Apparatus for Ensuring Seat Belt Usage and Checking Blood Alcohol Concentration

Smriti Bhatnagar, Richa Gupta, Kapil Kumar Singla

***Abstract*— An interface designed to ensure use of vehicle seat belt and a method with an ignition interlock for preventing operation of equipment when an operator's blood alcohol content is above a threshold level. A microprocessor takes necessary action in case of violation of any of these conditions. If the driver's blood-alcohol content is above the threshold level, the microprocessor sends a signal, which interlocks ignition, and if it is within the limits set in the microprocessor then it allows ignition. Next, after ignition, to check whether the driver is wearing the seat belt properly or not there are three transmitters. First transmitter sends a signal whether the seat is occupied or not. A second transmitter sends a signal whether the seat belt is latched or not and the third one checks whether the seat belt is extended enough to encircle the driver. When all the conditions are met the microprocessor sends the signal to disengage the disabling unit, which prevents gear engagement.**

I. INTRODUCTION

The present invention in field of driver safety system relates to an ignition interlock that measures the blood alcohol content directly from a body part of the operator. The interlock prevents operation of equipment in which it is installed. It also checks whether the driver is wearing seat belt or not and prevents operation of such a vehicle.

Thousands of lives have been claimed in the past years due to the non-usage of seat belts and drunken driving. However still the driving population ignores some simple means of saving lives and reducing the severity of injuries that can occur from automobile accidents [1][2][3]. Even legislation that requires the use of seat belts and does not permit drunken drivers to drive continues to be ignored by an alarming number of people.

The present systems include a breath-alcohol analyzer and a data logger that records vehicle activities and the test results. A driver must pass a breath test by blowing into the device before starting the vehicle. Unless the driver passes the test, the vehicle does not start [4][5]. However the disadvantage of such system is that they determine blood alcohol concentration through a measurement of breath alcohol concentration with help of a partition ratio. This partition ratio is based on 2100 ml of breath air containing the same weight of ethanol as 1ml of blood. A significant number of individuals have normal breath alcohol concentration noticeably above or below the threshold level. This leads to erroraneous determinations of blood alcohol concentration that render false indications of intoxication or non-intoxication of drivers whose normal blood alcohol differ from average [5].

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II. SYSTEM MODEL

The model illustrated in FIG. **1** consists of an interface connecting a Blood-Alcohol Detector and a Seat-Belt Detector. The signals from both the components are fed into a Microprocessor, which processes them and instructs the hardware controller to produce the desired effect.

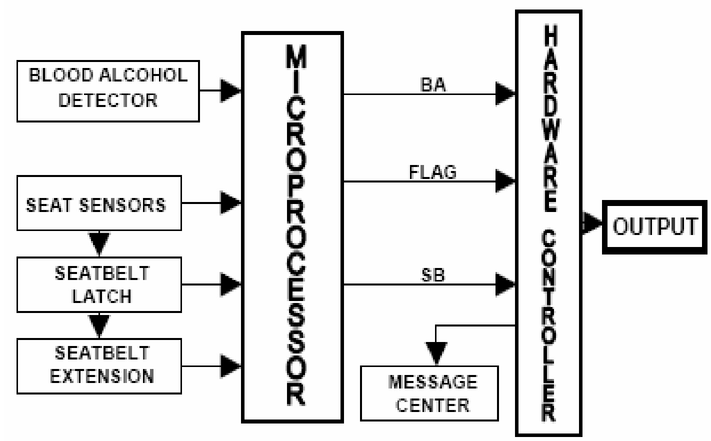

FIG. 1. Design of the Interface

A. *Description of Blood Alcohol Detector*

FIG. **2** is a perspective schematic view of the detection unit**.** The detection unit has a housing **5** with a hole **6** through its side of suitable size to insert a body part therein, such as

