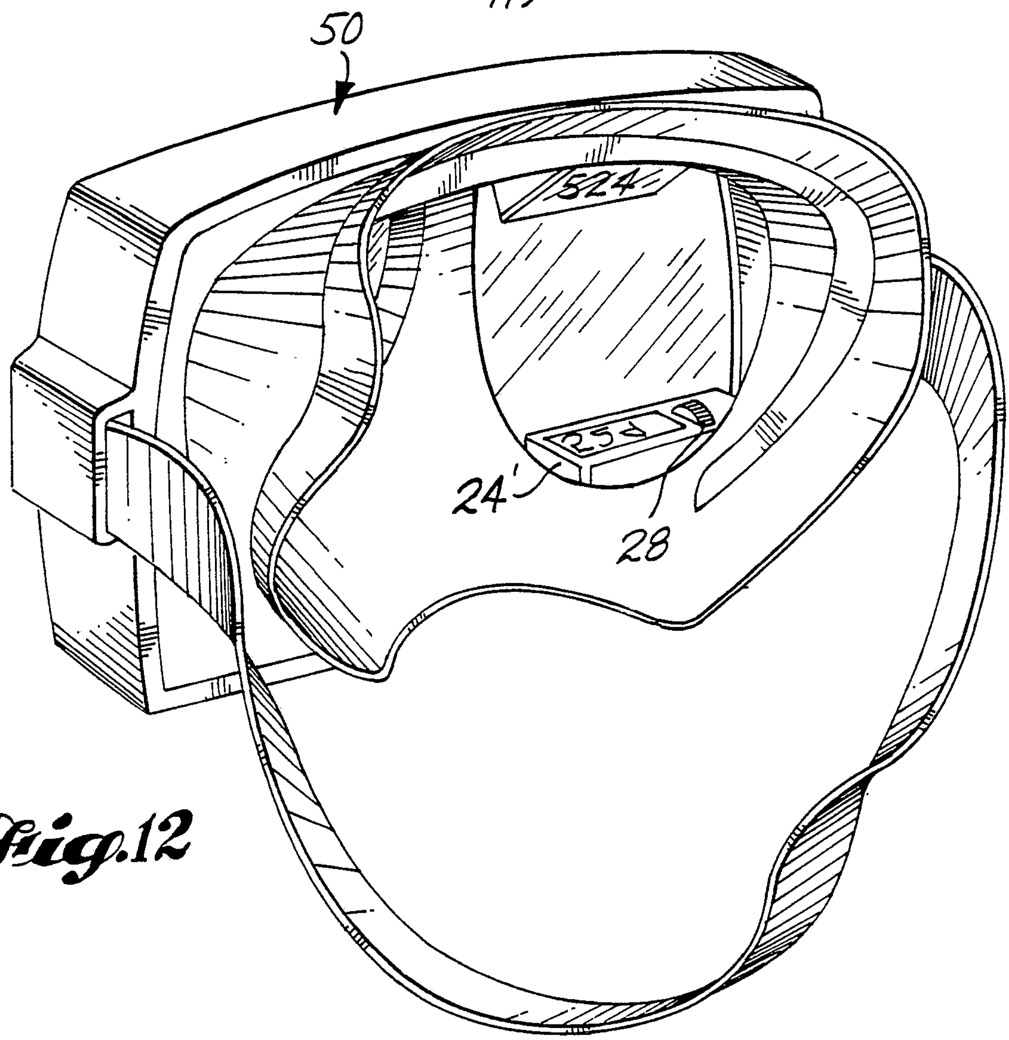


Fig.12

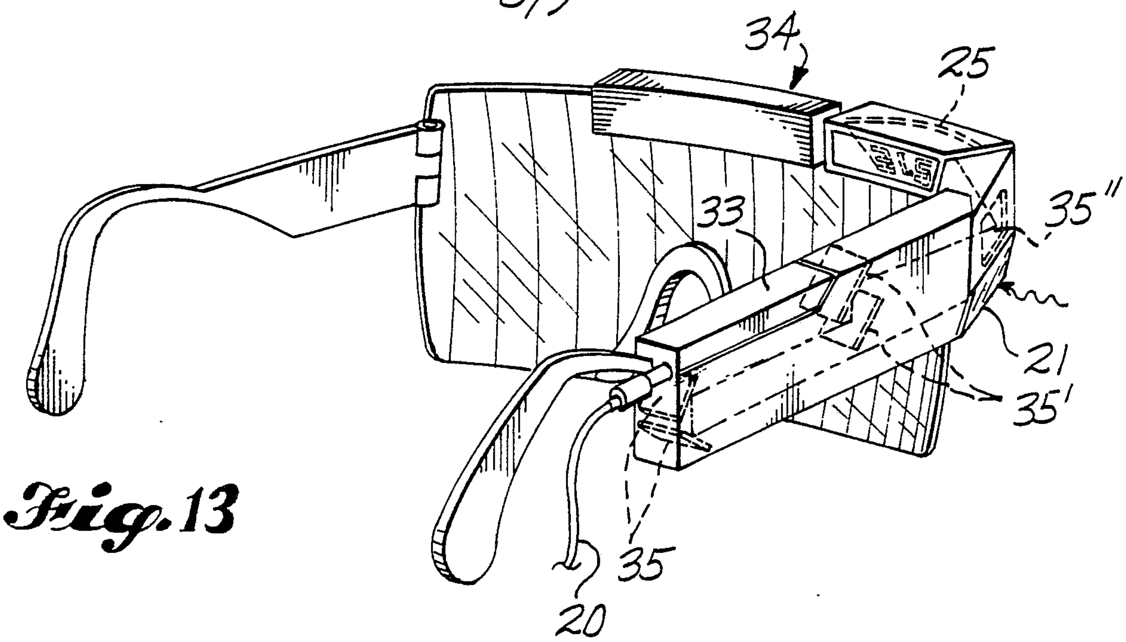


Fig. 13

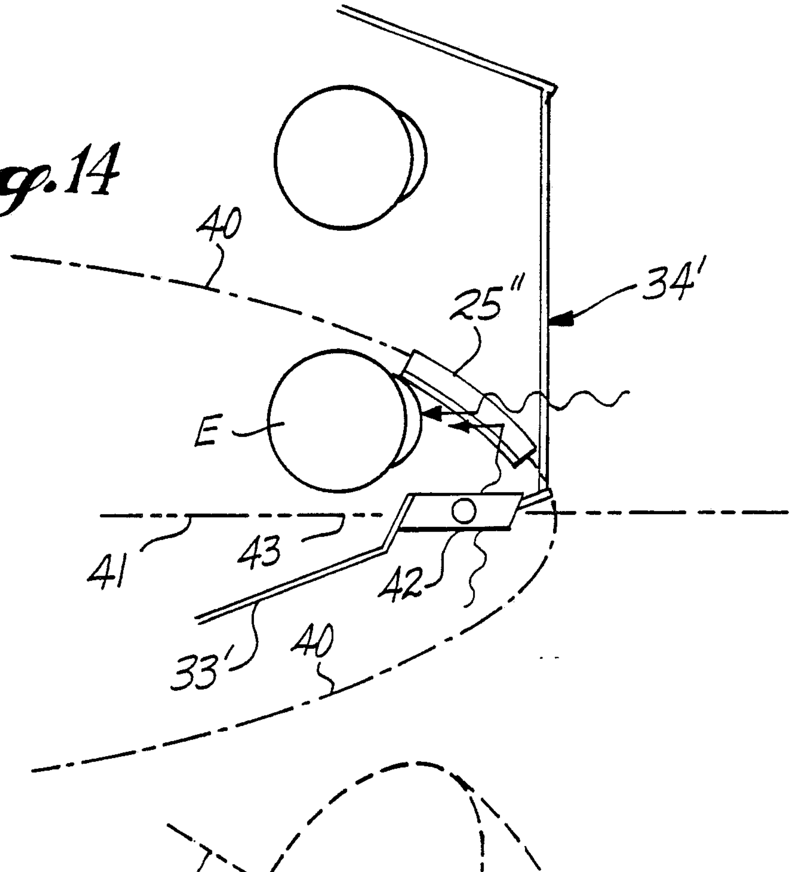


Fig. 14

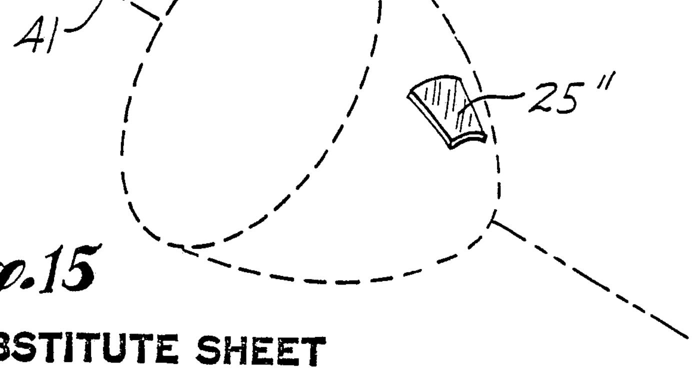


Fig. 15

SUBSTITUTE SHEET

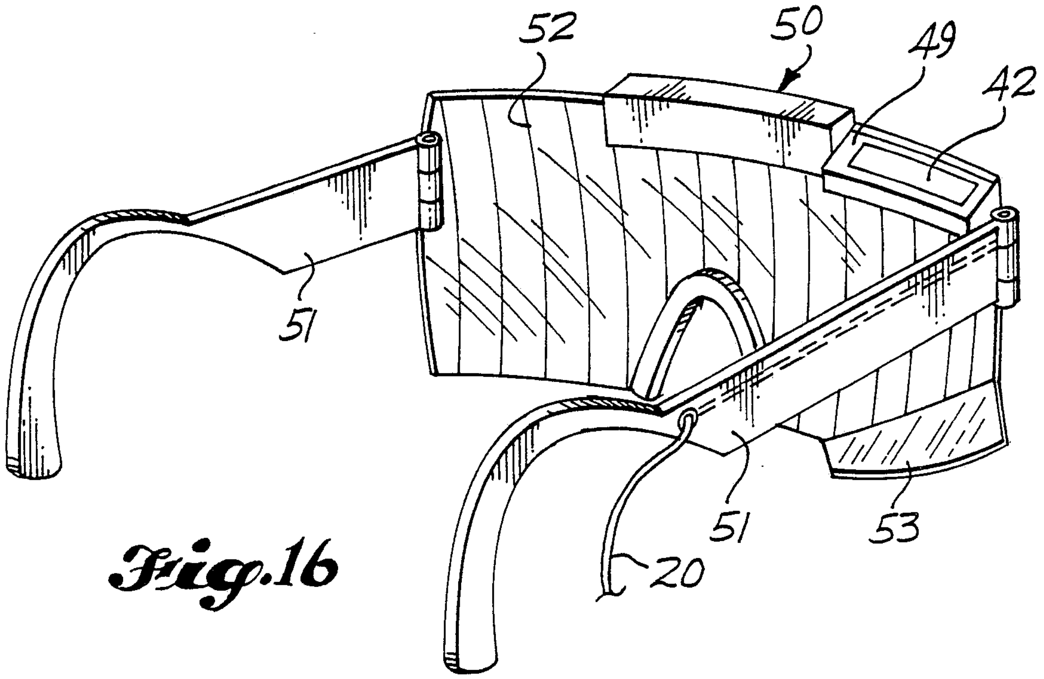


Fig.16

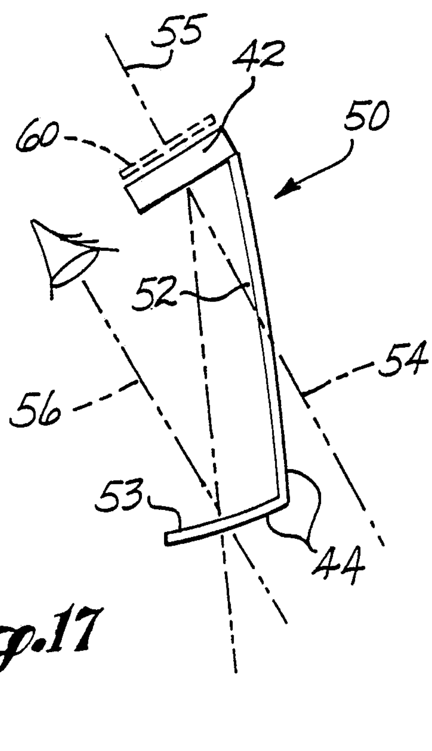


Fig.17

INTERNATIONAL SEARCH REPORT

International Application No PCT/US87/02455

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC
IPC(4): G01S 15/60; G01P 3/36; G05B 5/00; G02B 27/14
U.S. CL. 367/91; 324/160; 364/565; 350/174

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	367/90,91; 356/28; 324/160; 364/565 350/173,174; 73/490,493,597

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
A	US, A, 4,262,537 (Jander et al.) 21 April 1981, See the abstract.	1-6
A	US, A, 4,546,650 (Cameron) 15 October 1985, See the abstract.	1-6
X	US, A, 3,787,109 (Vizenor) 22 January 1974, See entire document.	7,9
A	US, A, 4,361,384 (Bosserman) 30 November 1982, See entire document.	7-10

* Special categories of cited documents: [15]
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
05 JANUARY 1988	25 JAN 1988
International Searching Authority [1]	**Signature of Authorized Officer [20]**
ISA/US	Louis M. Arana