DEVELOPMENT OF AN ELECTRO- MECHANICAL SPEED LIMITING DEVICE FOR AUTOMOBILES

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A PROJECT REPORT SUBMITTED TO
THE DEPARTMENT OF MECHANICAL ENGINEERING,
FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF MASTER OF ENGINEERING IN
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CERTIFICATION

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DEDICATION

This project is dedicated to Almighty God, who is my provider, supporter and redeemer and also to my dearest wife Mrs. Dorcas Olufunmilayo Akanji and to my children, 'Sayo, 'Tobi and 'Nike.

ACKNOWLEDGEMENT

First and foremost, I give thanks to Almighty God for His infinite mercies, His guidance and protection on me and for making it possible for me to complete the Master of Engineering Programme successfully.

My thanks go to my supervisor, Prof. L.O. Adekoya for the agape love he had for me, his fatherly role played during the supervision, his co-operation, his advices given me and for his friendly attitude. I pray that God Almighty will continue to shower His blessings on whatever he lays his hands upon.

I appreciate the role played by the entire staff of the Department of Mechanical Engineering, Federal University of Technology, Akure. The Head of Department of Mechanical Engineering, Prof. A.A. Aderoba, Dr. O.P. Fapetu, Prof C.O. Adegoke, Engr. T.I. Mohammed, Engr. E.L. Bello for supplying most of the materials needed for the project, Engr. S.A. Anjorin, Dr. S. Adejuyigbe, Engr. A.O. Akinola, Engr. M.A. Akintunde, Engr. P.K. Oke, and a host of others for their contributions to my academic success.

I express my sincere thanks to the Rector, Registrar, Bursar and the entire staff of the Department of Mechanical Engineering, Federal Polytechnic, Mubi, Adamawa State for sponsoring and releasing me for the programme.

Finally, I thank Mr. Gabriel Adediran and Mr. Solomon Adediran for unforgettable and useful advice given me during the design of the project.

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ABSTRACT

Overspeeding has become a problem to our motorists because they want to reach their destination on time, forgetting that it is better to be late than be the late. This project discusses the solution to the problem of overspeeding by developing an electro-mechanical speed-limiting device for automobiles, using Toyota and Peugeot cars as case studies.

A simple, portable and cheap electro- mechanical device was designed and constructed. It was installed under the throttle pedal to reduce throttle valve opening, the quantity of fuel supplied into the combustion chamber and finally reduce the speed of the vehicle.

The performance evaluation carried out showed that when the driver wanted to exceed the speed of 100km/hr, the circuit closed and a very loud alarm sounded and it was stopped when the speed returned to 100km/hr. Data analysis shows that the height of the device is inversely proportional to the speed of the vehicle and also that the percentage change in speed when ascending and descending a slope diminishes as the speed of the vehicle increases. Also, the statistical correlation between the height of mechanical device and the speed was 98%.

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NOMENCLATURE

d	-	Diameter of the work-piece (mm)
p	-	Pitch of the thread (mm)
d_p	-	Pitch diameter (mm)
P_c	-	Pitch circumference (mm)
α	-	Helix angle (degrees)
d_R	-	Root diameter (mm)
A_R	-	Root area (mm^2)
h	-	Height of the thread (mm)
A_h	-	Area of the head of bolt
S	-	Cutting speed (m/min)
N	-	Spindle speed (rev/min)
n	-	Number of flat surfaces on the nut
L	-	length of work-piece(mm)
b	-	breadth of the work-piece (mm)
H	-	Maximum height of the throttle pedal from the floor board in mm
h	-	Height of the mechanical device from the floor board in mm
ΔH	-	Maximum distance covered by the throttle pedal in mm
		Note: $\Delta H = H - h$
S.R.	-	Speedometer reading on a level road surface in km/hr.
S.R.A.	-	Speedometer reading when ascending a hill in km/hr
S.R.D	-	Speedometer reading when descending a slope in km/hr
P.C.S	-	Percentage change in speed when ascending or descending a slope in %

1. INTRODUCTION

Many souls have gone!-Several millions of people all over the country have become deaf, blind, mentally disturbed, lost one or two legs, etc due to accidents caused by overspeeding. The statistics of the accidents, which occurred in our country, Nigeria, have shown that most of the accidents were caused by overspeeding (Federal Road Safety Corps, FRSC, 1999). Hutchinson (1987) estimates that worldwide, half a million people are killed each year in traffic accidents. In addition about fifteen million people are injured each year (Trinca et al, 1988). Each year in the United States of America, almost 50,000 people loose their lives in traffic accidents. The cause of the accidents are attributed to human behaviour, the environment and mostly overspeeding (Trinca et al, 1988). We cannot sit down and continue watching our brothers and sisters in pools of blood. Therefore, there is a need to design and construct a system, which will reduce the speed of automobiles in order to minimize the number of accidents on our roads. Usually driver referred to their speedometer to determine speed. However, when other aspects of the driving task demand visual attention for example negotiating a freeway exit ramp, a driver may have to judge speed without looking at the speedometer. There is ample evidence that people can estimate normal driving speeds quite well without the aid of speedometer (Milosevic, 1986 and Evans, 1970). In driving, many drivers are adapted to a higher speed. People's inability to judge relative speeds of vehicles probably account for many accidents in which a car trying to pass another car has a head-on-collision with an on-coming car. The research evidence is somewhat mixed with respect to people's ability to judge the speed of on-coming vehicles (Triggs, 1988).

In order to develop a speed limiting device for automobiles, the following vehicle parts were studied for this project. They are: throttle pedal, throttle linkages, throttle valve in the carburetor, speedometer gear and speedometer gauge. This project concentrated more on the throttle pedal because depressing of the pedal affects both carburetor and speedometer gauge.

Automobiles consists of spark ignition engines (petrol engines) and compression ignition engines (Diesel engines) (Dolan, 1966). The manufacturers of Diesel engine road vehicles (DERV) incorporated a speed limiting device, called governor to the vehicle. A governor is a device used to limit high and low idle revolutions per minute and/or maintain a selected uniform revolutions per minute within the power range of the engine (William and Donald, 1985). Some imported spark ignition vehicles such as Toyota Camry-3s engine (new model), Toyota Crown (royal type) etc. are also incorporated with speed warning device which some manufacturers called speed limiting device. When the vehicle is moving at a speed beyond a preset maximum speed, the warning bell will start ringing, which many drivers ignored.

1.1 Objectives

The objectives of this project are as follows:

(i) To develop an electro-mechanical speed limiting device that will successfully control the speed of automobiles.

(ii) To carry out a performance evaluation of the device.

1.2 Methodology

The research/ project consists of the development of an electro- mechanical speed limiting device for automobiles, to be used to control the speed of vehicles in order to avoid overspeeding which can lead to accidents resulting into loss of life.

The following methods of approach were adopted to meet the identified objectives.

(a) Detailed knowledge of speed limiting devices was obtained through:

(i) Literature review

(ii) Interaction with related automobile industries and roadside mechanics / electricians to acquire data.

(b) The acquired data was documented for the purpose of developing a suitable model.

(c) The model was developed and tested.

(d) Experimental data was obtained for Toyota and Peugeot

1.3 Project Significance

The significance of this project are:

(a) to assist the nation to reduce the accidents caused by overspeeding, which always lead to loss of life and properties.

(b) to help individual vehicle owners to reduce the rate of fuel consumption (as an added advantage).

(c) to contribute to the knowledge of mechanical engineering especially in the automobile industry.

2. LITERATURE REVIEW

Detailed knowledge of a speed limiting device for automobiles was obtained through literature review, interaction with related automobile industries and roadside mechanics to acquire data. The acquired data shows that in order to develop a speed limiting device for automobiles, the following vehicle units such as throttle pedal, carburetor, speed sensor, speedometer gear and gauge need to be discussed.

2.1 Throttle Pedal or Accelerator Pedal

One of the most commonly used foot controls is the accelerator control of automobiles. In most automobiles, the accelerator is lower than the other pedals thus requiring the lifting of the foot from the accelerator to avoid releasing of fuel into the combustion chamber. In most of Peugeot and Toyota vehicles, accelerator pedals are situated at the right-hand side, above the driver's floor board. Due to its position, the accelerator pedal was operated by the right leg. Any depression on the accelerator pedal operates the throttle valve in the carburetor. Further depression along the highway increases the vehicle speed. Figure2.1 shows the relationship between accelerator pedal and the carburetor (Hillier, 1976).

2.2 Carburetor

Carburetor is a component which prepares a suitable mixture of fuel and air, and furnishes the mixture into the cylinder through the inlet manifold via throttle

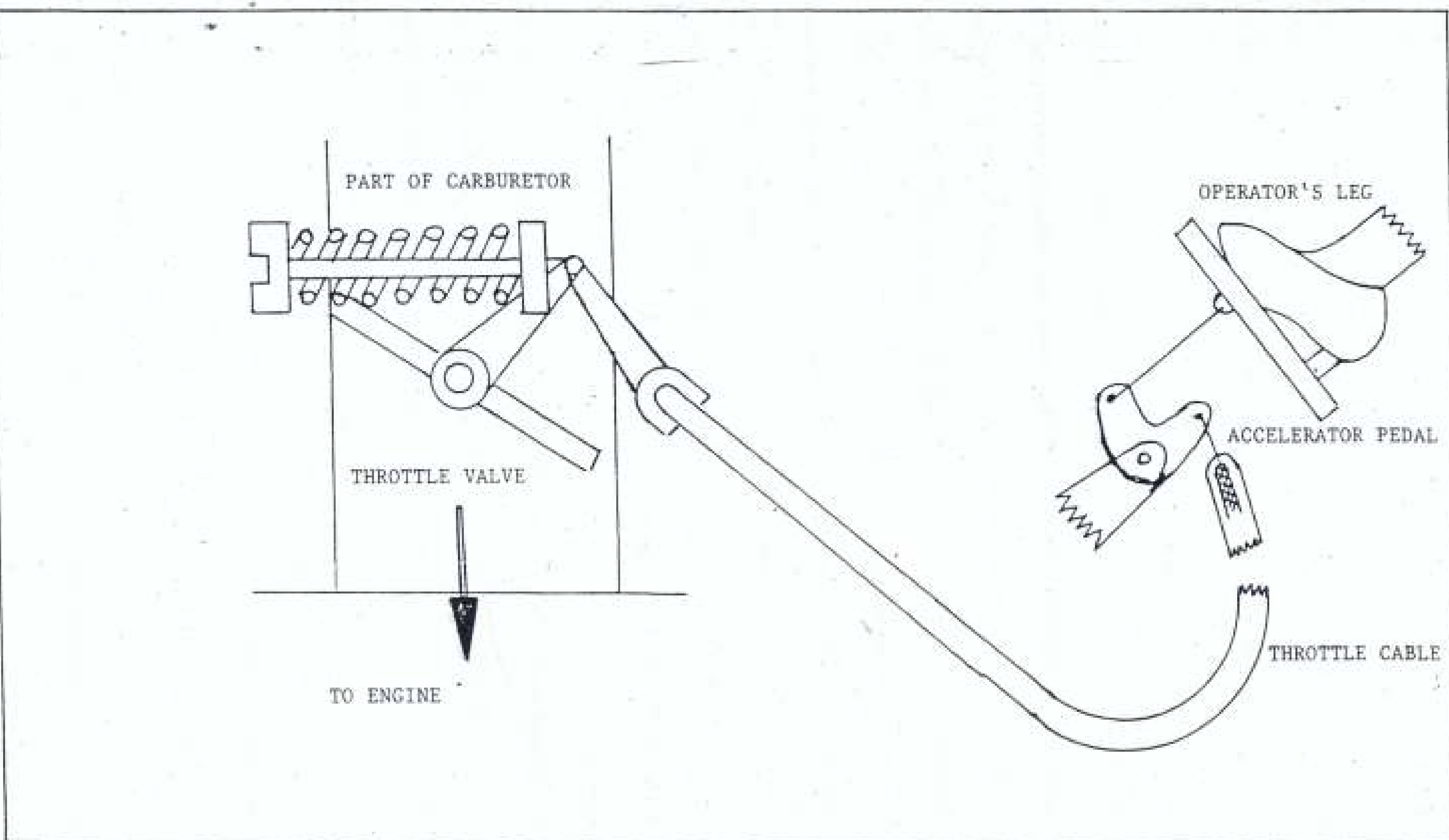


Fig.2.1 RELATIONSHIP BETWEEN ACCELERATOR PEDAL AND CARBURETOR (Hillier, 1976).

valve for combustion (James, 1970). Therefore carburetion is the formation of an inflammable mixture of air and a finely atomised light hydrocarbon (Dolan, 1966). The atomization is accomplished by discharging the liquid hydrocarbon through small holes or jets into a stream of moving air.

2.2.1 Carburetor Throttle Body

The carburetor throttle body, bolts to the pad on the intake manifold. Throttle plates are mounted in the lower section of the throttle body. A linkage mechanism or cable connects the throttle plate with the accelerator pedal. A fuel inlet connects to the fitting on the throttle body while an outlet return line to the tank connects to another fitting on the throttle body.

2.2.2 Computer Controlled Carburetor

A computer controlled carburetor normally uses a solenoid operated valve to respond to commands from a micro computer (Heinz, 1989). The computer calculates how rich or lean to set the carburetor's air-fuel mixture and at what speed to cut-off the fuel. In computer controlled carburetor, the air fuel ratio is maintained by cycling the mixture solenoid ON and OFF several times a second. When the computer sends a rich command to the solenoid, the signal voltage to the mixture solenoid is usually OFF more than it is ON. This causes the solenoid to stay open more. During a lean signal from the computer, the signal usually has more ON time. This causes less fuel to pass through the solenoid valve. The mixture becomes leaner.

2.2.3 Carburetor-Fuel System Components

The carburetor-fuel system consists of a fuel tank, fuel pump, fuel filter, carburetor, intake manifold and fuel lines. There are two basic types of carburetors, fixed venturi and variable venturi. Modern carburetors consist essentially of two parts, that is, float chamber and mixing chamber. The purpose of float chamber is to maintain a constant level of petrol in the float chamber. This level must be lower than the jet because pressure in the float chamber is higher than pressure around the jet (William and Donald, 1985). The float itself is usually a hollow brass pressing and controls a needle valve at the top of the chamber.

The carburetors have several systems (compound jet, air-bleed, power, acceleration, choke and idling), through which air-fuel mixture flows during different operating conditions. These systems produce the varying mixture required for the different operating conditions.

2.3 Speedometer and Odometer

The mechanical speedometer and odometer are not electrical devices. However, they are mounted on the car instrument panel, along with the other instruments. The speedometer tells the driver how fast the car is going. The odometer tells the driver the distance the car has traveled (James, 1970). Figure2.2shows a cutaway view of the assembly. There is a small magnet mounted on a shaft inside the speedometer. The magnet is driven by a flexible cable from the transmission (speedometer gear). The faster the car goes, the faster the magnet spins. This action produces a rotating magnetic field that drags

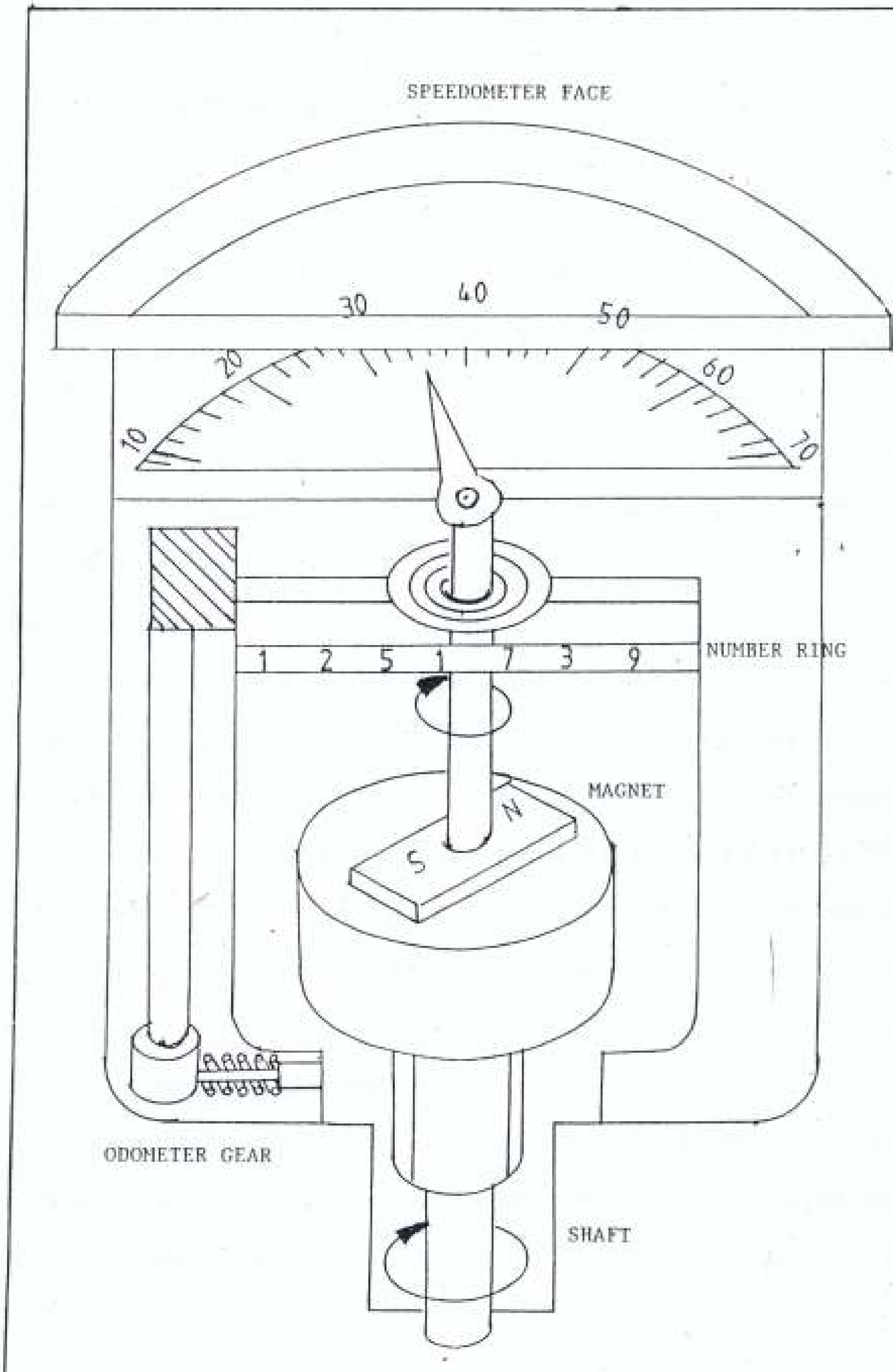


Fig.2.2 A SPEEDOMETER - ODOMETER ASSEMBLY

on the metal ring surrounding the magnet. The faster the spinning, the more drag on the ring. The spinning causes the ring to go around against the tension of a spring. This in turn, moves a pointer attached to the ring which indicates car speed. The odometer is operated by a pair of gears from the same rotating flexible cable that drives the speedometer. The motion is carried through the gears to the mileage rings on the odometer indicator. These rings turn to show how many miles or kilometers the car has been driven. The cable is usually driven from a pair of gears in extension housing of the transmission. One of these gears is on the main shaft of the transmission. The other is on the end of the flexible cable.

