

**ANALYSIS A 5HP ENGINE
PERFORMANCES FOR GO KART**

TAN TANG CHIN



**Universiti Malaysia Sarawak
2002**

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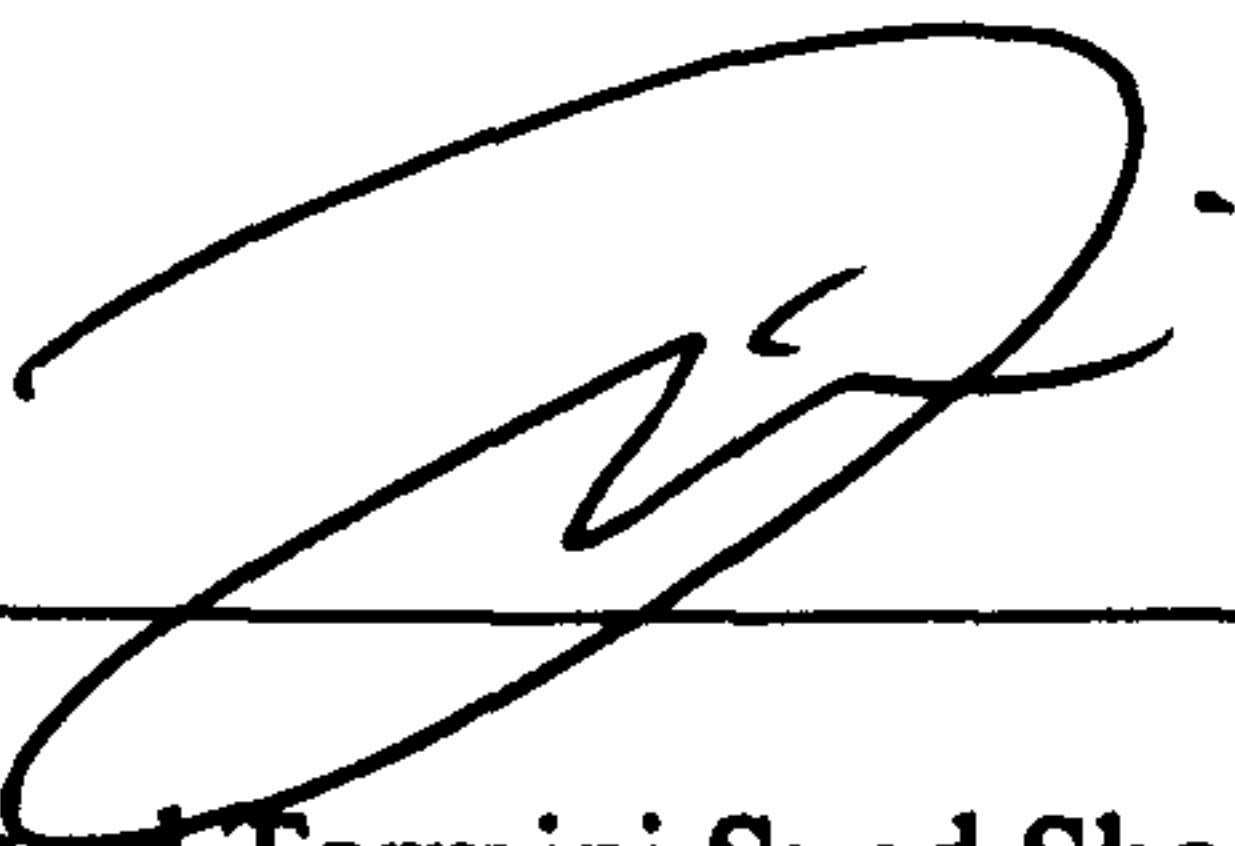
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ANALYSIS A 5HP ENGINE PERFORMANCES FOR GO KART

BY

TAN TANG CHIN

**Thesis Submitted to the Faculty of Engineering,
Universiti Malaysia Sarawak
As a partial Fulfillment of the Requirement for the Degree
of Bachelor of Engineering with Honours
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Abstract

Engine is a magnificent device whether in powering vehicle or generating electricity. This paper is about analyzing of a 5hp engine performances that used for go kart project that have been conducted by the author and associates.

The engine selected, Robin EY20, is a 5 horsepower four-cycle horizontal shaft gasoline engine. A chain drive system and centrifugal clutch is design as the transmissions unit. The detail information on the operation and parts function of EY 20 are include in second chapter.

Two experiments were carried out to verify the overall output power of the go kart and the actual air fuel ratio (A/F ratio). The overall output power of the go kart can be determine by speeding the go kart within a measured distances, where the author has choose 100m in this experiment. By this method, velocity, acceleration, force and also the total horsepower of the go kart can be clarified. While the actual A/F ratio experiment can be performed by a set of equipment, such as tachometer, exhaust gas analyzer and others, which will discuss further in the report. This experiment provides the detail on characteristic and performances of the engine.

The final chapter concludes the project achievement and recommendations are given which served as further improvement on the engine performances and efficiency.

Abstrak

Enjin merupakan satu alatan unggul mahupun dalam membekalkan kuasa kepada kenderaan atau menjana kuasa elektrik. Hasil kerja ini adalah mengenai analisis perestasi sebuah enjin 5 kuasa kuda yang digunakan dalam projek go kart, yang telah dilaksanakan oleh penulis dan rakan-rakan kerjanya.

Enjin yang dipilih, Robin EY20, merupakan sebuah enjin petrol empat lejang beraci mendatar yang mempunyai 5 kuasa kuda. Satu system berpandu rantai dan pencekam berdaya empar telah direka dan digunakan sebagai system penghantaran. Maklumat yang lebih jelas tentang operasi dan fungsi bahagian-bahagian bagi EY20 disertakan pada bab kedua.

Dua ujikaji telah dilaksanakan dengan bertujuan untuk memperolehi kuasa keluaran seluruhan bagi go kart dan nisbah udara dan bahan api (A/F ratio) yang sebenarnya. Kuasa keluaran seluruhan bagi go kart tersebut boleh diketahui dengan memecutkan go kart tersebut dalam suatu jarak yang diketahui, dalam experiment ini, penulis telah memilih 100m. dengan cara ini, halaju, pecutan, daya dan juga kuasa kuda seluruhan boleh dikenalpastikan. Manakala, ujikaji bagi menentukan dengan peralatan seperti tachometer, penganalisis gas ekzos dan sebagainya, di mana akan dibincangkan dengan lebih lanjutnya pada laporan ini. Ujikaji ini memberi makluman tentang keadaan dan perestasi enjin tersebut.

Bab terakhir memberi rumusan terhadap pencapaian projek dan cadangan-cadangan diberi sebagai tujuan bagi rujukan serta pembetulan yang dapat dilakukan pada masa hadapan.

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1 Introduction

Go kart racing is a cheaper and affordable way of motor racing by many people. One of the benefit that can be obtained from go-kart racing is that driver can start early, as young as the age of 5 or 6 years old, where this is the most suitable period for them to gain experience to be a professional driver when they grow up. Go-kart racing is also known as the high school for higher standard of racing championship title such as Formula One (F1) and other. When referring to famous driver such as Prost, Schumacher, Trulli, Verstappen, Fisichella and others, without forgetting the late Ayrton Senna (twice vice - world champion of go karting) has proven that go-kart is a tremendous school to produce driver of high-level performance.