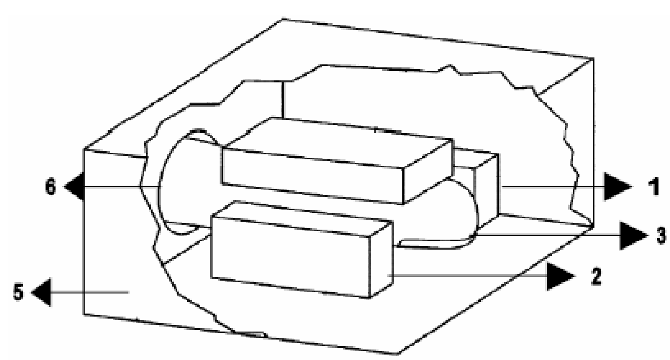

FIG. 2. Detection Unit

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finger **3.** The blood-alcohol detector has a first light source **4** and a spectroscopic detector **2** facing each other. When a finger **3** is inserted into the detection unit through the hole **6,** the first light source **4** and the detector **2** are disposed on opposite sides of finger **3.**

FIG. **3** schematically illustrates the operating blood alcohol detector as viewed from the top. This figure shows a first light source **1** emitting a preferably polychromatic light beam **4** through finger **3.** The term 'light' collectively refers to electromagnetic radiation both within and outside the visible spectrum. The first light source **1** is preferably a tungsten halogen lamp or one or more light emitting diodes [6]. A spectrographic detector **2** receives the light **4** emerging from the finger **3**. The spectrographic detector **2** senses the intensity of different wavelengths of the emerging light **2**. The spectrographic detector **2** transmits this intensity information to the microprocessor.

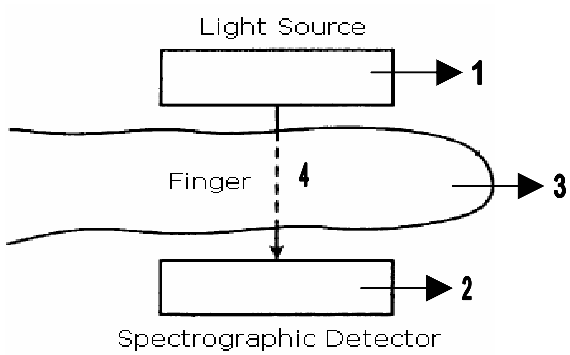

FIG. 3. Top view of the Detection Unit

The microprocessor then applies a statistical algorithm that compares the intensity information with the intensity of the wavelengths emitted by the first light source **1** to determine the percentage of alcohol contained in the blood circulating through finger **3**. Alcohol is known to have a sharp spectral absorbance at 1190nm. The intensity of the emerging light **4** near this frequency is inversely related to the amount of alcohol in the blood in the path of light **4.** Thus, a high absorbance, or low intensity, registered by the spectrographic detector **2** and the microprocessor near this wavelength indicates high blood alcohol content [6].

The absorbance of light in blood differs for different persons depending upon the amount of Hematocrit (HCT) in blood. Hematocrit measures the number of blood cells and the size of red blood cells. It gives the percentage of red blood cells found in whole blood. The normal Hematocrit levels are 40.7% - 50.3% for men and 36.1% - 44.3% for women. The statistical algorithm used by the microprocessor is designed considering these levels and works for the worst-case scenario.

When an operator wishes to start the vehicle, he or she presses the 'start' button on the dashboard **7**, energizing the interlock system. The system remains energized until a pre-selected time has elapsed. The operator inserts his or her finger **3** through the hole **6** of the detection unit and positions the finger **3** as shown in FIG. **2**.

Once the system is energized, the microprocessor activates the blood alcohol detector. When the microprocessor detects a light absorption reading that is within expected parameters for what a human finger would produce, the microprocessor determines whether the measured blood alcohol level is above or below the pre programmed threshold value. The microprocessor will determine that the test is passed if the blood alcohol reading is below the threshold value and thus sends the signal to the hardware controller that further closes the ignition circuit allowing the vehicle to be started and operated.

If the test fails because the measured blood alcohol content is higher than the benchmark, the microprocessor resets the system for a new test. If the test fails, the interlock prevents the vehicle from being operated. FIG. **4** shows an embodiment of the detector installed in a motor vehicle. A driver sits on the right side of the illustrated vehicle. The detection unit is installed beneath the driver's seat towards the outside of the vehicle. In other words, where the driver's seat is on the right side of the vehicle, the detection unit is located beneath the seat on the right side.