2.4 Speedometer Drive

Normally, a manual transmission has a worm gear on the output shaft that drives the speedometer gear and cable. The gear on the output shaft turns a plastic gear on the end of the speedometer cable. The cable runs through a housing up to the speedometer head (speedometer indicator assembly) in the dashboard. A retainer and bolt hold the cable assembly in the transmission extension housing. Whenever the output shaft turns, the speedometer cable turns. This makes the speedometer head register the road speed of the car.

2.5 Speed (Cruise) Control System

Speed control senses engine speed and controls the throttle opening of the carburetor. This system allows the driver to select a speed, set a control and take his or her foot off the accelerator pedal. This system will then hold the car to the speed set. If the car starts to slow down when going up a hill, the throttle valve automatically opens. If the car starts to speed up coasting down a hill, the throttle valve automatically closes.

The system includes two switches-SET and OFF-ON-RESUME- a throttle actuator, a speed sensor, an amplifier, wires, check valve assembly, vacuum reserve tank and vacuum hoses. The switches are mounted either in the spokes of the steering wheel or on the turn-signal lever. The speed sensor is located at the back of the speedometer. An electronic device "reads" the car speed by noting how fast the speed indicator in the speedometer is rotating (Robert, 1975). This information is fed to the electronic controller. The controller then compares this with the speed the driver has set in the memory. If the car speed is too low, the controller signals the vacuum-control valve. The valve then admits more air to the power unit. This causes the diaphragm in the power unit to move. The motion is carried to the throttle through linkage and the throttle opens to increase engine power, so car speed goes up. When the preset car speed is reached, the power unit eases off to prevent any further increase in car speed. When the OFF-ON switch in ON, the system memory is ready to accept a speed value set by the driver. When the driver accelerates to the desired speed and presses the SET switch, the system takes over and holds that speed. The speed may be decreased by moving the OFF-ON switch to OFF, or by tapping the brake pedal. When the driver moves the OFF-ON switch to RESUME, the system automatically accelerates the car to the preset speed. The layout of modern electronic speed control system is shown in Figure 2.3

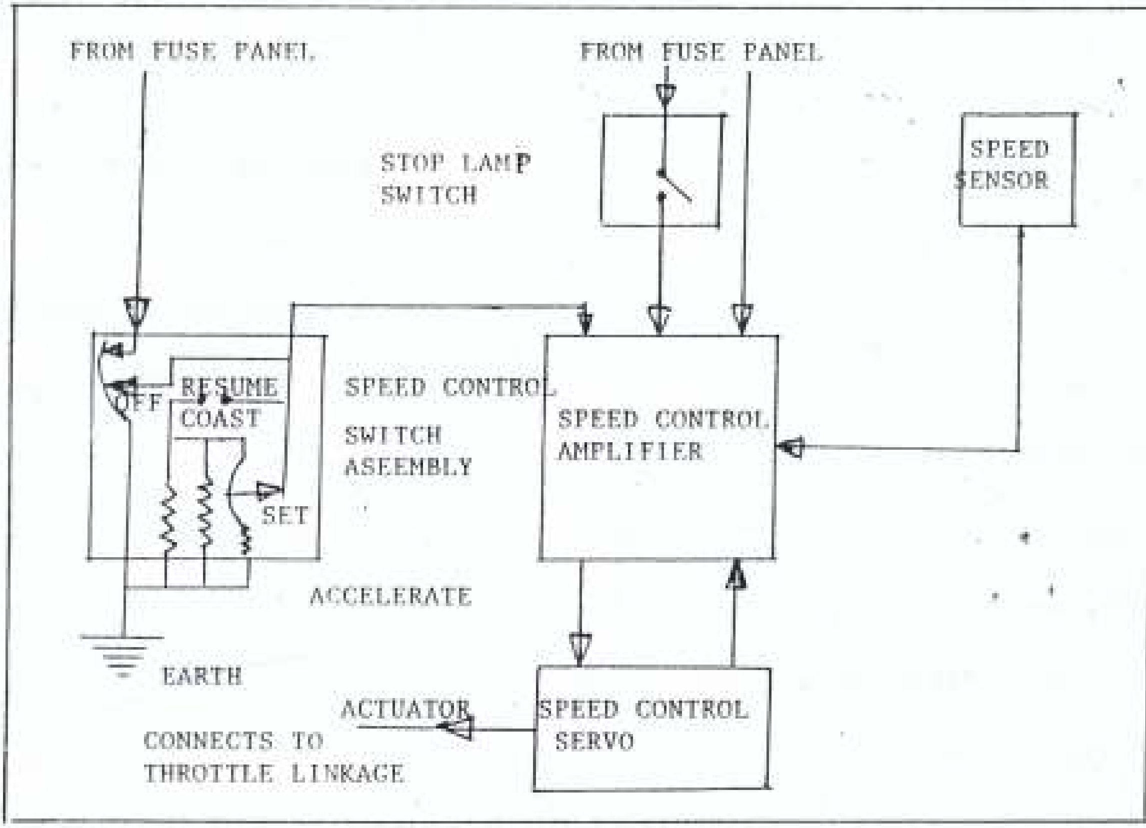


Fig 2.3 MODERN ELECTRONIC SPEED CONTROL SYSTEM

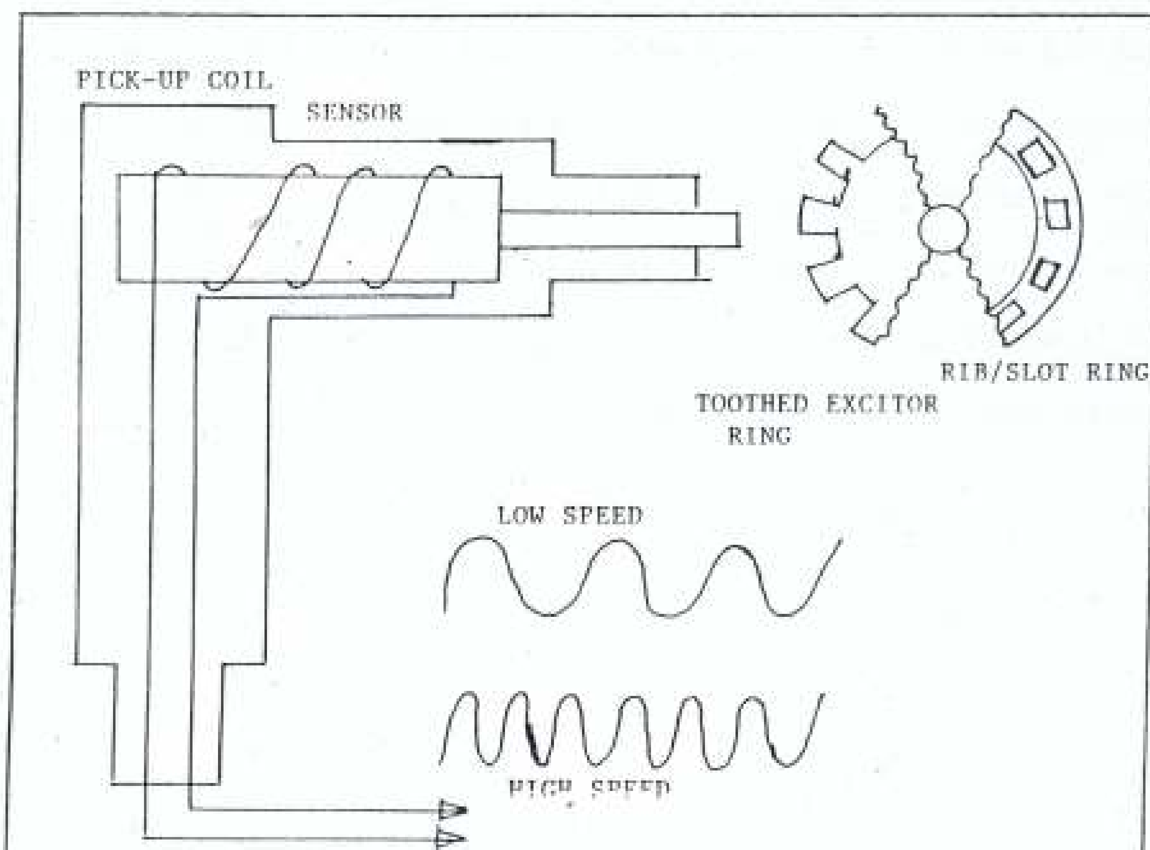


Fig 2.4 SPEED SENSOR AND EXCITOR

2.6 Speed Sensor and Excitor

The speed sensor uses a variable reluctance magnetic-sensing principle whereby a cylindrical permanent magnetic core with a coil wire wound around it, mounted on a stationary hub carrier, axle casing or back plate, produces a magnetic field (flux) which overlaps the rotating exciter ring as shown in Figure2.4The excitor may be of the tooth ring or rib-slot ring type attached to the rotating wheel hub or drive shaft. A number of teeth or slots are arranged radially which with the speed of rotation of the road wheel determine the frequency of signal transmitted to the electronic control unit. As the wheel and exciter revolve, the teeth and gaps and ribs and slots of the exciter pass through the magnetic cone, senses the charging intensity of the magnetic field of the sensor. The coil wrapped around the magnetic field as the teeth or ribs pass through the flux lines and so, an alternating voltage is induced in the coil, whose frequency is proportional to the speed of the rotating wheel. The voltage is transmitted to the control unit whenever the road wheels are rotating regardless of whether the brake is applied or not. The road wheel speed measured by the speed sensor provides the wheel deceleration and wheel acceleration signals for the electronic control unit. The merging and processing of the individual wheel speed sensor signals by the control unit provide a single reference speed, which is roughly the vehicle speed.

2.7 Throttle Position Engine Sensor

The carburetor sensor system monitors engine-operating conditions and reports the information to the computer (Team, 1991). A throttle position sensor is a variable resistor connected to the throttle plate shaft. When the throttle swings open for more power or close for less power, the sensor changes resistance and signals the computer. The computer can then cut off the fuel supply to the combustion chamber through the inlet manifold as the driver wants to exceed the speed limit specified for the vehicle.

Throttle position sensor uses contacts to report amount of throttle opening to the computer. Throttle shaft rotation causes different contacts to close. Each set of contacts is connected to the circuit resistor of different value. In this way, different current levels are produced for different throttle positions. The computer can then alter fuel mixture for idle and wide open throttle positions and at the same time cut off the fuel when overspeeding.

A bad throttle position can affect fuel metering, ignition timing and other computer outputs. Many throttle position switches use contact points or variable resistors that can wear and fail. A throttle position sensor signals the computer when the gas pedal is depressed to different positions for acceleration, deceleration, idle cruise and full power. It can cause wide range of performance problems. If shortened, it might make the fuel mixture too rich or if opened, too lean (Mark and Arnest, 1992).

A throttle positioner is used on the throttle body assemblies to cut off the fuel when the driver wants to exceed the maximum fixed speed limit. The computer actuates the positioner to open or close the throttle plate. In this way, the computer can maintain a precise a vehicle speed.

2.8 Vehicle Speed Sensor

This sensor senses the actual speed at which the vehicle is traveling (Team, 1992). A bad vehicle speed sensor will usually reduce the engine performance and fuel economy but will not keep engine from running. It provides data for precise control of fuel metering, ignition timing, etc. A bad vehicle speed sensor might also affect transmission torque converter lock-up. A vehicle speed sensor is tested in much the same way as an engine sensor. There are four types of speed sensors, they are: -

(I) Reed Switch type

(II) Photo Coupler type

(III) Electromagnetic Pick-up type

(IV) Magnetic Resistance Element type.

2.8.1 Reed Switch Type

This sensor is mounted in the analog combination meter. It contains a magnet, which is rotated by the speedometer cable, turning the reed switch ON and OFF. The reed switch goes ON and OFF four times each time the speedometer cable rotates once. The magnet has the polarities shown in Figure2.5 The magnetic force at the four areas of transmission between the North and South poles of the magnet opens and closes the contacts of the reed switch as the magnet rotates. The electrical circuitry of the reed switch type is shown in Figure 2.6

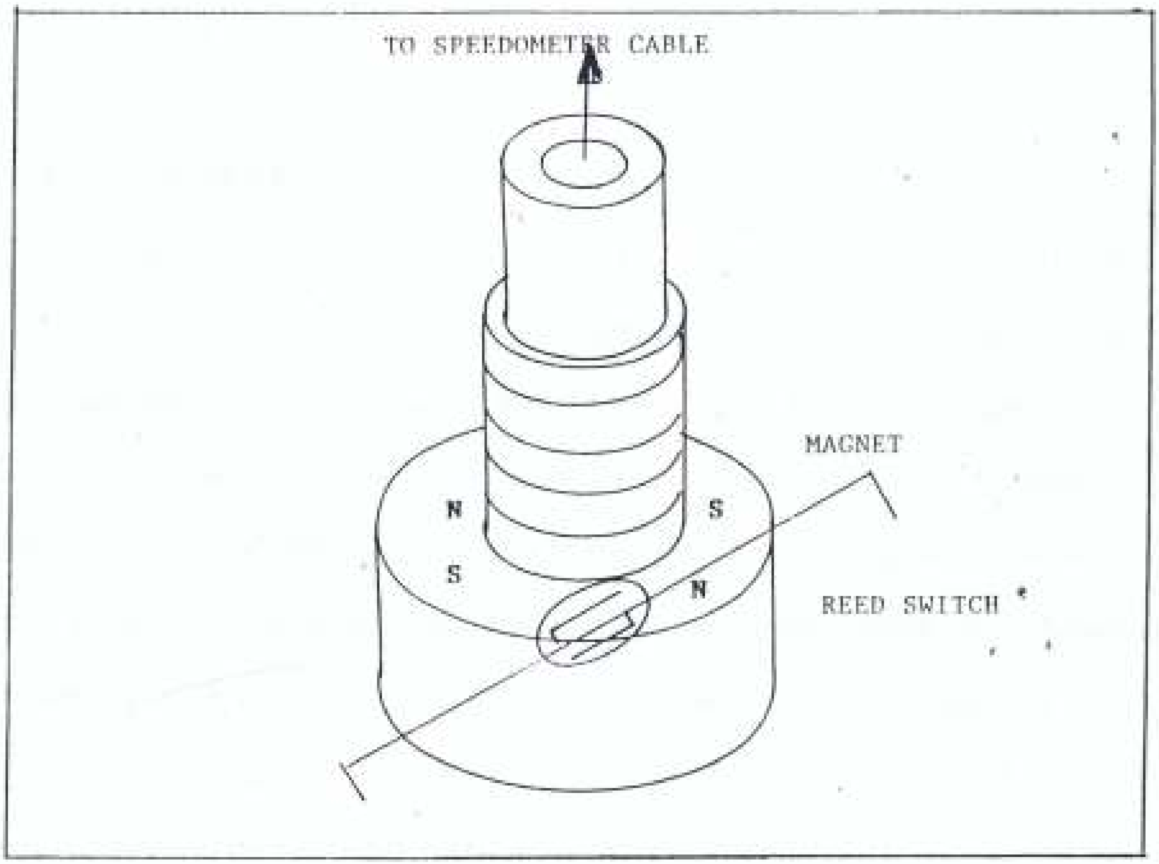


Fig 2.5REED SWITCH TYPE

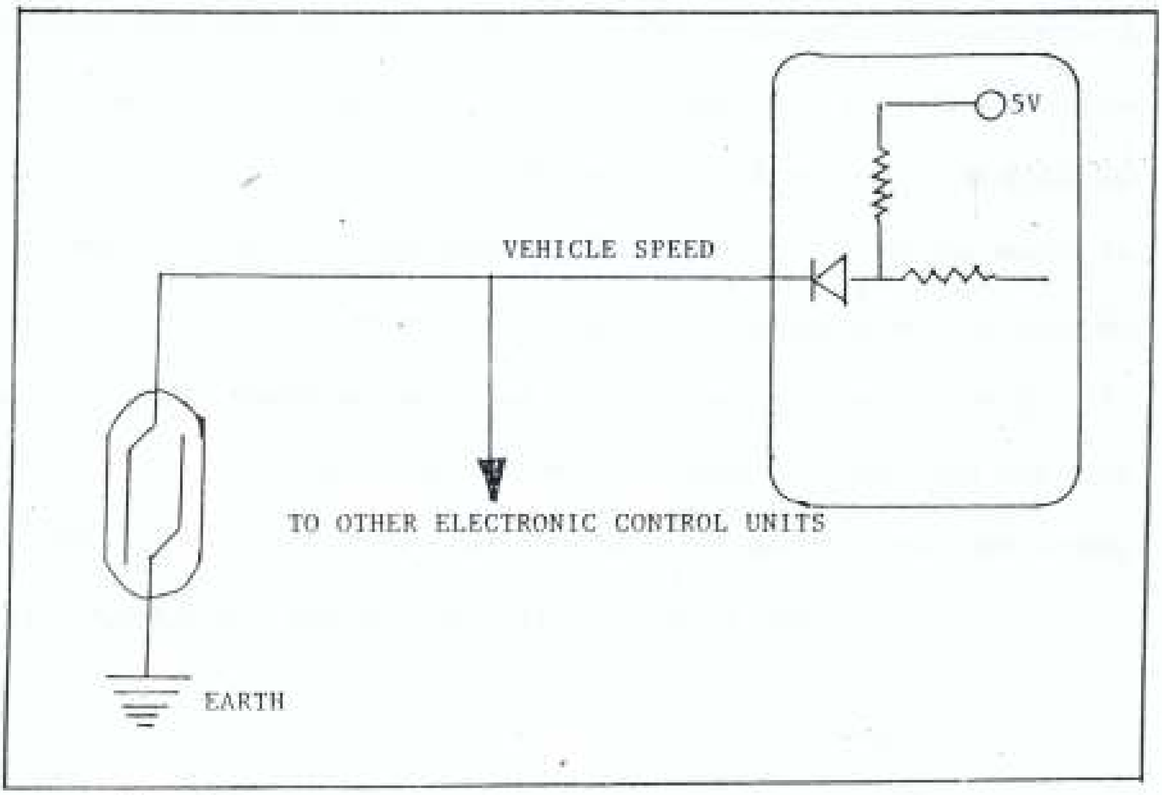


Fig.2.6 ELECTRICAL CIRCUITRY OF REED SWITCH TYPE

2.8.2 Photo Coupler Type

This sensor is mounted in the combination meter. It includes a photo-coupler made from a light emitting diode, which is aimed at a phototransistor. The light emitting diode and phototransistor are separated by a slotted wheel, which is driven by the speedometer cable. The slots in the slotted wheel generated light pulses as the wheel turns revolution of the cable. These twenty pulses are converted to four pulses by the digital meter computer, then sent as signals to the electric control unit. A sketch of a photocoupler type vehicle speed sensor is shown in Figure 2.7 and its electrical circuitry is shown in Figure 2.8.

