

(22) Date de dépôt/Filing Date: 2010/06/22

(41) Mise à la disp. pub./Open to Public Insp.: 2011/12/22

(45) Date de délivrance/Issue Date: 2014/04/08

(51) Cl.Int./Int.Cl. *G08G 1/09* (2006.01),
G08G 1/07 (2006.01)

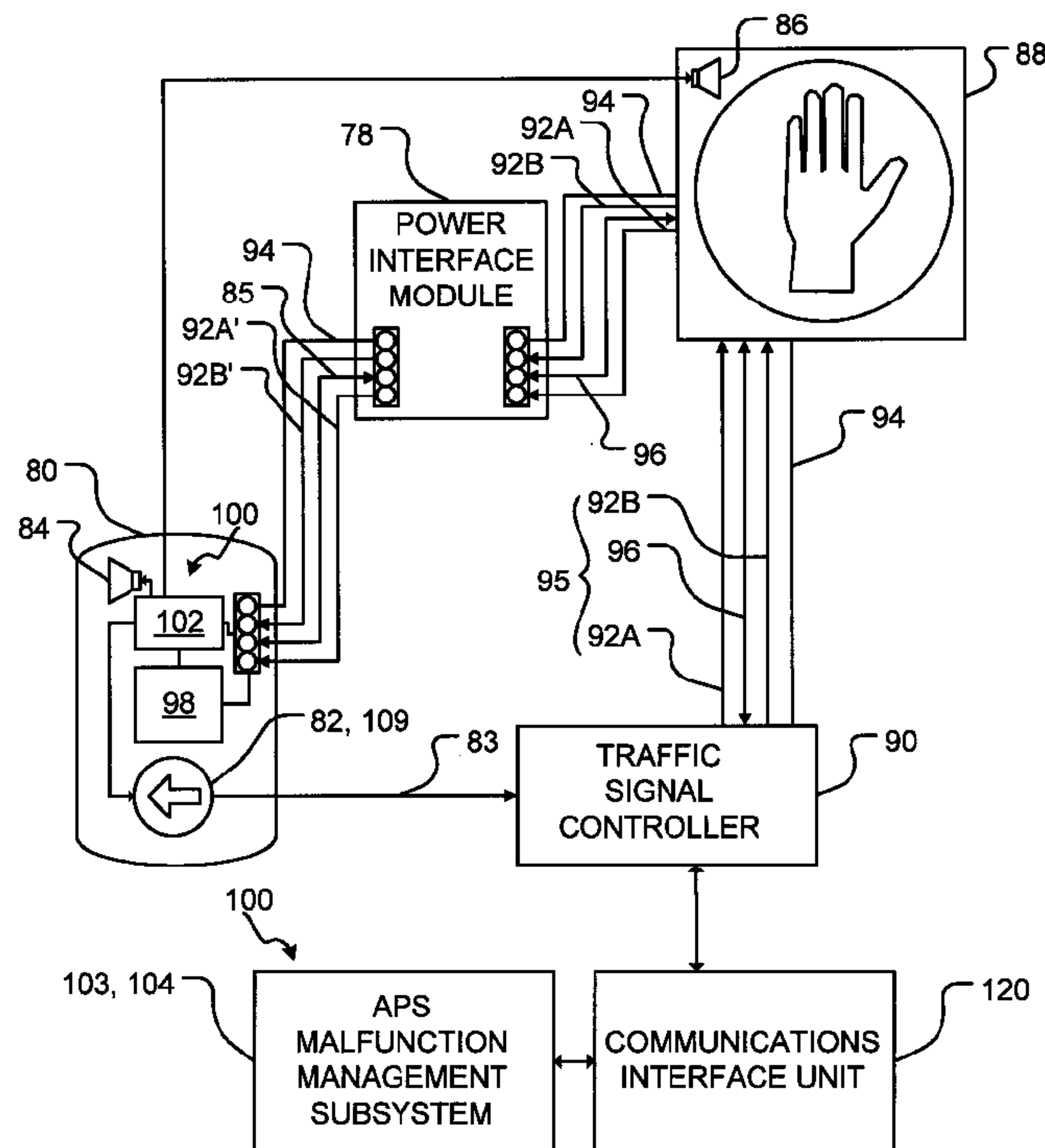
(72) Inventeurs/Inventors:
GUBBE, DOUGLAS DONALD, CA;
ATNIKOV, DAVID PHILIP, CA

(73) Propriétaire/Owner:
NOVAX INDUSTRIES CORPORATION, CA

(74) **Agent:** OYEN WIGGS GREEN & MUTALA LLP

(54) Titre : SYSTEME DE SIGNALISATION D'ACCESSIBILITE POUR PIETONS

(54) Title: ACCESSIBLE PEDESTRIAN SIGNAL SYSTEM



(57) **Abrégé/Abstract:**

Methods and systems are provided for conflict monitoring and error detection in accessible pedestrian signal systems. A primary conflict monitor and error detector is configured to control output of audible and vibrotactile pedestrian signal indications. The primary conflict monitor and error detector monitors the current traffic state, and verifies audio and vibrotactile control signals against the current traffic state and user settings to determine whether to enable output of audible and vibrotactile pedestrian signal indications. The primary conflict monitor and error detector may transmit information about the audio and vibrotactile control signals to a secondary conflict monitor and error detector, which verifies the information received against the current traffic state and user settings, and inhibits output of audible and vibrotactile pedestrian signal indications in the event of a detected conflict or error.

- 33 -

Abstract of the Disclosure

Methods and systems are provided for conflict monitoring and error detection in accessible pedestrian signal systems. A primary conflict monitor and error detector is
5 configured to control output of audible and vibrotactile pedestrian signal indications. The primary conflict monitor and error detector monitors the current traffic state, and verifies audio and vibrotactile control signals against the current traffic state and user settings to determine whether to enable output of audible and vibrotactile pedestrian signal indications. The primary conflict monitor and error detector may transmit information
10 about the audio and vibrotactile control signals to a secondary conflict monitor and error detector, which verifies the information received against the current traffic state and user settings, and inhibits output of audible and vibrotactile pedestrian signal indications in the event of a detected conflict or error.

ACCESSIBLE PEDESTRIAN SIGNAL SYSTEM

Technical Field

5 [0001] This invention relates to systems and methods for accessible pedestrian signal (APS) systems which provide non-visual pedestrian signal indications.

Background

10 [0002] APS systems provide pedestrian signal indications in a non-visual format such as: audible (e.g. sounds, tones, verbal messages, etc.) or vibrotactile (e.g. vibrating raised pushbutton surface) formats. APS systems may generate different types of signal indications for different applications. For example, APS systems typically have different audible “walk” indications for east-west and north-south crossings, in addition to pole locator tones, wait tones, and the like. It is important that APS systems provide correct pedestrian signal indications to protect the safety of visually impaired or visually and
15 hearing impaired pedestrians.

[0003] A traffic light control system typically incorporates a malfunction management unit (MMU) which monitors traffic signal channels for conflicting inputs and invalid signal voltage levels and the like, and responds to a detected failure or abnormal
20 condition. As conventional MMUs are designed for traffic control systems which provide basic visual traffic signal information, such MMUs may generally lack the control to reliably recognize and respond to conflict or error in non-visual pedestrian signal indications as generated by APS systems, and particularly, with respect to multiple types of audible indications for different applications.

25

[0004] There is a general desire to provide conflict monitoring and error detection for APS systems. There is a general desire to provide APS systems incorporating conflict monitoring and error detection which may be retrofit into existing traffic control systems.

30 **Brief Description of Drawings**

[0005] Exemplary embodiments are illustrated in referenced figures of the drawings. It is intended that the embodiments and figures disclosed herein are to be considered illustrative rather than restrictive.

- 2 -

[0006] Figure 1 schematically depicts a conflict monitoring and error detection system according to a particular embodiment which may be implemented for an APS button station.

5 [0007] Figure 2 schematically depicts a primary conflict monitor and error detector according to one embodiment that may be used in the conflict monitoring and error detection system of Figure 1.

10 [0008] Figure 3 depicts the contents of a sound file that may be used in the conflict monitoring and error detection system of Figure 1.

[0009] Figure 4 schematically depicts a specific implementation of the Figure 2 primary conflict monitor and error detector according to one embodiment.

15 [0010] Figure 5 schematically depicts a specific implementation of a secondary conflict monitor and error detector according to one embodiment that may be used in the conflict monitoring and error detection system of Figure 1.

20 [0011] Figure 6 is a flowchart illustrating a method of conflict monitoring and error detection according to one embodiment that may be performed by the primary conflict monitor and error detector of Figure 2.

25 [0012] Figure 7 is a flowchart illustrating another method of conflict monitoring and error detection according to one embodiment that may be performed by the primary conflict monitor and error detector of Figure 2.

[0013] Figure 8 is a flowchart illustrating a method of conflict monitoring and error detection according to one embodiment that may be performed by the secondary conflict monitor and error detector of Figure 5.

30

- 3 -

Description

[0014] Throughout the following description, specific details are set forth in order to provide a more thorough understanding to persons skilled in the art. However, well known elements may not have been shown or described in detail to avoid unnecessarily obscuring the disclosure. Accordingly, the description and drawings are to be regarded in an illustrative, rather than a restrictive, sense. As used herein, “actual” signals, indications, parameters, modes and the like refer to signals, indications, parameters, modes and the like actually generated, provided and/or output by an APS system, regardless of whether the APS system is functioning correctly. “Expected” signals, indications, parameters, modes and the like refer to signals, indications, parameters, modes and the like which are expected to be, or ought to be, generated, provided and/or output by an APS system which is functioning correctly.

[0015] According to particular embodiments, an APS system is integrated into a pedestrian button station provided at a pedestrian crosswalk. Each button station has a pushbutton which may be pushed by the pedestrian to request service from a traffic signal controller at the crosswalk (i.e. to request the go-ahead signal to cross the street). The pushbutton may be a vibrotactile raised pushbutton capable of providing vibrotactile pedestrian signal indications. The button station may include a “button” speaker (so-named as it is located at the button station). The APS system may optionally include an overhead speaker, typically mounted in or to a pedestrian signal head which provides visual pedestrian signal indications. The button and overhead speakers may play audible pedestrian signal indications such as sounds, tones, verbal messages and the like.

[0016] The button station incorporates a primary conflict monitor and error detector which controls the outputs to the button speaker (and the overhead speaker, if provided) and the vibration actuator for the pushbutton. In particular embodiments, the speakers and vibration actuator may be in a disabled state by default, and may be enabled only when the primary conflict monitor and error detector has verified that conditions are such that the speakers and vibration actuator may be enabled. For example, one condition that may be verified is whether the actual signals sent to the speakers or vibration actuator match the expected signals for the speakers or vibration actuator based on the current traffic state as determined from pedestrian signals (e.g. WALK, FLASHING DON'T WALK, or SOLID DON'T WALK) and user settings (which for an audio signal may define

- 4 -

parameters such as the sound type for a particular traffic state, frequency of sound output, etc., and for a vibrotactile signal may define parameters such as the mode of vibratory feedback for a particular traffic state).

