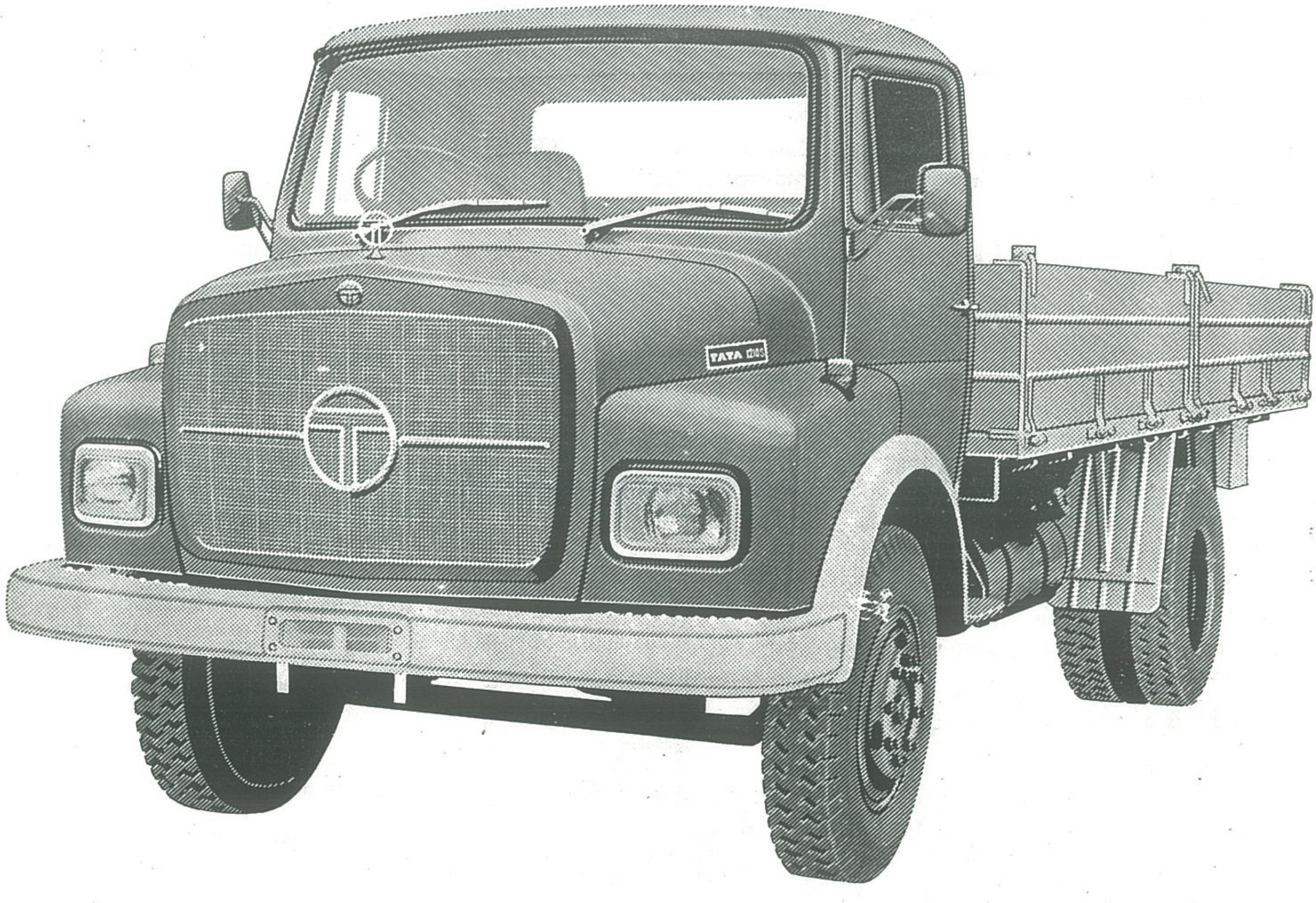
KNOW YOUR TRUCK SERIES

REPRINTS FROM **TELCO-PARIVAR** ISSUES FROM AUGUST 74 ONWARDS



TATA ENGINEERING AND LOCOMOTIVE CO. LTD.

PIMPRI POONA 411 018

Know Your Truck - I

In the near future, we will be producing a truck in Poona. This is the goal that we are all working for. All of us in TELCO put together know a great deal about trucks; but how much do we know individually ? It appears that whereas many of us know a lot about some parts of the truck, few know something about the truck as a whole.

With the next issue, therefore, TELCO PARIVAR will start a series of articles called KNOW YOUR TRUCK. This series will try and explain the working of an entire truck in a stimulating and interesting manner. You will be able to read about engines and injection pumps, gear boxes and rear axles, about Easy Ride seats and suspensions; and about brakes and clutches. Beyond the question of how a truck works, we hope to explain how it is designed, how it is tested, and why we place so much importance on quality.

It is our hope that these articles will give us all a better idea of how important our individual contributions are, however narrow they may sometimes seem.

As these articles appear, we would like you to write to TELCO PARIVAR and tell us what you think of them, and how you think they can be improved. In particular, if there is some part of a truck you want to read about, let us know.

For this issue, we have prepared a quiz for you. Let us see what you do know.

Q. Why is a truck called a truck?

A. The word 'truck' comes from an ancient Greek word meaning "wheel". In past ages, trucks used to be simple carts with wheels. Nowadays, they are the complicated pieces of machinery that you see on the road.

Q. When was the first modern truck made?

A. About 80 years ago, by a German Engineer named Benz.

Q. Why is our truck called a "diesel" truck?

A. The type of engine that is used in our truck was invented in the nineteenth century by an engineer named Rudolf Diesel. The engine is named after him, as is the fuel used in this engine.

Q. When did TELCO start manufacturing trucks?

A. 1954.

Q. How many trucks has TELCO produced so far?

A. We have produced over 3,00,000 trucks.

Q. What do the numbers "1210" that appear on our trucks mean?

A. The 12 represents the specified gross vehicle weight of our truck which means that it should not weigh more than 12 tons when loaded. The 10 means the engine develops 100 horse power.

Q. What do the truck designations "L", "LP", "LPT" and "SFC" stand for?

A. "L" stands for "conventional control" trucks, with the long nose, "LP" stands for the flat faced bus chassis with the full forward control, "LPT" stands for the truck chassis with the full forward control and flat face. "SFC" stands for "Semi-forward control".

SFC trucks will be introduced in 1975; they will have a short nose.

Q. What are the units in which goods and passenger movement are measured?

A. Goods movement is measured in ton-kilometres. This is obtained by adding together the distance that each ton of goods is moved. Passenger movement is measured in passenger-kilometres, obtained by adding together the distance travelled by every passenger.

Q. Why are trucks and buses important in India?

A. About 40% of the total goods movement in India is done by trucks. About 51% of the total passenger movement is by buses. Without trucks, commerce would come to a standstill. In Poona, you wouldn't be able to buy rice, wheat, vegetables, milk, kerosene and a host of other items if there were no trucks to transport them.

Q. What does a truck buyer look for in a truck?

A. A reasonable price, a reasonable cost of operation, but most of all, quality and reliability.

Q. Why are more than 60% of the trucks sold in India manufactured by Telco?

A. Because we manufacture the best trucks in India !

Know Your Truck - II

Introducing the Truck

A truck hauls goods from one place to another. There are many other ways of doing that: on foot, on bullock-carts, on bicycles, on trains, on airplanes. So what's special about trucks ? Let's look at some important characteristics of any means of transportation.

First comes mobility. How much of the surface of the earth is easily accessible to a vehicle of transport ? Our mobility ranking would be: Man (highest), bicycle, bullock-cart, truck, train, airplane (lowest).

Next comes load-carrying capacity. Here the ranking is train, airplane, truck, bullock-cart, bicycle, man: just the opposite of the ranking for mobility.

Third comes speed of transportation. The ranking is: airplane, train, truck, bicycle, bullock-cart, man.

Fourth is investment required. This includes both the cost of the vehicle as well as roads for trucks, rails for trains, airports for airplanes, etc. The ranking is man (lowest investment), bicycle, bullock-cart, truck, train, airplane (highest investment).

One final important characteristic is energy consumption for goods haulage. The ranking here is not entirely proved, but would approximately be: bicycle, train, truck, man, bullock-cart, airplane.

All of these rankings are shown in the accompanying table.

RANKING OF VARIOUS MODES OF TRANSPORTATION

	Truck	Man	Bicycle	Bullock-cart	Train	Airplane
Mobility	4	1	2	3	5	6
Load capacity	3	6	5	4	1	2
Speed	3	6	4	5	2	1
Investment	4	1	2	3	5	6
Energy Consumption	3	4	1	5	2	6

One thing is clear. The truck is a golden mean. It is neither outstandingly good nor outstandingly bad in any important characteristic. Our conclusion, therefore, is a happy one for Telco: trucks are certainly worth manufacturing and using!

Let us consider these five characteristics in further detail.

Mobility

For highspeed movement, a paved road at least $2\frac{1}{2}$ metres wide is necessary, generally with slopes of not more than about 1 in 4. For off-highway trucks, what is required is a reasonably firm path, about $2\frac{1}{2}$ metres wide, relatively free of large potholes or boulders. It is surprising how large an area one kind of truck or another can operate in. With four-wheel-drive, trucks can operate in rough, hilly terrain; with high flotation tyres, in sand and mud; with studded tyres in ice and snow; and with turbo-charged engines, up in the mountains.

Load Capacity

Trucks are in operation hauling anything from $\frac{1}{2}$ a ton to 40 tons or more. The more important question is, what is the ratio of the load carried to the weight of the empty truck? For the heavier truck, this ratio is in the neighbourhood of 3 : 1. (By way of comparison, the ratio would be 1 : 2 for a man and about 1 : 3 for an airplane).

Speed

How fast can trucks go ? They can go quite fast — up to 120 kilometres per hour (kph) in the USA. The maximum speed depends on the quality of the road. In India, the usual maximum is about 85 kph.

Investment

It is wrong to think only of the cost of a truck if one is comparing it with other means of transportation. One has to do what is called a "systems analysis". Typical costs that would be included in addition to the cost of building a truck are : a part of the cost of building and maintaining roads, the cost of having a supply network for fuel and spare parts, the cost of repair and maintenance facilities, and the cost of loading and unloading terminals. It is on this basis that trucks are ranked 4th in the table as far as investment goes.

Energy consumption

In these days of the energy crisis, the energy consumed by a machine in doing a certain piece of work has suddenly come into the spotlight. Let us compare a typical man and a typical truck doing the work of shifting a weight over some distance. A man consumes 3,000,000 calories of energy (which he gets by eating food) in a day. With that he might be able to carry 30 kgms over 50 kms. His energy consumption would be $3{,}000{,}000 \div (30 \times 50) = 2000$ calories per kg-kilometre. A medium sized truck consumes about 25 litres of diesel fuel while carrying about 8000 kgms. over a distance of 100 kms. The energy content of 25 litres is about 200 million calories. The energy consumption is thus $200 \times 10^6 \div (8000 \times 100) = 250$ calories per kg-kilometre. A truck thus consumes only one-eighth of the energy that a man does in cargo carrying.