2.8.3 Electromagnetic Pick – Up Type

This sensor is fitted to the transmission and detects the rotational speed of the transmission output shaft. This sensor consist of a permanent magnet, a coil and a core. A rotor with four teeth is mounted on the transmission output shaft. When the transmission output shaft rotates, the distance between the core of the coil and the rotor increases and decreases because of the teeth. The number of lines of magnet force passing through the core increases or decreases accordingly and AC voltage is generated in the coil. Since the frequency of this AC voltage is proportional to the rotational speed of the rotor, it can be used to detect the vehicle speed. Figure 2.9 shows a transmission output shaft with speed sensor while Figure 2.10 shows the speed sensor itself. Figure 2.11 shows the working principle of speed sensor while the Figure 2.12 is an electrical circuitry.

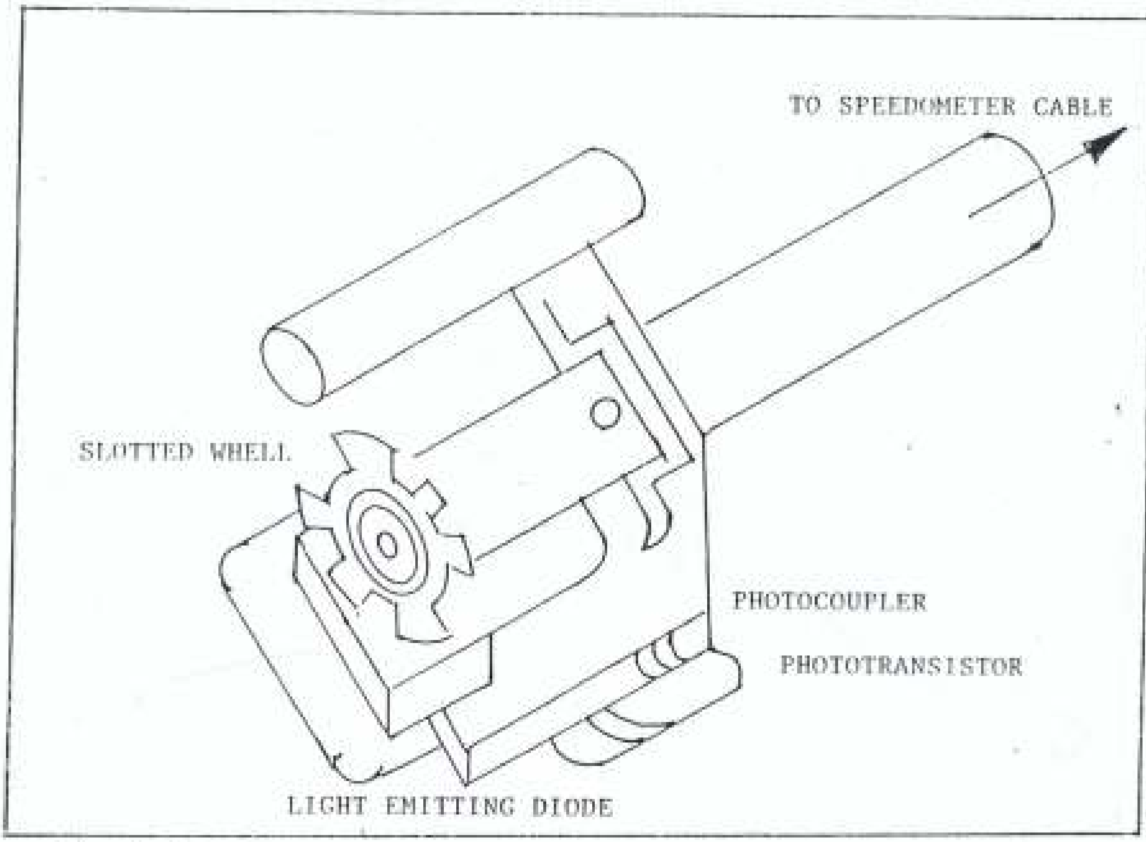


Fig.2.7 PHOTOCOUPLER TYPE SPEED SENSOR

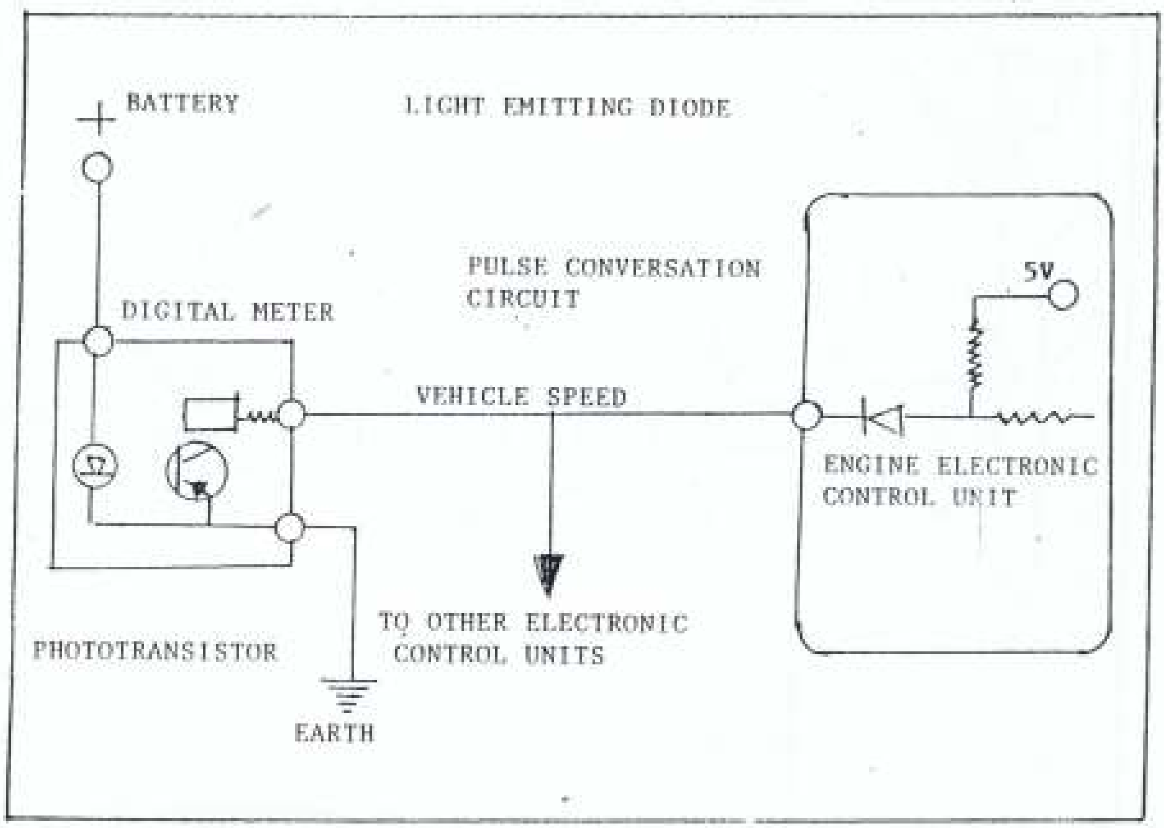


Fig.2.8 ELECTRICAL CIRCUITRY OF PHOTOCOUPLER TYPE SPEED SENSOR

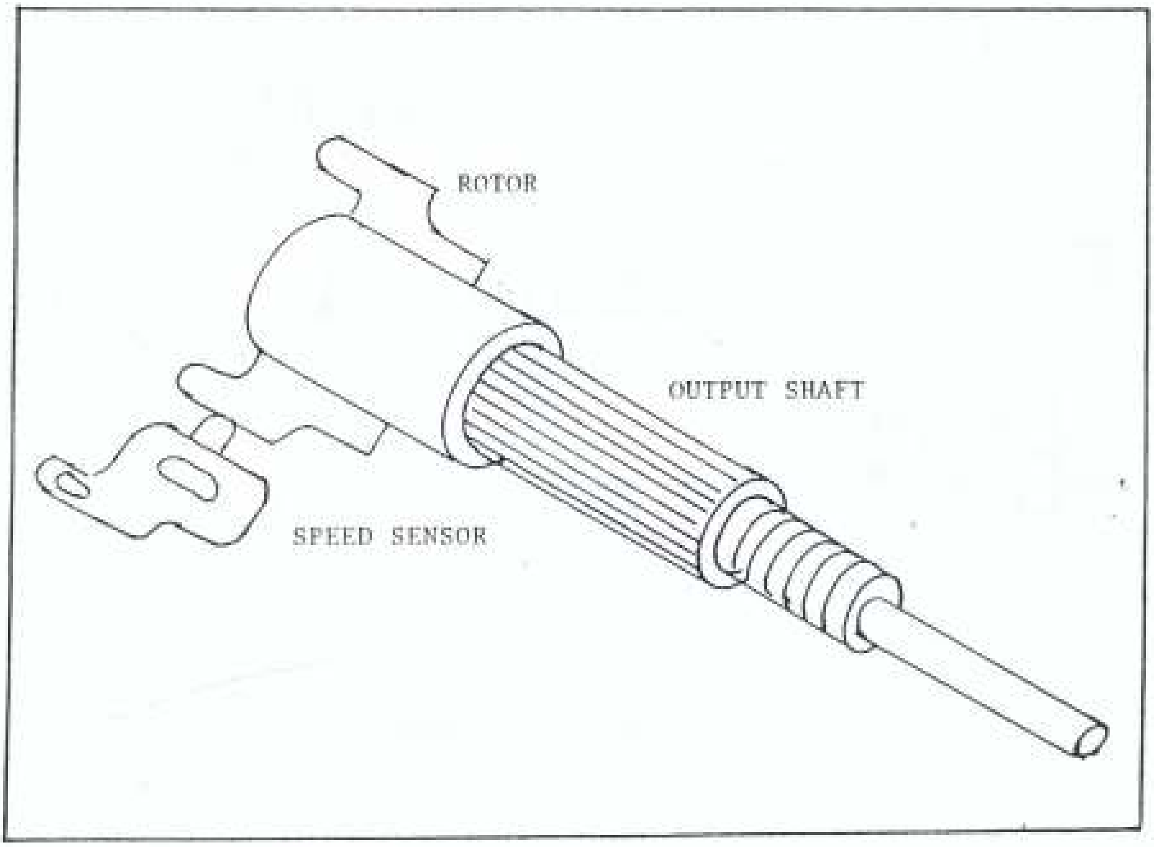


Fig.2.9 TRANSMISSION OUTPUT SHAFT

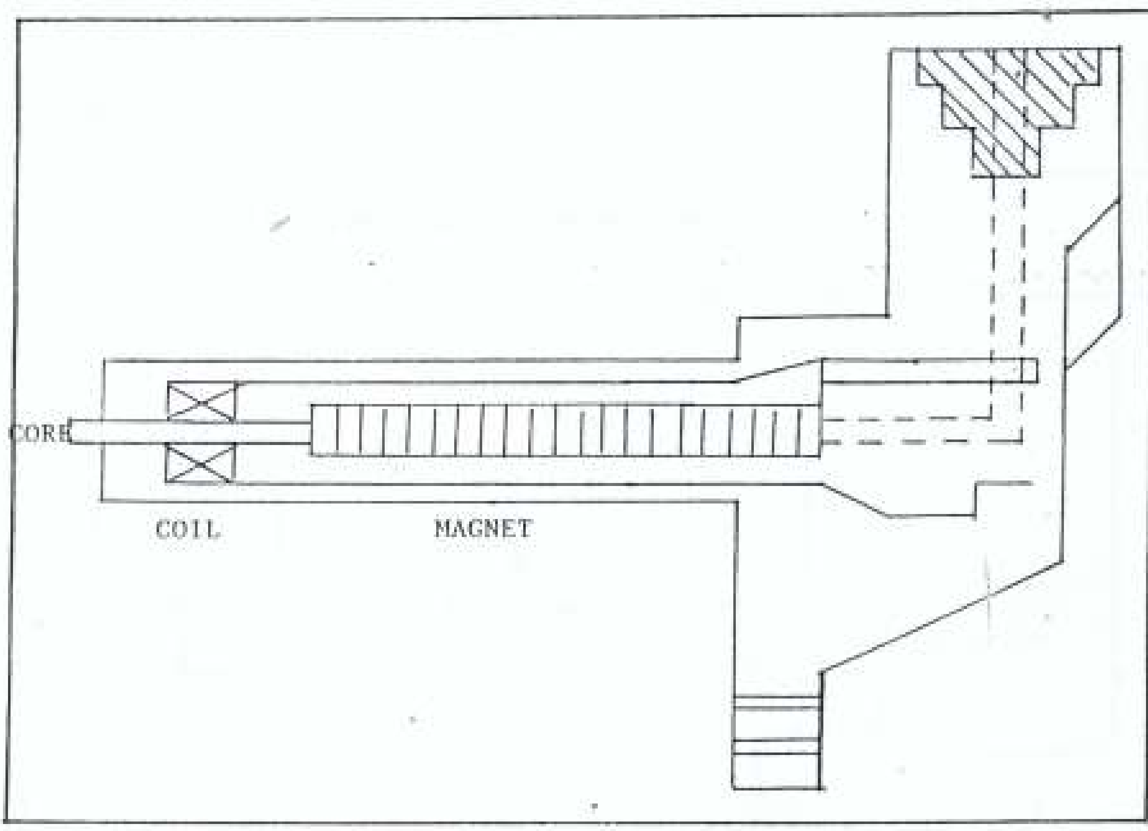


Fig 2.10 SPEED SENSOR

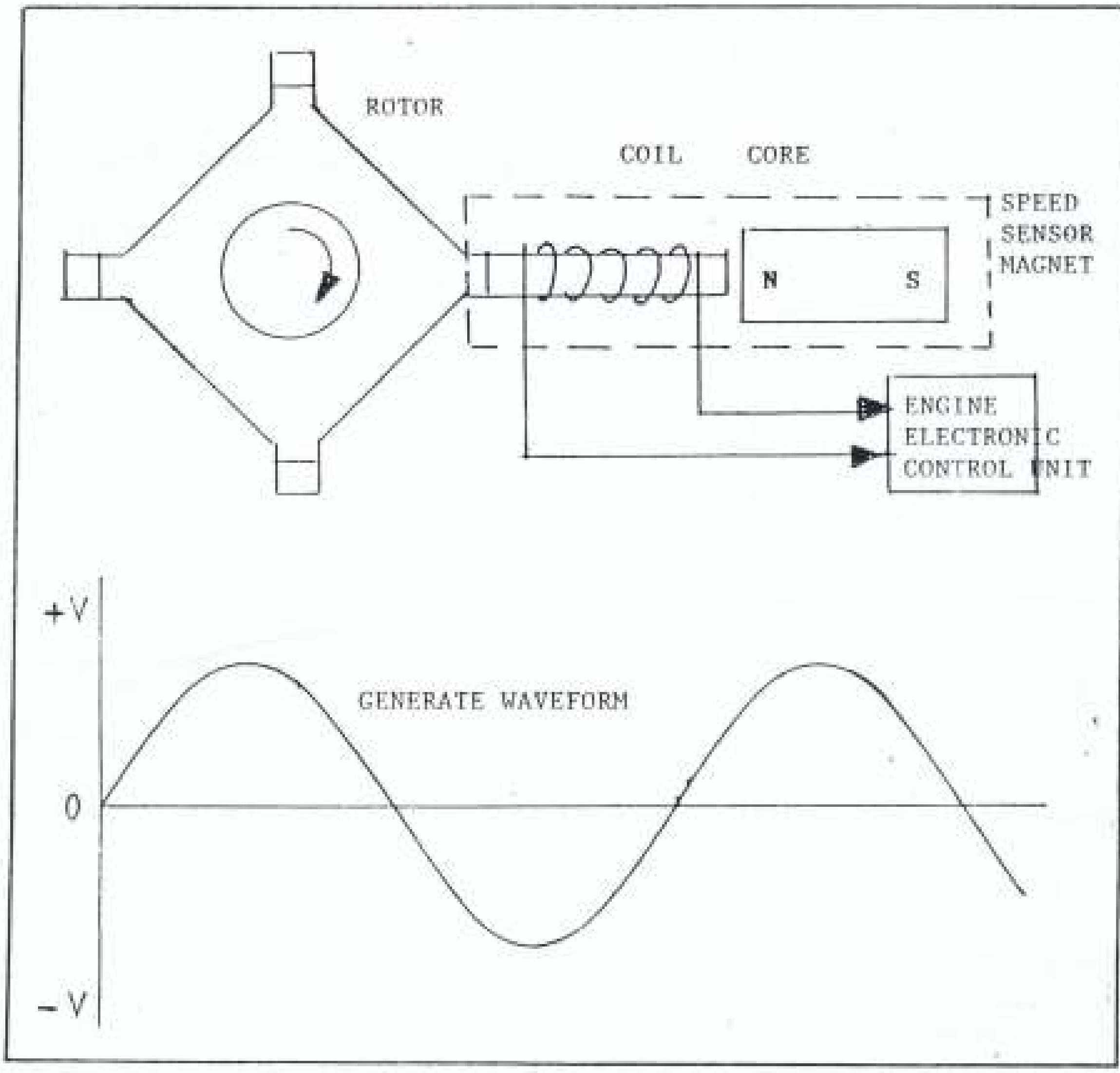


Fig 2.11 WORKING PRINCIPLE OF SPEED SENSOR

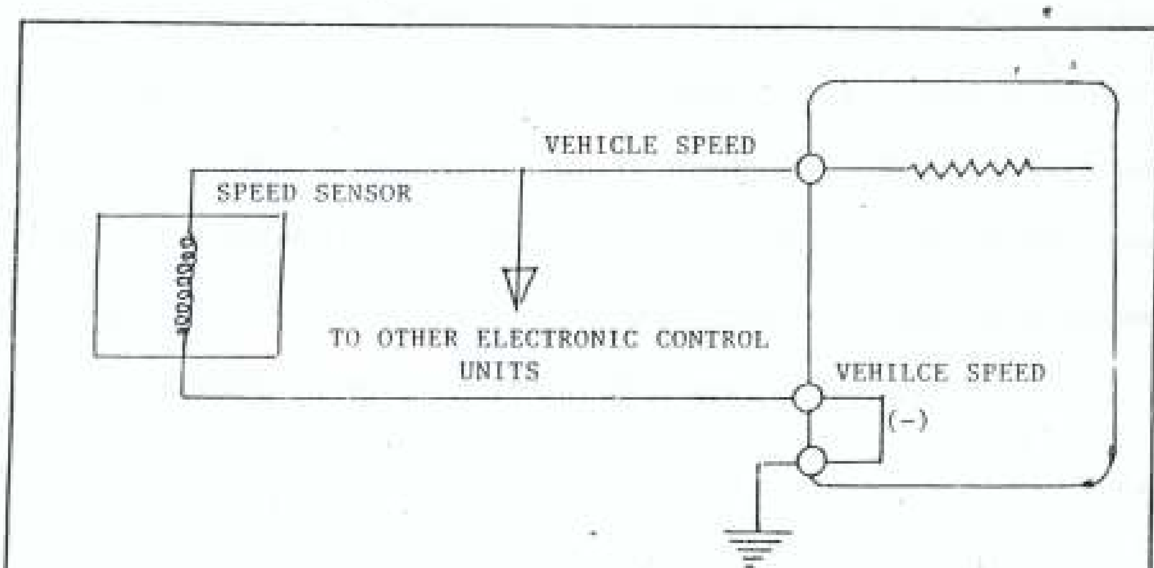


Fig 2.12 ELECTRICAL CIRCUITRY OF ELECTROMAGNETIC PICK-UP TYPE

2.8.4 Magnetic Resistance Element Type

This sensor is mounted on the transmission or the transfer and is driven by the drive gear of the output shaft as shown in Figure 2.13. This sensor consists of an hybrid integrated circuit with a built in magnetic resistance element and a magnetic ring, as shown in Figure 2.14.