5 **[0017]** According to particular embodiments, sound files representing audible pedestrian
signal indications are encoded with a digital code representing information about (i.e.
meta data) or identifying parameters of the signal indication such as: pedestrian signal
type, sound type, message, and length of the message. The primary conflict monitor and
error detector detects and receives signals to be sent to the speakers, decodes the portions
10 of the signals containing the digital code of a sound file, and based on such decoded
information, verifies that the sounds to be played by the speakers conform with the
current traffic state and user settings. In certain embodiments, the primary conflict
monitor and error detector also detects and receives signals to be sent to the vibration
actuator, and verifies that the signals conform with the current traffic state and user
15 settings.

[0018] In some embodiments, secondary conflict monitoring and error detection may be
implemented by an APS malfunction management subsystem. The button station may
transmit information about its actual non-visual pedestrian signal indications to the APS
20 malfunction management subsystem, which verifies such information against the current
traffic state and user settings (to determine whether the actual signals match the expected
signals), detects conflict or error, and responds to any detected conflict or error. Such
response may include inhibiting audible and/or vibrotactile output at the button station
where the conflict or error is detected. In particular embodiments, information about a
25 button station's actual non-visual pedestrian signal indications is sent to the APS
malfunction management subsystem over a powerline communications network.

[0019] Figure 1 illustrates a conflict monitoring and error detection system **100** according
to a particular embodiment for an APS button station **80** which includes a pushbutton **82**
30 and a button speaker **84**. An optional overhead speaker **86** is mounted in a pedestrian
signal head **88**. Speakers **84**, **86** are operable to play audible pedestrian signal indications
(e.g. sounds, tones, verbal messages and the like). Pushbutton **82** may comprise a
vibrotactile raised pushbutton which may be driven by an actuator **109** to provide

- 5 -

vibrotactile pedestrian signal indications (e.g. vibrations which may be detected by a pedestrian touching pushbutton **82**).

[0020] Pedestrians wishing to cross the street may request service from traffic signal controller **90** by pushing pushbutton **82**. Pedestrian input to pushbutton **82** is provided by wire **83** to traffic signal controller **90**. Traffic signal controller **90** generates traffic control signals including pedestrian signals, and communicates the pedestrian signals to pedestrian signal head **88**. The pedestrian signals are carried over two wires or lines: line **92A** which may assert the WALK signals and line **92B** which may assert the DON'T WALK (and flashing DON'T WALK) signals. Signals asserted on lines **92A**, **92B** determine the current traffic state for pedestrians at button station **80** (i.e. WALK, FLASHING DON'T WALK, or SOLID DON'T WALK).

[0021] Button station **80** receives pedestrian signals through a power interface module **78** connected between pedestrian signal head **88** and button station **80** (see Figure 1). Power interface module **78** may incorporate a rectifier circuit (not shown) to convert the AC voltage of lines **92A**, **92B** to a DC voltage at a voltage level suitable for use in button station **80** (for example, from 120V AC at lines **92A**, **92B** to 12V DC at lines **92A'**, **92B'**). In the illustrated embodiment, pedestrian signals provided to button station **80** are carried over a 12V DC line **92A'** providing the WALK signals and a 12V DC line **92B'** providing the DON'T WALK (and flashing DON'T WALK) signals.

[0022] As shown in Figure 1, an earth ground line **94** and an AC neutral line **96** are connected to traffic signal controller **90** and to pedestrian signal head **88**. Earth ground line **94** may be connected to DC common lines, in some embodiments. Information from button station **80** may be transmitted via a combination of lines **85** and **94** at the DC side of the power interface module **78** and lines **92A**, **92B** and/or **96** (collectively, a "powerline communications line **95**") at the AC side of the power interface module **78**. Line **85** may be a communications wire between button station **80** and power interface module **78**. Information from button station **80** may be communicated over the powerline communications line **95** to other button stations connected to traffic signal controller **90**. Information from button station **80** may be transmitted over powerline communications

- 6 -

line **95** to a secondary conflict monitor and error detector **103** through communications interface unit **120**.

5 [0023] An APS generator **98** in button station **80** generates control signals for providing non-visual (e.g. audible and vibrotactile) pedestrian signal indications, based on the pedestrian signals carried over lines **92A'**, **92B'** to button station **80**. APS generator **98** transmits the control signals to the appropriate outputs (e.g. speakers **84**, **86** and vibration actuator **109**). Before such control signals reach their intended outputs, they are processed and verified by a primary conflict monitor and error detector **102** of system **100**. Primary
10 conflict monitor and error detector **102** may be contained within button station **80**'s housing.

[0024] As shown in Figure 2, primary conflict monitor and error detector **102** controls the state of a relay or switch **106** connected between APS generator **98** and speakers **84**, **86**.
15 Relay **106** may be positioned prior to audio amplifier **108** in the path between APS generator **98** and speakers **84**, **86**. Primary conflict monitor and error detector **102** controls the state of a relay or switch **107** connected to vibration actuator **109**. In particular embodiments, relays **106** and **107** are by default in their open (disabled) state. It is only after primary conflict monitor and error detector **102** determines that certain conditions are
20 satisfied (or that no conflicts or errors are detected) that relays **106** and **107** are switched temporarily to their closed (enabled) states thereby enabling audible output from speakers **84**, **86** and vibrotactile output from pushbutton **82**.

[0025] In the illustrated embodiment, APS generator **98** controls the state of a relay or
25 switch **106A** connected to speaker **84** and a relay or switch **106B** connected to speaker **86**. APS generator **98** may control the state of relays **106A**, **106B** based at least in part on configurable user settings **91** for button station **80** stored in a memory **111** at button station **80**. User settings **91** are explained in further detail below.

30 [0026] According to certain embodiments, audio control signals sent to speakers **84**, **86** are encoded with digital codes or signatures which, when decoded by primary conflict monitor and error detector **102**, identify parameters of the audible pedestrian signal indications that are to be played by speakers **84**, **86**. Each sound available for output by

- 7 -

speakers **84**, **86** may be stored in audio format as a sound file **89** including a header **87** containing a digital code (see Figure 3). The audio control signals that are generated by APS generator **98** include the digital code for each sound file **89**. The digital code provides information about the sound in each sound file **89**, such as:

- 5 • Signal type (e.g. WALK, FLASHING DON'T WALK, SOLID DON'T WALK and/or other signal types).
- Sound code or number identifying the type of sound (e.g. chirp; cuckoo; click; beep; a particular tune; a verbal message such as "walk sign is on", "wait", "emergency vehicle approaching," or "train approaching"; etc.).
- 10 • Sound description (text field identifying the sound type in a written description - e.g. "chirp", "cuckoo").
- Length of the message (e.g. this may typically range from approximately 0.1 second to approximately 3 seconds).
- Message (e.g. walk - east-west crossing; walk - north-south crossing; wait or clear the
- 15 crosswalk; don't walk; pole locator; button press acknowledged; pedestrian call acknowledged; train crossing; error alert, etc.).

In certain embodiments, a portion of each header **87** may be represented as a sound reference number (see Figure 3). The sound reference number may identify information for certain fields such as signal type, sound type and/or message. The sound reference

20 number may be used as an index to a look-up table that identifies signal type, sound type, and/or message.

[0027] A plurality of sound files **89**, each sound file **89** representing a sound available for output to speakers **84**, **86**, may be stored in memory **111** at button station **80** (Figure 2). In

25 the Figure 2 embodiment, memory **111** also stores configurable user settings **91** for button station **80**. User settings **91** may define settings for button station **80** such as the sound type for a message and signal type; the order in which messages are to be played; the frequency at which a message is to be repeated; the maximum duration over which a particular message is to be repeated; the speakers from which the sounds are to be played

30 (e.g. button speaker, overhead speaker, or both); the volume of sounds, including maximum and minimum volume levels, gain above ambient volume levels, time-specific maximum volume levels (e.g. maximum volume levels applied during evenings or at night); order in which messages are to be played; and the like. Different user settings **91**

- 8 -

may apply depending on the operating conditions, such as whether the pedestrian's button push is long or short in duration.

[0028] Memory **111** may be accessible to processor **99** of APS generator **98** and
5 processor **110** of primary conflict monitor and error detector **102**. Processor **99** receives
pedestrian signals asserted on lines **92A'**, **92B'**, and executes instructions provided by
software stored in program memory **93** to retrieve user settings **91** from memory **111**,
select one or more sound files **89** from memory **111** (based on the input pedestrian signals
and user settings **91**), and generate audio signals **105** (control signals which are sent to
10 audio amplifier **108**). Audio signals **105** may be pulse-width modulated signals, in
particular embodiments. In other embodiments, processor **99** generates digital audio
signals. Digital audio signals may be converted to analog pulse-width modulated signals
by a signal converter for playback by speakers **84**, **86**. In some embodiments, processor **99**
may synthesize digital audio signals based on data (e.g. textual data) stored in memory
15 **111**.

[0029] In certain embodiments, processor **99** sends signals to selectively open or close
relays **106A**, **106B** based on relevant user settings **91**. Relevant user settings **91** may
identify, for example, one or more of: the speaker(s) from which each message is to be
20 played (e.g. button speaker, overhead speaker, or both), the frequency at which an audible
message is to be repeated; the duration of the audible message, and/or the like.

[0030] Audio amplifier **108** amplifies audio signals **105** to provide suitable audio
signals **97** to drive speakers **84**, **86** to play audible pedestrian signal indications. Primary
25 conflict monitor and error detector **102** detects and receives the audio signals prior to their
output to speakers **84**, **86**. In particular embodiments, conflict monitor and error
detector **102** detects and receives audio signals **97** prior to their amplification by audio
amplifier **108** and before their output to speakers **84**, **86**.

30 [0031] Primary conflict monitor and error detector **102** decodes each detected signal **97**.
In particular embodiments (such as those described with reference to Figure 3), each
sound file **89** may contain a digital code in a header **87**, represented by the first n bits of
each sound file **89**. Primary conflict monitor and error detector **102** may decode the

- 9 -

beginning portion of each detected signal **97** corresponding to header **87** of a sound file **89**. Primary conflict monitor and error detector **102** compares the decoded information with the current traffic state and user settings **91** (as accessed from memory **111**). Primary conflict monitor and error detector **102** may determine the current traffic state (e.g. WALK, FLASHING DON'T WALK, or SOLID DON'T WALK) by monitoring pedestrian signals carried over lines **92A'**, **92B'**.