What does the future hold ?

Progress is likely in two areas — reduction in investment and in energy consumption. Reductions in investment will arise from better production techniques, new materials and more comprehensive value engineering for the truck, and also from better road-building techniques. Lower energy consumption will come primarily from better engine design, but also from new tyre designs (with lower friction), and from aerodynamic styling.

Know Your Truck - III

What The Driver Sees and Does

Trucks encompass a variety so large that we could write (though you might not read) about them for the next twenty years. But there are characteristics common to most trucks; it is these that this series of aricles is about. A good place to start examining a truck is in the CAB where the driver sits.

The driver's SEAT is a good example of the care required in truck design. It must be adjustable so that drivers of differing heights can operate all the controls with ease. It must have a contour that is comfortable, but not excessively so, otherwise the driver might fall asleep. It must have a suspension that isolates the driver from bumps and jerks on the road. Some seats even have a mechanism for adjusting the softness of the seat and the back rest, because ideas of comfort vary from driver to driver.

In front of the driver is the STEERING WHEEL, which is supported by the STEERING COLUMN. The steering wheel is connected by a shaft to the STEERING GEARBOX and thence, through the PITMAN ARM, the TIERODS and the STEERING KNUCKLE, to the front tyres. When the driver rotates the steering wheel, the tyres rotate about a vertical axis, and the truck makes a turn.

On the DASHBOARD in front of the driver is the IGNITION KEY, which he turns on. He then pulls the STARTER SWITCH. The STARTER MOTOR starts cranking the CRANK SHAFT through a small clutch and a RING GEAR. As the ENGINE is cranked, the FUEL INJECTION PUMP starts injecting fuel into the engine. After a few turns of the crankshaft, the air inside the CYLINDERS gets hot enough for the fuel to start burning, and the engine starts idling (i.e. rotating at a low speed) by itself.

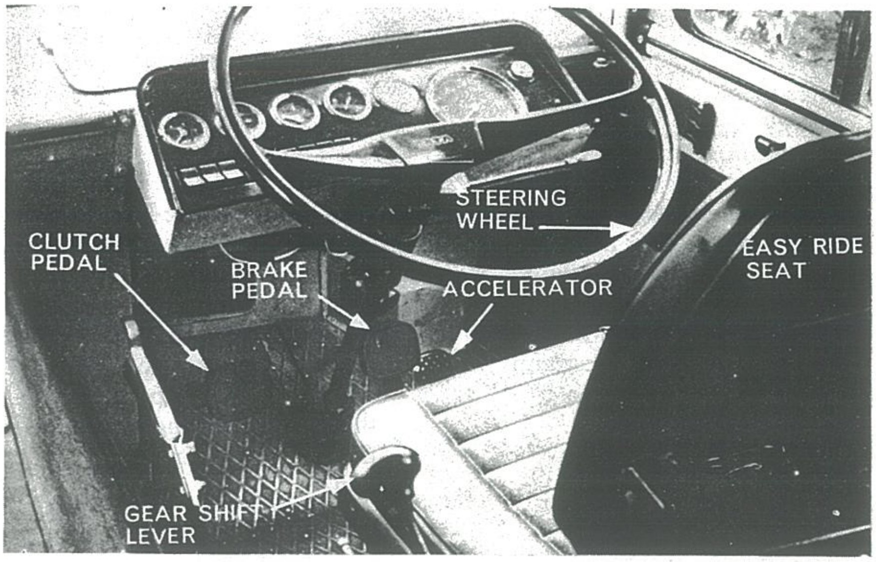
On the FIREWALL (which separates the driver and engine compartments) are three pedals. Near the driver's right foot are the ACCELETOR and BRAKE PEDALS. The accelerator pedal is connected to the fuel injection pump; when the pedal is depressed, the pump injects more fuel into the engine, which then develops more power. When the brake pedal is pressed, the BRAKES on the wheel are applied, thus slowing down the vehicle. In a truck, since it usually takes a lot of force to apply the brakes, the driver is helped by a compressed air system which adds to the force applied by the driver's foot. The brake and accelerator pedals are so positioned that they must both be operated by one foot, thus making it almost impossible to press both at once. Pressing both at once would simply make the brakes fight the engine: you would waste a lot of fuel in burning up your brakes.

Near the driver's left foot is the CLUTCH PEDAL. The clutch consists essentially of two steel plates with wear-resistant, high-friction linings riveted on to them. One plate is connected to the flywheel mounted on the crankshaft and rotates with the engine. The other is connected to the DRIVE SHAFT, which is the shaft going into the GEAR BOX. When the clutch pedal is not depressed, the two plates are pressed together by heavy springs, and they therefore rotate together. In this way, the gear box is connected to the engine. When the clutch pedal is depressed the clutch plates are separated, and the gear box and the engine are thus disconnected.

The GEARSHIFT LEVER is usually mounted on the floor of the cab, to the left of the driver. This lever enables the driver to "shift gears". Apart from the controls mentioned above, the driver also has to use a variety of other instruments; the headlights, the windscreen wipers, the handbrakes, the turn signal lights, the temperature, oil pressure and fuel gauges, and the speedometer.

You can imagine that designing the interior of a cab is no easy business. The driver must be comfortable; he must be able to see the road clearly; he must be able to operate all the controls and see all the gauges and dials easily; and there should be no possibility of his confusing the headlight switch (for example) with the windscreen washer switch.

We hope you now have an idea of some of the important parts of a truck, their names and their function.



Know Your Truck - IV

The heart of the matter?

In a poetic flight of fancy, an ERC engineer once remarked to some visitors that if an analogy were made between a truck and a man, then the engine would be the heart. A little reflection, however, suggests that an equation with the digestive system would be more apt. The basic function of the engine is to convert chemical energy into mechanical energy in a controlled fashion. The mechanical energy is then used to overcome various mechanical forces (friction, wind resistance, inertia) and thus propel the truck.

The basic food of the truck is the fuel it uses. Present day fuels are organic compounds with a high level of energy in their chemical bonds. These bonds are unstable at high temperatures, so that when the fuel is burned, the bonds break and release energy. This is the first stage of energy conversion: the energy now exists in a primitive mechanical state, with molecules flying around randomly at a higher velocity than previously. It is the task of the engine to convert this random energy into a more coherent form that can be easily tapped.

The science of Thermodynamics shows that there is a direct relation between the velocity of molecules in a **cylinder** and the temperature and pressure of the gas within it. Thus the burning of the fuel results in high temperature and pressure in the cylinder in which the fuel is burned. If one end of the cylinder is made movable, (in which case it would be called a **piston**), it would move because of the difference in pressure on its two faces — atmospheric on one, and high pressure due to combustion on the other. This is the second stage of energy conversion: conversion of thermal energy (the random motion of the molecules) into linear kinetic energy.

It is a sad fact of life that most earth-bound vehicles use wheels for propulsion. They require rotary kinetic energy. The third stage of energy conversion accomplishes the conversion of the linear kinetic energy of the piston to the rotary kinetic energy of the crankshaft. The mechanism used has been around for many centuries: the **crank** and **connecting rod.**

The requirements of energy conversion thus indicate the bare essentials of an engine: the fuel, the cylinder, the piston, the connecting rod and the crank. All the rest of what goes into an engine is aimed at three goals: first, improving the efficiency of energy conversion; second, decreasing the size of the engine for a given power (power is the rate of energy conversion); and last, improving the reliability of the engine.

The fundamental requirements for efficient energy conversion were stated by a Frenchman named Beau de Rochas as far back as 1862. They are:

1 The cylinder should have the smallest possible surface to volume ratio. This ensures that heat loss through the walls of the cylinder is minimised, so that as much thermal energy as possible is converted into mechanical energy.

2 The movement of the piston during the working (i.e. expansion) stroke should be as rapid as possible. This is also intended to minimise heat loss through the walls.

3 The expansion of the heated gases should be as large as possible. In this way, the efficiency of energy conversion is maximised.

4 The pressure at the start of the working stroke of the piston should be as high as possible. This, too, makes for a high efficiency of energy conversion.

When these principles are put into practice, due allowance is made for engineering feasibility and economy of production. Nevertheless, the principles do usually emerge unchanged. For example, **combustion chambers** tend to be hemi-spherical, and cylinders tend to have a length-to-diameter ratio of around one, thereby decreasing the surface-to-volume ratio. Further, modern engines are high speed, so that the piston movement is rapid. Next, there is an ongoing attempt to increase **compression ratios** as much as possible, thereby allowing maximum expansion of the gases. (The compression ratio is the volume of the cylinder when the piston has moved out as far as possible, divided by the volume when the piston has moved in as far as possible.) Finally, a great deal of attention is given to the timing of the burning of the fuel, so that the pressure at the beginning of the working stroke will be as high as possible.

Some of the requirements of a modern engine begin to emerge. It must have a system for delivering the correct amount of fuel and the correct amount of air (which is necessary for burning the fuel) at the correct time into the cylinder. Fuel delivery is regulated by the carburettor in the petrol engine; fuel delivery and timing are regulated by the **Fuel Injection Pump** in the diesel engine. Air delivery in both engines is regulated by **valves,** which are operated by a series of cams on a **camshaft.** The engine must have a lubrication system to minimise friction. High friction would result in both low efficiency and a high rate of wear. The engine must have a **cooling system** to keep temperatures in the cylinder low enough for engineering materials to be able to operate without loss of strength. Finally, the engine must have some controls so that a man can operate it with relative ease. The next few articles will go into these details.

Know Your Truck - V

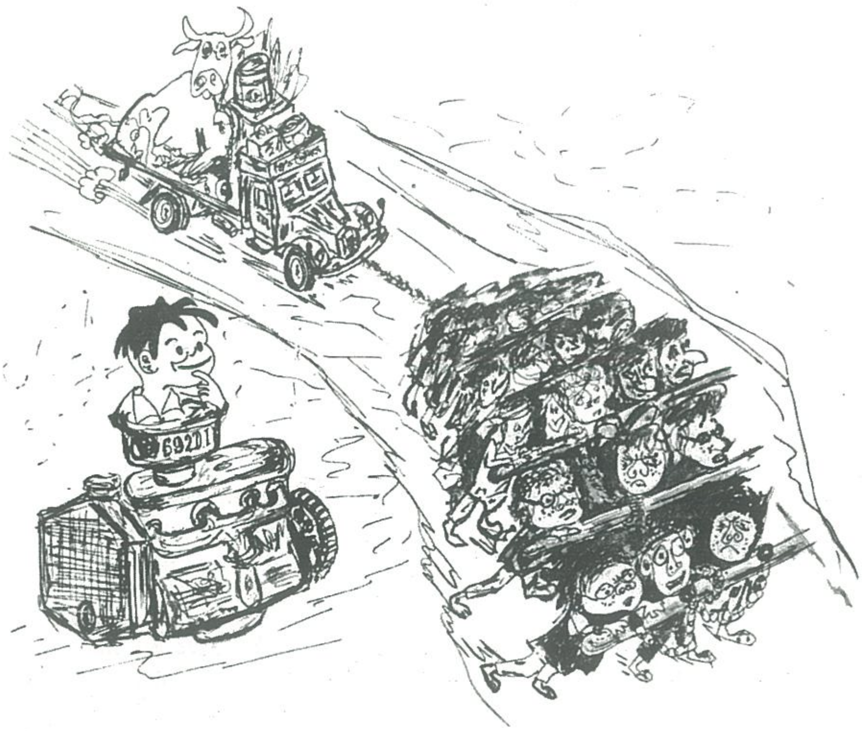
We were taking a stroll, enjoying the cool evening air of Poona, when we met a curious individual. He was short and rather plump, dark of complexion, heavy of build but with an exciting air of latent power about him. Overcoming our natural timidity, we walked over to him and addressed him with due courtesy, "What name do you go by sir?"