1.1 Definition of a Kart

By definition of International Karting Commission – Federation International Automobile (CIK-FIA), a kart is defined as *a land vehicle with or without bodywork, with 4 non-aligned wheels in contact with the ground, two of which control the steering while the other*

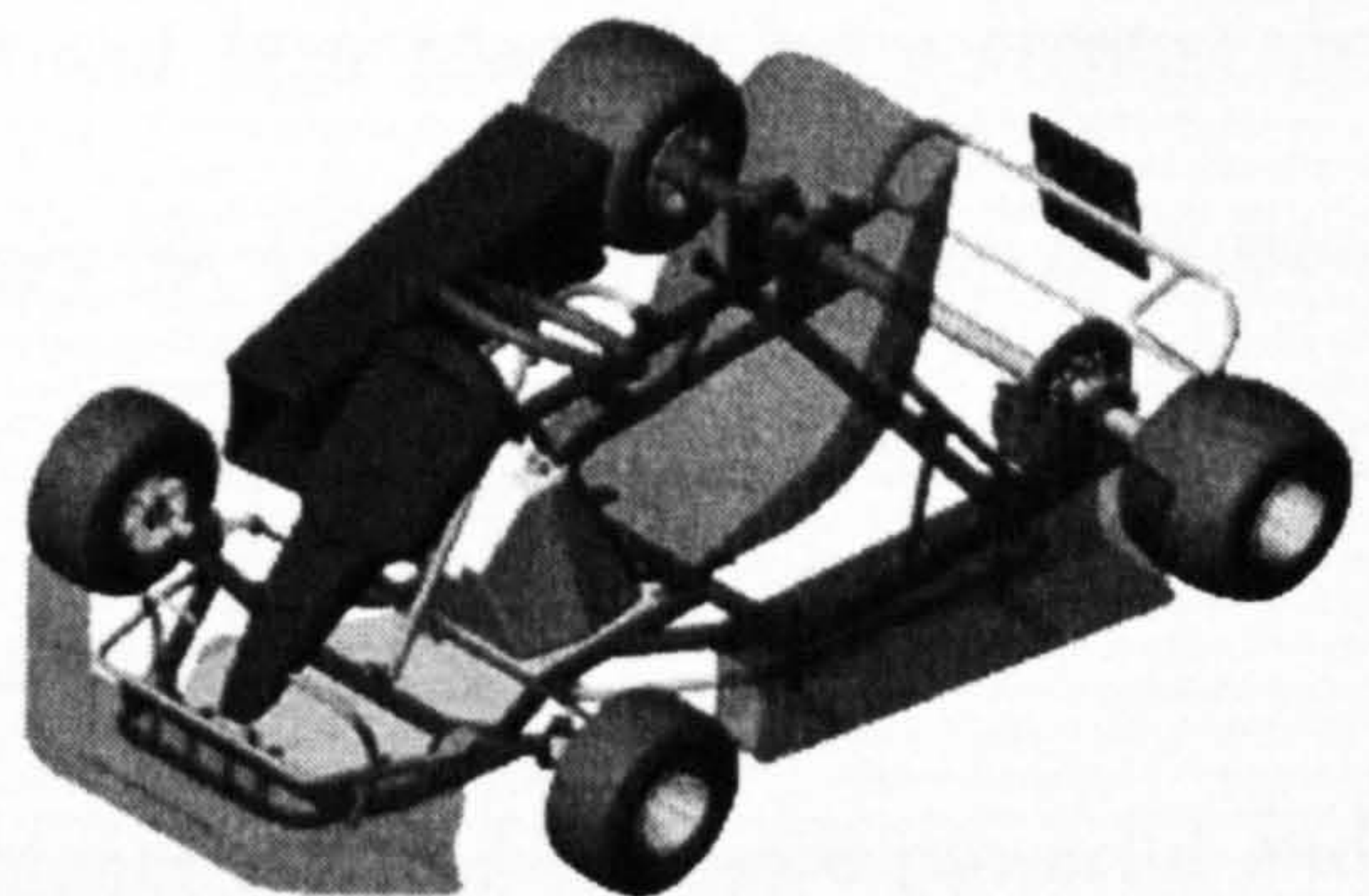


Figure 1.1-0 An example of go kart assembly
(Courtesy of www.4cycle.com, 1999)

two transmit the power. Its main parts are the chassis (which consists of a body frame work that are made out of a set of bent steel pipes that are welded together) with an engine, four wheels and tires attached to it. (www.fia.com - 2001 Karting Technical Regulations)

1.2 Go Kart Engine Development

Engine is the heart of a go kart where it produces power to move the kart. There was no right engine for go kart in the early time. People used modified small engines, which were used in lawn mowers, bush cutters, generators and others, as the kart engine. In America, three pioneers in go kart racing, Don Boberick, Art Ingles and Duffy Livingstone, have started up a go kart race at Rose Bowl in Pasadena, California in 1957. Roy Desbrow, a business partner of Duffy Livingstone, had constructed a kart called the "Drone", which it was powered by a 250cc engine originally used in an U.S. Army radio controlled drone airplane.



Figure 1.2-0 Don Boberick with Rathmann Xterminator prototype kart (Courtesy of <http://www.vintagekarts.com>, 2000)

In France go karting was started in 1959 and Jean Marie Balestre created the National Grouping of Go-carting (GNK) in February 29, 1960. Iame Company produced the first true engine of a go-cart called "Parilla" in 1959. Iame is also the builder of Komet K55 used in promotional category in 12 countries.

As go kart sports became more popular, higher demand for more powerful and high performance engines for racing purposes. These engines are able to produce higher output and engine speed, up to 10,000 – 16,000 RPM. Engine manufacturers, such as Yamaha, Honda, Kawasaki, Kohler, Tecumseh, Briggs & Stratton and others, are among the well-known go kart's engine builders.

1.3 Project Objectives and Aims

With conjunction of go kart project proposed by the author and associates, the author has been assign on analysing the performance of the selected engine, a 183cc (side valve, 4 stroke) Subaru Robin engine. Engine performances are the mean of “*the best combination*” of:

- Power output
- Fuel economy
- Emission control

The aim of this thesis is to work out method to obtain the performance of the selected engine. To obtain this, a set of careful experiments will be devised to produce the relevant result by using the available apparatus in the simplest mean.

This include obtaining the actual power of go kart, the brake horse power of the selected engine, the fuel efficiency of the engine and the emission of exhaust gasses. The method will be explained in methodology method.

This result will then be compared to the data provided by the manufacturer, namely Robin, to support of the validity of experimental data. Thereby, confirming the method used in the experiment.

This will prove to be important to give researcher a better understanding of how various parameter of an engine can be obtain and providing a platform for a more complex study on this topic.

2 Literature Review

Engine has been long used in powering the go kart due to the small size, low cost and high power, which also makes it suitable for recreation and racing purpose. A Robin EY20 is a 5 horsepower side-valve gasoline engine was selected to be the engine in the go kart project conducted by the author and associates. This section will cover where mostly about the theoretical areas, which are:

- i) Basic science of automobile,
- ii) Internal Combustion engine operation,
- iii) Part and operation of the Robin EY20,
- iv) Power transmission of the go kart system,
- v) Exhaust emission control.

2.1 Basic Science of Automobile

An automobile engine is a combination of parts such as engine block, crankshaft, pistons, connecting rod, carburetor, emission control and so on. Each of particular part consists of a single system that is combined with other parts to become a larger system, an engine, which is used to power a body, the chassis and body kit. Automobile engine is one best example of a system that works under the principle of basic science of physic.

2.1.1 Mass and Weight

Generally, mass defined as the *measure of how much matter an object or body contains* - the total number of subatomic particles (electrons, protons and neutrons) in the object. While, weight is the *results of mass multiply by the pull of earth's gravity*. Mass is

important for calculating how fast things accelerate when force been apply to them. The S.I. unit of mass is *gram (g)* or *kilogram (kg)*.