[0032] If certain conditions are satisfied (as described in further detail below), primary conflict monitor and error detector **102** moves relay **106** to a closed position, enabling signal **97** to be played by one or both of speakers **84**, **86** (depending on the state of relays **106A**, **106B** which are controlled by APS generator **98**). According to particular embodiments described herein, the portion of signal **97** that is output to and played by speakers **84**, **86** includes the audible pedestrian signal indication, but excludes sound header information. Header **87** of sound file **89** is not output to speakers **84**, **86** because relay **106** is maintained in its default open position while primary conflict monitor and error detector **102** is processing and decoding header **87**. Therefore, the portion of signal **97** that represents header **87** of sound file **89** is prevented from reaching speakers **84**, **86**.

[0033] In particular embodiments, for each signal **97** detected by primary conflict monitor and error detector **102**, primary conflict monitor and error detector **102** may evaluate whether the following conditions are satisfied:

- A valid header **87** is decoded from signal **97**. A missing, invalid or unrecognizable header is indicative of a conflict or error.
- A valid traffic state (i.e. WALK, FLASHING DON'T WALK, or SOLID DON'T WALK) is determinable from signals on lines **92A'**, **92B'**. Signals should be asserted on only one of lines **92A'**, **92B'** at any one time. A simultaneous assertion of signals (or no assertion of signals) on lines **92A'**, **92B'** is indicative of a conflict or error. For example, a short circuit (such as may be caused by water leaking into button station **80**'s housing) may result in simultaneous assertion of signals on lines **92A'**, **92B'**.
- The signal type of signal **97** (as determined by the signal type decoded from header **87**) matches the current traffic state (e.g. as determined by the signals on lines **92A'**, **92B'**). A mismatch in the signal type is indicative of a conflict or error.

- 10 -

- The sound type of signal **97** (as determined by the sound type decoded from header **87**) matches the sound type set in user settings **91** for the current traffic state. For example, for a current traffic state of WALK, user settings **91** may specify that the sound type is a cuckoo sound. A mismatch in the sound type is indicative of a conflict or error.

5

[0034] In other embodiments, other conditions may be evaluated by primary conflict monitor and error detector **102** to determine whether the actual signals match the expected signals for speakers **84**, **86** and vibration actuator **109**. For example, audio signals **97** may be evaluated to determine if the sounds to be played conform with other parameters defined in user settings **91** (e.g. the order in which messages are to be played, the frequency at which a message is to be repeated, the maximum duration over which a particular message is to be repeated, etc.).

10

[0035] If the foregoing conditions are satisfied (i.e. no conflict or error is detected), primary conflict monitor and error detector **102** closes relay **106** for a duration based on the message length, as specified in header **87**. Once relay **106** has closed for the determined duration, it returns to its default open position.

15

[0036] If one of the foregoing conditions is not satisfied (i.e. a conflict or error is detected), relay **106** is maintained in its default open position. Primary conflict monitor and error detector **102** may transmit an error message, providing information about the detected conflict or error, via powerline communications line **95** to an APS malfunction management subsystem **104** (described in further detail below). Audible output may remain disabled until button station **80**'s operation is reset by service personnel.

20

25

[0037] In addition to verifying audio signals to speakers **84**, **86**, vibrotactile control signals generated by APS generator **98** may be verified by primary conflict monitor and error detector **102** prior to being received at vibration actuator **109**. In the illustrated embodiment of Figure 2, primary conflict monitor and error detector **102** detects and receives control signals **112** for driving vibration actuator **109**. Control signals **112** are generated by APS generator **98** based on user settings **91** and the pedestrian signals carried over lines **92A'**, **92B'** and received at button station **80**. In certain embodiments, user settings **91** define characteristics for different modes of vibratory feedback. Traffic states

30

- 11 -

such as WALK or FLASHING/SOLID DON'T WALK may be associated with a particular mode of vibratory feedback. Control signals **112** drive vibration actuator **109** to provide one mode of vibratory feedback (e.g. constant vibration) during a WALK interval (i.e. while a signal on line **92A'** is being asserted), and another mode of vibratory feedback (e.g. 0.15 second of vibration every 1 second, or some other periodic vibration) during a FLASHING DON'T WALK or SOLID DON'T WALK interval (i.e. while a signal on line **92B'** is being asserted).

[0038] To determine whether to enable output of control signal **112** to vibration actuator **109**, primary conflict monitor and error detector **102** may compare the actual and expected modes of vibratory feedback. This comparison may be performed each time the current traffic state changes. The actual mode of vibratory feedback may be determined from control signal **112**. The expected mode of vibratory feedback may be determined from user settings **91** and the current traffic state (as ascertained from pedestrian signals on lines **92A'**, **92B'**). If the actual and expected modes of vibratory feedback match, primary conflict monitor and error detector **102** causes relay **107** to be closed in accordance with control signal **112**, enabling vibrotactile pedestrian signal output according to the actual and expected mode of vibratory feedback. In some embodiments primary conflict and error detector **102** causes relay **107** to be closed after a predetermined delay time and may maintain relay **107** in its closed position for a defined period. For example, for the FLASHING DON'T WALK or SOLID DON'T WALK mode, relay **107** may be closed for a period equal to the DON'T WALK message duration plus a relay advance time, and is thereafter opened; this is repeated so long as the WALK traffic state is not active and a walk_play_order state (a state set based on the order in which messages are to be played, as determined by user settings **91**) is not active. For the WALK mode, relay **107** is closed as long as certain conditions are true—e.g. the WALK traffic state is asserted and walk_play_order state is active. In particular embodiments, such as the one illustrated in Figure 2, signals **112** are amplified by an amplifier **113** to provide suitable signals to drive vibration actuator **109**.

30

[0039] A mismatch or difference between the actual and expected modes of vibratory feedback is indicative of a conflict or error. If there is a mismatch, relay **107** is maintained in its default open position. Primary conflict monitor and error detector **102** may transmit

- 12 -

an error message, providing information about the detected conflict or error, via powerline communications line **95** to an APS malfunction management subsystem **104** (described in further detail below). Vibrotactile output may remain disabled until button station **80**'s operation is reset by service personnel.

5

[0040] APS generator **98** and primary conflict monitor and error detector **102** may be implemented as software, hardware and/or a combination thereof. As illustrated in Figure 2, APS generator **98** may comprise a processor **99** which executes instructions provided by software stored in a program memory **93** accessible by processor **99**. As illustrated in
10 Figures 2 and 4, primary conflict monitor and error detector **102** may comprise a processor **110** which executes instructions provided by software stored in a program memory **101** accessible by processor **110**. Processors **99**, **110** may comprise central processing units (CPUs), microprocessors, field programmable gate arrays (FPGAs), or any combination thereof, or any other suitable processing unit(s) comprising hardware and/or software
15 capable of functioning as described herein.

[0041] As seen in Figure 4, software stored in program memory **101** may include functions **115** to perform the conflict monitoring and error detection steps described above, such as:

- 20 • Function **115A** for decoding an audio signal generated by APS generator **98** (e.g. to extract sound header information).
- Function **115B** for detecting a conflict or error with respect to an audio signal (e.g. by verifying the decoded sound header information for a sound file against the current traffic state and user settings, and identifying any mismatch in signal type or sound
25 type).
- Function **115C** for processing a vibrotactile control signal generated by APS generator **98** (e.g. to determine the actual mode of vibratory feedback).
- Function **115D** for detecting a conflict or error with respect to a vibrotactile control signal (e.g. by verifying the actual mode of vibratory feedback against the expected
30 mode of vibratory feedback based on the current traffic state and user settings, and identifying any mismatch between the actual and expected modes of vibratory feedback).

- 13 -

- Function **115E** for closing one or both of relays **106A**, **106B** if no conflict or error is detected by function **115B**. Function **115E** may determine which relays to close and the duration that the relays are to remain closed, based on decoded header information for a sound file **89**.
 - 5 • Function **115F** for closing relay **107** if no conflict or error is detected by function **115D**.
 - Function **115G** for generating and transmitting an error message for each conflict or error detected by functions **115B** or **115D**.
- 10 **[0042]** Figures 6 and 7 illustrate methods **200** and **230**, respectively, of conflict monitoring and error detection that may be performed by primary conflict monitor and error detector **102**. Method **200** verifies that pedestrian signals and audio control signals satisfy certain conditions prior to enabling output of the audio control signals to speakers **84**, **86**. Method **230** verifies that vibrotactile control signals satisfy certain conditions prior to enabling
- 15 output of the vibrotactile control signals to vibration actuator **109**.
- [0043]** Method **200** of Figure 6 begins at block **202** by receiving pedestrian signals **201** and determining a current traffic state on the basis of pedestrian signals **201**. If a valid traffic state cannot be determined at block **202** from pedestrian signals **201**, method **200**
- 20 proceeds to block **216**. At block **216** output of audio control signals to speakers **84**, **86** is disabled (and also output of vibrotactile control signals to vibration actuator **109** may be disabled), and an error message is optionally transmitted at block **218** to an APS malfunction management subsystem **104**. However, if a valid traffic state can be determined at block **202**, method **200** proceeds to block **204** at which an audio control
- 25 signal **203** is received and decoded.
- [0044]** At block **206**, it is determined whether the decoding of audio control signal **203** provides valid sound header information (e.g. identifying parameters of the audible pedestrian signal indication to be output at speakers **84**, **86**, such as an actual signal type
- 30 and an actual sound type). If invalid sound header information is provided at block **206**, output of audio control signals is disabled at block **216**, and an error message is optionally transmitted at block **218** to APS malfunction management subsystem **104**. Otherwise, method **200** proceeds to block **208** by retrieving sound user settings **205** from memory.

- 14 -

Sound user settings **205** may identify an expected signal type and sound type associated with the current traffic state determined at block **202**.

5 [0045] At block **210**, the expected signal type (as identified by sound user settings **205** at block **208**) is compared with the actual signal type (as provided by the sound header information at block **206**). If the expected and actual signal types differ, output of audio control signals is disabled at block **216**, and an error message is optionally transmitted at block **218** to APS malfunction management subsystem **104**. Otherwise, method **200** proceeds to block **212**.

10

[0046] At block **212**, the expected sound type (as identified by sound user settings **205** at block **208**) is compared with the actual sound type (as provided by the sound header information at block **206**). If the expected and actual sound types differ, output of audio control signals is disabled at block **216**, and an error message is optionally transmitted at
15 block **218** to APS malfunction management subsystem **104**. Otherwise, method **200** proceeds by enabling output of audio control signal **203** to speakers **84, 86** at block **214**. Output may be enabled for a period of time defined by the sound header information provided at block **206**. Method **200** may repeat (commencing at block **202**) for the next audio control signal **203** detected and received by primary conflict monitor and error
20 detector **102**.

