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THE MODERN MOTOR CAR

ITS MANAGEMENT, MECHANISM, AND MAINTENANCE

A Practical Handbook for the Use of Owners and Drivers

BY

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Second Edition, Revised

WITH ILLUSTRATIONS

LONDON
CROSBY LOCKWOOD AND SON
7, STATIONERS' HALL COURT, LUDGATE HILL
1912

BY THE SAME AUTHOR.

Handbook for Engineering Students.

Guide to the Engineering Profession.

Electrical Equipment of Collieries.

How to Become an Engineer.

To-day in Germany.

Indian Problems.

To-day in America.

PREFACE

THE appearance of a new book on motor cars seems to necessitate an explanation. In this case, the main object of the book is to give the reader a thorough working acquaintance with the elements and management of modern motor cars. It is an attempt to span the gulf dividing the pure theory of mechanics and mechanism and the practical working and management.

A considerable variety of cars are now on the market, but excepting a very few, the general arrangement is the same throughout, a difference existing in some of the details. There is a reason for everything about a motor car, and the driver or owner should make it his business to obtain a knowledge of the function of every part, and the proper management of the same. A few lessons are quite sufficient to learn the art of driving. By the manipulation of levers and pedals a novice may learn to drive in a very short time, but this is not enough; an intimate knowledge of the mechanism and management is highly essential. This can only be obtained by practical experience and reading, and the author hopes that the information contained in this book will be found useful to both driver and owner.

The Author's best thanks are due to the firms mentioned throughout the book for information and illustrations supplied.

NOTE TO THE SECOND EDITION

THIS work has been thoroughly revised and brought up to date. Automobile Engineering has made such rapid strides during the past year, that it has been found necessary to completely re-write Chapter II. The Author gratefully records his obligations to Mr. D. Gillespie, B.Sc., A.M.I.C.E., for his valuable assistance in preparing the new Edition.

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THE MODERN MOTOR CAR

CHAPTER I

THE ELECTRICAL IGNITION

Accumulators.—It is of first importance to the motor car driver that he should understand something regarding the principles of electrical ignition, and its application to motor cars. In an accumulator it must not be supposed that the electricity is stored or accumulated in the form of current, but rather, that a chemical change takes place, between two constituents, which causes the electricity to flow. Various devices and improvements have been made in the construction of accumulators, so that the efficiency, durability, and capacity may be increased. The lead plates are made in the form of grids, and the intervening spaces in the grids being filled with oxide of lead. The grids are immersed in dilute sulphuric acid contained in celluloid vessels, celluloid being used so that the interior of the accumulator may be inspected, and also because celluloid is not so brittle as glass and is less liable to break. The positive plates have narrow inclined shelves running horizontally, and a paste of red lead and sulphuric acid is pressed on to these shelves. The negative plates contain a paste of powered litharge and sulphuric acid. After pasting, the plates are dried and immersed in dilute sulphuric acid with a specific gravity of 1·9, and "forming" then takes place. When a current passes from the positive grid through the liquid to the negative grid, peroxide is formed on the positive, and spongy lead on the negative. This "forming" process goes on for four or five days with a weak charging current until the maximum charging rate is reached. The accumulator is then ready for use. The charging of the accumulator may be done by a primary battery, but a dynamo or generator is much more convenient. When the charging current is switched on to the accumulator, a chemical change takes place on the surface of the plates, and the plates assume different colours; the positive turning deep brown, and the negative stone grey. On the discharging of the accumulator (that is the using of the current for sparking in the cylinders), the chemical energy obtained by charging is converted into electric current. The process of charging and discharging may be repeated indefinitely. The negative plates generally exceed the positive plates by one. Stoppers are fitted at the top of the celluloid vessels in order that the electrolyte may be replenished from time to time. Two brass terminal screws on each accumulator afford means of connection to the outside circuit. The positive terminal is denoted by a cross or is painted red, and the negative by a stroke or is painted black. The plates are held in position by celluloid, glass, or vulcanite separators, between each pair of grids.

Charging Accumulators.—The usual way is to send the accumulators to an electrician to be charged, but accumulators may be charged wherever electric light is available. All that is necessary is to remove the cover from a switch in circuit with two or three lights. Put the switch at the "off" position, and ascertain which is the positive terminal. This may be done by connecting two pieces of insulated wire to each terminal of the switch. Scrape the wires with a penknife at the other end and dip them in a vessel containing slightly salted water, taking care to keep the wires apart. Bubbles of gas will issue from the negative wire. This may also be done by "pole finding" paper, which, when wetted and touched by the wires, the negative turns a carmine colour. Connect this wire to the negative terminal of the accumulator, the other wire to the positive terminal. The lamps will still be lighted, although a certain quantity of current passes through the accumulator. Care must be taken that the switch is "off" during charging. The acid in the accumulator will after a time turn milky, and gas will be given off freely. This may be taken as a sign that the accumulator is charged and ready for use in the motor car. The voltage should read between 4 and 5 volts. Another way, and perhaps the most convenient, is to connect the accumulator to a lamp-holder, and charge when the light is switched "on." An adapter with some flexible wire is all that is required. Fix the wires in the adapter and fix the adapter in the lamp-holder. The one end of the wire being connected to the positive or negative terminal of the accumulators, as the case may be, and the other end being connected at the lamp, and a small piece of wire connecting the lamp and accumulator. A 16, 30, or 50 candle-power lamp may be used according to the size of the accumulator and voltage of the circuit. To find the number of lamps required, multiply the voltage of the main circuit by the rate in amperes to which the accumulator should be charged. This rate is generally denoted on the accumulator. Divide the result obtained by 3 and divide again by the candle-power of the lamps required for insertion in the charging circuit, and the result will be the number of lamps to be inserted in the charging circuit. If lamps of different candle-power are used, the current may be more easily controlled. ½ ampere is taken by a 16 c.p. lamp, 1 ampere for 32 c.p. lamp, and 1½ ampere for a 50 c.p. lamp. By using these lamps separately or in combination a great variety of currents may be obtained. Perhaps the best person to charge accumulators is the working electrician. It has often happened that too heavy or too weak a charging current has ruined an accumulator.

Charging Accumulators by Alternating Current.—The method of charging accumulators in this case is quite different from the ordinary continuous current. A rotary "transformer" consisting of a small motor driven by the alternating current, drives a small continuous-current dynamo fitted on the same shaft. The current from the dynamo may be used in the usual way. Another way is to employ a "rectifier" consisting of four cells and an aluminium plate in each, immersed in a solution of ammonium phosphate. The aluminium electrodes act in the same manner as a valve and choke back the reverse current, only allowing the direct or continuous current to flow. This apparatus requires little attention, and may be connected up to the main circuit, and lamps may be used to form a resistance in the circuit.

The Edison Accumulator or Long Storage Battery.—While touring in America, I had the pleasure of visiting Edison's works at Orange, and inspecting the Edison accumulator. Some good results have been obtained by this form of cell, but as it is still in its infancy, it is impossible to predict what the future may have in store for it. Considerable mechanical skill is involved in the manufacture of this cell. In its simplest form it consists of two thin steel frames fitted with perforated pockets of steel. These pockets are packed with nickel oxide for the positive frame and iron oxide for the negative frame. A caustic potash solution is used as electrolyte.

When the charging current is switched on, the nickel oxide of the positive plate or frame is converted into nickel peroxide, and the iron oxide in the pockets of the negative plate is reduced to metallic iron. On taking the current from the battery, the nickel peroxide and the iron become oxydised. An Edison cell, with the normal discharge rate of 30 to 40 amperes, gives 80 per cent. of its normal ampere hours, with a 200-ampere discharging current. The voltage given is 1·35. The efficiency of this cell, compared with the lead plate accumulator, is low, but it has an advantage in that it will stand more rough usage, and is less liable to give trouble. From experiments made, it has been shown that if it is short circuited for two days, it will recover its original capacity after a couple of charges. The charging current may be four times the proper amount without detrimental effect. It may also be left discharged for some considerable time. This cell is used for motor traction work, and in some cases for private electrically propelled vehicles in the United States.

The Bosch Arc Light Electric Ignition.—The ignition of the mixture with the Bosch magneto is effected by means of an arc, which is formed between the electrodes of a sparking plug. This apparatus therefore belongs to the high-tension or jump spark type. The high tension current is generated in the winding of the rotating armature, without the use of a separate induction coil. During each revolution of the armature two sparks are produced, which are distributed to the different cylinders by means of a high-tension distributor.

The current is produced mechanically by transforming mechanical into electrical energy. The magnetic field is formed by permanent steel magnets of a practically unlimited life. As with this ignition system the spark is produced between the electrodes of a sparking plug, there is no need for any special ignition arrangement to the motor, besides the plugs. The make and break mechanism is entirely dispensed with. Furthermore, this system of ignition does not necessitate any movable parts on or inside the cylinders. Compared with other high tension ignition systems the Bosch arc ignition system requires no induction coil. High-tension current is generated directly in the armature winding.

The sparks differ very considerably from those of other systems. They do not appear as short sparks, but as small arcs which continue for a considerable time. These hot discharges will ignite much poorer mixtures than can be ignited with the usual jump spark system.

An arrangement for varying the timing of the ignition is fitted to the magneto itself, and permits of a variation of 35° measured on the magneto spindle. This corresponds to a timing angle with respect to the motor shaft of more than 45° for a 3-cylinder motor, 35° for a 4-cylinder motor, and about 24° for a 6-cylinder motor.

Description and Working of the Magneto.—A so-called shuttle armature rotates between the poles of two pairs of very strong steel magnets. The rotation of this armature in the strong magnetic field results in the induction in its winding of a strong electrical current, which reaches a maximum voltage twice in one revolution, or after rotating through an angle of 180°.

The current which is produced by turning the armature, rises by short circuiting the primary circuit through a contact breaker and breaking the circuit at a suitable moment. A spark jumps across the electrodes of the sparking plug, at the moment of the breaking of the primary circuit, causing the explosion in the cylinder. As the arc-like spark can only be produced when the armature is in a certain position, and also the ignition has to take place at a certain period during the movement of the piston, it is necessary that the armature shall be positively driven. The speed at which the magneto must be driven depends on the number of cylinders. For 3-cylinder motors the armature must run at a speed corresponding to three-quarters the speed of the

One third actual size.

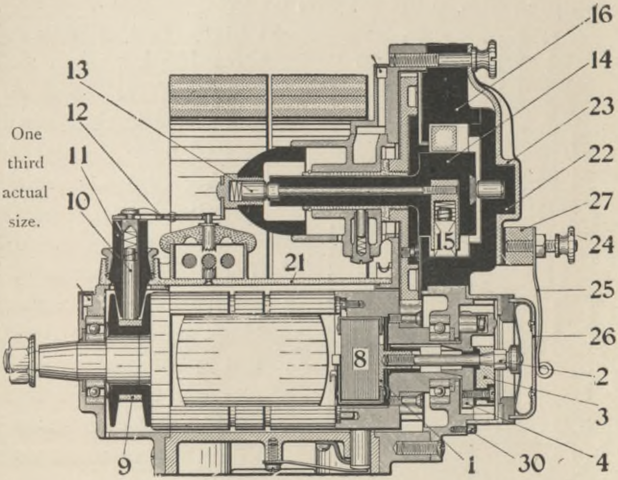

FIG. 1.

1. Brass plate.
2. Contact breaker screw.
3. Platinum screw block.
4. Contact breaker disc.
5. Long platinum screw.
6. Contact breaker spring.
7. Contact breaker lever.
8. Condenser.
9. Slip ring.
10. Carbon brush.
11. Carbon holder.
12. Connecting bridge.
13. Contact carbon.
14. Rotating distributor piece.
15. Distributor carbon.
16. Distributor disc.
18. Contact plug.
19. Fibre roller.
20. Timing lever.
21. Dust cover.
22. Cover.
23. Triangular clamp.
24. Nut for switch wire (short circuit).
25. Spring for fastening brass cap.

crankshaft. For 4-cylinder motors it must be run at the same speed as the crankshaft, and type "DR6," which is for 6-cylinder motors, must be run at one and a half times the speed of the engine. The armature is wound in two parts, one is a primary winding consisting of a few turns of heavy wire, and the other a secondary winding consisting of many turns of fine wire. The end of the primary winding is connected to the brass plate 1 (see Figs. 1 and 2). In the centre of this plate is screwed the fastening screw 2, which serves, in the first place, for holding the contact breaker in its position, and, in the second, for conducting the primary current to the platinum screw-block 3 of the contact breaker. Screw 2 and screw-block 3 are insulated from the contact breaker disc 4, which is metallically connected with the armature core. The platinum screw 5 is arranged in the screw-block 3. Pressed against this platinum screw by means of a spring 6 is the contact breaker lever 7, which is connected to the armature core, and therefore with the beginning of the primary winding. The primary winding is therefore short circuited as long as lever 7 is in contact with platinum screw 5. The circuit is interrupted when the lever is rocked. A condenser, 8, is connected in parallel with the gap thus formed. The beginning of the secondary winding is connected to the end of the primary, so that the latter is a direct continuation of the former. The end of the secondary winding leads to the slip ring 9, on which slides a carbon brush,

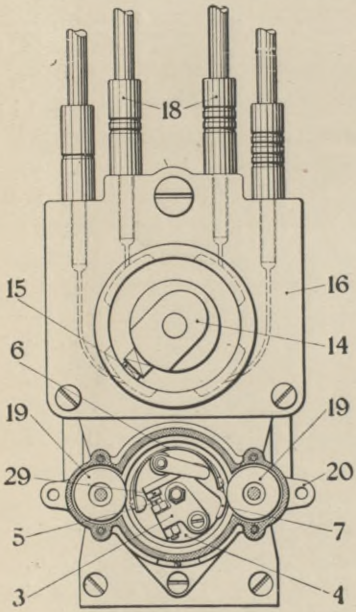

FIG. 2.

10, which is insulated from the magneto frame by means of the carbon holder 11. From the brush 10 the secondary current is conducted to connecting bridge 12, fitted with a central carbon brush 13, and through the rotating distributor piece 14, which carries a radial contact carbon, 15, to the distributor disc 16. In the distributor disc 16 are embedded metal segments, of which there are three in type "DR3," four in type "DR4," and six in type "DR6." During the rotation of the carbon 15, the latter makes contact with the respective segments, and always connects the secondary current with one of the contacts. Connected to the segments are sockets which serve for the reception of the contact plugs 18. These plugs serve as terminals for the cables leading to the sparking plugs of the individual cylinders.

