ACtion

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GM introduces CCC/ *AC components play vital role*

The General Motors Computer Command Control System will be utilized to precisely control emissions to the atmosphere on the majority of General Motors 1981 model cars. It is designed to electronically control the air/fuel ratio in a spark ignition engine carburetor or throttle body injection system near stoichiometry—a chemically-balanced air and fuel mixture—so that the three-way catalytic converter is able to both oxidize and reduce exhaust gas constituents.

The Computer Command Control System was designed and developed by the General Motors Emissions Control System Project Center to meet 1981 and subsequent model year emissions standards while attaining effective use of the maximum fuel economy potential of each engine system consistent with good vehicle performance and driveability. The total automobile environment encompasses vehicle system design, government certification schedules, vehicle assembly, field service and customer use, all facets of which are effectively addressed by the Computer Command Control System.

Components of CCC

Each General Motors engine/drive

General Manager's Comments

train system equipped with the Computer Command Control System utilizes fuel controls which provide "closed loop" air/fuel ratio management. The components providing basic fuel control at the precise stoichiometric point (generally either 14.6 to 1 parts of air to fuel or 14.7 to 1 parts of air to fuel) consist of the exhaust oxygen sensor, carburetor and the electronic control module.

The exhaust oxygen sensor, manufactured by AC Spark Plug Division at the Wichita Falls, Texas plant, is located in the engine exhaust manifold. It consists of a cone shaped zirconia ceramic body coated on the inside and outside with platinum. The zirconia body is placed inside a louvered metal shield to protect it from highly erosive exhaust gases expelled from the engine.

The inside surface of the exhaust oxygen sensor is open to the atmosphere (ambient air) and the shielded outer surface exposed to the exhaust gases from the cylinders. The difference in oxygen pressure between these surfaces (inner and outer) generates a voltage signal that is sent to the electronic control module. The exhaust oxygen sensor indicates whether the exhaust mixture is "lean" (excess oxygen) or "rich" (reduced oxygen content), sending a low voltage electrical signal to the electronic control module. "Rich" exhaust content is signalled to the electronic control module by higher output voltage than "lean" operation.

During "closed loop" operation, the electronic control module (ECM), manufactured by Delco Electronics Division, generates the appropriate control correction signal to the carburetor or throttle body injection system to maintain the exhaust mixture near stoichiometry. The electronic control module provides a control signal in the corrective direction at a fixed rate, whenever the exhaust oxygen sensor indicates a "lean" or "rich" mixture. When the exhaust oxygen sensor indicates a mixture change is required, the ECM carburetor control signal "steps" in the opposite direction of the previous signal and begins to integrate in the corrective direction.

Other programs in the ECM allow increased flexibility in the selection of the integrator rate and the proportional "step" values within various engine operating modes. The microcomputer is based on the use of an integrated chip micro-processor which adapts individually to the automotive size and power requirements, while providing the capability to trim carburetor air/fuel ratio, adjust engine idle speed and provide spark timing control.

The GM Computer Command Control System must also operate in several other modes to satisfy normal engine requirements. The decision whether the system is to operate in either the "open" or "closed" loop is based on information provided by the coolant temperature sensor, the time since engine start, and exhaust oxygen sensor voltage.

During the initial engine crank, all ECM control outputs are curtailed, which allows the carburetor to remain at a "rich" mixture. The enrichment feature also operates at high engine loads.

In addition to receiving signals from the exhaust oxygen sensor and coolant temperature sensor, other sensors which monitor engine speed and throttle setting are also hooked to the ECM. Able to make thousands of calculations a second, the computer constantly adjusts the air/fuel ratio and spark timing.

The continuously powered memory (CPM) feature of the ECM is used to compute the "open loop" carburetor signal and provide initial adaptive memories for the transition between the startup and warmup phases. This limited portion of ECM memory is powered directly from the vehicle battery. If the battery has been disconnected, the nominal carburetor calibration values are substituted for continuously powered memory values. CPM is memory used to store information when the ignition switch is turned off.

