ELECTRONICS IN ROAD TRANSPORT VEHICLES

The object of this paper is to give an insight into the increasing use of electronics being used on road transport vehicles and to outline the benefits from such use and the special servicing requirements that will be required.

Electroncis are playing an increasing role in the operation of heavy duty road transport vehicles and it is only a matter of time before you as operators of such vehicles become involved. The main areas in which electronics are or will in the near future be involved in are instrumentation, communciation, transmission control, engine control and anti-skid braking.

City buses, tour and long distance coaches, trucks and trailers with electronics in some or all of these areas are already in operation on New Zealand roads.

Electronic Systems comprise various types of:

- Sensors
- Electronic Control Units
- Actuators
- Associated Wiring Harness

Sensors supply information to the ECU.

Electronic control units receive information from sensors compare this information to specific vehicle data stored in memory function and instruct actuators to carry out required tasks.

Actuators are electrically operated devices that do work in response to electrical signals.

Transmission Control

Electronic transmission controls may be used with either Planetary or Syncromesh type gearboxes.

Fig 1 shows pheripheral components and circuitry for typical planetary gearbox which includes gear selection switch, throttle position sensor, engine and road speed sensors, brake controls, retarder operating control and drive programme. The ECU used in this system may be fitted with 2 seperate pre programmed microprocessor controlled gear shift programmes to provide maximum efficency for either economy or power. These programmes may be selected either by dash mounted switch for the driver or key switch for operations managers.

Cont...

The ECU receives incoming signals supplied by the various sensors, process these signals and compares the information to specific vehicle data in the processor memory. It then signals the gear shift solenoids, torque converter lock up valve, retarder control, and gear shift regulator to select the most efficient gear for the load conditions.

The ECU is also fitted with safety circuits to inhibit starter operation when the vehicle is in gear, to prevent engine over speeding due to selection of too lower gear for particular road speed.

Block diagram of typical ECU is shown in Fig 2.

The easy shift gear change system for conventional gearboxes is shown in Fig 3 this system uses an ECU to control a pneumatic system which carries out the work of physically selecting the gears required.

The system is easy to install, has no expensive linkages, simplifies installation with tilting cabs etc.

- The operation is extremely easy
- The driver decides when
- Standard shift pattern no familiarization problems
- Quick precise gear location during both up and down shifts
- Possiblity to skip gear steps within green range of engine operating speed
- Also fitted with gate interlock and warning buzzer to prevent engine over speeding during down shifts

Electronic Engine Control

Increasing use of electronic engine controls is being made in order to meet overseas air pollution requirements.

Bosch have developed an electronic engine control for diesel injection pumps. This will have widespread effect on engines used in the road transport industry. Fig 4 shows system currently in use overseas where the fuel quantity delivered to the engine is controlled by an ECU.

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The ECU received signals from a range of input sensors monitoring accelerator position, air fuel and engine temperatures, air intake pressure, fuel pump control rack position and vehicle engine speed. These signals are processed and compared to specific vehicle data stored in the microprocessor memory. The ECU then signals the injection pump mounted actuator to position the pump control rack so as the pump delivers the exact amount of fuel required for the conditions. This results in:

- Greater economy
- Less engine wear
- Less air pollution
- Consistant vehicle performance

Further development to help engine manufacturers meet the American 1991 EPA emission regulations where as well as fuel quantity injection timing and duration are also electronically controlled is shown in Fig 5.

Anti Skid Braking ABS

Undoubtedly the most significant aid to road safety which has been brought about by the use of electronics in road transport vehicles is the introduction of ABS.

When wheels lock up under braking there is:

- Loss of stability on the road, ie; the vehicle skids
- Loss of steerability
- The vehicle trailer or semi trailer breaks away
- The braking distance is longer
- The tyres are damaged

In an emergency or panic situation the driver cannot always cope. ABS provides optimum braking while at the same time ensures that the vehicle retains it steerability.

Bosch ABS which has been available for service for 6 years after being under development and testing for over 15 years is a sophisticated control which is applied to the vehicles braking system, and prevents wheel lock up even under emergency or panic situations on slippery road surfaces, even ice and snow.

Wheel sensors measure wheel rotational speed from pulse rings mounted on the wheel hub, Fig 6. The ECU, Fig 7 process and compares these signals and by way of special 2 channel pressure modulation valves, Fig 8 fitted to each axle controls the braking pressure to the wheel brake cylinders.
Fig 9 shows operation of ABS. Fig 10 curves of friction co-efficient against brake slip.

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The central unit of the pressure modulation valve controls pressure build up and reduction while the two downstream valves control the pressure in the brake cylinder of each wheel.

If the co-efficients of friction differ greatly between the right and left hand wheels (eg: ice on the edge of road and good grip in th centre of road) a modified control process is applied to the front axle which provides a compromise between longer stopping distance and manageable steering correction. By limiting the braking forces on the front axle, it is possible to reduce the yawing moment to such an extent that control over the vehicle is maintained, even under emergency braking conditions.

Safety

The driver is kept informed of the integrity of the ABS by a dash mounted warning light which is energized if any faults are present in the system.

The ECU carries out self monitoring of the entire system.

- When the ignition is switched on
- When the vehicle drives off
- Whenever the vehicle stops
- Constantly while the vehicle is in motion

If a failure occurs during braking with ABS function the intelligent system does not immediately switch off. Depending on the type of failure part of the system will switch off and the ABS light on the dash will be switched on to warn the driver.

Advantages of ABS

ABS prevents locking of wheels and consequently provides directional stability, steerability and optimum stopping distances.

Avoiding an accident means to save costs.

- Cost of vehicle damage
- Consequential cost (downtime, legal fees, damage to other property, drivers compensation etc)
- Costs for excessive tyre wear and tear

To put it in a nutshell.

There are cases when ABS pays for itself if you use if only once.

Critical driving situations can also arise when driving off or accelerating, especially on slippery surfaces on hills or curves if the powered wheels spin.

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By expanding ABS to ABS/ARS anti skid braking with traction control, prevents wheel spin during drive off and acceleration.

ASR provides maximum control of propulsion on surfaces that are slippery on one or both sides such as when pulling out of bus stops on the side of the road accelerating through curves or starting off on hills.

The ASR logic in the ECU, Fig 11, monitors the speed of the powered wheels and recognises when a wheel is tending to spin. The ASR controls the powered wheel speed through two control circuits.

1. Brake Control

At speeds up to 30Km/h if a powered wheel tends towards spinning it is braked and the wheel speeds are synchronized.

2. Engine Control Circuit

If both powered wheels are tending to spin the driving torque of the engine will be reduced by the electronic engine control. At speeds above 30Km/h the spinning of one of the powered wheels will also be prevented with the aid of the engine control system.

Fig 12 shows ASR operation.

ASR - Increases safety - spinning wheels transmit low cornering forces, handling becomes unstable.

- Limits wear and repair costs - spinning wheels lead to high rates of wear to tyres and drive line.

- Is always ready and switches on automatically when needed. It can also differentiate between cornering and wheel spin.

The ABS/ARS carries out its own safety checks before driving off as well as constantly during driving. Depending on the fault, it will shut down completely or partially and immediately warn the driver by means of warning light while service braking continues to function normally.