From the end of the secondary winding, the high-tension current is led to the respective cylinders, the current produces the arc which causes the explosion, then returns through the motor frame and armature core back to the beginning of the secondary winding. Diagram of wiring is shown in Fig. 3. The disc which drives the distributor brush 15 is geared according to the different types, from the armature shaft so that the distributor brush is revolving at the same speed as the camshaft of the motor. These magnetos are designed to only run in one direction, and it is therefore necessary to state when ordering whether the magneto is to run "clockwise" or "anti-clockwise" when looking at the driving end of the magneto. The contact breaker is fitted into the rear end of the armature spindle, which is bored out and provided with a keyway. The contact breaker is held in position by screw 2, by removing which the contact breaker can be easily taken out; in replacing same, care should be taken to see that the key fits into the keyway, and that the screw 2 is well tightened up. The

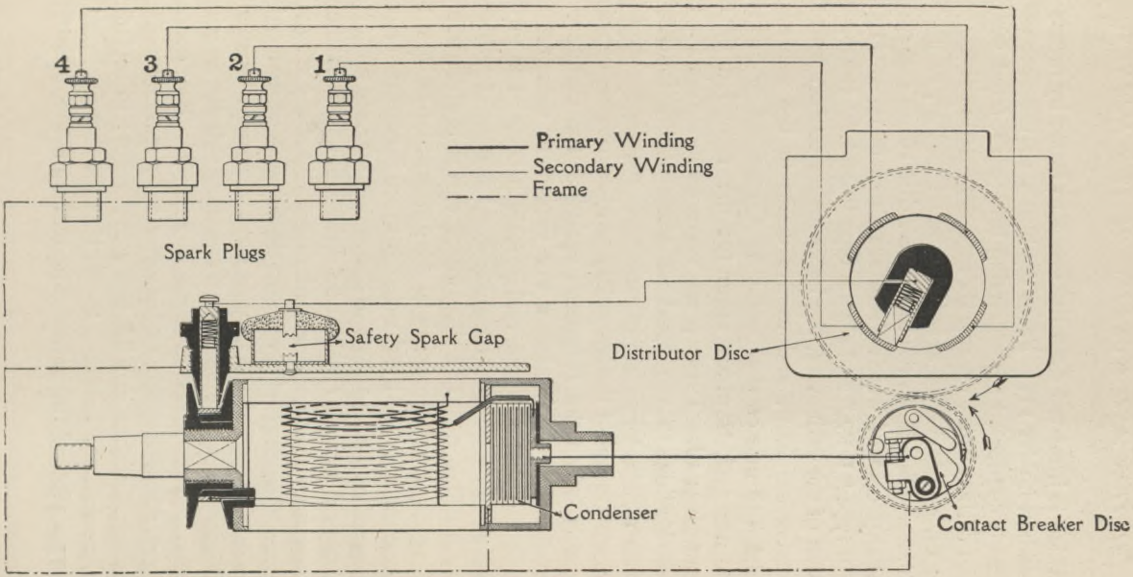
4
3
2
1
Spark Plugs
Primary Winding
Secondary Winding
Frame
Safety Spark Gap
Distributor Disc
Condenser
Contact Breaker Disc

FIG. 3.

short circuiting and interrupting of the primary circuit is effected twice during each revolution of the armature by means of the contact breaker lever 7 on one hand, and the fibre rollers 19 on the other. As long as the lever 7 is pressed against the contact screw 5, the primary circuit is short circuited, and the rocking of the levers by the fibre rollers 19 effect the break of the primary circuit; at the same moment ignition takes place. The distance between the platinum points, when lever is lifted on fibre rollers, must not exceed 0·5 millimetre. This distance may be adjusted by means of the screw 5.

Units of Measurement of Electricity. — The measurement of electricity is determined in units. The volt is the unit of electrical pressure, which, if made to flow through a conductor of one ohm resistance, produces a current of one ampere. The ampere is the constant electrical current which, when passed through a solution of nitrate of silver in water, deposits 0·001118 gramme per second, or an ampere may be described as the current given by an electro-motive force of one volt through a resistance of one ohm. The ohm is the unit of resistance, and its value is equivalent to the resistance offered by a column of mercury 106·3 centimetres long by 14·4521 grammes in mass at a temperature of melting ice. The watt is the unit of electric power, and represents the power developed in the circuit, when one ampere flows through it, so that the number of watts developed in any circuit equals the product of the current in amperes flowing through it into the electro-motive force in volts at its terminals. One watt is the power developed by 44·25 foot pounds of work done in a minute, or one watt is equal to $\frac{1}{746}$ of a horse-power, and 746 watts equal one electrical horse-power. One kilowatt $= \frac{1000}{746} = 1{\cdot}34$ horse-power.

The Induction Coil.—The induction coil is simple in construction, but its action is not so easily understood. If two battery wires are quickly brought together and separated a small spark will be noticed. If, however, the wires are brought together with great care, it will be noticed that no spark is given until they actually touch and are separated. For exploding the mixture in a petrol engine, a high electrical pressure is required in order that the spark may cross the gap between the points of the sparking plug, which is somewhat large. Thousands of volts would be required to spark across a gap $\frac{1}{32}$ of an inch wide. It will therefore be seen that high-pressure electricity is not obtainable by a battery of cells and an apparatus called the induction coil is therefore used. It transforms electricity at low pressure from one or two cells into high-pressure electricity which is capable of "jumping" the gap in the sparking plugs. We must give some consideration to the properties of magnetism before attempting to describe the induction coil. A magnet is a body usually made of iron or steel and possessing the property of attracting iron or other magnetic bodies. Magnets possess two poles, north and south. If similar poles of two magnets are brought near each other they repel, whilst attraction takes place between two dissimilar poles. Magnets are divided into two classes, permanent and temporary. A substance found in nature called loadstone has magnetic properties. It is a compound of iron and is found in Norway, Sweden, and America. But permanent magnets are usually made of steel, while temporary magnets, or electro-magnets as they are generally called, lose their magnetism as soon as the magnetizing power is withdrawn. If a piece of magnetized steel, either in the form of a horseshoe or a bar, be placed under a sheet of paper and iron filings sprinkled on top of the paper, it will be observed that the iron filings arrange themselves in curved lines. These lines are known as "lines of magnetic force." Each particle of iron, by induction, becomes a magnet with its north pole towards the south pole of the neighbouring particle, and *vice versa.* These lines of force are quite invisible to the eye; they have no positive existence any more than the actual existence of lines of latitude and longitude on the surface of the globe. Both are abstract conceptions adopted by scientists for the purpose of measurement only. If a rod of soft iron having a coil of wire wound round it and the ends of the wire connected to a source of electricity, the rod will be found to become magnetic. If the contact be broken the magnetism disappears. This is what we call electro-magnetism. If we take a bobbin which has been wound with wire, we find on connecting to a source of electricity, that the interior of the hole in the bobbin possesses a strong magnetic field. If an iron rod be held near the aperture it will be strongly attracted, and will tend to be drawn into the hole. The larger the number of turns of wire on the bobbin, the stronger the magnetism becomes. The induction coil consists of a bundle of soft iron wires or a short bar, around which a coil of thick insulated copper wire is wound. This coil is termed the primary coil. Vulcanite fibre is placed over this coil, then a large number of turns of fine insulated wire are wound over this again. This is called the secondary coil. Sometimes each layer of turns in the secondary coil is separated from the other by paper covered with paraffin wax. After winding, the whole coil is steeped in melted wax and the ends of the secondary are fixed to two terminals, within half an inch of each other. A feature of the induction coil is that the two windings are not connected to each other in any way. When a current is passed through the primary coil for a second only, simultaneously an "induced" current is produced in the secondary coil. The secondary current is of greater force than the primary, because there are more turns of wire on the secondary coil; this high-pressure current can bridge across a small space or gap in the form of a spark, sufficient to ignite a mixture of petrol gas. High tension current is a name given to the current coming from the secondary coil. For igniting the explosive mixture in petrol engines, induction coils are of two classes, viz., the trembler coil and non-trembler coil. The difference being that a mechanical device is fixed to one coil which enables the current to be interrupted with great rapidity. The trembler has an armature or soft iron disc held by a spring and mounted over the magnetic core of the induction coil. Attracted by the magnetism in the core another spring with a platinum pin contact is brought into operation. This contact touches a screw, which is also tipped with platinum. When the spring is depressed the contact is broken and the current in the coil ceases, and a spark occurs at the sparking plug. Contact is made again at the platinum points by the little armature suddenly springing back. Again, the armature is attracted and another spark takes place at the sparking plug; this process goes on continuously with great rapidity.

Magneto Ignition.—This kind of ignition is almost universally used for motor cars. The magneto is merely a dynamo or generator, in which the armature revolves in a magnetic field. The magnetism is produced by permanent steel magnets, and the armature in revolving cuts the lines of magnetic force and induces electric current in the armature. The armature is usually a shuttle-shaped piece of iron, or composed of sheet metal discs. A number of turns of copper wire are wound over it, and the two ends of the wire are connected to the collecting rings, which are fixed to the same spindle as the armature. Flexible strips of copper or brushes press gently on these collecting rings or commutator. Wires from the brushes convey the current to the point where sparking is required. Gear wheels or a friction drive keep the armature revolving. Permanent magnets are employed in the magneto, as electro magnets take some time to excite or become magnetic.

Contact Make and Break.—The contact make and break, or commutator, as it is often called, assumes several forms. Some types consist of a steel spring fixed on a small pillar at one end, and having a roller at the other. On this spring is a platinum point, and directly over this is a platinum-tipped screw. A projection or striker on the cam touches the roller at a given time and consequently forces the spring up, so that the platinum points are in contact, thus allowing a current to flow from the battery through the coil. The spring returning to its position breaks the contact, and a spark occurs at the sparking plug. The spring is attached to the base plate, but the contact screw is insulated; non-trembler coils are fitted with this type. Other types are known as the positive make and break, because the contacts are pressed firmly together by a cam. The tension set up in the spring causes separation, and the break makes a spark at the plug. The breaker is of multiple type when more than one cylinder is used, thus enabling each plug to spark in the cylinder at the proper time.

Conductors and Insulators.—Substances are classified according to their power of conducting electricity. The metals come first because they offer little resistance. Silver, copper, aluminium, zinc, brass, tin, lead, antimony, charcoal, and carbon, may be classified as good conductors. Marble, slate, leather, paper, wool, sulphur, oil, gutta percha, ebonite, shellac, mica, and glass, are all insulators or non-conductors.

Sparking Plugs.—These are of simple construction and usually consist of porcelain and metal. They are screwed into the combustion chamber of the engine. A central rod passes right through the porcelain, one end terminating in a point at the "firing" end of the plug, the other is fitted with terminals for attachment to the high-tension wires. A short piece of wire is connected to the brass fitting of the plug, and barely touches the central rod. The spark takes place across this small gap. Numerous types of sparking plugs are in existence, some fitted with protected points, others made so that the spark may take place at two or more points. Some of the latest types are easily detachable, and the points may be examined without unscrewing the plug itself.

Faults in Electrical Ignition.—Amongst the many causes of trouble with motor cars, a goodly number lie at the door of the electrical ignition. It is so easy for a current to find a path of less resistance than the one by which it ought to go. Faults in wiring, induction coil, sparking plug, and commutator may be easily remedied when one has acquired a full understanding of the nature and possibilities of the electric current. Care should be taken that all the surfaces and wires in contact be thoroughly clean and firmly fixed to the various terminal screws. These screws ought to be periodically inspected to ensure their being screwed up tight. With a low-tension current insulation is easily obtained. In many cases the low-tension wires are enclosed in a brass tube with only the terminal ends exposed; this is a plan which is decidedly approved of, as nothing looks more unworkmanlike than loose wires about a car. If left free, these wires are generally the cause of a great deal of trouble. High-tension wires require more care, as the conditions are somewhat different. The insulation in this case is made of thick rubber, and the wire is composed of strands. The wires are enclosed in a metal or vulcanite tube which extends from the coil to the plugs. Care should be taken to keep the wires away from any hot metal or moving mechanical part. The reason for heavy insulation on high-tension wires is that the high-pressure current may jump across a gap to find a path of least resistance. Terminals and contacts should be kept free from oil. When attaching high-tension wires to terminals, remove the insulation for about an inch and peel off the braiding for half an inch, care being taken not to cut the wire. The wires should be cleaned thoroughly with a sharp knife and twisted together to keep them from spreading, or they may be soldered to a metallic connecting terminal ring. The contacts of the sparking plug should be kept clean, surface leakage is sometimes caused by the porcelain part of the plug emitting moisture. When the sparking points of the plug become carbonized by the heat in the cylinders acting on the oil, they should be cleaned with fine emery cloth. The distance between the points should admit of a visiting card being inserted. Faults in the induction coil are likely to take place at the terminals or contact breaker. If the former, this can be easily remedied by looking over the connections and ascertaining if the screws are tight. If the fault is at the contact breaker, it may happen that the contact screw requires adjusting. The platinum points, through time, wear away and require renewal. If they become dirty, the electrical connection will be faulty; they should then be cleaned and filed up square. Enough space must be given for the trembler to move at a given rate. Occasionally the platinum points work loose, and do not give proper contact. In this case they should be riveted up tight. No inexperienced person should be allowed to tamper with the inside of the coil, as its construction is somewhat delicate. The safer and more economical plan is to send the coil to an experienced electrician to be repaired. The commutator sometimes gives trouble; the surfaces in contact must be kept clean. Early sparking may be due to an accumulation of metal dust near the contact piece. This applies specially to the high-tension distributor.

Fault Testing.—When the engine stops, attention should at once be directed to the ignition system, as the majority of minor faults will be usually found there. Take the wires off the plugs and hold by the insulation, turn the engine so as to make contact, and bring the end of the wire near the cylinder. If a bright spark is obtained the fault will not lie on the high-tension side. Examine the battery wires, perhaps a loose screw may be giving the trouble. Sometimes a wire breaks inside the insulation, in this case replace by a spare length of wire. If the sparking plug is suspected, replace by a spare one and examine the old one thoroughly at leisure. Care should be taken to see that the battery is sufficiently charged before running the car. A small voltmeter or low resistance lamp may be used for this purpose. The lamp should be connected across the terminals, and according to the brightness of the light some idea will be gained of the charge in the accumulator. The voltmeter should also be connected across the terminals. If the voltage falls below 1·8 per cell, the accumulators should be immediately charged. If a battery is completely discharged the plates begin to buckle and sulphate, and if not attended to immediately the accumulator will be ruined. The level of the solution or electrolyte should be noted from time to time and replenished by new solution of the proper specific gravity. Occasionally a leak may develop in the celluloid or vulcanite of which the accumulator is constructed. This should be attended to immediately, as the strong acid readily attacks brass and woodwork. The terminals should be kept free from erosion so that a good metallic connection with the wires is ensured. When accumulators have been in use for a considerable time, a deposit is formed in the bottom of the cell, sometimes to such an extent that short circuiting takes place. The magneto system of ignition has decided advantages over the battery of accumulators. Often both are carried, or a set of dry cells instead of the accumulator to start the engine, then the magneto is switched in circuit.

CHAPTER II

THE ENGINE

The Engine and its Cycle of Operations.—The petrol engine works on the same principle as the ordinary gas or oil engine. The feature of the motor car engine is its extreme lightness, small bulk, and great power. The engine consists of several main parts, a combination of which constitutes a complete working machine. In its simplest form the petrol motor has only one cylinder, but by increasing the number of cylinders increased power is obtained, and smoother running is ensured due to the more uniform turning moment of the crankshaft. Each cylinder has a piston moving freely in it, and a connecting rod attaching the piston to the crankshaft. Valves admit the explosive charge and exhaust the burnt gases from the cylinder. These valves are actuated by toothed wheels or cams. During the working of the engine the cylinder is kept at a low temperature by water circulating round the water jacket, were this not provided the cylinder would soon become so hot, due to the constant explosion of the gases, that the piston would "seize" and the engine stop working. The water is kept cool by means of a radiator round the surface of which the air circulates. The cycle of operations form the general working principle of the petrol motor. To begin with, we have the admission stroke when the piston is going down and the inlet valve admits the explosive mixture into the cylinder. On the piston reaching the end of the stroke, the inlet valve closes and no more gas is admitted. Compression of the gas takes place as the piston rises again. By compressing the gas it is made highly explosive, and explodes with much greater force than it would otherwise do if it were in its normal state. At the correct moment, the electric spark explodes the mixture, and the piston is forced down by the explosion and a circular motion is imparted to the crankshaft. On the up stroke again, the exhaust valve opens, and the burnt gases escape through the silencer to the atmosphere. The kinetic energy stored up in the flywheel enables the crank to continue its revolutions until another explosion gives it new momentum. In this way the dead centre is avoided. Part of the engine energy is stored in the flywheel and the remainder drives the back wheels against the resistance to traction. It will be observed that there are four complete operations, each performing a separate function. The suction stroke, when the gas is taken into the cylinder. The compression stroke, when the gas is compressed to about 80 pounds per square inch. The explosive stroke, when the work is done on the piston by the force of the explosion. The exhaust stroke, when the burnt gases are ejected from the cylinder. This is termed the otto cycle, that is, one explosive stroke for every four made by the piston. The openings of the valves at the proper instant is performed by cams actuated by small cogwheels driven from the crankshaft of the engine.