[0047] In addition to performing method **200**, primary conflict monitor and error detector **102** may perform method **230** of Figure 7. Method **230** begins at block **220** by receiving pedestrian signals **201** and determining a current traffic state on the basis of
25 pedestrian signals **201** (this step may use the current traffic state already determined at block **202** of method **200**). At block **222**, a vibrotactile control signal **207** is received and evaluated to determine an actual mode of vibratory feedback for the vibrotactile pedestrian signal indications to be provided by output of vibrotactile control signal **207** to vibration actuator **109**. At block **224**, vibrotactile user settings **209** are retrieved from memory.
30 Vibrotactile user settings **209** may identify an expected mode of vibratory feedback associated with the current traffic state determined at block **220**.

- 15 -

[0048] At block 226, the expected mode of vibratory feedback (as identified by vibrotactile user settings 209 at block 224) is compared with the actual mode of vibratory feedback (as determined from the vibrotactile control signal 207 at block 222). If the expected and actual modes of vibratory feedback differ, output of vibrotactile control signals is disabled at block 230, and an error message is optionally transmitted at block 232 to an APS malfunction management subsystem 104. Otherwise, method 230 proceeds by enabling output of vibrotactile control signal 207 to vibration actuator 109 at block 228. Method 230 may repeat (commencing at block 220) for the next vibrotactile control signal 207 detected and received by primary conflict monitor and error detector 102. In particular embodiments, method 230 may repeat (commencing at block 220) for the next vibrotactile control signal 207 which is detected and received by primary conflict monitor and error detector 102 after the current traffic state has changed (as it may suffice to verify only the first vibrotactile control signal 207 received during a particular traffic interval, and not every vibrotactile control signal 207 generated for the traffic interval).

[0049] System 100 may provide secondary conflict monitoring and error detection. As seen in Figure 1, a secondary conflict monitor and error detector 103 may be implemented by an APS malfunction management subsystem 104. Subsystem 104 may be housed within a cabinet which houses traffic signal controller 90. Subsystem 104 may handle secondary conflict monitoring and error detection for all button stations 80 that are in communication with traffic signal controller 90 (i.e. which is generally all button stations 80 located at a traffic intersection). Subsystem 104 may communicate with traffic signal controller 90 via a communications interface unit 120. Communications interface unit 120 processes and decodes information received by traffic signal controller 90 over powerline communications line 95. Communications interface unit 120 may communicate with traffic signal controller 90 by way of discrete digital inputs/outputs, Ethernet, USB (universal serial bus) connection, SDLC (synchronous data link communications) interface, and the like. Communications interface unit 120 is not necessary for all communications. In some embodiments, subsystem 104 receives at least some inputs directly from traffic signal controller 90 (e.g. pedestrian signals carried over lines 92A, 92B).

- 16 -

[0050] Subsystem **104** receives input from a plurality of sources, and monitors the information received for conflict or error. If a conflict or error is detected at an APS button station **80**, subsystem **104** responds accordingly. For example, for particular conflicts or errors, subsystem **104** inhibits output of audible and/or vibrotactile pedestrian signal indications at the APS button station **80** at which the conflict or error is detected. In certain embodiments, for some conflicts or errors, subsystem **104** may transmit inhibit commands via powerline communications line **95** to inhibit output of audible and/or vibrotactile pedestrian signal indications at the APS button station **80** at which the conflict or error is detected. For particular conflicts or errors, subsystem **104** may transmit inhibit commands via powerline communications line **95** to each APS button station **80** connected to a traffic signal controller **90**, to inhibit output of audible and/or vibrotactile pedestrian signal indications at the button stations.

[0051] In particular embodiments, subsystem **104** receives and monitors the following inputs:

- Pedestrian signals carried over lines **92A**, **92B**, received via communications interface unit **120** (see Figures 1 and 5) (or directly from traffic signal controller **90** signal outputs). Subsystem **104** may monitor current traffic state (e.g. WALK, FLASHING DON'T WALK, or SOLID DON'T WALK) based on such pedestrian signals.
- Information from button station **80** carried over powerline communications line **95**, received via communications interface unit **120** (see Figures 1 and 5). For example, primary conflict monitor and error detector **102** of button station **80** may transmit the following information about control signals **105** over powerline communications line **95**: button station **80**'s identification number (unique to each button station); and sound header information, such as for example, sound reference number, or sound code (sound type) and signal type. To avoid or reduce congestion on the powerline communications network, primary conflict monitor and error detector **102** may be configured to transmit only the header information for each new sound file (i.e. to transmit only "new" sounds on the network). In certain embodiments, primary conflict monitor and error detector **102** may also periodically transmit information about vibrotactile control signals **112** over powerline communications line **95**. For example, an identification of the actual mode of vibratory feedback to be provided by output of

- 17 -

vibrotactile control signal **112** may be transmitted each time the pedestrian signal status changes.

5 **[0052]** As seen in Figure 5, subsystem **104** may store a local copy of user settings **91** for each button station **80** in memory **116**. This local copy may be updated each time the user settings **91** at a button station **80** are reconfigured or changed by service personnel.

10 **[0053]** In certain embodiments, output of audible and/or vibrotactile pedestrian signal indications may be inhibited if subsystem **104** detects one or more of the following conflicts or errors:

- The signal type received over the powerline communications line **95** does not match the current traffic state.
- The sound type received over powerline communications line **95** does not match the sound type specified in user settings **91** for the current traffic state.
- 15 • The mode of vibratory feedback received over powerline communications line **95** does not match the mode of vibratory feedback specified in user settings **91** for the current traffic state.

20 **[0054]** If one of the foregoing conflicts or errors is detected, subsystem **104** may inhibit audible and vibrotactile output at the button station **80** where the conflict or error is detected. In some embodiments, depending on the severity and/or number of occurrences of the conflict or error detected, one or both of audible and vibrotactile output at button station **80** may be inhibited, or audible and/or vibrotactile output at button stations **80** connected to a traffic signal controller **90** may be inhibited. The steps to be taken may
25 allow for graceful degradation so that functional components may continue operating—for example, in particular embodiments, if the error or conflict occurs only once, then only the affected audible or vibrotactile output at the button station is inhibited; however, if the error or conflict is a repeat occurrence, then all audible or vibrotactile output is inhibited at the button station. The audible and/or vibrotactile outputs may remain inhibited until
30 button station **80**'s operation is reset by service personnel.

[0055] In some embodiments, if a conflict or error is detected, subsystem **104** communicates an alarm or error message to a central traffic control communications unit

- 18 -

(not shown) via an Ethernet, hardware (e.g. digital output), or other connection. In some embodiments, subsystem **104** may cause other error-free button stations **80** within the traffic intersection to play a “maintenance call” sound until button stations **80** are reset by service personnel.

5

[0056] Subsystem **104** may be configured to maintain an event log. The event log may include normal events and errors. An error report may be generated and stored in an event log repository **121** each time subsystem **104** receives an error message from a primary conflict monitor and error detector **102** (as transmitted at block **218** of method **200** of Figure 6 or block **232** of method **230** of Figure 7, for example) or each time subsystem **104** has detected a conflict or error as described above. An error report may include: time and date of error; phase information for the button and intersection at the time the error occurred (e.g. WALK or DON'T WALK, or north-south or east-west crossing); sound type expected; sound type detected; button station identification number; and button station location.

15

[0057] Subsystem **104** may include a real-time clock **119** (see Figure 5) which may be used to provide a synchronization signal to the button stations **80** to synchronize output of audible pedestrian signal indications. Clock **119** may be used by button stations **80** to adjust the volume settings for the audible pedestrian signal indications and/or inhibit audible pedestrian signal indications at one or more speakers according to the time of day. Clock **119** may be used by button stations **80** to determine when to play special alert messages (e.g. alerts regarding construction or traffic patterns, AMBER alert or emergency alert messages, etc.) according to the time of day. Clock **119** may also provide time-stamps for event logging purposes.

20

25

[0058] Subsystem **104** may be implemented as software, hardware and/or a combination thereof. As illustrated in Figure 5, subsystem **104** may comprise a processor **118** which executes instructions provided by software stored in a program memory **114** accessible by processor **118**. Processor **118** may comprise a central processing unit (CPUs), one or more microprocessors, one or more field programmable gate arrays (FPGAs), or any combination thereof, or any other suitable processing unit(s) comprising hardware and/or software capable of functioning as described herein.

30

- 19 -

[0059] Software stored in program memory **114** may include functions **117** to perform the conflict monitoring and error detection steps described above, such as:

- Function **117A** for detecting a conflict or error with respect to a button station **80**'s audio or vibrotactile control signals.
- Function **117B** for generating and recording an error report with respect to a conflict or error detected by function **117A**.
- Function **117C** for transmitting an alarm or error message to a central traffic control communications unit regarding a conflict or error detected by function **117A**.
- Function **117D** for inhibiting output of audible and/or vibrotactile pedestrian signal indications at the button station **80** where a conflict or error is detected by function **117A**.

[0060] Figure 8 illustrates a method **300** of conflict monitoring and error detection that may be performed by secondary conflict monitor and error detector **103**, as implemented by APS malfunction management subsystem **104** of system **100**. Method **300** may provide redundant conflict monitoring and error detection for system **100** for a button station **80**, in conjunction with primary conflict monitor and error detector **102** implementing methods **200** and **230** (Figures 6 and 7).

20

[0061] Method **300** begins at block **302** by determining a current traffic state on the basis of pedestrian signals **301** (either received as direct inputs from lines **92A**, **92B** or through a communications interface unit). If no valid traffic state is determinable from pedestrian signals **301**, method **300** proceeds to block **320** by inhibiting output of all audible and vibrotactile pedestrian signal indications at button stations **80** that are affected, and generating an error report at block **322** (and optionally transmitting the error report to a central traffic control communications unit).

25

[0062] If a valid current traffic state is determinable at block **302**, method **300** proceeds by receiving button station information at block **304**. Button station information may comprise a button station identification number **303** identifying the button station **80** which is transmitting the information to APS malfunction management subsystem **104**. At block **306**, audio signal information (such as sound header information **305**) is received for

30

- 20 -

an audio control signal generated for output to button station **80**'s speakers **84**, **86**. At block **308**, vibrotactile signal information (such as a mode of vibratory feedback **307**) may be received for a vibrotactile control signal generated for output to button station **80**'s vibration actuator **109**. Button station information, audio signal information, and
5 vibrotactile signal information may be conveyed over powerline communications line **95** to communications interface unit **120**, which relays such information to APS malfunction management subsystem **104**.

