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(54) **Vehicle monitoring system.**

(57) This invention provides a vehicle monitoring system 10 capable of printing out any data recorded by the monitoring system 10 during a journey.

In order to make it possible to produce a compact and effective system, the monitoring system of the invention has a plurality of on-board sensors 12 for measuring various vehicle-operating parameters and an on-board central processing unit (CPU) 14 to which the sensors 12 are operatively connected. An on-board printer 16 is connected to the CPU 14 for printing out data in response to signals processed by the CPU 14.

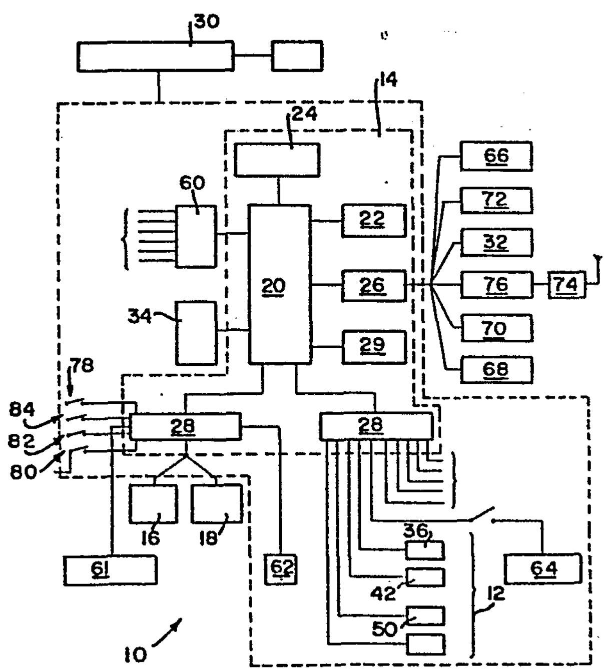

FIG. I

EP 0 129 949 A2

Croydon Printing Company Ltd

VEHICLE MONITORING SYSTEM

THIS INVENTION relates to a vehicle monitoring system and more particularly to an on-board vehicle monitoring system.

Vehicle monitoring systems which record and store data of vehicle operating parameters have been utilized by vehicle fleet operators for vehicle fleet management. Two such examples of these prior art devices are shown in US Patent No. 4 188 618 to Wieshart and US Patent No. 4 258 421 to Juhasz et al.

US Patent No. 4 188 618 discloses a digital tachograph system having digital memory means. Vehicle performance data are stored in a data memory located in the vehicle. Only when the vehicle returns to a base can the information be obtained. This is done by coupling the vehicle to an off-board fixed-base unit. The stored data are then transferred from the vehicle and analysed at an off-board fixed-base unit where the date are read out.

US Patent No. 4 258 421 discloses a vehicle monitoring and recording system. Operating parameters are sensed by a plurality of sensors, and the data obtained by the sensors are then processed and stored in a data recorder. For accessing this data when the vehicle returns to its base, the data must first be transferred to a portable data link, where they are again stored. Finally, the data are transferred to a fixed data processing subsystem by moving the portable data link to and coupling it with the fixed data processing subsystem. The stored data must thus be transferred via a portable data link to remote computing means where they are analysed and printed out.

A disadvantage of these prior art devices is that remote computing and printing devices are required, which are expensive. In the case of fleet operators operating large fleets, the cost of an in-house main frame computer can be offset over a whole fleet. However, in the case of fleet operators operating small fleets, the cost of an in-house main frame computer would tend to raise operating costs to a significant degree, which would raise the end price of their services to the consumer. This would make their costs uncompetitive with respect to fleet operators operating large fleets.

Another significant problem is that downtime of the off-board computer results in the total data from the fleet of vehicles being inaccessible and, possibly, lost.

Accordingly, it is an object of the invention to provide an on-board vehicle monitoring system which is relatively inexpensive in comparison to units known to the Applicant, and which can be utilized by fleet operators operating either large fleets or small fleets, without significantly affecting the operating costs of the fleets or restricting access to information of the whole fleet because of a single computer malfunction.

It is another object of the invention to provide an on-board vehicle monitoring system which is simple to install and which can be adapted to be used in a wide range of vehicles.

It is yet a further object of the invention to provide an on-board vehicle monitoring system having an on-board printer, the printer being capable of being initiated at the end of a journey or after a predetermined period of time to print out any data recorded by the monitoring system during the journey.

According to the invention, there is provided a vehicle having a monitoring system having a plurality of on-board sensors for measuring various vehicle-operating parameters; and an on-board central processing unit (CPU) to which the sensors are operatively connected. The CPU comprises a microprocessor; an erasable programmable read-only memory (EPROM) connected to the microprocessor and in which a central program is stored; a random access memory (RAM) connected to the microprocessor and wherein various vehicle-operating parameters and calibration factors are stored; at least one interface adaptor connected to the microprocessor; an on-board clock circuit for providing clock pulses to the CPU, and also for time-keeping purposes; and means for entering into said CPU various calibration factors as well as various vehicle-operating parameters which are not to be exceeded.