The orientation of magnetic force is changed by the rotation of the magnet fitted to the magnetic ring, with the result that the output of the magnetic resistance element becomes an alternating waveform, as shown in Figure 2.16. The comparator in the speed sensor converts the alternating waveform into a digital signal, which is then inverted by the transistor before being sent to the combination with the number of poles of the magnet fitted to the magnetic ring. There are two types of magnetic ring (depending on the vehicle), the type with 20 magnetic poles and the type with 4 magnetic poles. The 20 poles type (as shown in Figure 2.17) generates a 20 cycle waveform (I.e. 20 - pulses for each rotation of the magnetic ring) while the four- pole type (as shown in Figure 2.18 and 2.19) generates a 4-cycle waveform . in the 20 - pole type, the frequency of the digital signal is converted from 20 pulses for each revolution of the magnetic ring to 4 pulses by the pulse conversion circuit in the combination meter, then the signal is sent to the engine electronic control unit. In the case of 4 pole type, there are two different kinds, in one type, the signal from the speed sensor passes through the combination meter before going to the engine electronic control unit. In the other type, this signal goes directly to the

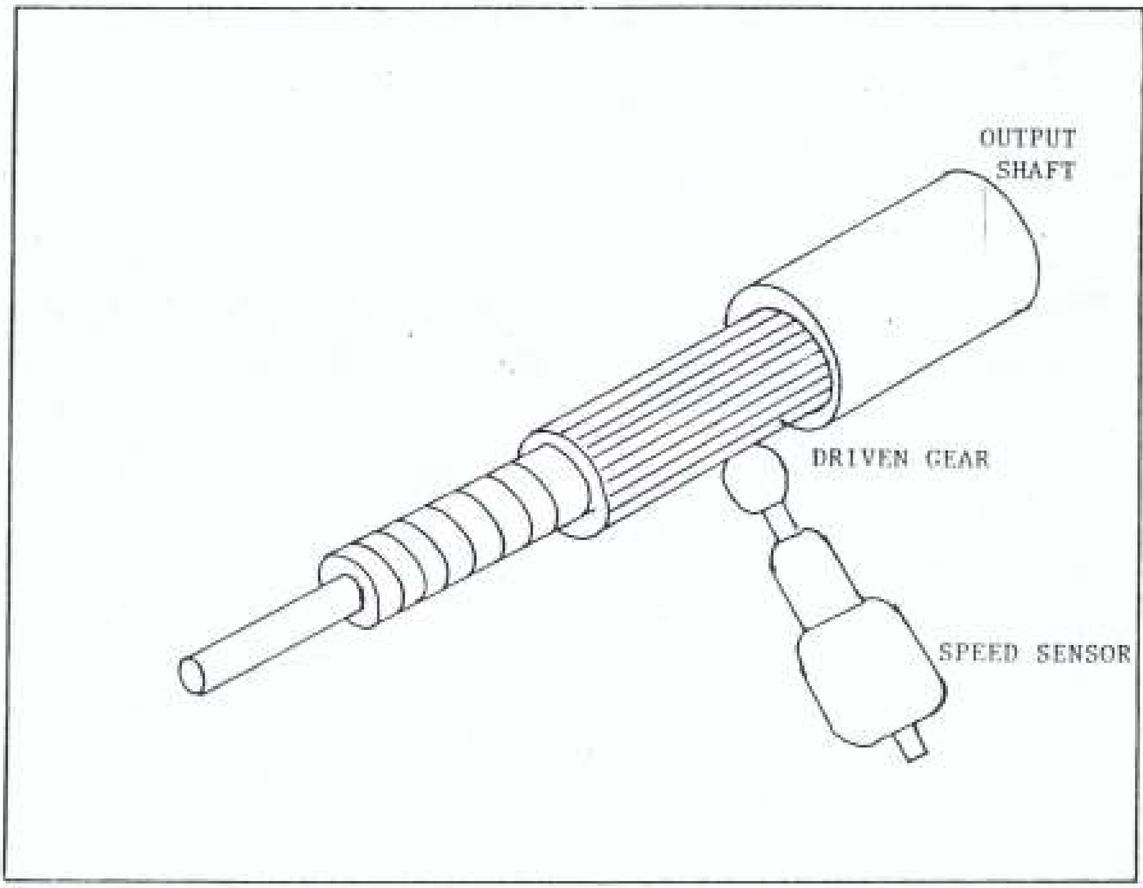


Fig_2.13 TRANSMISSION OUTPUT SHAFT

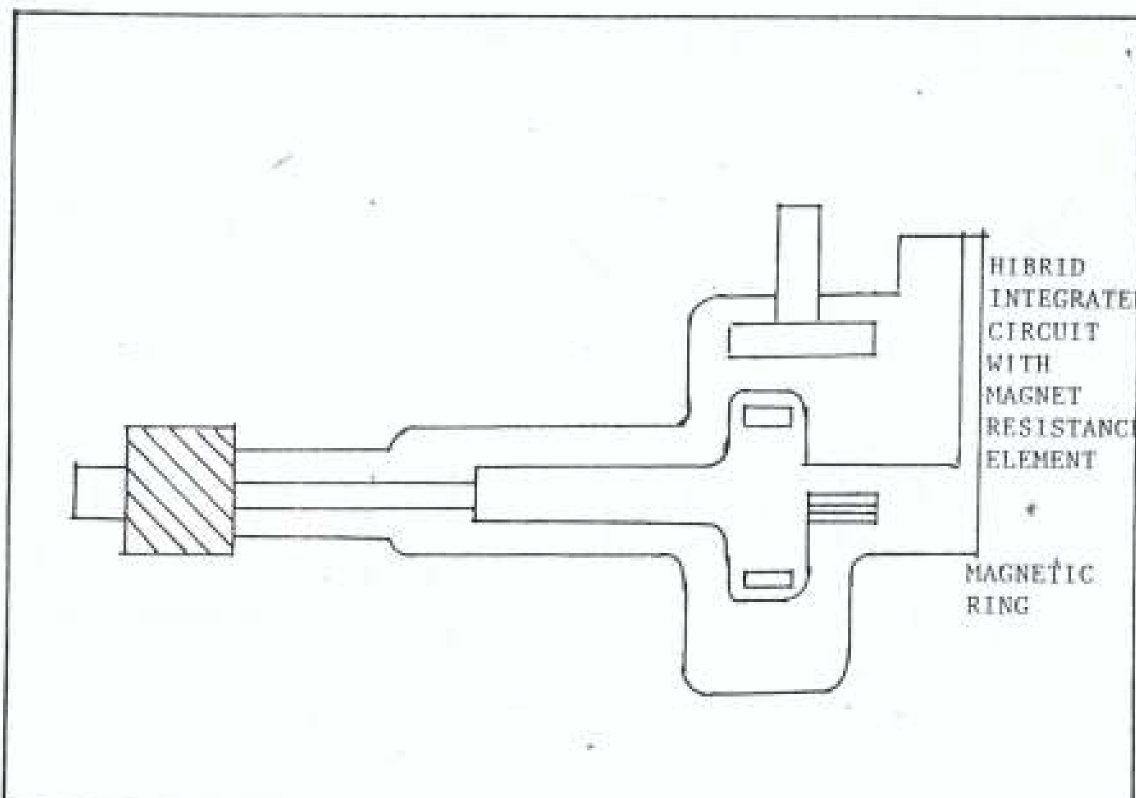


Fig 2.14 SPEED SENSOR

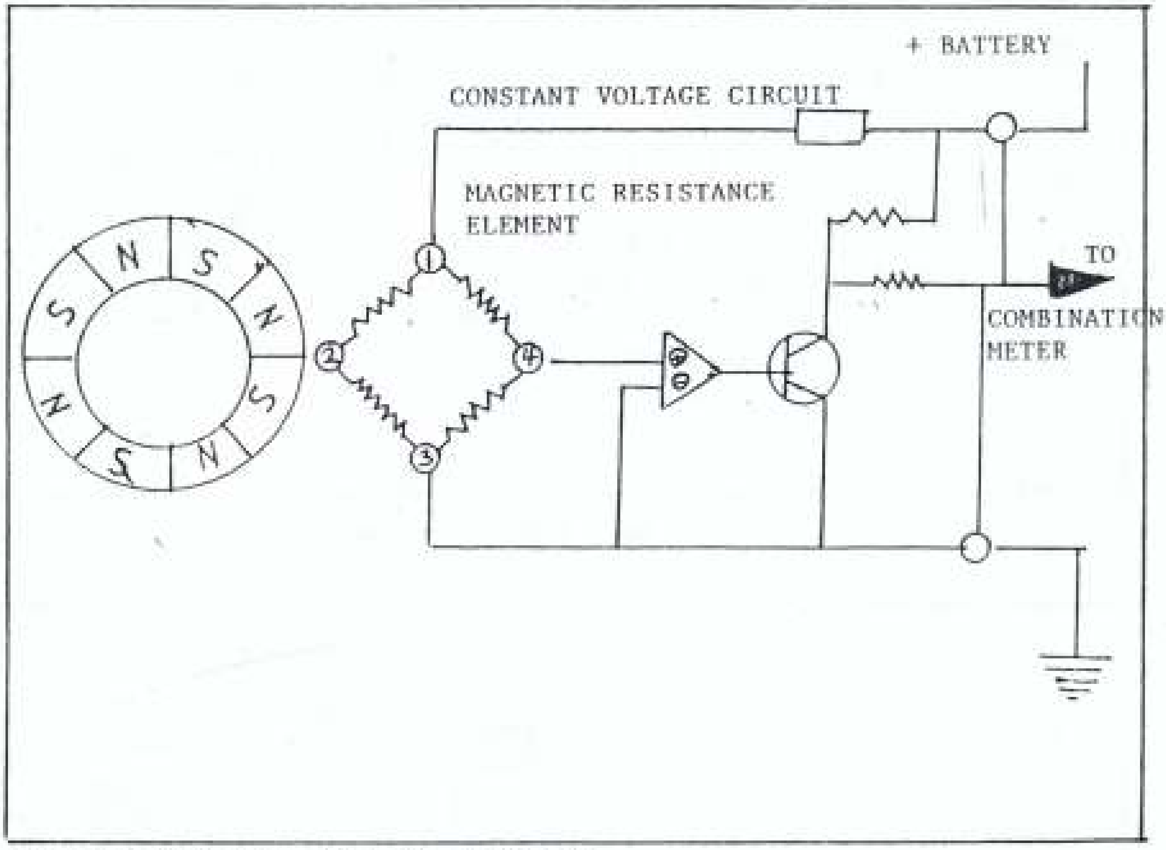


Fig 2.15 20-POLE TYPE SPEED SENSOR

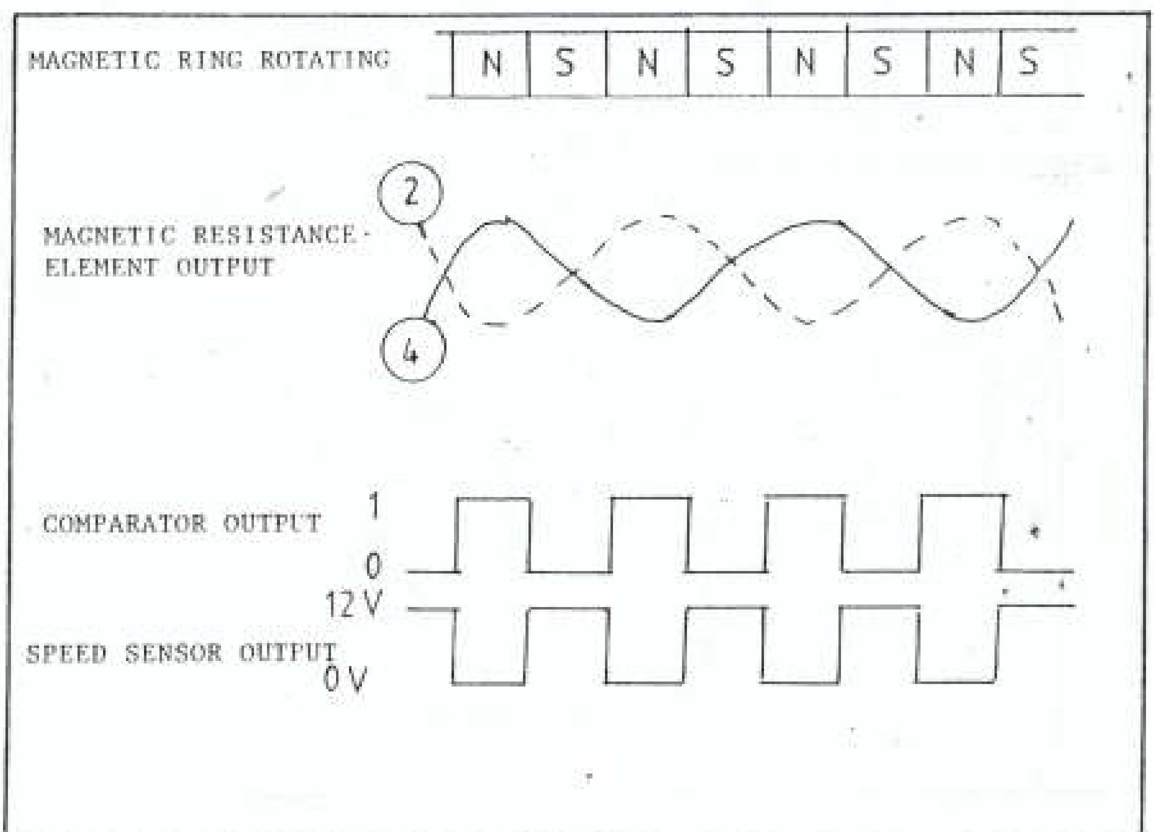


Fig2.16ALTERNATING WAVEFORM

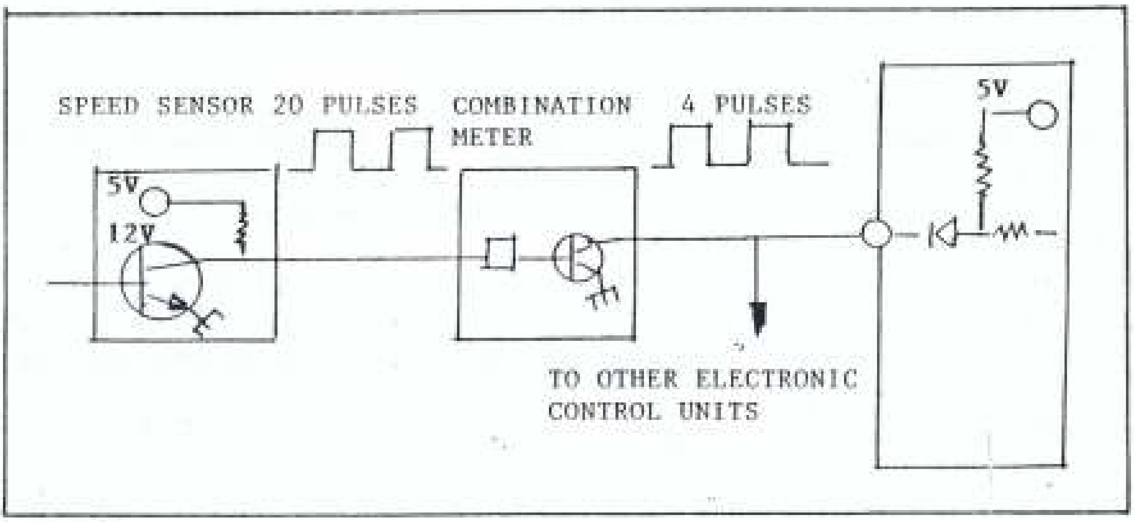


Fig 2.17 20-POLE TYPE OUTPUT VOLTAGE TYPE

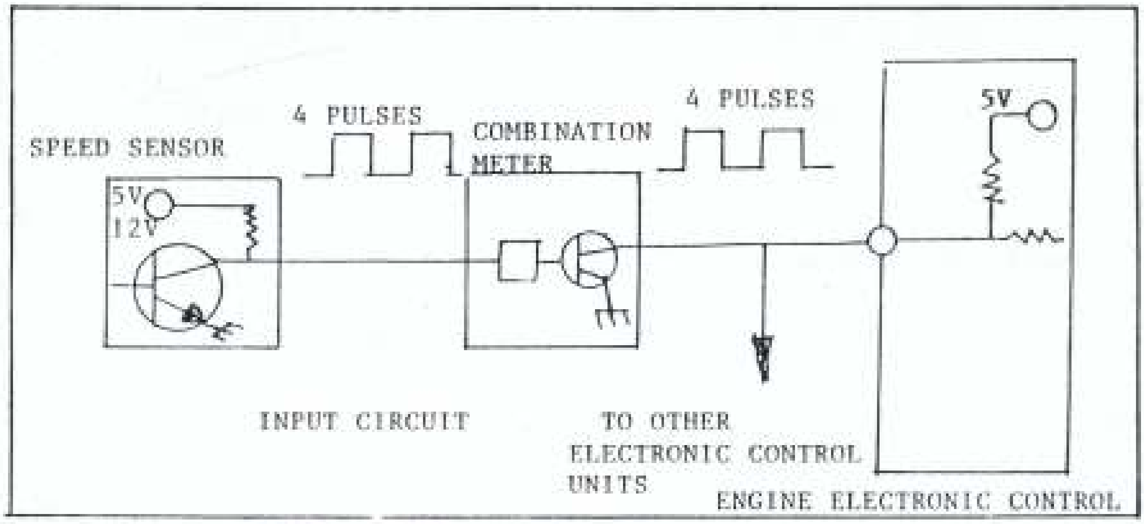


Fig 2.18 4-POLE TYPE OUTPUT VOLTAGE TYPE

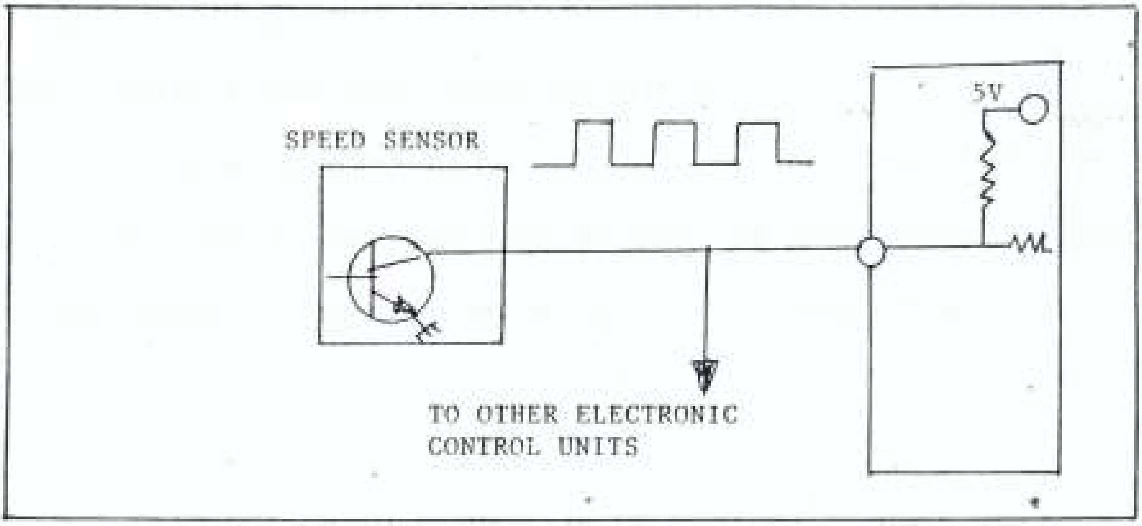


Fig 2.19 4-POLE TYPE VARIABLE RESISTANCE TYPE

engine electronic control unit without passing through the combination meter. The output circuitry of the speed sensor differs depending on the vehicle model. As a result, the output signal also differs depending on the model. One type is the output voltage type and the other is the variable resistance type. The types of

magnetic resistance element type speed sensor presently used by Toyota are shown in the table below:

	TYPE OF MAGNETIC RING	TYPE OF SIGNAL
1	20 pole type 20 pulses/revolution	Output voltage type OV to 5 – 12V
2 3	4 pole type 4 pulses/revolution	Variable resistance type $0\Omega - \infty$

2.9 Twelve Ways of Measuring Speed

According to (Douglas, 1959) the twelve ways of measuring speed are:

2.9.1 Simple Counter and Separate Stop Watch:

It requires dexterity since the counter is held with one hand and the stop watch with other hand. Average speed measured during one minute interval by noting the counter readings at beginning and end of time interval as shown in Figure 2.20

2.9.2 Combination Counter and Stop Watch

Counter starts when button is pressed and the watch automatically stops counter hand at end of a given time. Dial is calibrated in revolutions per minute and measures average speed. It is shown in Figure 2.12.

