Automatic Gearing for Cars
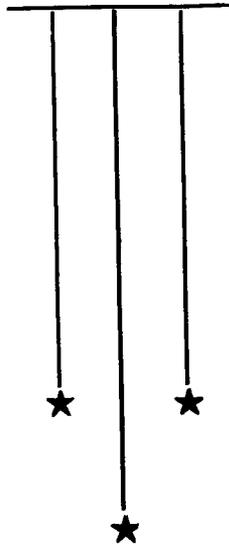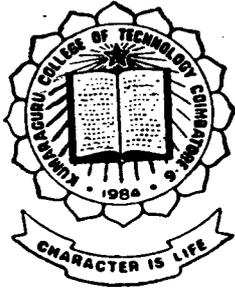
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SYNOPSIS

The objective is the automation of transmission in automobiles. It works with microprocessor as the key device which controls the system. This system operates the mechanical which automatically shifts gears when the speed of the vehicle crosses the limits of the gear that is currently in engagement.

The speed is sensed by an optocoupler and the calculated speed fed into the microprocessor through an electronic counter. If the calculated speed lies out of speed limits of the gear in engagement then instructions are sent from the microprocessor to initiate a gear change cycle. The speed limits of each gear are stored in the microproceser. Pneumatic devices have been incorporated to manipulate the clutch and accelerator mechanisms, appropriatedly during gear changing, which are operated by the instructions of microprocessor.

Two stepper motors are used to operate a system of gears which involves the gear shifting mechanism. As per the instructions from the microprocessor the stepper motor rotates. The rotation of stepper motors are converted into corresponding linear and angular motions involved in gear shifting by the gear shifting mechanism. The overall

CHAPTER 1

INTRODUCTION

This project deals with the automation of gear changing in automobiles using a microprocessor based control system.

The principle involves the sensing of the gear box output shaft speed and the engine speed (in a particular case) at regular pre determined intervals. This value of speed is compared with the speed limit of the currently engaged gear which is pre determined and stored in the microprocessor memory. There are two possibilities.

    i)   If the value is greater a change to a higher gear is effected.

    ii)   If the value is smaller, a change to a lower gear is effected.

A change of gear is effected only and only if the speed attained is equal to the upper speed limit of the gear that is in engagement (in case of shifting to a higher gear) and if the speed attained equals the lower speed limit of the gear that is in engagement (in case of shifting to a lower gear).

The sequence of operations which takes place when a gear change cycle is to be effected is :

i)   Speed measurement

ii)   Reduction of acceleration

iii)   Disengaging the clutch

iv)   Actual shifting of gears

v)   Engagement of clutch

vi)   Restoration of acceleration

This can be achieved using a microprocessor based control system with modifications on gear box, clutch and accelerator.

1.1   Speed Sensing

This is the initial process of the gear shifting mechanism opto couplers are used to sense the speed. [An additional wave shaping circuitry as interfaces to the microprocessor has to be incorporated]. At pre determined intervals the microprocessor checks whether the measured speed lies within the bounds contained by these limits. The sensed speed is fed to the microprocessor through gates where its perform the function of calculating the speed in rpm and then comparison takes place.

1.2   Reduction of Acceleration

A torsion spring mechanism is used for the automatic reduction of engine speed prior to gear change and its restoration after the gear change. This mechanism involves a torsion spring linkage between two shafts one of which

is linked to the drivers accelerator pedal and the other to the throttle valve. The latter is operated by the action of the piston of the pneumatic cylinder which in turn, is operated by a solenoid valve. The solenoid valve is closed or opened whenever required by instructions from the microprocessor. By using a proper circuitry and a Programmable Peripheral Interface (PPI) the solenoid valve is interfaced to the microprocessor. The important point that should be noted here is that its operation and control has no effect on the position of the accelerator pedal held by the driver prior to its automatic function.

1.3   Clutch Disengagement

For the automatic disengagement of the clutch a similar pneumatic arrangement to that of the acceleration reduction system. The operation of clutch is controlled by the working of a piston, within a cylinder through which pressurised air is sent. Opening and closing of the solenoid valve as per the microprocessor instructions, allows the pressurised air through the cylinder which leads to the desired motion of the piston. This motion of the piston will disengage the clutch. The solenoid valve is identical to the one used in previous case.

1.4. Gear Shifting

Two stepper motors are required for the actual automatic gear change. Before going into the mechanism used here, we shall recall the system in the manual gear shifting arrangement. During a manual gear change the driver manipulates the gear shift lever so that its motion produces the required change of gear. Certain gear changes require motion of the gear shift lever along two perpendicular planes. Motion along one plane causes the transverse selector lever which selects the longitudinal gear selector rod corresponding to the chosen gear. The other motion moves the selector fork, connected to the longitudinal gear selector rods, which in turn moves the dog, engaging the gear.

The control system is to be placed in addition to the existing manual system. For automatic gear changing an additional gear selector box has been designed. Two stepper motors of different capacity are used to operate the gear selector box. Rotation of the stepper motors causes meshing of the gears in the gear selector box, in the required combinational sequence. This leads to a gear change.

The function of one stepper motor is to operate the arrangement that selects one of the longitudinal selector rods. Rotation of the stepper motor is converted into a trans-

verse motion. The **second** stepper motor performs the operation of engaging the gear that is to be selected and engaged. This motion results in angular motion of the gear shift lever, engaging the required gear. Each of the stepper motors is actuated by a train of pulses. These pulses are sent to the microprocessor when the required gear shift subroutine is invoked.

1.5   Engagement of Clutch

After the selected gear has been engaged the clutch has to be engaged smoothly. This is done in a similar way as done for disengagement of the clutch.

1.6   Restoration of acceleration

After the selected gear has been engaged the throttle valve is opened thus restoring the acceleration. This is analogous to the one described for reduction of acceleration.

Display and Information Systems

A better interaction between the driver and the control system is furnished hereby. By this the driver is being enabled to make optimum use of the system and communicate with it. There are switches at the dashboard which he can operate to set maximum speed limits, and to give instructions to

start or stop digital displays are also provided showing the speed and the gear in engagement. By manipulations specific aural signals during every gear change can be generated and audio alarms can be made when the preset speed limit is exceeded.

Hardware and Software

The hardware in the control system is centered around a INTEL 8085 microprocessor. The microprocessor has interfaces for the stepper motors, opto-electronic coupler solenoid valves operating the pneumatic circuitry along with standard interface controllers.

The software is assembled in modules, the division being functional in nature. The software is aimed at optimal usage of the system.

2. SPEED MEASUREMENT THE IMPORTANT FACTOR

Speed measurement is the important feature since the switching of gears is according to the variations in speed. Measurement of speed is based on the following parameters.

Speed

In automobiles switching of gears is effected when the speed is changed above or below the speed limit of the gear on which the vehicle is currently running. Fundamentally variations in driving conditions arising from traffic density variations and the drivers wish to either accelerate orbitrately or to stop, necessitate change in gears. So the speed with which the vehicle is running completely determines the gear which should be engaged, to satisfy conditions of driving or drivers wish.

Torque is the another parameter which necessitates or effects a gear change in load causes change in torque which in turn causes change in speed. Torque is indirectly proportional to speed. Hence an increase in the torque will reduce the speed and a decrease in the torque will increase the speed. Change in torque is caused by change in load which is primarily because of variations in road conditions and the variabble load on the vehicle. Having decided that measurement

of speed best suits our purpose it is necessary to decide where the actual measurement is to be done. Measurement of speed at the propeller shaft is sufficient to decide whether gear change is necessary. Hence it is possible to mount the speed sensing mechanism on the propeller shaft itself. During the starting of vehicle from rest it is not possible to get the speed from the propeller shaft. In this case it is necessary to measure the engine speed and actuate the gear shifting mechanism to engage the first gear as soon as a predetermined engine speed is attained. Hence both the engine speed and the propeller shaft speed are measured.

Circuitry

The conventional opto-electronic coupler consists of a diode phototransistor arrangement. The phototransistor conducts whenever light from the diode is incident on it. A disc with four rectangular slots cut on its surface is mounted on the propeller shaft. When the shaft rotates a portion of the disc is continuously interposed between the diode and the phototransistor. The light to the transistor is shut on and off, because of the presence of slots on the disc, at a rate which depends on the speed of rotation of the disc which rotates at the propeller shaft speed. A sequence of pulses whose width depends on the propeller shaft speed is obtained since

the phototransistor is alternatively driven on and off.

The train of pulses are highly distorted at the output of opto electronic coupler. The pulses should be properly shaped and refined before fed to the microprocessor in order to avoid errors in counting arising due to equivocation in sensing the level of the pulses. To accomplish this, two inverter gates are used for wave shaping. These pulses are fed to the counter which gives the speed in binary form.

To Measure period (or Frequency)

Measuring the frequency requires counting of transducer pulses for a fixed sampling time whereas measuring the period requires measuring the elapsed time for a fixed number of transducer pulses. Usually it is faster and easier to measure the period rather than the frequency. The sampling time shoudl be of as short duration as possible as several other decisions and operations have to be carried out in a short interval of time. Hence smaller the, sampling time lesser the reliability of the count if frequency measurement is undertaken because even a small error, in the number of pulses counted within the predetermined sampling time will correspond to a large error in rpm/rps.
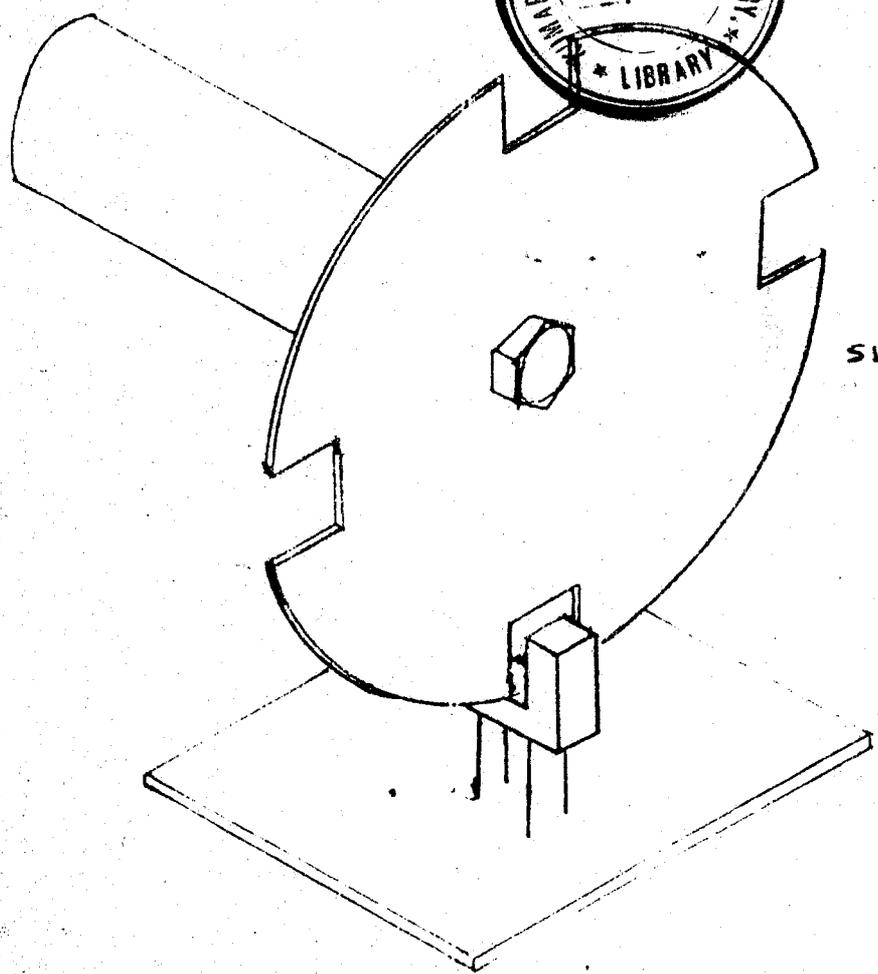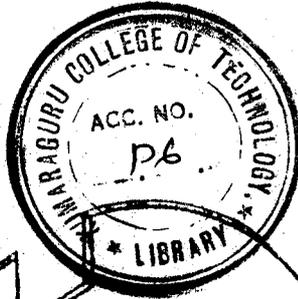
SLOTTED
DISC

OPTO
COUPLER

AGFOC

SPEED SENSING UNIT

NOT TO SCALE	DRG. No. 2.1.1

Speed Measurement

Speed measurements are based onthe measurement of the average duration of one pulse that is generated when the slotted disc distorts the light to the phototransistor. The time is noted when a slot comes in between the diode transistor arrangement when there is a brief period of conduction. The opto electronic coupler line is fed to one line of a port in the PPI 8255 and it is continuously sensed for its states.