The invention comprises providing an on-board printer connected to the CPU for printing out data in response to signals processed by the

CPU; and means for initiating printing by said on-board printer at or after the end of a vehicle journey for printing out data in response to signals processed by the CPU during the vehicle journey or during a predetermined period of time.

The CPU may include a plurality of interface adaptors. The interface adaptors may be asynchronous communication interface adaptors (ASCIA's) and peripheral interface adaptors (PIA's).

The printer may include a random access memory (RAM), a microprocessor and a read-only memory (ROM) whereby data printed out by the printer are printed in alpha-numeric characters.

The CPU and printer may be housed in a lockable box having a hinged cover, the lockable box being mounted in a suitable position on the vehicle. The cover may include a switch connected to an input terminal of one of the PIA's for initialising the program stored in the EPROM when the cover is closed, and for initiating printing by the printer of the data stored in the RAM during the course of the journey when, at or after the end of a journey, the cover is opened.

A paper feed switch may be connected to an input terminal on one of the PIA's, to advance paper in the printer.

Each on-board sensor may be connected to an input terminal of at least one of the PIA's.

A battery back-up system may be provided to provide power to the CPU and on-board sensors if the vehicle electrical system fails or is disconnected for any reason.

The means for entering the various vehicle operating parameters and calibration factors into the RAM of the CPU may be provided by, a keypad/display unit which is removably connected to an input terminal of one of the ASCIA's.

Monitors may be provided for monitoring vehicle engine parameters comprising at least one of cooling temperature and oil pressure which are fed into the microprocessor via a sixteen channel analogue to digital convertor. A warning lamp may be situated on the dashboard of the vehicle and may be connected to an output terminal of one of the PIA's to be activated in response to one of the parameters being exceeded. An audible signal may be connected to an output terminal of one of the PIA's to be activated in response to one of the parameters being exceeded.

A solenoid switch may be connected to an output terminal of one of the PIA's to switch off the engine if one of the vehicle engine parameters is exceeded for a period in excess of a preset duration. A switch may be connected to an input terminal of one of the PIA's to override the solenoid switch if the solenoid switch is activated while the vehicle is in a potentially dangerous situation. This action would be recorded on the print-out.

A radio may be connected via a modulator/demodulator (MODEM) link to an input terminal of one of the ASCIA's to transmit data processed by the CPU to an in-house main frame computer. Bar codes may be printed on the print-out to transmit data processed by the CPU to an in-house main frame computer.

A driver-operable video display unit (VDU) with an integral keypad may be connected to an input terminal of one of the ASCIA's to enable the driver of the vehicle to enter into the CPU data of any delivery transactions effected en route.

A card reader for reading a plastic card which is punched or which has a magnetic strip embedded therein, may be connected to an input terminal of one of the ASCIA's to enable the driver of the vehicle to sign on and off.

An embodiment of the invention will be described, by way of example, with reference to the accompanying drawings, in which

Figure 1 is a schematic block diagram of a vehicle monitoring system;

Figure 2 to 5 show distance and speed sensor connections of the system;

Figure 6 shows a fuel-measuring sensor;

Figure 7 shows a printer of the system; and

Figure 8 is a schematic illustration of components of the system in a cab of a vehicle.

An on-board vehicle monitoring system in accordance with the invention is designated generally by reference numeral 10. The vehicle monitoring system 10 comprises a plurality of sensors 12 which can measure various vehicle operating parameters and transmit these parameters to a central processing unit (CPU) 14 in a cab 13 of a vehicle, where these signals can be processed. The CPU 14 is connected to a printer 16 which is housed in a lockable box and/or a recording unit 18 so that processed signals can either be printed out on the printer 16 or recorded on tape via the recording unit 18 in the form of a cassette tape unit.

The CPU 14 is located in a box 15 in the vehicle cab 13 and comprises a microprocessor 20 having erasable programmable read-only memory (EPROM) 22, in which a central program is stored, an internal random accessory memory (RAM) 24 wherein various vehicle operating parameters and calibration factors are stored, one or more asynchronous communication interface adaptors (ASCIA's) 26 (only one being shown), and one or more peripheral interface adaptors (PIA's) 28 (two being shown) connected to the microprocessor 20. Both the ASCIA's 26 and the PIA's 28 may have a plurality of input terminals and output terminals. A clock circuit 29 is also included and is utilized to provide clock pulses to the CPU 14 also for time-keeping purposes.