[0063] At block **310**, method **300** proceeds by retrieving user settings **309** (including
10 audio and vibrotactile user settings) associated with the current traffic state determined at block **302**. User settings **309** may be retrieved from memory accessible to APS malfunction management subsystem **104** (such as memory **116** shown in Figure 5). Method **300** then evaluates the actual parameters of the audible and vibrotactile pedestrian signal indications (as may be determined from the block **306** audio signal information and
15 the block **308** vibrotactile signal information) against the expected parameters of the audible and vibrotactile pedestrian signal indications as identified by user settings **309** associated with the current traffic state. For example, at block **312**, method **300** compares the actual and expected signal types for the audible pedestrian signal indications. At block **314**, method **300** compares the actual and expected sound types for the audible
20 pedestrian signal indications. At block **316**, method **300** compares the actual and expected modes of vibratory feedback for the vibrotactile pedestrian signal indications. If the actual and expected parameters match, method **300** proceeds to block **318**, at which APS malfunction management subsystem **304** may wait for the next audio or vibrotactile signal information to be received (e.g. by way of communications interface unit **120**).

25

[0064] If there is a difference between the actual and expected parameters at any of blocks **312**, **314**, or **316**, method **300** proceeds to block **320**. At block **320**, output of all of the affected audible and vibrotactile pedestrian signal indications may be inhibited, regardless of the conflict or error which led to block **320**. In other embodiments, output of one or
30 both of the audible and vibrotactile pedestrian signal indications may be inhibited, depending on the conflict or error which led to block **320** (e.g. an invalid traffic state at block **302** may result in inhibition of all affected audible and vibrotactile pedestrian signal indications, whereas an error in audible pedestrian signal indications at blocks **312** or **314**

- 21 -

may result in inhibition of affected audible pedestrian signal indications only). An error report is generated at block **322** (and optionally transmitted to a central traffic control communications unit).

- 5 **[0065]** Method **300** may repeat (commencing at block **302**) each time new information is received through communications interface unit **120**.

10 **[0066]** In other embodiments, method **300** may be implemented as part of a conflict monitoring and error detection system **100** which does not include a primary conflict monitor and error detector **102** performing the methods of **200** and **230** at button station **80**. For example, APS generator **98** (or another suitable component at button station **80**) may be adapted to provide information about audio and vibrotactile control signals over powerline communications line **95** for verification by APS malfunction management subsystem **104** using method **300**.

15

15 **[0067]** Where a component (e.g. module, processor, controller, server, circuit, interface, device, amplifier, etc.) is referred to above, unless otherwise indicated, reference to that component (including a reference to a “means” should be interpreted as including as equivalents of that component any component which perform the function of the described component (i.e., that is functionally equivalent), including components which are not structurally equivalent to the disclosed structure which perform the function in the illustrated exemplary embodiments of the invention.

20 **[0068]** Conflict monitoring and error detection system **100** and components thereof may be configured to perform a method according to the embodiments described herein. For example, primary conflict monitor and error detector **102** (Figure 4) may implement methods **200** and **230** (Figures 6 and 7) by executing software instructions provided by functions **115**. Secondary conflict monitor and error detector **103** (Figure 5) may implement method **300** (Figure 8) by executing software instructions provided by
30 functions **117**. Particular embodiments may also be provided in the form of a program product. The program product may comprise any medium which carries a set of computer-readable signals comprising instructions which, when executed by a data processor, cause the data processor to execute a method of the invention. Program

- 22 -

products according to the invention may be in any of a wide variety of forms. The program product may comprise, for example, physical media such as magnetic data storage media including floppy diskettes, hard disk drives, optical data storage media including CD ROMs, DVDs, electronic data storage media including ROMs, flash RAM, or the like.

5 The computer-readable signals on the program product may optionally be compressed or encrypted.

[0069] While a number of exemplary aspects and embodiments have been discussed above, those of skill in the art will recognize certain modifications, permutations,
10 additions and sub-combinations thereof. For example:

- In some embodiments, conflict monitoring and error detection system **100** may comprise only a primary conflict monitor and error detector **102** (provided within each button station **80**), without a secondary conflict monitor and error detector **103**.
- In other embodiments, conflict monitoring and error detection system **100** may
15 comprise a conflict monitor and error detector **103** implemented by an APS malfunction management subsystem **104**, without a primary conflict monitor and error detector **102** as described herein. A processor may be provided at each button station **80** to receive control signals generated by APS generator **98** for driving speakers **84**, **86** and vibration actuator **109**. Such processor may decode or process the
20 control signals (e.g. so as to extract the sound header information for an audible control signal and to determine the mode of vibratory feedback for a vibrotactile control signal) and transmit the decoded information to APS malfunction management subsystem **104** for verification against the current traffic state and user settings.
- The APS systems described herein include a button speaker **84** and an overhead
25 speaker **86**. In other embodiments, different combinations of speakers may be provided. Conflict monitoring and error detection system **100** may be adapted to control output for different combinations of speakers.
- Processors **99**, **110** may be substituted with a single processor or control and
30 processing unit capable of providing the signal generation, conflict and error detection, and output control functions described herein.
- Communications interface unit **120** may receive signals from traffic signal controller **90** indicating special events, such as, for example: train approaching, emergency vehicle approaching, new construction or traffic patterns, AMBER alert or

- 23 -

emergency alerts, etc. Upon receiving such signals, communications interface unit **120** may send a request to button station **80** to generate audible alert messages. The alert messages may be preloaded in button station **80** or may be downloaded (from communications interface unit **120**, for example) to button station **80** over powerline communications line **95**.

- Prior to deployment and from time to time, secondary conflict monitor and error detector **103** may be run through a series of tests to verify that the unit is operating normally. To run such tests, verification software may be provided on a computer or hardware device which is connected to secondary conflict monitor and error detector **103**; the software may send test signals to secondary conflict monitor and error detector **103** and record and verify the response.
- In some embodiments, one or more of the relays used to control audible or vibrotactile output (e.g. relays **106**, **106A**, **106B** and/or **107**) may be placed in a closed (operative) position as the default position. When one or more errors or conflicts are detected, the relay may be switched to an open (inoperative) position until the error or conflict is resolved.

It is therefore intended that the following appended claims and claims hereafter introduced are interpreted to include all such modifications, permutations, additions and sub-combinations as are within their true spirit and scope.

20

- 24 -

WHAT IS CLAIMED IS:

1. A method of conflict monitoring and error detection for an accessible pedestrian signal (APS) system, the method comprising:

5 monitoring pedestrian signals from a traffic signal controller to determine a current traffic state;

receiving and decoding an audio control signal generated for output to a speaker, the audio control signal encoded with a digital code identifying a plurality of actual parameters for an audible pedestrian signal indication;

10 retrieving from a memory of the APS system a first plurality of expected parameters for the audible pedestrian signal indication associated with the current traffic state;

comparing the plurality of actual parameters with the first plurality of expected parameters; and

inhibiting output of the audio control signal to the speaker if one or more of the following errors are detected:

15 a valid traffic state is indeterminable from the pedestrian signals; and
the plurality of actual parameters differs from the first plurality of expected parameters.

2. A method according to claim 1, comprising:

20 receiving a vibrotactile control signal generated for output to a vibration actuator to provide a vibrotactile pedestrian signal indication;

evaluating the vibrotactile control signal to determine an actual mode of vibratory feedback for the vibrotactile pedestrian signal indication;

25 retrieving from the memory an expected mode of vibratory feedback associated with the current traffic state;

comparing the actual mode of vibratory feedback with the expected mode of vibratory feedback; and

inhibiting output of the vibrotactile control signal to the vibration actuator if the actual mode of vibratory feedback differs from the expected mode of vibratory feedback.

- 25 -

3. A method according to claim 1, the method comprising:

providing an APS malfunction management subsystem;

transmitting information about the current traffic state and the plurality of actual parameters for the audible pedestrian signal indication over a powerline communications

5 line to the APS malfunction management subsystem;

retrieving from a local memory of the APS malfunction management subsystem a second plurality of expected parameters for the audible pedestrian signal indication associated with the current traffic state;

10 comparing the plurality of actual parameters with the second plurality of expected parameters; and

inhibiting output of the audio control signal to the speaker if the plurality of actual parameters differs from the second plurality of expected parameters.

4. A method according to claim 3, wherein the plurality of actual parameters, the first

15 plurality of expected parameters, and the second plurality of expected parameters comprise a sound type.

5. A method according to claim 4, wherein the plurality of actual parameters, the first plurality of expected parameters, and the second plurality of expected parameters comprise

20 a signal type.

6. A method according to claim 5, comprising:

providing a first switch connected between the speaker and a source of the audio control signal; and

25 maintaining the first switch in an open position if output of the audio control signal to the speaker is inhibited.

7. A method according to claim 2, comprising decoding the audio control signal to identify a message duration from the first plurality of actual parameters, wherein if no error

- 26 -

is detected, output of the audio control signal to the speaker is enabled by placing the first switch in a closed position for the message duration.

8. A method according to claim 6 or 7, comprising:

5 receiving a vibrotactile control signal generated for output to a vibration actuator to provide a vibrotactile pedestrian signal indication;

evaluating the vibrotactile control signal to determine an actual mode of vibratory feedback for the vibrotactile pedestrian signal indication;

10 retrieving from the local memory of the APS malfunction management subsystem an expected mode of vibratory feedback associated with the current traffic state;

comparing the actual mode of vibratory feedback with the expected mode of vibratory feedback; and

15 inhibiting output of the vibrotactile control signal to the vibration actuator if the actual mode of vibratory feedback differs from the expected mode of vibratory feedback.

9. A method according to claim 8, comprising:

providing a second switch connected between the vibration actuator and a source of the vibrotactile control signal; and

20 maintaining the second switch in an open position if output of the vibrotactile control signal to the vibration actuator is inhibited.

10. A method according to claim 3, comprising transmitting an error message to a central traffic control communications unit if the output of the audio control signal to the speaker is inhibited.

25

11. A method according to claim 8, comprising:

transmitting information about the actual mode of vibratory feedback for the vibrotactile pedestrian signal indication over the powerline communications line to the APS malfunction management subsystem;

- 27 -

retrieving from the local memory of the APS malfunction management subsystem a second expected mode of vibratory feedback for the vibrotactile pedestrian signal indication associated with the current traffic state;

5 comparing the actual mode of vibratory feedback with the second expected mode of vibratory feedback; and

inhibiting output of the vibrotactile control signal to the vibration actuator if the actual mode of vibratory feedback differs from the second expected mode of vibratory feedback.