The Cylinder.—It is highly essential that the cylinder be kept in excellent condition, as it is here that the engine power is generated. By excess of petrol and oil a deposit forms which considerably reduces the power and efficiency of the motor. This deposit may be removed by carefully scraping the cylinder walls : if the deposit still continues to be found more air must be admitted with the petrol. This carbon deposit frequently accumulates to such an extent that the cylinder becomes hot and ignition takes place without aid from the electric spark, this is called "self-firing." By cutting off the spark it is possible to tell whether the engine is self-firing or not, if so, use a weaker mixture after thoroughly cleaning the cylinder. The use of wrong oils, or having too much oil, is another cause of deposit. To remedy this inject a little paraffin into the cylinder head through the sparking-plug openings, one at a time, and start the engine and most of the deposit will be ejected through the orifice. To test for leaky valves, put a little soap and water round the suspected place, and turn the engine by hand. Hissing and spluttering will take place at the leak. It often happens that a certain cylinder misses fire, on examination, the plug may be found to be working inefficiently. It may then be taken for granted that the plug in that particular cylinder is in short circuit, caused by dirt or oil inside or breakage of the porcelain. The only remedy is to replace by a new plug. By accelerating the engine, a misfire at any of the plugs can usually be detected. It is much better to test a car on a slight gradient than when standing still. There is a good chemical on the market at the present time for ejecting carbon deposit from the cylinders It may be injected through the sparking-plug orifice.

Overheating.—Overheating may be attributed to one or other of the following causes. Want of water in the tank or circulating system. Too rich an explosive. Insufficient lubrication. Too little radiating surface. Retardation of ignition. Wear of back wheel bearings. Constant use of the accelerator when travelling at slow speed. Air locks in the water pipes. Dealing with the causes given, the first may be detected by the burning of oil or a squeaking noise in the cylinder, probably caused by the piston "seizing." If on examination no water is found in the circulating system, the engine must be allowed to cool before putting in a fresh supply of water, else the cylinder jacket may crack. In the second case, more air must be admitted. A smoky exhaust is often the cause of using too rich a mixture, and this can only be ascertained to any extent when the car is stationary. In the third case, the results are somewhat similar to those of the first, with attendant loss of power. The oil tank and bearings should be replenished. Too little radiation surface forms the fourth cause. This may be an error in the design of the radiator. The general rule for radiators is that the radiation is 7 feet per horse-power, that is the single tube type. With metal tubular radiators the length is about 16 to 20 inches per horse-power. The fifth cause gives loss of power and overheats the engine, the remedy is to advance the ignition point to a position just free from knocking. The sixth cause applies more particularly to cars with live axles, sometimes the brake segments become worn, and extra friction is caused by the segments being relatively lower than the brake-drum. Springs should be fixed to the blocks and bands, so that they may be entirely removed, when the brakes are released by the brake-lever. The seventh cause has its effect on the piston and cylinder owing to the increased piston speed. The purpose for which acceleration should be used is to give an increase of power when required for short periods. The eighth cause is an air lock in the water pipes. An air lock which means the air that has been drawn into the water pipes, makes a small cushion between two bodies of water and thus prevents a free passage. To expel the air from the pipes, open the drain cock and allow the old water to run away. Then put in fresh water, still keeping the drain cock open until the water flows through.

The air is thus driven out of the pipes through the drain cock by the head of water behind it. Every precaution should be taken against overheating, usually caused by insufficient cooling water, bad lubrication, racing the engine for long periods, and running the engine on low gear with forward ignition and much explosive mixture.

Piston Rings.—The piston rings have slots cut in them to allow of their expansion. These slots should be kept as far away from each other as possible, as the gases find their way through them to the other side of the cylinder. When new piston rings are required, the cylinder must be disconnected from the crank chamber, and the pistons carefully removed from the cylinders. The relative position of the slots on the rings should be noted. If they are opposite one another, this would explain lack of compression, as well as lack of power. Sometimes it happens that a ring has become broken, in which case the inside of the cylinder should be examined to see if any abrasion has taken place. The operation of putting on new piston rings usually requires two persons. The ring must first be opened by springing the two ends apart, at the slot. This may be done by reverse pliers, which may be procured for this purpose, or a blunt-pointed tool may serve equally as well. These rings are made of grey cast iron of the first quality, and are brittle, so that they require careful handling. After scraping any deposit from the groove, the ring should be slipped on the piston. Strips of tin placed axially along the piston facilitate the operation of getting the ring into the slot. If the ring is found to be a shade too large, it may be rubbed down by placing it flat on a piece of emery cloth and rubbing. Perhaps a little filing will be required before they can be sprung into the groove, but care must always be taken that a slight space be left at the ends of the piston rings, else "jamming" or "seizing" may take place in the cylinder. After the cylinder has been replaced, the engine should be run for a short time with plenty of lubrication. Provided the rings have been properly fitted, and the engine well lubricated, it is possible to cover thousands of miles before renewal of piston rings is required again. Trouble from piston rings is less frequent with cylinders of large diameter than small ones.

Valves.—It is necessary to see that the springs in the automatic ignition valves are not too strong, nor too weak. If the former, insufficient mixture during the suction stroke will take place. If the latter, some of the explosive mixture on the compression stroke will leak past the valve. A spare spring should always be carried, they often wear and lose their power by the heat developed in the cylinder. Mechanically operated valves are more satisfactory; they do not depend for their action upon springs. The valve, in this case, is opened at a given point, and shut with equal certainty. Valves made of nickel steel are preferable to the ordinary valves, as it is almost impossible to fracture them, and they seldom require grinding. When grinding the valves, the utmost care should be taken to prevent emery dust entering the cylinders. The valve seat should be well cleaned with paraffin after grinding. Should a valve break and get into the cylinder, the broken parts may be got out by the use of a permanent magnet suspended to a piece of wire. The valve parts are numbered by the makers, and they must be put back in the same position with the corresponding numbers. In removing the wheels, which regulate the action of the valves, small marks should be made so that they may be put back in the same position. It frequently occurs that a valve stem becomes short owing to the knocking action of the tappet against the end. In course of time this shortening will cause incorrect firing, and the timing and lift will be altered. When a case like this occurs, the valve stem may be lengthened in the following way. The bottom of the stem is softened, and a small hole drilled axially in it, and tapped with a screw tap. A cheese-headed screw of the same diameter of head as the valve spindle is screwed into the tapped hole. This will give sufficient length to the valve stem. The screw head may be case-hardened. Another way is to braze a piece of tool steel to the end of the stem.

Crankshaft and Crank Chamber.—The smooth running of an engine depends to a large extent upon the crankshaft bearings being in a true line, or technically "correct alignment." The bearings should be adjusted from time to time to take up any wear. It should be remembered that the force of the explosion is resisted by the crankshaft bearings, and so slackness is bound to take place at the bearings through wear causing the engine to knock. A knock is developed when one end of the crankshaft is higher than the other, and the mass of crankshaft and flywheel rotates from side to side. The remedy is to make the lower brass higher so that the shaft alignment is true; in other words, the piston rod and crankshaft to be at right angles to each other. The causes usually ascribed to knocking are loose bearings, or an unlubricated piston, but it often occurs that the seat of trouble has been found in other parts, such as a twisted crankshaft or want of clearance between the valve stem and tappet. A thick deposit of carbon on the top of the piston and walls of the cylinder may cause a knock. Advanced ignition also causes a knock. An air outlet pipe is usually fixed to the crank chamber; this pipe should be made long enough to prevent the oil from being blown out. Air pressure in the crank chamber is caused by the crank revolving at a high speed, and the suction of the pistons on the upward stroke. If the air pressure is excessive, an examination of the piston rings should be made; they may be worn out and require renewal. Water in the crank chamber is often the cause of annoyance, and may be caused by a crack in the water jacket, or water finding its way through the inspection door in the process of cleaning. The majority of crank chambers are divided in the centre by a partition to prevent the oil rushing to one side or the other, depending upon whether the car is ascending or descending a hill. In my own experience with an American car, I found on descending a steep gradient that the oil flowed to the fore cylinders and flooded them, while the cylinders nearest the steering-wheel were almost dry. A partition fitted in the crank chamber by the makers would have obviated this fault. It might not be out of place here to describe what is meant by a "back fire." A "back fire" is an explosion which tends to drive the engine the reverse way. It does not happen that the engine will be reversed every time, as the engine power may be sufficient to overcome the reverse force. By advancing the spark too far when the engine is running slowly, a "back fire" may be caused, also by shutting the throttle and ignition when running at high speed. A "back fire" sometimes takes place when starting an engine if the spark lever is not at the retard position on the arc. This causes an early explosion to take place, and serious accidents have happened by the starting handle springing in the reverse direction.

Setting Valves and Timing Ignition.—The timing of the engine has always been a stumbling-block to many motorists. Let us suppose the engine is fitted with inlet valves of the mechanically operated type, and fitted on the opposite side of the cylinders to the exhaust valves. A mechanically operated inlet valve should begin to open immediately following the shutting of the exhaust valve, and the proper instant for the valves to operate is when the piston is exactly at the top of the cylinder. Let us turn our attention to the fore cylinder only, because, if one is properly timed, the timing of the others is bound to be correct. Take off the compression tap on the top of the combustion head, push a cycle spoke or wire through the opening until the piston is felt to be at the top of the cylinder. The large pinion connected to the inlet cam shaft should now be turned in the reverse direction to the rotation of the crankshaft until the front inlet valve begins to open. This is all that is required for the inlet valves. Now, turn the exhaust cam shaft in the same direction as the inlet until the exhaust valve shuts, then mesh the small pinion with the two large wheels. Most makers provide marks on the flywheel of the engine indicating when the piston is at the top and bottom of the cylinder; the gear wheels are also marked in some cases. In the multi-cylinder type of engine care should be taken to connect the high-tension wires, after returning, to the correct cylinders, else they will fire at the wrong time. In timing an engine fitted with magneto, the armature should be a degree or two past the maximum position. Note that the low-tension contacts are about to separate when the piston in any of the cylinders is at the top of the explosive stroke, and the ignition about one-third advanced. Mesh the pinions, and gear the chain at this position; the timing of the distributor does not require altering, as it is driven as a separate unit.

Specification of Rolls-Royce 40–50 H.P. Chassis.

Engine.—The engine is of the six-cylinder vertical type (having cylinders of not less than $4\frac{1}{2}$ in. × $4\frac{3}{4}$ in.), developing approximately 48 h.p. at 1200 revolutions per minute.

Valve Lifters.—The induction and exhaust valves are operated by means of rocking levers pivoted at one end, and fitted at the other with a roller lying between the valve spindle and the cam. These levers are fitted in pairs, one inlet and one exhaust, mounted on one base, and attached to the crank chamber by studs. The introduction of the roller and lever eliminates the side pressure exerted on the lifter slides when cam and tappet rod come into actual contact. The side pressure, which is now taken by the pivot on which the lever hinges, cannot cause the tappets to stick or wear unduly sideways.

Engine Suspension.—The engine is suspended on the frame by a patented device, which allows the members of the frame relative movement to one another for the negotiation of rough roads without involving extra strain on the arms of the crank chamber.

Cylinders.—The cylinders are cast complete in groups of three, there being no internal joints to maintain or leak. Cast iron of a hard and close grain is employed to ensure a good wearing surface. The valves are arranged along one side of the engine and are operated by a single cam shaft. The inlet and exhaust valves, which are of nickel steel, are similar and interchangeable.

Crankshaft.—The crankshaft is cut out of a hard and tough *solid forging* of nickel steel, machined on all the surfaces with a view to ensuring soundness. The bearing surfaces both of journals and pins are of exceptionally liberal proportions in order to reduce the wear to a minimum, and at the same time to obtain a rigid shaft. The shaft is carried by the largest possible number of bearings to prevent the possibility of deflection, there being one bearing on each side of every crank.

Bearings.—The bearings both for the journals and pins have an anti-friction lining carried in a phosphor-bronze bush, and in each case are provided with "liners" in the joints to facilitate the adjusting of the bearings for wear.

Lubrication.—Forced lubrication is provided for the engine, the oil being supplied by a positive valveless pump specially arranged to give a constant pressure of oil. The pressure may be regulated from 1 to 20 lbs. per square inch, by a simple adjustment, and thus the quantity of oil delivered to the engine may be varied. The pump is driven from the crankshaft through gearing. The oil is delivered to the three main bearings, and is forced through them and along channels drilled in the shaft to the connecting rods and the smaller intermediate bearings. It is taken to the small end bearing on the connecting rod by means of a copper pipe, connected to the big end bearing, through which oil is forced. An extra supply of oil, the means of controlling which is covered by a patent, is provided for the cylinder walls when the engine is working with the throttle almost or fully open. The supply of oil is controlled by a valve which is interconnected with the mechanism operating the throttle.

The oil is collected in the base of the engine and is passed through a large filter before it is again passed through the bearings. There are no "drip feeds" to watch and adjust.

Crank Chamber.—The crank chamber is of cast aluminium, and is in halves jointed horizontally, the upper half carrying the complete bearings for the crankshaft, so very materially assisting to ensure perfect lubrication and alignment. The lower half of the crank chamber is so made as to be readily detachable for the purpose of inspection, or for taking up the wear in the bearings or big ends, which may be accomplished without dismantling the engine.

Cams.—The cams on the half-speed shaft are not separate pieces attached to the shaft, but are part of it, the whole being machined from a solid bar of steel, and afterwards carefully case-hardened. They are driven by completely enclosed spur wheels, with a view to ensuring good lubrication, silence, and protection from dirt.

Carburetter.—The carburetter is of the float feed spray type, fitted with a special patented automatic valve, which accurately adjusts the carburation for all speeds of the engine, and enables the engine to run "dead-slow," with a maximum of torque when required. A throttle is provided to enable the gas to be shut off by the governor when descending hills, or when the speed becomes excessive. A means of adjusting the jets from the driver's seat is also provided on the steering column.

Control.—The control of the engine is secured by the use of a sensitive and efficient centrifugal governor acting on the throttle before mentioned. This governor is capable of maintaining the car at almost any speed, from a walking pace up to the maximum speed of the car, the desired adjustment being effected by the hand lever on the steering wheel. Provision is also made for accelerating to the maximum by using the driver's foot pedal.

Fuel Pressure System.—The petrol is carried in an elliptic tank at rear of chassis, and is pressure-fed to carburetter. A power pump, driven from the countershaft of gear box, supplies filtered air to the tank, the pressure being regulated by a valve under the loose footboard and indicated by a pressure gauge on the dash. A hand-pump, also mounted on the dash, provides pressure for starting, or at any time, and is connected as required by a three-way tap on the nearside of frame. The petrol tap is situated on the off-side of chassis.

Ignition.—Two complete independent ignitions are provided, high-tension with trembler coil and accumulators, and high-tension magneto.

The accumulator ignition is of a special design, known as the improved Rolls-Royce synchronized ignition. It is of the high-tension type, two independent sets of accumulators being provided, each of about 60 ampere hours capacity, and each of which should, when fully charged, be capable of running the car 400 miles. This system of ignition has been adopted because of its extreme simplicity and the ease it offers in restarting the engine, which if the engine is warm can usually be done by merely turning the switch, without the necessity of the driver leaving his seat.

The distributor for the accumulator ignition is fixed on the front of the engine under the bonnet in an accessible position. The low-tension make and break is made on platinum points by means of a cam, whilst the high-tension contact is made through a revolving platinum contact to stationary points. The "timing" is effected by revolving the body of the distributor. The distributor spindle is mounted on ball bearings.

The induction coil, with single trembler, is of a special type. It is designed to be very economical in current, and to work perfectly at the highest speeds.

The Rolls-Royce Company fit two distinct equipments, each of which is entirely independent of the other. The system allows of either magneto or accumulator ignition or both being used. The magneto is of the high-tension type, which does not require a coil. A distributor is mounted on the magneto for the magneto ignition. The magneto is driven through gears from the crankshaft.

Two ignition plugs are provided to each cylinder—one for the magneto ignition, situated over the exhaust valve, and the other, for the accumulator ignition, situated over the inlet valve.

Radiator.—The cooler is made up of thin vertical corrugated tubes, through which the water circulates. Its appearance is as neat as that of the "honeycomb" type, and it is without the disadvantage of an enormous number of soldered joints, which, sooner or later, through expansion and contraction of the mass, are apt to give way and leak, as well as being practically impossible to repair in case of accident.

Fan.—A fan is placed behind the cooler to prevent the water from boiling. The fan is driven off the engine by a special belt, which is easily adjustable. The fan spindle is mounted on ball bearings.