The vehicle monitoring system 10 can normally be powered by the electrical power system of the vehicle, but further includes a battery back-up system 30. This battery back-up system 30 can be used when the vehicle battery is disconnected for any reason. The battery back-up system is connected only to power the CPU 14 and the sensors 12 so that, if the vehicle's electrical system fails, data can be recorded and retained in the internal RAM 24 of the CPU 14. Upon reconnection of the vehicle's battery, this recorded data can either be printed out on the printer 16 or recorded by the cassette tape unit 18. The time at which the battery was disconnected can also be recorded and retained, and details fed out when the vehicle's battery is reconnected.

A key pad/display unit 32 in the box 15 is connected to one of the input terminals of one of the ASCIA's 26. Various vehicle parameter limits which are not to be exceeded, can be entered into the RAM 24 via the key pad/display unit 32. These vehicle parameter limits can include the following: over-speeding or over-revving; excessive acceleration or deceleration; maximum idling time; maximum fuel consumption; freewheeling; battery power failure (as described above); and start and stop times. The operation of the system 10, having regard to these parameters, will be described in more detail hereafter. The box is then locked to prevent the driver from having access to the unit 32.

The vehicle sensors 12 will now be described in greater detail. Referring to Figure 2, there is shown a schematic diagram of a distance sensor 36 in use. The distance sensor used is of a commercially available type. A vehicle's speedometer cable 38 is removed from the gearbox 40 of the vehicle, and the distance sensor 36 is then screwed into the gearbox 40 where the speedometer cable 38 originally entered the gearbox 40. The speedometer cable is then screwed into the other end of the distance sensor 36. Alternatively, as shown in Figure 3, the distance sensor 36 may be spliced into the speedometer cable 38 at the end of the cable, near where it enters the gearbox 40.

A vehicle engine speed sensor 42 (RPM sensor) is shown in use in Figure 4. Certain vehicles have a power take-off point 46 provided on their engines 44. The RPM sensor 42 may be screwed into this point. This gives a reading of one-half of the engine speed and the system 10 must be calibrated accordingly. Alternatively, as shown in Figure 5, if no power take-off point 46 is provided, the RPM sensor 42 may be attached to a D-terminal of a vehicle's alternator 48. If no D-terminal is provided, one can be fitted prior to installation of the RPM sensor 42.

Referring now to Figure 6, there is shown a fuel-measuring sensor 50 for use with the system 10. Heavy diesel engines having injector pumps 52 make use of fuel to cool and lubricate the injector pump 52. This fuel is conveyed back to a fuel tank 54 of the vehicle for re-use. Hence, when measuring the fuel usage of heavy diesel engines, two sensors are required, one sensor 50.1 in a line 56 conveying fuel to the engine, and another sensor 50.2 in a line 58 which conveys fuel back from the injector pump 52 to the fuel tank 54. Signals from the two sensors 50.1, 50.2, which are each connected to input terminals of one of the PIA's, are fed via the PIA 28 into the microprocessor 20 where they are processed and the fuel usage is determined. When the system is used on petrol engines, only one sensor is required as in this case no fuel is used to cool the injector pump. On light diesel engines, one flow sensor is used due to the fact that the return flow is minimal. The return flow is redirected back to the inlet line through a cooling and degassing tank and then used by the engine. The cooling and degassing tank is a commercially available unit.

If desired, various other vehicle parameters, such as coolant temperature, oil pressure, vehicle location, and the like, may be fed into the microprocessor 20 via a 16-channel analogue to digital convertor 60 connected to the microprocessor 20. Alternatively, these parameters may be converted into digital signals and fed into the microprocessor 20 via input terminals of one of the PIA's 28. Warning lamps and/or audible signals 61 can be connected to output terminals of one of the PIA's 28, and these may be activated in response to one of these parameters being exceeded.

A solenoid switch 62 is also provided to operate when one of the vehicle parameters is exceeded for a certain period of time, eg if the oil pressure remains low for too long. This solenoid switch 62, which is connected to an output terminal on one of the PIA's 28, switches off the engine of the vehicle. A switch 64 is connected to an input terminal of one of the PIA's 28, and this switch can be used by the vehicle driver to override the solenoid switch 62. For example, if the vehicle is being decelerated by the effect of engine braking while descending a slope, and the solenoid switch 62 cuts off the engine, the driver can then operate the switch 64 to de-activate the solenoid switch 62.

A video display unit (VDU) 66 may be connected via an input terminal of one of the ASCIA's 26 to the microprocessor 20. This unit 66, which is driver-operable, is used to enter data into the CPU 14. For example, a driver who delivers a quantity of goods to a customer, could enter the customer name and number, quantity of goods delivered, etc., into the CPU 14 via the VDU 66. The CPU 14 can then process this data and print out an invoice on a printer 68. Details of the transaction could also be recorded on a tape unit 70 for processing when the vehicle returns to base.

A card reader 72, which reads a plastic card (not shown) which is either punched or has a magnetic strip embedded in it, can be connected to an input terminal of one of the ASCIA's 26. The card reader 72 is used by the driver to sign on and off and can be used, for example, to determine the time worked by the driver in determining his wages.