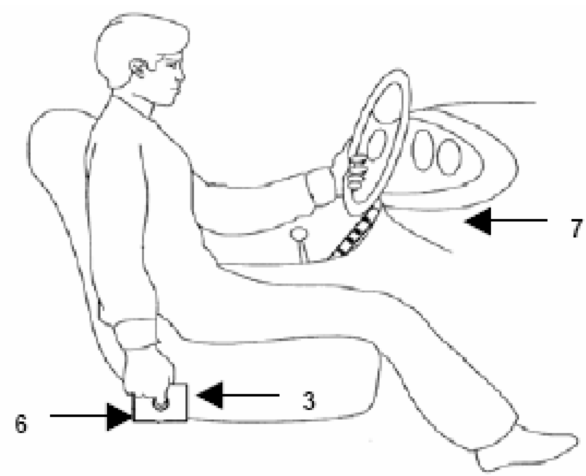

FIG. 4. Illustration of the Position of the Detector in the Vehicle

The finger hole **6** in the detection unit is oriented the driver may easily insert his or her finger **3** therein, but such that the hole **6** is effectively inaccessible to other vehicle occupants when the vehicle doors are closed or when the vehicle is in motion. In the illustrated position of the detection unit the driver merely reaches down to his side to comfortably insert his finger **3** into hole **6** with the fingertip facing up as shown in FIG. **2**.

FIG. **5** illustrates that the microprocessor is connected to a relay through a hardware controller. The relay is switchable by the microprocessor to open or close an ignition circuit in the vehicle. The ignition circuit supplies electrical power necessary for the vehicle to function. Thus the vehicle may only be started when the ignition circuit is closed. When the circuit is open, the vehicle does not receive electrical current needed for it to run. Ignition circuit may supply power to devices such as starters or spark plugs.

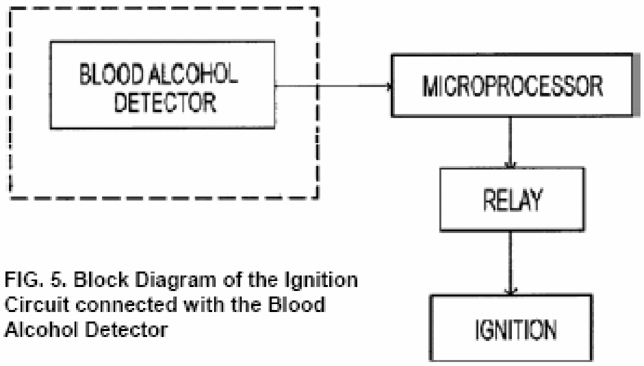

FIG. 5. Block Diagram of the Ignition Circuit connected with the Blood Alcohol Detector

B. Description of seat belt detector

Reference made to FIG.**1**.Illustrated therein is a block diagram the method to ensure seat belt usage in a motor vehicle. Such method, used to ensure use of seat belt in motor vehicle, comprises a first means, designated as the seat sensor, disposed in the first predetermined location in such motor vehicle for generating and transmitting a first signal when an occupant is detected in a seat. Such first means would include a detection device in the driver's seat of the motor vehicle. Seat sensor would transmit a signal when an occupant is detected.

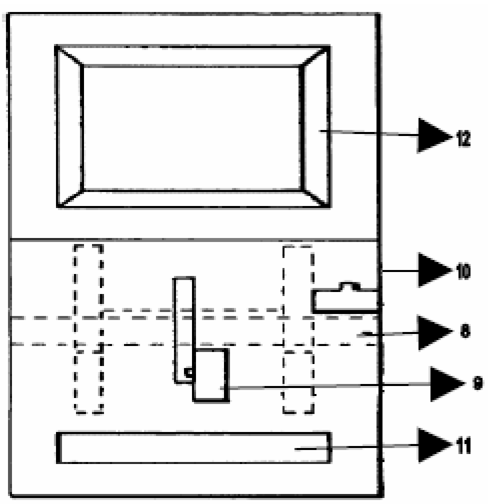

FIG. 6. Front View of the Female Portion of the Seat Belt

There is a second means, designated as Seat Belt Latch, disposed in the second predetermined location for generating and transmitting a second signal representative of such seat belt being one of unlatched and latched. The Seat Belt Latch transmits the second signal indicating that the seat belt for the seat where driver is positioned is latched or unlatched. A third means, designated as Seat Belt Extension, disposed in the third predetermined location for receiving the second signal and for generating and transmitting a third signal when such seat belt, that was detected as being latched by the Seat Belt Latch, does not extend a sufficient distance so as to encircle the driver of the vehicle. Seat Belt Extension is used to prevent the driver from engaging the seat belt but not putting it around himself or herself.