Water Pump.—The circulating pump is of the centrifugal type, and is driven from the crankshaft through spur gears in such a manner as to minimize wear in the glands or bearings. The rotating portion of this pump is practically in equilibrium.

Clutch.—The transmission clutch is of the internal cone type. It is of very large diameter with a wide face, and the "external" is made up of a heavy section of the fly-wheel, to ensure the friction surfaces remaining sufficiently cool even though, through imperfect operation, the clutch may be required to slip considerably.

The clutch is an extremely "gentle" one to operate, and requires very little pressure on the clutch pedal. The spring is of special pattern, to give practically constant pressure throughout its range. No end pressure is exerted on any of the rubbing faces when the clutch is in the transmitting position. The clutch is self-contained with a view to ensuring concentricity, and is connected to the change-speed gear-box by a patent oil-retaining universal joint, the wearing surfaces of which are hardened.

Gears.—The change-speed gear is of the sliding gear type, "gate" change, with three forward speeds and one reverse, with a "direct drive" on the third speed. The normal gears are so arranged that the car can run up all moderate hills without changing off the "direct drive," and a sufficient reduction is allowed when running on the second gear for the car to mount steep hills without further change being necessary. Care has been exercised to make, wherever possible, the parts from solid forgings of specially tough steel. All wearing parts are case-hardened, and are ground to proper dimensions after hardening.

Foot Brake.—The foot brake is of the external clip type, having metal-to-metal faces, and is effective in either direction.

It is situated at the end of the gear-box and acts through the differential gear. A hard steel drum of very large diameter is used, providing ample wearing surface. The levers carrying the brake blocks are drawn together by a lever on a floating fulcrum. The brake is so arranged that the pull applying the brake reduces the reaction of the brake on the bearings, and thus relieves the gear-box bearings of a considerable portion of the load which is imposed on them by the usual type of brake. The straps are also anchored in such a manner that to whatever state the brake has worn they will always grip the brake-drum evenly without straining any of the fixings.

Hand Brakes.—The hand brakes are of the internal, expanding, double-acting type, being applied by expanding two curved levers (expanding clip) within a drum, which, in its turn, is an integral portion of driving wheel hub. One such brake is fitted to each rear wheel.

A special design of balanced and adjustable toggle is used to expand the clips, which adjustment together with an additional provision—external to the brake drum and readily accessible—gives an easy and ample range of movement to the shoes. Special attention has been paid to the wearing surface of the toggle and for its adequate lubrication.

The brakes are equally effective in either a forward or backward direction. No material is used in the construction which will char, and so reduce the brake power through heat, and the clips are supported and held off the brake drum so as to be quite clear of it when the brake is in the "off" position, and to prevent rattling. Special care has been taken in the design to prevent oil obtaining access to the faces of the brake. These two side brakes are compensated by means of a differential gear.

Front Axle.—The front axle is a solid forging of chrome nickel steel, and in each end is fixed a substantial hardened pin upon which the stub axle is carried. The stub axle is a nickel steel forging, and has mounted on it the ball bearings on which the road wheels rotate. Considerable trouble and care have been expended to render this pivot waterproof.

The load of the vehicle is taken on two ball thrust bearings, to render the steering easy.

A special hub is used for the road wheel, which is oil-retaining and dirt-excluding.

The levers which control the road wheels and the method of fixing (which is patented) are designed with a view to obtaining the strongest and most reliable construction.

Steering.—The steering is by means of a steel worm working in a phosphor bronze nut, provision being made for taking up any wear in the nut. The lever spindle runs on ball bearings, and large bearing surfaces are provided for all wearing parts.

Rear Axle.—The rear axle is of the type specially commended by the judges of the Royal Automobile Club in their report on one of their reliability trials. It is of particularly strong construction, consisting of a central substantial steel case containing the bevel gears and the differential, and attached are two solid drawn steel tubes, flanged and bolted to the steel case.

Upon each of these solid drawn tubes is mounted a road wheel which revolves on ball bearings. Inside the tube is the revolving shaft driving the road wheel from the differential situated in the bevel gear case.

The diameter and proportion of these flanged axle tubes are such as to render the axle light, and at the same time so rigid, that a tie rod is unnecessary.

On the ends of the driving shafts are machined solid keys, and on the keyed portion is fitted a jaw clutch which engages with suitable teeth cut in the outer edge of the road wheel hub. This construction utilizes the great strength afforded by the large diameter of tube, and avoids the bending strain set up by repeated reversals which is developed in axles of the revolving type, which, with heavy cars, entails great risk of fracture without warning. It also compensates by the use of the jaw clutch for wear which may arise between the road wheel hub and the axle.

It will thus be seen that in this system the live axle carries no weight, and is therefore subjected practically to no greater strain than the cross shaft of a chain-driven car.

Situated in the central steel case is a bevel wheel which is of large diameter, and is turned from a solid forging of tough steel, and has its teeth planed (out of the solid) by a machine which produces teeth of a high degree of accuracy. The pinion working with this bevel wheel is also turned out of a tough steel forging. The bevel gears are carefully case-hardened.

The pinion and shaft are carried by two large ball bearings, arranged with a view to ensuring the bevel teeth being exactly parallel with one another, and so increasing the efficiency and reducing the wear.

Balls of large diameter are used to take the end thrust of the bevel gears, and the bevel wheel is mounted on ball bearings. The axle and wheel hubs are arranged to form an oil-retaining and dust-excluding case.

Suspension.—The chassis is hung on six springs, two at the front and four at the rear, which provide a most luxurious suspension to the car. The front springs are semi-elliptic, and the rear ones three-quarter elliptic.

The springs are very long and exceptionally flexible by reason of their being made up of a large number of thin plates, instead of a small number of thick ones. The ends of the springs are bushed, and run on hardened bolts of ample diameter. All spring bolts are provided with a grease lubricator.

The heads of the spring bolts are of a shape which positively prevents the bolt from rotating in the shackle, and forms the subject of a patent.

The prevention of the bolts from moving in the shackle eliminates wear, and consequent slack between the shackle and bolt.

Shock Absorbers.—The shock absorbers, of the friction type, are provided with large coil springs, which compensate for wear of the friction surfaces and maintain an equal shock-damping effect at all times with a minimum of attention.

The connections between the shock absorbers and the axles embody ball and socket joints, the balls being of hardened steel and the sockets of bronze. The joints may be readily lubricated by means of the greasers provided.

Frame.—The frame is of a special pressed steel pattern, being deepened in the centre to prevent deflection, and is long enough (102 inches behind the dashboard) to provide satisfactory and roomy carriage work, the wheels being placed well back for this purpose.

Tyres.—Grooved Dunlop, unless otherwise arranged.

Wheels.—The wheels are of the artillery pattern, with wooden spokes.

Equipment.—Every chassis is supplied complete with wheels, bonnet and tyres, and includes the following spare parts :—1 complete valve with spring, cotter and collar, valve lifter, assortment of spare nuts, spring washers and split pins, 6 sparking plugs, 6 copper and asbestos washers for above, 1 hammer, 1 screwdriver, 1 pair pliers, 1 file and handle, 1 oil-can, set of box keys and "tommy" bar, 1 small adjustable spanner $5\frac{1}{2}$ inches long, 1 large adjustable spanner 10 inches long, also a complete set of fixed spanners, 1 platinum-tipped blade for trembler, 1 platinum-tipped blade for commutator, 1 platinum-tipped screw for trembler, 1 platinum-tipped screw for commutator, platinum point file, spark gap gauge, 1 hub cap spanner, 1 hub ring spanner, 1 valve cover spanner, 1 key for joints of exhaust box, 1 petrol tank filler spanner, 1 oil syringe, 1 tube for spanners, 1 wedge for use when lubricating springs, front number plate clips.

General.—Ball end thrust bearings are used whenever it is considered that end pressure would otherwise be likely to cause trouble through collar friction. These require little or no adjustment, and are very satisfactory.

Great care has been taken, both in the general design and construction, to ensure the utmost reliability and simplicity, and with this aim in view, a great many parts, as will be noticed in the description, are made from solid forgings at greatly increased expense, to reduce the number of keys, bolts, and other fixings, and to obtain the maximum strength for a given weight.

PARTICULARS OF THE 40-50 H.P. ROLLS-ROYCE CHASSIS.

Cylinders, Number of	6
Bore	$4\frac{1}{2}''$ 113 mm.
Stroke	$4\frac{3}{4}''$ 119 mm.
H.P. at 1200 revs. (approximately)	48
H.P. according to Royal Automobile Club Official Rating	48·6
Total length over all	195″
Width of frame.	36″
Wheel Base	$113\frac{1}{2}''$
Wheel Track	56″
Length of Frame behind Dash	102″
From Dash to centre of Back Wheels	92″
Tyres of Front Wheels	895 mm × 135 m.m.
Tyres of Rear Wheels	895 mm. × 135 mm.
Weight with Tyres	$23\frac{1}{4}$ cwt.

The Napier Car.

This car, illustrated in Figs. 4, 5, 6, and 7, is built in five different powers, ranging from 15 H.P. up to as much as 90 H.P. The 15 H.P. has a four-cylinder engine, whilst the other models have six-cylinder engines, which in high-powered cars give greater smoothness and flexibility than can be obtained from a big engine having only four cylinders. The six-cylinder Napier was introduced as early as 1903, since when the principle has been widely adopted by other makers.

In each type of Napier engine the cylinders are cast in pairs, and the crankshaft has a bearing between each pair of cranks. The inlet and exhaust valves are interchangeable in each type, and are on one side of the engine.

Lubrication is effected by an enclosed rotary pump which takes the oil from the pump under the crank case and forces it through oil-ways drilled in the crankshaft leading to the bearings. This system is positive acting, and prevents all emission of smoke from the exhaust.

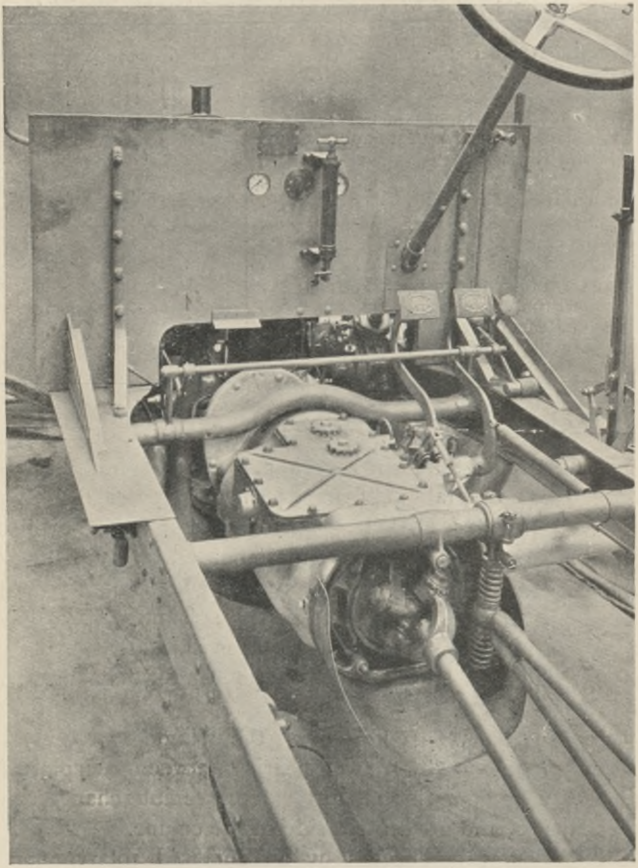

FIG. 4.—Napier Gear-box.

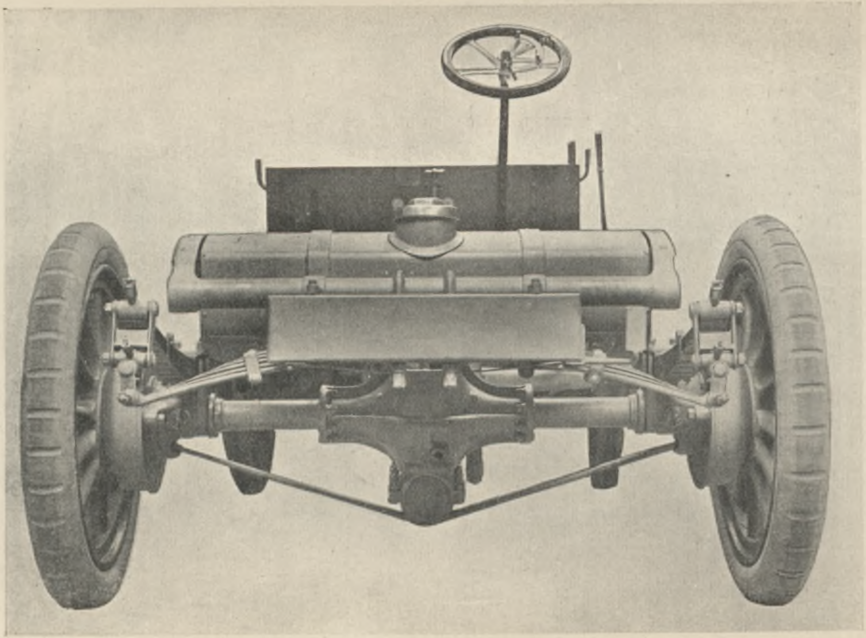

FIG. 5.—Back view of Napier Chassis.

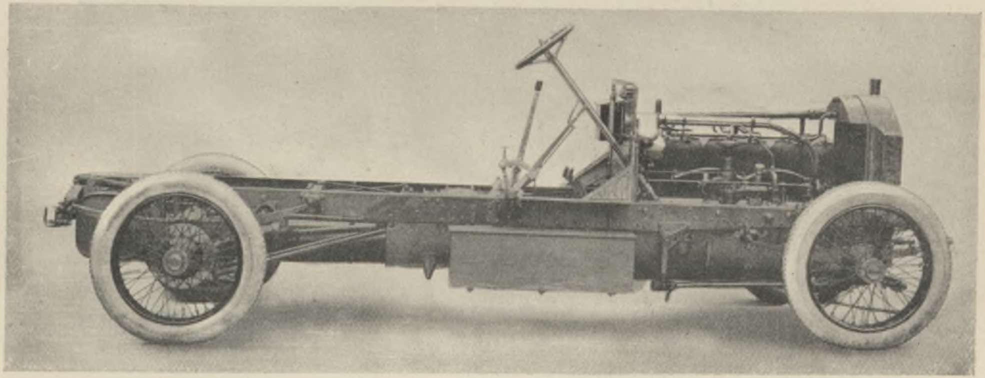

Fig. 6.—Elevation of Napier Chassis.

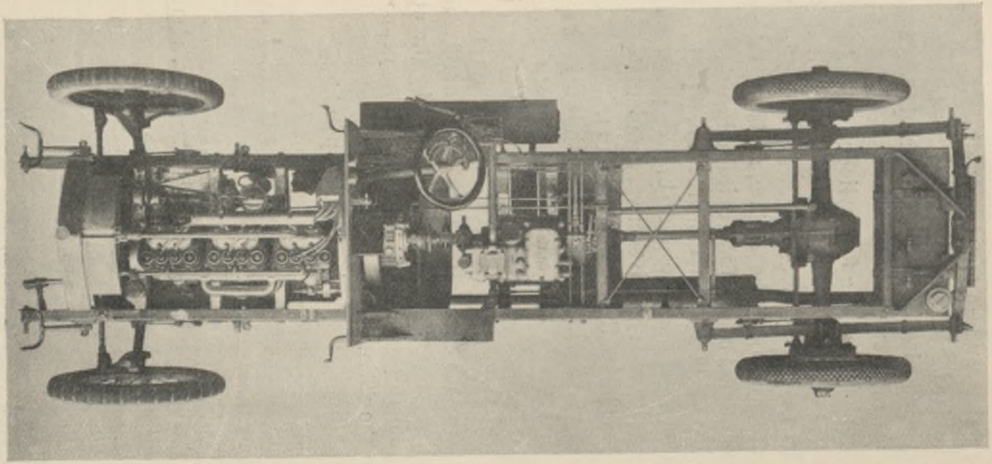

FIG. 7.—Plan of Napier Chassis.