The answer was given in a throaty roar, "I am called SixninetytwoDI."

"Indeed!" we said. "A most charming name. Doubtless it has some significance?"

"I am an engine," (he said) "I have six cylinders, each 92 millimeters in diameter, with direct injection of fuel into my combustion chambers. That is how I get my name. Why six, you ask. Why not two? If you have studied your vibration theory, you will recall that 6 is a good number for getting a balance of power and keeping things smooth.

My ancestors were designed with two combustion chambers per cylinder. One was a "pre-combustion" chamber into which the fuel was injected. The fuel started burning there, created a high pressure, and caused a mixture of air and fuel to be injected at high velocity into the main combustion chamber. It was thought that as a result of this high velocity, the mixing of air and fuel would be good and combustion efficient. Also those engines were supposed to start well in cold weather.



The modern idea, however, is to inject the fuel directly into the main chamber and do away with the pre-combustion chamber entirely. This simplifies matters quite a bit; it also makes the engine more powerful and allows a 15% saving in the fuel consumption, So that explains my name. Now let me give you some statistics.

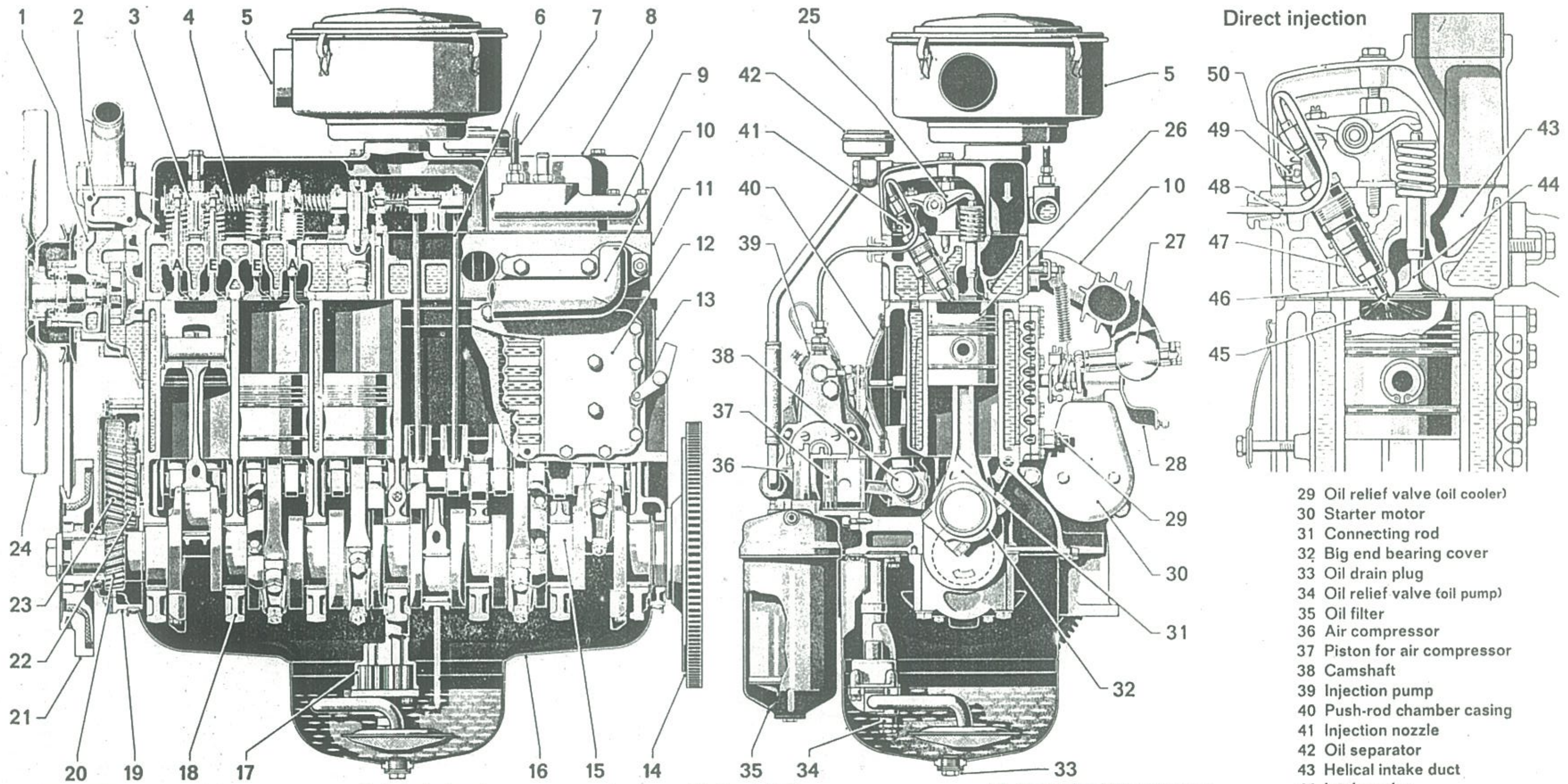
I weigh 382 kilogrammes. And I fit inside a rectangular space of 570 × 880 × 1044 mm. That is called my envelope. It is important that my envelope be as small as possible, so that I can arrange all my gadgets neatly under the hood with me. And I can develop as much as 110 horse power. A horse-power, by the way is what it takes to lift 75 kg at the rate of one metre every second. What's more, I weigh only 3.5 kgs for every horse-power, I develop. Did you know that I can pull a twelve-ton truck at 80 kilometers per hour on a flat road with power to spare! Or pull it up a gradient of 1 in 5 if necessary. All I need is a gear box and a rear axle.

When I am running at 1800 revolutions per minute, it takes me only 160 gms. of fuel per horse power per hour, if I am developing 60 horse-power. That works out to 11.6 litres per hour. I idle at about 650 rpm. And my governor does not allow me to go much faster than 2800 rpm., for fear that I should wear out fast and vibrate too much.

Did you know that I cost about Rs. 22,000 to buy? You might also be interested to know that it takes quite a few crores of rupees of investment just to make me. Superb modern technology, beautiful machines; expert quality control; the best production men. It takes years to design and develop my type of engine."

With that, he accelerated and roared off into the night.

Know Your Truck - VI OM 352



1 Water pump
2 Cooling water thermostat
3 Rocker arm support
4 Rocker shaft
5 Oil-bath air filter
6 Push rod
7 Cooling water tele-thermometer
8 Cylinder head cover
9 Cooling water manifold
10 Exhaust manifold
11 Cylinder head
12 Oil cooler with cover
13 Cylinder crankcase
14 Flywheel with starter ring gear
15 Crankshaft
16 Oil pan
17 Oil pump
18 Crankshaft bearing cover
19 Timing gear housing
20 Crankshaft gear
21 Vibration damper
22 Drive wheel (injection pump)
23 Camshaft gear
24 Fan
25 Rocker arm
26 Piston
27 Throttle flap (exhaust brake)
28 Lever for exhaust brake
29 Oil relief valve (oil cooler)
30 Starter motor
31 Connecting rod
32 Big end bearing cover
33 Oil drain plug
34 Oil relief valve (oil pump)
35 Oil filter
36 Air compressor
37 Piston for air compressor
38 Camshaft
39 Injection pump
40 Push-rod chamber casing
41 Injection nozzle
42 Oil separator
43 Helical intake duct
44 Intake valve
45 Piston head depression
46 Multihole nozzle
47 Protective sleeve
48 Fuel feed line
49 Leak oil line
50 Nozzle holder

Know Your Truck - VII

Crankshaft

The literal meaning of "Crankshaft" is a shaft with right angle bends (i.e. cranks). The crankshaft sits in bearings at the bottom of the engine. (See item 15 in the full-page diagram of last month). It is connected by connecting rods to the pistons. As the pistons oscillate, the crankshaft is forced to rotate.

Telco's engines all have six cylinders. Our crankshaft thus has six **crankpins;** these are offset cylinders to which the connecting rods are attached. Each crankpin is bordered by two **webs.** The webs are connected by crankshaft **main bearing journals.** These journals sit in bearings. There are seven main bearing journals in all. The crankshaft rotates about the axis of these journals.

The crankshaft is one of the most complex components in the truck. In Telco, Poona, we will start with a billet weighing about 85 Kg. This will then be transformed elsewhere into a forging weighing about 61 Kg. The forging will then pass through about Rs. 4 Crores worth of machinery, to emerge as a fully finished crankshaft weighing about 37 Kg.

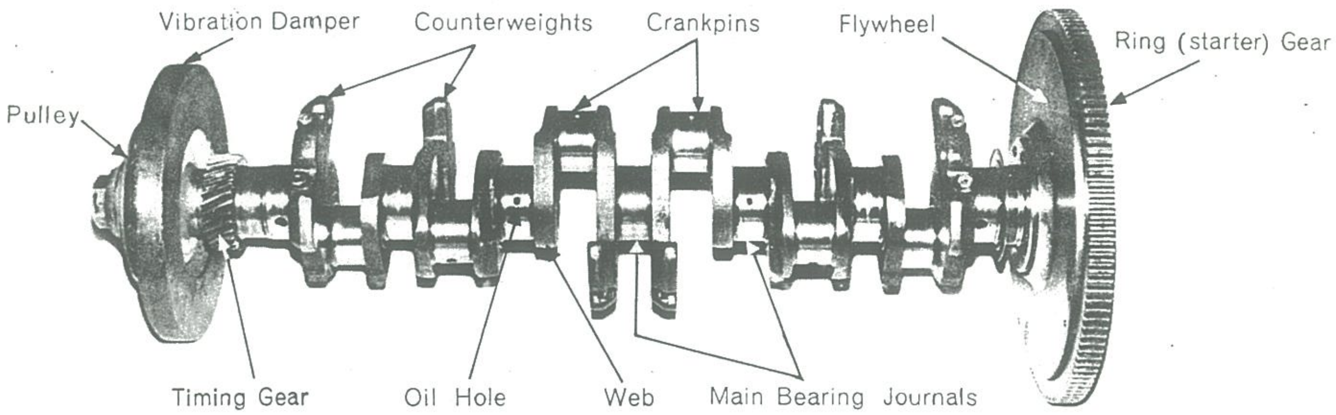
Practically every operation performed on the crankpins and main journals is a precision one. The diameters have to be controlled within 10 to 15 microns. The surface finish has to be excellent in order to ensure good lubrication. Telco, Poona's crankshafts, in addition, will have crankpins and main bearings ground to a slightly convex shape so as to ensure a good pressure distribution under load. The precision required can be appreciated when one considers the amount of convexity generated — around 0.002 mm !