2.1.2 Force

Force is around everyway and the most force common that can be found is weight. Forces cause acceleration, which proven by Newton's Second Law that states – *the acceleration (a) of an object is directly proportional to the force (F) applied, and inversely proportional to the object's mass (m)*. This can be summarized into equation 2.1:

$$\text{Force, } F = \text{mass, } m \times \text{acceleration, } a \quad (2.1)$$

Usually, there is more than one force acting on the object form different direction at the same time. When a car is in rest position, gravity exerts a downward force on the car. Another upward force that is equal and opposite acted on the tires so that the car does not move as illustrated by figure 2.1-0.

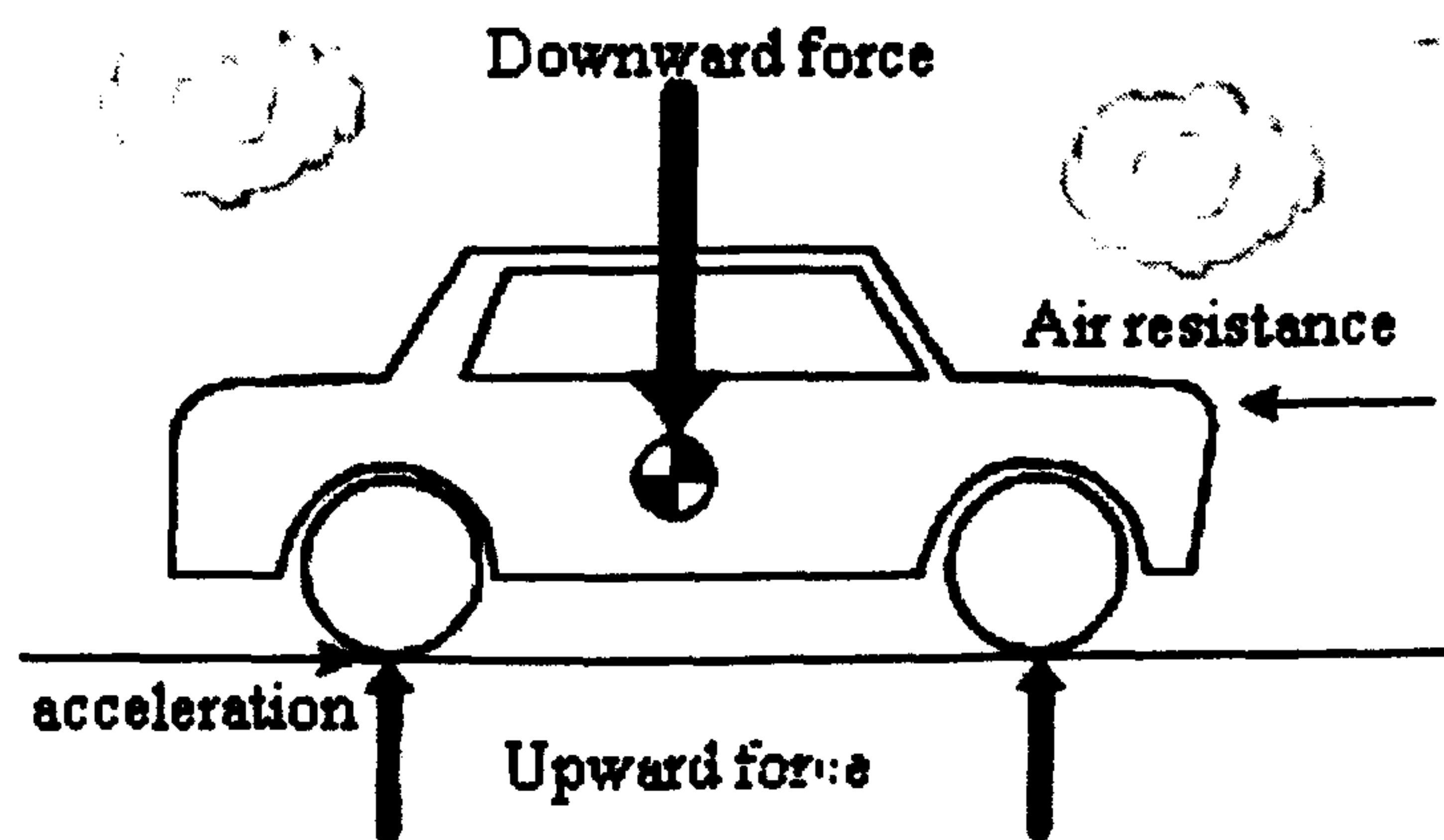


Figure 2.1-0 Forces act on a car as start moving (extracted from www.howthingswork.com)

When the car begins to accelerate, some new force comes into act. The rear wheel exerts force against the ground in horizontal direction which make the car to start accelerate. When the car is moving slowly, almost all the force goes into accelerating the

car. The car resists the acceleration, with a force equal to its mass multiplied by its acceleration. As the car start to move, the air exerts a force against the car, which will grows larger as the car gains speed. This aerodynamic drag force acts in the opposite direction of the force of the tires, which is propelling by the car, leaving less force available for acceleration. Eventually the car will reach its top speed, the point at which it cannot accelerate any more. At this point, the driving force is equal to the aerodynamic drag. The S.I. unit of force is Newton (N) and 1 Newton is equal to 1 kg.m/s^2 .

2.1.3 Torque

Torque is a force that tends to rotate or turn things. It is related to force just as work is, where it can be measured in a combination of distance and force. As for example, each time when we apply force on a wrench to loosen or tighten a screw, or nut torque has been generated. Therefore, when 20 pounds of force applied on the end of a 1-foot wrench 20 foot-pounds of torque was created to the bolt. A car engine, which also known as reciprocating engine, creates torque and uses it to spin the crankshaft. The crankshaft converts linear motion of the piston into rotating motion by the help of piston rod or connecting rod. The customary units of torque measurement are compound unit is distance times force, which is Newton meter (N.m).