10 12. An accessible pedestrian signal (APS) system comprising:

a pushbutton for providing pedestrian input to a traffic signal controller;

an APS generator connected to receive pedestrian signals from the traffic signal controller and configured to generate an audio control signal for output to a speaker based at least in part on the pedestrian signals;

15 a primary conflict monitor and error detector configured to control output of the audio control signal to the speaker and to monitor the pedestrian signals, the primary conflict monitor and error detector receiving and evaluating the audio control signal and inhibiting output of the audio control signal to the speaker if one or more errors are detected with respect to the audio control signal or the pedestrian signals, wherein the
20 primary conflict monitor and error detector is configured to transmit information relating to the audio control signal and the pedestrian signals over a powerline communications line; and

a secondary conflict monitor and error detector connected to receive and evaluate the information transmitted over the powerline communications line and configured to
25 inhibit output of the audio control signal to the speaker if one or more errors are detected with respect to the audio control signal or the pedestrian signals.

13. An APS system according to claim 12, wherein the primary conflict monitor and error detector monitors the pedestrian signals to determine a current traffic state, and

- 28 -

detects an error with respect to the pedestrian signals if an invalid traffic state is determined.

14. An APS system according to claim 13, comprising a first repository for storing a plurality of local user settings, the local user settings defining an expected sound type associated with the current traffic state, wherein the APS generator is configured to output the audio control signal encoded with a predefined digital code identifying an actual sound type for the audio control signal, and wherein the primary conflict monitor and error detector decodes the audio control signal to ascertain the actual sound type and detects an error with respect to the audio control signal if the actual sound type does not match the expected sound type associated with a current local user setting.

15. An APS system according to claim 14, wherein the digital code encoded in the audio control signal further identifies an actual signal type for the audio control signal, and wherein the primary conflict monitor and error detector decodes the audio control signal to ascertain the actual signal type and detects an error with respect to the audio control signal if the actual signal type does not match the current traffic state.

16. An APS system according to claim 15, comprising a first switch connected between the APS generator and the speaker, wherein the first switch is moved by the primary conflict monitor and error detector to a closed position to enable output of the audio control signal to the speaker if no error is detected with respect to the audio control signal or the pedestrian signals, and otherwise is maintained in an open position to inhibit output of the audio control signal to the speaker.

25

17. An APS system according to claim 16, wherein if the first switch is moved to the closed position, the primary conflict monitor and error detector decodes the audio control signal to identify a length of time for the audio control signal, and maintains the first switch in the closed position for the identified length of time.

- 29 -

18. An APS system according to claim 16, comprising a vibration actuator connected to drive the pushbutton to provide vibrotactile feedback, wherein the APS generator is configured to generate a vibrotactile control signal for output to the vibration actuator
5 based at least in part on the pedestrian signals, and wherein the primary conflict monitor and error detector is configured to control output of the vibrotactile control signal to the vibration actuator, the primary conflict monitor and error detector receiving and evaluating the vibrotactile control signal, and inhibiting output of the vibrotactile control signal to the vibration actuator if one or more errors are detected with respect to the vibrotactile control
10 signal.

19. An APS system according to claim 18, wherein the local user settings define an expected mode of vibratory feedback associated with the current traffic state, and the primary conflict monitor and error detector evaluates the vibrotactile control signal to
15 identify an actual mode of vibratory feedback, and detects an error with respect to the vibrotactile control signal if the actual mode of vibratory feedback differs from the expected mode of vibratory feedback associated with the current traffic state.

20. An APS system according to claim 18, comprising a second switch connected
20 between the APS generator and the vibration actuator, wherein the second switch is moved by the primary conflict monitor and error detector to a closed position to enable output of the vibrotactile control signal to the vibration actuator if no error is detected with respect to the vibrotactile control signal, and otherwise is maintained in an open position to inhibit output of the vibrotactile control signal to the vibration actuator.

21. An APS system according to claim 20, wherein the secondary conflict monitor and error detector comprises a second repository containing button station user settings defining a button station signal type and a button station sound type associated with the current traffic state, the secondary conflict monitor and error detector configured to:
25

- 30 -

retrieve the button station user settings from the second repository; and
detect an error with respect to the audio control signal if one or more of the button
station signal type or the button station sound type associated with the current traffic state
does not match the corresponding information received over the powerline
5 communications line.

22. An APS system according to claim 21, wherein the primary conflict monitor and
error detector is configured to transmit information relating to the vibrotactile control
signal over the powerline communications line, the secondary conflict monitor and error
10 detector configured to inhibit output of the vibrotactile control signal to the vibration
actuator if one or more errors are detected with respect to the vibrotactile control signal.

23. A computer program product comprising a computer readable medium having
instructions recorded thereon for execution by a processor, the instructions configured to
15 operate the processor to:

monitor pedestrian signals from a traffic signal controller to determine a current
traffic state;

receive and decode an audio control signal generated for output to a speaker, the
audio control signal encoded with a digital code identifying a plurality of actual parameters
20 for an audible pedestrian signal indication;

retrieve, from a memory accessible to the processor, a plurality of expected
parameters for the audible pedestrian signal indication associated with the current traffic
state;

compare the plurality of actual parameters with the plurality of expected
25 parameters; and

inhibit output of the audio control signal to the speaker if one or more of the
following errors are detected:

a valid traffic state is indeterminable from the pedestrian signals; and
the plurality of actual parameters differs from the plurality of expected

- 31 -

parameters.

24. A computer program product according to claim 23, wherein the instructions are configured to operate the processor to maintain a first switch connected between the speaker and a source of the audio control signal in an open position if output of the audio control signal to the speaker is inhibited.

25. A computer program product according to claim 24, wherein the instructions are configured to operate the processor to decode the audio control signal to identify a message duration from the first plurality of actual parameters, wherein if no error is detected, the processor enables output of the audio control signal to the speaker by placing the first switch in a closed position for the message duration.

26. A computer program product according to claim 24, wherein the instructions are configured to operate the processor to:

receive a vibrotactile control signal generated for output to a vibration actuator to provide a vibrotactile pedestrian signal indication;

evaluate the vibrotactile control signal to determine an actual mode of vibratory feedback for the vibrotactile pedestrian signal indication;

retrieve from the memory an expected mode of vibratory feedback associated with the current traffic state;

compare the actual mode of vibratory feedback with the expected mode of vibratory feedback; and

inhibit output of the vibrotactile control signal to the vibration actuator if the actual mode of vibratory feedback differs from the expected mode of vibratory feedback.

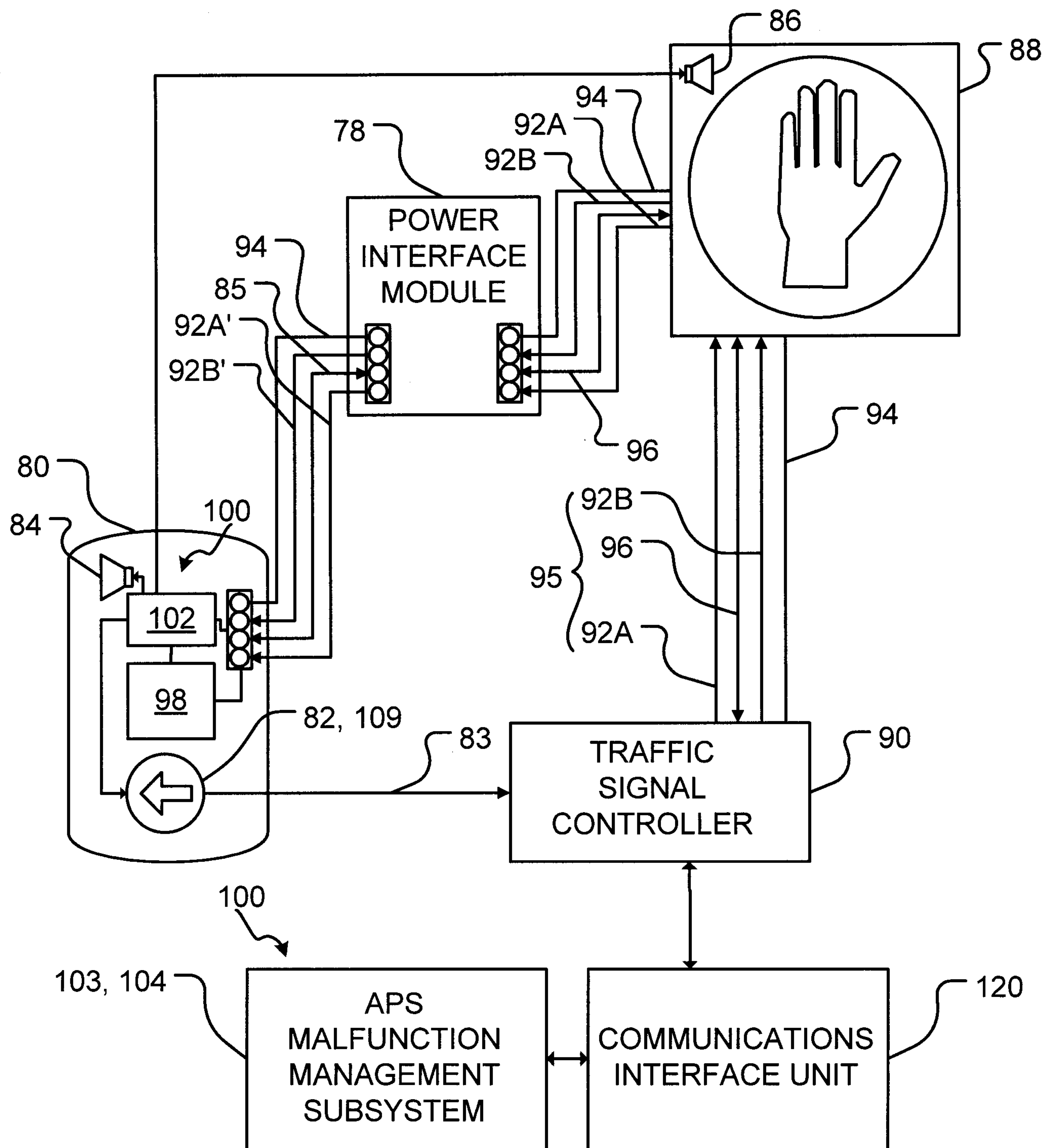
27. A computer program product according to claim 26, wherein the instructions are configured to operate the processor to maintain a second switch connected between the vibration actuator and a source of the vibrotactile control signal in an open position if