Measurement of speed starts when the sensor line goes from low to high and back to low state. At this point a count is commenced. The count is incremented everytime a predetermined time interval (chosen to be 0.5 ms) has elapsed while the sensor line is low when the sensor line goes high again the count will be stopped. It is essential to note that the counts give the duration of the off period that is the period for which the phototransistor is cut off.

From the cut off time and the distance between the adjacent slots the speed of revolution in rpm can be calculated.

Calculation

The disc has four slots each of width 2 cm cut on its circumference. The slots are in rectangular shapes.

Diameter of the disc	:	17 cms
Circumference	:	3.14 x 17 = 53.4 cm
Maximum rpm	:	2000
Maximum rps	:	33.33
Minimum rpm	:	180
Minimum rps	:	3

At **2000 rpm** rime for 33.3 rev is 1 second.

Therefore time for 1 revolution $= \dfrac{1}{33.3} = $ **0.03 seconds**

To travel **53.4 cm** along the circumference time taken = **0.03 sec**

Distance between slots (arc) $= \dfrac{Circumference \ width \ of \ 4 \ slots}{Number \ of \ slots}$

$=$ (53.4 x 8) / 4

$==$ 11.35 cm

To travel **11.35 cm** time taken = (11.35 x 0.03) / 53.4

$=$ 0.00638 sec

i.e., OFF time at 2000 rpm $=$ 6.376 milliseconds

At the minimum of 3 rpm OFF time = (11.35 x 0.337) / 53.4

$=$ 70.14 milliseconds

$=$ 70 milliseconds

For delay intervals of 0.5 milliseconds count in case of an arbitrarily chosen reference speed of 1000 rpm (16.67 rps) = 26.

For other count the corresponding speed

$$= \quad (26 \times 16.67) \text{ / per count}$$

$$= \quad 433 \text{ per count}$$

Thus for any other count obtained the speed in rpm / rps can be directly calibrated.

The following elucidates the speed evaluation technique :

1. *Number of counts*

2. *Repeat steps 3 to 5 for number of counts*

3. *Wait for high to low transition of sensor level*

4. *Increment counter till subsequent low to high transition*

5. *Store the COUNT*

6. *Find average*

7. *Calibrate it to rps / kmph*

The pulse width is measured through software delay loops of half millisecond duration each starting from the commencement of the sampling time. Four consecutive measurements are taken are their average is used for further processing.

2.2 The Accelerator

Accelerator helps to increase the speed or decrease the speed by varying the quantity of air fuel mixture supplied to the engine. Manipulation of the accelerator operates the throttle value which varies the quantity of the air fuel mixture. Hence if the driver wants to accelerate he simply presses the accelerator pedal which increases the air-fuel mixture and results in increased speed. The converse holds good for decceleration. The reduction of acceleration is the first step to be carried out before a gear change. It is to prevent the engine from running away and to avoid jerks that might otherwise occur due to changing gears without reducing the acceleration.

Here we need an arrangement for reducing the acceleration automatically before the gear change. A conclusion is arrived to change a gear when the speed measurement is out of bounds of the speed limits of the gear that is engaged. The said earlier the first step is reducing the acceleration automatically without affecting the accelerator pedal of the driver. The driver should not feel any inconvenience of this.

The Torsion-spring mechanism is used for this purpose. By this mechanism the throttle valve which aids in acceleration or deceleration is linked to the accelerator pedal by

means of two shafts. This forms a sort of flexible coupling The first shaft is connected to the accelerator pedal through proper linkages and the second shaft is connected to the throttle valve by means of a screw.

The second shaft is accelerated by means of the single acting pneumatic cylinder fitted with a solenoid valve which is a two way two position direction control value. the pre-load of the torsion spring (0.5 kgf) holds the two shafts so that they move together. Here the preload is very small and when override control of the throttle is exerted there is negligible force reaction at the pedal with no movement required of or forced upon the driver. The dip cylinder can position the throttle valve shaft.

Over the operating pressure range the force available is much larger than the required to move the lever. This is due to the area of the piston. Most of this unutilized force is absorbed by the internal return springs of the cylinder. Hence an air pressure (throttle) valve positioning relationship is established and it is relatively insensitive to pedal position and throttle valve shaft force.

The solenoid valve is operated by a 24 V dc signal during a gear changing. At the solenoid valve opens presu-

55

PLAN

M8

ELEVATION

φ60
φ70
φ20

3

φ30
φ60

10 10

20
30

5

50
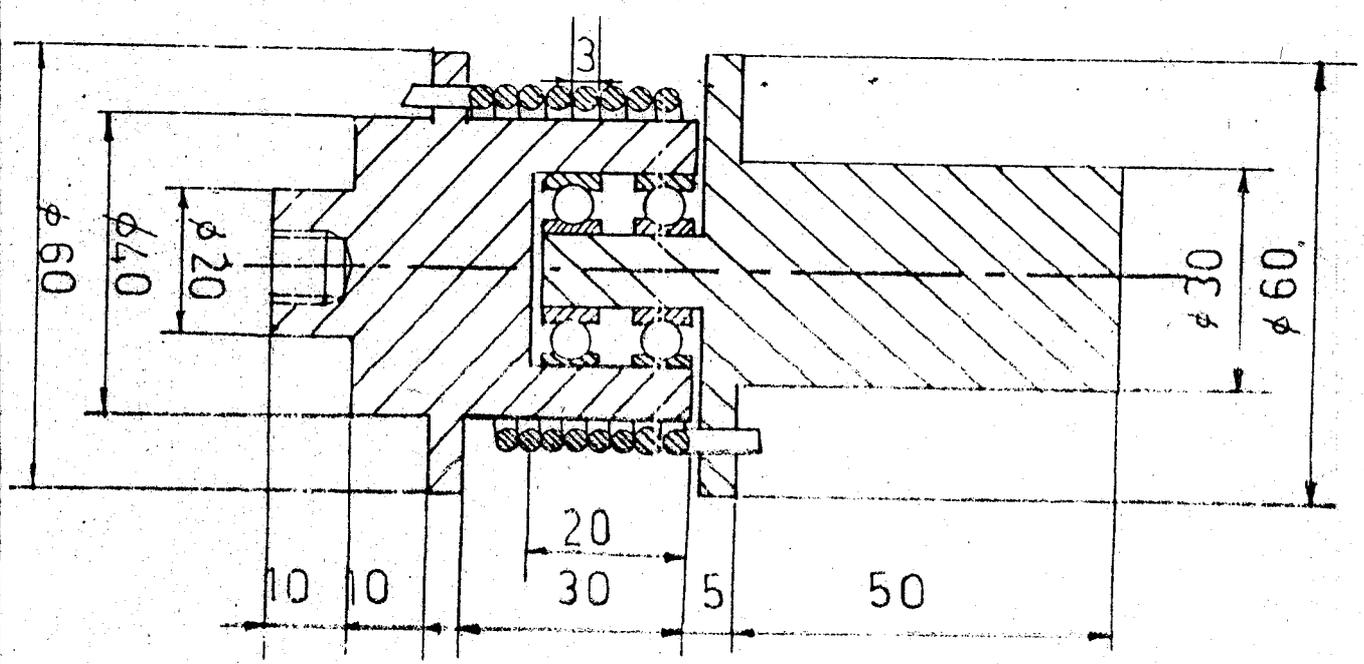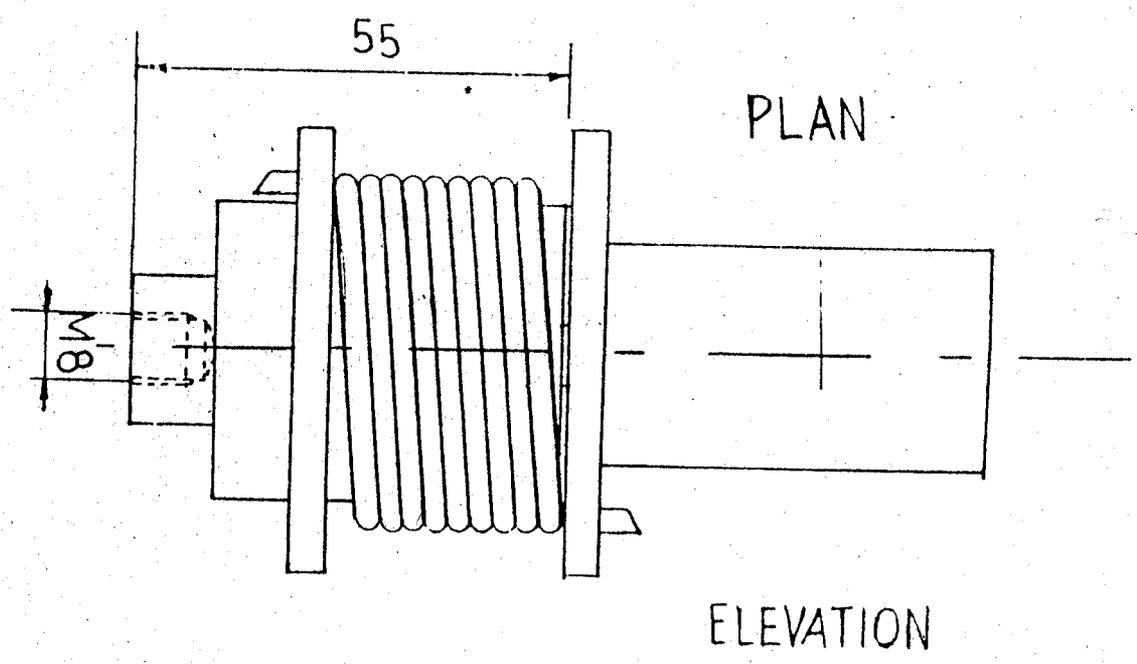
rised air flows from a compressor to the cylinder at a pressure of 6 kgf / cm^2. This moves the piston to the other side, the torsion spring mechanism operates and the acceleration is got reduced. The return of the piston is by means of spring action and it restores the acceleration to its original position after the gear change. The process of controlling the accelerator is done by recalling a special subroutine in the memory. This subroutine has commands to operate the solenoid valve.

Selection of Diameter of the Piston

Load rating of the spring	=	7.5 kgf
Preload on the spring	=	0.5 kgf
Net load on the piston	=	7 kgf
Air pressure from the compressor	=	6 kgf/cm^2

$$\text{Area of the piston} = \frac{\text{Load on piston}}{\text{Pressure of air}}$$

$$= 7/6 = 1.167 \ cm^2$$

$$\text{Dia of the piston} = (1.167 \times 4/3.14)^{0.5}$$

$$= 12.2 \ mm$$

$$\text{Available standard size} = 12.5 \ mm$$

2.3   The Clutch

Clutch is a device which provides a means of connecting the drive from the engine to the gear box.

The main functions of a clutch are :

i)   To disconnect the engine power from the gear box as required under following circumstances :

a)   To start the engine warm it up and run it at high speed to develop enough power to move the vehicle from rest.

b)   Disconnect power to gear box for easy shifting of gear, so that the noise and damage to the gears is avoided.

c)   Disconnecting drive from engine to stop the vehicle after application of brakes.

ii)   Allow the engine to take up load gradually without shock or jerk.

Requirements of Clutch

1)   Torque transmission. The clutch should be able to transmit the maximum torque of the engine.

ii)   Gradual engagement : The clutch should positively take the drive gradually without the occurrence of sudden jerks.