Once the crankshaft is fully machined, it is balanced by mounting suitable **counterweights** on the webs. Let us look into the question of balancing in a little detail. If one ties a stone to a string and starts to whirl it around, a tension is generated in the string. If the stone is large enough, or the rate of rotation is high enough, the string might break. This clearly shows by analogy that if a shaft rotates about its axis, and if it has an eccentric mass attached to it, radial forces are created. If these radial forces are large enough, the bearings that support the shaft may be destroyed. In the case of the crankshaft, the eccentric masses are those of the connecting rods and pistons. The counterweights are selected in such a way as to just cancel out the effects of these eccentric masses.

The crankshaft is subjected to a series of impulses from the connecting rods, which cause it to twist to a certain extent. When these impulses occur at a certain rate (the rate depends on the rpm of the engine), the twisting can increase to such an extent that the crankshaft can even break. To counteract this, a **vibration damper** is attached to the front (radiator) end of the crankshaft. The vibration damper has a rubber element in it which helps to absorb the twisting vibrations by dissipating energy through internal friction. Analysis of these twisting vibrations and design of both the crankshaft and the vibration damper so as to reduce the amplitude of vibrations is a fine example of the application of modern engineering techniques in truck design.

At its front end, the crankshaft carries a gear through which it drives the Crankshaft and injection pump, as well as a pulley through which it drives the fan belt, alternator and water pump. At its rear (clutch) end, it carries a **flywheel,** which helps smooth out the impulses from the connecting rod by its inertia. On the periphery of the flywheel is a **ring (starter) gear,** through which the starter motor drives the crankshaft. Through the flywheel, the crankshaft is connected to the clutch and thus to the gearbox.

The crankshaft is the most expensive single component in our truck. The reason why is apparent. Starting with design and ending with manufacture, it is a technically sophisticated precision component.



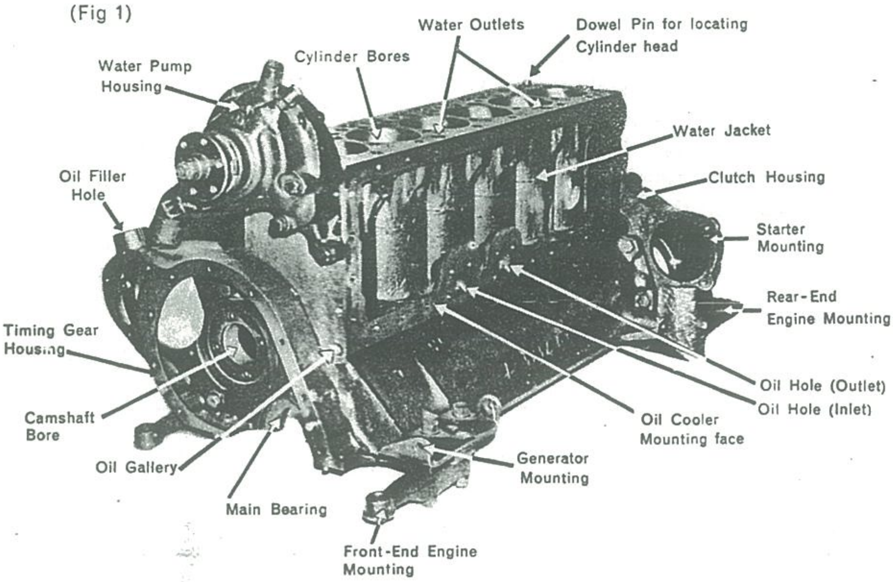
Know Your Truck Series Reprints Part II

Know Your Truck - VIII

CYLINDER BLOCK AND HEAD

The Cylinder block is the basic framework and the main container of the power of an engine. In it are produced the high pressure gases which push the pistons down and rotate the crankshaft. The Cylinder Block for our truck has six 92 mm bores, one behind the other, often referred to as in-line cylinders.

(Fig 1)



Engine Block (Fig 1) & Cylinder Head (Fig 2) alongwith some external parts of the engine.

These cylinders are surrounded by water jackets through which relatively cold water is circulated, thus preventing the heat generated during the combustion of diesel fuel from softening the block.

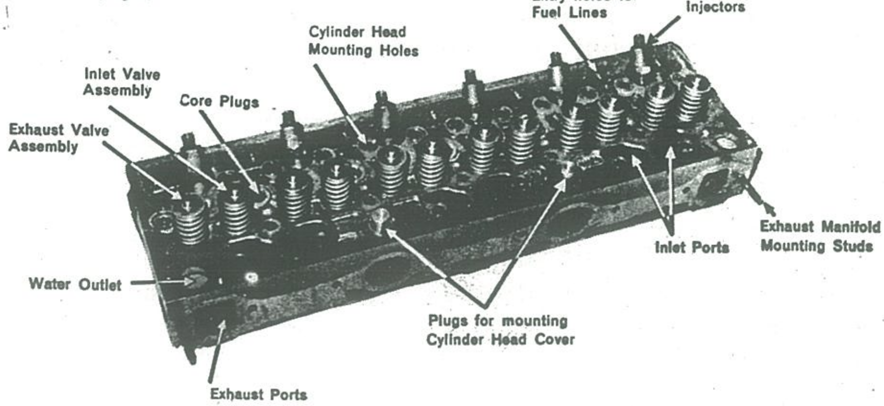
The manufacture of the cylinder block is a feat in itself. The production of the casting — the most massive of all the castings to be produced in our foundry — requires special care. There are about 15 different types of cores which have to be carefully assembled, and their shifting controlled to a minimum. Since it is a heavily cored casting a large quantity of gas is evolved during the pouring of the metal; this is released through special vents, thus preventing porosity of the block.

The numbers of machining operations too, are so incredibly large, that it is little wonder that we have to build special purpose machines and transfer lines to take care of the machining complexities. Some of the precision operations required are — accurate boring of the cylinders, with an ovality and a taper of not more than 10 microns (a micron is one-thousandth of a millimeter); and a special type of honing which produces a smooth cross-hatched pattern on the walls of the cylinders. This helps in maintaining an unbroken film of oil between the piston-rings and the cylinders, thereby reducing friction considerably. It is because of this that we can proudly claim an engine life of 2 lakh kilometres before the engine needs to be dismantled and the cylinders rebored to a slightly larger size. In this case we also recommend fitting slightly oversized pistons so as to match the new size of the cylinders. This makes the engine run as good as new. And remember, we have allowed for the reboring to be done upto two times, so as to allow a total life of around five lakh kilometers.

After having talked of the brawn, let us also pay due regard to the brain. That word is suggestive of something complicated in the head.

(Continued overleaf)

(Fig 2)



What we are referring to is the 'Cylinder Head', the most complicated casting our foundry at Poona will cast. The Cylinder Head sits on a gasket on top of the block and seals, with the help of valves, the pressure produced in the cylinder during the power stroke, yet allowing free flow of air during the intake and the exhaust strokes. The design of the cylinder head too, is quite complex. The transfer passages, especially for the inlet, have to be as large as possible to avoid excessive pressure losses. The inlet passage has also to provide a good rotational motion (called "swirl") to the incoming air, which increases the combustion efficiency. All this runs contrary to the need for a stiff uniform cylinder head. The passages for the cooling water have to be carefully designed as otherwise extremely high thermal stresses are set up due to a steep temperature gradient through the cylinder deck, from the combustion face to the cooling water. This could cause the cylinder head to crack. As a matter of fact, in most of the engines it is the cylinder head which imposes a limit to the maximum power output obtainable from the engine. The design is further complicated by the lack of any satisfactory data available to the designer. Little wonder that you will find so many test-rigs in our Engine Section at ERC, all helping develop better engines.

Machining the Cylinder Head is quite complicated, involving the most precise precision boring operation of the Valve Seats and Valve Guide Bores. We have 6 Transferlines for Cylinder Head Machining at our Works in Jamshedpur. Two of these Transferlines have been supplied by our Machine Tool Division.

692 D.I. ENGINE VITAL STATISTICS

1. Dimension : 1055-650-1107 mm (42-26-44 inches)
2. Dry Weight : 428 kg.
   (Please note that figures given in Know Your Truck No. 5 are incorrect).
3. Displaced volume : 4788 c.c.
4. No. of cylinders : 6.
5. Bore : 92 mm.
6. Stroke : 120 mm.
7. Power (DIN rating) : 112 PS at 2800 rpm.
8. Torque : 30 metre-kg. at 2000 rpm.
9. Firing order : 1-5-3-6-2-4.
10. Compression ratio : 17 : 1
11. Minimum specific fuel consumption : 170 grams per PS — hour.
12. No. of main bearings : 7 (Area per bearing : 55 sq.cm.).
13. Cooling system capacity : 20 litres.
14. Crankcase oil capacity : 14 litres max, 10 litres min.
15. Injection timing : 23° Before Top Dead Centre (TDC) at low speeds, increases to 31° before TDC through automatic centrifugal timer.

DIN and SAE ratings

These ratings describe the controlled conditions under which the power of an engine must be measured. Because the test conditions are standardised, power ratings, fuel consumption, etc. of different engines may be compared with a minimum of misunderstanding.

The DIN 70020 rating specifies an ambient atmospheric pressure of 760 mm of mercury and an ambient temperature of 20°C. Various accessories have to be driven by the engine, and the power measured is the net output of the engine at the end of the crankshaft.

The SAE 816a rating specifies an ambient atmospheric pressure of 746.2 mm of mercury, and an ambient temperature of 30°C. This rating measures the gross power output of the engine, part of which, in practice, will be utilised to drive the fan, generator etc.

The newer SAE 816b rating is similar to the DIN 70020 rating, in that it also measures net power output.

In case the standard atmospheric conditions prescribed by the ratings are not available, the ratings also give formulae depending on the actual air pressure and temperature for calculating the rated output form the measured output.

Know Your Truck - IX

PISTON, RINGS AND CONNECTING ROD

The word "Piston" derives from a Latin word meaning to pound or to beat. The name is apt; pistons take a terrific pounding and beating in the course of their daily work, which is to receive and transmit the explosive pressure in the combustion chamber to the crankshaft through the connecting rods.

Our pistons are hollow forgings made from a light-weight, high-strength aluminium-silicon alloy with small amounts of copper, nickel and magnesium to help improve strength, toughness, distortion control, corrosion resistance and heat transfer.