In the 15 H.P. and 30 H.P. models, magneto ignition is fitted as a standard. To the 45 H.P. and higher powers a special synchronized system with accumulator is fitted in addition to the magneto.

Water circulation in the four-cylinder types by thermo-syphon, except in the model specially designed for hot climates. In the six-cylinder engines it is effected by a turbine pump driven by the engine, as is also the case in the above-mentioned model for tropical climates.

The clutch is of special construction, consisting of a number of thin steel and phosphor bronze plates within an oil containing case. This gives a very smooth engagement, and slip may be allowed without detriment.

The gear-box, a view of which is shown in Fig. 4, is simple and of sound construction. The gear shafts are of large diameter and are mounted on roller bearings, in the case of the 15 H.P. and 30 H.P. types; on the other models ball bearings are used. Three speeds and a reverse are provided, the top speed being obtained by direct drive from the engine to the back wheel axle. The gear wheels are cut from the solid. The shafts have castellations cut in them, and the gear wheels have corresponding grooves to slide on them. Each gear, when in mesh, is held by a special locking mechanism, and cannot get out of engagement except by movement of the driver's lever.

Both back and front axles are of special "unbreakable" steel. The front is "H" section, and the back, shown in Fig. 5, consists of casing carrying the two spring seats and enclosing the driving shafts and differential gear. The shafts are mounted in ball and roller bearings, and the differential and driving bevel gears are cut from the solid, as in the case of the change-speed gear wheels.

The propeller shaft is fitted with a universal joint at each end, the wearing surfaces of which are of hardened steel and of large dimensions. The forward universal joint may be clearly seen in Fig. 4.

Brakes are metal-to-metal throughout; those at the back are of the internal expanding type, and are actuated by the lever at the side of the driver, whilst a very powerful foot brake is provided to the main driving shaft of the gear-box.

The suspension is by very long and flexible road wheel springs. Several models are fitted in addition with a transverse back spring. This latter is shown very distinctly in Fig. 5.

Fig. 6 shows an elevation of 65 H.P. six-cylinder Napier chassis, and Fig. 7 shows plan of 45 H.P. six-cylinder chassis.

The Daimler Sliding Sleeve Engine.

(20 *and* 30 *H.P. Models.*)

This engine has the cylinders cast in pairs, the bore and stroke being 90 × 130 mm. in both cases, the 20 H.P. model having four, and the 30 H.P. model six cylinders. Detachable heads are fitted, the water jackets in these being supplied from the cylinder jackets by an internal connection which dispenses with the necessity for external connecting piping. The centrifugal water pump, and the dual type magneto, are driven from a cross-shaft placed transversely at the front of the engine, and driven by spiral gears from the eccentric shaft. A silent chain transmits the motion from the rear end of the crankshaft to the eccentric shaft. The crankshaft itself is ground up from a solid chrome-nickel steel stamping, and, in the engine, a bearing is provided between each throw.

The cycle of operations is the usual four-stroke. The crankshaft, connecting-rod, piston and cylinder are similarly arranged to the parts in a standard engine, but the novel and essential feature consists of the interposition of two cylindrical sleeves between the piston and the cylinder. These sliding sleeves move up and down over a small

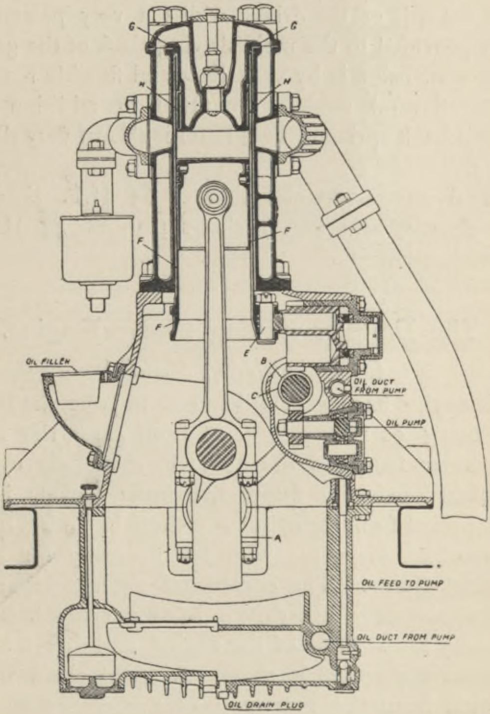

FIG. 8.—Sectional View of Daimler Engine.

travel, their motion being communicated by short connecting-rods which are in turn operated by an eccentric shaft turning at half the speed of the crankshaft. In the sectional view, Fig. 8, the two sleeves are denoted by A and B, while the actuating rods are C and D, worked by the eccentric shaft W. In the cylinder, two large ports will be observed, the one marked I being the inlet port, and G the exhaust port. The sleeves in their turn are provided with circumferential ports, the inlet ports being indicated at H, and the exhaust ports at F. When the motion of the sleeves brings the two sleeve ports H into line with the cylinder port I, the gas from the carburetter has free entry into the cylinder. Similarly, when the exhaust ports F register with the cylinder port G, the burnt gas can be expelled from the cylinder.

Let us take the important "events" of the cycle in order, and examine the relative positions of the sleeves with respect to the piston and cylinder. When the inlet valve is on the point of opening, the piston is, of course, just starting its downward stroke. The inner sleeve is moving upwards, and the outer sleeve downwards, and the two sleeve ports are rapidly coming into line with the inlet port of the cylinder.

By the time the piston is halfway down its stroke the inlet ports in the sleeves have come fully into line with the cylinder port, so that there is a clear opening for the gas to be drawn in.

As the piston reaches the bottom of its travel, the sleeves move upwards, till, when the piston begins to return on its compression stroke, the port in the inner sleeve is no longer in communication with the cylinder. The exhaust port is also closed, and therefore the gas is compressed by the rising of the piston.

Explosion point corresponds, as far as the position of the piston is concerned, to the point of opening of the inlet valve during the preceding downward stroke. But now both of the ports in the inner sleeve are securely sealed by the pressure of the broad junk ring situated at the bottom of the cylinder head. Thus the explosion expends its full energy in driving the piston downward.

When the piston has descended about three-quarters down on the power stroke, the downward movement of the sleeves brings the inner ports from behind the junk ring in the cylinder head, and as the exhaust port in the outer sleeve is already in line with the cylinder port, the exploded gases can escape from the cylinder.

The exhaust ports in the sleeves soon come fully into line with the cylinder exhaust port, and before the piston begins to ascend on its exhaust stroke the major portion of the burnt gases has already escaped from the cylinder. When the piston reaches the top of the stroke, the outer sleeve has moved down so far that the exhaust port is closed and the inlet is again opened. This completes the cycle of operations.

The pistons are of cast iron of close grain, while the sleeves are made from a very tough grade of iron. White-metal lined bearings are fitted to the connecting-rod big ends, the gudgeon pin bearings being of hardened steel.

Each pair of cylinders is connected by an aluminium inlet pipe branch to the carburetter. On the other side of the engine a separate exhaust port for each cylinder communicates with the large silencer, which lies along the rear portion of the frame.

A few words as to the lubrication. The pump, troughs, and all parts of the system are connected to the top half of the basechamber, the bottom half simply acting as an oil reservoir. The pump draws the oil, which has been previously filtered, out of the base and forces it through separate pipes to a series of troughs placed beneath the connecting-rods, scoops on the ends of which splash the oil to every bearing. An additional refinement is provided by hinging the troughs and connecting the actuating lever to the throttle control, so that the level of the oil is raised whenever the throttle is opened. Thus the supply of oil is automatically varied in accordance with the work which has to be done. A sight gauge is, of course, placed on the dashboard to keep the driver informed as to the oil circulation.

Two other engine components which call for notice are the patent "vibration-damper," fitted to the six-cylinder models to prevent the occurrence of the periodic tremor to which long six-cylinder crankshafts are liable, and the air pump, which forces the petrol from the rear tank to the carburetter. Fig. 9 shows general arrangements of 30 H.P. six-cylinder Daimler engine.

Turning next to the transmission, the well-tried leather cone clutch is fitted, and connected to the gear-box by a new form of balanced flexible coupling. Four speeds and reverse are provided. The gate change-lever has a side-rocking motion; this is easier in operation than the sliding type. A special sliding universal joint is placed behind the gear-box so that the rear flexible joint has no sliding motion. This re-arrangement has been found to give smoother running on rough roads.

Final drive is by worm, which is placed below the axle. To reduce the work imposed on the universal joints, the engine and gear-box are slightly inclined, so that the drive from crankshaft to wormshaft is in a straight line when the car is normally loaded.

The brakes are of the external band type, the foot brake being situated at the rear wheels and the hand brake on a drum at the rear of the gear-box.

The special features of the springing are the swivel shackles at the back ends of the front springs, which relieve the frame of side twist when the axle rises obliquely, and the auxiliary spiral springs at the rear of the car.

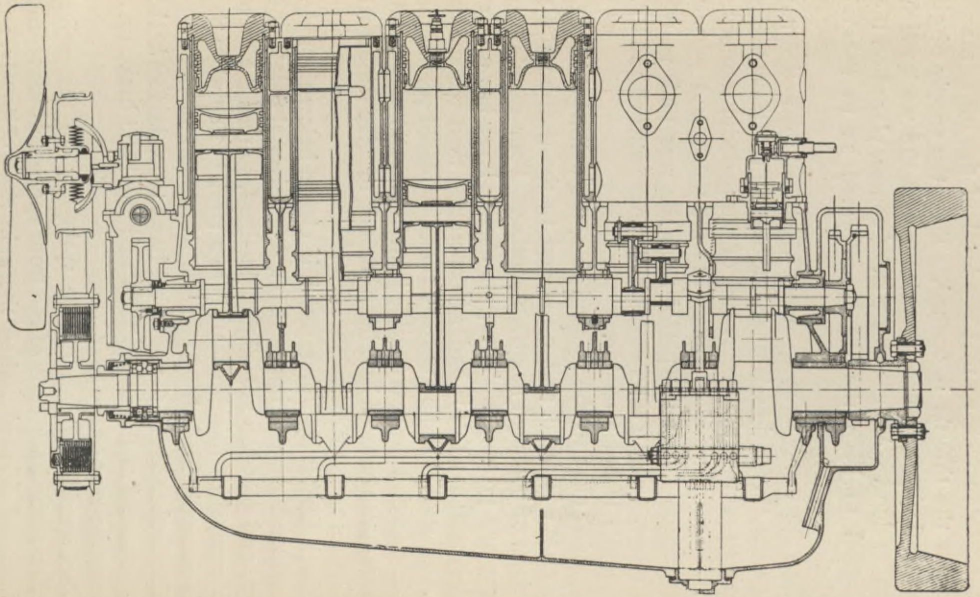

Fig. 9.—General arrangement of 30 h p. Daimler Engine.

The 25 H.P. Single Sleeve Argyll Engine.

The new type of valve known as the sleeve-valve is becoming a serious rival of the hitherto unchallenged poppet type. Its original drawbacks have gradually been removed, and cooling and lubrication troubles eliminated by the usual process of carefully watched experiments and tests. Once efficient lubrication and cooling are obtained, the large bearing surfaces in valves of this type render the parts practically free from wear.

The new Argyll design differs from other sleeve-valve engines, in that it has only one sleeve. The mechanism is very simple, the moving parts consisting of a single vertical sleeve working between piston and cylinder, and its operating disc and pin. The general arrangement is shown in Fig. 10, which is a vertical cross-section through the engine.

The sleeve F is about $\frac{1}{8}$ inch thick, and is longer than the cylinder walls, extending below them sufficiently far to allow of a pair of lugs being formed on it, one vertically above the other. These carry the flattened end of a pin by means of a fitted bolt E, so that the pin is free to swing radially in a horizontal plane. Opposite the pin is a disc rotated by a worm B on the lay shaft C, and into an eccentrically bored hole in this disc the pin slides. The hole in the disc is approximately $\frac{5}{8}$ inch out of centre, the "throw" of the eccentric thus being about $1\frac{1}{4}$ inch. The lay shaft is geared to the crankshaft by a chain.

As the disc rotates the pin actuates the valves, giving it an elliptical movement, a complete ellipse being described once every two revolutions of the crankshaft. Thus the sleeve has not only a reciprocating movement, but an oscillatory movement of nearly the same amplitude. This combined movement has an advantage over either of the movements alone, there being no abrupt change of direction,

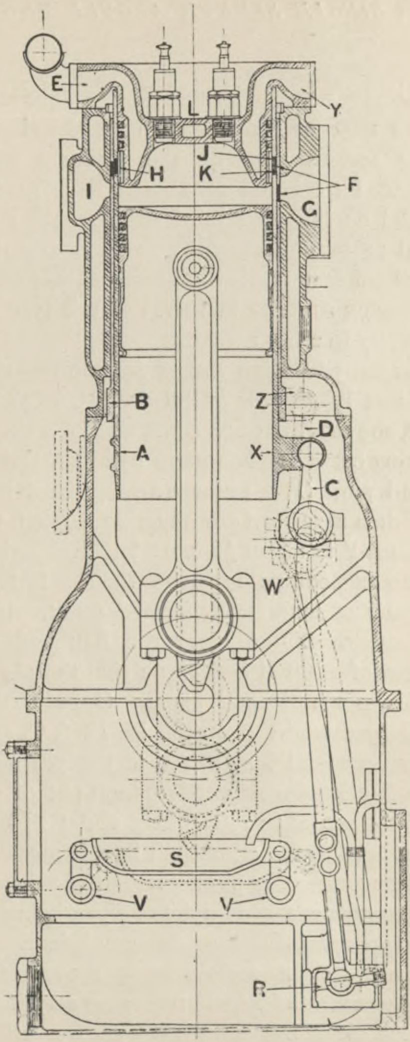

FIG. 10.—Vertical Cross-section of Argyll Single Sleeve Engine.

consequently the action is smooth and the oil film is effectively retained. The pin swinging horizontally about its pivot on the sleeve has a small movement backwards and forwards in its hole, thus acting as a pump and automatically distributing the oil over itself and its pivot.

There are six ports in the cylinder wall, three for the inlet and three for the exhaust. There are only five ports in the sleeve, one of them doing service both for inlet and exhaust. Quick opening and closing of the exhaust ports is obtained by arranging that they begin to open just when the sleeve is in the fastest part of its downward travel, and begin to close when it is in the fastest part of its axial motion. The inlet ports are arranged in a similar manner.

The sleeve when at the top of its stroke, projects about four inches above the cylinder head, which latter takes the form of a pocket, or hollow plug fitting down inside the sleeve. A small flange rests upon the end of the inside wall of the cylinder, making a water-tight joint with it. The bottom of the cylinder head is domed, the sparking plug being placed centrally in the top of the dome. The jacket water has free passage into the interior of the cylinder head, thus ensuring efficient cooling. The gas tight joint between the sleeve and cylinder head is obtained by two rings, the upper one of the ordinary piston ring type, the lower one a junk ring about $1\frac{3}{4}$ in. deep. Lubrication of the sleeve is obtained by a double set of spiral oil-grooves on its outer surface, with special arrow-shaped grooves between the ports.

Turning now to the engine itself, it will be seen that the crankshaft, connecting-rod, and piston are of the usual type. The piston has holes drilled in the trunk to allow oil to reach the sleeve. The four cylinders are cast in pairs. The bore is 100 mm., and the stroke 130 mm. The lubrication is of the forced feed type. The oil, after being led direct from the reservoir to all bearings, returns through a filter to be used over again. A constant oil level is maintained for the connecting rods under all road conditions. A special tell-tale on the dashboard enables the driver to feel whether the oil is circulating satisfactorily, as well as see, this contrivance being very useful in night driving. The water pump, radiator, and fan are ample, but present no unusual points of interest.