2.9.3 Centrifugal Tachometers

Centrifugal governor type mechanisms with weights, which move outwardly from shaft as speed increases causing sleeve to move up. Sleeve moves indicator pointer through linkage in proportion to speed. Care must be taken to avoid over speeding. It is shown in Figure 2.22.

2.9.4 Generator Tachometers

D.C. voltage generated in proportion to speed and displayed on a D.C indicator or recorder. This system does not use gearing and is usually limited to 150-200 rpm at full scale. Generator is matched with a particular indicator because voltage is not exactly linear with speed. It is shown in Figure 2.23.

2.9.5 Generator Tachometers

A.C. voltage is generated in proportion to speed and displayed on an A.C. indicator. This system does not use gearing and usually limited to full scale reading of 500rpm minimum and 500rpm maximum. It covers wide range and does not require brushes. It is shown in Figure 2.24.

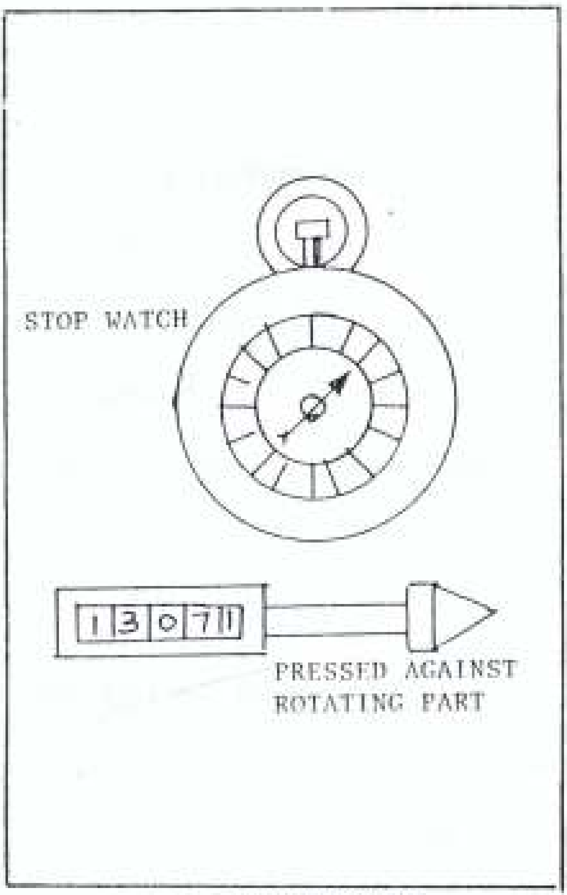


Fig 2.20 SIMPLE COUNTER AND STOP WATCH

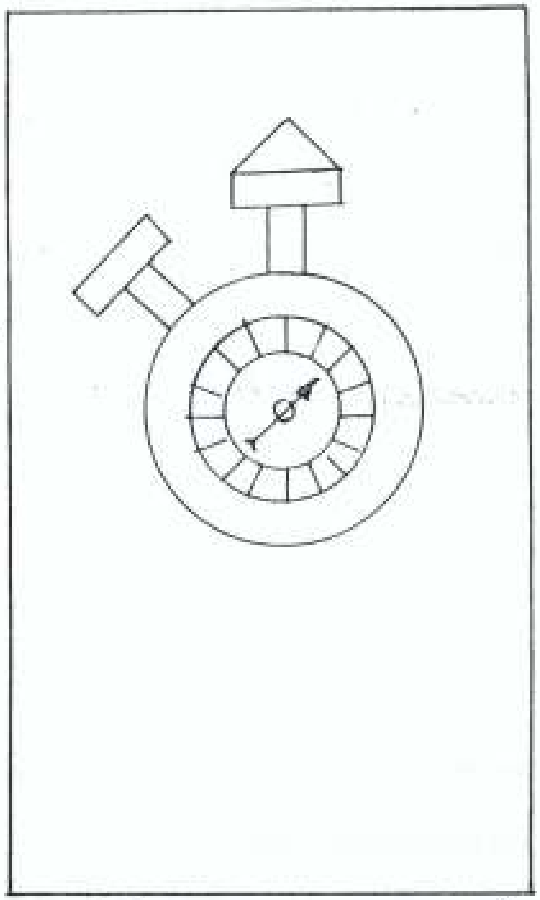


Fig 2.21 COMBINATION COUNTER AND STOP WATCH

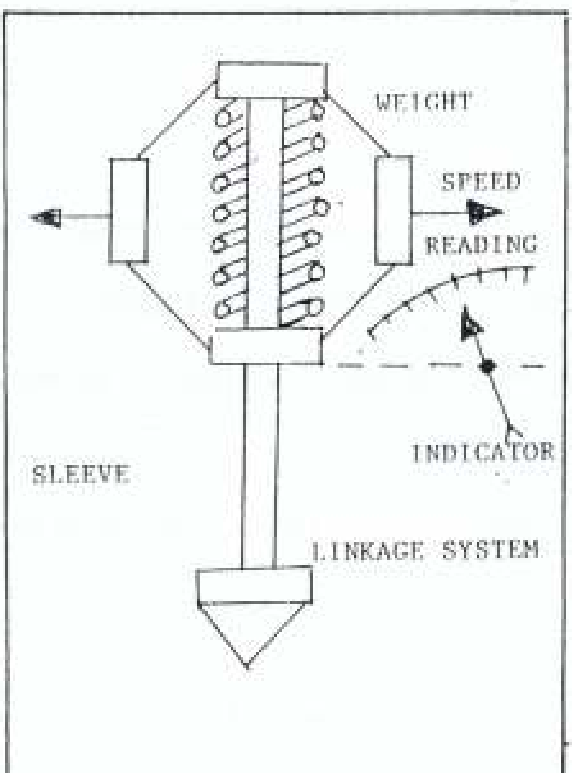


Fig 2.22 CENTRIFUGAL TACHOMETER

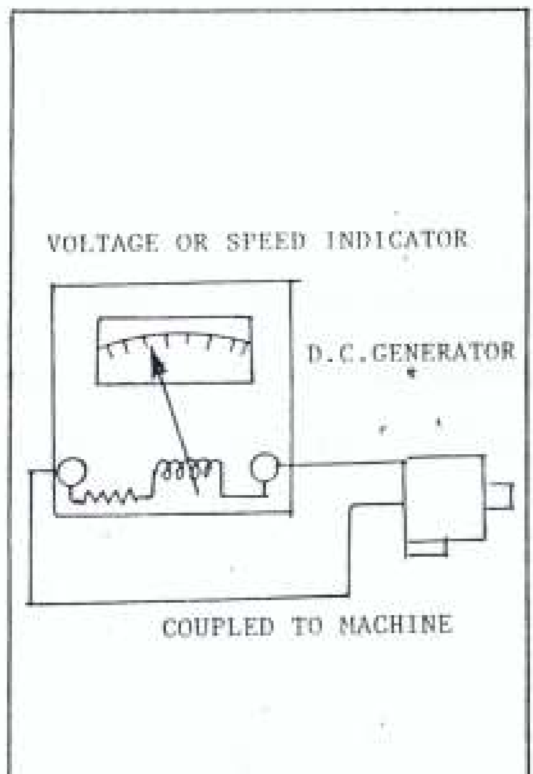


Fig 2.23 GENERATOR TACHOMETER

2.9.6 Drag Cup Tachometers

Flexible shaft drives small permanent magnet in drag cup. Motion of magnet sets up eddy currents in wall of drag cup, resulting rotary force causes drag cup to follow. Hair spring balanced to produce a pointer deflection proportional to speed. This system is simple and inexpensive, but with limited accuracy and speed range. It is shown in Figure 2.25.

2.9.7 Stroboscopic Tachometers

A fast flashing light is used to view rotating part. Frequency of flashing adjusted until rotating parts appear to stand still. Frequency reading corresponds to revolutions per minute of rotating part. It requires no accessible shaft and absorbs power from rotating part. However, the system requires constant adjustment if speed changes. It is shown in Figure 2.27.

2.9.9 Photoelectric Tachometers

A constant light source is focused to shine on a rotating disc. The light reflects into a modulator by dark and light spots on rotating part. Frequency of modulations proportional to rotating speed and measured by frequency meter. Speed up to 3,000,000 rpm can be measured. This is shown in Figure 2.28

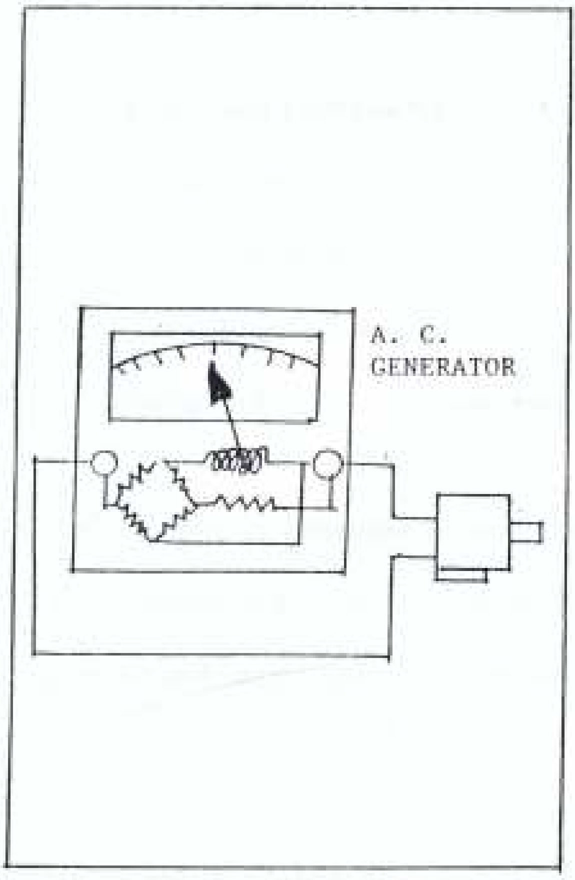


Fig 2.24 GENERATOR TACHOMETER

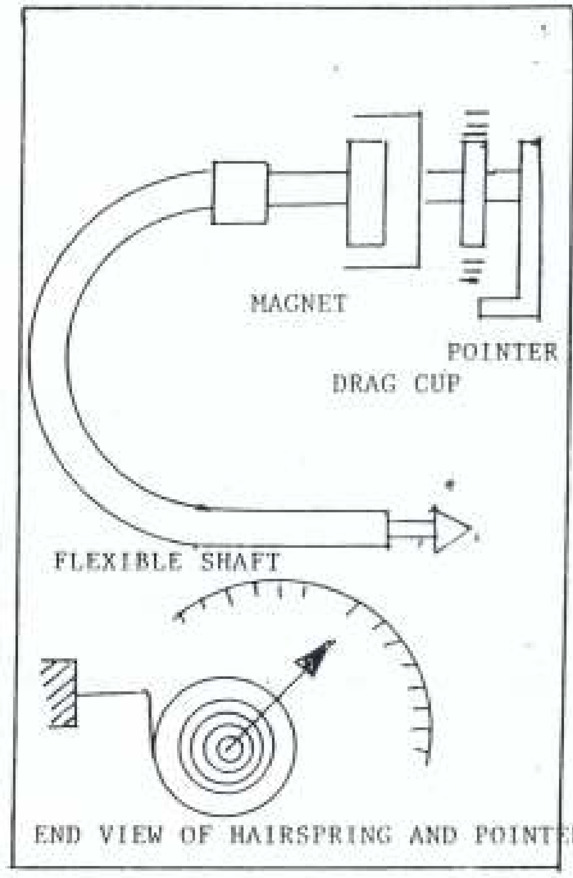


Fig 2.25 DRAG CUP TACHOMETER

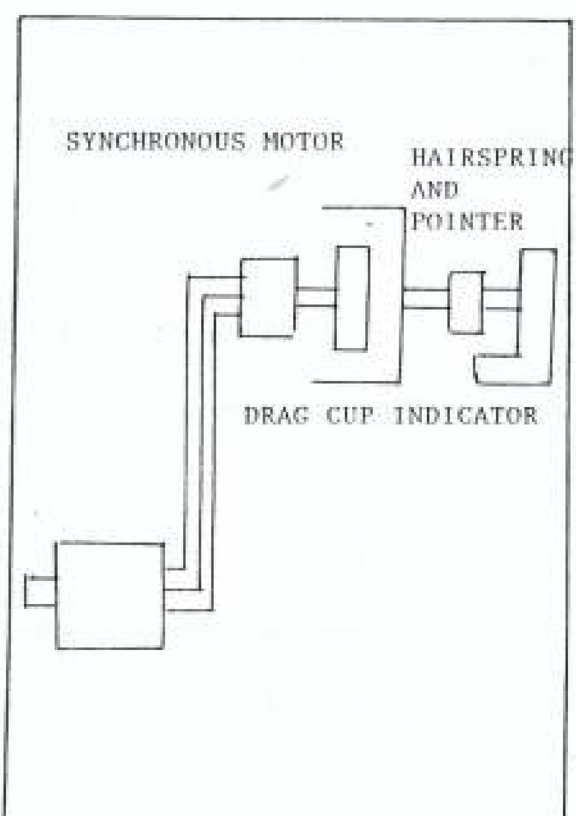


Fig 2.26 DRAG CUP INDICATOR

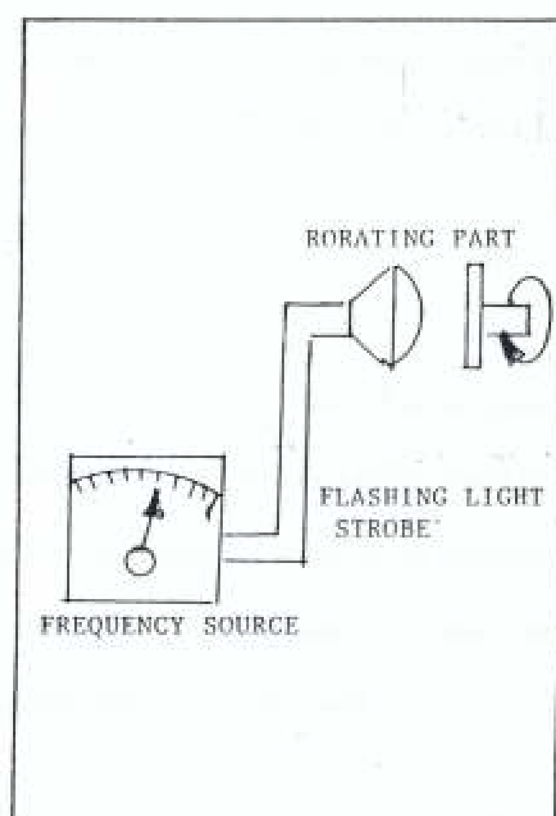


Fig 2.27 STROBOSCOPIC TACHOMETER

2.9.10 Vibration Feed Tachometers

A comb made up of a set of accurately turned steel reeds is held against any part of rotating machine, such as the case of motor. Vibration of machine vibrates on reeds in tune with machine frequency is read directly on a scale above the comb. It requires no access to a rotating shaft and ranges from 500- 12,500rpm. It is shown in Figure 2.29.

2.9.11 A.C. Frequency Responsive Tachometers

It is similar to A.C. generator but measures generated frequency (not voltage). It is very expensive and ranges from 500-800 rpm with good accuracy. It is shown in Figure 2.30.

2.9.12 Commutated Tachometers

Rotating double pole, double throw switch charges and discharges capacitor. The resulting average D.C. current is linear with speed. This system is very accurate. Linearity allows multiple range indicators and rotating switches are interchangeable. This is shown in Figure 2.31.