Servicing Vehicles with Electronic Systems

When carrying out service work on vehicles with electronic systems it is essential that the manufacturers safety procedures are followed if expensive ECU's are not to be inadvertently destroyed.

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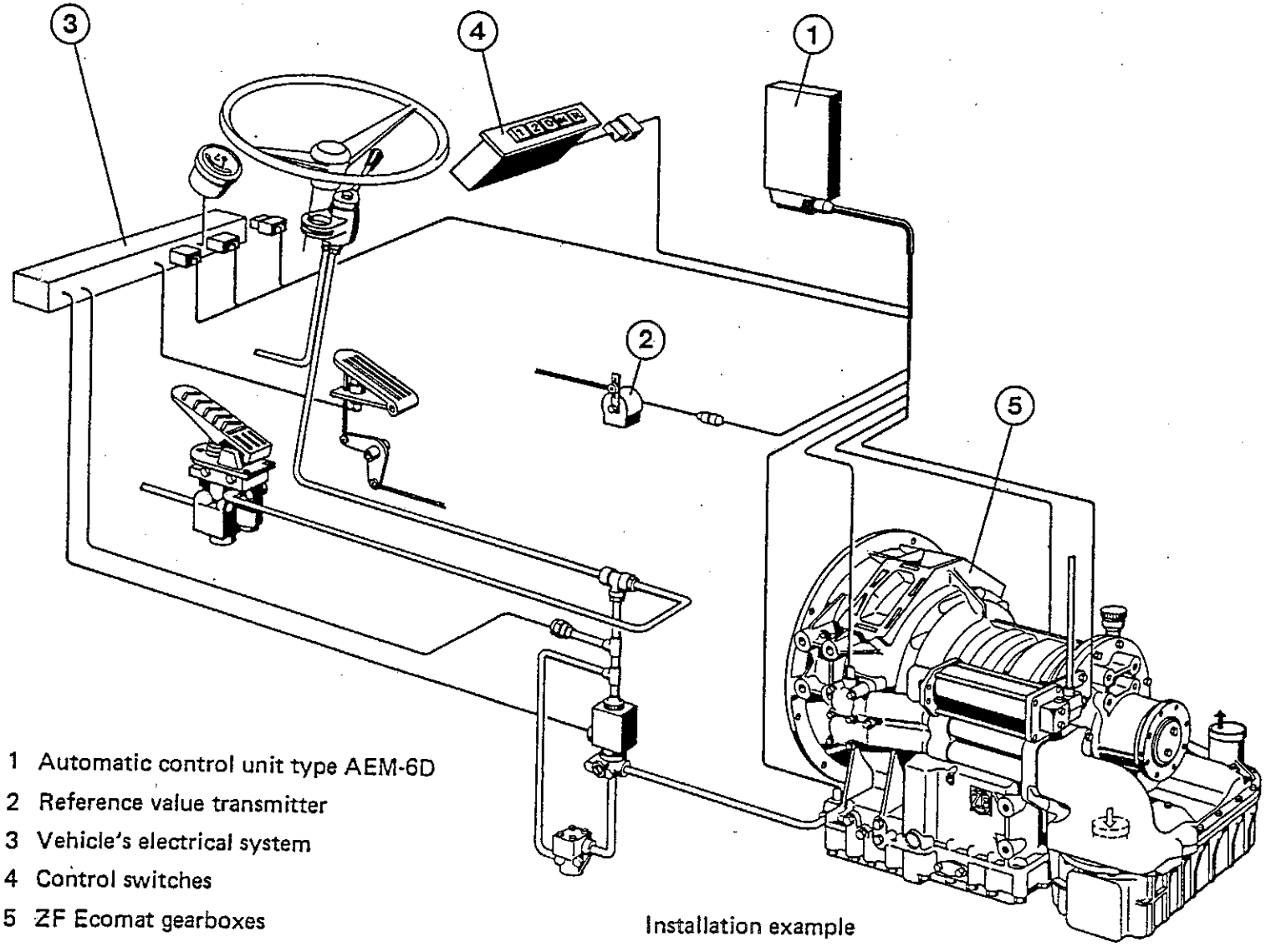
The following are some of the essential DO's and DON'T's

- Before carrying out any electrical welding ensure the plugs are removed from all ECU's and that both battery terminals are disconnected
- Do not use a fast charger or jump start for starting engine
- Never disconnect the battery from the vehicle electric system with the engine running
- Never connect or disconnect the ECU with the ignition switched on
- Always disconnect the battery from the vehicle system when fast charging
- Never use high pressure (steam) cleaner in the engine compartment
- Never allow the antennae lead of a CB radio or radio telephone to run in close parallel proximity to the wiring of integrated circuits.
- Always use the correct test equipment and manufacturers recommended procedure when trouble shooting the circuitry.

The main advantages of using electronic controls are:

- Improved efficiency
- Greater reliability
- Long life
- Lower maintenance
- Self checking functions
- Unable to be adjusted away from specifications

While electronics have a very high reliability factor it is essential that retraining of service personell be undertaken to ensure they are kept up to date with new developments service and diagnostic procedures if the maximum benefits for this new technology are to be obtained.



1 Automatic control unit type AEM-6D
2 Reference value transmitter
3 Vehicle's electrical system
4 Control switches
5 ZF Ecomat gearboxes