This card reader 72 can also be used for security purposes or to turn the vehicle on and off.

If desired, a radio 74 may be connected via a modulator/demodulator (Modem) link 76 to an input terminal of one of the ASCIA's 26. The radio 74 may transmit all data processed by the CPU 14, ie data which is printed out on printer 16, recorded on tape unit 18, or retained in removable RAM 34. The radio 74 may also be used to capture the transaction described with regard to the VDU 66 above, and transmit it to an in-house main frame computer. In addition, the radio can be used to direct vehicle driver operations.

Finally, a paper feed switch 84, connected to an input terminal of one of the PIA's, is provided to advance the paper in the printer 16.

Vehicle operational data measured by the sensors 12, which are connected to input terminals of one of the PIA's 28, is fed into the microprocessor 20 via the PIA 28. These data are then processed by the microprocessor 20, utilizing the central program which is stored in the EPROM 22. The data are compared with the pre-entered vehicle parameter limits stored in the RAM 24. If any of these pre-entered limits is exceeded, this is then reported via the microprocessor 20 and is either printed out on the printer 16 or recorded on the cassette tape unit 18, both of which are connected to output terminals on one of the PIA's. If desired, the deviations from the pre-entered limits may be recorded in removable RAM 34. The RAM 34 may then be removed and processed remote from the vehicle, when the vehicle returns to its base.

Having regard to the sensors described above, the vehicle parameter limits are measured and set as follows:

Over-speeding:
This is specified in km/h or mph and is usually set at a figure slightly higher than the actual speed limit. This parameter is measured by the distance sensor 36 and the clock 29, and is converted accordingly by the microprocessor 20, utilizing the program stored in the EPROM 22.

Over-revving: This is specified in RPM and is measured by the RPM sensor 42 and the clock 29. This figure can be set at the discretion of the user.

Excessive Acceleration and Deceleration: These are both specified in km/h per second, or mph per second, ie the maximum rate of change of speed in one second. This is usually achieved in first gear, a figure of 15 km/h per second being frequently used in light delivery vehicles. Once again, use is made of the distance sensor 36 and the clock 29, and the measured value is converted accordingly by the microprocessor 20 as described above.

Maximum Idling Time:
This figure, measured by the clock 29, is specified in seconds and is used to curb fuel wastage and unscheduled stops. An average figure could be 90

seconds although this may vary, depending on the wishes of the vehicle fleet operator.

Maximum Fuel Consumption: This figure is specified in litres per second per RPM, and in this case the fuel sensor 50, the RPM sensor 42, and the clock 29 are used in the calculation of this parameter. In place of litres, the system 10 can be calibrated to measure in Imperial gallons or US gallons.

Freewheeling: This figure is specified in km/h per RPM, or mph per RPM, and use is made of the distance sensor 36, the RPM sensor 42, and the clock 29.

Start and Stop:
These are determined from the clock 29 and the information is used to print the time when a vehicle starts and stops, respectively. These data are also used for delivery checking if the vehicle is used for delivery purposes.

Prior to the use of the system 10, after its installation in a vehicle, the system 10 must be calibrated for use with that particular vehicle. This may be done either by the vehicle fleet operator or by the installer of the system 10.

Once calibration factors for the vehicle have been determined, these calibration factors are read into the internal RAM 24 of the CPU 14 via the keypad/display unit 32.

A switch 78 is provided in a cover of the printer 16 and connected to an input terminal of one of the PIA's. When the cover is closed by the vehicle fleet operator, the program stored in the EPROM 22 of the CPU 14 is initialized, and a header to the program, as designated by A in Table I, is printed out. While the vehicle is in operation, the sensors 12 monitor its operation and if any of the parameter limits stored in RAM 24 are exceeded, these 'incidents' are printed out, as shown by B in Table I. In addition, a data print is included in the print-out setting out the code and time of the 'incident'. The data print comprises the following: time, speed, RPM, and fuel consumption. From these figures, an accurate analysis of the 'incident' can be made.

When the vehicle returns to base, the fleet operator can open the cover of the printer and this intiates that portion of the program to print out a summary as designated by C in Table I, by means of switch 80 connected to an input of one of the PIA's. All that would appear on the print-out would be that data shown in column 2, ie the numerical code. If, however, a printer 16 as shown in Figure 7 having its own RAM 86, microprocessor 88, and ROM 90, were to be used, the print-out would appear as in Table II, ie with alpha-numeric characters. In this case, A, B and C refer to the same portions of the print-out as described above, except that the data print is abbreviated in portion B of Table II.