W
B
C
D
A
B
A
C
D
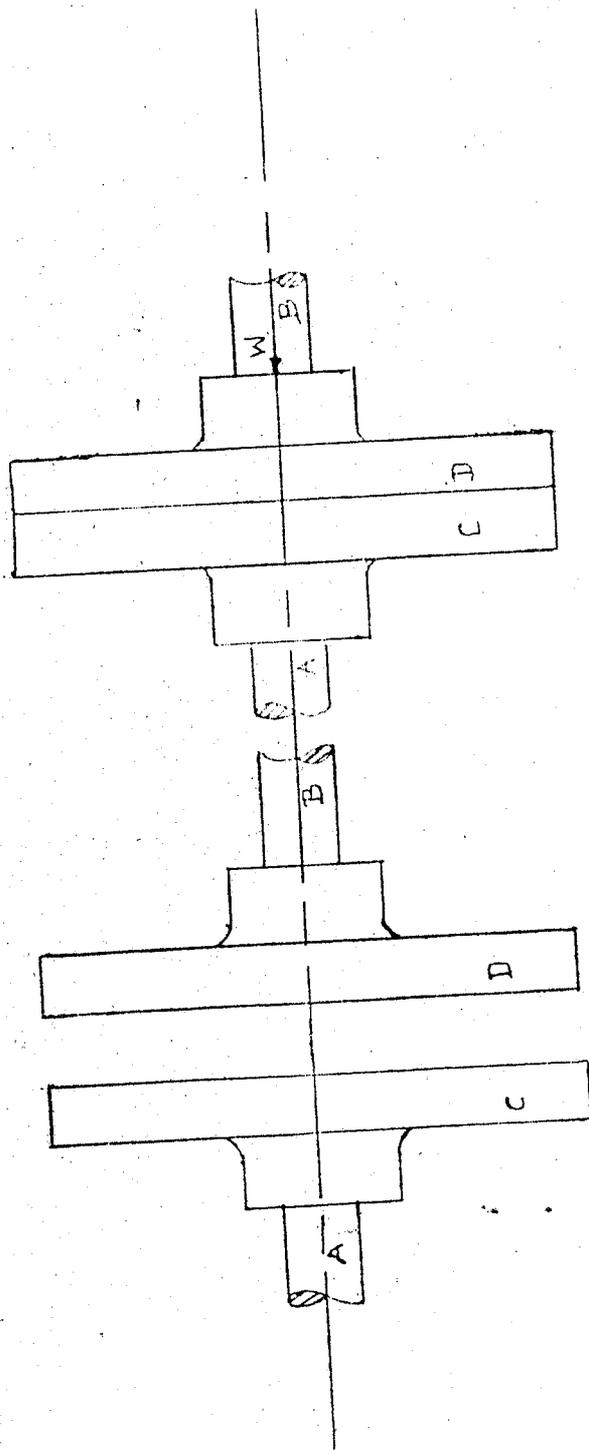
DRG NO: 2.3.

PRINCIPLE OF OPERATION OF A CLUTCH

AGFOC

iii)   Heat dissipation : During clutch application large amounts of heat are generated. The proper design of the clutch should ensure adequate dissipation of the heat.

iv)   Dynamic balancing : This is necessary particular in high speed clutches.

v)   Vibration clamping : To eliminate the noise produced in the transmission suitable mechanism should be incorporated within the clutch.

vi)   Size : The size of the clutch must be smallest possible so that it should occupy minimum amount of space.

vii)   Clutch free pedal play : To reduce effective clamping load on the carbon thrust bearing and wear thereof sufficient clutch free pedal play must be provided in the clutch.

viii)   Ease of operation : For higher power transmissions the operation of disengaging the clutch must not be tiresome to the driver.

Principle of a friction clutch

The principle of a friction clutch may be explained by means of figure.

Let shaft A and disc C be revolving at the same speed say N rpm. Shaft B and the disc D keyed to it are stationary initially when the clutch is not engaged (figure a). Now

apply some axial force N to the disc D so that it comes in connect with the disc C. As soon as the contact is made the force of friction between C and D will come into play and consequently the disc D will also be revolving. The speed of D depends upon friction force present, which in turn is proportional to the force W applied. If W is increased gradually the speed of D will be increased correspondingly till the stage comes when the speed of D becomes equal to the speed of C. Then the clutch is said to be fully engaged (fig. b).

Torque transmitted = Coefficient of friction x axial load applied x effective mean radius of friction surface

$$i.e., \quad T = W R$$

Usually a clutch pedal will be provided for the driver to engage or disengage. Here the system is fully automised and no need for driver to concentrate on this. The disengaging and engaging of clutch is done by means of pneumatic circuits and devices.

As in case of acceleration mechanism, air is supplied from a compressor at a constant pressure of 6 kgf/cm^2. A solenoid operated two way two position direction control valve is used in the circuit to engage and disengage the clutch.
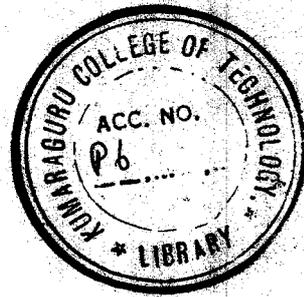
A force of about 75 kgf is required at the end of the lever, projecting out of the clutch carrying, to disengage the clutch. This determines the diameter of the cylinder to be used.

Load required to disengage the clutch $=$ 75 kgf

Air pressure from the compressor $=$ 6 kgf/cm^2

$$\text{Area of piston} = \frac{\text{Total load}}{\text{Pressure of air}}$$

$$= \frac{75}{6}$$

$$= 12.5 \ cm^2$$

$$\text{Diameter of piston} = \left(\frac{12.5 \times 4}{3.14}\right)^{0.5}$$

$$= 40 \ mm$$

Dia of piston available
in standard size $=$ 50 mm

For engaging of the clutch a flow control valve with an integrated check valve is incorporated. The engaging of the clutch should be smooth and gradual.

A 24 V dc operates the solenoid valve and when it gets opened it connects the piston directly to the compressor through a flow control valve with an integrated check valve. The flow of pressurised air at 6 kgf/cm^2 passess from the

PNEUMATIC CIRCUIT
CLUTCH AND ACCELERATOR

ACCELERATOR DIP CYLINDER
ϕ 25 x 50 mm

CLUTCH CYLINDER
ϕ 50 x 30 mm   75 KgF

CHECK
VALVE

FLOW CONTROL
VALVE

2 POSITION 2 WAY SOLENOID
OPERATED   DIRECTION
CONTROL VALVE

24V DC

24V DC

C   6 KG/CM²
COMPRESSOR
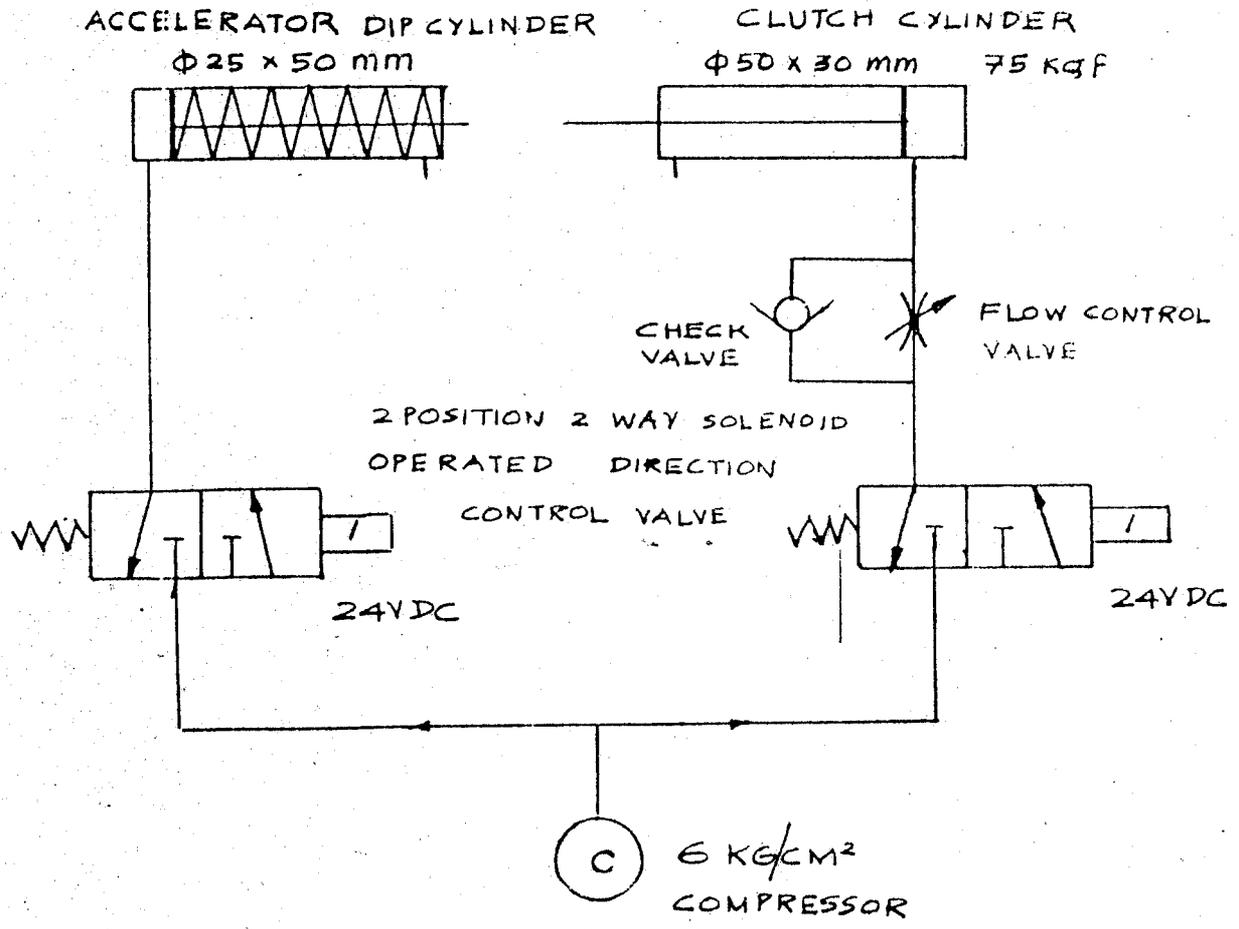
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ACCELERATOR UNITS
DRG NO: 2.3.2

compressor to the cylinder through the check valve and the flow control valve does not come into play during this process. When the pressurised air enters the cylinder it pushes the piston to the other end and this movement dis-engages the clutch. The disengagement process is activated by Calling a special subroutine in the memory of the micro-processor.

As the solenoid valve closes the piston is pushed back by the spring force. The piston is moves to the other end of the cylinder thereby engaging the clutch smoothly. During this process the pressurised air passes through the flow valve and, the check valve prevents the flow of air through it in the opposite direction. For engagement of the clutch another subroutine is called from the memory of the micro-processer.

2.4 The Stepper Motor

The stepper motor is incremental digital control device. It translates an input pulse sequence into a proportional angular movement, rotating one angular increment for each input pulse. The shaft position is determined by the number of pulses and its velocity is determined by the pulse frequency. The shaft speed in steps per second is equal to the incoming frequency in pulses per second.

The main advantage of a stepper motor is that it is able to operate is open loop commands which are the simplest forms of incremental servo systems. The commonly used stepper motor is phase pulse type. In this type the motor comprises an m-phase stator winding, which is a group of coils fitted into stator structure and n pole rotor which has no winding and hence no carbon brushes and slip rings. The number of steps per revolutions is determined by the number of phases and poles and thus has to be an even in tezer. Examples are 4, 8, 20, 48, 72, 96, 100 and 120 steps per revolutions.

The stator windings are excited by successive switching of dc voltage supplied into the various phase windings in a sequential order.