The carburetor, manufactured by Rochester Products Division, includes a pulse width modulated solenoid which controls the fuel metering system. Incorporated with the carburetor is an integral throttle position sensor which is linkage driven and mounted in various locations on the carburetor, depending on the vehicle application. Some GM models use throttle body injection (DEFI).

The engine coolant temperature sensor is a thermistor which produces a resistance variation with temperature. The information provided by this component is used for various control decisions by the ECM, including "open loop" operation. It is also manufactured by AC.

Manifold pressure and throttle position switches are used in some Computer Command Control Systems to provide information for the adaptive and enrichment features.

How CCC works

In the basic Computer Command Control System, secondary air is directed to the engine exhaust manifolds, the dual-bed three-way oxidizing/reducing converter, based on coolant temperature and first "open loop" condition, the air cleaner for silencing, or is diverted to the atmosphere. All 1981 GM vehicles use AIR pumps or PULSAIR systems. The air control and diverter valves controlled by the computer are functions of various operating states such as "closed loop," engine load, coolant temperature and certain malfunction conditions. The computer controlled air management

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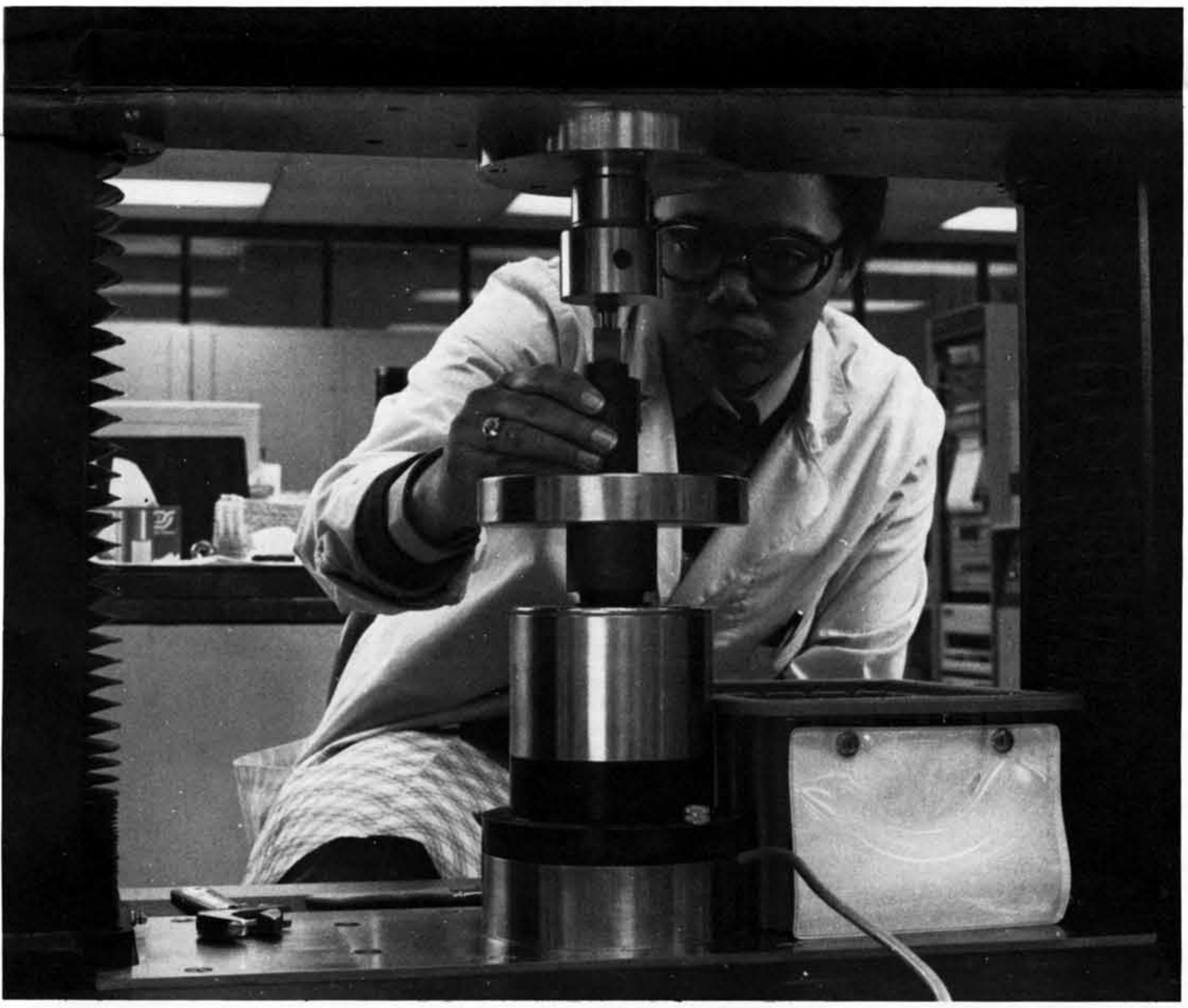
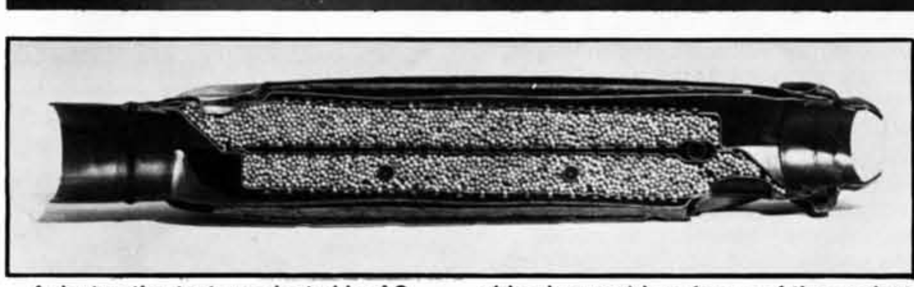
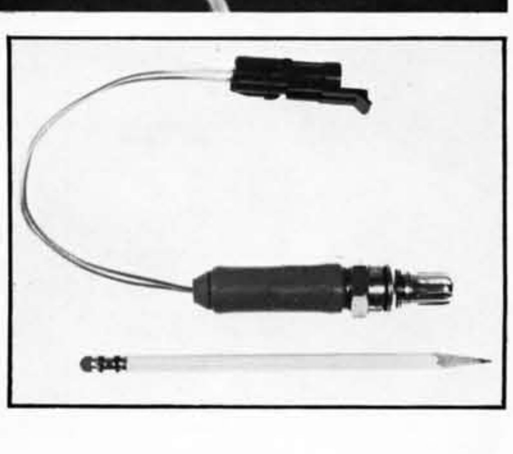