Instead of the cover having to be opened each time a summary is required, the system 10 can be programmed to print out a summary at a certain time of the day, everyday, eg at 5 pm. That portion of Table II marked C could then be headed 'AUTO-SUMMARY'. It is also possible to program the system 10 to give a summary to date which would give a weekly or monthly summary, as the case may be. Similarly, the summary to date can be printed automatically on, say, a certain day of each month, eg the 25th of each month. Portion C could then be headed 'SUMMARY TO DATE' or 'AUTO-SUMMARY TO DATE', as the case may be. The line reading 'Date' could then be replaced by 'DATE L' which stands for Date Last, ie the last day on which a summary had been printed out.

The system 10 can also automatically print out an accident report. An accident report switch 82 connected to an input terminal of one of the PIA's, is provided which initiates the system 10 when the vehicle is subject to extremely rapid deceleration. The accident report prints out the last ten seconds of the vehicle's activity prior to the rapid deceleration.

Hence, using Table I, as an example, the information can be analysed from the trip print-out as follows:

The vehicle started its trip at 11h49, as can be seen by ..1, which is the start code immediately beneath the part designated A, the vehicle then travelled without incident until 11h53 when the vehicle over-revved, as shown by ..3, which is the over-rev code, in the upper part designated B. Attached to this code is the data print-out which says that the vehicle, at 11h53, was travelling at 3 km/h, exceeding the rev limit which was set at 5000 RPM by doing 5124 RPM, and that the fuel efficiency was 21 litres per 100 kilometers. As the vehicle used in the test was a light passenger car, it would not be possible to do 3 km/h at 5124 RPM even in first gear, it would indicate that the driver revved the engine excessively when engaging the clutch.

Again, at 11h53, in the second part designated B, we see the driver again over-revved the engine by doing 5046 RPM at a speed of 51 km/h, the fuel consumption being 21 litres per 100 kilometres. He then travelled within limits until he stopped at 12h00, as indicated by ..0, which is the code for stop, in the third part designated B.

The summary indicates that the vehicle was in motion for 6 minutes, idling for 3 minutes, the driver over-revved the vehicle twice, started once, and stopped once. He used 0,3 litres of fuel, travelled 4,4 kilometers at an average speed of 38,5 km/h. The fuel efficiency was 12,8 kilometres per litre, or 7,8 litres per 100 kilometres.

The trip, whether of 10 minutes duration or of 10 hours duration, will produce a similar summary print-out but including appropriate data.

Reg or fleet no.	372504. =	
Opening Km.	4972.0 =	
Time	1149..1 =	Start
Time	1149.0 =	Speed
R.P.M.	0.384.9999 =	ℓ/100 Km
Time	1153..3 =	Over-rev
Time	1153.3 =	Speed
R.P.M.	5.124.21 =	ℓ/100 Km
Time	1153.3 =	Speed
R.P.M.	5.124.21 =	ℓ/100 Km
Time	1153..3 =	Over-rev
Time	1153.51 =	Speed
R.P.M.	5.046.21 =	ℓ/100 Km
Time	1153.51 =	Speed
R.P.M.	5.046.21 =	ℓ/100 Km
Time	1200..0 =	Stop
Time	1200.0 =	Speed
R.P.M.	0.000.9999 =	ℓ/100 Km

SUMMARY		
Total Running time	0006 =	
Total idling time	0003 =	
Total stationary time	0000 =	
Incident total	0..2 =	Over-speed
Incident total	2..3 =	Over-rev
Incident total	0..4 =	Excessive acceleration
Incident total	0..5 =	Excessive deceleration
Incident total	0..7 =	Excessive idling
Incident total	1..1 =	Starts
Incident total	1..0 =	Stops
Incident total	0..6 =	Freewheeling
Incident total	0..9 =	Battery disconnection
Factor flowmeter 1	(0.5000 =)	
Factor flowmeter 2	(0.0000 =)	
Factor distance sensor	(0.4600 =)	
Factor R.P.M. sensor	(0.1000 =)	
ℓ Used	0.3 =	
Opening kilometers	4972.0 =	
Kilometers travelled	4.4 =	
Closing kilometers	4976.4 =	
Average Speed	38.5 =	
Fuel efficiency (km/ℓ)	12.8 =	
Fuel efficiency (ℓ/100Km)	7.8 =	
Reg no or fleet no.	372504.=	

TABLE I

Reg:	CSB097T
Date:	84/01/23
Time:	07H35
Op Km:	113425.6
Start:	11H49
Over-rev:	5124
Duration:	00003
Time:	11H53
Over-rev:	00002
Duration	00002
Time:	11H53
Stop:	12H00

SUMMARY

Reg:	CSB097T
Date:	84/01/23
Time:	12H40
Run Tim:	000H07
Idl Tim:	000H04
St Tim:	004H54
%Utiliz:	003.6
Fuel U:	0.3
Km/ℓ:	12.8
ℓ/100Km:	7.8
Av Speed:	38.5
Km Tr:	4.4
Op Km:	113425.6
En Km:	113430.0