Installation example

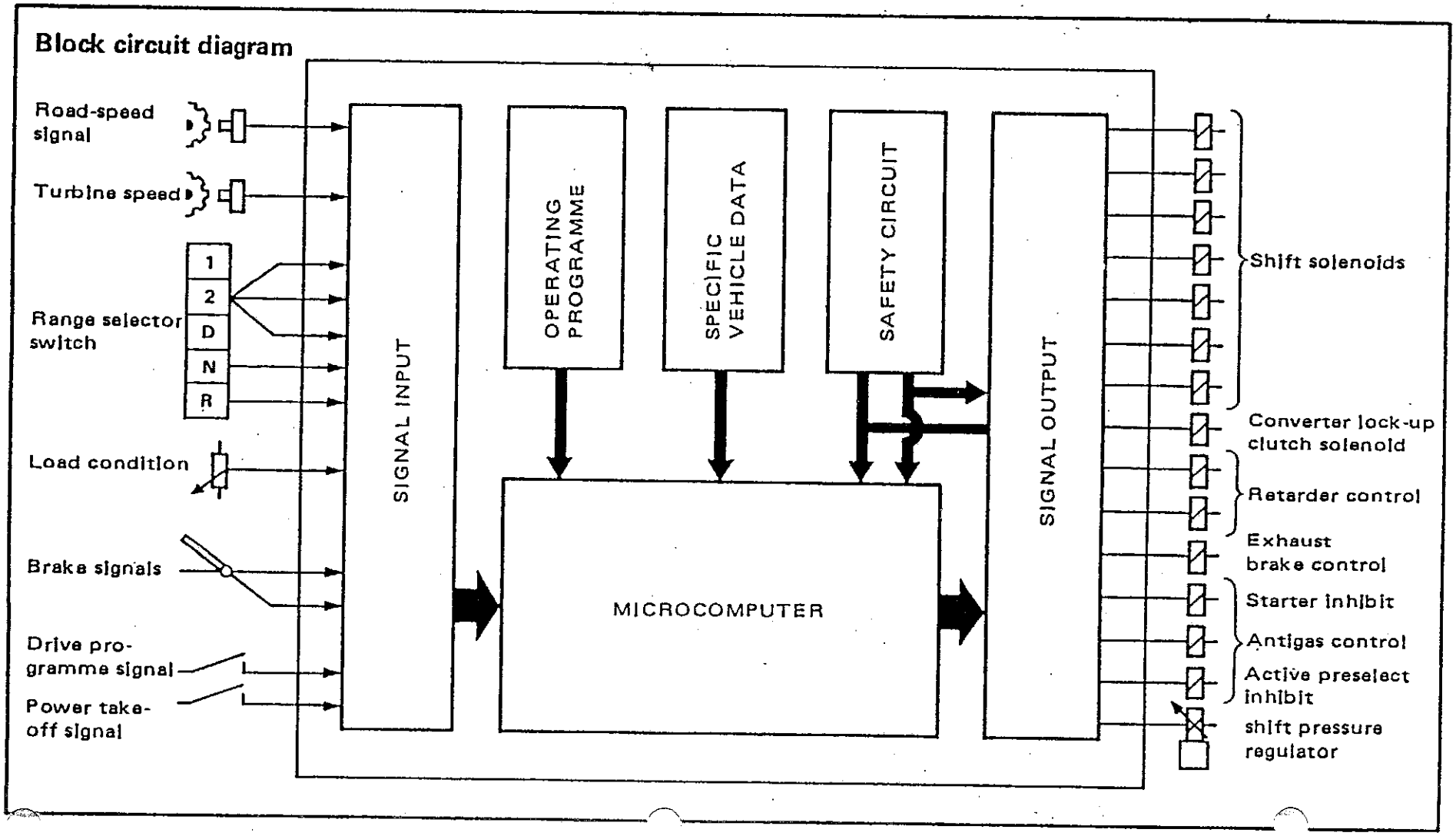

Block circuit diagram
Road-speed signal
Turbine speed
Range selector switch
1
2
D
N
R
Load condition
Brake signals
Drive programme signal
Power take-off signal
SIGNAL INPUT
OPERATING PROGRAMME
SPECIFIC VEHICLE DATA
SAFETY CIRCUIT
MICROCOMPUTER
SIGNAL OUTPUT
Shift solenoids
Converter lock-up clutch solenoid
Retarder control
Exhaust brake control
Starter inhibit
Antigas control
Active preselect inhibit
shift pressure regulator