A destructive test, conducted by AC-Wichita Falls employe Diane Washington, is used to determine the isostatic strength of the fired ceramic element in exhaust oxygen sensors manufactured for the 1981 GM Computer Command Control System. The sensor (shown again at right with wiring harness) is only one of the products AC supplies for CCC. AC-Milwaukee produces the dual-bed three-way catalytic converter (above), and AC-Flint builds the coolant temperature sensor used with the system.

General Manager's Comments *(continued from front page)*

CCC comes on-stream

system is used to optimize secondary air management scheduling to meet stringent standards. PULSAIR is supplied by Delco Electronic Division and the electric air management valve by Rochester Products Division (AIR).

The electronic control module must be able to react to two basic types of signal information. This is necessary because sensors in the GM Computer Command Control System generally provide analog signals, that is, signals of a continuous nature such as "rich" or "lean" oxygen content, coolant temperature, etc. Therefore, analog signals provided by sensors must be converted to digital information which then enables the computer to make decisions in milliseconds to respond to the needs of the engine and drive train.

The General Motors Computer Command Control System includes a self-diagnostic capability which, when used in conjunction with the system service procedure, permits the service technician or mechanic to isolate a malfunction in the system and make repairs or replacement. An instrument panel lamp labeled "check engine" and a diagnostic lead from the ECM are provided. When a system fault is detected by the ECM, the "check engine" light appears on the cluster. With the diagnostic lead grounded, the "check engine" lamp flashes a code to the mechanic indicating the general area of the malfunction (supplied by Packard Electric Division). A dwell tachometer and digital voltmeter are then used to further isolate the fault.