- 32 -

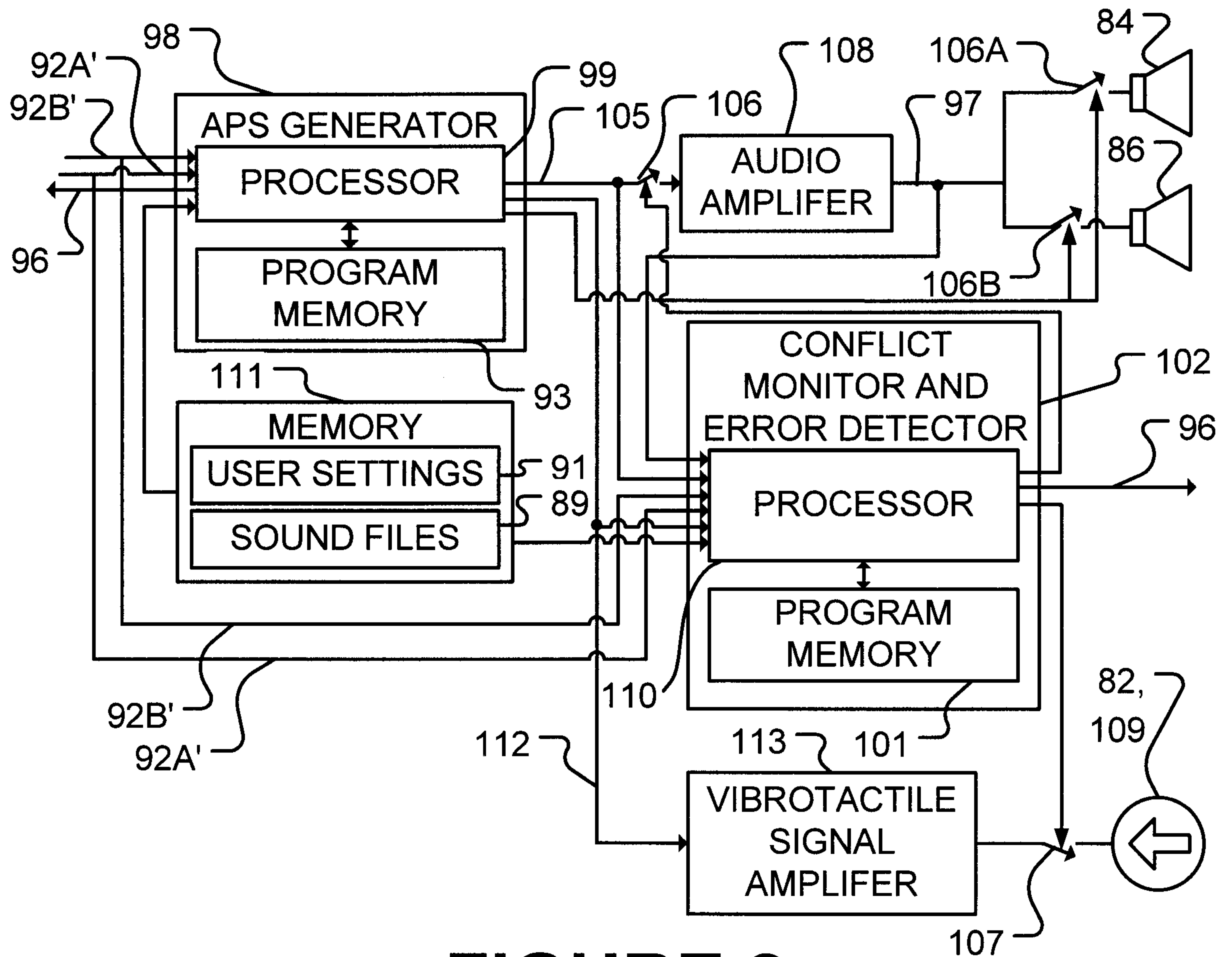
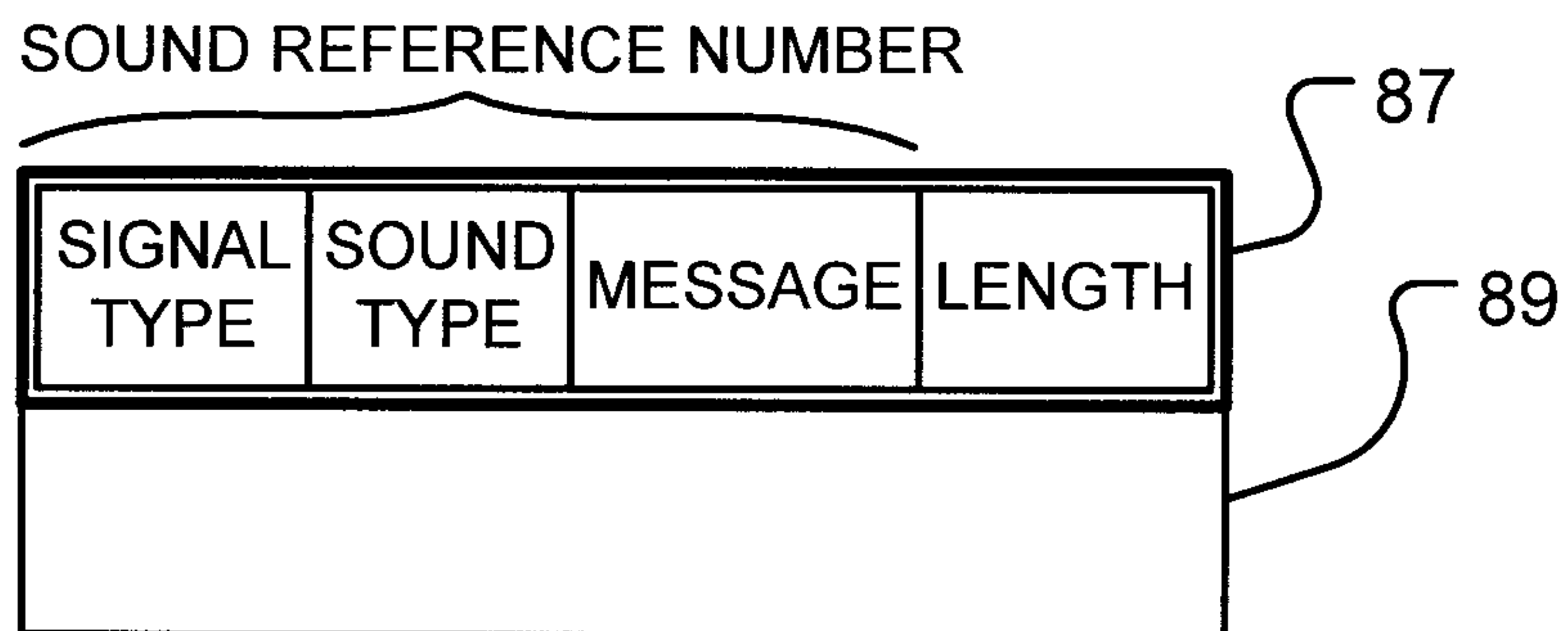
output of the vibrotactile control signal to the speaker is inhibited.

28. A computer program product according to claim 23, wherein the instructions are configured to operate the processor to transmit information about the current traffic state
5 and the plurality of actual parameters for the audible pedestrian signal indication over a powerline communications line to an APS malfunction management subsystem.

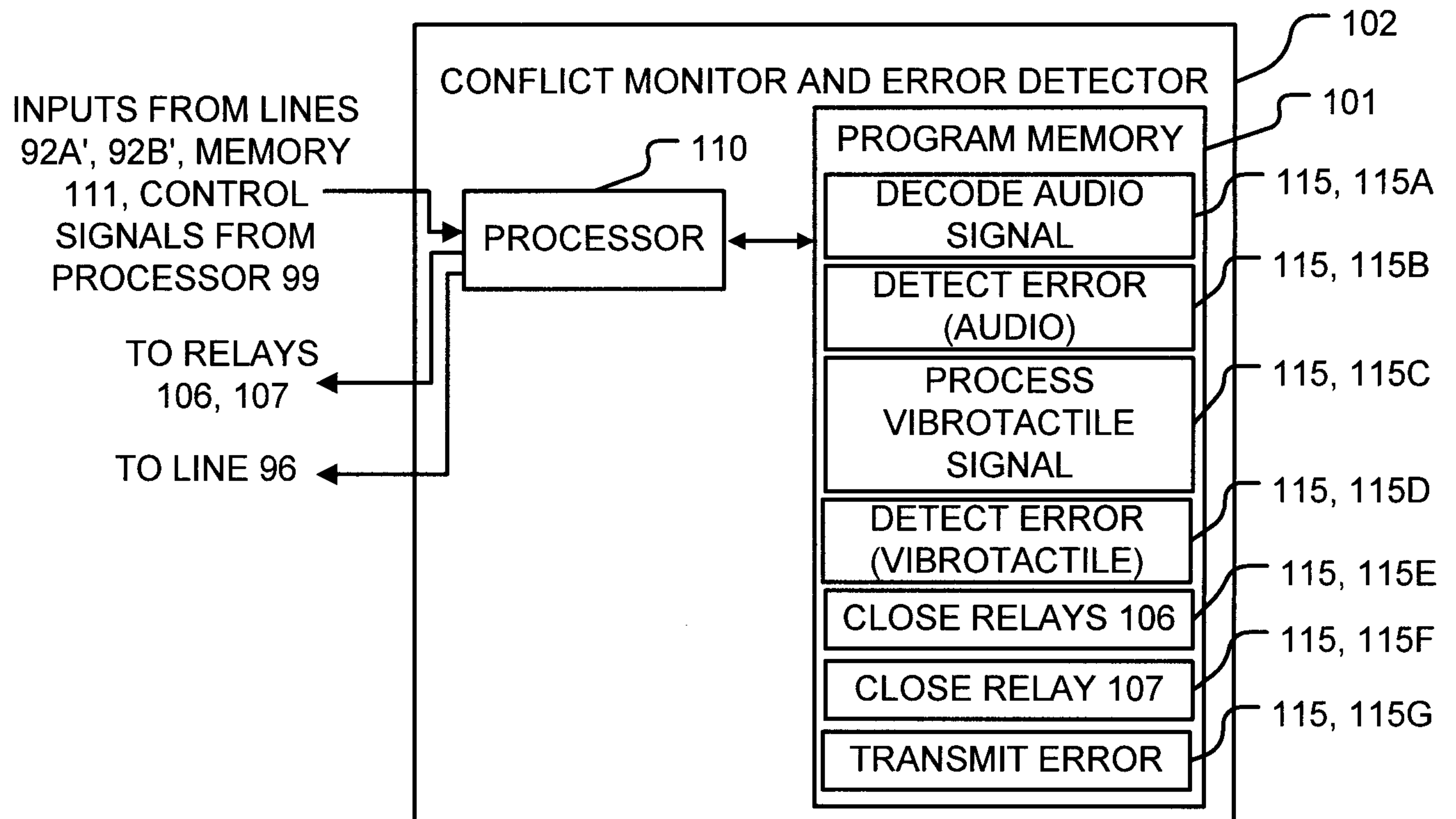
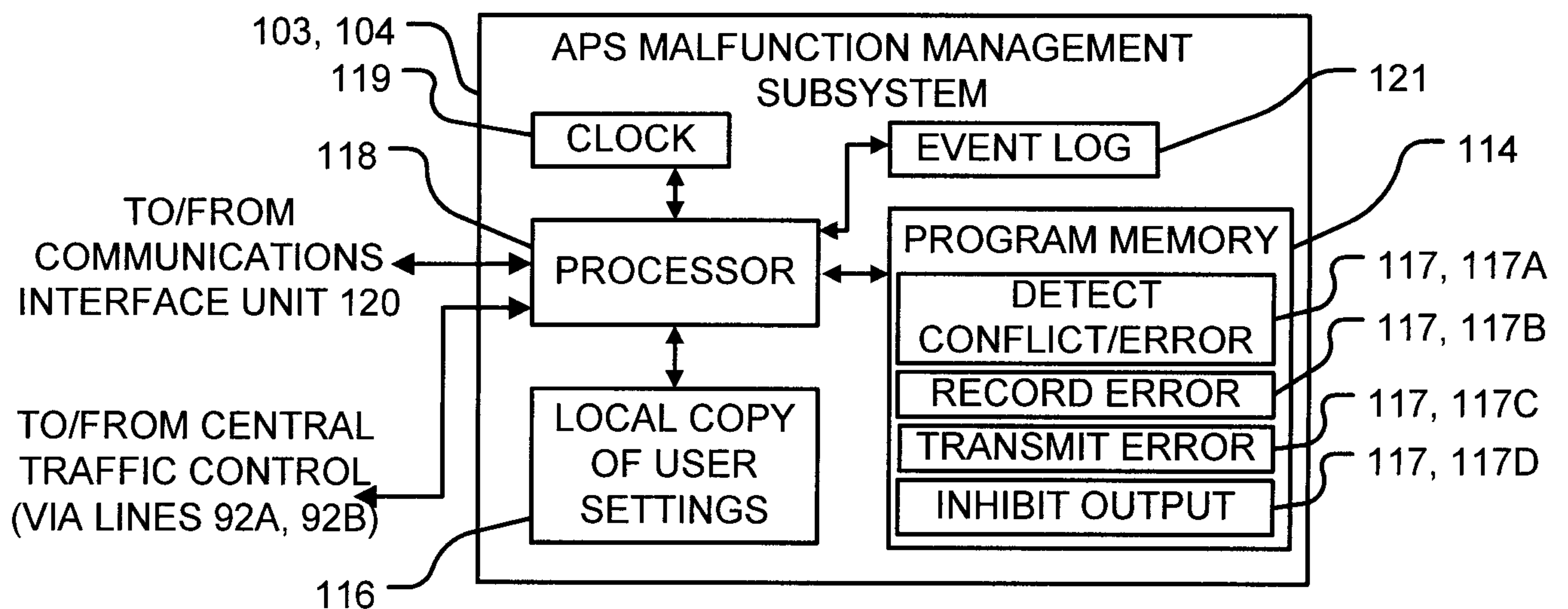
1/6