Fig 2

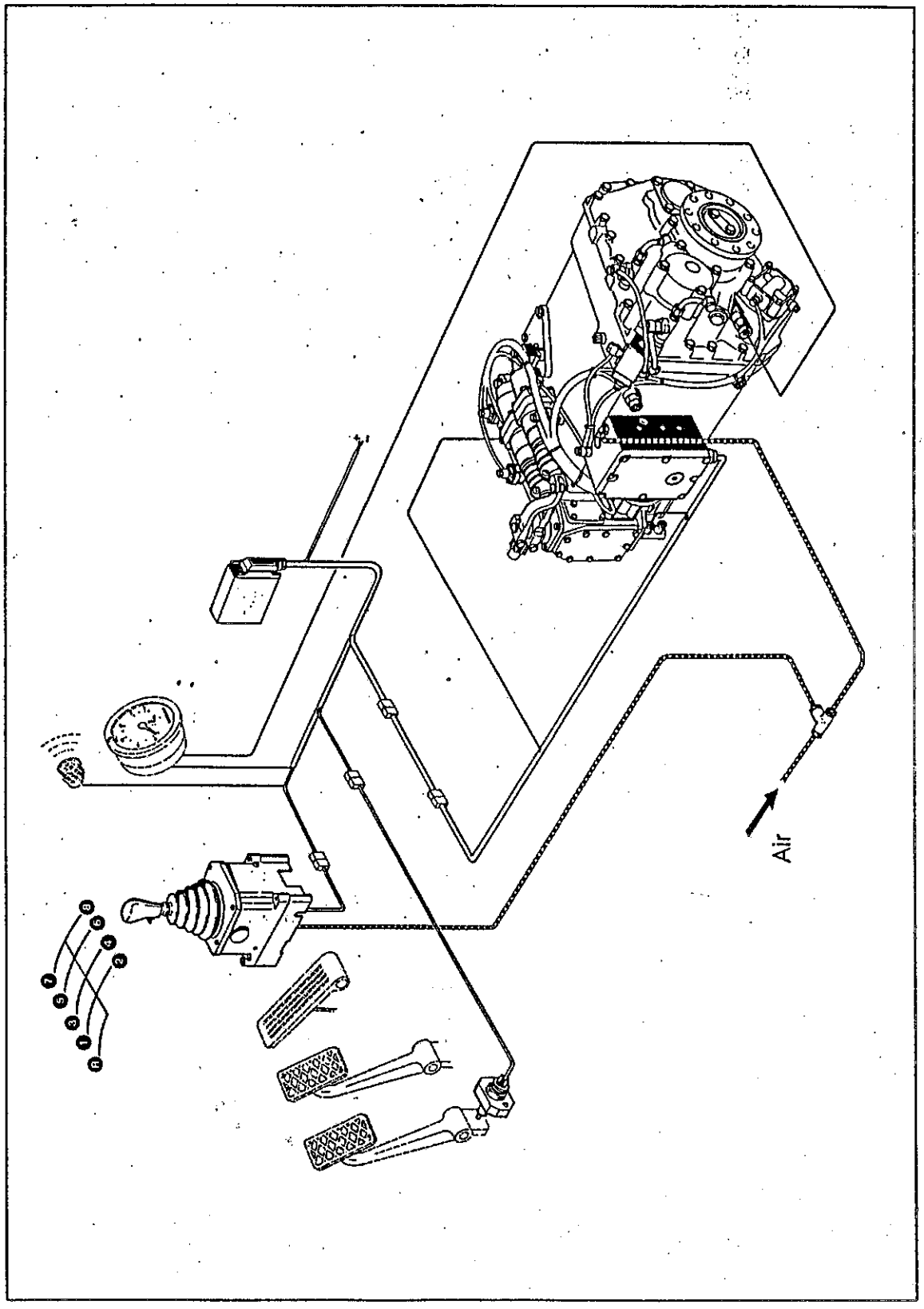


Fig 3

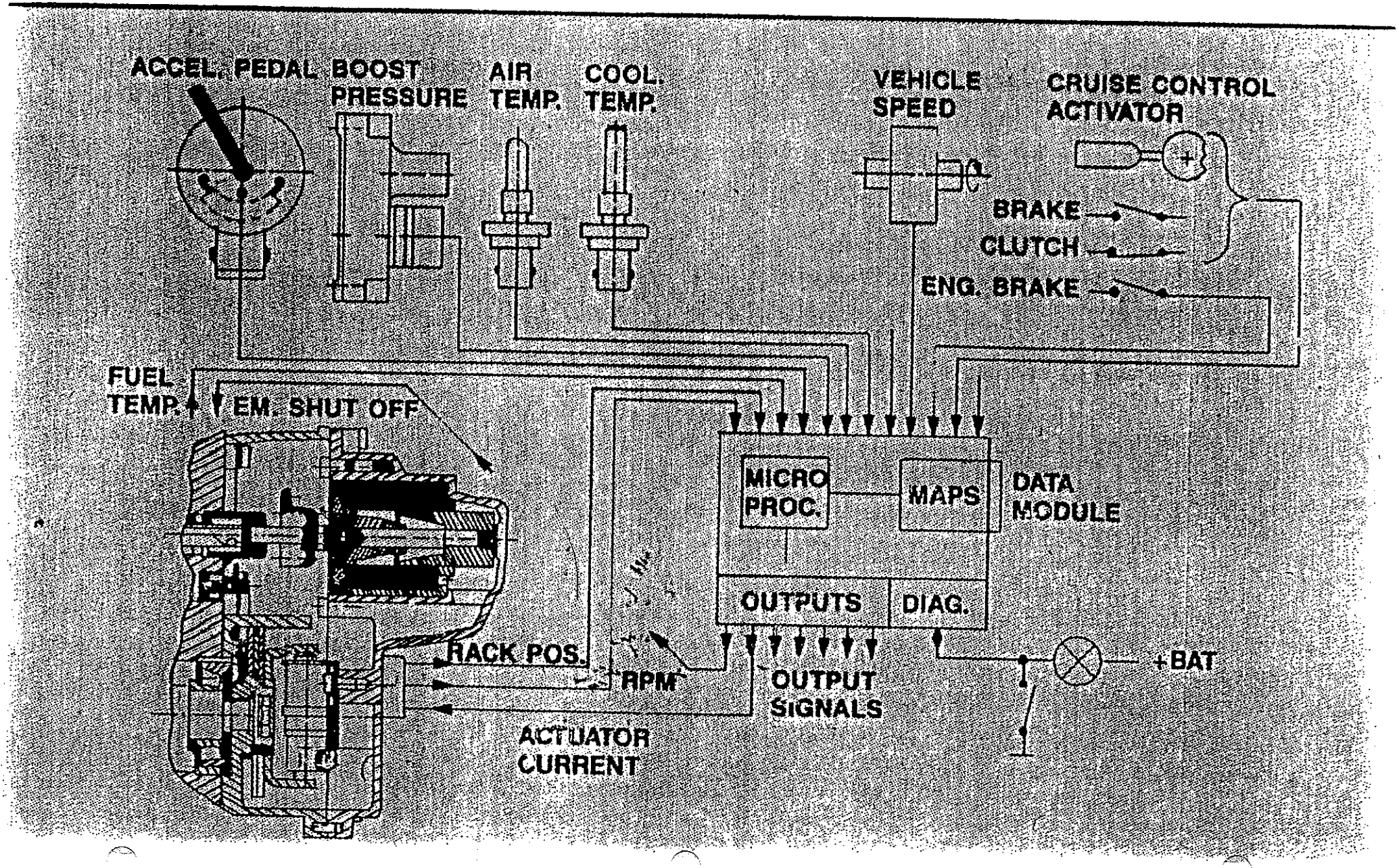

ACCEL. PEDAL
BOOST PRESSURE
AIR TEMP.
COOL. TEMP.
VEHICLE SPEED
CRUISE CONTROL ACTIVATOR
BRAKE
CLUTCH
ENG. BRAKE
FUEL TEMP.
EM. SHUT OFF
MICRO PROC.
MAPS
DATA MODULE
OUTPUTS
DIAG.
RACK POS.
RPM
ACTUATOR CURRENT
OUTPUT SIGNALS
+BAT

Fig 4

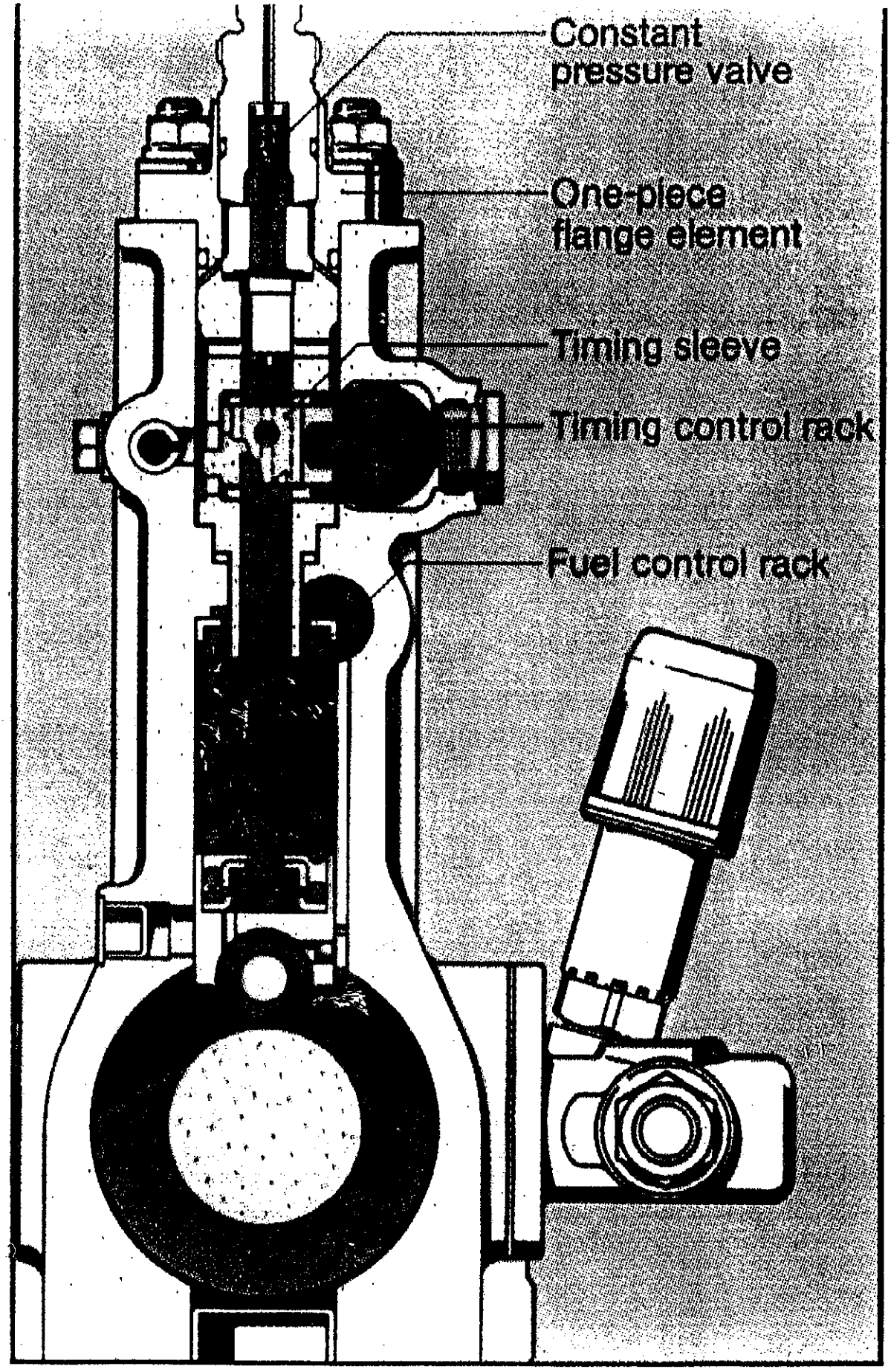

Constant pressure valve
One-piece flange element
Timing sleeve
Timing control rack
Fuel control rack