The converter's role

The three-way catalytic converter plays a very important role in the Computer Command Control System. Catalytic control of hydrocarbon (HC) and carbon monoxide (CO) emissions require an oxidizing action where oxygen is added to the exhaust constituents to render them harmless. Catalytic control of nitrogen oxides emissions requires a reducing atmosphere in the exhaust where oxygen is removed from the harmful compound to render it harmless.

There are available a variety of catalysts that can control all three emissions (HC, CO, NO_X) simultaneously, but these three exhaust constituents must be held at the precise stoichiometric mixture for optimum conversion. These are used in what are categorized as single-bed converters. In addition, the Computer Command Control System has been implemented with dual-bed converters which contain both a three-way catalyst (in the first bed) and an oxidizing catalyst (in the second bed). The first bed is used to reduce NO_X to basic nitrogen and to use the oxygen from the NO_X to oxidize some of the HC and CO. Air is introduced before the second bed and the remaining HC and CO are then fully oxidized to harmless carbon dioxide and water vapor. The dual-bed converter utilizes a more extensive air management control system with air being switched between the converter and engine exhaust ports or diverted depending on commands to the air management system.

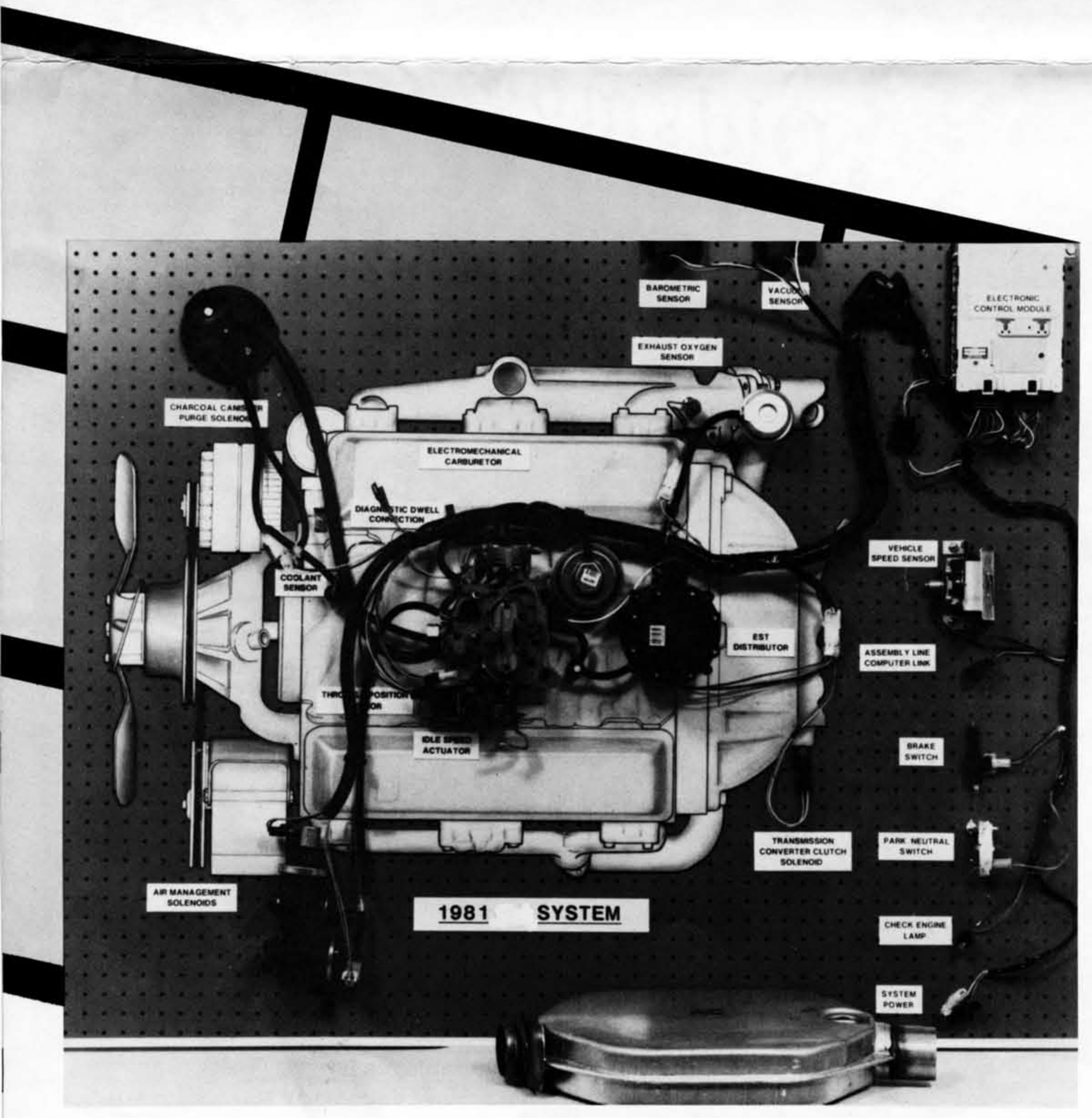
The two beds—three-way and oxidizing—are separated by an air chamber to which secondary air is supplied by a metal tube connected to the air management system of the overall Computer Command Control System.

