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[54] **MICRO-COMPUTER SYSTEM FOR CONTROL AND DIAGNOSIS OF MOTOR VEHICLE FUNCTIONS**

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[52] **U.S. Cl.** **364/431;** 364/424; 73/116; 123/417; 324/379

[58] **Field of Search** ..... 364/424, 425, 551, 200, 364/900, 431; 324/378–380; 73/116, 117.2, 117.3; 340/151, 52 F, 53; 123/117 D, 32 EA, 32 EB

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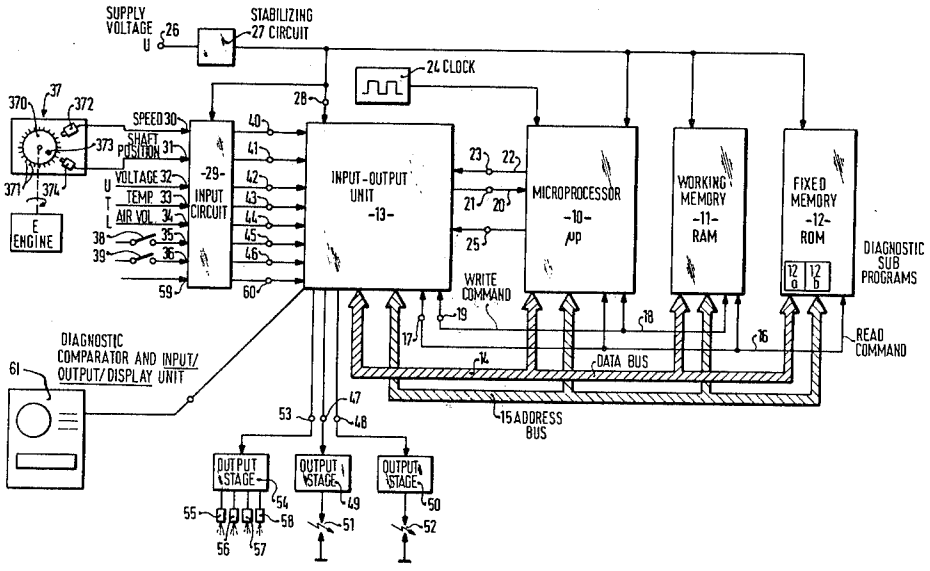
[57] **ABSTRACT**

In order to permit diagnosis of operation and function parameters in a motor vehicle which is equipped with an electronic microprocessor control system without the necessity of providing in the diagnostic equipment substantial additional memory capability, the control system includes a sub-program for diagnosis. A first subprogram executed by the control system in response to a command from the diagnostic equipment gives the appropriate actual operational data to the diagnostic equipment. A second subprogram simulates nominal values for specific vehicle data under various operating conditions and compares these with the actual values. The resulting information is given to an operator by a display and can additionally include various instructions, e.g. repair instructions or a trouble shooting sequence based on the diagnosis.