Reference is now made to FIGS. **6**, **7a** and **7b**. Illustrated therein is the female portion of the seat belt, according to the Seat Belt latch, to ensure seat belt usage.

Such female portion has a hinge pin **8** for permitting the female portion to move from a home position to a latched position. There is micro-switch **9** and a cam portion **10** to detect that such male portion of the seat belt is secured in slot **11** and a latch button **12** for releasing the male portion of the seat belt. The micro-switch **9** and the cam portion **10** is a detection device and could be selected from a photocell and an infrared device [7]. FIG. **7a** shows the female portion of the seat belt in a home position while FIG. **7b** shows the belt in a latched position.

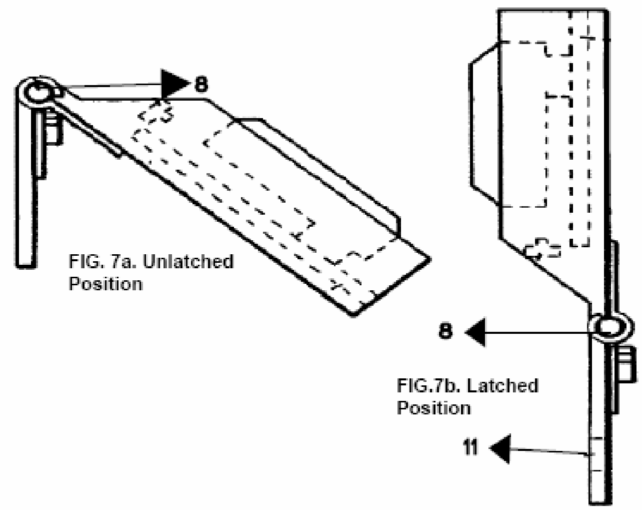

FIG. 7a. Unlatched Position

FIG.7b. Latched Position

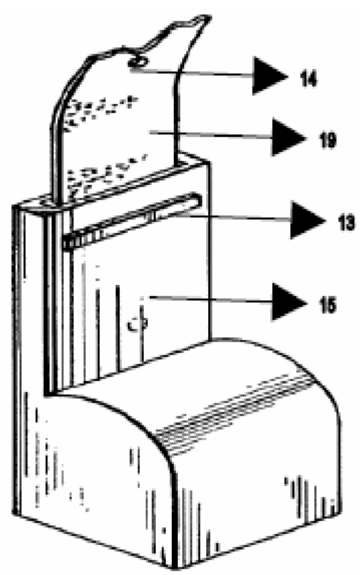

FIG. 8. Seat Belt Extension

Reference is now made to FIGS. **8** and **9**. Illustrated therein are the embodiments for the Seat Belt Extension for determining travel of the movable portion of the seat belt **19** [7] so as to insure it has traveled sufficiently to encircle an occupant. In the embodiment a non-conductible cam **16** is disposed on a threaded spindle **17** that is connected to the recoil shaft **18** of the seat belt **19**.

The threaded spindle **17** may be separate part of it or it is preferred that it is simply a threaded portion of the seat belt shaft **18**. As the movable portion of the seat belt **19** is extended outward, the threaded spindle **17** rotates causing the cam **16**, which is designed so that it cannot rotate, to move laterally away from the seat belt housing until it contacts a switch **20**. It would require one full revolution of such seat belt shaft **18** to cause the cam **16** to move sufficiently in a lateral direction to contact the switch **20**. One full revolution of the seat belt