The chassis, however, has several interesting features. All four wheels are braked, and all brakes can be operated simultaneously, either by hand or foot, or both together. Each brake is adjustable, or the whole four may be adjusted together. The pull on the brake actuating rods is taken diagonally from front to rear hubs, and the operation is compensated to ensure even application all round. The special feature in the brake mechanism is the method of providing the universal joint which is necessary to accommodate the varying angle of the front wheels to the frame proper. The braking of all four wheels makes use of all the weight of the car in obtaining a grip on the road, besides the fact that braking the front wheels does not cause the skidding which is often the outcome of braking the rear wheels.

Fig. 11 shows plan of new Argyll chassis.

Steam Cars.—The steam car is quite different from the popular petrol car. The power in this case is generated on a different principle. A high-pressure boiler generates steam, and a twin-cylinder engine utilizes the energy by expansion of the steam in the cylinders in the same way as in the ordinary steam engine. No variable change-speed gearing is required, and this is a point greatly in favour of the steam car. A wide range of power may be controlled very simply by admitting more or less steam into the cylinders. There is an ease of working and flexibility about the steam car that is wanting in the petrol car. The vibration is

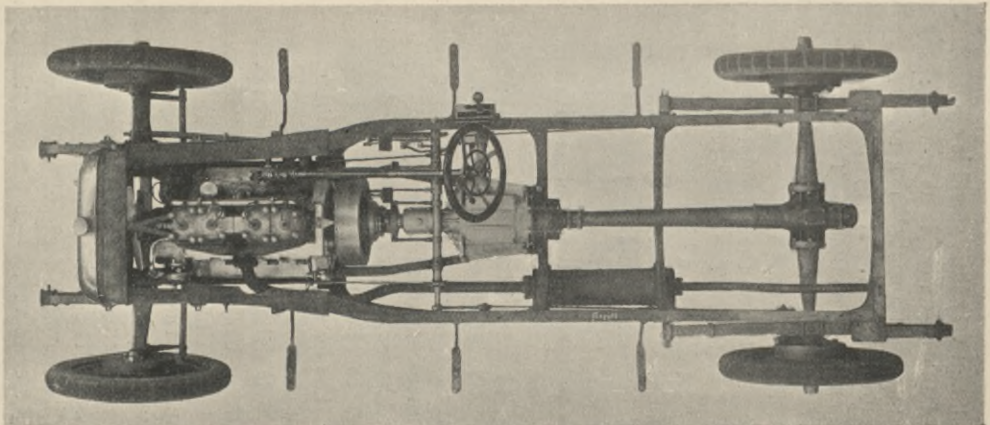

FIG. 11.—Plan of new Argyll chassis.

practically nil, and very little sound is emitted. Briefly the mechanism of the steam car is as follows: engine, boiler and heater, pumps, transmission gear, water and petrol tanks and controlling gear. No flywheel is required, as the action of the engine is constant. The working pressure of the boiler is about 200 lbs. per square inch, and a regulator worked automatically keeps the pressure constant. Some boilers are constructed on the "tubular" system, and others on the "flash" system. The latter contains a heavy steel or copper tube raised to a high temperature, and a stream of water is pumped into it at definite periods. The water is "flashed" into steam at high pressure, and enters the cylinders to do its work. In the White steam engine almost all the working parts are fitted with ball bearings to eliminate friction.

Racing-Car Engines.—The official rules under which the car is raced govern to a large extent the design of the engine. It is usual in these rules to limit certain measurements and dimensions of the engine, and this is the reason why peculiar shapes and extraordinary design have been adopted so as to obtain the maximum of power under a certain rule. The horse-power of an engine is considered by the Royal Automobile Club rule as being dependent only on the number of cylinders and the square of the diameter of the cylinder. Under this rule engines were designed with a very long stroke in proportion to the bore of the cylinder. Another rule may limit the cylinder capacity of the engine, so that the best results in this case would be obtained by having the stroke slightly larger than the bore of the cylinder. The weight of the engine is sometimes limited, in which case the designer would cut down at every point, and yet contrive to lose none of the strength and stability.

Engines for racing purposes should have as high a speed of revolution as possible, and the reciprocating parts can then be made very light. This is a feature among American cars—high speed and light reciprocating parts. The valves require to be large, and the lift will be greater than in ordinary pleasure car engines.

A most successful type of engine for fast touring is the Austrian Daimler. Four separate cylinders are used, of 105 mm. bore, 165 mm. stroke. According to the rating rule, the horse-power is 20, but the engine develops 90 h.p. The cylinders are made separately, so as to obtain the maximum amount of bearing surface for the crank shaft. The valves are placed on each side of the engine, thus allowing a narrow radiator and bonnet for wind cutting. The valves are very large, and are operated by an overhead cam-shaft and rockers. Although the exhaust valves have only cooling ribs, this somewhat new departure has been successful. The valve seating, however, is water-cooled. The carburetter is fitted with a hot-water jacket and also a cold air supply, is pressure fed, and fixed close to the valves. A gear-driven centrifugal pump is used for water circulation. The pistons are made of pressed steel.

CHAPTER III

THE ENGINE ACCESSORIES AND DRIVING GEAR

(Fig. 12 shows plan and elevation of a chassis.)

Carburetters.—The soul of the engine is the carburetter. The engine should work perfectly under all circumstances; it is therefore necessary that the carburation should remain constant at all speeds in the widest range and with varying inlet aperture openings. In a word, the proper quality and quantity of mixture must be admitted to the cylinder under the most variable conditions.

A slight variation in the petrol supply makes a considerable difference between the making of a very powerful mixture and a weak one. It will be seen, therefore, that accurate adjustment and proper regulation is essential. The actual adjustment of the ignition and throttle can only be ascertained by experience. Too much petrol forms a solid carbon deposit in the engine cylinder; too little petrol causes diminution in the power of the engine. Of course it is to advantage to run a car on a very weak mixture, when small power is required. Some trouble is often experienced by petrol dripping from the carburetter, in this case examine the needle valve; the needle may have become blunt by the continual lifting. The float inside the carburetter is so weighted that a small bead of petrol should stand on the jet. Care should be

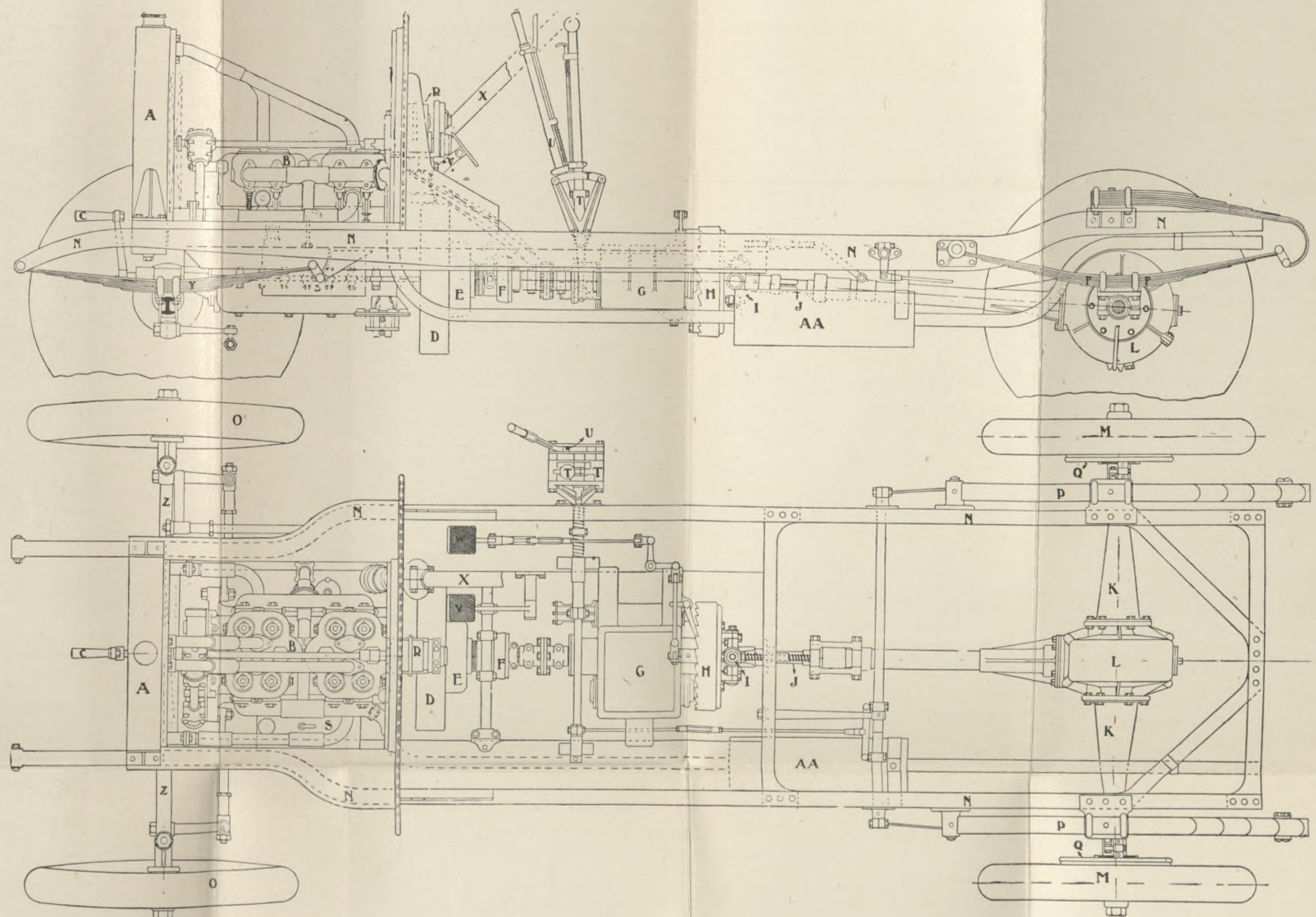

FIG. 12.—Plan and elevation of chassis.

AA, Silencer.
A, Radiator.
B, Engine.
C, Starting handle.
D, Flywheel.
E, Clutch.
F, Clutch brake.
G, Gear-box.
H, Foot brake drum.
I, Universal joint.
J, Cardan shaft.
KK, Back axle casing.
L, Differential casing.
MM, Road wheel (driving).
NNNN, Frame.
OO, Front wheels.
PP, Back springs.
QQ, Hand brake drums.
R, Ignition.
S, Lubricator tank.
TT, Gate change and speed lever.
U, Hand brake lever.
V, Clutch pedal.
W, Foot brake pedal.
X, Steering column.
Y, Front spring.
Z, Front axle.

[*To face page* 58.

taken not to grind the needle too much, else the petrol will overflow at the jet.

It sometimes happens that a small hole finds its way into the float and petrol escapes inside. This destroys the buoyancy of the float. The presence of petrol in the float can be detected by shaking it. Another way is to put the float in hot water; small bubbles of air will emerge from the leak by expansion of the air inside. A small quantity of solder on the spot will remedy the trouble. Occasionally the carburetter becomes flooded with water and chokes the jet. If a car is being run in damp weather, moisture may condense and water mix with the petrol. Sometimes water enters the petrol tank in the form of rain while the tank is being replenished in wet weather. Motoring over a rough road will sometimes cause the carburetter to flood; the float jolts up and down and the needle valve admits sudden supplies of petrol. By slightly closing the cock on the petrol tank this may be remedied.

Petrol vapour is not formed so quickly in cool weather as in summer; it is therefore sometimes necessary to heat up the carburetter in winter, and that is why carburetters are placed near the engine. Some carburetters have a jacket round the spray chamber, and hot gases from the exhaust act as the heating medium. There are usually small openings for an extra supply of air on the top of the spray chamber. This is required in hot weather, when a much larger supply of air is used, so as to give the best explosive mixture. The adjustment of these openings is controlled by hand. The petrol tank is usually situated under the seats or at the rear of car, and has an outlet pipe in direct communication with the carburetter. The height of the tank must be a little above the carburetter to allow the petrol to pass down by gravitation. The air and petrol in the form of vapour pass through a large pipe into the admission valve chambers. The pipe must be of large diameter and short so that the petrol vapour will not condense, as would be the case in a long, narrow pipe.

The principle of the carburetter is simple, and a short description of the Longuemare type will enable the reader to grasp the working and mechanism of this delicate apparatus. It consists of two separate parts, the float and spray chamber. At normal the float chamber is almost full of petrol and the float well up. At this position the little needle valve at the foot of the chamber is shut, and the supply is cut off. As the petrol is used the float sinks and causes two little lever arms to lift the needle valve, then more petrol rushes in and the needle valve is again closed. The petrol enters freely from the float chamber into the spray chamber. The top of the fine spray tube is slightly higher than the level in the float chamber. At the bottom of the spray chamber the air is admitted through small openings.

During the suction stroke of the engine a partial vacuum is created in the spray chamber, and a small supply of petrol issues through the fine tubes in the form of spray; at the same instant a supply of air is admitted through the openings at the bottom. The air mixes with the petrol vapour above the spray maker, and the explosive mixture passes away ready for use in the cylinder. A little plunger at the top of the float chamber is used for "bobbing" the float previous to starting the engine. This ensures a good supply of fresh petrol coming into the spray chamber. A throttle valve fitted into the pipe leading from the carburetter to the engine controls the quality of mixture. The control is generally from the steering wheel. Should a popping noise occur in the carburetter it is almost always caused by excessive air being admitted into it.

A choked carburetter is often the cause of much trouble to the motorist. Sometimes particles of foreign matter float about the jet. After flooding the carburetter, the engine runs for a few revolutions and then stops. These particles

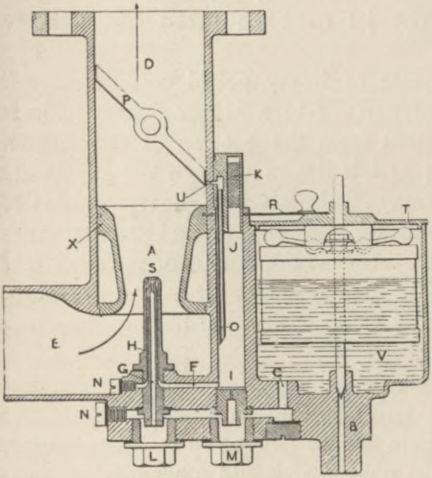

FIG. 13.—Vertical section of the Zenith carburetter.

*DESCRIPTION OF ZENITH CARBURETTER.

"Fig. 13 represents the section of a 'Zenith' carburetter. The two sprays, main and compensating, are disposed concentrically within one another. Both have their opening in *S*, the ordinary spray in the centre, and the compensating spray in ring shape. It may be seen that the space *H* communicates through *F* with the pipe *J*, which opens into the atmosphere, the petrol flowing through the gauged orifice *I* located in the centre of the said pipe.

"*O* is a small tube branching at some distance off the bottom of pipe *J*; this tube finishes in *U* shape, in touch with the edge of the butterfly when the latter is in its closing position.

"When the engine is running normally, the action of the small tube is nil, but there are two cases where this tube plays an important part:

"1. When the motor stops, the pipe *J* fills up with petrol which greatly facilitates the starting of the engine, throttled to a considerable extent: effectively, as the suction in *U* towards the edge of the butterfly is very powerful, the small quantity of petrol contained in the pipe is rapidly exhausted, and the motor starts at the first revolution, without necessity of any previous artifice such as flooding the carburetter, etc.

"2. When an engine is running out of gear and very slowly, it requires but a weak air inlet: consequently, the depression round the concentrical sprays is extremely weak, not sufficient in fact to exhaust the petrol stocked in the pipe *J*. The fuel will then rise in the said pipe until it reaches the end of tube *O*, when it will be strongly sucked up and sprayed in *U*, thus providing the very charge of fuel necessary to keep the engine running slowly out of gear.

"*K* is a gauze pipe which keeps the dust away from pipe *J*, and also serves as a centre of rotation for the flat spring *R*, the duty of which it is to fix the cover *T* on the float chamber.

"The 'Zenith' carburetter is also provided with a gauge-glass to inspect the level of the petrol.

"The long spray *G* and the compensating spray *I* can easily be taken down, through only turning off the hexagon nuts *L* and *M* and unscrewing both sprays by means of the special wrench supplied with each carburetter."

* Société du Carburateur "Zénith," Lyons.

have been agitated by the flooding action and have been drawn up to the jet and blocked it. On the stopping of the engine the particles fall away from the jet, so that numerous effects to keep the engine running are made before the cause is known. The jet must be taken out and the particles removed.