The stepper motors may be constructed for unidirectional

$i_a \longrightarrow$

a

N_a

θ

$d \quad i_d \longrightarrow$ N_b

N

$i_c \longrightarrow$

$i_b \longrightarrow$

(a)

Torque

pull out torque.

pull in torque.

slew range

starting range

pulse rate steps/sec

(b)
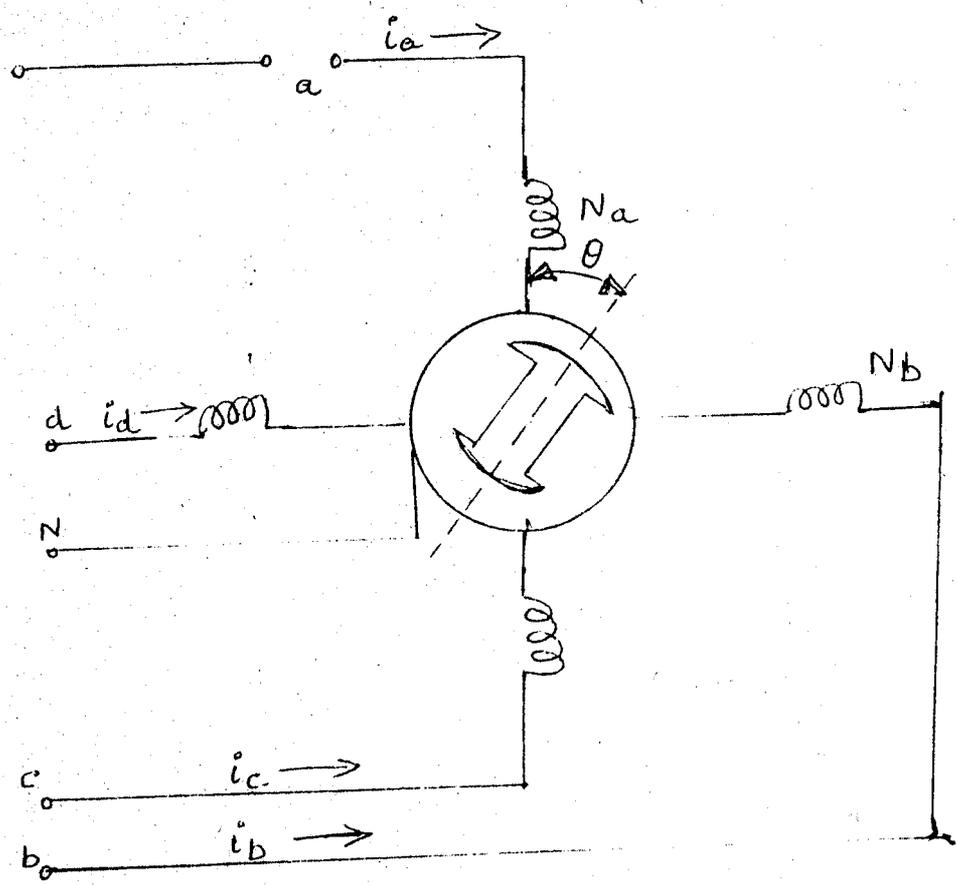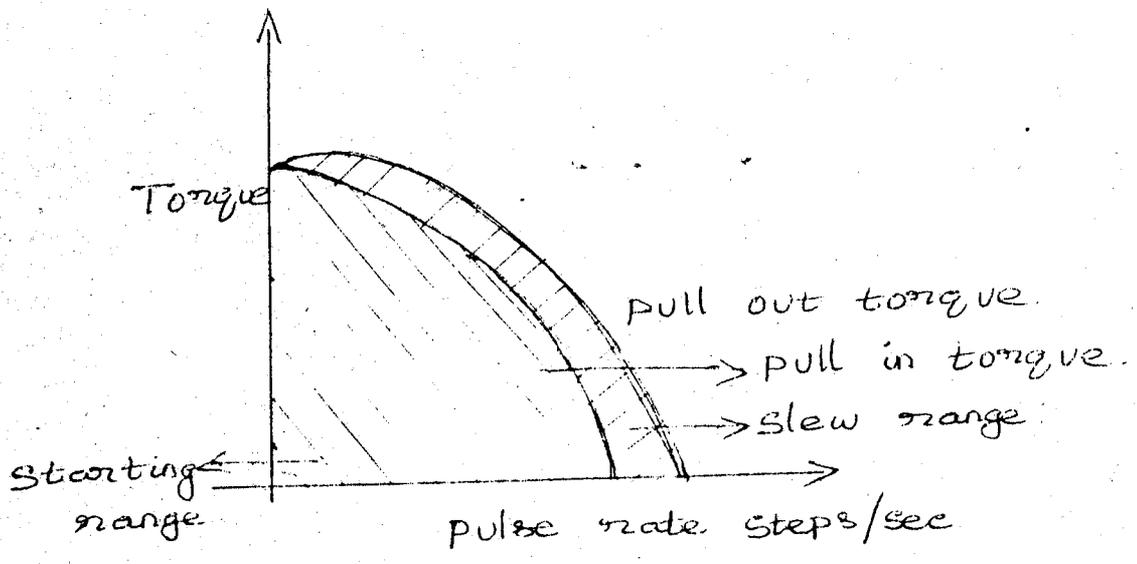
AGFDC

STEPPER MOTOR

DRG NO: 2.4.1 -

or bi-directional rotation. Reversing a unidirectional stepper motor requires simply a change in the order of phase excitation.

The characteristic of a stepper motor are frequently presented as torque versus. Stepping rate of pulses applied to the drive unit. As the stepping rate is increased the motor can provide less torque because the rotor has less time to drive the load from one position to next as the stator winding circuit pattern is shifted. The starting range is that in which the load position follows the pulses without loosing steps. The slew range is that in which the load velocity follows the pulse rate without loosing steps, but cannot start, stop or reverse on command. The maximum torque point is the maximum holding torque of the excited motor to a steady load.

The relevance of the stepper motor is switching off gears is understood by considering the fact that rotary motion of the stepper motor can be converted to the linear motion required along the bridge of the "H" pattern as well as into the angular motion required for swtiching between gears on the same selector rod.

2.5 The Gear System

Transmission :

The word transmission means the whole of the mechanism that transmits the power from the engine crankshaft to the rear wheels. However, the transmission is also being used very commonly for a mechanism which provides us with suitable variation of the engine torque whenever required. This may be a gear box, a torque converter or may be a gear box, a torque converter or an automatic transmission. Specifically we are concerned with the gears for different speeds and a selector gear box.

Functions of Transmission

The main functions which are performed by the transmission are :

i) The torque or the tractive effort produced by the engine varies with speed only within narrow limits. But the practical considerations for the running of automobile under different conditions demands a large variation of torque available at the wheels. The main purpose of the transmission is to provide a means to vary the leverage or torque ratio between the engine and the road wheels are required.

ii) The transmission also provides a neutral position so that the engine and the road wheels are disconnected

VARIOUS RESISTANCES TO THE VEHICLE MOTION

RESISTANCE

TOTAL RESISTANCE

MISCELLANEOUS RESISTANCE

GRADIENT RESISTANCE

WIND RESISTANCE

SPEED
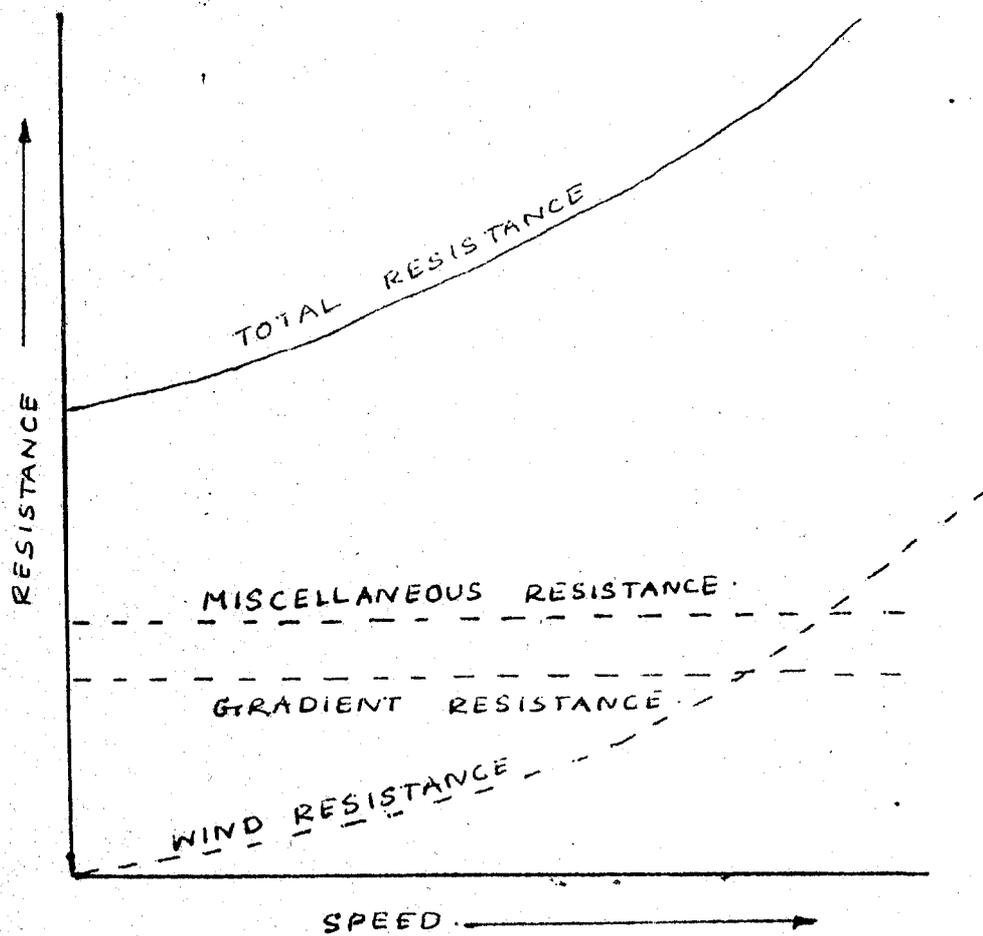
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TOTAL RESISTANCE TO VEHICLE MOTION

AT DIFFERENT GRADIENTS
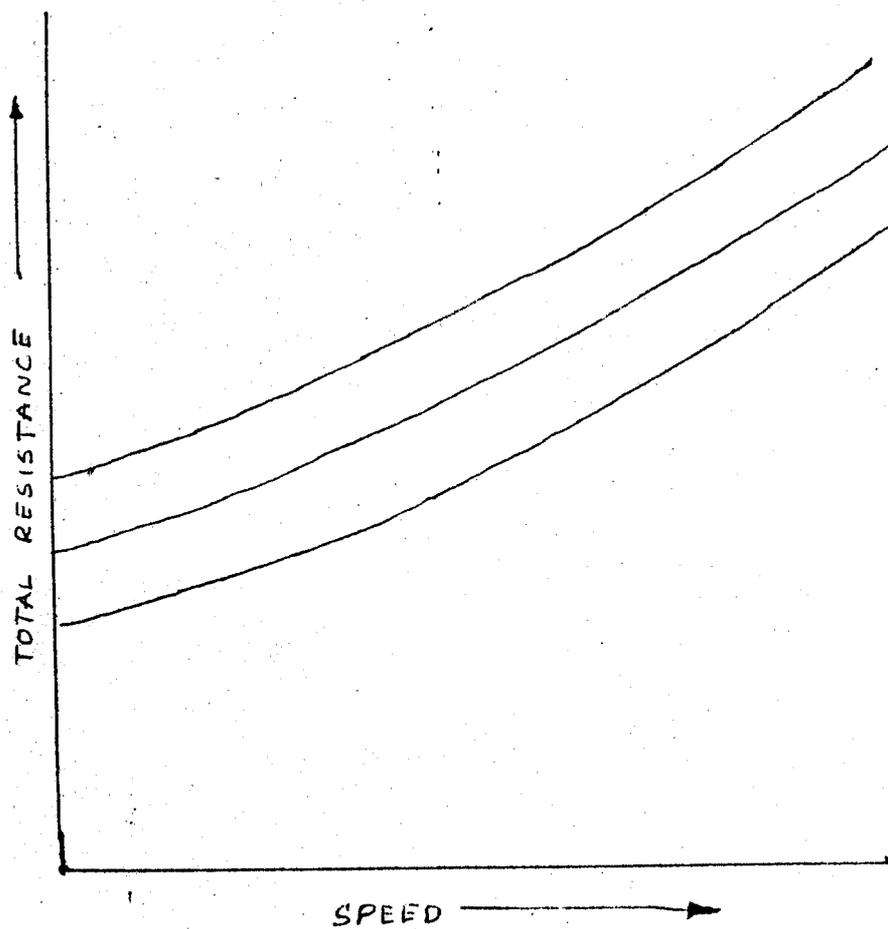
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even with the clutch in the engaged position.

iii)   A means to back the car by reversing the direction of rotation of the drive is also provided by the transmission.

Resistances on Moving Vehicle

The resistance are :

i)   Resistance due to wind

ii)   Resistance due to gradient

iii)   Rolling resistance

i)   Resistance due to wind

The moving vehicle has to face wind resistance - the faster the vehicle runs, more resistance it has to face. To reduce this air resistance the front portion of the vehicle is given slope so that air can be easily torn apart. To sum of these air resistance. depends upon.

a)   Vehicle speed

b)   Direction of the wind with respect to vehicle movement

c)   Velocity of the wind

ii)   Resistance due to gradient.

This is the component of the vehicle weight parallel to the plane of the road. In general a vehicle has to exert more power climbing steep hills.