The design of pistons is no easy matter, for they operate in a particularly hostile environment: high combustion pressures, high temperatures, high inertia loads and relatively poor lubrication. The high temperatures lead to significant thermal expansion and distortion, despite which the piston and rings must seal the high pressure gases in the combustion chamber without seizing. High temperatures also lead to softening and weakening of the material, to counter which heat transfer paths have to be carefully designed.

The piston is slightly barrel shaped to help counter the varying amounts of thermal expansion from one section to another. In any one section, moreover, the piston is not circular when cold, but slightly elliptical. At a higher temperature, the expansion is not uniform in all directions, due to the presence of the gudgeon pin bosses inside the piston. The net effect is to make the piston circular at operating temperatures. The elliptical shape is achieved by cam turning or grinding. Despite their complex shape, the weights of the pistons in a set have to be controlled within ± 2% to ensure engine balance.

If the entire piston were in contact with the cylinder bore, it would seize. A small clearance is, therefore, maintained betwen the piston and the bore. This, however, could lead to leakage of gases and loss of power. This is where the piston rings enter.

Piston rings are made of cast iron, which has good thermal and lubrication properties. They fit into grooves near the top of the piston. Their size is such that they press against the cylinder bore with a controlled pressure. A slight gap is maintained between the ends of the rings so that they remain flexible. These gaps are staggered around the piston from one ring to the next to decrease gas leakage.

Our pistons have four rings each. The lowest is a chrome-plated oil control ring whose job it is to remove the oil from the cylinder walls and transfer it to the inside of the piston, from where it falls back into the sump. If the oil were left on the walls, it would burn due to the high temperature, leading to high oil consumption, sludging and pollution.

The next ring is a counterbored scraper with a twist such that on the downstroke, only one edge contacts the bore, giving an oil scraping action. On the upstroke, it sits more-or-less flush with the bore.

The top two rings are for compression control. The upper one of these is chrome-plated to prevent scuffing (metal-to-metal contact leading to scratches in the contacting surfaces).

Inside the piston are two bosses in which is a highly polished steel pin, called the gudgeon pin. The small end of the connecting rod goes over the gudgeon pin. Our gudgeon pin is of the "fully floating" type, which means that it can rotate relative to both the piston and the connecting rod. The gudgeon pin is not on the centre line of the piston, but is offset by a slight amount to counter a phenomenon known as "piston slap", which can lead to excessive noise and high wear rates. Piston slap results from a combination of gas pressure, piston inertia, connecting rod angle and piston/bore clearances.

Our latest attempts at design improvements in the areas mentioned above are the development of pistons with cast inserts, "keystone" compression rings and comformable oil rings.

Cast inserts are used to reduce wear in the ring grooves. The inserts are made of a hard nickel steel alloy. Wear occurs because of the constant motion of the rings in the grooves.

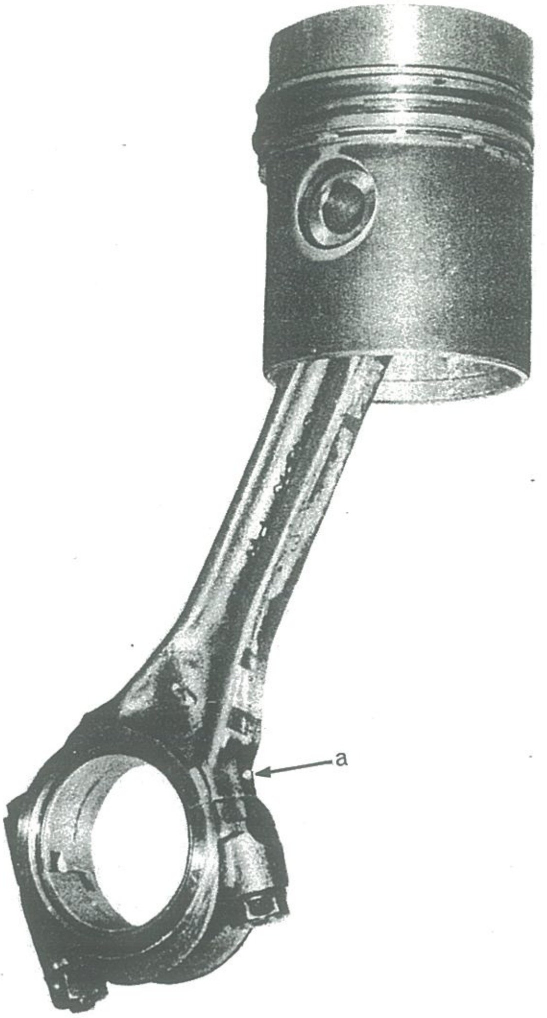
Keystone rings have a groove seating surface that is not perpendicular to the axis of the piston. This makes the ring tend to slide out, thus helping to stop ring sticking caused by the build-up of carbon deposits.

Conformable oil rings have a spring behind them that presses them against the cylinder bore so as to obtain a closer fit and a better oil control action.

The connecting rod is another highly stressed part; it is a steel forging. Its lower end is split to allow assembly onto the crankshaft. The spitting is done along an angle to the centre line of the rod, so that it can be introduced through the bore for assembly. In its small end, it carries a replaceable bearing bush, which has to be cooled in liquid nitrogen to facilitate assembly. In its lower (big) end, the "conrod" carries replaceable bearing shells. The bearing shells are again critical. Their important characteristics are fatigue strength, corrosion resistance, scoring resistance and embeddability — an index of their ability to absorb wear particles. These properties generally work against one another, and it is another of the fascinating tasks of engineering to choose the optimum material.

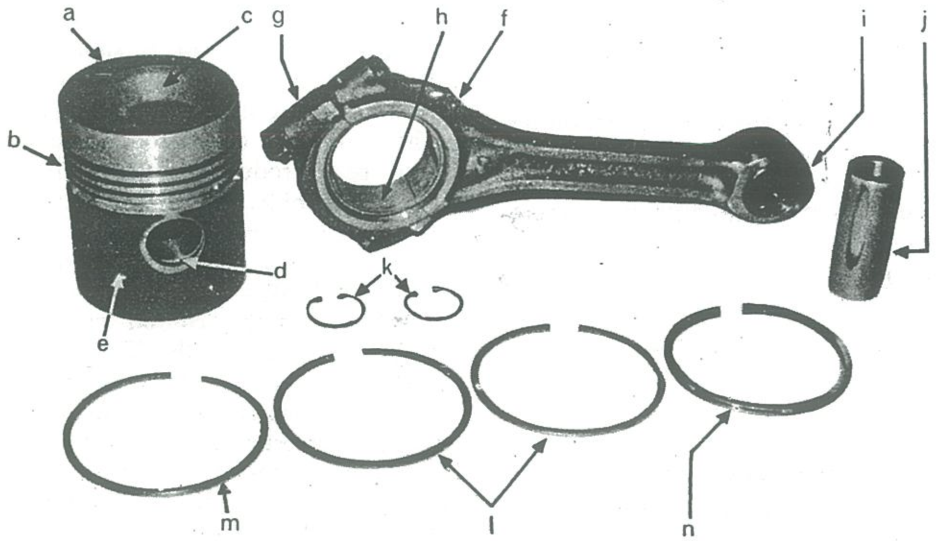
To maintain engine balance, the weight of the connecting rod also has to be maintained within tight limits – 20 gms for a set. This is done by grinding off small amounts of material from the elongated shank of the connecting rod.

*   *   *



ASSEMBLED VIEW

Assembly of piston, rings, gudgeon (piston) pin and connecting rod. There are six such assemblies in each engine. The pistons go into the bores of the cylinder block. The lower or big ends of the connecting rods encircle the crank-pins on the crankshaft. The hole at 'a' squirts an oil jet on to the cylinder walls and helps to lubricate the contact between the piston and rings and the cylinder wall. To facilitate assembly, the big end is split in such a way that the surface between the connecting rod and the big end cap is not perpendicular to the axis of the connecting rod.



DISASSEMBLED VIEW

(a) piston,
(b) piston ring grooves,
(c) combustion chamber, offset to suit the location of the injector,
(d) circlip grooves,
(e) skirt,
(f) connecting rod,
(g) big end cap,
(h) bearing shells,
(i) small end,
(j) gudgeon pin,
(k) circlips, for locating the gudgeon pin axially in the piston,
(l) compression rings,
(m) scraper ring,
(n) oil control ring.

Know Your Truck - X

To run an engine efficiently, you have to control its temperature, that is, prevent the heat generated during the combustion of the fuel from overheating the engine parts, breaking down the lubricating oil, and causing the engine to seize.

On an average 30 to 35% of the heat generated has to be dissipated by the cooling system. On our engine of 100 bhp, this amounts to about 60,000 K cals/hour, which is equivalent to boiling-off more than 110 kg. of water in an hour !

Let us look at the various items which constitute the cooling system and their function.

(i) Coolant.
(ii) Radiator, Jacket, Hoses, etc., through which the coolant flows.
(iii) Pump.
(iv) Fan.
(v) Thermostat.
(vi) Temperature indicator.

In our engine, water (with a small amount of anti-corrosive fluid) acts as a coolant, which by flowing through the jacket, cylinder head, etc. (see Know Your Truck VIII) picks up the heat and transfers it to the air via a radiator. The radiator is a device which holds a large volume of water in close contact with air, so that the heat will transfer from the water to the air. It consists of a number of long tubes, through which water flows. These are surrounded by fins made of copper, which is a good thermal conductor. The air passes around the outside of the tubes between the fins, absorbing heat from the water during the passing.