For 1981, AC Spark Plug Division is supplying either 250 cubic inch (4.3 litre) pellet-supported dual-bed three-way oxidizing/reducing converters or 170 cubic inch (2.6 litre) monolith-supported dual-bed three-way oxidizing/reducing converters for use in Computer Command Control System-equipped passenger cars.

In addition, two-way oxidizing pellet-supported converters in either the 260 cubic inch or 160 cubic inch displacement sizes are also being supplied by AC for those vehicles not equipped with the GM Computer Command Control System—passenger cars to be sold in Canada and light trucks. In addition, GM passenger cars sold in the U.S. with either a standard or optional 5.7-litre diesel engine will not be equipped with the Computer Command Control System or catalytic converters.

The total number of catalyst formulations involved in Computer Command Control System three-way catalytic converters has more than doubled with 15 bead or pellet types and 6 monoliths for 1981 models. By comparison, in 1979, when oxidizing catalysts prevailed, there were 7 bead and 2 monolith catalyst formulations used. Very precise manufacturing controls are employed at AC-Milwaukee Operations including laser scanning and special optical bar code readers to differentiate the various formulations.

AC Spark Plug Division had manufactured 37 million catalytic converters at the Oak Creek, Wisconsin facility up to the start of the 1981 model year.



Expanded CCC capabilities

Expanded Computer Command Control System capabilities include electronic spark timing (EST), idle speed control (ISC), torque converter clutch control (TCCC), controlled canister purge (CCP), early fuel evaporation controls (EFE), exhaust gas recirculation (EGR), and system self diagnosis (SSD). Added system components include the electronic spark timing distributor, idle speed actuator, vehicle speed sensor, and barometric pressure sensor.

The major component provided to support electronic spark timing is the EST distributor, manufactured by Delco-Remy Division. The distributor contains an engine crankshaft position sensor which is conditioned by an integrated electronic module supplied by Delco Electronics Division to provide a reference position signal to the ECM. It also provides limited spark control/timing control capability for use during engine crank and as an ECM backup. Electronic components vary slightly from engine to engine, but for 1981 models, computer control has essentially replaced earlier mechanical hardware used by General Motors to provide emissions control, fuel economy and driveability.

Conclusion

The 1981 Computer Command Control System designed by the GM Emissions Control System Project Center, with components built by the various divisions at locations around the nation, is much more sophisticated than General Motors' earlier California three-way catalyst systems. Utilizing high technology, it is capable of providing the level of system accuracy required to precisely monitor and control various engine and drive train components at correct intervals and in programmed sequences to comply with present and future government emissions and fuel economy regulations.

It is the most effective engine management system ever developed anywhere. The system developed at considerable risk by General Motors has already been proven in a wide variety of vehicle applications supplied in large volumes for customer and company car use in prior model years. It will provide General Motors the means to meet all of 1981's more demanding emissions standards, while still giving the customer maximum fuel economy without compromising his needs for satisfaction with vehicle performance.

The General Motors Computer Command Control System has a five-year or 50,000-mile warranty.

John R. Wilson
General Manager