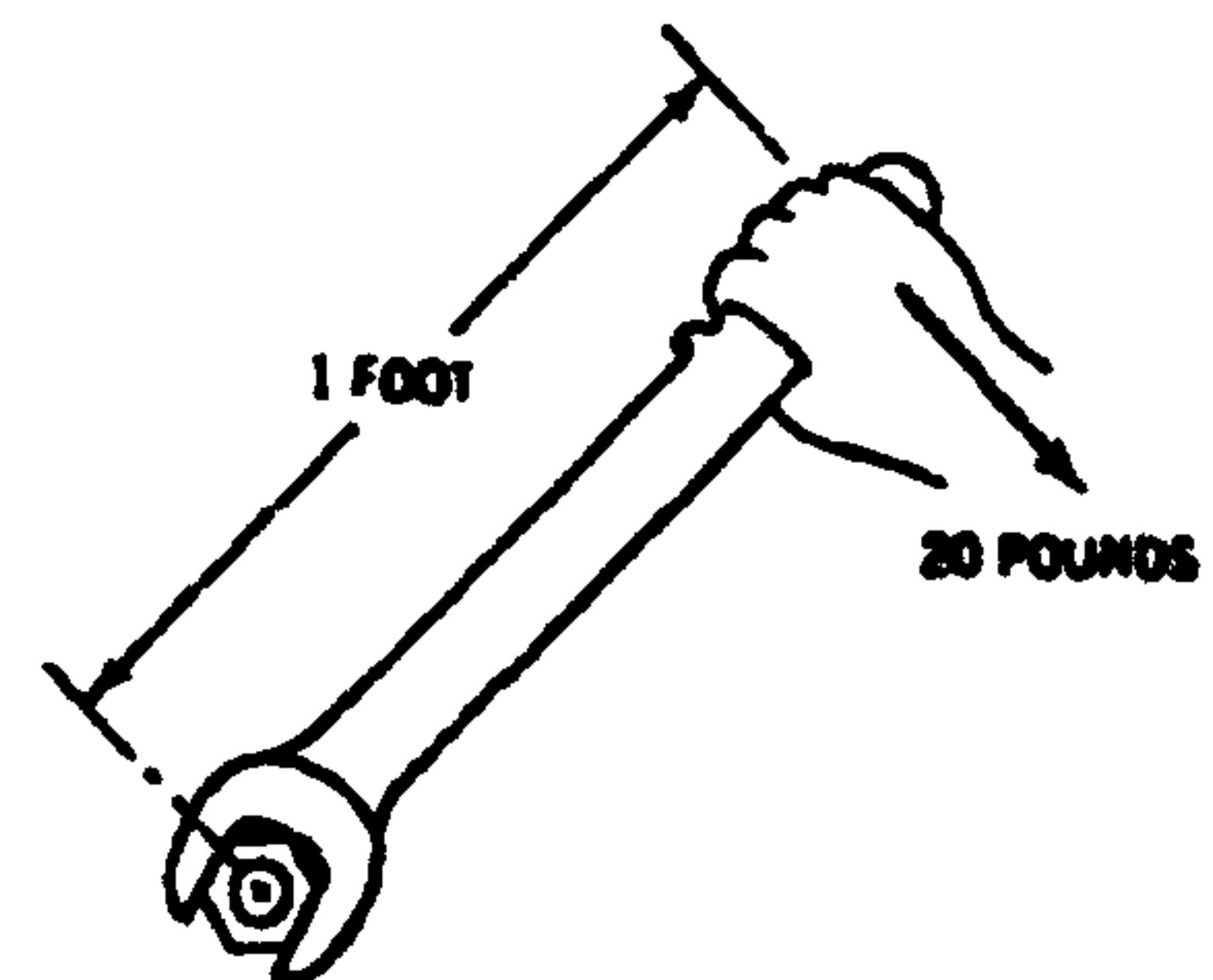


Figure 2.1-1 A 20 foot pounds of torque been produced on the bolt. (extracted from Automotive Engine Performance, 1989)

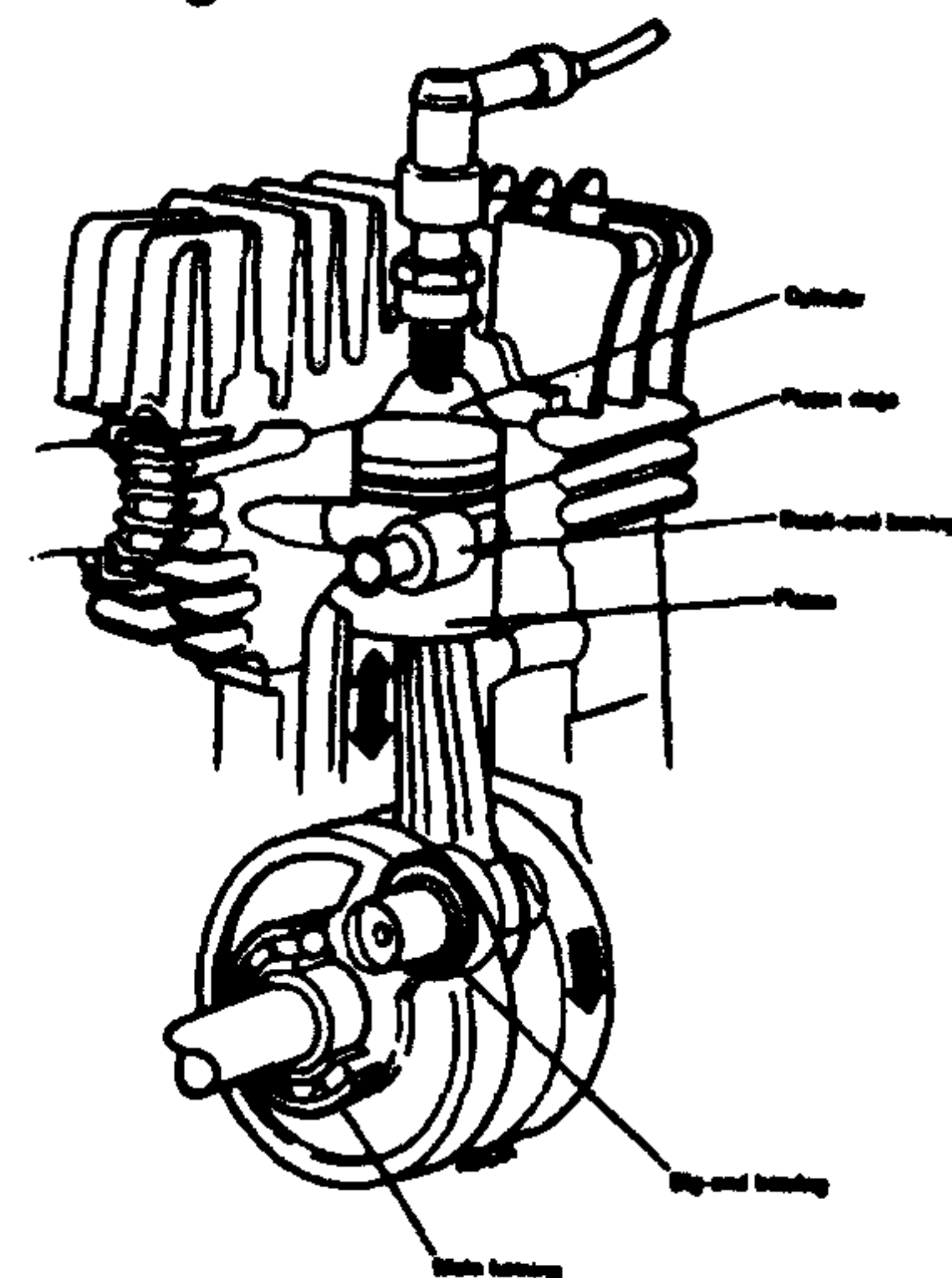
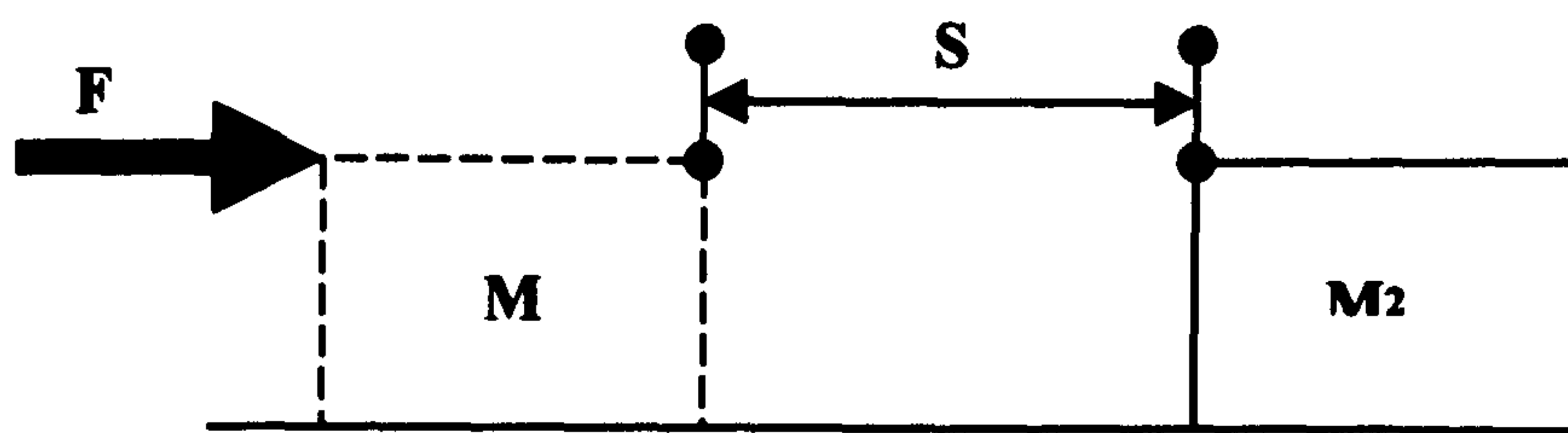