COOLING SYSTEM

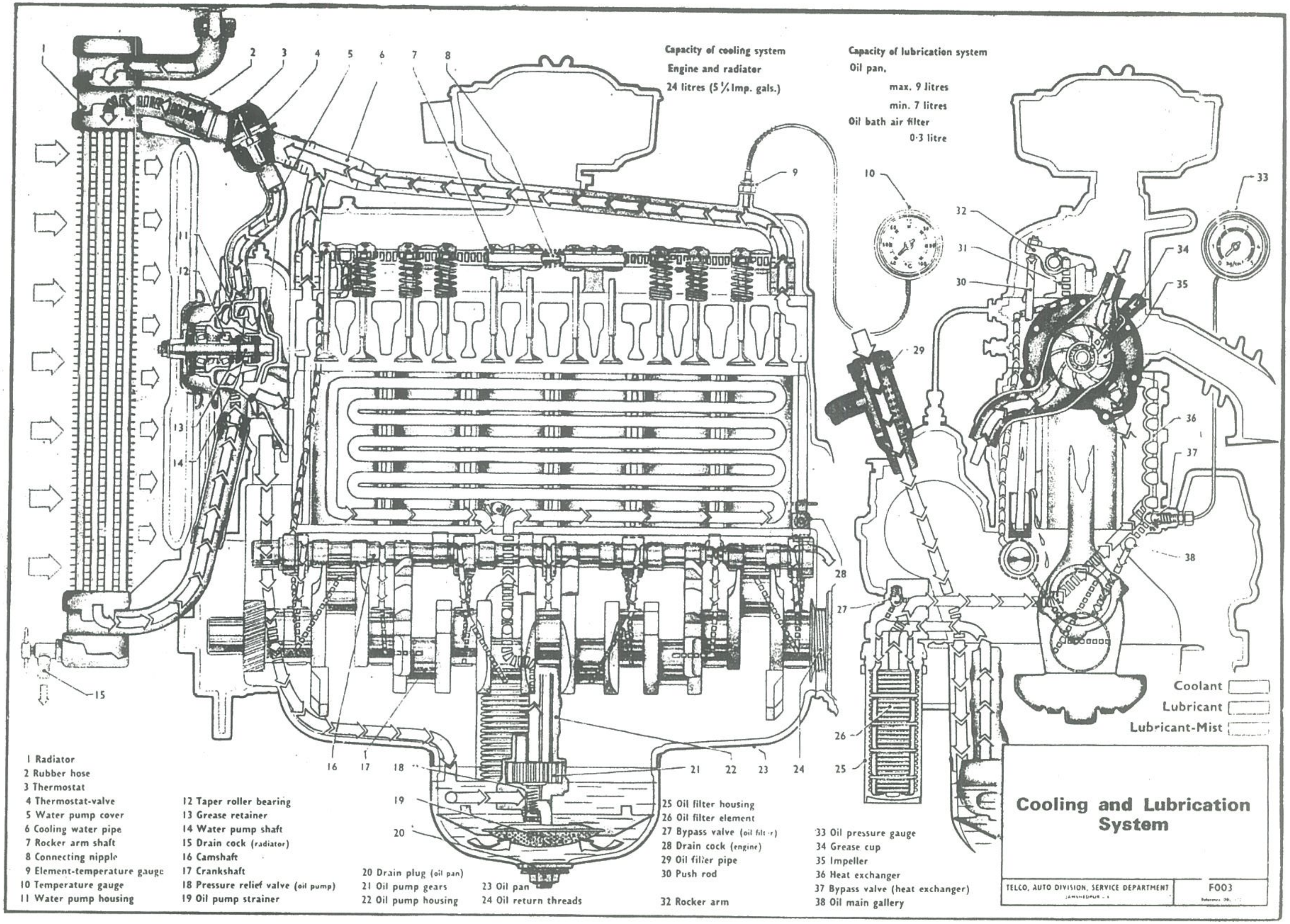
Since the water flows through narrow and intricate passages and encounters resistance, a pump has to be used. This pump is driven by a belt from the pulley mounted on the front end of the crankshaft, and it forces water through the cooling system. Also, as the engine moves faster, the pump circulates a larger amount of water, thereby keeping the rate of heat removed in proportion to the rate of heat generated.

The engine fan, mounted on the water pump shaft and driven by the same belt that drives the pump and the generator, does to the air what the pump does to the water. It provides a powerful draft of air through the radiator, thus enhancing the rate of heat removal. When the vehicle is moving forward, the grill allows a further draft of air through the radiator. On high RPM engines, to limit the power consumed by the fan, and the noise it makes, a fan with slightly flexible blades is used. With this design, the blades flatten out at high speed. The result is that each blade pushes less air and the power consumption and noise are controlled.

The thermostat introduces an additional element of sophistication for temperature control. It is generally placed in the water passage between the cylinder head and the top of the radiator. Its purpose is to close off this passage when the engine is cold so that water circulation is restricted and the engine reaches operating temperature more quickly. Then, when the engine reaches operating temperature, the thermostat valve begins to open and the water can circulate between the jacket and the radiator.

To further improve the efficiency of the cooling system, a spring-loaded radiator pressure cap is used. This concept is based on the fact that the higher the pressure, the higher the boiling point of water. Each additional pound/sq. inch of pressure increases the boiling point by 1.80°C. In our truck, the use of the radiator cap increases the pressure by 7½ pounds/sq. inch. The water may, therefore, be circulated at a temperature upto 113°C. without boiling. At higher pressures, the cap automatically opens and reduces the pressure in the system. The cap thus allows efficient vehicle operation even at high altitudes where the atmospheric pressure is low. With the water entering the radiator at a higher temperature, the difference in the temperature of water and air is greater, and heat is more readily removed from the radiator. The pressure cap also prevents loss of water caused by surging when the vehicle is quickly braked to a stop.

By now, hopefully, we are convinced that the engine cooling system is an indispensable system, and that a vehicle would not run for long if this system were to malfunction. It is, therefore, in the interest of the driver to maintain this system with care and while driving, give the telltale temperature indicator on the control panel its due attention.


Capacity of cooling system
Engine and radiator
24 litres (5 ¼ Imp. gals.)
Capacity of lubrication system
Oil pan,
max. 9 litres
min. 7 litres
Oil bath air filter
0·3 litre
Coolant
Lubricant
Lubricant-Mist
1 Radiator
2 Rubber hose
3 Thermostat
4 Thermostat-valve
5 Water pump cover
6 Cooling water pipe
7 Rocker arm shaft
8 Connecting nipple
9 Element-temperature gauge
10 Temperature gauge
11 Water pump housing
12 Taper roller bearing
13 Grease retainer
14 Water pump shaft
15 Drain cock (radiator)
16 Camshaft
17 Crankshaft
18 Pressure relief valve (oil pump)
19 Oil pump strainer
20 Drain plug (oil pan)
21 Oil pump gears
22 Oil pump housing
23 Oil pan
24 Oil return threads
25 Oil filter housing
26 Oil filter element
27 Bypass valve (oil filter)
28 Drain cock (engine)
29 Oil filler pipe
30 Push rod
32 Rocker arm
33 Oil pressure gauge
34 Grease cup
35 Impeller
36 Heat exchanger
37 Bypass valve (heat exchanger)
38 Oil main gallery
Cooling and Lubrication System
TELCO, AUTO DIVISION, SERVICE DEPARTMENT
F003

Know Your Truck - XI

ENGINE LUBRICATION

Not many of us would be willing to work under the conditions that the engine lubrication system encounters : too much pressure, lots of heat, dirty working conditions, conflicting expectations and not enough time in which to get the job done. But work it has to, and by-and-large does, except when it is confounded by human neglect.

The engine lubrication system has three primary functions : to lubricate metal interfaces so as to reduce friction and wear; to cool surfaces which get heated by friction or by hot gases; and to clean surfaces which get deposits built up on them. These requirements are often in direct conflict with each other. For example, to clean the engine, the oil must get dirty; to lubricate it, it must be very clean. The only solution is to have a good oil fixation system to remove the dirt continuously. Furthermore, to lubricate well, the oil must be reasonably thick; but to spread over a surface in a short period of time, it has to be thin. To cool the surfaces, it comes into contact with, it also has to be thin. Thus, the choice of a good engine oil involves a series of compromises, depending on the piston speed, the bearing loads, and the outside temperature.

The main areas that the engine oil has to cool are the cylinder walls, the pistons and rings (which reach temperatures as high as 550°C), and the several bearings throughout the engine. In other words, the oil has to cool those areas which cannot possibly be cooled by the water cooling system. The cooling load for the lubrication system usualy decides the quantity of oil in the system. The amount required for lubrication is very small by comparison.

Where does all the heat extracted by the oil go ? It is partly dissipated from the sump or oil pan. (Please see item 23 in the figure accompanying KNOW YOUR TRUCK X. In addition, the oil passes through a cast-iron heat exchanger, known as the oil cooler, bolted to one side of the engine (item 36). This Casting comes into contact with the cooling water, thus helping dissipate heat.

The most difficult areas to lubricate are the Crank Pin and Gudgeon Pin bearings. These are subjected to high and fast-fluctuating pressures, and high temperatures. Moreover, to reach the Crank Pin Bearings, the oil has to pass through narrow oil holes in the Crankshaft, which cause a great deal of resistance to flow. To generate enough pressure to overcome this resistance, an oil pump is used (items 21, 22). This is a positive action gear pump; the gears are driven by a shaft which, in turn, is driven by a gear on the Camshaft. Incidentally, the oil pump housing is one of the more difficult castings to produce.

Before the oil enters the oil pump, it has to pass through a strainer (item 19) in the sump, which removes dirt, sludge and the larger metal particles. From the pump, the oil goes to the oil filter (items 25, 26).

Oil filters are of two types : the full-flow type and the bypass type. In the full-flow type, which we are now thinking of changing to, all the oil from the pump passes through the filter before flowing to the bearings. The filtering element is usually a special paper, impregnated with resin to keep it from disintegrating in the presence of moisture, and pleated to increase its surface area. It removes particles down to a size of about 10 microns. (Smaller particles do not do much harm, and are removed when the engine oil is drained). To prevent bearing starvation (no oil) in case the filter gets clogged, there is always a bypass valve, either in the filter or in the cylinder block. As pressure builds up in the filter due to clogging, the spring-loaded bypass opens and allows unfiltered oil to flow to the bearings.

Other areas that the oil must lubricate are : the valve train, the camshaft bearings, the timing gears. The lubrication system is finely balanced to supply all of the various bearing parts with just the right amount of oil. What is important is the quantity as well as the quality. A high pump pressure does not guarantee that sufficient oil is available at all bearings, because dirt blocking a passage could nevertheless cause a bearing to starve. The life of the oil and the filter are thus things requiring strict control, and stretching recommended limits shortens the life of the engine. In India, this is one of the main areas of engine abuse.

SLUDGE

Sludge formation occurs mainly due to water being churned with oil. The water either condenses from the air used to ventilate the crankcase or from the combustion gases that leak past the pistons. Sludge formation is extremely harmful and must be countered by frequent oil changes. It is accelerated by short-distance trips, in which the engine never warms up enough to make the water evaporate.

ADDITIVES

Engine lubricating oils are at present, hydrocarbons. To improve their characteristics, a variety of additives are used :

(a) Viscosity-index improvers, which reduce viscosity changes as the oil temperature changes;
(b) Pour-point depressants which keep the oil flowing at lower temptratures;
(c) Oxidation inhibitors, which slow down certain chemical reactions;
(d) Corrosion inhibitors, which deter corrosion of metal surfaces by acids that may form;
(e) Rust inhibitors, which deter rust formation;
(f) Foam inhibitors, which deter foam formation due to churning of the oil in the sump;
(g) Detergent-dispersants, which help clean the engine, much like a soap;
(h) Extreme-pressure agents, which help lubricate areas under very high pressure, such as bearings, gears and valve trains.

VISCOSITY RATING

The Society of Automotive Engineers (SAE) rates oil in two different ways, for "Winter weather" and for other weather. Winter oils are tested for Viscosity at 15°C and at 100° C; there are three grades: SAE5W (thinnest) SAE10W and SAE20W (thickest). The "W" indicates winter grades. For other than winter use, the grades are SAE20, SAE30, SAE40 and SAE50. Some oils have multiple ratings; an SAE10W-30 oil, for example, is equivalent to SAE10W, SAE20W and SAE30 oils.