Sometimes the cause of heavy petrol consumption is due to heating the carburetter to a higher degree than is necessary, so that, apart from the suction of the engine, a large quantity of petrol is drawn through the jet in the form of pure vapour. This gives a heavy explosive mixture which is bad for the engine and "soots" the valves and plugs. In this case the hot air or water should be cut off from the heating chamber by means of a tap. It is only in cold, frosty weather that the heating chamber is absolutely required.

Silencers.—The exhaust pipe from the combustion head of the engine terminates in the silencer. All the waste gases expand here before passing to the atmosphere, thereby minimizing the noise that would otherwise be made by direct impact with the atmosphere. In its simplest form the silencer consists of a long cylinder of sheet steel or aluminium of large capacity, perforated with holes in certain places. Baffle plates are arranged inside the silencer, so that the gases impinge upon them on their way to the atmosphere, and are distributed and expanded—in a word, the pressure is reduced. It is desirable to have the exhaust pipe as far away from the combustion chamber of the engine as possible, as the quantity of heat developed is often excessive. This is especially noticeable when the spark is retarded for any length of time. In this case the explosive mixture passes into the exhaust without being thoroughly burnt up, and it is certain that combustion takes place in the exhaust pipe and sometimes in the silencer.

Explosions often occur by the ignition of the unburnt mixture by the heat given off from the exhaust pipe. Another cause of explosions in the silencer is due to cutting off the spark, instead of cutting off the throttle in the engine control. This means that fresh explosive mixture is drawn from the carburetter and passes unignited to the silencer, where it will explode if the temperature is high enough. Care should be taken to keep the silencer clean. An accumulation of mud will not keep the silencer cool, but rather tend to make it retain its heat. The silencer should offer as little resistance as possible to the passage of the gases. A "cut-out" device or free exhaust is used for increasing the power of the engine.

The majority of silencers may be taken apart for the purpose of cleaning, and all carbon deposit should be removed from the baffle plates, and inside walls of the silencer. The superior makes of cars are now fitted with an auxiliary expansion chamber midway between the engine and silencer; this ensures quiet running, as the exhaust gases do not issue in puffs from the end of the silencer pipe. A very effective type of silencer is one in which the exhaust gases enter by a large tube into the expansion chamber, and leave by two small tubes running parallel with the silencer. The back pressure in this type is very slight.

Change-speed Gear and Transmission.—The power from the engine to the driving wheels of the car is transmitted through a clutch and then to a shaft, which is in communication with the change-speed gear; from this another shaft is connected to the differential gear fixed on the driving or live axle. A different arrangement is used with chain drives; instead of the live axle being divided into two separate pieces, the driving shaft is in two parts. By means of the clutch, the engine may be started up by hand, and then the power gradually transmitted to the driving axle. It also cuts off the power from the driving wheels when required, so that the driver is able to control the running of the car. The clutch in its simplest form consists of a large hollow drum keyed to the engine shaft. It has a taper inwards. A coned boss fitted to the end of the transmission shaft fits into the drum. The periphery of the boss is covered with leather, and is thrust into the drum by the action of a spring. The friction between the surfaces being sufficient for connection.

A pedal and lever generally control the movement of the cone, the pedal being actuated by the driver's foot. By pressing the pedal down the engine is thrown out of gear. On engaging, the clutch slips slightly so that only a certain amount of the power is transmitted; this is increased as the pressure is reduced from the pedal until the cone of the clutch is running at the same speed as the engine shaft. Sometimes the clutch "seizes" or becomes "fierce," and a violent jerking of the car results; this is harmful to the engine and gear. The application of a little castor oil on the leather face may prevent this, and exceptional care should be exercised in putting the clutch in gear until the faces become smoother. When the leather becomes much worn, the copper rivets have a tendency to "seize" with the cast iron face of the drum. The rivets should be hammered down or the leather renewed.

Grit may cause a clutch to become "fierce." In this case a thorough cleaning is the only remedy. Sometimes too strong a spring will cause "fierceness." When this happens, heat the spring gently until it loses some of its temper, or substitute by using a weaker one. The reverse of "seizing" is "slipping"; to avoid slipping squirt some paraffin on the leather face and tighten up the spring. If this has no effect, a new leather must be fitted; but before deciding upon this, shake a little Fuller's earth between the surfaces. Resin is sometimes used, but after a time is apt to cause "seizing." Careful adjustment of the parts of the

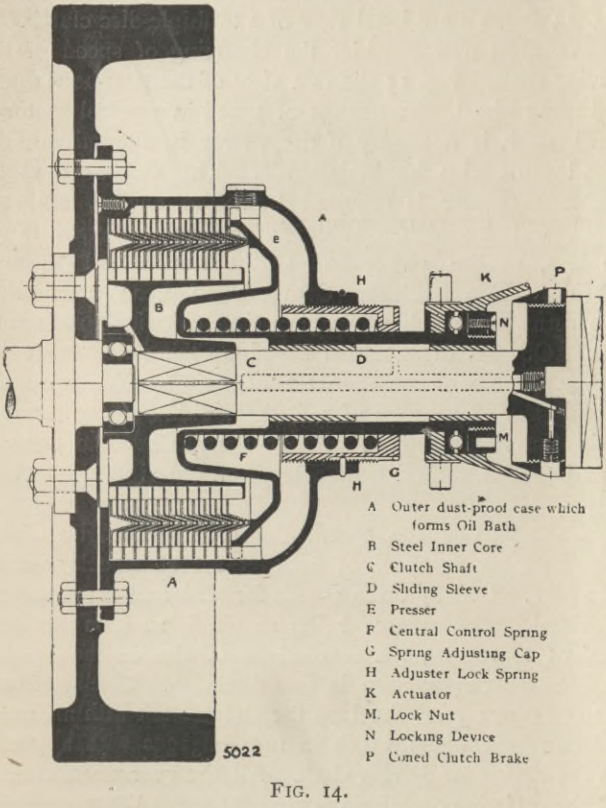

FIG. 14.

clutch should be made, as this is a very important part of the mechanism of the car. Instead of using leather against cast iron, friction is also obtained by forcing a number of thin steel discs into contact. The discs run in oil, and the oil film on the surface of the discs acts as a cushion when the discs are in contact. Metal-to-metal clutches are also used; in this case lubrication is essential. Fig. 14 shows a sectional view of a multiple-disc clutch.

We must now consider the changing of speed of the driving shaft. Fig. 15 shows a view of the gear-box, drum, and sprag wheel. The range of speed in a petrol motor is small, so it is necessary if the power is maintained, the speed must also be maintained. The steeper the hill, the more power is required from the engine, and the speed will be higher although the rate of travel will be less, as the power has to be transmitted through gearing. The ordinary change-speed gear consists of two series of wheels of varying sizes contained in a gear-box. One set of wheels is keyed on the clutch shaft and they engage with another set of wheels sliding on the driving shaft by means of a feather, which allows them to slide but not to rotate without the shaft. The change-speed gear is worked from a lever on the right side of the driver.

On changing the speed, the clutch must be disengaged, so as to allow of another set of wheels coming into play. Usually three speeds forward and a reverse are provided. The reverse being required, as it is not convenient to reverse the revolutions of the engines, petrol engines must always run in one direction. The usual way is to engage a gear wheel on the clutch shaft with an intermediate gear wheel, which in turn engages with a pinion on the engine or driving shaft. All the gear wheels run in oil, the oil being contained in the gear-box. When changing from one speed to another it is necessary to disengage the clutch very quickly. The movement of the change-speed lever must be definite and decisive. The "gate" change system, which is the most popular at the present time, is easily manipulated. A special feature of this system is that the gears cannot be missed. The lever moves through slotted ways, which lock it firmly for each change of speed.

The difference between the gate change and the quadrant is that in the gate change the lever is moved forward

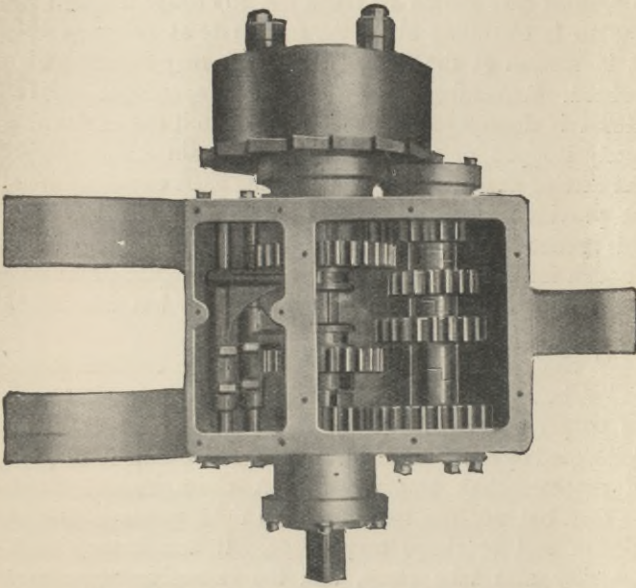

FIG. 15.—Gear-box, brake drum, and sprag wheel.

or backward through slotted gates, each slot corresponding to a different gear, while in the quadrant system the lever moves along a notched quadrant, and a "trip" on the end of the lever engages in the notches which correspond with the different gears.

Practice makes proficient in the matter of gear changing.

It makes all the difference between ascending or failing to ascend a steep hill. It is advisable to take out the clutch when driving over a newly macadamized road covered with stones, which have not been rolled. The back wheels are "eased" and drive slowly, but without much "grip." If the clutch is taken out when going downhill, great care should be taken not to engage it again until the car is travelling about the same rate as the gear which is in motion at the time, as the shaft may be strained or twisted. Remember never to change the speed gear until the clutch is disengaged. Never reverse until the car is absolutely stopped, or the engine will be strained and possibly the driving shaft twisted. The driving shaft coupling should be provided with some means of protection from dust; this generally takes the form of a leather bag, roomy enough for the joints to work. It is a temptation to leave this coupling unoiled when it is covered, but this should never be neglected.

A chain is a very efficient agent for the transmission of power, but constant care and attention is necessary to ensure its proper working and efficiency. Possibly the extra care demanded by chain driving is the cause of the rapid advance of propeller-shaft transmission. A chain should always be free, but not too loose. If too tight, power is lost by friction and breakage may ensue. If too loose, breakage may also take place, and the excessive "jumping" and "knocking" may lead to disaster. The chain should be soaked in tallow; this introduces lubricant into every link and rivet. Remember that it is the inside of the rollers that need lubrication. To oil the outside of the chain is worse than useless. Adjustment of the chain is usually done by rods and nuts. After a car has travelled a few thousand miles a slackness occurs in the chains; this slack must be taken up by lengthening the bars or rods. It is advisable to carry a spare chain, or at least a few spare links and pins.

When changing speed on a chain-driven car with a direct drive on top, care must be exercised in changing from first speed to second. It is best to change immediately into second from first when the car has started to run. It sometimes happens that a driving chain breaks through a pin giving way. If no spare pins or rivets are carried, an ordinary split pin or stout steel wire may be used as a makeshift. Driving a car on one chain should not be resorted to except in emergency, as the gearing is strained unequally.

Steering Gear.—The usual arrangement for steering is by the wheel and inclined pillar principle. A pillar or spindle is mounted and passes up through a hollow brass tube to the steering wheel. The inclination of the pillar is set at an easy angle for driving. At the end of the spindle is a quick threaded worm, which meshes in a toothed quadrant carrying an arm or lever, which in turn is connected to one of the jointed steering axles by a jointed rod. The two axles are connected together, so that the steering wheel, in turning the worm screw, causes the quadrant lever to move the connecting rod to and fro. This motion is transmitted to the two front wheels.

Another method adopted is the worm and nut mechanism, the advantage being that "backlash" or wear is easily taken up by adjusting the two halves of the nut. "Backlash" is frequently seen in cars possessing the worm and quadrant steering gear, and is not very easily remedied. The action of the worm and nut mechanism is as follows: On rotating the steering wheel, the screw causes the nut to move through an arc of a circle about its centre, so the rod of the fork and steering arm must move in a backward or forward direction, and this motion is transmitted to the two front wheels. It is very important that the different parts of the steering gear should be periodically examined and the pivots kept secure.

Brakes.—The weight of the car and the momentum gained whilst travelling make it necessary that we should have efficiency and power at the brakes. If the brake be applied suddenly, when the car is travelling quickly, the momentum of the car will be sufficient to overcome the frictional resistance between the tyres and the road, thus causing the car to skid. This happens almost without exception if the roads are greasy or very dusty. Heat is generated in the tyre when the car skids, and the wear caused by the friction is excessive.

The ordinary form of brake is one in which a steel band lined with leather passes over a metal drum fixed to the hubs of the driving wheels. Wire ropes or rods tighten the bands on the drums through the medium of the brake lever on the right side of the driver. A pedal brake is also used, and this is very convenient, as the main brakes on the hubs of the driving wheels are only used in emergency or when the car is at a standstill on a hill, but they may also be applied when the car is travelling down a long steep incline. The foot brake is more convenient for driving in traffic.

Referring to the main brakes, the pressure is equally exerted on the two drums by the application of the brake lever. The metal-to-metal expanding brake is much in use. Leather wears out quickly with constant use, and is apt to get burned if the brake is kept on for long periods. In the metal-to-metal type, brass segments are made to press on the interior of a revolving metal drum which is well lubricated, and considerable frictional resistance is set up without much wear and tear. Some makers adopt a water-cooling system for brakes, and this is very effective and useful when motoring in hilly districts. It is necessary that the band should embrace the drums almost all the way round, otherwise the brake efficiency is lowered. A close fit may be ensured by applying some emery dust to the drum. When the drum revolves, the brass or iron shoes will wear equally and grip firmly all the way round. After the operation the drum should be flooded with petrol to clean away the emery dust. It is not necessary to lubricate leather brake drums and bands unless they become very fierce, in which case apply a very small quantity of grease.

The adjustment and position of the brake lever and pedal should be so arranged that the maximum power may be applied without much effort on the part of the driver. The brakes should be applied gently. If they are applied suddenly on greasy roads, the car may completely turn round. I have frequently noticed when shipping cars that the dock porters are at a loss to tell the brake lever from the change-speed lever. I merely record this and offer the suggestion that, when despatching a car by rail or boat, the change speed lever should be blocked at the neutral position and a tag with the word "brake" on it should be attached to the brake lever. Noise is sometimes caused by the vibration of brake rods, bands or shoes, and perhaps a little spring or bracket attached to the loose part may make all the difference between a noisy and a silent car. The knuckle joints may become rusted at the brake connections; a small quantity of oil or grease should be applied to these parts regularly. Should a small pin give way through rusting, or a joint break, considerable damage may be done upon application of the brakes, by the car turning round through only one brake acting.

Perhaps the most vital points in the care of a car are the brakes and steering mechanism, for one depends on the other to a great extent. When the tension rods become loose they should be tightened up so that the brake pedal will act immediately. In well-finished cars all the nuts on the brake connections are locked in some way so that they cannot work loose. The clutch must always be taken out before applying the brakes. In addition to the brakes, a large car should be provided with a "sprag." The "sprag" is attached underneath the car, and a wire rope within reach of the driver enables it to be released quickly. If a car should stop on a steep hill, it may be prevented from running backward by dropping the "sprag." The best way is to let down the "sprag" before ascending and not when the car has started to run backwards, else the "sprag" may be bent or the car jump over it. By switching off the ignition when running downhill a braking effect may be obtained, due to the compression in the cylinders and friction of the moving parts of engine and gear.

Tyres and Wheels.—Tyres are expensive, not only at first cost but also in upkeep and repair, so it is important that they should receive every care. The ordinary beaded-edge tyre is so arranged that the beads are encased in the channels of the rim. The fabric is woven specially for heavy strains, and a rubber cover is fixed over this. On top of the rubber a tread is usually vulcanized, which is made thicker in the middle to allow for wear. The inner tube should be made of rubber of the finest quality and fairly thick, the joint in the tube being vulcanized. Reinforced inner tubes are very satisfactory and can be honestly recommended. The spare inner tube should be carefully packed up. It is not enough that they be rolled up anyhow and placed in the tool-box. After expelling the air, they should be folded up in a roll, the end of the roll containing the valve. Another way is to lay the tube flat with the valve in the centre, and fold from each end.