Figure 2.1-2 A reciprocating engines convert the linear motion of the piston into rotating motion at crankshaft. (extracted from Motorcycle Basic Manual, 1989)

2.1.4 Work

Work is *simply the application of a force over a distance*, with one catch - the distance only counts if it is in the direction of the force applied. Lifting a weight from the ground and putting it on a shelf is a good example of work. The force is equal to the weight of the object, and the distance is equal to the height of the shelf. Same as torque, the S.I. unit for measurement of work are in Newton meter (N.m).

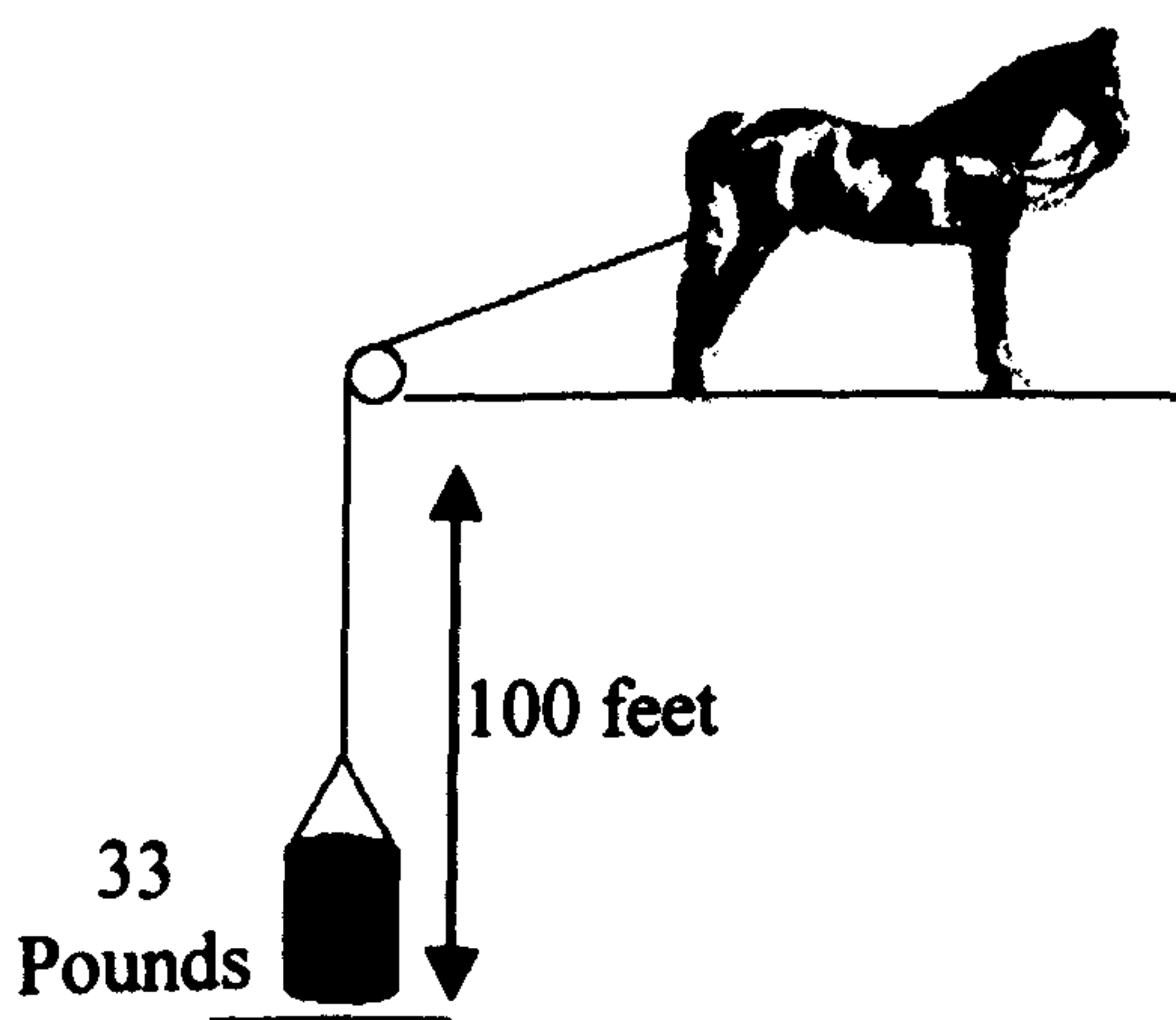


Work, $W = \text{Force, } F \times \text{Distances, } S$

Figure 2.1-3 A simple example of work.

2.1.5 Power

Power is a measure of how fast work can be done. The SI unit for power is the *watt*. One watt is equal to one *Newton-meter per second* (Nm/s). Another way to look at power is by *horsepower*, which invented by the engineer James Watt (1736 – 1819). In



Watt's judgment, one horse can do 33,000 foot-pounds of work every minute. So imagine a horse raising coal out of a coalmine as shown. A horse exerting one horsepower can raise 330 pounds of coal 100 feet in a minute, or 33 pounds of coal 1000 feet in one minute, or 1,000 pounds 33 feet in

Figure 2.1-4 One horse can do 33,000 foot-pounds work every minute (extracted from www.howthingswork.com).

one minute, etc.

2.1.6 Energy

Energy is a measure of how long we can sustain the output of power, or the ability to do work. There are several type of energy such as, chemical energy, potential energy, kinetic energy and other. Energy can change in to different form as force applied on it, for example, chemical energy of the gasoline are convert into kinetic energy, as combustion occur in the combustion chamber, by the arrangement of piston, connecting rod and crankshaft. One common unit of energy is the kilowatt-hour (kW-hr).