Know Your Truck - XII

ALL ABOUT FUEL

In a diesel engine fuel is injected into a charge of compressed and heated air and ignites spontaneously. Fuel is drawn by a pump from the fuel tank; it is compressed to an extremely high pressure in the Fuel Injection Pump (FIP) and an accurately metered quantity of it is squirted into the engine cylinders by the injection nozzles.

The fuel injection system on our 692 D.I. Engines comprises of the following items :

(1) Fuel Tank, (2) Feed Pump, (3) Filter, (4) Fuel Injection Pump (FIP), (5) Injectors, (6) Governor, (7) Injection Timer.

The fuel feed pump draws fuel from the fuel tank which is mounted on the longmember. It is operated by an eccentric on the Camshaft of the fuel injection pump. This camshaft, in turn, is driven by the valve camshaft through a pair of gears. The rotation of the eccentric pushes a plunger, which, in turn, pushes the fuel. A return spring pulls the plunger back. However, the amount of fuel delivered per stroke by this pump is far in excess of the requirements of the engine. Therefore, as excess fuel pressure builds up, it presses against the return spring and does not allow the plunger to go back and make contact with the spindle. The pumping action therefore stops. It is resumed the moment the excess fuel is depleted. This intermittent process thus allows the supply and demand of the fuel to match exactly and at the same time ensures a 'solid' column of fuel at the suction end of fuel injection pump.

The fuel from the feed-pump cannot be allowed to enter the high pressure FIP unless it is absolutely clean. To ensure this, a dual filter is used. This consists of two bowls, one with a cloth insert for preliminary filtration, the other with a paper insert for final filtration. It is worthwhile to remark that in a fuel injection system, the role of fuel filtration cannot be over-emphasised.

The precision of the parts used is so high (typical clearances are of the order of 2-5 microns) that the smallest of dirt particles can ruin the life and efficiency of the engine. If dirt particles escape past the filters, they either clog the injectors or find their way into the cylinders where their abrasive action can make the engine seize.

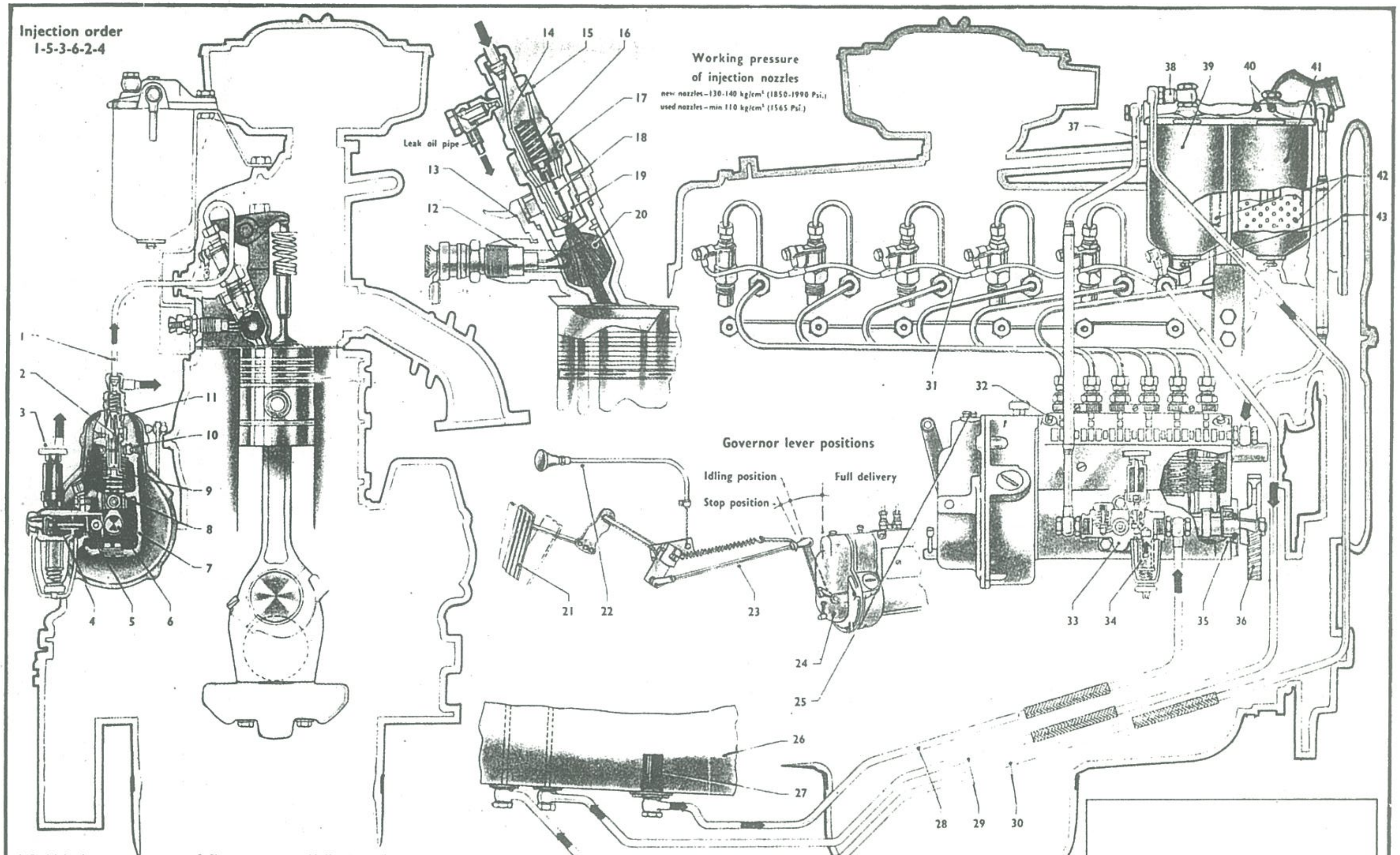
The function of the fuel injection pump is to supply the engine with fuel in quantities exactly metered in proportion to the amount of power required and timed with the utmost accuracy, so that the engine will run smoothly and deliver its output with the greatest economy. The FIP contains as many plungers as there are engine cylinders and each plunger element delivers fuel to the nozzle on one cylinder. Since an engine operates under varying combinations of load and speed, the optimum fuel requirement of the engine also varies greatly. These varying requirements are met as follows :

Even though the plunger stroke is constant and fixed, the effective or pumping stroke is varied by rotating the plunger in relation to the barrel. This is possible because there is a helical groove in the plunger which meets a "spill port" in the barrel. Relative rotation, therefore, allows the spilling of the fuel to occur at different points in the piston stroke, thereby varying the amount of fuel fed to the engine. The rotation of the plungers is caused by depressing the accelerator pedal.

The governor used on our vehicle is called a variable speed governor. This means that once the driver has selected a particular engine speed by depressing the accelerator pedal suitably, the governor will not allow the speed to fluctuate by more than a small amount between full load and no-load. This facilitates comfortable driving, as any variation in the gradient of the road is taken care of automatically and the driver does not have to move his foot. The governor also guards against idling instability arising from the metering of very small quantities of fuel and limits inertia stresses that arise from sudden acceleration of massive moving parts.

The injector consists of a nozzle valve and a nozzle body. The nozzle valve takes the form of a needle accurately lapped into the nozzle body to the closest fit within which it will work freely. When fuel from the FIP is fed to the mouth of the nozzle at high pressure, it lifts the nozzle needle against the pressure of a spring, permitting the fuel to be injected through four tiny holes in the nozzle directly into the combustion chamber.

Fuel when injected into the hot air charge in the cylinders, does not ignite instantaneously. There is a small delay period during which the fine particles of fuel first get sufficiently heated for self-ignition and then the pressure rise takes place as the combustion of the fuel occurs at a rate dependent on the temperature and the speed at which the fuel finds oxygen for combustion. For economy, we want the maximum pressure to occur just after the piston has reached the top dead centre (TDC — the topmost position of the piston) on the compression stroke; therefore the fuel has to be injected some time before the piston reaches TDC. This injection advance is more or less constant in terms of time, and thus varies with respect to the position of the piston as the engine rpm varies. It is for this reason that we have a sensitive centrifugal timer which can vary the point of fuel injection as required.



1 Fuel injection pressure pipe
2 Plunger: injection pump
3 Hand primer: feed pump
4 Plunger: feed pump
5 Roller tappet: feed pump
6 Camshaft
7 Injection pump housing
8 Roller tappet: injection pump
9 Sleeve
10 Control Rod
11 Delivery valve
12 Glow plug
13 Cyl. head
14 Fuel passage
15 Banjo union
16 Pressure spring
17 Nozzle holder
18 Nozzle needle
19 Nozzle body
20 Pre-combustion chamber
21 Accelerator pedal
22 Engine idling control
23 Governor linkage
24 Governor (injection pump)
25 Governor flap oiler
26 Fuel tank
27 Fuel tank strainer
28 Fuel suction pipe
29 Fuel return pipe (Leak oil)
30 Fuel overflow pipe
31 Leak oil pipe
32 Bleeding screws
33 Fuel feed pump
34 Prefilter
35 Ball bearing
36 Driven gear
37 Fuel delivery pipe
38 Overflow valve
39 Fuel filter, primary
40 Bleeding screws
41 Fuel filter, secondary
42 Fuel filter elements
43 Drair plugs

Fuel System

TELCO, AUTO DIVISION, SERVICE DEPARTMENT | F 004

Know Your Truck - XIII

THE ELECTRICAL SYSTEM

The electrical system of the vehicle functions by converting a part of the mechanical output of the engine to electrical energy and supplying it to various electrical systems (headlight, starter, horn, etc.).

The electrical system is required to operate unfailingly for very long periods, with meagre attention, and under widely varying climatic conditions. Therefore, its duty is very exacting, thus necessitating intricate design for high reliability.

The system can be broadly classified into following areas: (1) Generation, (2) Regulation, (3) Distribution, (4) Storage, (5) Starting, (6) Lighting & (7) Accessories.

Conversion of mechanical energy to electrical energy is done by a dynamo which consists of an armature wound with coils of wire and rotated by means of a belt drive from the crankshaft. The armature rotates between magnetic poles formed by the field windings on stationary yokes. The rotation of the armature in the magnetic field induces a voltage in the armature windings. This voltage is made available at two terminals through the commutator and contact brushes. In this manner mechanical energy is converted into electrical energy when the engine is running.

In order that the energy be available when the engine is stationary, a secondary source of supply in the form of a battery is provided. This battery may be likened to a storage tank.

With the engine running, the voltage produced by the dynamo causes a current to flow into the battery which charges the battery by an electro-mechanical conversion process. The dynamo voltage increases with increase in speed of the engine, while the battery voltage remains substantially constant. The required voltage matching is done by the regulator. The regulator automatically opens the dynamo-battery circuit when the dynamo voltage falls below that of the battery, and closes the circuit when the dynamo voltage is a little higher than the battery voltage. The operation of this cut-out switch (Regulator) is effected magnetically. The cut-out also limits the voltage and current output to the specified values.