9 Claims, 2 Drawing Figures



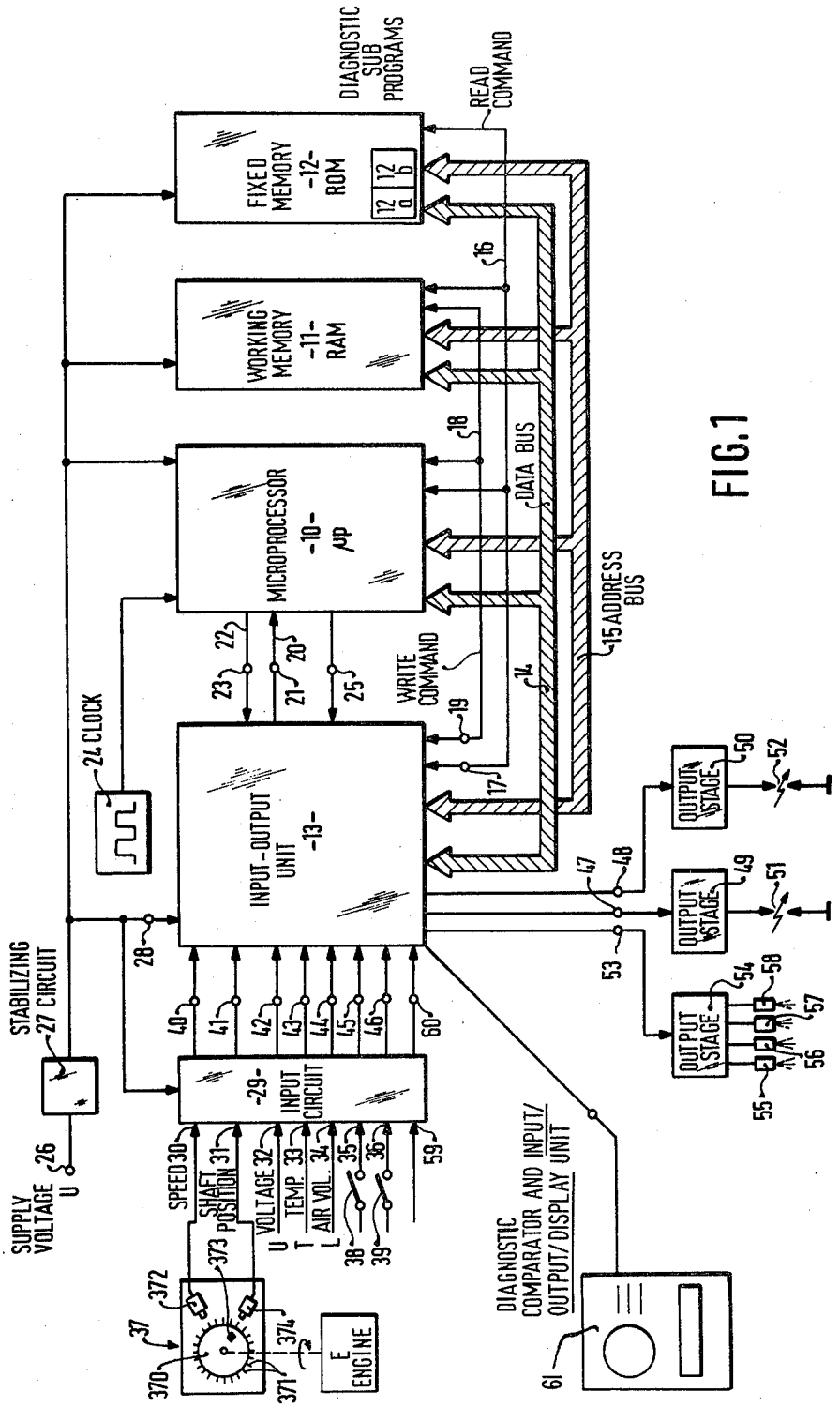


FIG.1

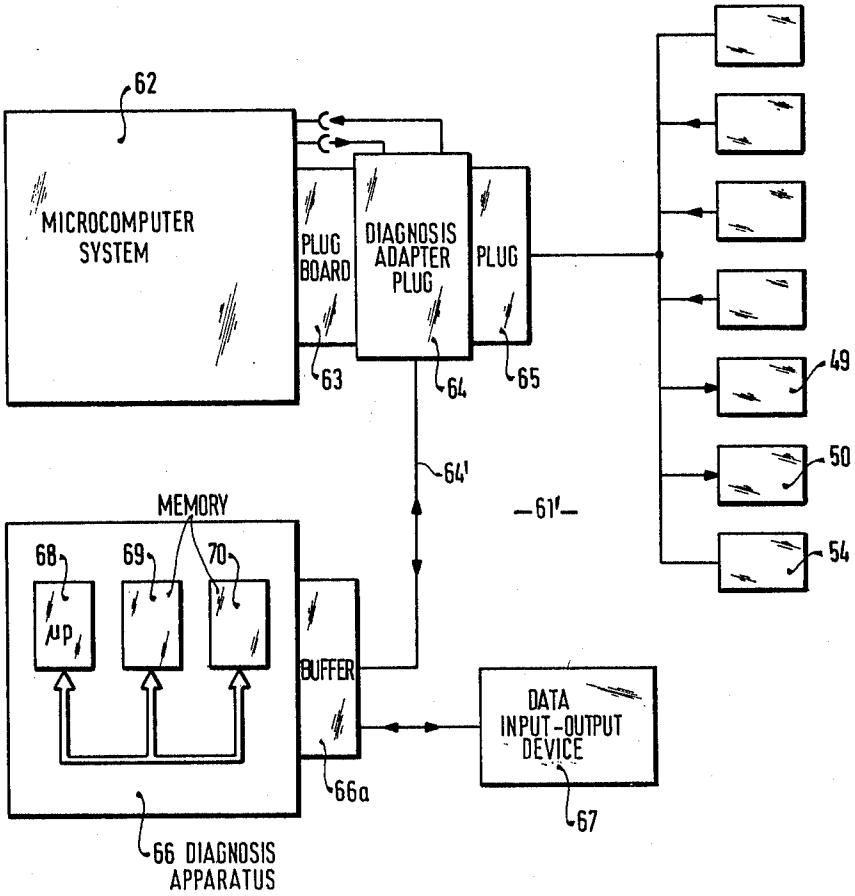


FIG. 2

MICRO-COMPUTER SYSTEM FOR CONTROL AND DIAGNOSIS OF MOTOR VEHICLE FUNCTIONS

The present invention relates to a motor vehicle control apparatus which has a micro-processor to control operating functions, and more particularly to apparatus which can be used for diagnosis of the functions of the vehicle.

BACKGROUND AND PRIOR ART

Micro-processor controls for automobiles and other motor vehicles are known and are described, for example, in the following technical literature: "Electronics", Jan. 20, 1977, page 102 ff; "Electronic Design", No. 1, Jan. 4, 1977, p. 34 ff; SAE-paper No. 750432, "Application of Microprocessors to the Automobile", p. 65 ff; "Elektrotechnische Zeitschrift", vol. 28, 1976, No. 15, p. 496 ff; "Computer", August 1974, page 33 ff.

In addition, hard-wired calculators for controlling the functions in a motor vehicle or in a combustion engine are known, e.g. from the U.S. Pat. No. 4,082,069 (corresponding to U.S. application Ser. No. 660,858, filed Feb. 24, 1976), MAYER et al.

Diagnostic equipment for connection to sensors in motor vehicles is known. Such diagnostic equipment is connected by means of an intermediate plug which can be plugged into a matching socket in the vehicle. The sensors deliver their signals directly to the diagnostic equipment. There, after being converted, shaped and processed, if necessary, these signals are displayed or processed further. Such diagnostic equipment often is complex and costly and is generally suited only for checking relatively few operational parameters or sensors in the powered vehicle.

THE INVENTION