2.10 Vehicle Speed Sensor

This sensor tells the computer how fast the car is traveling. The Vehicle Speed Sensor is driven by the speedometer cable. The speedometer cable drives a pulse generator in the speedometer pinion housing. Some cars have the speedometer pinion drive the pulse generator. As the pulse generator makes one revolution, a certain number of pulses or voltage signals are sent to the computer. The computer must be programmed

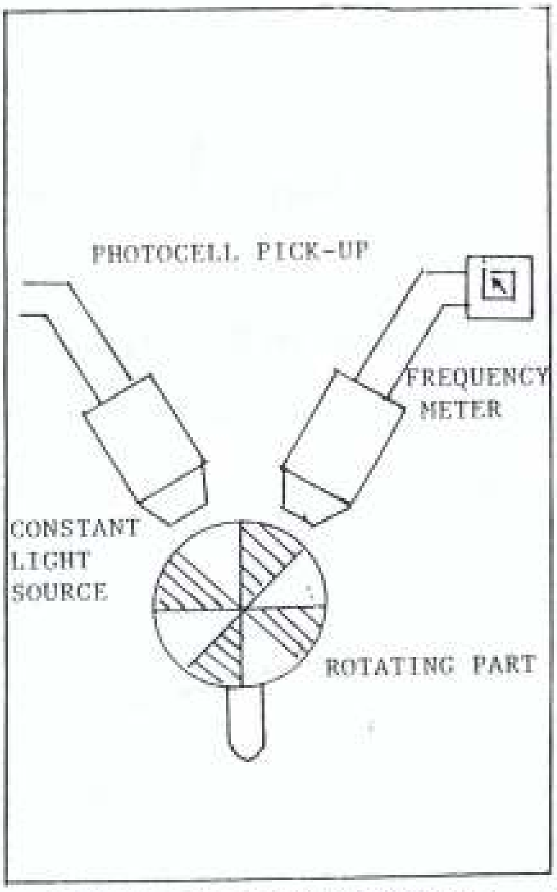


Fig 2.28PHOTO-ELECTRIC TACHOMETER

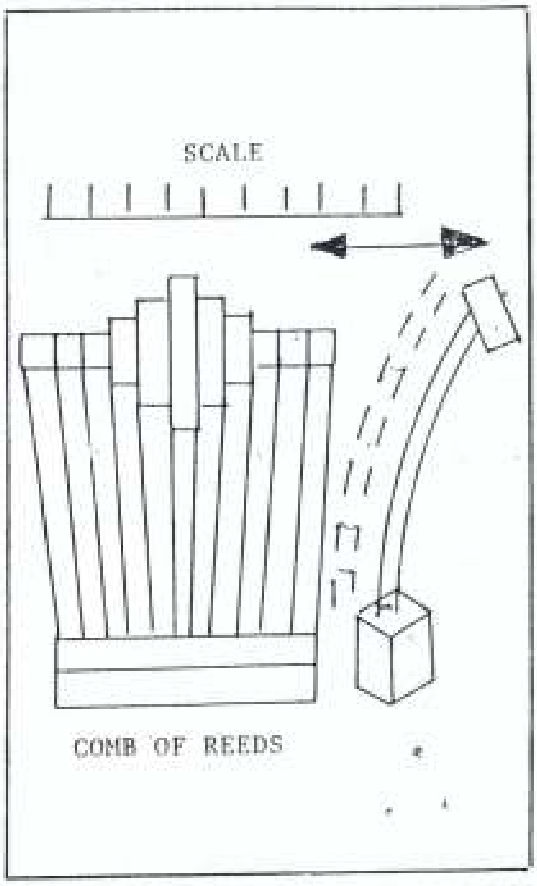


Fig 2.29 VIBRATION FEED TACHOMETER

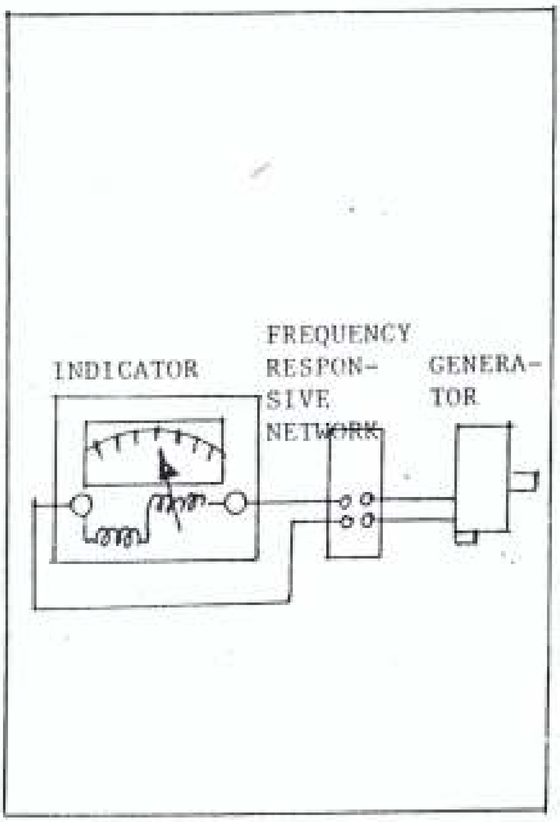


Fig 2.30 A.C. FREQUENCY RESPONSIVE TACHOMETER

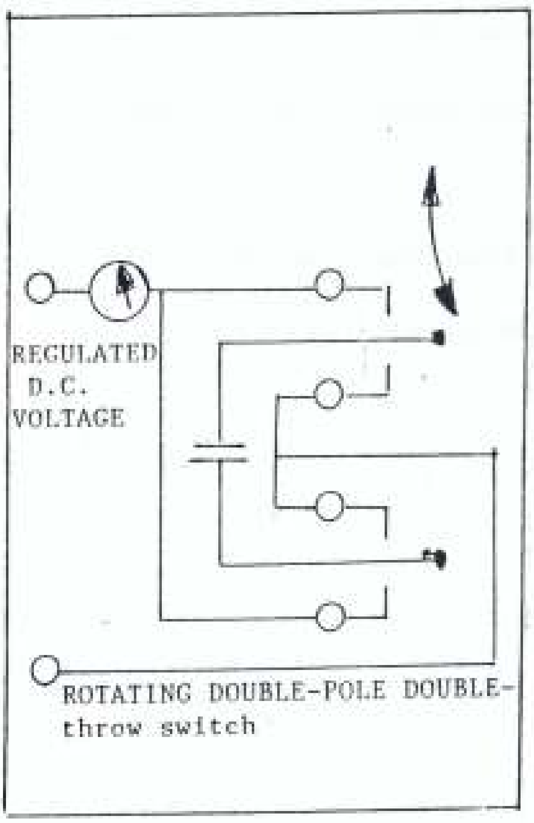


Fig 2.31 COMMUTATED CAPACITOR TACHOMETER

to know how many pulses equal to one revolution of the speedometer cable. The information is also used for a digital dash and trip computer, if the vehicle is so equipped.

In Figure 2.32 the engine speed sensor monitors crankshaft motion. The slotted wheel rotates with the crankshaft. The sensor is mounted in the engine block. The engine speed sensor shown in Figure 2.33 monitors the rotation of the distributor shaft. Lastly, Figure 2.34 shows the vehicle speed sensor mounted on the transmission housing and monitors vehicle (William et. al. 1995).

2.11 Engine Speed Sensor Service

When operating properly, the engine speed sensor generates a small voltage signal which is proportional to the speed of the engine. If the sensor is faulty, the correct voltage will not be produced (Clifford, 1977). A defective engine speed sensor can cause problems with the ignition system and prevent the engine from running. A voltage check is commonly recommended for the engine speed sensor. As the engine is cranked, a small voltage should be produced in the sensor. If the voltage is not within the manufacturer's specifications, the sensor must be recommended for checking of the resistance of the sensor coil. The resistance should be within the recommended range.

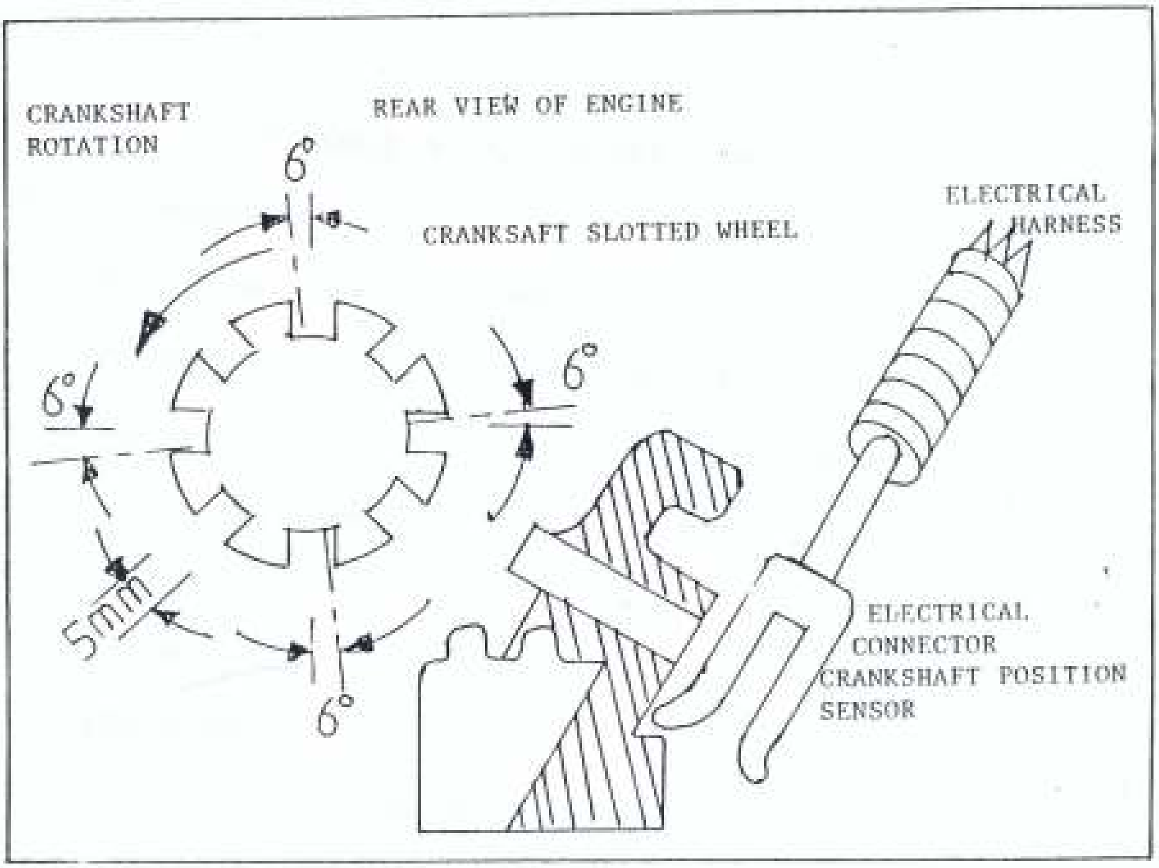


Fig 2.32ENGINE SPEED SENSOR

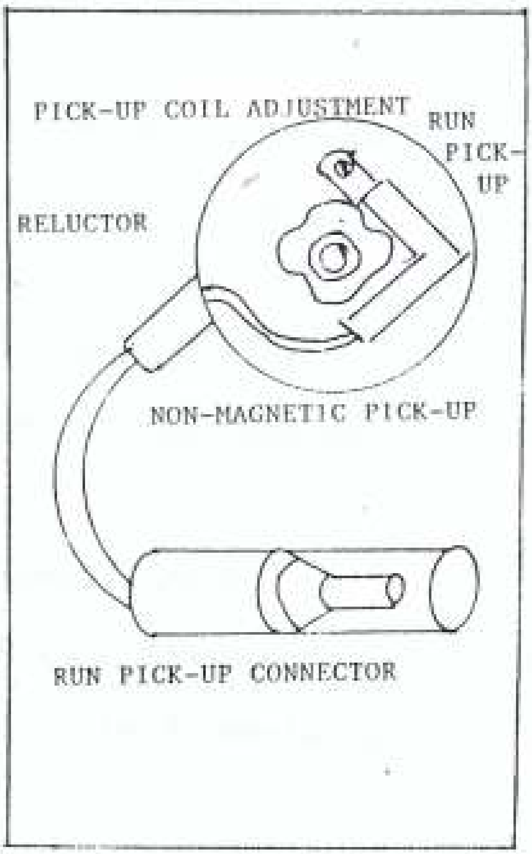


Fig 2.33SPEED SENSOR FOR DISTRIBUTOR SHAFT

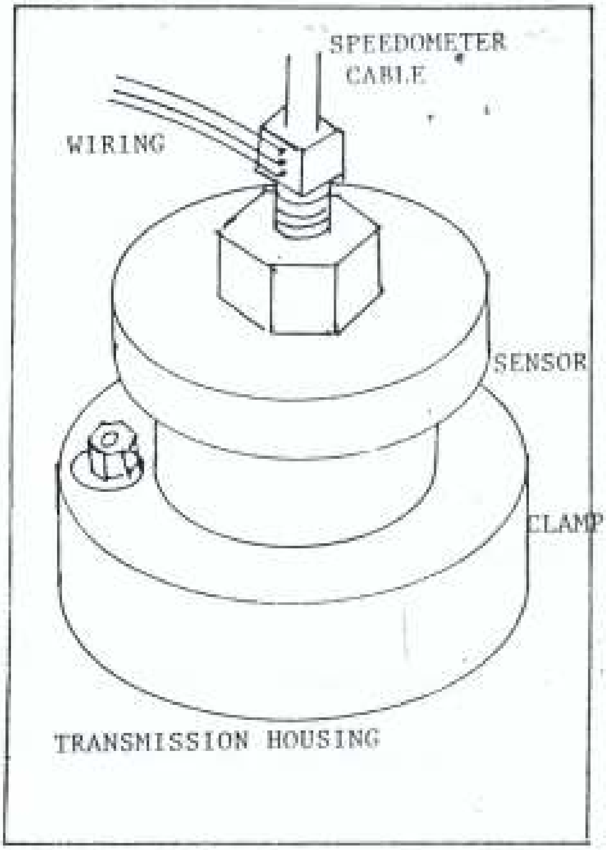


Fig 2.34 VEHICLE SPEED SENSOR

3. DESIGN AND CONTRUCTION

3.1 Design Considerations

Interaction with mechanics, drivers, owners of fleet vehicles, Federal Road Safety Corps, Traffic Police and automobile companies have shown that there is a need to develop a speed limiting device for automobiles. This device must have the following characteristics (Warren and Luzadder, 1977).

It must be:

(i) Portable

(ii) Light in Weight

(iii) Simple to build, assemble and easily maintained

(iv) Made of common materials

(v) Safe and easy to use by all vehicle owners

(vi) Easily demonstrated in the vehicle

(vii) Affordable by automobile owners

Though this system exist in some vehicles in this country, but due to high cost of sensor in the existing system, it is not easy for the owners of fleet vehicles to install the system in their vehicles, even if they want to do so. Therefore, there is a need to develop a simple, portable, low- priced, speed limiting device which cannot be easily removed.

3.2 Definition of Problem

Overspeeding, as mentioned earlier, is a problem to our motorists, which must be solved in order to reduce the rate of accidents on our roads. Therefore, the main objective of this device is to find solution to the problem of overspeeding by developing a cheap electro-mechanical device, which will be placed under the throttle pedal of the vehicles. The main function of this device is to control the speed of vehicles moving on our roads.

3.3 Generation and Evaluation of Alternative Solutions

The interaction with related automobile industries and road-side mechanics/electricians have shown that there are several methods of reducing speed of vehicles. Some of them are briefly described below:

(i) **Float Level Adjustment:** The float level can be adjusted to reduce the level of fuel inside the float chamber, so that the fuel can be cut off if the speed is about to exceed a specified speed (e.g. 100km/hr). The main disadvantage of this method is that if the fuel is cut off when overtaking another vehicle, it can lead to accident if another vehicle suddenly appears in front. Due to that disadvantage, this method was discarded.

(ii) **Retardation of Ignition and Engine Timing:** Another method considered is to retard the ignition and engine timing of the vehicles. During the performance test, it was observed that rate of fuel consumption was too high which means that this method is not economical for an average Nigerian vehicle owner.

(iii) **Speed Limiting Sensor:** A similar device to the existing speed limiting device in some vehicles can be designed and constructed using speed limiting sensor. Due to high cost of the sensor, which can not be affordable by the vehicle owners, it was discarded.

(iv) **Electro-Mechanical Device:** Finally, a portable electro-mechanical device was designed and constructed. The mechanical unit of the device was placed under the throttle pedal while the electrical unit of the device was connected to the carburetor. The electrical device will make noise if the driver exceeds 100km/hr. This method was finally chosen because of its simplicity, reliability, low price, durability and the fact that it cannot be easily removed.

3.4 Condition of Use

This device must be connected to the floor-board under the throttle pedal. Also, the round-headed bolt should be welded to the base after road test to avoid drivers from re-adjusting them. The switch must be connected to carburetor and the alarm should be hidden inside the door or in the fender on the driver's side, as described by (Hawkes and Abinett, 1984)

3.5 Description of the Electro-Mechanical Device

As the name implies, the device was divided into two, namely, mechanical and electrical units. The mechanical unit can be divided into three basic components, namely, base, round-headed bolt and locknut. The base is the main body of the mechanical unit, which accommodates other components. It is made up of an internal screw threaded collar, which stands in a tripod stand of 40mm height. The collar is 50mm diameter and 20mm thick. The legs were attached to the floor board of the vehicle directly under the throttle pedal. The round-headed bolt is M15 x 2 and 55mm long and the diameter of the head is 40mm and 10mm thick. The throttle pedal head has direct contact with the head of the round-headed bolt. A locknut is used to prevent the round-headed bolt from loosening after setting it to a particular height during the road testing.

The electrical device was made up of switch, alarm, spring, cables and 12V battery. The switch was connected to the carburetor through a spring. A cable was used to connect the switch to the alarm and the battery. A line diagram in Figure3.1 shows the assembly of the electrical and the mechanical units.

3.6 Working Principle of the Electro-Mechanical Device

The mechanical unit will be placed under the throttle pedal while the electrical unit will be connected to the carburetor. The mechanical unit has been set in such a way that the speed of vehicle can reach 120km/hr but when the speed exceeds 100km/hr the alarm will make noise to warn the driver not to exceed 100km/hr. It is possible to overtake another vehicle at 120km/hr and return to 100km/hr after overtaking so that the alarm will stop making noise. The assembly of the mechanical unit is shown in Figure3.2 while the exploded view is shown in Figure 3.3

3.7 Construction of Mechanical Components

The construction of the mechanical unit and some brackets of electrical unit was carried out in the production workshop, using the power hacksaw machine, lathe machine, milling machine, guillotine, grinding machine, drilling machine and welding machine.