Fig 5

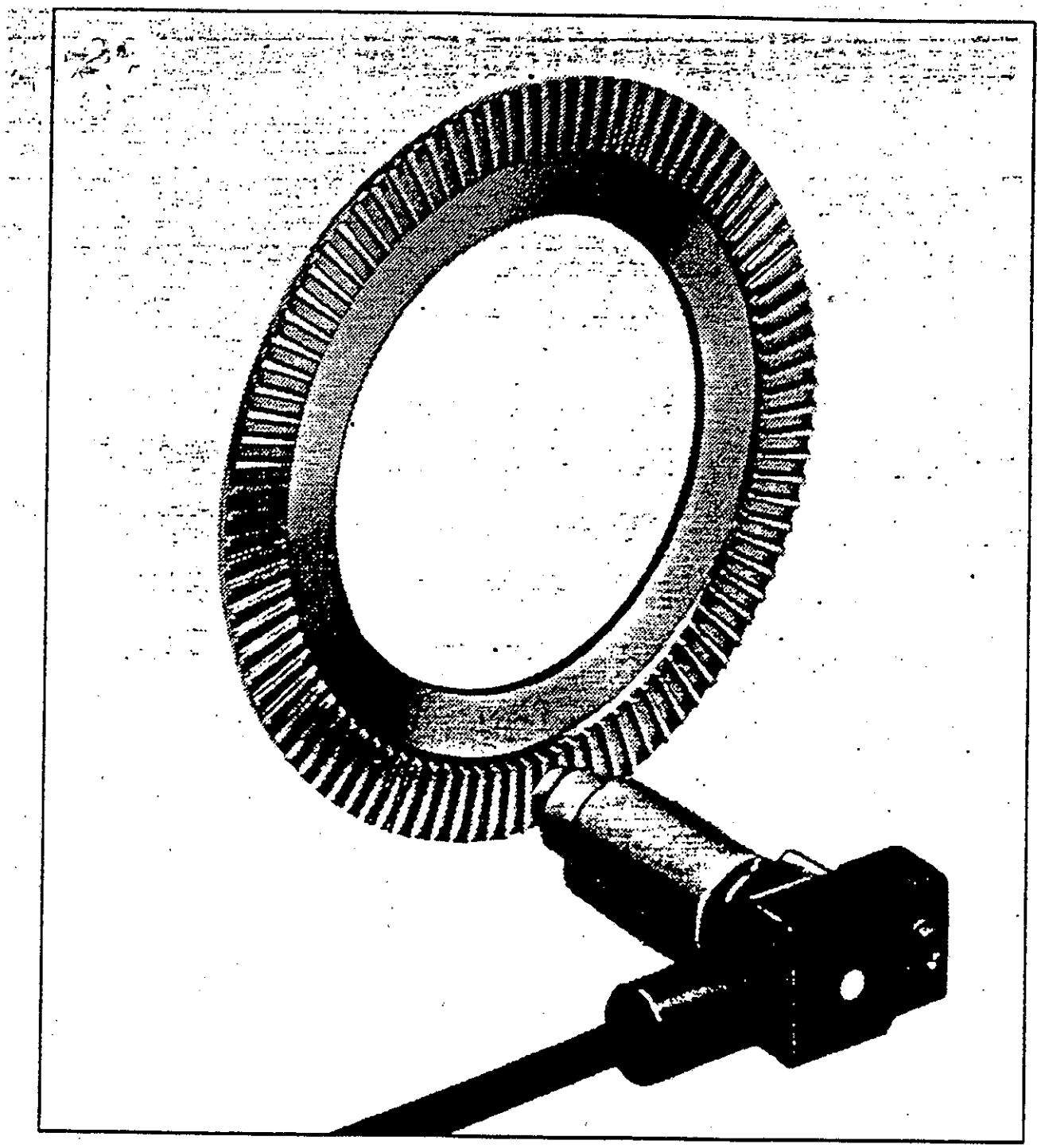
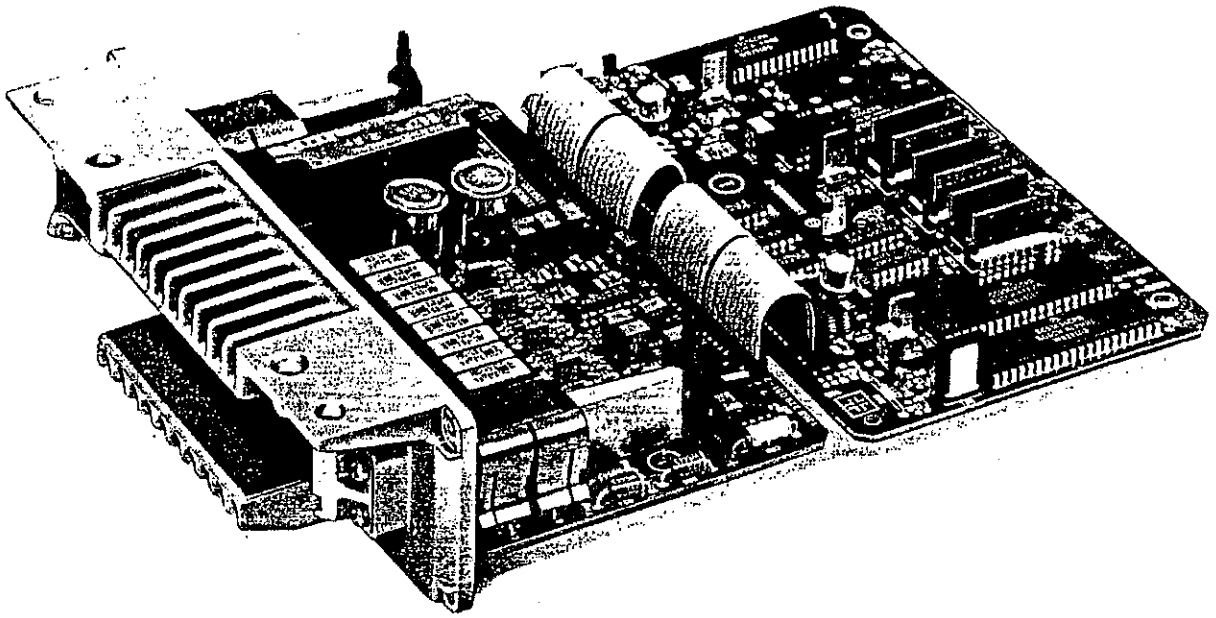


