to the status of the brakes, headlights and windshield wipers therefrom, together with the information about the vehicle speed and direction. It is contemplated that the person utilizing the software in the external computer can navigate easily through the data and examine it using on-screen menus. Retrieved data can be saved in, *e.g.*, ASCII format and, perhaps, exported to other software applications running on the external computer 128, or read back in later on by the vehicle data processor 100 for subsequent processing and/or storage.

Also included within the vehicle data processor 100 of the present invention is well-known, commercially-available GPS circuitry 112. In its broadest sense, the GPS circuitry may comprise a signal receiver and transmitter for communicating with various types of satellite or ground-based radio navigation systems, as discussed hereinbefore. The GPS 112 may also include signal processing circuitry which determines the location of the vehicle 104 containing the vehicle data recorder 100 of the present invention from these transmitted radio signals. In the alternative, the microcontroller 144 may operate on the received GPS signals for determining the vehicle location, perhaps by the well-known method of triangulation. While many different types of global positioning systems are commercially-available, it is contemplated that the GPS may comprise the Model Magellan GPS 2000, GPS 4000, or Trailblazer XL. In the alternative, the GPS may comprise the Model Garmin GPS 38, GPS II, GPS 45, or GPS 45 XL. These modern global positioning systems are rapidly decreasing in cost, thereby making them more popular for various consumer applications, such as automobiles.

The primary function of such a GPS 112 is to determine the position, on the earth's surface, of the subject vehicle 104. Once determined, the microcontroller 144 stores this vehicle location continuously in SRAM memory 156. Thus, vehicle location data is also available to the external computer 128 through the serial communication circuitry 196.

However, of significant importance is that the microcontroller 144 can store the location of the vehicle 104 at the exact time of the occurrence of the vehicle abnormal condition, regardless of whether the vehicle is subsequently moved from that position after the occurrence of the abnormal condition. This ability to "freeze" the vehicle location at the time of accident is of significance when reconstructing the vehicle accident and apportioning liability for improper vehicle operation.

Finally, the vehicle data recorder 100 of the present invention includes a radio signal transponder 200 that interfaces with the microcontroller 144. The transponder 200 transmits various information to different notified entities 124. In an exemplary embodiment, the transponder comprises a radio frequency signal generator, that transmits the aforementioned stored data to the appropriate rescue authorities, such as police, fire and/or ambulance personnel.

The transponder 200 may transmit signals indicative of various vehicle conditions that are directly determined from the sensed data. For example, the microcontroller may contain software that determines the severity of the accident, depending upon the largest magnitude of acceleration sensed by any of the three accelerometers 108. In the alternative, other criteria may exist for determining the severity of the accident.

The transponder 200 may simply be a radio frequency transmitter. On the other hand, the transponder may comprise other communication means, such as a cellular phone or citizens band radio. It suffices for the broadest scope of the present invention that the transponder merely comprise some means of transmitting signals indicative of both the sensed vehicle operating parameter data and operating conditions derived therefrom.

Referring now to FIG. 3, there illustrated is a flowchart of software executed by the microcontroller 144 primarily in reading in the sensed vehicle operational data and calculating vehicle velocity therefrom. This routine may represent one of several routines executed by the microcontroller in implementing the functions of the vehicle data recorder 100 of the present invention. For example, as mentioned hereinbefore, the microcontroller may execute software routines that determine the location of the vehicle 104 based on the radio navigation signals sensed by the GPS signal receiver 112. Further, the microcontrollermy execute software which determines parameters such as the severity of the accident from the sensed acceleration data.

With regard to the software routine of FIG. 3, after an enter step 204, the microcontrollermay execute a step 208 in which it retrieves information regarding the calibration set points of the various sensors used in the vehicle data recorder 100 of the present invention. This calibration information may be stored as constants in the E/ROM memory 152.

Next, the microcontroller 144 executes a step 212 in which it initializes various variables stored in the SRAM 156. These variables are utilized in the various calculations that the microcontroller will execute in calculating the various vehicle operational parameters.

The microcontroller 144 then executes a step 216 in which it reads the values of the various sensors utilized with the vehicle data recorder 100 of the present invention. Referring also to FIG. 2, those sensors include the three gyroscopes 136, the three accelerometers 108, the compass 140, the vehicle lights 176 (*e.g.*, headlights, taillights, directional lights, parking lights) , the vehicle brakes 180 and the windshield wipers 184. These values are continuously available to the microcontroller for calculation purposes from both the ADC 132 and the signal processor 188 of FIG. 2.

The microcontroller then executes a step 220 in which it calculates true acceleration by subtracting the "tilt" values, output from each of the three gyroscopes 136, from the corresponding accelerometer output values. As discussed in detail hereinbefore, such subtraction or "decoupling" of the gyroscope data from the accelerometer data results in true acceleration readings output from the three accelerometers 108.