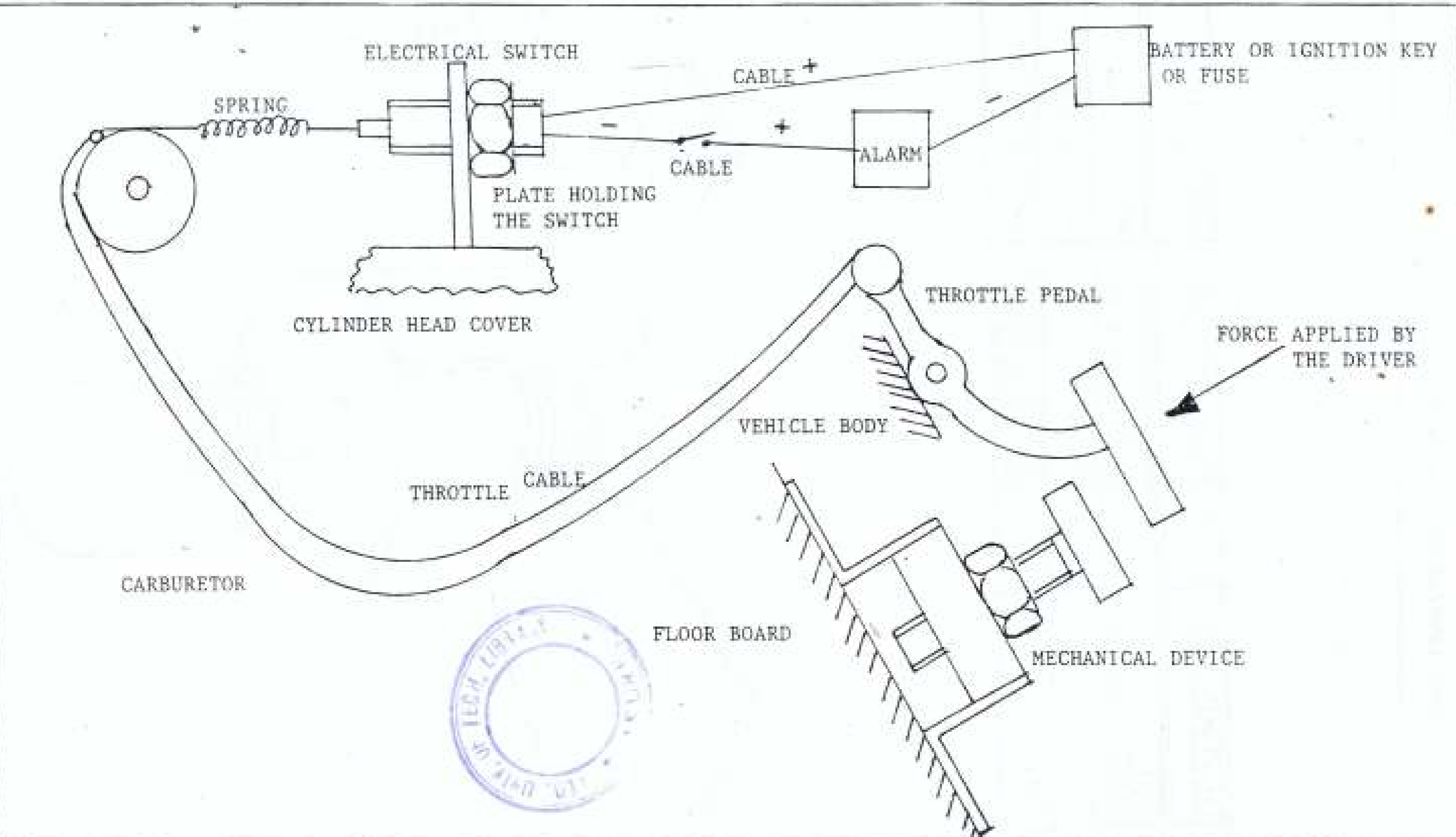
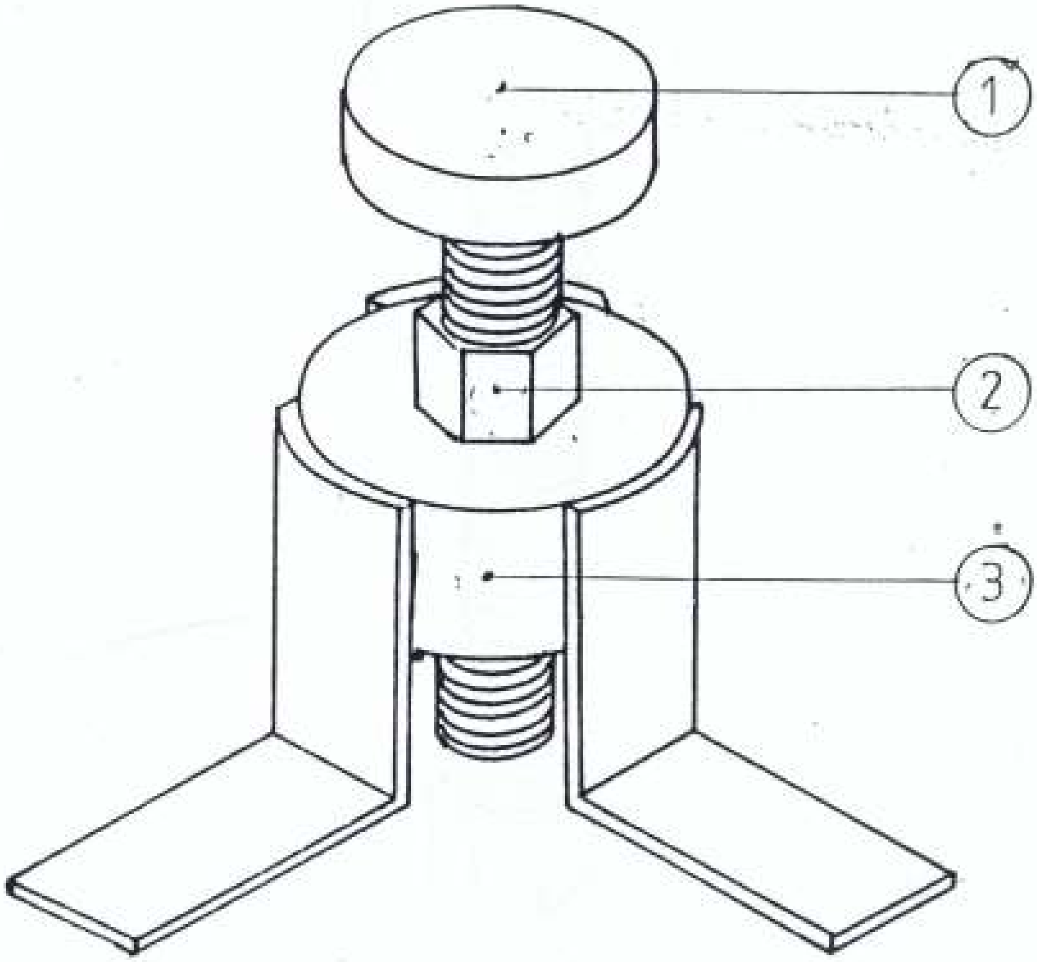


Fig 3.1 ASSEMBLY OF ELECTRICAL AND MECHANICAL DEVICES



3	BASE	1	COLLAR Ø50 × 20 STAND.. 80 × 20	MILD STEEL	
2	NUT	1	M15 × 2	MILD STEEL	
1	ROUND-HEADED BOLT	1	HEAD Ø40 × 10 THREAD M15 × 2	MILD STEEL	
S NO	DESCRIPTION	NO OFF	DIMENSIONS	MATERIAL	REMARK

Fig 3.2 ASSEMBLY DRAWING OF MECHANICAL DEVICE

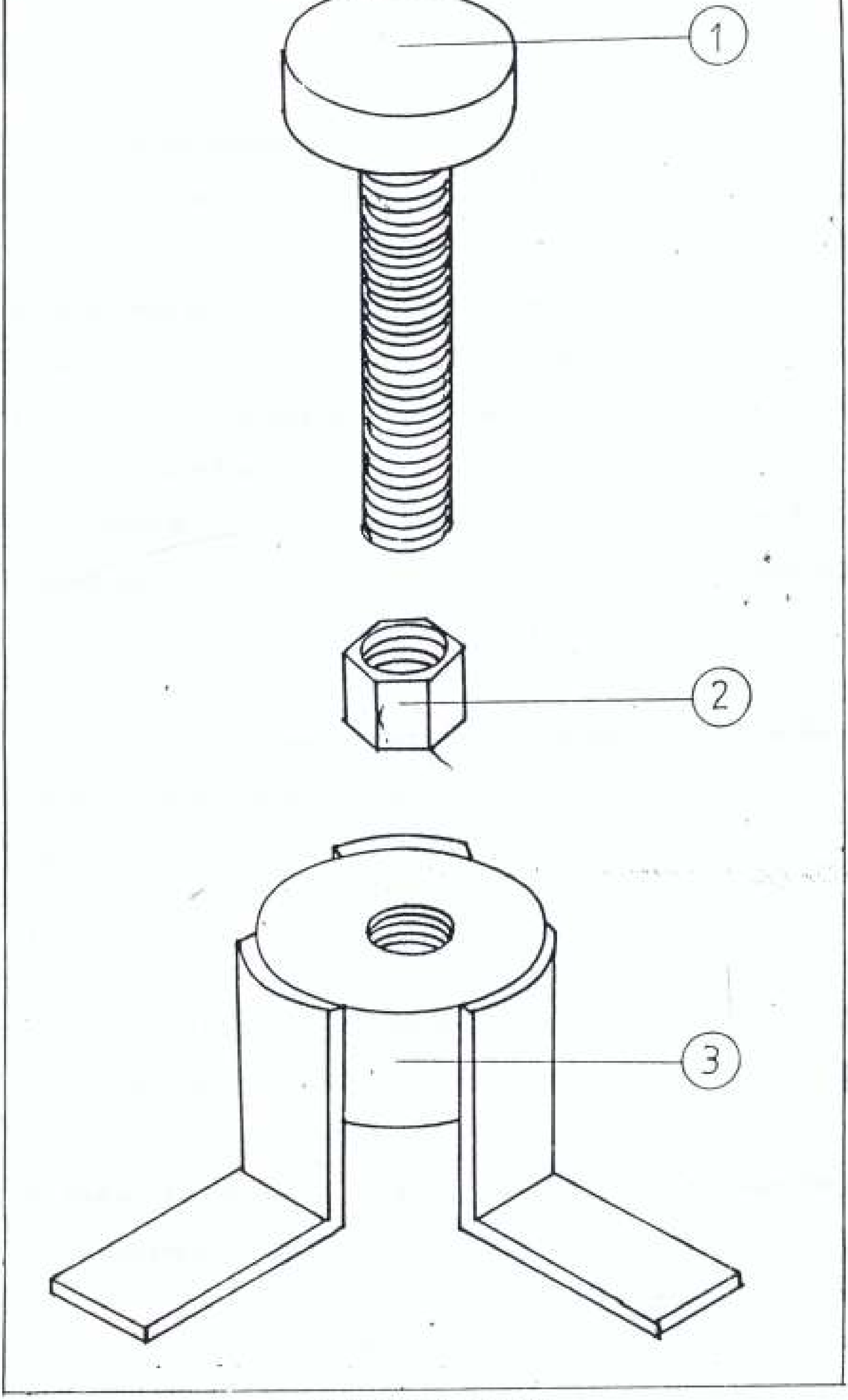


Fig 3.3 EXPLODED VIEW OF MECHANICAL DEVICE

A shaft of 50mm diameter, 200mm long was cut, from which the collar, the round-headed bolt and nut were produced. The thread (internal and external) was produced on the lathe machine while the hexagonal nut was produced on the milling machine. Three pieces of 0.5mm thick sheet metal of 100mm long and 30mm wide each was bent at a height of 40mm and welded to the collar to serve as tripod stand. All these components are shown in detail in the working drawing in Figure 3.4

3.8 Selection of Materials

Though the force acting on the device via the throttle pedal is very small but for durability and strength, a mild steel which is an alloy of iron and up to 0.45% carbon was chosen to construct the device (Khurmi and Gupta, 1979).

3.9 Cost Analysis

Three basic unit costs were considered when costing mechanical unit. They are material cost, labour costs and overheads.

Material cost	-	₦1,250.00
Labour cost	-	₦785.00
Overheads	-	₦ 560.00
Total	-	₦ 2, 595.00

Material costs and labour costs were considered in the case of electrical units.

Material cost	-	₦ 5, 565.00
Labour costs	-	₦ 1, 350.00
		₦ 6, 915.00

The total cost for both electrical unit and mechanical units for device is Nine thousand, five hundred and ten Naira only (₦ 9, 510.00)

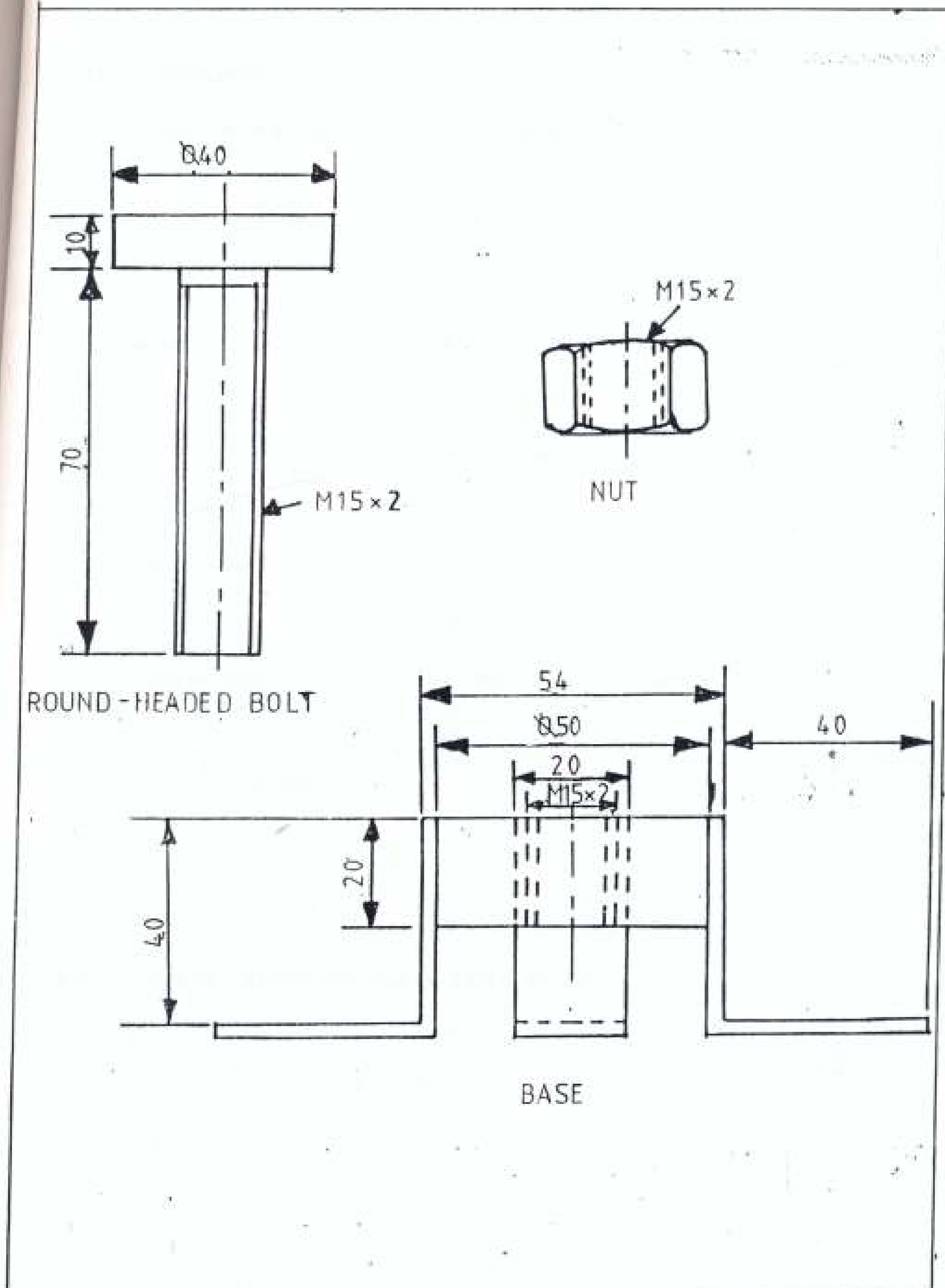


Fig 3.4 WORKING DRAWING FOR MECHANICAL DEVICE

3.10 Calculations

$$\text{Rpm of driving wheel} = \frac{\text{Vehicle Speed}}{\text{Wheel Circumference}}$$

$$= \frac{V}{2\pi r}$$

$$\text{Vehicle Speed} = \text{Wheel circumference} \times \frac{N}{G}$$

$$V = \frac{2\pi r N}{G} \text{ m/min}$$

$$\text{Engine Rpm. N} = \frac{V \times G}{2\pi r}$$

$$\text{Vehicle Speed} = \frac{V \times 1000}{60} = \frac{2\pi r N}{G}$$

V is in km/hr

$$\frac{N}{V} = \frac{1000 \times G}{2\pi r \times 60} = \frac{2.65\,G}{r}$$

3.10.1 Round – Headed Bolt and the Collar for Base

(i) Pitch diameter, $d_p = d - 3/4h$

$d_p = d - (3/4 \times 0.86603P)$

$= d - 0.6495P$

if $P = 2d = 15nm$

$d_p = 15 - (0.6495 x 2)$

$d_p = 13.701mm.$

(ii) Pitch circumference, $P_c = d_p \times \Pi$

$= 13.701 x \Pi$

$= 43.043mm$

(iii) Helix angle, α

$\tan \alpha = \frac{pitch}{P_c}$

$\tan \alpha = \frac{P}{P_c} = \frac{2}{43.043}$

$= 0.04647$

$\alpha = 2.66^\circ$

(iv) Root diameter $d_R = d - (2x0.6495 P)$

$= d - 1.2990P$

$= 15 - (1.990P)$

$= 15 - (1.2990x2)$

$= 15 - 2.598$

$= 12.402mm.$

(v) Root Area $= \frac{\Pi d^2_R}{4}$

$= \frac{\Pi x (12.402)^2}{4}$

$A_R = 120.8mm^2$

(vi) Area of head A_h

Diameter, d_h=40mm

$$A_h=\frac{\Pi d_h^2}{4}=\frac{\Pi \times 40^2}{4}$$

$=1256.6mm^2$

(vii) Area of throttle pedal head, A_t

Length=100mm

Breath=45mm

$A_t=100 \times 45$

$4500mm^2$

(viii) Height of the thread, h=0.8663P

$h=0.086606 \times 2$

=1.73206mm.

(ix) To machine the hexagonal head on the milling machine using dividing head.

$$\frac{40}{n}=\frac{40}{6}=6\frac{4}{6}=6\frac{16}{24}$$

this means, 6 complete turns plus 16 hole on 24-hole circle

4. TESTS, RESULTS AND DISCUSSIONS

As mentioned earlier, this project used Toyota and Peugeot cars as case studies. According to McGeoch and Randall (1996), there are about one hundred and thirty (130) types of Peugeot and about fifty – eight(58) types of Toyota available in the world market. Detail of each model are shown in Appendices I and II.

4.1 Experimental Procedure

The mechanical device was tested alone by placing it under the throttle pedal, and setting it to a height, h, as shown in Figure 4.1. The vehicle was driven along Mubi-Mararaba Road of Adamawa State. The speedometer reading corresponding to a particular height, h, was observed as the throttle pedal moved a distance, ΔH. The vehicle was driven on both level road and slopes.

Later on, the electrical device was fixed to the carburetor as shown in Figure 3.1. One tyre at the rear (for front engine rear wheel drive) was suspended and the car was started. The gear was engaged and the throttle pedal was depressed for a distance, ΔH. Electrical device was set to make noise, as soon as the speedometer reading wanted to exceed 100km/hr. Then, the rear was jacked down and the car tested on the same road mentioned above.

The circuit of the electrical device closed immediately the speedometer reading was about to exceed 100km/hr and there was a loud noise from the alarm. Note that the bigger mechanical device was used for the Peugeot model while the smaller mechanical device was used for Toyota model because, throttle pedal height, H for Toyota model was smaller than that of Peugeot model.