Fig 6



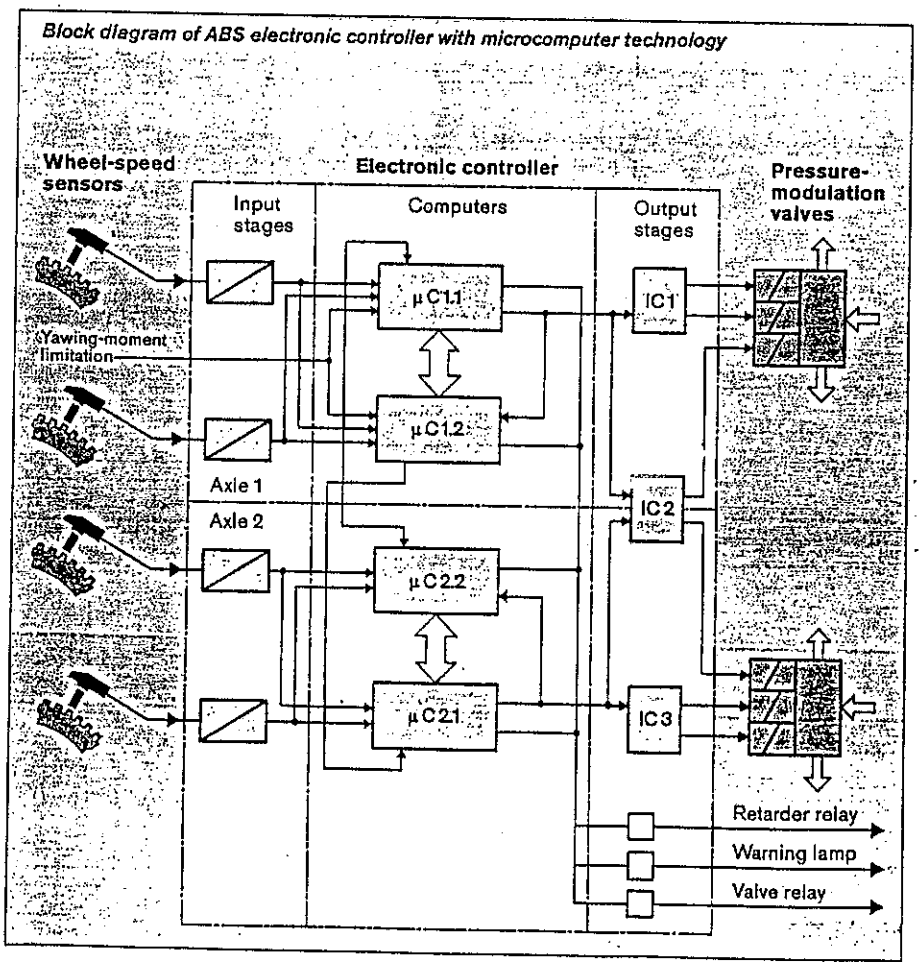
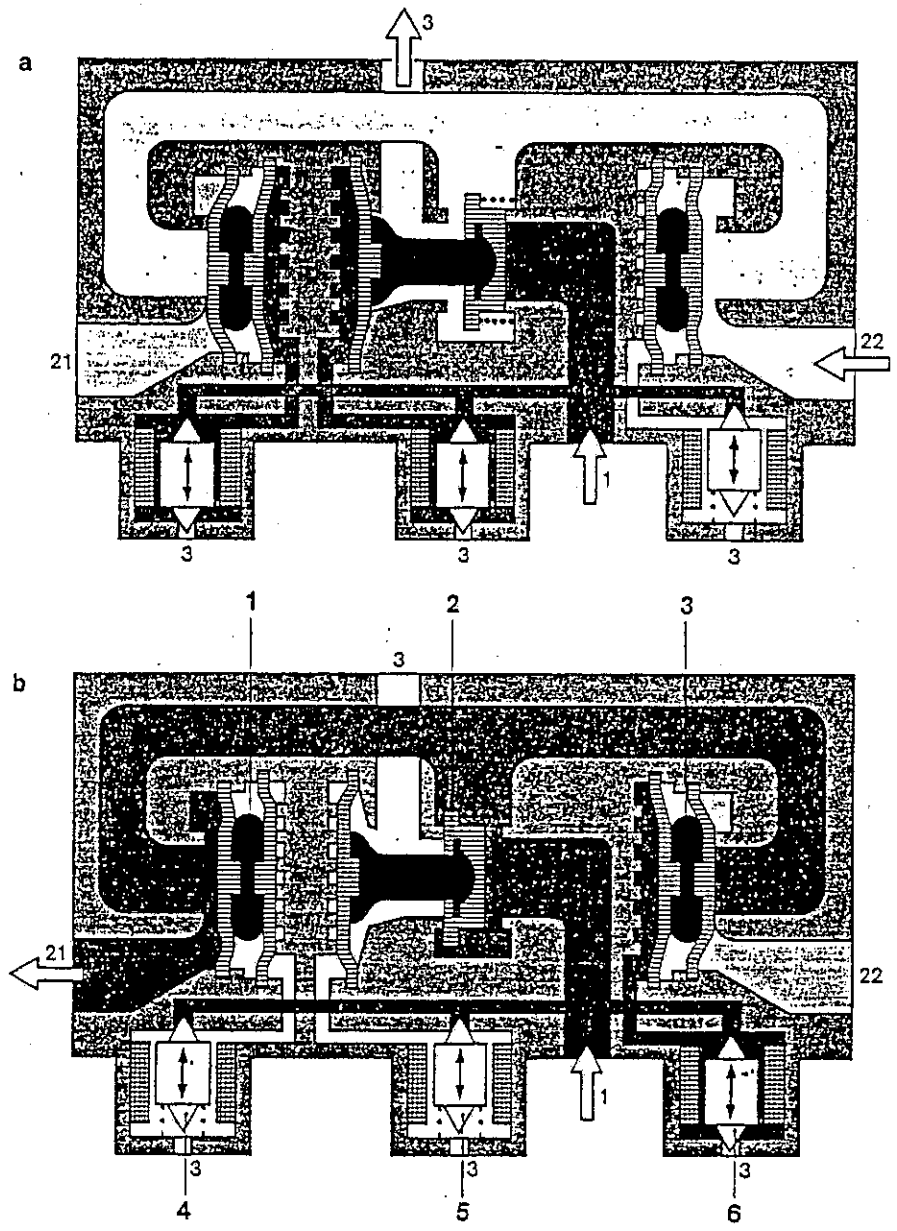

Block diagram of ABS electronic controller with microcomputer technology
Wheel-speed sensors
Electronic controller
Input stages
Computers
Output stages
Pressure-modulation valves
µC1.1
µC1.2
µC2.2
µC2.1
IC1
IC2
IC3
Yawing-moment limitation
Axle 1
Axle 2
Retarder relay
Warning lamp
Valve relay

Fig 7



Sectional Drawing of the Pressure-Control Valve during Full Brake Application

a Pressure decrease at port 22 due to a danger of locking in wheel 2.
b Pressure increase at port 21 because even more brake pressure can be applied to wheel 1.