The microcontroller 144 then executes a step 224 in which it calculates vehicle velocity in each of the X, Y and Z directions of vehicle travel. The specific velocity values are calculated by integrating the decoupled acceleration data from the three accelerometers 108.

Next, the microcontroller executes a step 228 in which it increments a counter by a value of one. This counter was initially set to zero in the initialized variables step 212. The purpose of this counter is for the microcontroller to read the sensors and calculate the corresponding acceleration and velocity data ten times before it eventually writes this data to memory.

Next, the microcontroller checks, in a test 232, to see if the counter equals a value of ten. If not, the microcontroller branches back to the step 216 where it reads the sensors and calculates acceleration and velocity. Instead, if the counter does equal ten, the microcontroller then resets the counter to zero, in a step 236, and checks, in a test 240, whether the velocity equals zero. If so, the microcontroller 144 branches back to the step 216 where it reads the sensors and begins the data collection and calculation process over again. Instead, if the velocity does not equal zero, then the microcontroller executes a step 244 where it reads the various sensors. Next, the microcontroller writes the various values of the sensed data to the SRAM memory 156 in a step 248.

The microcontroller 144 then checks, in a test 252, the integrity of the power to the various electronic components within the vehicle data recorder 100 of the present invention. If the power is above a predetermined threshold, the microcontroller then branches to the step 220 where the microcontroller decouples the gyroscope data from the accelerometer data to calculate true vehicle acceleration. The microcontroller then continues on with the routine, as described hereinbefore. Instead, if there is a problem with the power, the routine exits in a step 256.

In general, when the microcontroller 144 writes various data values to the SRAM memory 156, the microcontroller initially writes the data into consecutive memory locations until those locations have been filled. While writing the data to the memory, the microcontroller may stamp or assign the time-of-day to each data value in the manner previously described. Once the memory has been filled by the microcontroller, any new data then gets written over the oldest data. In this way, the memory will always contain the most recent data pertaining to vehicle operation. Depending upon the amount of SRAM memory 156 provided, together with the number of sensors within the vehicle data recorder 100 of the present invention, and the sampling rate of the ADC 132, typically the vehicle data recorder 100 of the present invention can store anywhere from 1 to 5 hours of data for subsequent retrieval and vehicle accident reconstruction.

Generally, vehicle data is continuously recorded during normal vehicle operation. The vehicle data recorder 100 then determines that an accident has occurred when the X-direction accelerometer 108 senses a deceleration value which exceeds a predetermined threshold. For example, it is generally known that, during a typical vehicle accident, a deceleration value of at least 65 Gs will be achieved. Therefore, the software executed by the microcontroller can recognize this threshold as the onset or beginning of an accident and may then restrict the amount of data that is subsequently written to memory once this threshold has occurred. For example, the microcontroller may write data to memory for the next sixty seconds once that predetermined vehicle deceleration value has been achieved.

Generally, when a vehicle accident has occurred, the microcontroller will continue to sense and write data to memory with regard to the vehicle lights 176, brakes 180 and windshield wipers 184. This data collection may occur for a predetermined period of time, or until the vehicle speed equals zero, or until the vehicle power goes below a predetermined threshold. Also, the X-direction accelerometer would continue to have its data written to memory during the entire duration of the accident. However, since both the Y and Z-direction accelerometers have relatively less maximum sensitivity, these accelerometers 108 would typically saturate at some point during a typical accident, and cease to provide useful data. Yet the measured data from these accelerometers, both prior to the crash and somewhat during the time of the crash, would nevertheless be still written to memory, to assist in the accident reconstruction process.

Typically, the microcontroller 144 may determine the relative direction of the vehicle 104 prior to and during any accident by vector summation of the two acceleration components in the X and Y directions. In the alternative, the compass 140 provides an absolute value of vehicle direction.

The vehicle data recorder 100 of the present invention has been described herein for use on an automobile. However, it is to be understood that the vehicle data recorder may be utilized on any type of land, water or air-based vehicle or craft. It suffices for the broadest scope of the present invention that the vehicle data recorder utilize accelerometers that are affected by gravity such that they produce false acceleration readings when the vehicle is inclined. The vehicle data recorder also provides gyroscopes 136 that measure identical values of tilt or inclination of the vehicle data recorder 100, as those values are also measured, undesirably, by the accelerometers 108. The vehicle data recorder 100 of the present invention then utilizes the gyroscope data to "decouple" the false acceleration components from the accelerometer outputs due to the effects of gravity.

It should be understood by those skilled in the art that obvious structural modifications can be made to the embodiments described and illustrated herein without

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