The distribution of electrical energy is done by an earthed or single pole system in which the return path is provided through the vehicle frame. In our vehicle the negative terminal is connected to the chassis.

The engine is started with the help of a starter motor. Its function is to rotate the crankshaft at a sufficiently high speed to produce combustion of the charge inside the cylinders. This speed is normally of the order of 100 rpm. Under severe conditions of cold and humidity, and when the engine has been standing for a long time, the effort required for turning the crankshaft will be higher and it will have to be rotated at a much higher speed for starting the engine. Therefore the power output of the starter motor for a given engine is decided by the extreme conditions that the engine is likely to encounter but its size is limited by space availability. The starter motor is fixed on the cylinder block in such a way that the pinion on the end of the motor shaft engages with the flywheel gear when the starter switch is closed. The limitation on the size of the motor necessitates a high gear reduction between the starter and the crankshaft, so as to increase the cranking torque to an adequate level.

Among the various electrical systems, the headlights are of great importance. Good road illumination with strong and uniformly distributed beam is provided upto 200 yards in front of the vehicle, the limit of visibility being considerably greater than the braking distance at high speed. It is also essential to have several warning and signalling devices, such as horns, flashers, brake lights, parking lights, gauges or lights indicating the proper functioning of various engine systems, windscreen wipers, windscreen washer etc. These aggregates are also operated by the electrical energy produced by the system.

There is an increasing emphasis these days on the substitution of electronic solid-state systems for electro-mechanical systems with moving parts which are often sluggish and unreliable. Horns, flashers, and guages are good examples of units where such improvements are in the works. For ease of making connections, the fuse box can be replaced by a printed circuit board. Another possibility is the replacement of the dynamo by an alternator for the generation of electricity; this has the following advantages:

(a) the alternator can work at higher speeds than the dynamo.

(b) it is lighter and more compact and robust in its construction, permitting better utilisation of the space availability for increased output.

(c) Higher output even at low engine speeds. This is of particular interest in the case of bus applications wherein operation at near idling speed is quite considerable.

(d) Inherent self regulation of maximum current at high speeds.

However, the major disadvantage of an alternator is its high maintenance cost and the need to train service personnel in the use of solid-state devices.

In automobiles, copper cables are exclusively used because of their ease of soldering and good joint reliability, and have been the standard practice for battery cables. Jumper cables, however, were frequently aluminium. The use of aluminium cables posed problems on account of soldering problems (to the brass lug), poor joint efficiency and galvanise corrosion of the joint. The substitution is, however, important from the point of view of reducing the use of imported copper. Telco has achieved a remarkable breakthrough and successfully replaced the copper cables by flash butt welded aluminium cables, using an ingeneous zinc base alloy connector which is as easily solderable to the conventional Brass lugs as copper, and ensures good joint strength and reliability and corrosion protection of the joint. It is found that the voltage drop is lower than that across copper cables due to higher joint efficiency, and the temperature rise too, is appreciably lower.

Know Your Truck - XIV

ALL ABOUT MR CLUTCH

"And where would your good friend Mr ENGINE go if it were not for me !", a small voice quipped feeling very neglected.

We looked down and saw a small, compact and rotund gentleman smiling up at us.

"And whom do we have the honour of addressing ?" we asked him politely.

"I am called Twoeighty Dia Clutch".

"But surely, Sir, you are not serious when you say that Mr ENGINE cannot do without you."

"No, my dear human, it wasn't a tall claim. Mr ENGINE can surely work without me, but his mobility would be nil. He wouldn't be able to move about. I help in transferring the mechanical energy that he generates to his legs — the wheels."

"But, how do you achieve this," we chimed in unison.

"Pardon us, Sir, but you look so small and.....well.....vulnerable."

"Do not let my size deceive you," he chuckled.

"Even though I weigh only 11.5 kgs — my girth being 330 mm and my height 75 mm — you human design engineers have made each one of my 30 odd components count. Why — even this beautiful brass impregnated Asbestos coat that I am wearing today plays a very important role in Mr ENGINE'S transmission of power."

"No ! Not really Mr Clutch !" we replied amazed.

"Yes Sir ! You see my anatomy can be roughly split up into two distinct zones — The Clutch Disc and the Pressure Plate. This beautiful coat of mine is rivetted on to the Clutch Disc. Normally, the nine springs distributed evenly around the periphery of the pressure plates jam the Clutch Disc and hence the coat, on to the flywheel which is mounted on the crankshaft of Mr ENGINE. Therefore....."

"You mean to say, Sir, that when the crankshaft revolves, due to the frictional forces between the flywheel and your coat your clutch disc revolves also," we cut in excitedly, beginning to understand this litlle Muhammad Ali.

"Exactly, and because the clutch disc is itself mounted on the gear box drive shaft, the engine power is transmitted to the gear box, from where, through a combination of gears, it is transferred to the wheel."

Now, suppose I did not exist what would happen ? You humans would climb into the cab of your truck and start the ignition. Nothing would happen, the engine just wouldn't start. But if I existed, all you would have to do is to press the clutch pedal mounted in the cab thereby through a system of levers removing the pressure on my coat and making the flywheel free to revolve. After the ignition, when the engine now begins to growl uniformly, slowly releasing the clutch pedal would again engage the gears and the truck would now start moving slowly, picking up speed as the accelerator is pressed and the clutch pedal released completely.

Releasing the clutch pedal actually jams the pressure plates with a thrust load of 690 kg on to my coat which is forced on to the flywheel."

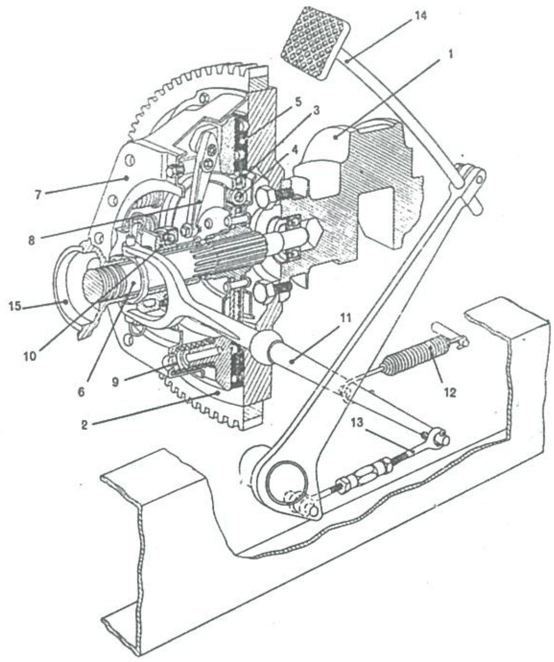
"But your coat, Sir, wouldn't it burn out if it is jammed on to a running flywheel in this fashion ?"

"It is made up of high heat resisting material. It generally lasts me for 70,000 kms. Now, if you know your solid mechanics well you would be curious to know how the shock of sudden contact with the flywheel is absorbed. Seven springs mounted between the coat and the clutch disc act as dampers and dampen this sudden shock for me whenever I am engaged suddenly with the flywheel.

"It is getting late," Mr Clutch yawned at us.

"Where do you stay ?" we asked him.

"I am housed next to Mr ENGINE. I have a circular disc shaped Cast Iron Cabin all to myself just behind Mr Engine's house. I am not made here you know. I am purchased for every truck of yours. The MRTP act enforced by our Government forces you truck people to purchase me from ancilliary industries. I must be going now or else the poor Engine would be stranded too long." With that Mr Clutch slipped away into the night !



1. Crankshaft, 2. Flywheel with Ring Gear, 3. Clutch Disc with Lining, 4. Damper Springs, 5. Clutch Lining, 6. Gear Box Drive Shaft, 7. Protective Housing (Pressure Plate Assy.), 8. Release Lever, 9. Pressure Springs, 10. Clutch Release Bearing with Sleeve, 11. Release Yoke, 12. Return Spring, 13. Linkage, 14. Clutch Pedal, 15. Gear Box Front Cover.

Know Your Truck - XV

MORE ABOUT MR CLUTCH

Having understood the basic construction of a clutch assembly, it is worthwhile to know more about some of the requirements and functoins of the individual components.

To begin with, anybody who looks at a clutch, is immediately attracted by the asbestos coat or the so-called clutch lining.

The function of clutch linings is to provide a friction surface for the transmission of power from the engine to the gear box and thence to the wheels. Part of this energy is converted to heat whereas the bulk is converted into useful work. The heat generation is higher at the beginning of clutch engagement, diminishing to zero at the point of engagement.

It is therefore required, that the lining should have high resistance to heat and excellent wear characteristics. As the heat generation is higher at the beginning, the engagement should be quick which means the lining should have high coefficient of friction.

These properties are generally provided by asbestos. This is impregnated with brass powder. The structure is generally of moulded type or woven type, and the former is preferred (which is used in our trucks today).

To increase the wear life of the lining small leaf springs, called cushion springs, are provided between the linings, along the circular face so that the pressure plate forces is applied uniformly and gradually.

The pressure plate assembly consists of two major parts, viz. the pressure plate and the sheet metal cover. The pressure plate is a grey iron casting with sufficient mass to absorb and conduct away the heat generated during the engagement cycle. It is rigid and should provide uniform pressure on the disc assembly.

The sheet metal cover is generally a pressing or in some cases is a casting and must be rigid enough, not to deflect excessively.

The thrust springs are located between the pressure plate and the sheet metal cover to provide the thrust force.

The pressure plate carries release levers which move the pressure plate in the sheet metal cover for engaging and disengaging.

Introduction to the family of Mr Clutch

So far we have been talking to Mr Clutch who is of friction type and operates in dry conditions. It will be interesting to get introduced to his family which consists of different characters.

Firstly, we have, the **multiple disc clutch,** consisting of two or more such single discs. This has an increased torque capacity which is more advantageous in static or low speed applications where high static torque is required.

Then there is the simplest type of of clutch, the positive contact clutch, where the engaging surfaces interlock to form a rigid junction. This can be of either the square-jaw or the tooth type.

There is also the **overrunning** or **free wheeling clutch,** where the driving and the driven members are coupled by the elastic tension of an intermediate member like roller, sprag etc.

We also see the **Magnetic clutch** which employs magnetic flux to couple the clutch members.

Instead of operating 'dry', the clutch operates in 'wet' conditions where entry of oil from bearings or other parts is difficult to be sealed completely. Sometimes oil is circulated to dissipate the heat. These are known as 'wet type clutches'. Wet clutch does not mean that it operates immersed in oil but is designed for use in contact with oil

A variation of this type of clutch is the **fluid coupling.** This is generally used in conjunction with a mechanical clutch. This consists of an impeller, and a rotor or turbine in a housing partially filled with oil. There is always a slip when torque is developed by circulation of oil between the members. There is, however, no multiplication of torque.

For such applications where a torque multiplication is required like in our excavator applications, we have a **Torque Converter** which consists of a third reaction member for this purpose.

You have not met all the members of the clutch family. There are infinite types and variations of a normal clutch which could provide interesting reading.

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