A Diaphragm valve:
1 Holding valve for channel 21
2 Central valve
3 Holding valve for channel 22

B Solenoid valves:
4 Pilot valve for holding valve (1)
5 Pilot valve for the central valve
6 Pilot valve for holding valve (3)

Ports:
1 Compressed-air supply (from the service-brake valve)
21 Compressed-air outlet (to the brake cylinder of wheel 1)
22 Compressed-air outlet (to the brake cylinder of wheel 2)
3 Vent

Pressureless
Partial pressure
Operating pressure

Fig 8

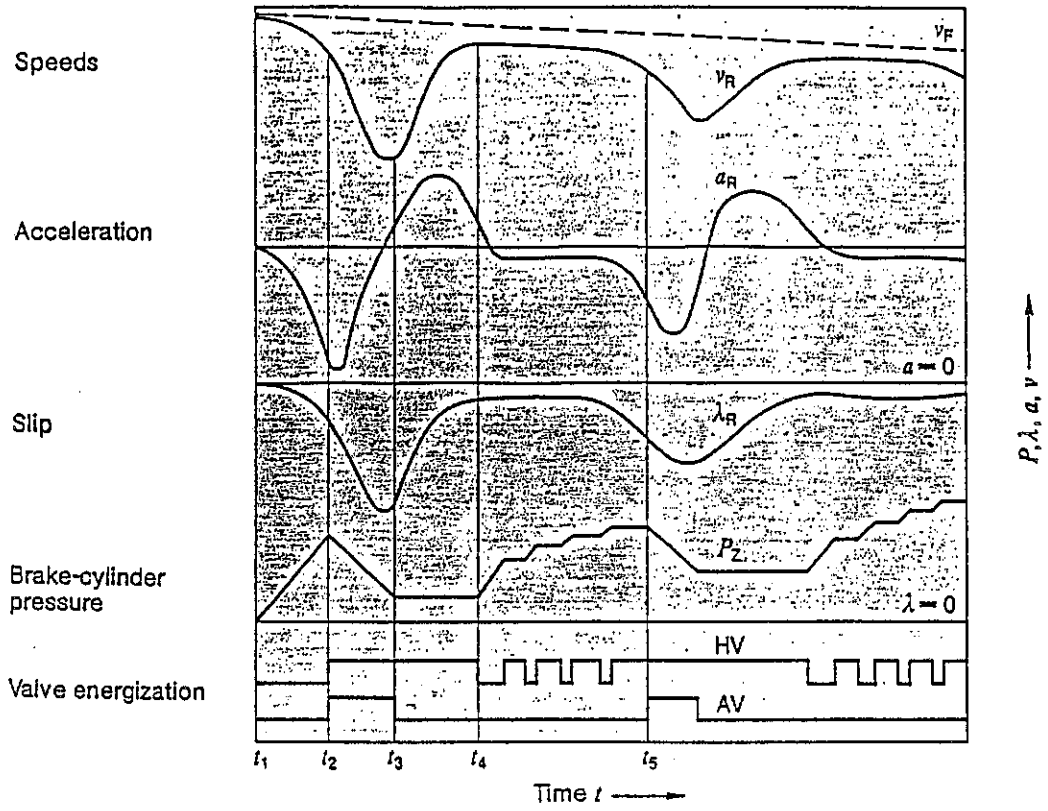


Fig 9

ABS OPERATION

VF = Vehicle Speed

VR = Wheel Speed

aR = Wheel Acceleration or Decelaration

λ = *Slip*

Pz = Brake Cylinder Pressure

HV = Pressure Holding Valve of the Pressure Control Valve

AV = Outlet Valve of the Pressure Control Valve

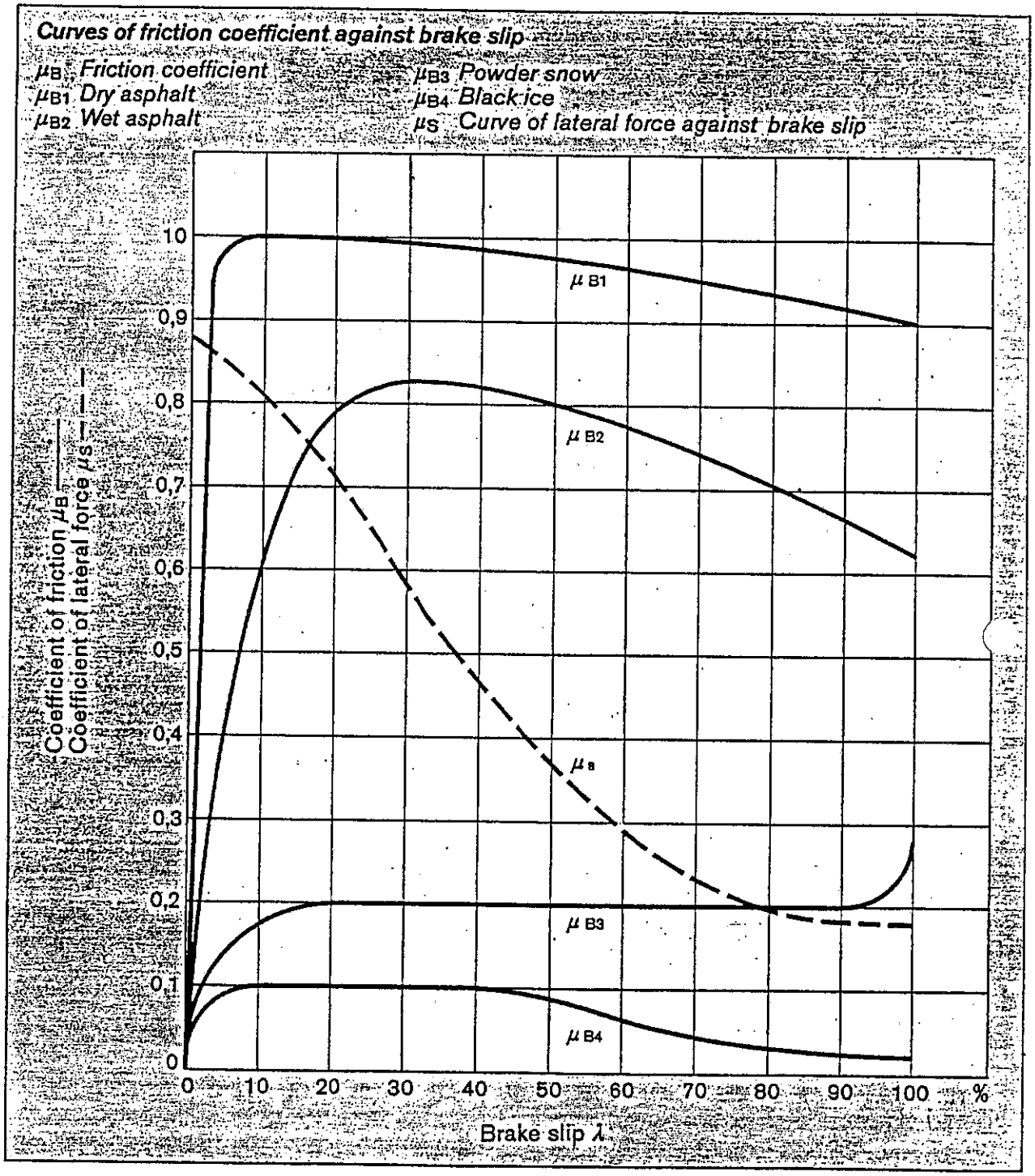

Curves of friction coefficient against brake slip
μB Friction coefficient
μB1 Dry asphalt
μB2 Wet asphalt
μB3 Powder snow
μB4 Black ice
μS Curve of lateral force against brake slip
Coefficient of friction μB
Coefficient of lateral force μS
1,0
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
μ B1
μ B2
μ S
μ B3
μ B4
0
10
20
30
40
50
60
70
80
90
100
%
Brake slip λ