INCIDENTS

Ov Speed:	000
Ov Rev:	002
Ex Acc:	000
Ex Dec:	000
Ex Fuel:	000
Freewhl:	000
Trips:	001
Batt Dis:	000
Ext 1:	000
Ext 2:	000

TABLE II

CLAIMS

1. An on-board vehicle monitoring system which includes; a plurality of on-board sensors for measuring various vehicle-operating parameters; an on-board central processing unit (CPU) to which the sensors are operatively connected; an on-board clock circuit for providing clock pulses to the CPU, and also for time-keeping purposes; means for entering into said CPU various calibration factors as well as various vehicle-operating parameters which are not to be exceeded; an on-board printer connected to the CPU for printing out data in response to signals processed by the CPU; and means for initiating printing by said on-board printer at or after the end of a vehicle journey for printing out data in response to signals processed by the CPU during the vehicle journey or during a predetermined period of time.

2. An on-board vehicle monitoring system as claimed in Claim 1 wherein the on-board sensors comprise means to measure at least one of:

speed of the vehicle; revolutions per minute of an engine of the vehicle; vehicle acceleration; vehicle deceleration; vehicle idling time; fuel consumption; and vehicle start and stop times.

3. An on-board vehicle monitoring system as claimed in Claim 1 or Claim 2 wherein the CPU

includes; a microprocessor; an erasable programmable read-only memory (EPROM) connected to the microprocessor and in which a central program is stored; a random access memory (RAM) connected to the microprocessor and wherein various vehicle-operating parameters and calibration factors are stored; and at least one interface adaptor connected to the microprocessor.

4. An on-board vehicle monitoring system as claimed in Claim 3 wherein the CPU includes a plurality of interface adaptors.

5. An on-board vehicle monitoring system as claimed in Claim 4 wherein the interface adaptors are asynchronous communication interface adaptors (ASCIA's) and peripheral interface adaptors (PIA's).

6. An on-board vehicle monitoring system as claimed in any one of the preceding claims wherein the printer includes a random access memory (RAM), a microprocessor and read-only memory (ROM) whereby data printed out by the printer are printed in alpha-numeric characters.

7. An on-board vehicle monitoring system as claimed in any one of the preceding claims wherein the CPU and printer are housed in a lockable box having a hinged cover, the lockable box being mounted in a suitable position on the vehicle.

8. An on-board vehicle monitoring system as claimed in Claim 7, insofar as it is dependant on Claim 5, wherein the cover includes a switch

connected to an input terminal of one of the PIA's for initialising the program stored in the EPROM when the cover is closed, and for intiating printing by the printer of the data stored in the RAM during the course of the journey when, at or after the end of a journey, the cover is opened.

9. An on-board vehicle monitoring system as claimed in Claim 5 wherein a paper feed switch is connected to an input terminal of one of the PIA's, to advance paper in the printer.

10. An on-board vehicle monitoring system as claimed in Claim 5 wherein each on-board sensor is connected to an input terminal of at least one of the PIA's.