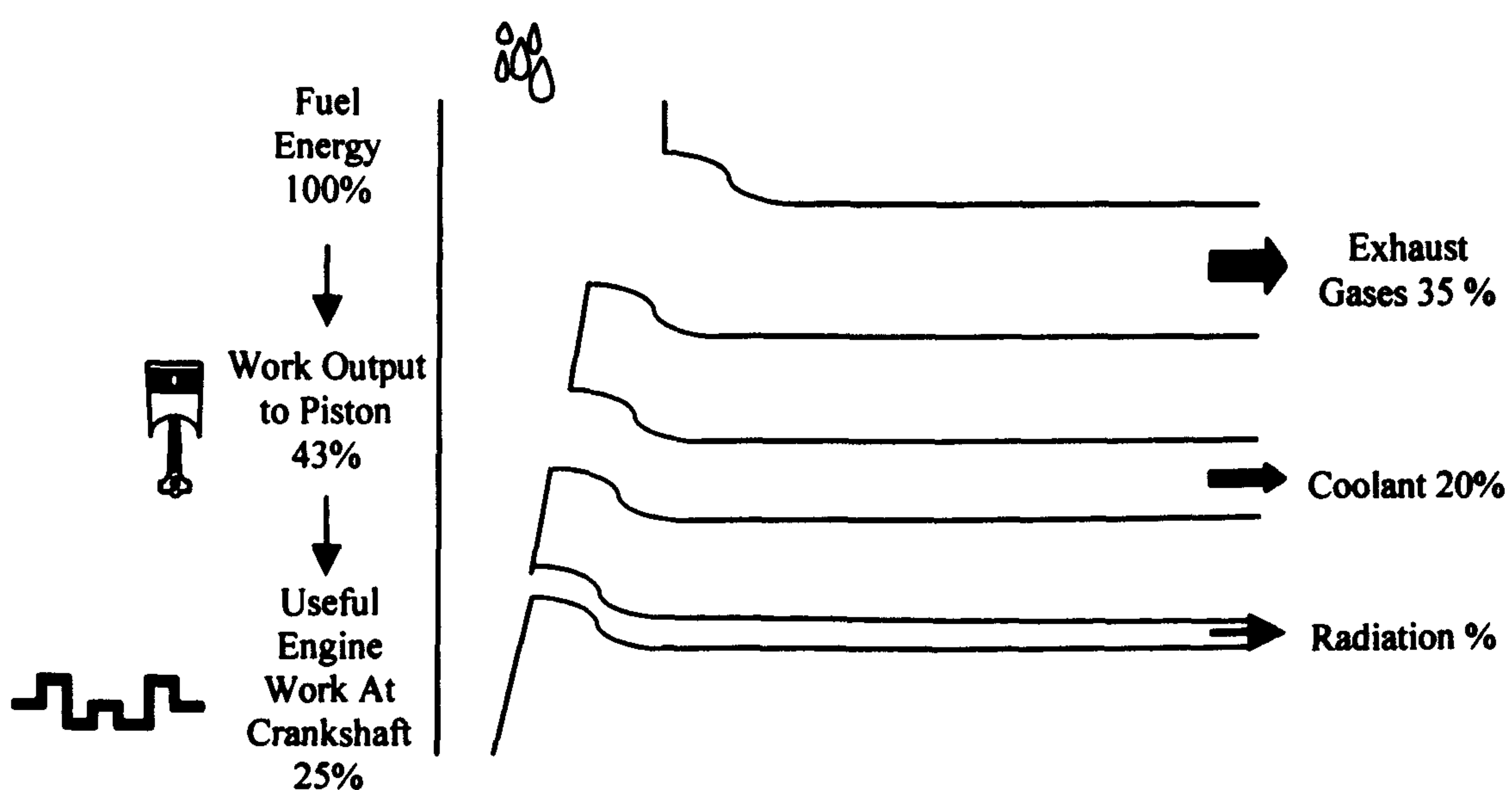


Figure 2.1-5 Only about 25 percent of an engine's potential energy is available as mechanical power at the crankshaft.

2.2 Internal Combustion Engine

Any of a group of devices in which the reactants of combustion (oxidizer and fuel) and the products of combustion serve as the working fluids of the engine is known as *Internal Combustion Engine*. Such an engine gains its energy from heat released during the combustion where its convert the *chemical energy* (fuel normally gasoline or diesel) to *kinetic energy* (which are the movement of the piston and crankshaft). This process occurs within the engine and is part of the thermodynamic cycle of the device (engine). Useful work generated by internal-combustion (IC) engine results from the hot, gaseous products of combustion acting on moving surfaces of the engine, such as pistons, a turbine blade or a nozzle.

Generally, internal-combustion engines are divided into two groups: *continuous-combustion engines* and *intermittent-combustion engines*. The continuous-combustion engine is characterized by *a steady flow of fuel and oxidizer into the engine*. A stable flame is maintained within the engine (e.g., jet engine). During the combustion process, the thermodynamic events occur simultaneously as the oxidizer and fuel, and the products of combustion flow steadily through the engine.

On the other hand, the intermittent-combustion engine is characterized by *periodic ignition of air and fuel* and commonly is referred to as a *reciprocating engine*. Discrete volumes of air and fuel are processed in a cyclic manner. Gasoline piston engines and diesel engines are examples of this second group. By contrast, combustion processes in this type of engine occur in succession and are repeated for each full cycle.

2.2.1 Four-Stroke Engine

Among the different techniques of recovering power from the combustion process, *four-stroke cycle engine* has been the most widely applied due to the high efficiency and its outstanding performance as a prime vehicle in the ground transportation industry. Based on the conception of more than 100 years old, four-stroke engine (illustrated in Figure 2.0) was first built by a German engineer Nikolaus A. Otto in 1876.

In a four-stroke engine, the engine needs to perform four up and down strokes to complete a full cycle. These four strokes are known as:

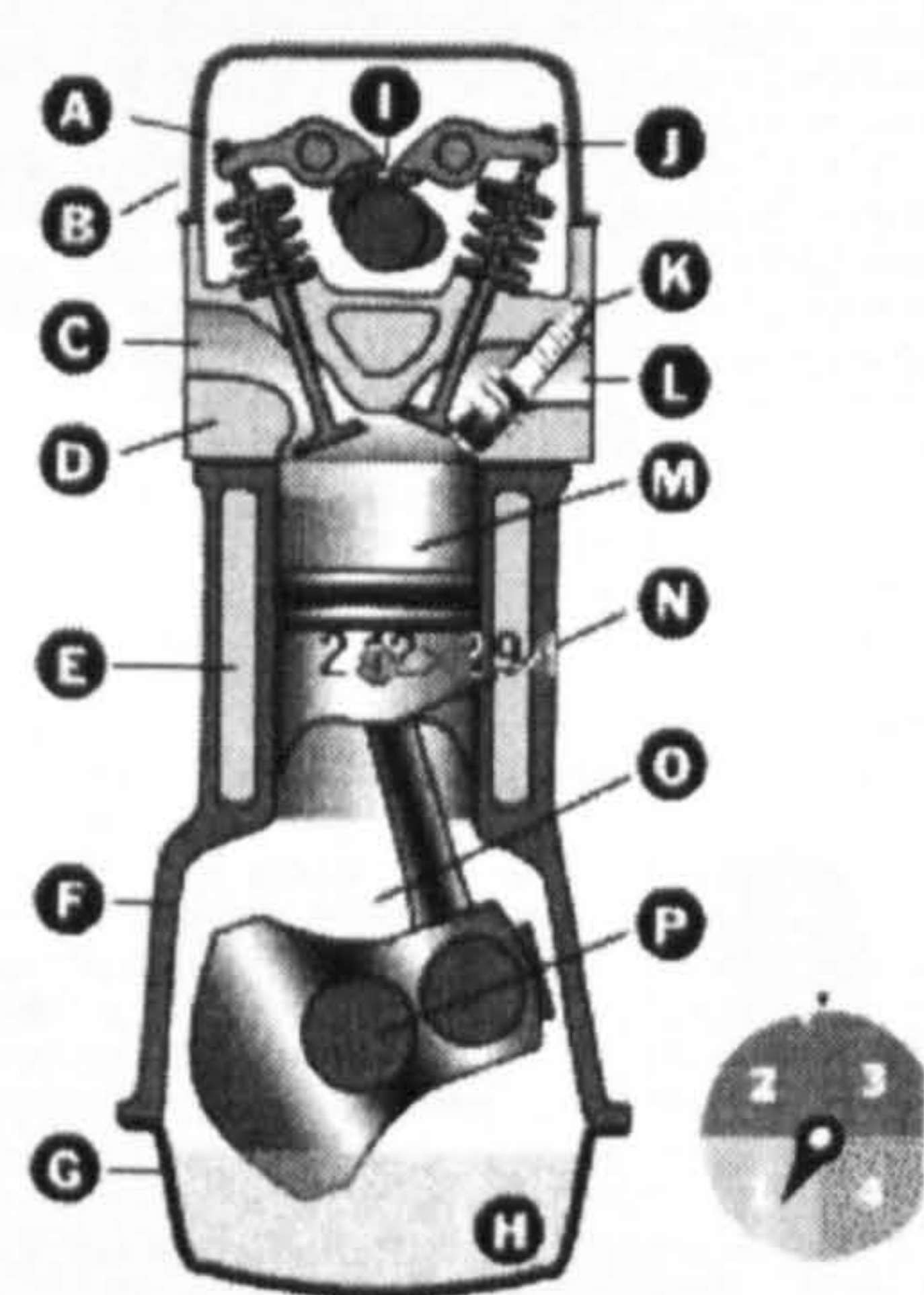


Figure 2.2-0
Intake Stroke (extracted from www.howthingswork.com)

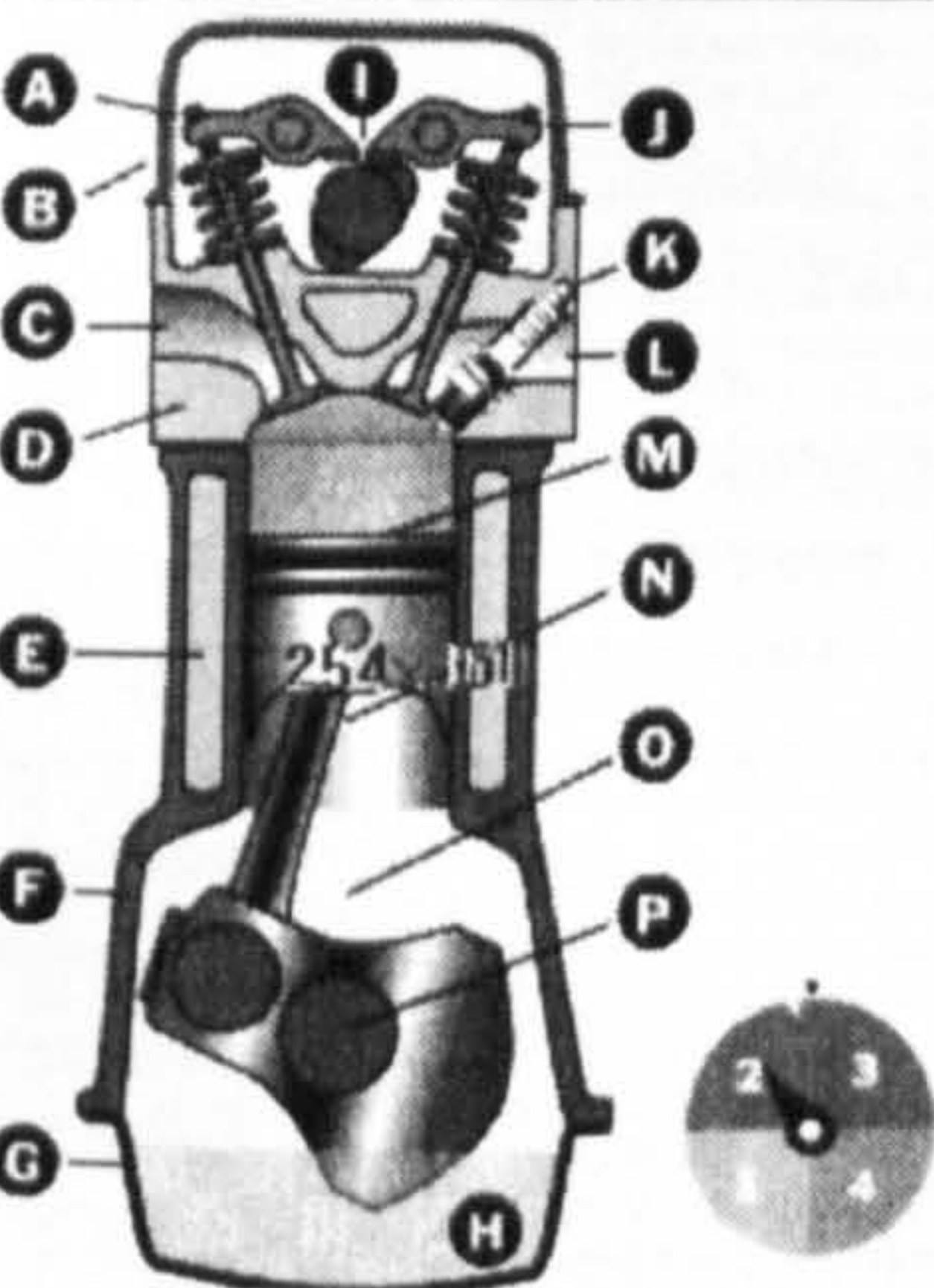


Figure 2.2-1
Compression Stroke (extracted from www.howthingswork.com)

- *Intake stroke* – During this stage, the inlet valve opens while the piston first moves downward until the *Bottom Dead Center (BDC)*. Due to the piston movement, pressure inside the cylinder chamber will be decreasing where a partial vacuum will be created. Mixture of gasoline vapor and air will suck into the cylinder through the intake port.
- *Compression stroke* – After the piston reached the BDC, it rises upward due to the inertia moment of the crankshaft. The mixture is compressed as the piston ascends toward the *Top Dead Center (TDC)* with both intake and exhaust valves are closed.