It is an object to provide an apparatus for controlling motor vehicle functions which are dependent on operational parameters and are repeated, especially those serving to determine the ignition, the injection of fuel, and possibly other functions, and monitoring the effectiveness of the controller.

Briefly, a micro-computer system of the vehicle and installed thereon has an on-board microprocessor connected by a data bus and an addressing bus to each of at least a fixed-value memory (Read-only memory—ROM, programmable read-only memory—PROM; eraseable PROM-EPROM), a working memory (Random Access Memory—RAM), and an input-output unit to which there are connected control elements to control operation of vehicle functional elements, the internal or external signal sources to provide signals to the microprocessor, and preparation circuits for signals dependent on operational parameters. All these elements are part of the operational, functional, and control components of the motor vehicle itself. The input-/output unit, including a process-channel mechanism of the micro-computer system is connected to diagnostic equipment through which it can be given a diagnosis command, so that specific vehicle data in accordance with a diagnostic program can be given to the diagnostic equipment. The system includes apparatus to furnish a subprogram which can take data stored in the memory against which actual operations are checked to thereby derive diagnostic data.

The apparatus in accordance with the invention has the advantage that motor vehicles which are equipped with a microcomputer system can be checked relatively simple. The subprogram in the main program permits interrogation or checking of various sensing locations and the corresponding values can then be displayed or further processed.