Therefore it depends upon

a)   Gradient

b)   Type of road

iii)   **Rolling Resistance**

Practically more force is required to move the stationary vehicle and once the vehicle starts rolling, less power is required. This is known as rolling resistance and this depends upon the following factors.

a)   Ground ie plain - pucca road

b)   Tyres i.e. cross section of tyres thin or balloon tyres.

c)   Weight ie what is the weight of vehicle and the total load it is carrying.

d)   Power required to move the transmission.

From the above discussion it is obviously understandable the variation of total resistance affecting the speed of the vehicle. Hence it is necessary to provide a gear box so that torque can be increased to cope up with the resistances which a vehicle has to face.

The essence is that for low load conditions the torque required will be low and hence a gear corresponding to low torque and hence high speed can be engaged and vice versa.

At the outset it should be noted that any gear has a lower and higher speed limit within which it can be engaged. A gear automation system is based on the principle that as the speed of the vehicle, changes above or below the speed limits of the gears that is currently engaged, then the next higher or lower gear is to be engaged depending upon the speed.

Existing system of auto gearing

The modern developing science world is already familiar with the automated gear transmission systems.

In the existing system the gear ensuring is effected by either torque convertor or fluid coupling. The gear box used is epicyclic gear box. Here we do have sun, planet and annulus gears. The different speeds are got by braking. The input is fed at the sun and the output taken through the planet. This system has a sensing system which brakes the appropriate gear corresponding to the speed that has to be sensed. The braking is done by hydraulic peak.

Selector Gear System

The gear system selected in general can be used for cars. This system is synchromesh arrangement. The positional orientations of the gears are shown in figure.

The main purpose of the synchromesh unit is to synchronize the speed of the two gears before they are engaged.

The gear box arrangement is of H-type. There are two selector rods. Each selector rod when chosen can be used to engage only one of the two gears at a time. For instance if the selector rod 2 is used, the first or the second gear can be engaged. The positions corresponding to the two gears are assigned for the given selector rod. The selector rods are provided with selector forks. These selector forks rest on the moving dogs which are moved to engage the required gear.

Mechanism of Shifting Gears

For shifting between two gears sharing the same selector rod, only an angular motion of the gear shift lever is necessary. In this there are two such instances viz., between first and second or vice versa and between third and fourth or vice versa.

PLAN

GEAR SELECTOR RODS

GEAR SHIFT LEVER

SELECTOR FORK

DOG CLUTCH
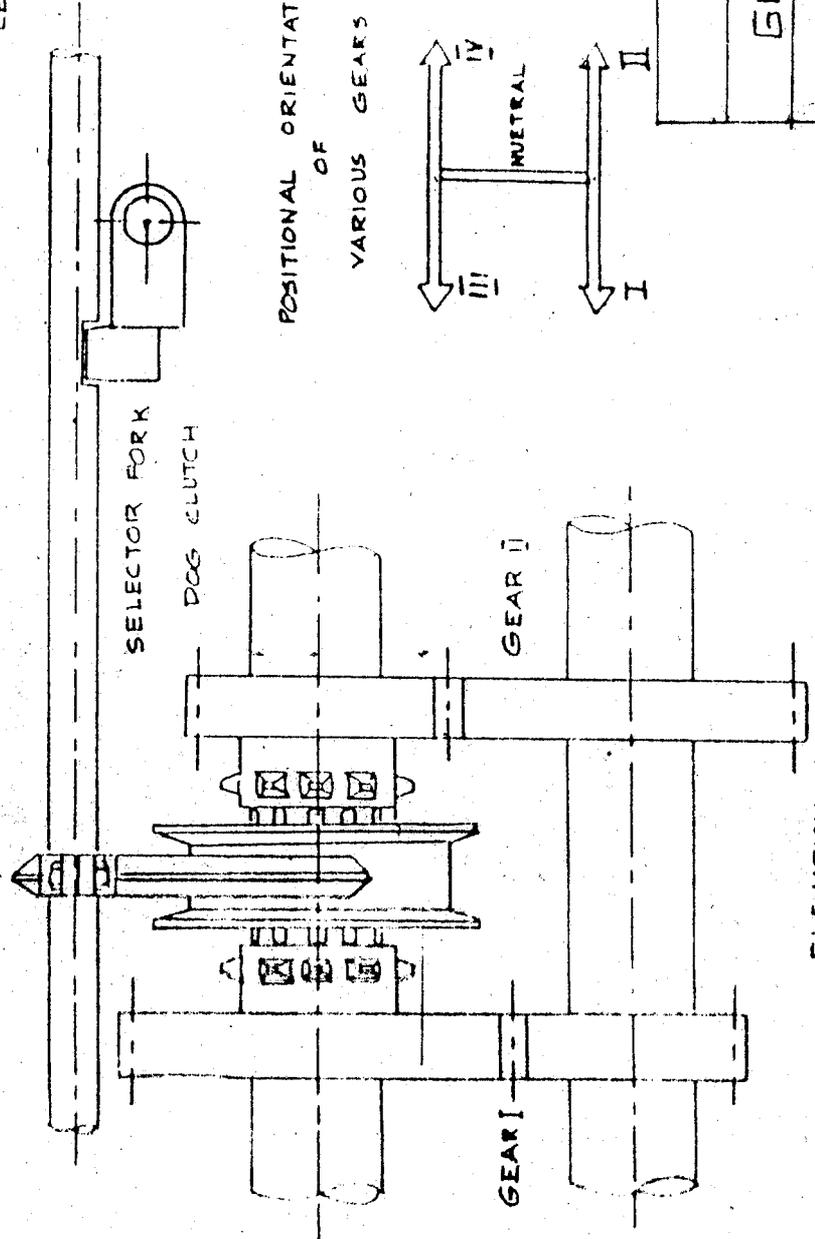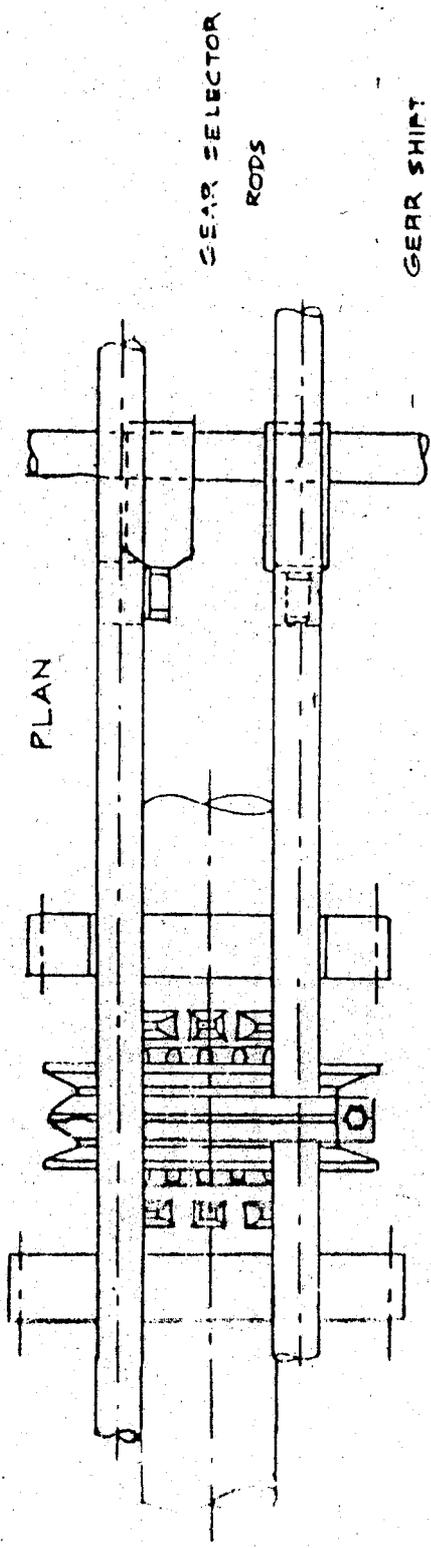
POSITIONAL ORIENTATION OF VARIOUS GEARS

IV

III

NEUTRAL

II

I

GEAR II

GEAR I

ELEVATION

SCHEMATIC DIAGRAM OF GEAR
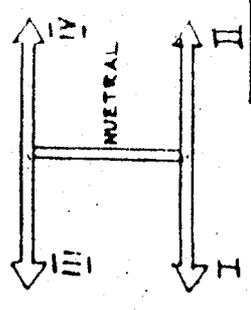
A6FOC

GEAR SYSTEM

SCALE 1:1 | DRG NO 2.5.B

35

PLAN

ELEVATION
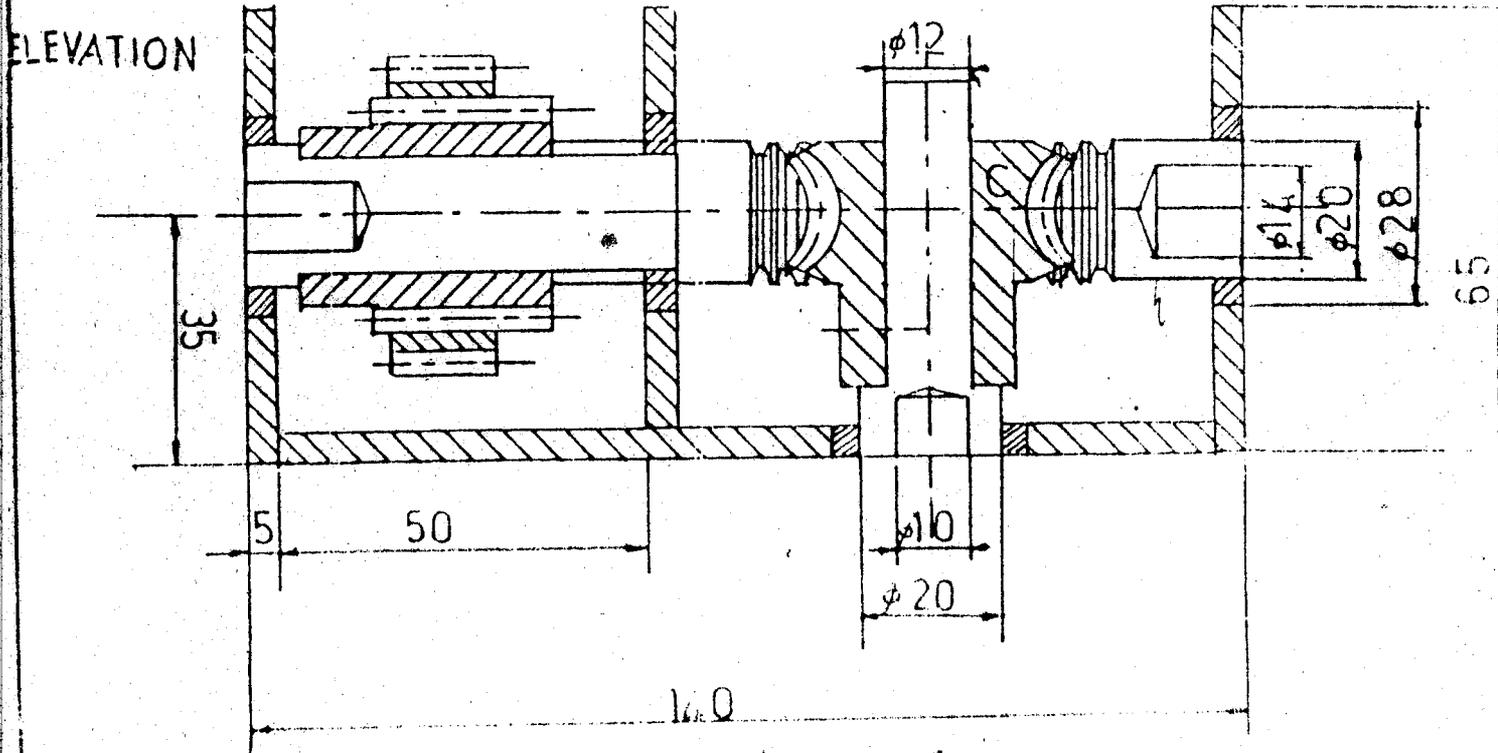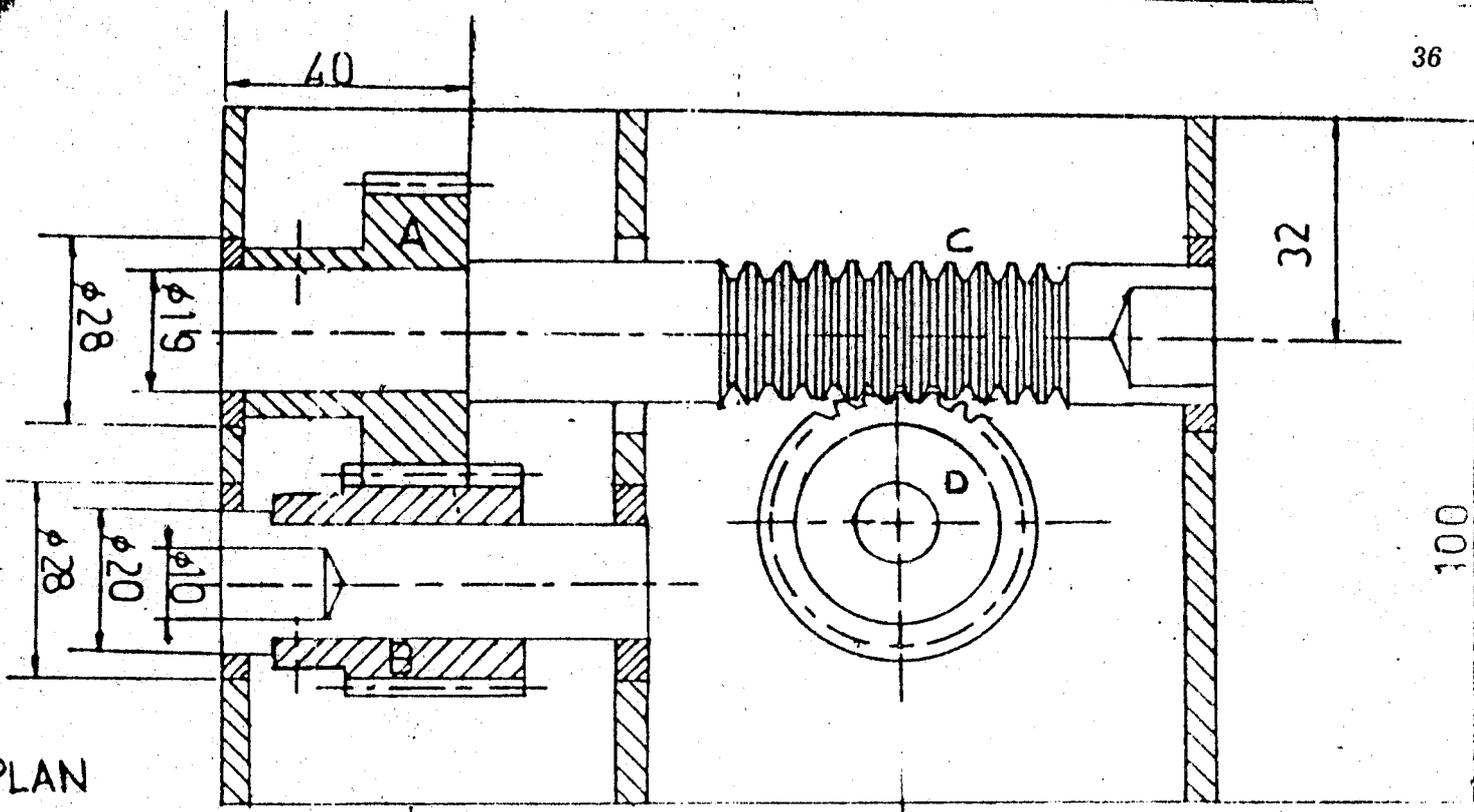
AGFCC