**FIGURE 1**

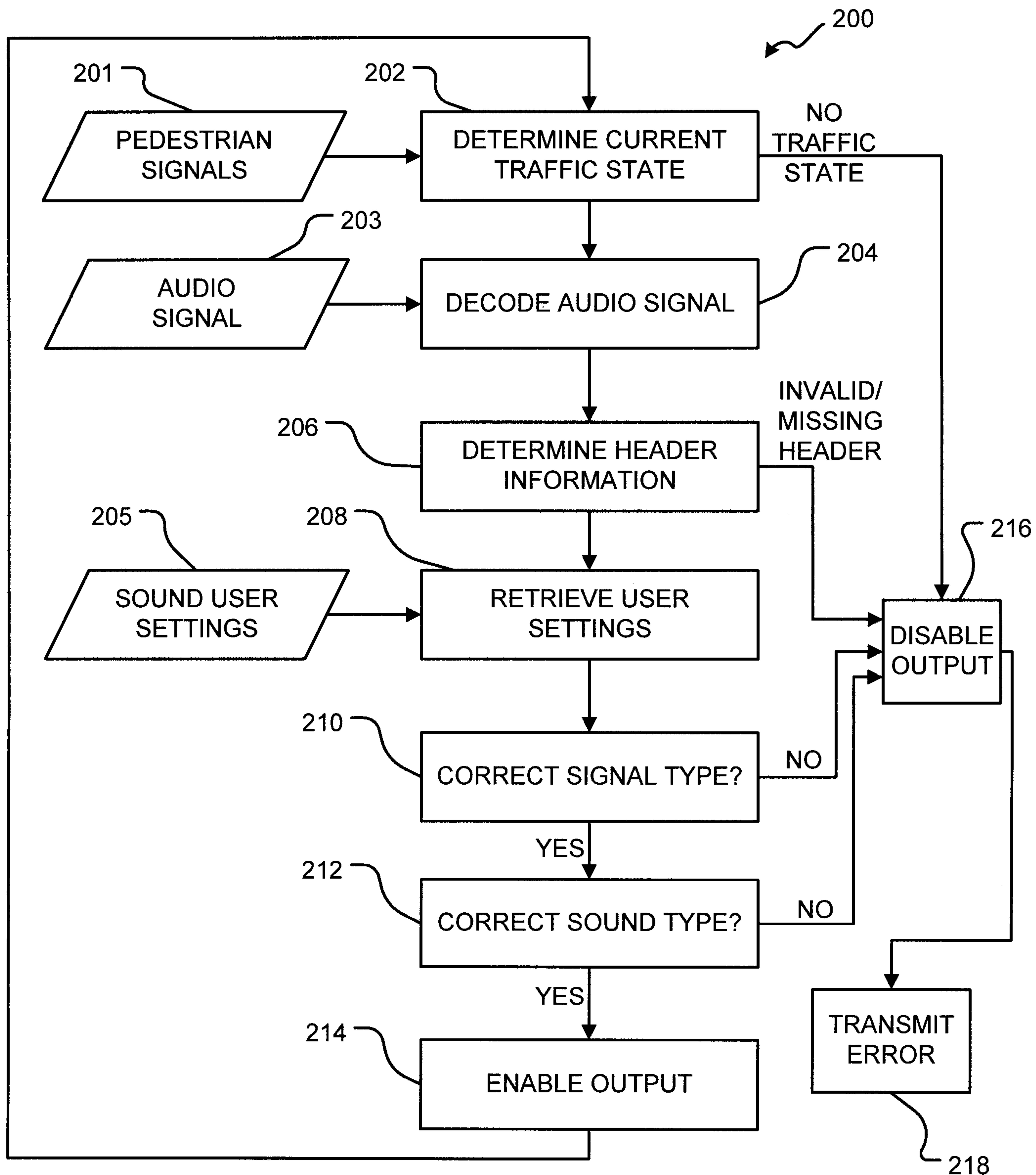
2/6

**FIGURE 2****FIGURE 3**

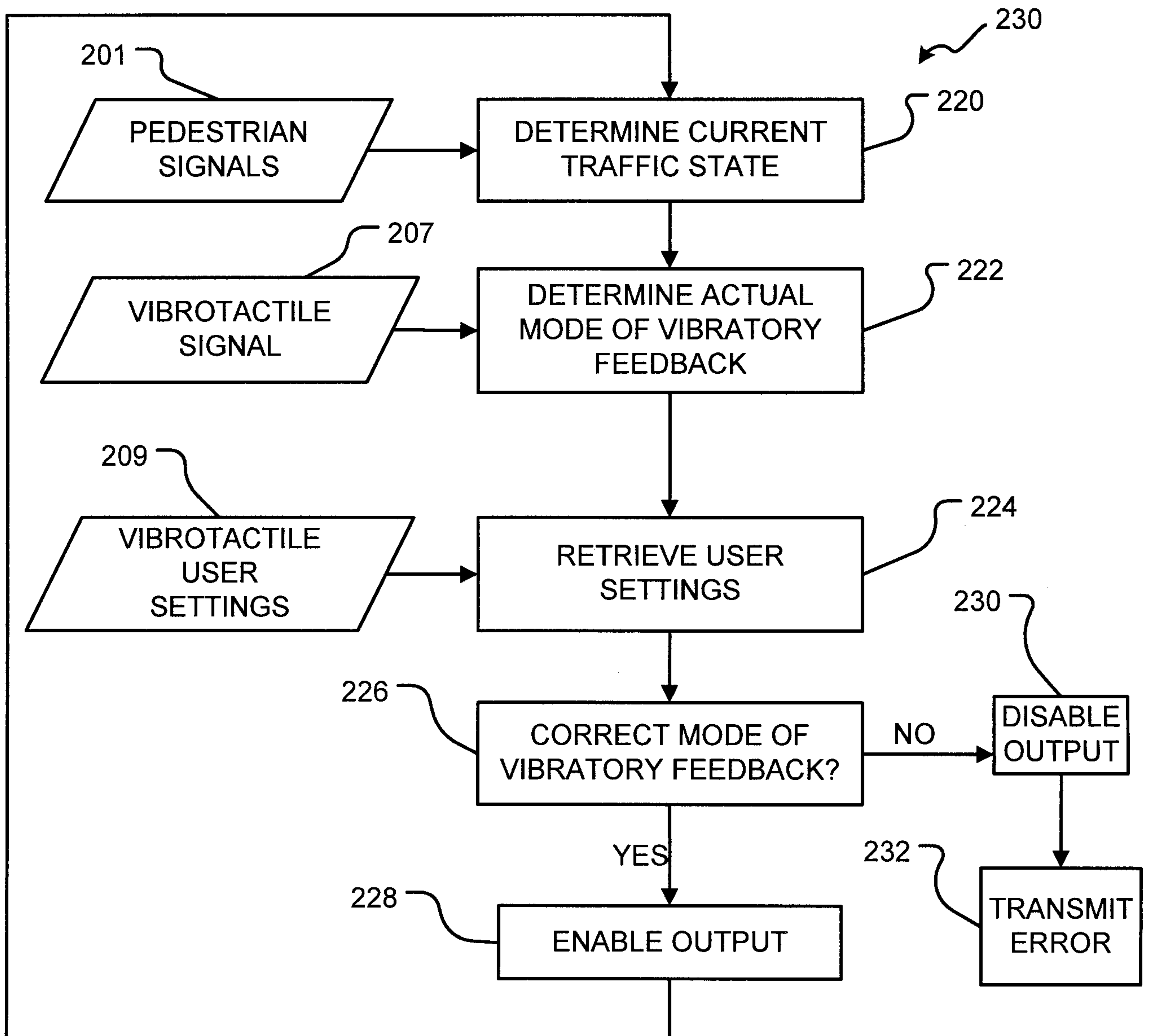
3/6

**FIGURE 4****FIGURE 5**

4/6

**FIGURE 6**

5/6

**FIGURE 7**