The diagnostic subprogram thereby requires only a limited number of storage places in the already present memories of the micro-computer system.

The number of storage places needed in the micro-computer system of the vehicle can be substantially reduced by using diagnostic equipment in combination with a control device with a micro-processor and a memory connected thereto since the required diagnostic program can in large part also be put into these memories.

Drawings, illustrating a preferred embodiment, wherein:

FIG. **1** is a simplified block circuit diagram of a micro-computer system for a motor vehicle with diagnostic equipment connected to an input/output unit;

FIG. **2** is a simplified block circuit diagram of a micro-computer system with diagnostic equipment connected thereto which has output units capable of working from a diagnosis program.

In the micro-computer system illustrated in FIG. **1**, a microprocessor **10** is connected through a data bus **14** and an address bus **15** to a working memory (RAM) **11**, a fixed value memory (ROM, PROM or EPROM) **12**, and an input/output unit **13**. Depending upon the content of the information to be transmitted, or upon the number of addresses which can be selected, the data bus **14** can consist of, e.g. **8** individual lines and the address bus **15** can consist of, e.g. **16** individual lines. A read-command line **16** which connects the component elements **10** to **12** is connected by a terminal **17** with the input/output unit **13** and serves to read-out applied or stored information. A write-command line **18** connecting the component elements **10, 11** is likewise connected by a terminal **19** to the input/output unit **13** and serves to read-in information into the memory **11**. A program interrupt-command line **20** leads from the input/output unit **13** over a terminal **21** to the microprocessor **10**. This line serves to interrupt a program just running in the microprocessor upon presence of previously predetermined information. A clear-command line **22** leads from the microprocessor over a terminal **23** to the input-/output unit **13**. It serves to provide certain initial conditions, e.g. for the beginning of a program. A frequency generator **24** is connected with the microprocessor **10** via a terminal **25** to provide this component with a basic time or clock frequency. A frequency, preferably derived from the clock by division, is connected from processor **10** preferably via a terminal **25** to the input/output unit **13**. A terminal **26** leading to a supply voltage is connected to a stabilizing circuit **27**. The stabilized output voltage of this circuit is led to a terminal **28**, as well as to various component elements which have electronic circuit equipment.

An input circuit **29** has eight inputs **30** to **36** and **59** which are connected to external signal sources. The input **59** can thus be connected, e.g. with a simple switch which gives a diagnosis command to the micro-computer system. The instantantaneous condition, e.g. of an internal combustion engine, is reported to the computer system by means of the signal source. A transducer arrangement **37** is connected with the inputs **30**,

31. Transducer 37 has a star-wheel 370 which is coupled to the crankshaft of a combustion engine E; it has a plurality of teeth or projections 371 arranged on its periphery. These teeth are sensed by a first pickup 372. Each ferromagnetic tooth generates a flux change in the inductive pickup 372 which results in a voltage signal. The resulting signal, which is dependent upon the speed of rotation, is fed to the input 30. A reference marker 373 is provided on the wheel 370. The reference marker 373 is sensed by a second pickup 374 and the reference mark or crankshaft position signal is fed to the input 31. Further information from the combustion engine or the vehicle with which it is used is applied to the inputs 32 to 36. Input 32 provides a supply voltage U signal; Input 33 a temperature T signal; input 34 intake air volume (per unit time) L signal; input 35 throttle plate setting signal, e.g. by a switch 38, and input 39 a signal representative of position of the starting switch of the engine. The extent of the operational conditions of the engine can be expanded as desired and is not limited to the information presented above, e.g. may include exhaust gas data.