SELECTOR GEAR BOX

1:1 DRG No. 2.5.4

However for a gear to change from second to third or third to second a combination of linear motion and an angular motion of the gear shift lever has to be assigned with reference to the H pattern bridge.

The combinations of motions of the gear shift lever for all possible gear changes are shown in table. The distances is the angular play required for the linear motion are also specified.

Gear Shifting Process

The rotation i.e. the angular motion and the linear motion of the gear shifting mechanism is achieved by a gear selector specially designed for the AGFOC.

The plan and elevation of this is shown in the figure. The linear and angular motions of the gear shift lever. are obtained by stepper motors. For angular motion a 10 kg-cm stepper motor is used. For linear motion 3 kg-cm stepper motor is used.

The selector gear box is shown in figure. The active mechanism of gear shifting is described below.

As per the considerations of speed, imposed on gear engaging, if a speed that is sensed at any instant calls for a change in gear, then a series of operations has to

be done depending on the gear which is now engaged.

Gears A and B in mesh one spur gears, gear A capable of moving the face width of gear B through a linear distance of 6 mm. Gear A is mounted on shaft 1 and B on shaft 2, shaft 2 being connected to the 10 kg cm stepper motor, which is responsible for the angular movement of selector inside the gear box.

Gears C and D are of rack and pinion type, the pinion being gear D mounted on shaft 3, is in mesh with the rack of shaft 1.

The shaft 3 is connected to the 3 kg cm stepper motor, the rotary motion of which is responsible for the linear motion of shaft 1. The outer end of shaft 1 is connected to selector rod 1 of the gear box. The shafts 1 and 2 are supported by bush bearings mounted on mild steel frames.

When it is necessary for a gear to be changed the acceleration is cut down (to a minimum) and the clutch disengaged as discussed earlier.

Now picturing the table and the H type arrangement, if a change of gear is necessary say from 1 to 2 then stepper motor (10 kg cm) is operated with instructions from the software so that the shaft 2 rotates resulting in angular

motion required to cause a first gear to second gear change.

However, a change from second to third gear requires with the stepper motors to be rotated (refer H pattern). Instructions from the software first cause rotation of the 10 kg cm stepper motor which brings about an angular motion of the shaft to change the gear and bring it neutral required along the bridge wne of the H-pattern, to select the other selector rod. Now instructions come for the operation of 3 kg cm stepper motor which operates the rack and pinion bringing about a linear motion there by selecting the other selector rod.

Once the other selector rod has been chosen and angular motion is necessary to engage the third gear. This is achieved by instructions which operate. 10 kg cm stepper motor which causes the rotation of the shaft through the required angle.

Similarly, for the reverse direction is from a shift of gear from higher level to lower level. The table shows the stepper motors required the operate for a given gear transition and direction of rotation of stepper motor.

GEAR TRANSITION	Direction of Rotation		Degrees of Rotation	
	10 GKCM N-m	3 KGCM N-m	10 KGCM	10 KGCM 3 N-m
Nuetral to 1 gear	Anti Clockwise	-	60°	-
1 gear - 2 gear	Clockwise	-	120°	-
2 gear-3 gear	Anti clockwise	Anti clockwise	20°	-
3 gear - 4 gear	Clockwise	-	120°	-

AGFOC

DRG. NO : 25.5

CHAPTER 3

3.1 Microprocessor kit-SDA 85

The 8085 System Design Aid (SDA) is a complete Single Board Microcomputer system, based on the industry standard 8085A, incorporating all the features required for it to function as a trainer and as prototype system in user applications.

The system consists of a keyboard, an address display of 4 digits, a data display of 2 digits, read only and read/write memory, 48 programmable I/O lines, 3 programmable 16 bit counter/timers, an 8 bit interrupt instruction part and serial interfaces for TTY, CRT and Teleprinter.

The 8085A CPU, operating with a 6.144 MHz crystal, constitutes the heart of the system. The low order address lines ($A\emptyset$ to $A7$) are demultiplexed using an 8212, 8 bit latch/buffer. A 74LS138, 3 line to 8 line decoder, is used to generate the chip selects for the onboard IC's and the addresses are as given in the specifications. The address lines A15, A14, A13, A12 & A11 are used for this purpose. The 74LS139, dual 2 line to 4 line decoder is used to generate chip selects for RAM and to produce the MEMRD and MEMWR signals.

A 2K x 8 EPROM (2716) contains the monitor software and provision is there, onboard, for another 2716. 1K x 8 RAM is provided with provision for an optional 1 K x 8. Two 8255's (PPI's) are provided

that allow the CPU 48 programmable I/O lines. The addresses are given in specifications. 8255 is a powerful support I. C. and a number of Interfaces are available, as options, that use its capability. THe INTR line, terminated at connector J2, provides Interrupt capability.

The keyboard/display functions are handled by another powerful peripheral I.C., the 8279 Keyboard/Display Controller. The scan lines issued by the 8279 are decoded by the 74LS156, dual 2 line to 4 line decoder and fed to the keyboard and display drivers.

Three 16 bit Programmable Counter/Timers are made available using an 8253 peripheral I.C. One of the counter/timers is used by the Single Step Logic and the remaining two are accessible from connector J4.

An 8 bit interrupt instruction port is provided and it allows the user to jam an RST instruction onto the data bus in response to an INTR interrupt, when the CPU issues INTA. The inputs are all pulled up and this automatically issues an RST 7 instruction (op. cide FF) causing a branch to RAM location IFAEH. By suitably altering jumper connections, this can work as an 8 bit input port, if required.

The control group contains the necessary logic to generate the external Data BUFFER ON signal and the Buffer Enable signals.

Logic for single stepping through a User Program is included alongwith a wait state Generator (that can be disabled by removing U27 (74LS74). The clock frequency is divided by 2 before being fed as an input to the 8279. The address lines are buffered using two 74LS241 bus drivers and the lines are terminated at connector J3.

The data control lines are buffered, using a 74LS245 bus transceiver and 74LS241 bus driver and the lines are terminated at connector J4.

The SID and SOD lines of the CPU are used to implement the serial interface, to TTY, CRT and a teleprinter. The 20 mA current loop interface for TTY uses two PNP transistors and the RS-232-C interface for CRT is implemented using 1488 and 1489 TTl/ElA level translators.

The teleprinter interface requires ±60V and provides a 60 mA current loop interface using high voltage transistors.

Specifications

The specifications of the system are given below.

U		8085A
MEMORY	ROM	2716x1 [expansion 2716x1]
	RAM	2114x2 [expansion 2114x2]
I/O	PARALLEL	48 lines, 8255x2
	SERIAL	Through SID/SOD lines. Interfaces are provided for TTY, CRT and Tele-printer
Interrupts		TRAP, RST, 7.5, RST 6.5, RST 5.5, and INTR. An 8 bit interrupt Instruction port is provided.
Timer		8253x1
Interfaces		All Bus and Parallel I/O signals are TTL compatible. Optional Bus drivers for Bus expansion available. I/O connection and bus connection through flexible flat cables.
Keyboard/Display		Implemented using the 8279 keyboard/ display controller, six seven - segment displays, four for the address field and two for the data field.
Addresses	ROM	0 to 7FF H
		800 to FFF H (optional)
	RAM	1C00 to 1FFF H
		1800 to 1BFF H (optional)
	8279	2000 H - Data
		2001 H - Control

8255(1)	30 H	-	Port A
(PPI)	31 H	-	Port B
	32 H	-	Port C
	33 H	-	Control 1
8255 (2)	38 H	-	Port A
(PPI)	39 H	-	Port B
	3A H	-	Port C
	3B H	-	Control 2
8253	28 H	-	Counter 0
(TIMER)	29 H	-	Counter 1
	2A H	-	Counter 2
	2B H	-	Control
8212	1Ø H	-	Input port
	INTA	-	Interrupt instruction port
			(RST Instruction)

Monitor Commands GO, SUBSTITUTE MEMORY, EXAMINE REGISTER, SINGLE STOP, BLOCK MOVE, INSERT, DELETE, DISPLAY/PUNCH A PAPER TAPE, READ A PAPER TAPE, READ AN EPROM, PROGRAM AN EPROM

Power Supply Basic Kit Requirement - 5V ± 5%, 1.5A ± 12 V ± 10%, 100 mA

Option 001 & 003 Integral Supply specification - 5V ± 5%, 2.5A ± 12 V ± 10%, 250 mA 20V to 26V, 100 mA

Ordering Information Part Number MS - SDA85-1

Description 8085 System Design Aid.

3.2 System Functioning

The controlling system for the various translatory and rotary motion during gear shifting is taken over by the processor. The processor controls 2 stepper motors for gear shifting and two solinoid valves on line in pneumatic circuit for acceleration and clutch control. The processor selected for this system is INTEL 8085.

For this system, to function the processor requires a memory (RAM) capacity of 2 K bytes and EPROM of 1 K byte capacity. It also requires 2 programmable peripheral interface (PPI) chips for its external communication to the stepper motors, solinoid valves speed sensors and display.

Peripheral Interfacing

The peripheral interface chip selected is 8255A. This chip has 3 ports named port A, port B and port C/ 8 bit. The 3 ports have 3 basic modes of operation. The mode selected is basic I/O mode.