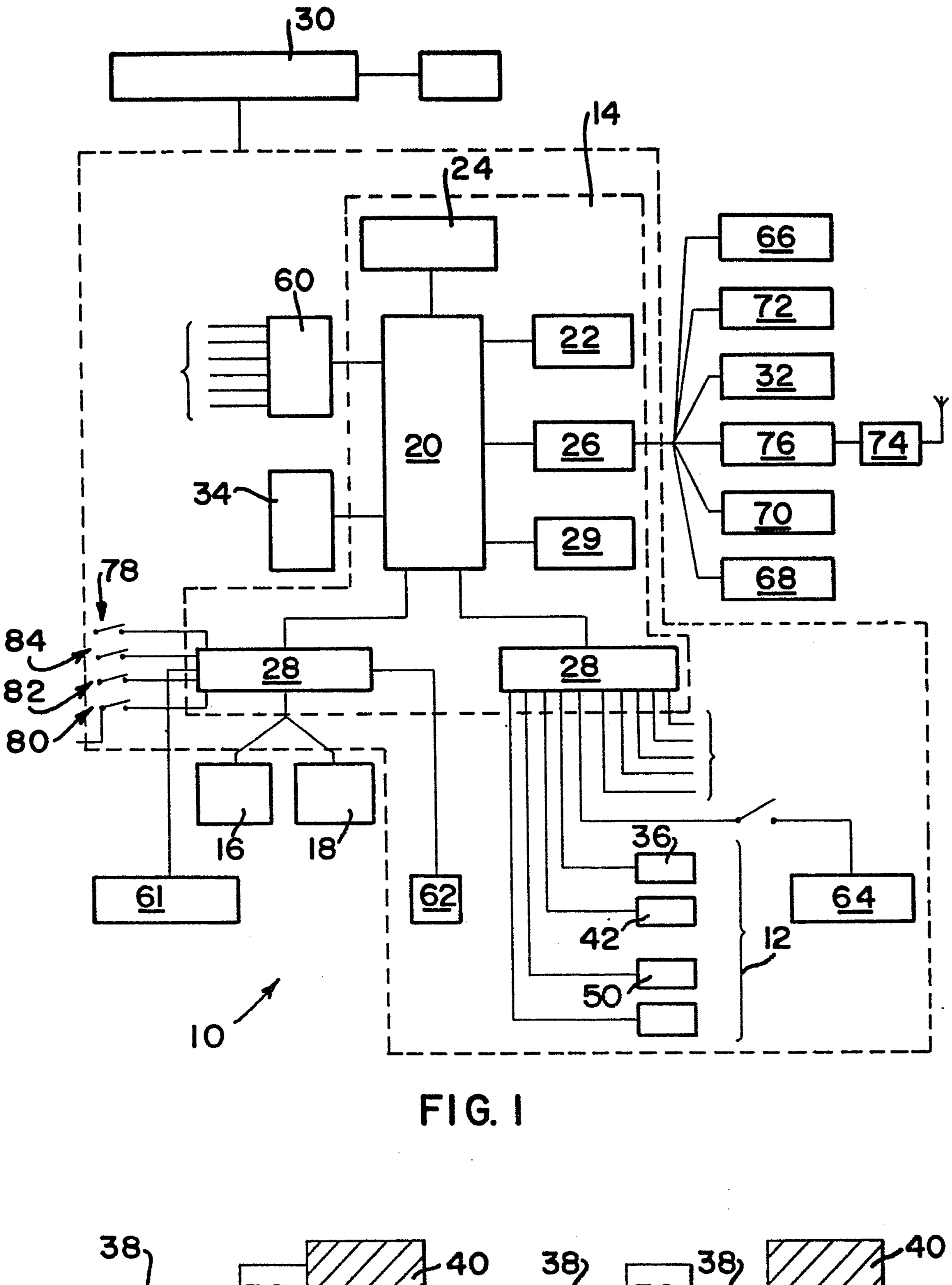

FIG. 1

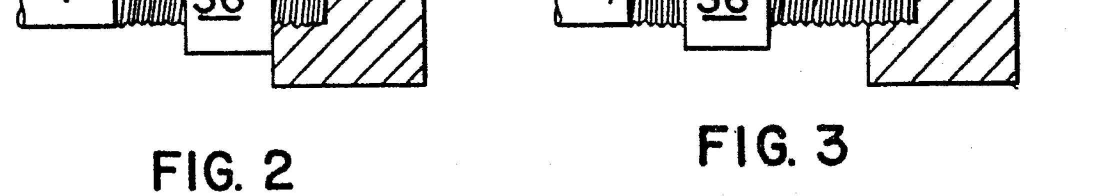

FIG. 2

FIG. 3

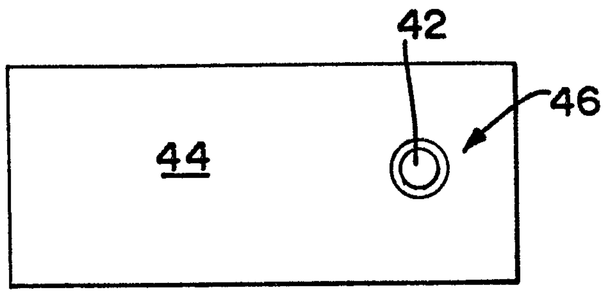

FIG. 4