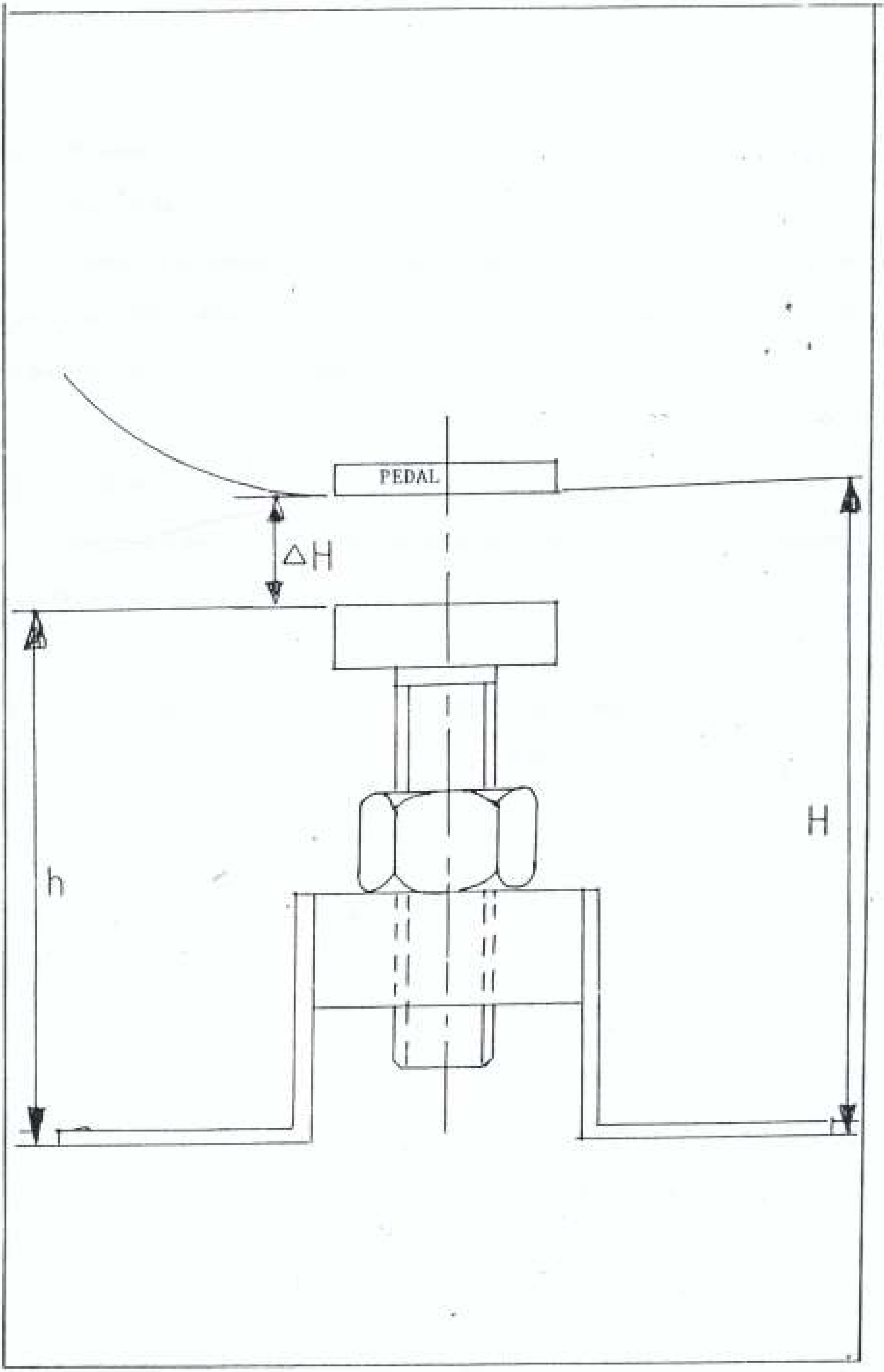


Fig 4.1 EXPERIMENTAL DIAGRAM

4.2 Results

4.2.1 Raw Data

Tables 4.1 to 4.6 show the test results of three types of Peugeot and Toyota cars on a level road while Tables 4.7 and 4.8 show the test data for slopes for different height of the throttle pedal from the floor board.

4.2.2 Analysis

Tables 4.9 and 4.10 show the analysis of the data when ascending or descending a slope. Note:

$$P.C.S = \frac{S.R.A - S.R. \times 100}{S.R} = \frac{S.R.D - S.R \times 100}{S.R}$$

TABLE 4.1 Experimental data for Peugeot 504 Station wagon on a level road for H = 135mm

S/No	h(mm)	ΔH (mm)	S.R. (Km/hr)
1	90	45	120
2	92.5	42.5	110
3	95	40	100
4	97.5	37.5	90
5	100	35	80
6	102.5	32.5	68
7	105	30	55

Table 4.2: Experimental data for Peugeot 505 saloon on a level road for H = 130mm.

S/No	h(mm)	ΔH(mm)	S.R. (Km/hr)
1	85	45	123
2	87.5	42.5	110
3	90	40	102
4	92.5	37.5	90
5	95	35	79
6	97.5	32.5	69
7	100	30	60

Table 4.3: Experimental data for Peugeot 504 Pick-up on a level road for H = 140mm.

S/No	h(mm)	ΔH(mm)	S.R. (Km/hr)
1	95	45	121
2	97.5	42.5	109
3	100	40	100
4	102.5	37.5	90
5	105	35	82
6	107.5	32.5	69
7	110	30	58

Table 4.4: Experimental data for Toyota Corolla 1.6GL on a level road for H = 83mm.

S/No	h(mm)	ΔH(mm)	S.R. (Km/hr)
1	40	43	105
2	45	38	100
3	50	33	92
4	55	28	85
5	60	23	80
6	65	18	63
7	70	13	54

Table 4.5: Experimental data for Toyota Starlet 1.31 on a level road for H = 85mm.

S/No	h(mm)	ΔH(mm)	S.R. (Km/hr)
1	40	45	112
2	45	40	107
3	50	35	100
4	55	30	93
5	60	25	88
6	65	20	80
7	70	15	75

Table 4.6: Experimental data for Toyota Lite-Ace on a level road for H = 88mm.

S/No	h(mm)	ΔH(mm)	S.R. (Km/hr)
1	40	48	115
2	45	43	105
3	50	38	101
4	55	33	91
5	60	28	86
6	65	23	80
7	70	18	62

Table 4.7: Speedometer reading for Toyota Corolla 1.6GL on a slope for H = 83mm.

S/No	h(mm)	S.R.A (km/hr)	S.R.D. (Km/hr)
1	40	100	110
2	45	95	107
3	50	86	102
4	55	77	95
5	60	69	91
6	65	51	79
7	70	39	71

Table 4.8: Speedometer reading for Peugeot 504 Station Wagon on a slope for H = 135mm.

S/No	h(mm)	S.R.A (km/hr)	S.R.D. (Km/hr)
1	90	114	126
2	92.5	104	118
3	95	94	110
4	97.5	80	102
5	100	70	94
6	102.5	56	86
7	105	40	76

Table 4.9: Percentage Change in Speed for Toyota Corolla 1.6GL on a slope for H = 83mm

S/No	S.R. (Km/hr)	S.R.A. (km/hr)	P.C.S. (%)	S.R.D (Km/hr)	P.C.S (%)
1	105	100	-4.76	110	4.76
2	100	95	-4.76	107	7.00
3	92	86	-6.52	102	10.98
4	85	77	-9.41	95	11.76
5	80	69	-13.75	91	13.75
6	63	51	-19.05	79	25.40
7	54	39	-27.78	71	31.48

Table 4.10: Percentage Change in Speed for Peugeot 504 Station Wagon on a slope for H =135mm

S/No	S.R. (km/hr)	S.R.A. (km/hr)	P.C.S. (%)	S.R.D (km/hr)	P.C.S (%)
1	120	114	-5.00	126	5.00
2	110	104	-5.45	118	7.27
3	100	94	-6.00	110	10.00
4	90	80	-11.11	102	13.33
5	80	70	-12.50	94	17.50
6	68	56	-17.65	86	26.47
7	55	40	-27.27	76	38.18

Table 4.11: Statistical Correlation Between Height of the Device and Speed of Peugeot 504 Station Wagon on a Level Road for H = 135mm.

x	y	xy	x^2	y^2	X	Y
90	120	10800	8100	14400		
92.5	110	10175	8556.25	12100		
95	100	9500	9025	10000		
97.5	90	8775	9506.25	8100	97.5	89.0
100	80	8000	10000	6400		
102.5	68	6970	10506.25	4624		
105	55	5775	11025	3025		
682.5	623	59995	66718.75	58649		

The following equations are used.

Source: (Adejuyigbe, 1999)

$Y_{pt}=a+bx_{ip}$ ----------------------------------(1)

$Y_{pt}=a+bx_{ip}$ ----------------------------------(2)

$$b = \frac{n\sum X_{ip}Y_{pt} - (\sum X_{ip})(\sum Y_{pt})}{n\sum X^2_{ip} - (\sum X_{ip})^2} \quad \text{------------------ (3)}$$

$$r = \frac{n\sum X_{ip}Y_{pt} - (\sum X_{ip})(\sum Y_{pt})}{\sqrt{n\sum X^2_{ip} - (\sum X_{ip})^2} \cdot \sqrt{n\sum Y^2_{pt} - (\sum Y_{pt})^2}}$$

Note: X_{ip} = x - Height of the mechanical device from the floor-board in mm.

Y_{pt} = y – Speedometer reading on a level road surface in km/hr.

X_{ip} = x – Average height of the mechanical device.

Y_{pt} = y – Average speedometer reading on a level road surface.

a and b – are the parameter of the regression equation.

r = Correlation.

To determine the equation of regression line from equation (3)

$$b = \frac{(7959995) - (682.5)(623)}{7(66718.75) - (682.5)^2}$$

$$b = -\frac{5232.5}{1225}$$

b= -4.27

from equation (1)

y = a + bx

89 = a + (-4.27x97.5)

a = 505.5

using equation (1) to write equation of regression line.

$y = a + bx$

$y = a + 505.5 - 4.27x$

using equation (4) to calculate the correction, r

$$r = \frac{7(59995) - (6825)(623)}{\sqrt{7(66718.75) - (6825)^2}\ \sqrt{7(58649) - (623)^2}}$$

$$= \frac{-52232.5}{(35)(149.7)}$$

$r = -0.9987$

$r^2 = 0.9973$

This has a very high correlation.

Table 4:12: Statistical Correlation Between Height of the Device and Speed of Peugeot 505 Saloon on a level road for H = 130mm.

x	y	xy	x^2	y^2	X	Y
85	123	10455	7225	15129		
87.5	110	9625	7656.25	12100		
90	102	9180	8100	10404		
92.5	90	8325	8556.25	8100	92.5	90.43
95	79	7505	9025	6241		
97.5	69	6727.5	9506.25	4761		
100	60	6000	10000	3600		
647.5	633	57817.5	60068.75	60335		

To determine the equation of regression line. From equation (3)

$$b = \frac{7(57817.5) - (647.5)(635)}{7(60068.75) - (647.5)^2}$$

$$b = \frac{-5145}{1225}$$

$b = -4.2$

from equation (2)

$y = a + bx$

$90.43 = a + (-4.2 \times 92.5)$

$a = 478.93$

Using equation (1) to write equation of regression line

$y = a + bx$

$y = 478.93 - 4.2x$

Using equation (4) to calculate the correction, r

$$r = \frac{7(57815) - (647.5)(633)}{\sqrt{7(60068.75) - (6475)^2}\ \sqrt{7(603350 - (633)^2}}$$

$$= \frac{-5145}{(35)(147.2)}$$

$r = -0.9989$

$r^2 = 0.9978$

This has a very high correlation.

Table 4..13: Statistical Correlation Between Height of the Device and Speed of Peugeot 504 Pick-Up on A Level Road for H = 140mm

x	y	xy	x^2	y^2	X	Y
95	121	11495	9025	14641		
97.5	109	10627.5	9506.25	11881		
100	100	10000	10000	10000		
102.5	90	9225	10506.25	8100	102.5	89.857
105	82	8610	11025	6724		
107.5	69	7417.5	11556.25	4761		
110	58	6380	12100	3364		
717.5	629	63755	73718.25	59471		

To determine the equation of regression line. From equation (3)

$$b = \frac{7(63755) - (717.5)(629)}{7(73718.75) - (717.5)^2}$$

$$b = -\frac{5022.5}{1225}$$

b= -4.1

From equation (2)

y= a + bx

89.857 = a + (-4.1x102.5)

a= 510.1

Using equation (1) to write the equation of regression line

y= a + bx

y= 510.1-4.1x

Using equation (4) to calculate the correlation, r

$$\text{Correlation, } r = \frac{(63755) - (717.5)(629)}{\sqrt{7(73718.75) - (717.5)^2}\ \sqrt{7(594710 - (629)^2}}$$

$$r = \frac{-5022.5}{(35)(143.72)}$$

r= -0.998

r^2= 0.9969

This has a very high correlation.

Table 4.14 Statistical Correlation Between Height of the Device and Speed of Toyota Corolla 1.6GL. on A Level Road for H = 83mm.

x	y	xy	x^2	y^2	X	Y
40	105	4200	1600	11025		
45	100	4500	2025	10000		
50	92	4600	2500	8464		
55	85	4625	3025	7225	55.0	82.7
60	80	4800	3600	6400		
65	63	4095	4225	3969		
70	54	3780	4900	2916		
385	579	30650	21875	49999		

To determine equation of regression line using equation (3)

$$b = \frac{7(30650) - (385)(579)}{7(21875) - (385)^2}$$

$$b = \frac{-8365}{4900}$$

b= -1.71

From equation (2)

Y= a + bx

82.7 = a +(-17.71x55)

a= 176.75

Using equation (1) to write equation of regression line.

y= a + bx

y= 176.75-1.71x

using equation to calculate the correlation, r

$$r = \frac{7(30650) - (385)(579)}{\sqrt{7(21875) - (385)^2}\ \sqrt{7(49999) - (579)^2}}$$

$$r = \frac{-8365}{(70)(121.4578)}$$

r= -0.984

r^2=0.968

This has a very high correlation.

Table 4.15: Statistical Correlation Between Height of the Device and Speed of Toyota Starlet on A Level Road for H = 85mm.

x	y	xy	x^2	y^2	X	Y
40	112	4480	1600	12544		
45	107	4815	2025	11449		
50	100	5000	2500	10000		
55	93	5115	3025	8649	55.0	93.57
60	88	5280	3600	7744		
65	80	5200	4225	6400		
70	75	5250	4900	5625		
385	655	35140	21875	62411		

To determine the equation of regression line from equation (3)

$$B = \frac{7(35140) - (385)(655)}{7(21875) - (385)^2}$$

from equation (2)

$y = a + bx$

$93.57 = a + (-1.26x55)$

$a = 163.1$

Using equation (1) to write equation of regression line.

$y = a + bx$

$y = 163.1 - 1.26x$

To calculate correlation, r, use equation 94)

$$r = \frac{7(35140) - (385)(655)}{\sqrt{7(21875) - (385)^2}\ \sqrt{7(62411) - (655)^2}}$$

$$r = \frac{-6195}{(70)(88.61)}$$

$r = -0.99874$

$r^2 = 0.997$

This has a very high correlation.

Table 4.16 Statistical Correlation Between Height of the Device and Speed of Toyota Lite-Ace on A Level Road for H = 88mm.

x	y	xy	x^2	y^2	X	Y
40	115	4600	1600	13225		
45	105	4725	2025	110205		
50	101	5050	2500	10201		
55	91	5005	3025	8281	55.0	91.43
60	86	5160	3600	7396		
65	80	5200	4225	6400		
70	62	4220	4900	3844		
385	640	34080	21875	60372		

To determine the equation of regression line. From equation (3).

$$b = \frac{7(34080) - (385)(640)}{7(21875) - (385)^2}$$

$$b = \frac{-7840}{4900}$$

$b = -1.6$

From equation (2)

$y = a + bx$

$91.43 = a + (-1.6x55)$

$a = 179.43$

Using equation (1) to write equation of regression line

$y = a + bx$

$y = 179.43 - 1.6x$

using equation to calculate correlation, r

$$r = \frac{7(34080) - (385)(640)}{\sqrt{7(21875) - (385)^2}\sqrt{7(60372) - (640)^2}}$$

$$r = \frac{-7840}{(70)(114.035)}$$

$r = -0982$

$r^2 = 0.9646$

This has a very high correlation.

4.2.3 DISCUSSIONS

The data obtained in Tables 4.1 to 4.6 show that the height of the device is inversely proportional to the speedometer reading. The higher the height of the device the lower the speedometer reading and vice versa. It means that it is possible to travel at a particular speed throughout a journey after setting the height of a device. It is also possible to allow the driver to move up to a speed of 120Km/hr to overtake another vehicle and return back to 100km/hr after overtaking in order to do away with the noise of the alarm.

Tables 4.7 and 4.8 show the raw data obtained during road test when vehicle was ascending and descending a slope. It was observed that at a particular height, the speed of the vehicle is higher when descending a slope than when ascending a slope due to the weight of the vehicle.

The data of Tables 4.9 and 4.10 show that as the speed of the vehicle decreases, the percentage change in the vehicle speed increases. This shows that the higher the speed, the lower the percentage change in speed when ascending or descending a slope and the lower the speed of vehicle the higher the percentage change in speed. This is due to the inertia of the vehicle which retards the speed of the vehicle when ascending a hill and increases the speed of the vehicle when descending a slope.

Furthermore, it was observed that the throttle pedal of Peugeot travels for a distance of about 45mm before the speedometer reads 120km/hr while that of Toyota travels for about 50mm to attain the same speed.

Finally, Tables 4.11 to 4.16 show that the statistical correlation between the height of mechanical device and the speedometer reading was very high.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The following conclusions could be made from the research effort:

i. A simple electro-mechanical device was conceived, designed, fabricated and tested.

ii. Tests results showed that the device successfully limited the travel speed of automobiles

iii. The device is simple to install and operate.

5.2 Recommendations

The following points are recommended for the use and promotion of this device:

(i) The mechanical device should be permanently welded or fastened to the floor board of the vehicle.

(ii) Further work should be carried out by another student(s) to improve the performance of the device

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7. APPENDICES

7.1 Appendix I

TOYOTA

S/No	Model	Types
1	4. Runner	1
2	Camry	6
3	Carina	6
4	Celica	6
5	Corolla	13
6	H-Ace	5
7	Hi-Lux	3
8	Lite-Ace	3
9	Mr2	3
10	Model-F Space Cruser	1
11	Previa	1
12	RAV	1
13	Starlet	3
14	Supra	2
15	Tarago	1
16	Tercel	1
17	Town-Ace	2
	TOTAL	58

Source: (McGeoch, and Randall, 1996)

7.2 Appendix II

PEUGEOT

S/No	Model	Types
1	Peugeot 106	13
2	Peugeot 205	26
3	Peugeot 305	5
4	Peugeot 306	7
5	Peugeot 309	22
6	Peugeot 405	24
7	Peugeot 406	2
8	Peugeot 504	4
9	Peugeot 505	5
10	Peugeot 605	10
11	Peugeot 806	2
12	J5	3
13	Boxer	1
14	Express	3
15	Sportman	2
16	Triaxle	1
	TOTAL	130

Source: (McGeoch, and Randall, 1996)

7.3 Appendix III

Rule of thumb for interpreting coefficient of correlation, r

VALUE OF r	INTERPRETATION
.90 - 1.00	Very high correlation
0.70 - 0.90	High correlation
0.40 - 0.70	Moderate correlation
0.20 - 0.40	Low correlation
0.0 - 0.20	Slight correction

Source :(Aderoba, 1995)