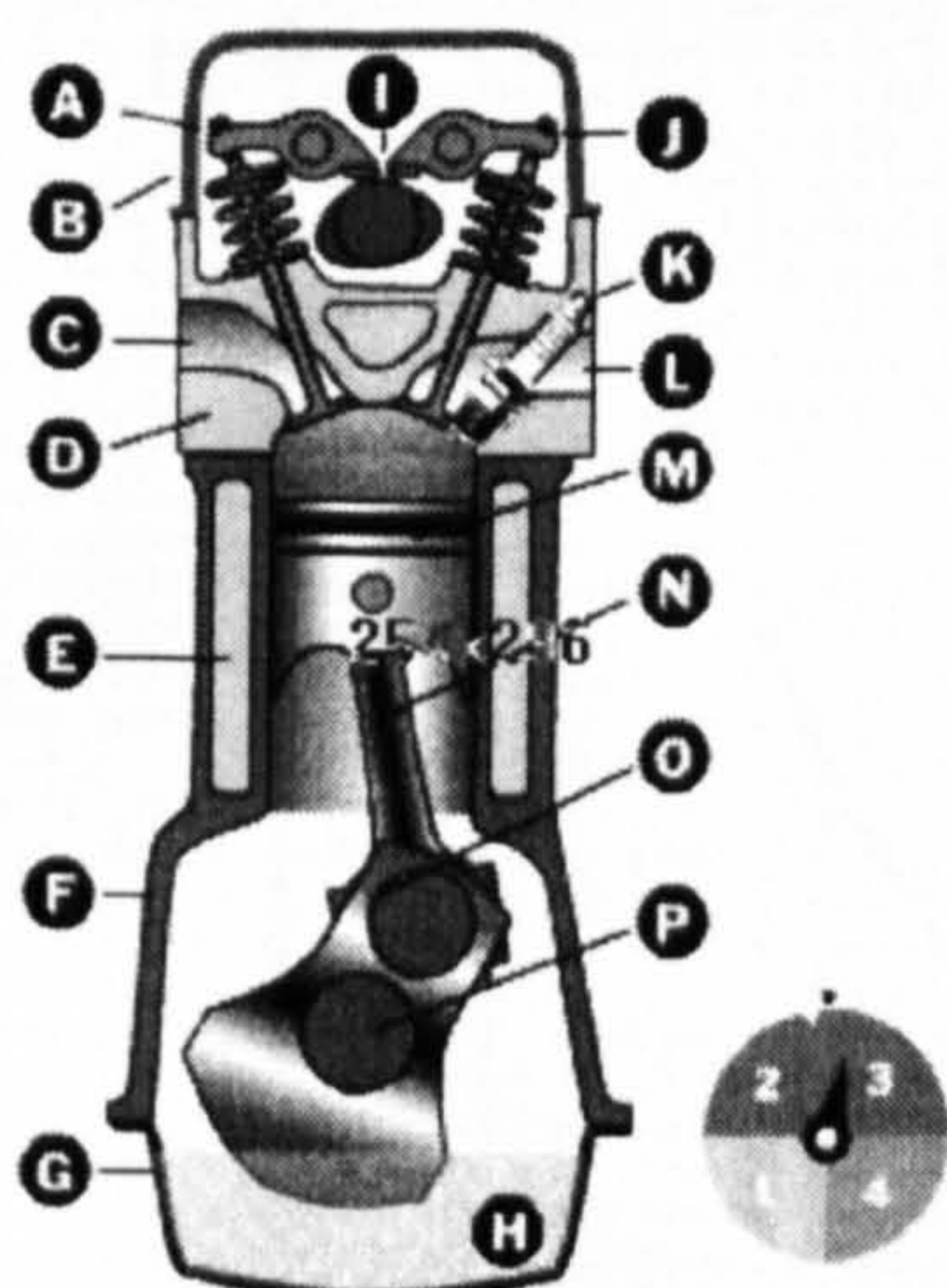


Figure 2.2-2
Power Stroke (extracted from
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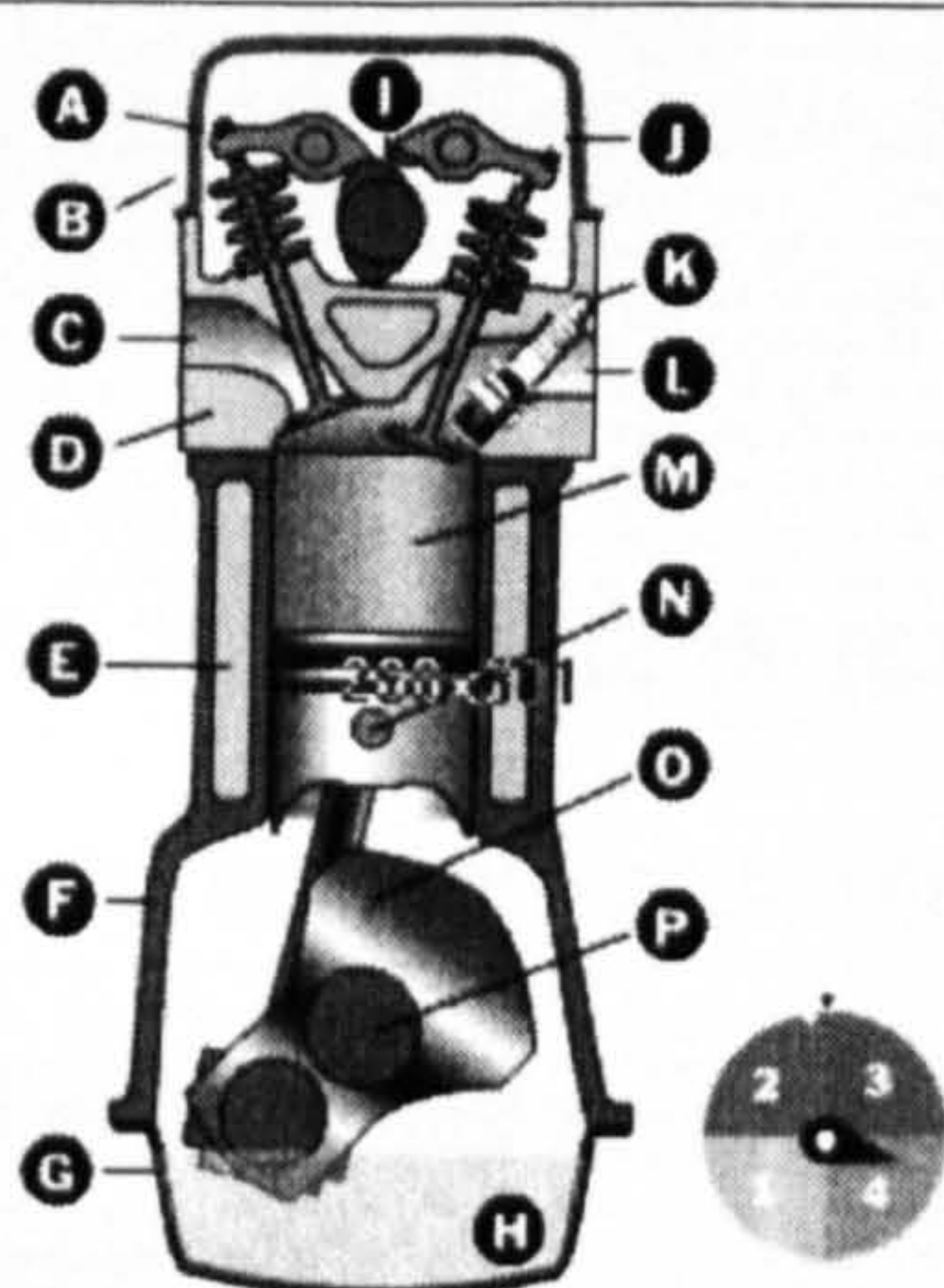


Figure 2.2-3
Exhaust Stroke (extracted from
www.howthingswork.com)

A Intake Valve, Rocker Arm & Spring	I Camshaft
B Valve Cover	J Exhaust Valve, Rocker Arm & Spring
C Intake port	K Spark Plug
D Head	L Exhaust Port
E Coolant	M Piston
F Engine Block	N Connecting Rod
G Oil Pan	O Rod Bearing
H Oil Sump	P Crankshaft

- ① INTAKE
- ② COMPRESSION
- ③ COMBUSTION
- ④ EXHAUST
- ▼ Spark
- Top Dead Center

Figure 2.2-4
Legend (extracted from
www.howthingswork.com)

- *Power/combustion stroke* – As soon as the piston reached the TDC, an electrical spark produced by the spark plug ignited the charge. With both valves still closed, the ignition of the charge created a large explosion where the pressure inside the combustion chamber increased due to the expansion of the burned gas. Pressing on the piston crown toward the BDC again.
- *Exhaust stroke* – During the exhaust stroke, the ascending piston forces the spent products of combustion through the open exhaust valve. The cycle then repeats itself. Each cycle thus requires four strokes of the piston – intake, compression, power, and exhaust – and two revolutions of the crankshaft.

A disadvantage of the four-stroke cycle is that only half as many power strokes are completed as in the two-stroke cycle that will be explain later and only half as much power can be expected from an engine of a given size at a given operating speed. The four-stroke cycle, however, provides more positive clearing out of exhaust gases (scavenging) and reloading of the cylinders, reducing the amount of loss of fresh charge to the exhaust.