Port configuration

PORT 01

$A_0 - A_7$ these 8 bits are utilised to transfer the engine speed to the processor. The engine speed is measured by digital pulses transudced by an optocoupler. These digital pulses are converted into 8 bit binary data and then fed to the port A.

46a

SPEED TRANSDUCER1

SPEED TRANSDUCER2

SOLENOID VALVE1

SOLENOID VALVE 2

MOTOR1

MOTOR 2

DISPLAY

BINARY DATA

BINARY DATA

POWER AMP

POWER AMP

POWER AMP

POWER AMP

BINARY TO 7 SEGMENT DECODER

8255 PPI

8255 PPI

INTEL 8085 CPU

EPROM

RAM
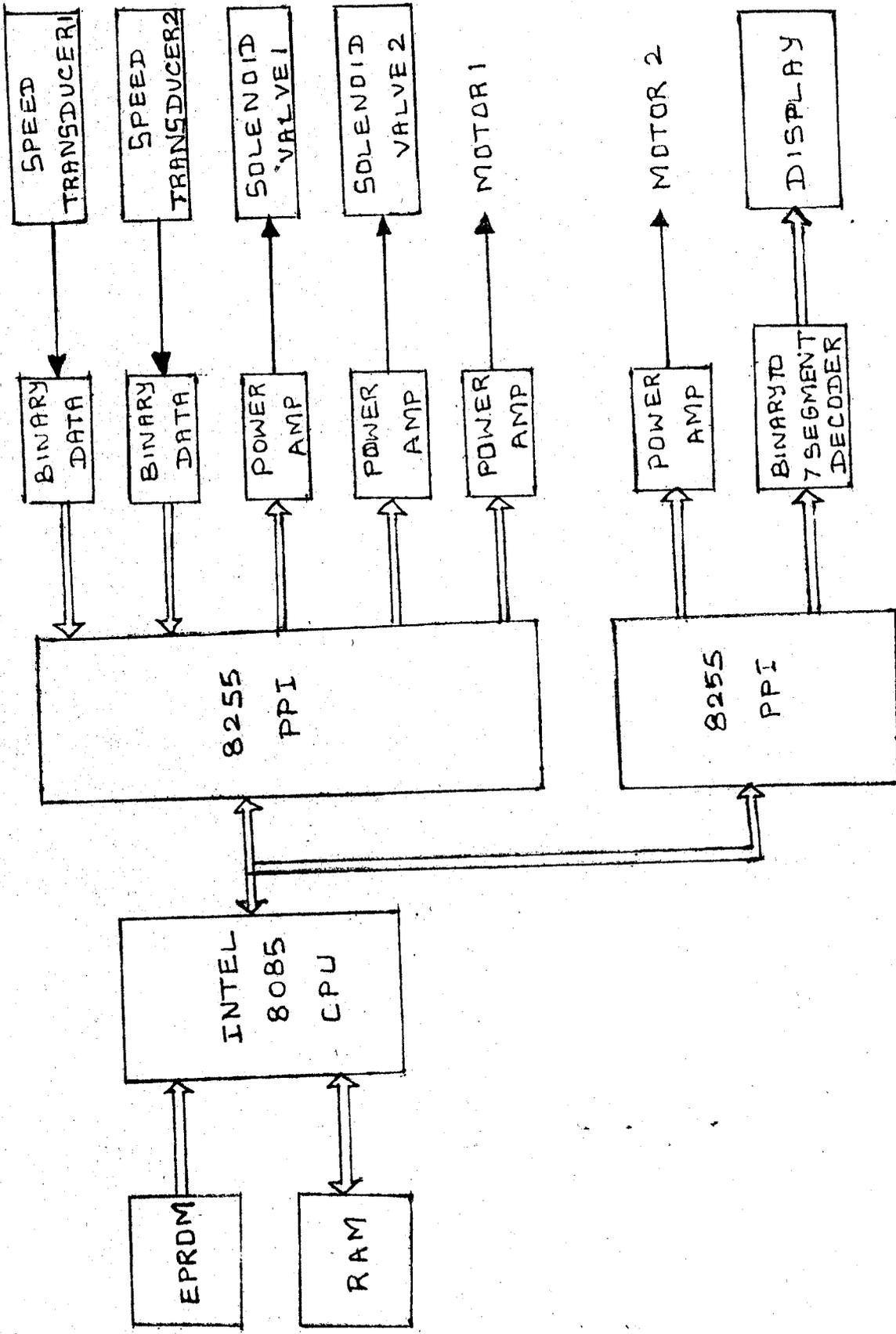
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DRG NO: 3.3.1

B_0 - B_7 these 8 bits are utilised to transfer the propeller shaft speed to the processor. The propeller shaft speed is measured by digital pulses transduced by an optocoupler. These digital pulses are converted into 8 bit binary data and then fed to the port B.

C_0 - C_1 these two bits are utilised to control (energise) two solenoid valves which in turn control accelerator and the clutch mechanism through pneumatic circuit.

C_2 - C_5 these four bits control the stepper motor 1 to accomplish the gear change from 1 - 2, 2 - 1, 3 - 4, 4 - 3. This is achieved by the following procedure.

S.No.	Gear Shaft pattern	Angular rotation	Direction	No. of pulse output
1	1 - 2	60	Clockwise	30
2	2 - 1	120	Anticlockwise	60
3	3 - 4	60	Anticlockwise	30
4	4 - 3	120	Clockwise	60

PORT 02

A_0 - A_7 these 8 bits display the current speed of the vehicle and the gear. This is accomplished by decoding the binary data 8 bits into 7 segment display. The maximum speed that can be

displayed is 99 Km/hr.

C_2 - C_5 these 4 bits control the stepper motor 2 which in turn helps in shifting from second to third and vice versa.

S.No.	Gear shift pattern	Angular motion	Direction	No. of pulse output
1.	2 - 3	20	Clockwise	10
2	3 - 2	20	Anticlockwise	10

POWER AMPLIFIERS

Two bits C_0 C_1 whose outputs are amplified from 5 volts to 24 volts through a power amplifier and fed to the solenoid valves.

The 8 bits (port 01, C2 - C5 and port 02, C2 - C5) output the maximum of 5 volts. This is stepped up to 24 volts by a set of 8 amplifiers.

3.3   SOFTWARE

Initially port   01 A, B are selected to be input ports to input the engine and propeller shaft speeds Port C is used as output to solenoids and stepper motor 1.

Port   02, A is selected to be an output port to display the instant speed and gear. Port C is used as an output port to control the stepper motor 2.

The two data engine and propeller shaft speeds are taken in and stored in particular location. The idling speed is set to be N. This speed N is compared with the engine speed C. If C is greater than N the solenoid valves energise to disengage the accelerator and clutch. Stepper motor 1 changes the gear position from neutral to first gear by receiving 30 consecutive pulses from the processor. The solenoid valves denergise to engage the clutch and accelerator.

If C is less than N the control is once again transferred to compare C with N.

The maximum speed limit further the first gear is N1. N1 is compared with C. If C is greater than N1 the two solenoid valves operate to disengage the clutch and acceleration. The stepper motor 1 is rotated through 120° anticlockwise by 60 pulses. The solenoid valves denergise to engage to clutch and accelerator.

If C is less than N1 then C is compared with N. If C is less than N the control system operates in the reverse order to shift to neutral. If C is greater than N the control goes to check if C is greater than N1.

N2 is the set maximum speed for second gear. Now C is compared with N2.

If C is greater than N2, the control goes to solenoid valves to disengage the clutch and accelerator. The stepper motor 1 is rotated through 60° clockwise by 30 pulses and then the stepper motor 2 is rotated through 20° clockwise by 10 pulses. The stepper motor 1 is further rotated by another 60° clockwise by 30 pulses. Then clutch and accelerator are engaged.

If C is less than N2. Once again C is compared with N1. If C is less than N1, the control goes to solenoid valves to disengage the clutch and accelerator, the two stepper motors are operated in the reverse order to shift to second gear and then engage the clutch and acceleator.

N3 is the set maximum speed for third gear. Now C is compared with N3.

If C is greater than N3, the control goes to solenoid valves to disengage the clutch and accelerator. The stepper motor is rotated

through 120° anticlockwise by 60 pulses. The solenoid valves denergise to engage the clutch and accelerator.

If C is less than N3, once again Č is compared with N2. if C is less than N2 the control goes to solenoid valves to disengage the clutch and accelerator, the stepper motor 1 is operated in the reverse order to shift to third gear and then engage the clutch and accelerator.