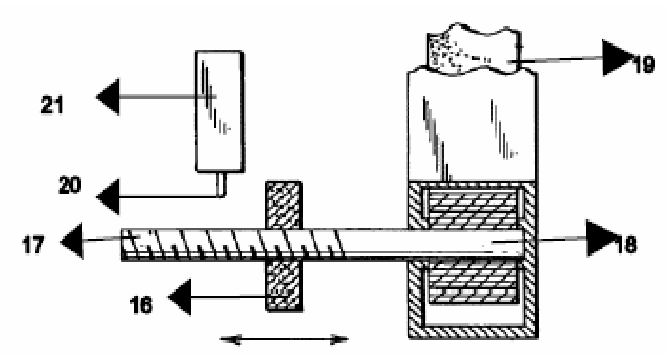

FIG. 9. Apparatus to check sufficient extension of the of the seat belt

shaft **18** would entail movement of the seat belt **19** for approximately four inches. When the switch **20** is tripped by the action of the cam **16** resulting from movement of the male portion of the seat belt **19**, the signal that was sent out indicating that the seat belt **19** had not moved sufficiently to encircle an individual would cease. When the male portion of the seat belt is disengaged and the movable portion of the seat belt **19** is retracted to its housing the threaded spindle **17** to which cam **16** is connected would rotate in the opposite direction causing cam **16** to return to its original position and since it is disengaged from the switch **20** a signal would again be emitted indicating that the male portion of the seat belt **19** is not extended sufficiently. Initially a gear lock inhibits movement of the vehicle. Signals from all the three means are fed into the microprocessor. If the response for all the means is positive then the microprocessor sends a signal to the hardware controller, which in turn disengages the gear lock.

The mechanism for gear lock uses a typical electric solenoid actuator as shown in FIG **10**. It consists of a coil **27**, armature **24**, spring **28**, and stem **26**. The coil **27** is connected to an external current supply **23**. The spring **28** rests on the armature **24** to force it downward. The armature **24** moves vertically inside the coil **27** and transmits its motion through the stem **26** to the valve **25**. When current flows through the coil **27**, a magnetic field forms around it. The magnetic field attracts the armature **24** toward the center of the coil **27**. As the armature **24** moves upward, the spring **28** collapses and the valve **25** opens which unlocks the gear. When the circuit is opened and current stops flowing to the coil **27**, the magnetic field collapses. This allows the spring **28** to expand and shut the valve **25** and the gear is locked again.

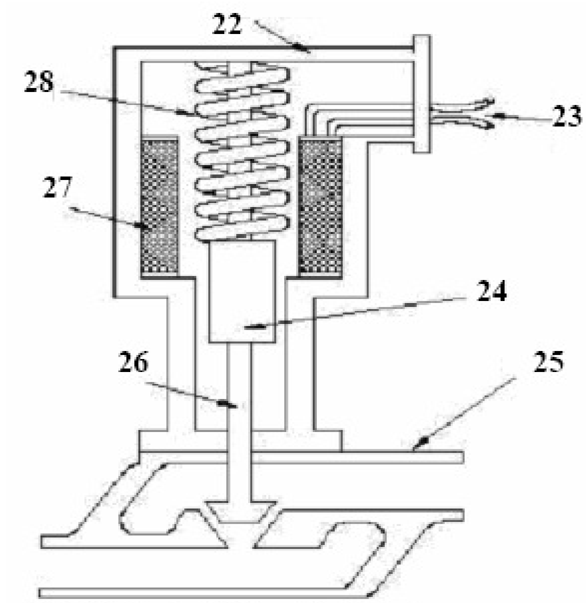

FIG.10. Electric Solenoid Actuator

C. Microprocessor logic

With reference made to FIG. **1** both the blood alcohol detector and the seat belt detector are interfaced through a common microprocessor, which is connected to the hardware controller through lines BA, SB and FLAG. Initially the lines connecting the microprocessor and the hardware controller i.e. BA and SB will be set at zero and flag would be set at one. If the driver passes the blood alcohol test, the line BA becomes high and the hardware controller unlocks the ignition. After this if the driver latches the seat belt and it encircles the driver properly the line SB also becomes high and the hardware controller disengages the gear lock. When both the lines become high the flag is automatically set to zero. Now if the seat belt is unlatched then the hardware controller instead of engaging the gear lock, sends a signal to message center which in turn activates the beeper. The beeper is deactivated if the driver rectifies his act by latching the seat belt. Switching off the ignition can also deactivate the beeper. The system is reset when the driver turns off the ignition.

III. CONCLUSION

The focus of the work was to design an efficient driver safety system that could ensure seat belt usage by the driver and keep a check on his blood alcohol level and inhibit the operation of the vehicle if the latter is above the threshold level.

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