Fig 10

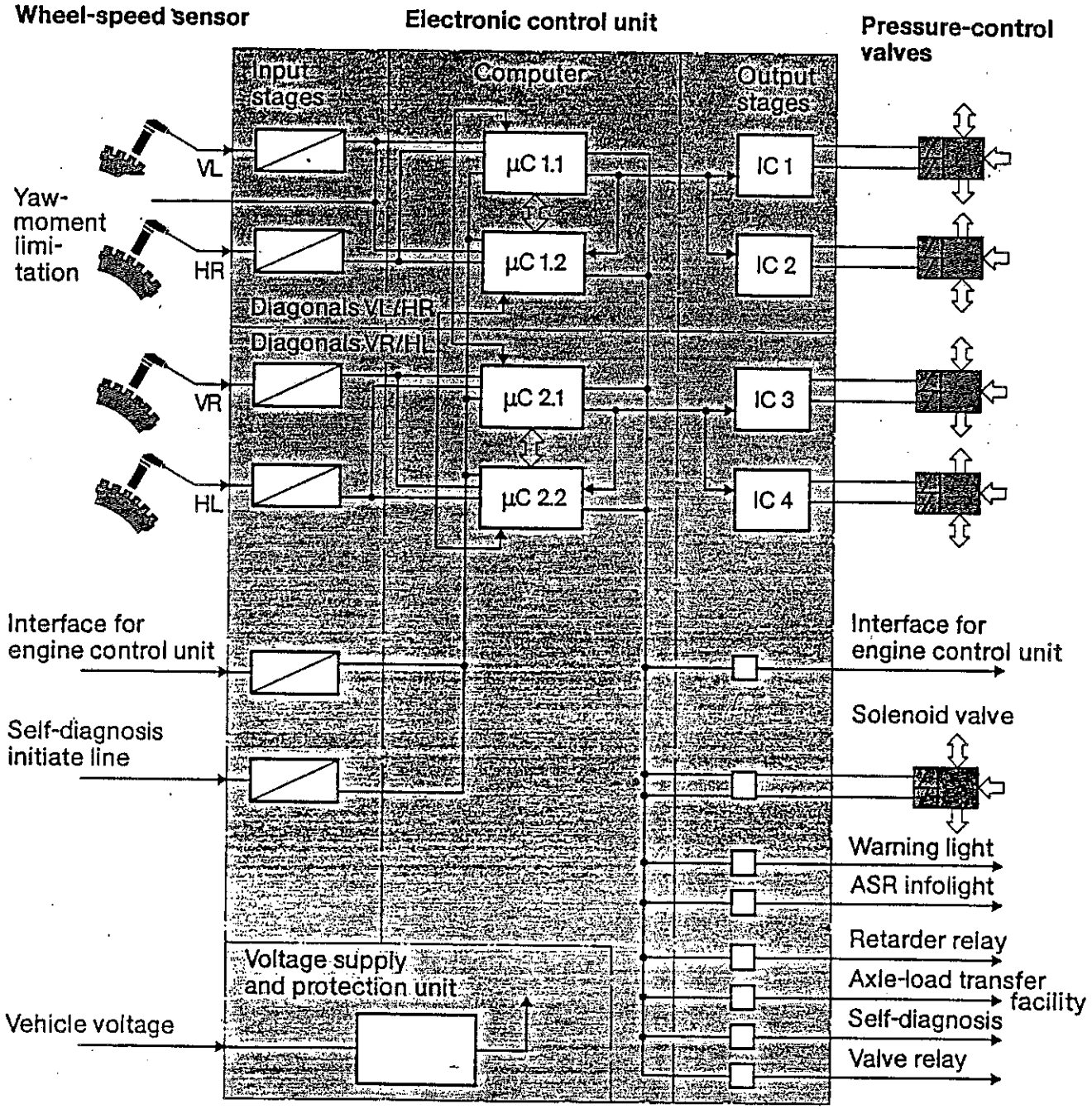


Fig 11

ABS/ARS ECU

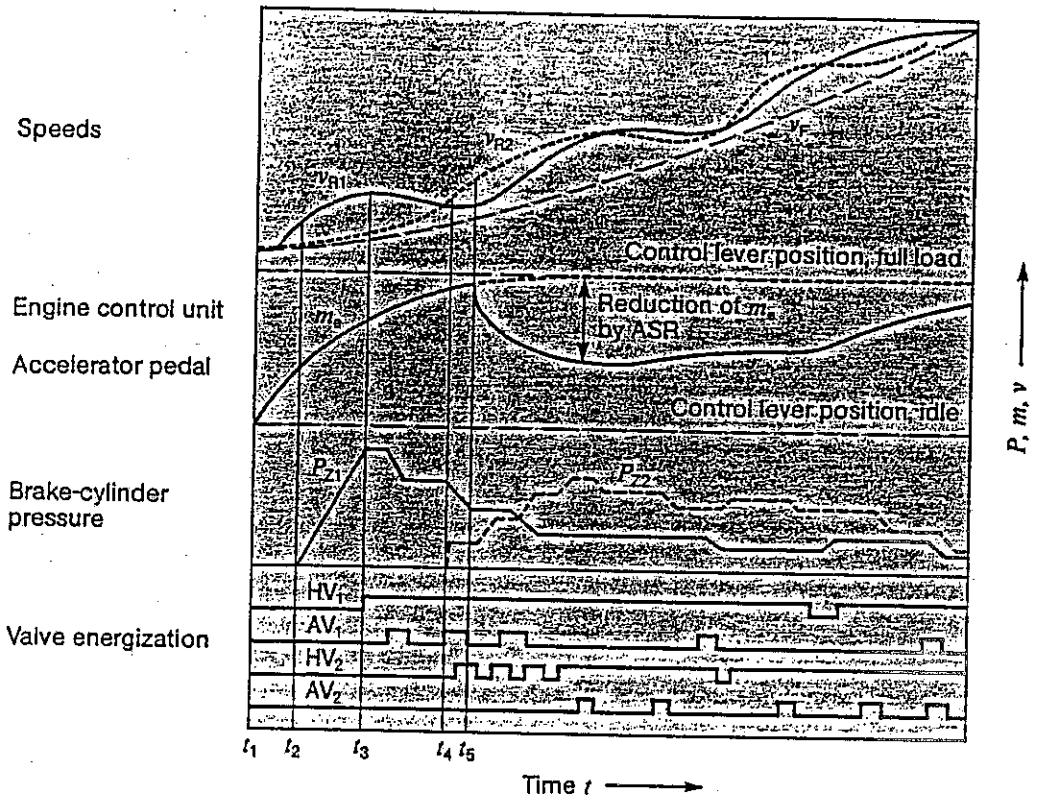


Fig 12 ASR Operation

VF = *Vehicle Speed*

VR1, VR2 = *Speed of Powered Wheels*

Me = *Injected Fuel Quantity*

PZ1, PZ2 = *Brake Pressure in the brake cylinders of the powered driving wheels*

HV1, HV2 = *Pressure holding valves of the pressure control valves for the powered wheels*

AV1, AV2 = *Outlet valves of the pressure control valves for the powered wheels.*