START

INPUT B, C
N, N_1 N_2 N_3 N_4

Compare
C, N

$< N$

$> N$

Shift neutral

Shift I gear

$< N$

$> N$

Compare
B, N

$< N_1$

Compare
B, N_1

$> N_1$

Shift II gear

Shift I gear

$> N_1$

$< N_1$

Compare
B, N_2

$< N_2$

Compare
B, N_1

$> N_2$

1

2

C - Enginespeed
B - Propeller shaft
     speed
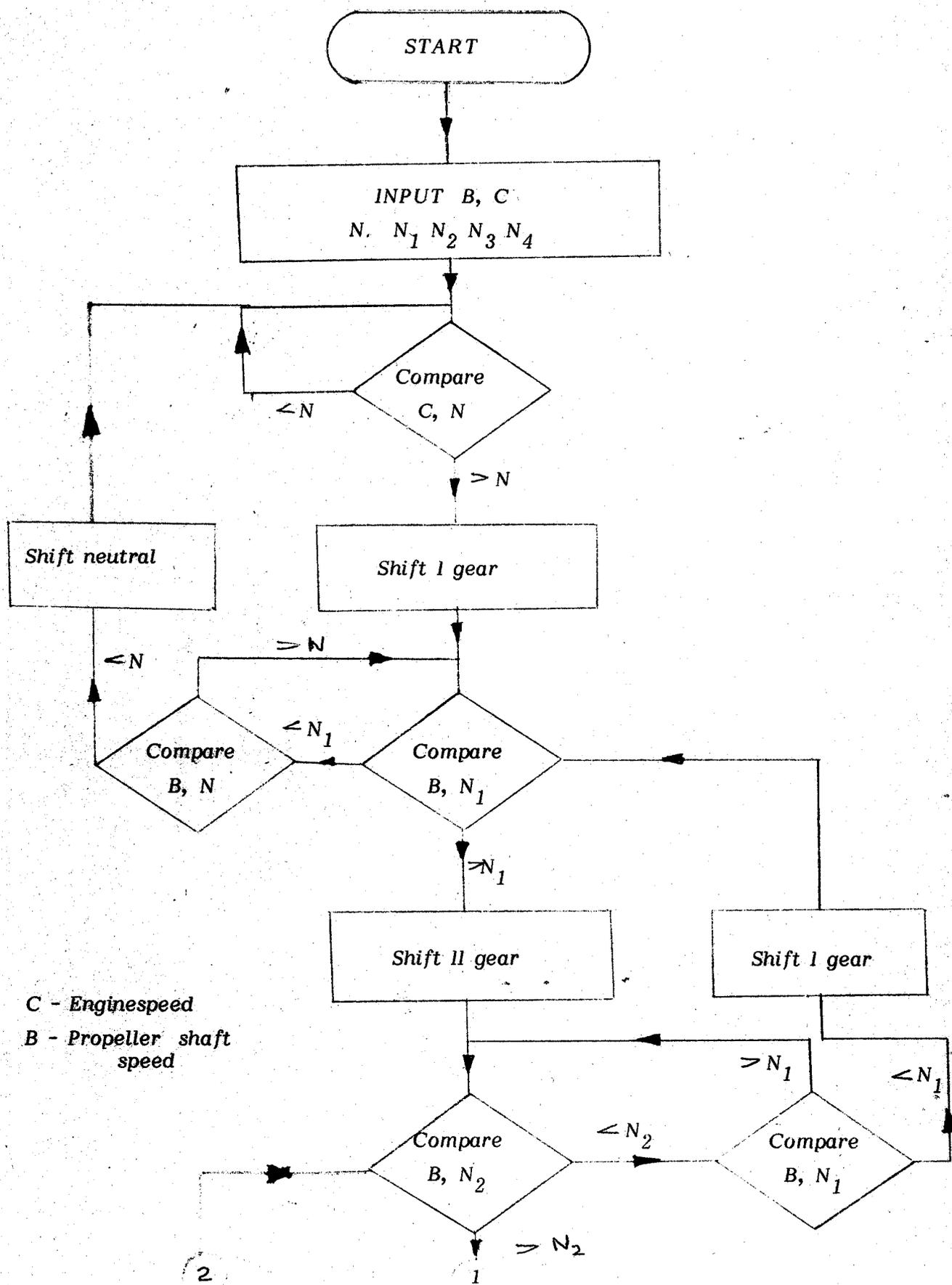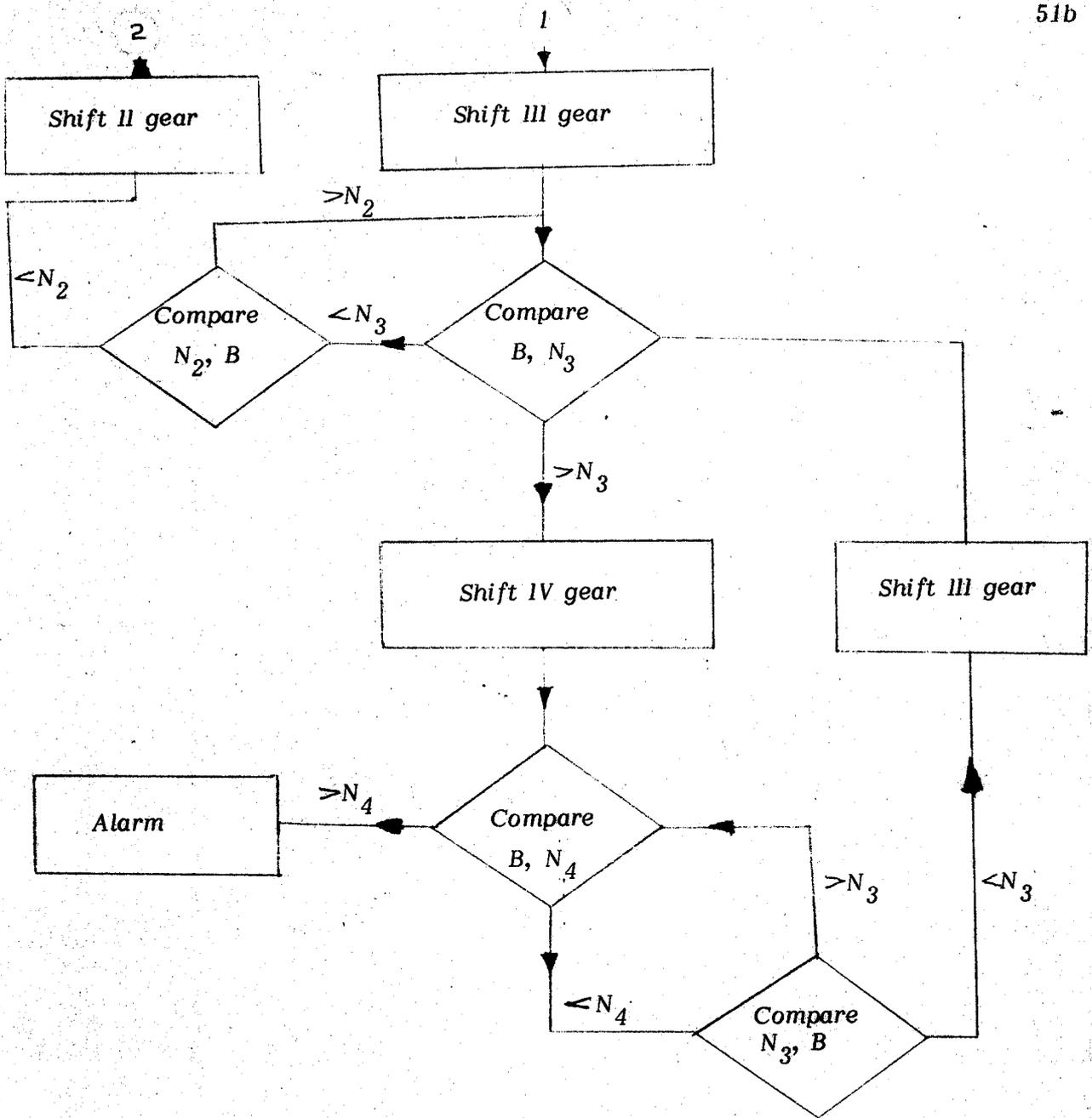
```
4000

4000        MVI C, 00
            MVI B, 00

4010        IN PORT A            I/P
            MOV C, A             C-Engine Speed
            IN PORT B            I/P
            MOV B, A             B-propeller
4020        MVI A, N             Shaft speed
            CMPC                 N-idling speed
            JC 4050              Speed check
            JMP 4010

4050        JMP 8000
            PUSH C
            PUSH D
            PUSH E
            MVI E, 03

4060        MVI D, OC            Shifting neutral
            MOV A, D             to 1st gear
            ADD E
            MOV E, A

            OUTPORT E
            DEC E
            JZ 8100
            JP 4070
            MOV A, D
            RLC
            MOV D, A
            JMP 4060

4070        MVI, A, N1           Speed check N1 - 1st gear
            CMP B                maximum speed
            JC 4100
            MVI A, N
            CMP B
            JC 4070
            JMP 8000
```

```
              PUSH C            If propeller speed    idling
              PUSH D            speed shifting to neutral
              PUSH E
              MVI E 03
              MVI D 24
              MOV A D
              ADD E
              MOV E, A
      4090    MVI F, 1E
              OUTPORT E
              DEC F
              JZ 8100
              JP 4020
              MOV A, D
              MOV D, A
              JMP 4090

      4100    JMP 8000
              PUSH C
              PUSH D
              PUSH F
              MVI E, 03
      4120    MVI D, OC
              MOV A, D
              ADD D,            Shifting 2nd gear from  1st gear
              MOV E, A
              MVI F, 3C
              OUTPORT E
              DEC F
              JZ 8100
              JP 4130
              MOV A, D
              RRC
              MOV D, A
              JMP 4120
```

```
4130        MVI A, N2
            CMP B                   Speed check
            JC 4200                 N2 - ll gear

4140        MVI, A, N1
            CMP B
            JC 4140
            JMP 8000                If propeller shaft speed
            PUSH C                     N1 then shift to 1st gear
            PUSH D
            PUSH E
            MVI E, 03
            MVI D, 24
            MOV A, D
            ADD E
            MOV E, A

4150        MVI F, 1E
            OUTPORT E
            DEC F
            JZ 8100
            JP 4130
            MOV A, D
            RLC
            MOV D, A
            JMP 4150

4200        JMP 8000
            PUSH C                  Shifting from ll to lll gear
            PUSH D
            PUSH E
            MVI E, 03
            MVI D, OC

4250        MOV A, D
            ADD D
            MOV E, A
            MVI F, 3C
            OUTPORT E
```

```
              DEC F
              JZ 4300
              MOV A, D
              RLC
              MOV D, A
              JMP 4250

    4300      MVI E, 03
              MVI D, OC

    4350      MOV A, D
              ADD D
              MOV E, A
              MVI F, OA
              OUTPORT  2 E
              DEC F
              JZ 4400
              MOV A, D
              RLC                    Shifting from 2nd to 3rd gear
              JMP 4350

    4400      MVI E, 03
              MVI D, OC
              MOV A, D
              ADD D
              MOV E, A
              MVI F, 24
              OUTPORT      1E
DEC F         DEC  F
              JZ 8100
              JP 4450
              MOV A, D
              RLC
              MOV D, A
              JMP 4420

    4450      MVI A, N3
              CMP B                  Speed check
              JC 4600
```

```
4460      MVI, A, N2
          CMP B
          JC 4450
          JMP 8000
          PUSH D              If propeller shaft
          PUSH E              speed is  N2
          MVI E, 03
          MVI D, 1E
4470      MOV A, D            Shifting from IIIrd to II
          ADD E               gear
          MOV E, A
          MVI, F, 1E

          OUTPORT E
          DEC F
          JZ 4480
          MOV A, D
          MOV D, A
          JMP 4470

4480      MVI, E, 03
          MVI D, OC
4490      MOV A, D
          ADD D
          MOV E, A
          MVI F, OA
          MVI F, OA
          OUTPORT    02 E
          DEC F
          JZ 4500
          MOV A, D
          RRC
          MOV D, A
          JMP 4490

4500      MVI, E, 03

4510      MVI D, OC
          MVA, D
```

```
                ADD  D
                MOV  E, A
                MVI  F, 24
                OUTPORT   01 E
                DEC  F
                JZ  4600
                MOV  A, D
                RRC
                MOV  D, A
                JMP  4510

4600            MVI  D, OC

4610            MOV  A, D                    Shifting from lll to lV
                MOV  E, A                    gear
                MVI  F, OA
                OUTPORT   01E
                DEC  F
                JZ  8100
                JP  4620
                MOV  A, D
                RLC
                MOV  D, A
                JMP  4610

4620            MVI, A, N4                   Speed check
                CMP  B
                JC  4800
                MVI, A, N3
                CMP  B
                JC  4900
                JMP  8000                    If propeller shaft speed
                PUSH  C                         N3, shifting the gear
                PUSH  D
                PUSH  E
                MVI  E, 03
                MVI  D, 3C

4640            MOV  A, D
                ADD  E
                MOV  E, A
```

4. TIPS TO DRIVERS

In this section we give about the details of faculities available to the driver. The driver should make proper and optimum use of controls at his disposal. A knowledge about these controls will be very much helpful to the driver.

The system includes the visual display systems. The display system consists of a panel of seven segment display. The speed of the vehicle, the current gear in engagement etc. A set of switches is also available to the driver. When the driver wants to start the vehicle he has to press the proper switch. When the switch is on the microprocessor checks the state of all the controls and displays a code symbol corresponding to the all correct state. Then the driver can proceed normally.

Corresponding to the preconceived faults specified codes can be flashed. If one of the codes is flashed then the driver shall switch off the automatic system and move to the manual system. This is usually not needed. But in case of emergency this has to be considered. When a gear change take place an award signal is effected. Every specific gear change taking place can be recognized by the generation of particular frequency. The driver should have an overall knowledge about the working of the system and handle the system with much care.

5. COST ESTIMATION

S.No.	Particulars		Price
1.	Stepping motors	10 kg cm x 1	750.00
		3 kg cm x 1	450.00
2.	Transistor board x 2		500.00
3.	Edge connectors x 5		250.00
4.	Optocoupler x 2		110.00
5.	Accelerator auxiliary unit amplifiers		300.00
6.	Power amplifiers		
7.	Microprocessor development system		5000.00
8.	I/O extension board		1300.00
9.	Pneumatic tubes		50.00
10.	Pneumaticl cylinders x 2		700.00
11.	solenoid values x 2		600.00
12.	Flow control valves x 2		100.00
13.	Fittings and accessories		500.00
14.	Extension gear box		450.00
16.	Installation cost		250.00
17.	Compressor 6 kg/cm^2		3000.00
18.	Man power for design and fabrication		4000.00
19.	Overheads		500.00
		Total Rs.	18,810.00

6. ADVANTAGES AND APPLICATIONS

The AGFOC system has a wide range of applications and it is more advantageous.

The driver has no much strain over the gear changing process. At the speed increases or decreases the gear changes automatically. Hence the driver needs no care regarding the gear changing. The vehicle can run smoothly. The driver feel relax. T@he fuel is saved as the gear changes automatically at proper time. Possibility of damage of gears is less in this system.

The basic concept of AGFOC system can be applied to any type of vehicle. Using the concept of AGFOC the same can be extended to heavy vehicles like buses, lorries etc.

7. MEANS OF IMPROVEMENT

This project can be still improved by using various techniques which are available in this modern world.

In this project we have used two stepper motors for changing gears. This system of changing gears can be improved by using only one stepper motor and instead of the second stepper motor we can use energised coils which gets magnetised and attracts the iron rod which combined together enhances the gear change

Further this can still be improved by using the pneumatic circuits which can be designed properly using flow control valves and compressors etc. for changing gears.

Ultimately the improvement of this project goes on developing until this science age exists which is expanding daily.

8. CONCLUSION

The automatic mechanism for the CARS is clearly designed, considering all the influencing factors like speed, clutch engagement and disengagement, using solenoid control valves and a microprocessor.

Automation in automobiles is one of the modern techniques which is still developing. Looking back from the scientific age we cannot but note what appeared to be a dream in the past has come to a thrilling reality. Ofcourse, one of this is "AUTOMATIC GEAR CHANGING FOR CARS". Hope automation will still provide the easiest means of handling the automobiles especially CARS as we have considered in this project.