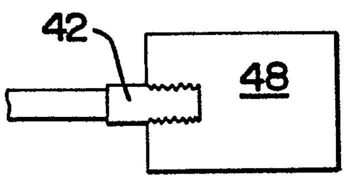

FIG. 5

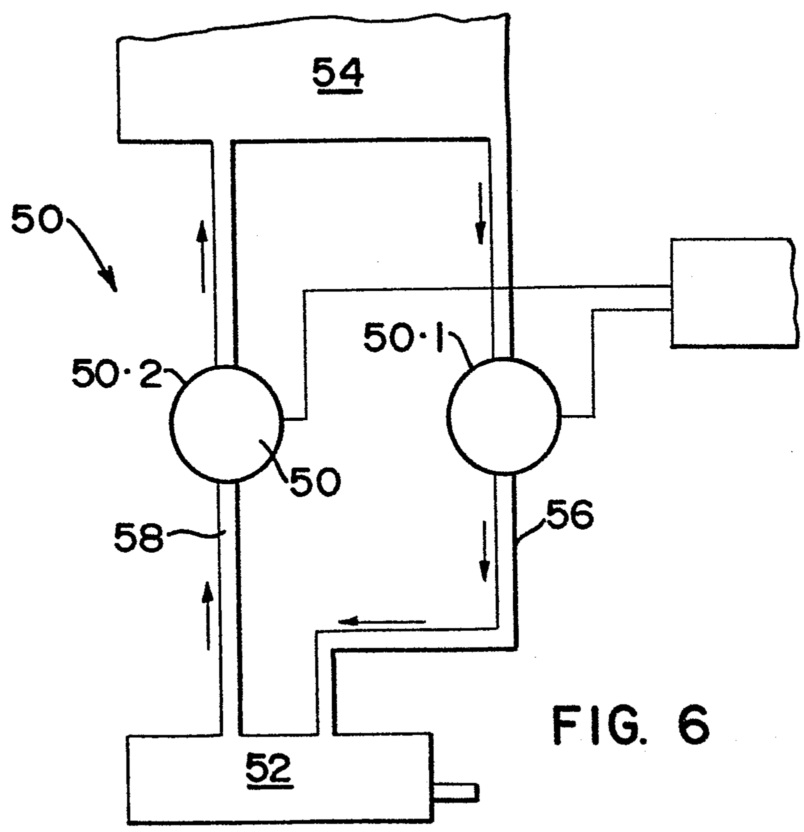

FIG. 6

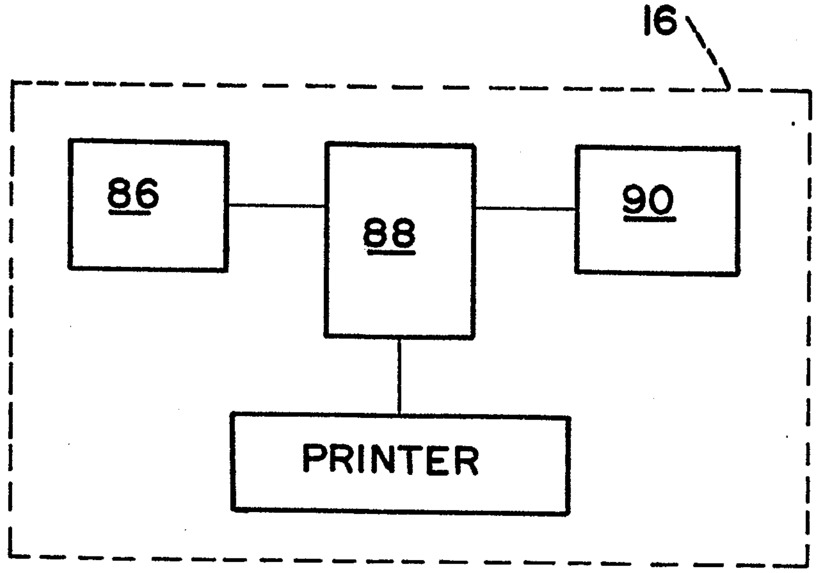

FIG. 7

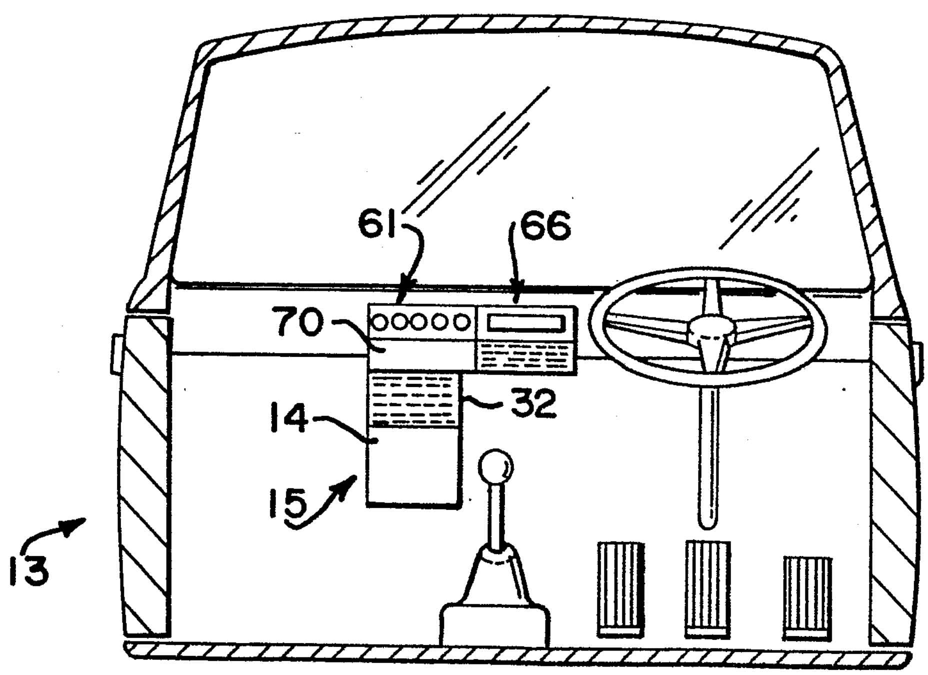

FIG. 8