The presented input function signals at the inputs 30 to 36 are processed, noise limited, or filtered, and digitalized in the input circuit as necessary. At the output side this information is led via the terminals 40 to 46 and 60 to the input/output unit 13. To the extent that the information is presented in analog form at the input circuit 29, it is converted into digital signals by means of one or more analog-digital converters in the input circuit 29. Signal wave shaping can also be carried out, e.g. by Schmitt triggers. Two end stage outputs of the input-/output unit are connected via terminals 47, 48 with switching end stages 49, 50 which are designed as ignition output stages. Such ignition output stages include, in a known manner, a semiconductor switch in the primary circuit of an ignition coil system. At least one ignition path 51, 52 or one spark plug is connected in the secondary current circuit of the ignition system. A further output switching stage 54 for controlling fuel injection through injection valves 55 to 58 (four are illustrated) is likewise connected to the input/output unit 13. Further functions of the motor vehicle can also be controlled or regulated by the input/output unit 13, for example an electronic transmission control, a vehicle brake, or a level control, or other controlled functions.

OPERATION

The general mode of operation of a microprocessor system such as that presented here is readily apparent to those skilled in the art. Reference is made to DE-OS No. 2732781 (corresponding to U.S. application Ser. No. 916,827, filed June 19, 1978, now U.S. Pat. No. 4,204,256, May 20, 1980 Klötzner assigned to the assignee of this application).

Information applied externally to the input/output unit 13 is processed together with fixed memory information by the microprocessor 10, within the scope of a program stored in the fixed memory 12. The computed results which here are the signals for controlling the ignition and for fuel injection, are transferred to the output switching stages 49, 50, 54 and used for carrying out the desired switching commands. Final and intermediate values are in part stored in the working memory 11 and then retrieved and processed as necessary by the microprocessor, as known.

The number of microprocessors, fixed value memories, and working memories used is not limited by the illustration of FIG. 1, but can be expanded as desired, independently of the information to be processed, the scope of the program, and the scope of the stored data. The number is, of course, dependent on the type of components used in each case, or on their operational and memory capabilities.

In accordance with the invention, a diagnostic arrangement is connected to the input/output unit 13 which features, for example, a known type of visual data display device, a picture tube, and/or an indicating device for the operational instructions, and/or a connection for a printer. When a diagnosis command, for example derived externally from an operator-controlled switch, periodically during operation of the vehicle based on time or distance travelled, or generated by the diagnostic program itself, is given to the input/output unit via the input 59 and the terminal 60, then a diagnosis of operation of engine and/or the vehicle is carried out with a subprogram stored a section 12*a* of the read-only memory 12. With this diagnosis program, the information of interest is given serially to the diagnostic equipment 61 through the input/output unit 13.

The data and test values specific to the motor vehicle can include, for instance, actual test or go/no-go limit values according to a first diagnostic subprogram, e.g. the rotational speed, the battery voltage, the transmission rotational speed (by an input to stage 29, which is not shown), or the like. The test values can be obtained, for example, by means of a test value source connected at 59 to the input circuit 29. By means of a second diagnosis subprogram, which is stored in section 12*b* of the read-only memory, the computed values of, e.g. the ignition advance angle, the dwell angle, the fuel injection time, or the like, can be individually read and transmitted through the input/output unit 13 to the diagnostic equipment 61. Limit values can be stored in memory 12.

Certain operating conditions of the combustion engine which are particularly suited for diagnostic purposes, such as for example idling, can be simulated in accordance with the diagnosis subprogram by generation of certain input signals. The thus presented values and the then computed operational data by the microcomputer system can likewise be picked up and applied to the diagnostic equipment 61 through the input/output unit 13.

In accordance with the data in the subprogram stored in the read-only memory 12, command and actual value comparisons can also be carried out with the help of the microcomputer system. An error indication derived therefrom can be applied to the display of diagnostic equipment 61 through the input/output unit 13. In such command or nominal-actual comparisons, the nominal or command or desired vehicle specification and operation data is stored in the read-only memory 12.

For diagnosis of this type, with which the motor vehicle or the electrical equipment of the motor vehicle can be tested for proper functioning, there is required only simple and known diagnostic equipment which can be connected with the microcomputer system with only two additional lines. By means of the described equipment, there is possible a simple diagnosis which is independent of the then pertaining use of the vehicle, since all the testing conditions can be automatically entered in accordance with a particular diagnosis program. The unit 61 functions essentially as a comparator for the diagnostic program data with actual function dependent vehicle data, or derived, computed data, applied thereto

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