Deterioration may set in in various ways, by water finding its way into the interior of the cover, by being exposed too long in the sun, and by insufficient inflation.

The tyres should be periodically examined and any cuts cleansed with naphtha and filled with rubber solution. In another section * of the book the subject of puncture repairing is taken up. Delay caused by tyre troubles may be lessened by having the wheels fitted with detachable rims. The Goodyear principle is one which I have found to work splendidly. The Dunlop detachable, where the wheel and rim are provided with driving pieces for expansion and contraction, is much in favour. The "Stepney" wheel, with its fittings to grip the rim and spokes of the wheel, takes away the strain from the punctured tyre. It finds much favour amongst motor taxi-cabs. Carrying the detachable principle further, we have the completely detachable wheel such as the Rudge-Whitworth type, which may be taken off and replaced in a few seconds. The wheel in this case has wire spokes, and has a special kind of hub. The wire-spoked wheels are coming into favour, the rim weight being so very much less than the ordinary artillery wood wheel.

* Touring.

CHAPTER IV

THE PETROL, WATER, AND LUBRICATING SYSTEMS

Petrol.—Petrol is one of the numerous products of petroleum; after being distilled, it is refined so that no residue is left behind after burning. To ascertain the quality of petrol we must use an instrument called a densimeter to determine its density or specific gravity. The lighter the spirit the more volatile it is, and the best petrol has a density of 0·69 to 0·7 at 60° F., but the usual quality of petrol supplied to users of motor cars varies from 0·666 to 0·738. The handling and storage of petrol require considerable attention, owing to its inflammable nature. The Board of Trade regulations must be strictly observed; petrol must be kept in metal tins not exceeding two gallons capacity and fitted with air-tight stoppers. Sixty gallons is the maximum amount that may be stored in one place at any given time. The safest way of storing petrol is in an underground concrete pit. Care should be taken not to approach petrol with a naked light. Serious accidents have occurred through neglect of this precaution. Electric incandescent lamps are the safest lighting medium. In the event of a fire a large quantity of sand or earth should be thrown over the burning spirit. Chemical extinguishers are very effective.

Petrol Storage Regulations.—These regulations, dated July 31st, 1907, were made by the Secretary of State under section 5 of the Locomotives on Highway Act, 1896, as to the keeping and use of petroleum for the purposes of light locomotives.

"(1) The following shall be exempt from licence under the Petroleum Act, 1871, namely:—

"(*a*) Petroleum spirit which is kept for the purpose of, or is being used on, light locomotives when kept or used in conformity with these regulations.

"(*b*) Petroleum spirit which is kept for the purpose of, or is being used on, light locomotives by or by authority of one of His Majesty's principal Secretaries of State, the Admiralty or other department of the Government.

"(2) These regulations shall apply to petroleum which is kept for the purpose of, or is being used on, light locomotives, and for which (save as hereinafter provided) no licence has been granted by the local authority under the Petroleum Act, 1871, and shall not apply to petroleum spirit which is kept for sale or partly for sale and partly for use on light locomotives, and which must be kept in accordance with the provisions of the Petroleum Acts as heretofore, except that regulations 13 and 14 shall apply to the petroleum spirit which is kept partly for sale and partly for use on light locomotives. These regulations shall not apply to the keeping or use of petroleum spirit by or under the control of any Government department. Such keeping or use may be the subject of regulations to be made by the department concerned.

"(3) Where for any special reason a person keeping petroleum spirit for the purpose of light locomotives applies for a licence under the Petroleum Act, 1871, and the local authority see fit to grant such licence, such petroleum spirit shall be subject only to regulations 8 and 15 and the conditions of such licence, in so far as the said conditions are not contrary to the said regulations 8 to 15.

"(4) Where a storehouse forms part of, or is attached to, another building, and where the intervening floor or partition is of an unsubstantial or highly inflammable character, or has an opening therein, the whole of such building shall be deemed to be the storehouse, and no portion of such storehouse shall be used as a dwelling or as a place where persons assemble. A storehouse shall have a separate entrance from the open air distinct from that of any dwelling or building in which persons assemble.

"(5) The amount of petroleum spirit to be kept in any one storehouse, whether or not upon light locomotives, shall not exceed 60 gallons.

"(6) Where two or more storehouses are in the same occupation and are situated within 20 feet of one another, they shall for the purposes of these regulations be deemed to be one and the same storehouse, and the maximum amount of petroleum spirit prescribed in the foregoing regulation shall be the maximum to be kept in all such storehouses taken together. Where two or more storehouses in the same occupation are distant more than 20 feet from one another, the maximum amount shall apply to each storehouse.

"(7) Any person who keeps petroleum spirit in a storehouse which is situated within 20 feet of any other building, whether or not in his occupation, or of any timber stock or other inflammable goods not owned by him, shall give notice to the local authority under the Petroleum Acts for the district in which he is keeping such petroleum spirit, that he is so keeping petroleum spirit, and shall renew such notice in the month of January in each year during the continuance of such keeping, and shall permit any duly authorized officer of the local authority to inspect such petroleum spirit at any reasonable time. This regulation shall not apply to petroleum spirit kept in a tank forming part of a light locomotive.

"(8) Every storehouse shall be thoroughly ventilated.

"(9) Petroleum spirit shall not be kept, used or conveyed except in metal vessels so substantially constructed as not to be liable, except under circumstances of gross negligence or extraordinary accident, to be broken or become defective or insecure. For such vessel shall be so constructed and maintained that no leakage, whether of liquid or vapour, can take place therefrom.

"(10) Every such vessel, not forming part of a light locomotive, when used for conveying or keeping petroleum spirit, shall bear the words "petroleum spirit highly inflammable" conspicuously and indelibly stamped or marked thereon, or on a metallic or enamelled label attached thereto, and shall be of a capacity not exceeding two gallons. Provided that this limitation of capacity shall not apply in any place of storage which is licensed under the Petroleum Act, 1871, unless such limitation is required by the conditions of the licence.

"(11) Before repairs are done to any such vessel, that vessel shall, as far as practicable, be cleaned by the removal of all petroleum spirit and of all dangerous vapours derived from the same.

"(12) The filling and replenishing of a vessel with petroleum spirit shall not be carried on, nor shall the contents of any such vessel be exposed in the presence of fire or artificial light, except a light of such construction, position and character, as not to be liable to ignite any inflammable vapour arising from such spirit, and no fire or artificial light capable of igniting inflammable vapour shall be brought within dangerous proximity of the place where any vessel containing petroleum spirit is being kept.

"(13) In the case of all petroleum spirit kept or conveyed for the purpose of, or in connection with, any light locomotive, (*a*) all due precautions shall be taken for the prevention of accidents by fire or explosion, and for the prevention of unauthorized persons having access to the petroleum spirit kept or conveyed, and to the vessels containing or intended to contain, or having actually contained, the same; and (*b*) every person managing or employed on, or in connection with, any light locomotive shall abstain from every act whatever which tends to cause fire or explosion, and which is not reasonably necessary, and shall prevent any other person from committing such act.

"(14) In the storehouse or in any place where a light locomotive is kept or is present, petroleum spirit shall not be used for the purpose of cleaning or lighting, or as a solvent or for any purpose other than as fuel for the engine of a light locomotive.

"Provided that where due precaution is taken to prevent petroleum spirit from escaping into a sewer or drain and provision made for disposing safely of any surplus petroleum spirit and where no fire or naked light is present, quantities not exceeding one gill may be used for the cleaning of a light locomotive at a safe distance from any building, place of storage of inflammable goods or much frequented highways, or for the repair of tyres, under suitable precautions.

"This regulation shall apply to premises on which petroleum spirit is kept for the purpose of, or is being used on, light locomotives, whether such premises are licensed or not, unless the local authority see fit, in the case of licensed premises, to grant an exemption by a special term of the licence.

"(15) Petroleum shall not be allowed to escape into any inlet or drain communicating with a sewer."

Water Cooling.—We now pass to the consideration of the water-cooling system and the arrangements for keeping the cylinder cool during the working of the engine. All stationary gas and oil engines are provided with large tanks, and natural circulation is caused by the rising of the heated water to the top of the cooling tank, the supply of cold water from the bottom of the tank filling the displacement. A different arrangement must be provided for motor cars, as the natural circulation through the water jackets is comparatively slow. A small circulating pump driven by gearing or belt is therefore used to force the water at high speed through the pipes and jacket. The water on leaving the jacket is at high temperature and requires cooling. This is done by the radiator, which is formed like a honey-comb or made of flanged tubes. A large cooling surface is therefore exposed to the air, and cooling rapidly takes place. The passage of air is assisted by the introduction of a small fan driven from the crankshaft and revolving behind the radiator.

In some cases the flywheel and fan are combined, the spokes of the flywheel forming the blades of the fan. It is sometimes found that the honey-comb radiator is apt to leak; this may be stopped by blocking up the hole at each end of the leaky tube with corks. Several devices are used, among which the "Simplex" plug is the most popular. This plug has two little flat plates with leather facings. One plate has a short length of spiral spring with a hook at the end for attaching to the loose plate. The spring is pulled through the leaky tube and hitched to the inside plug, the tension of the spring making a good joint at the leather faces. Acids are advertised to prevent the circulating water from freezing in winter time. These should be studiously avoided. A little glycerine added to the water will be found useful. Too much lubricating grease should not be used in the water circulating pump. The hot water melts it, and it sometimes finds it way to the radiator tubes and chokes them. Sometimes trouble is experienced with water pipe connections, and it is found that wire armoured rubber hose with steel clips is a very effective connection.

If ordinary rubber is used for connecting the radiator to the jackets, the rubber should be of the first quality. The fastening clips should be broad so as to embrace a large piece of tubing, otherwise the tubing will be pinched and leakage will occur sooner or later. If a rubber joint bursts, let out the circulating water and bind the burst with rubber insulating tape (*i.e.* if a spare length of tubing is not carried), then wind with a layer of soft copper wire or cord. Rain water is best for radiators, as the water spaces are about the thickness of a visiting card, and hard water leaves a deposit. Hard water should be avoided, owing to the large percentage of calcium carbonate held in suspension. This causes a thick layer of lime to be deposited on the inside of the tubes, and the engine will heat up quickly owing to inefficient circulation. It is an excellent plan to collect the rain water in barrels and use it for the radiator and for washing the body work. If steam is observed issuing from the radiator, the circulating system must be looked over. It may be that the pump is not working properly. An examination of the pump driving gear and circulation gauge will tell this.

Lubrication.—It is very necessary to the smooth running of a car that every moving part of the engine and gear be kept lubricated. It is better to be on the safe side by over-lubrication than to allow the parts to run dry. There are different systems of distributing oil. The usual way is to attach a small tank to the splashboard or other convenient place, and a few sight-feed lubricators in front denote that the oil supply is working regularly. Much trouble has been experienced through the use of unsuitable oil. The motor car requires oil of the best quality, and possessing certain properties. Two kinds of oil are in general use; a light machine oil for outside working parts, and a heavy cylinder oil for lubricating the inside of the engine, made heavy so as to withstand the high temperature generated by the explosive charge. The system of splash lubrication enables the moving parts inside the engine to be lubricated. A small hand pump is provided so that a given quantity of oil may be injected into the crank chamber at regular intervals. Individual lubrication cups are provided at the parts not within reach of the lubricating system.

The utmost care must be taken in selecting oils, and careful inquiries made regarding the quality and nature of the oils recommended by dealers. Numerous troubles have been traced to bad lubrication. The makers of the car are perhaps the best authority on oils for that particular car, and usually they have no direct interest in the sale. Some cars are fitted with automatic lubrication, no attention being required as to the regulation and adjusting of the supply. A tank having distributing tubes to the bearings holds the oil, and a mechanism admits it at given intervals. Grease lubrication is used for axles and parts not requiring very much attention. Stauffer's type of lubricator is the most successful. It consists of a brass cup, containing the grease, and fitted with a screw cap. On screwing down the cap, the grease is squeezed into the bearing or journal. A slight turn of the cap being sufficient to supply a fair quantity of grease. An advantage possessed by this kind of lubrication is that, when the journal gets hot, the bearing is flooded with hot liquid grease.

Whilst visiting Niagara Falls I inspected a graphite factory. This firm turn out a finely powdered graphite lubricant which is exceedingly well adapted for motor car axle lubrication. When it is necessary to remove the old grease from the cups, they should be thoroughly cleaned out with paraffin. The same applies after the dirty oil is removed from the crank chamber. Flood the chamber with paraffin, as particles of metal in a finely divided state are often held in suspension in the old oil. These particles grind the bearings and cause damage. The gear-box should be treated in a similar fashion. If grease is used in the gear-box instead of oil, the gear-box should be cleaned with petrol or hot water. The old oil may be used again, if it is heated and passed through fine muslin. It is a mistake to put grease into a gear-box designed for oil, as the grease gets into the oil pipes and blocks the passage. The hub caps of the driving wheels should be filled with oil or grease every 250 miles, then screwed up so that the grease will be forced around the axle. Both oil and grease are used for hubs, and equally recommended by the makers, although oil, being more liquid, runs out of the bearing quicker. Over-lubrication in the crank chamber causes white smoky fumes to issue from the silencer. This also is the cause of dirty plugs and misfiring. The steering joint requires lubrication; this may be done by oil or grease.

The chains on a chain-driven car require some attention. They should be thoroughly cleaned with paraffin so that each roller is revolving freely on its rivet. Refined Russian tallow should be put along with the chain in a pan and warmed. Care being taken not to heat the chain too much, as it will lose its temper by softening. The chain should then be brushed before putting on the wheels. The leaves of the springs require a little lubrication; this may be done by opening the leaves with a screw-driver and passing some grease between them. The shackles should also be lubricated. In the superior makes of cars, lubricators are fitted to the shackles at each of the bearing spindles. Some cars have only oil holes provided.

Trouble is frequently experienced at the commutator. The commutator should be slightly lubricated, especially those with a rolling contact maker. Imperfect firing is often caused by oil becoming hard and solidified, so that the commutator should be washed with petrol and a thin film of fresh grease applied. Never use poor or cheap oil. It is false economy. To avoid carbon accumulating in the cylinder, it is a good plan to inject kerosine into the cylinder, say, once a fortnight. Do this after the engine has been running and is hot. Remove the plugs, and pour in half a wine-glassful of kerosine oil. Replace the plugs, but do not connect up. Turn the engine slowly by hand, so that the kerosine finds its way through the rings. Allow the engine to stand for half an hour, connect up the plugs, and start the engine. A dense blue smoke will be emitted, until the kerosine has been all burned away. When the engine has stopped smoking, the plugs should be taken out and cleaned.

CHAPTER V

TOOLS AND SPARES—LAMPS—DRIVING—TOURING—THE MOTOR HOUSE

Tools and Spares.—When purchasing a new car, the buyer should see that it is provided with a set of solid-ended spanners. When a nut is inaccesible to the ordinary spanner, a box spanner is used. It is desirable, then, to possess a complete set of spanners adaptable to all nuts on the car, including special spanners for sparking plugs and wheel caps. A good adjustable spanner is necessary and is very useful for tightening the smaller nuts. A pair of gas pliers and a pair of flat cutting pliers are also required. Several files of different grades, including a very fine file for platinum points, cold chisel, screwdrivers and a pin driver, form part of the outfit. Regarding the spare parts, it is well that a full complement of these should be carried. A set of valves, springs, cotters, and piston rings for the engine and a spring and leather for the clutch are necessary. Sparking plugs and copper washers, steel brake cables, washers for joints, spare parts of magneto and contact maker should all be carried. Asbestos sheeting and string, copper wire, low-tension cable, high-tension cable, insulating tape, emery powder and cloth, oil-can, paraffin injector, Stauffer grease, graphite lubricant, calcium carbide, petrol funnel and strainer, spare rubber hose and clips for water circulation, spare lamp wicks and burners for head lamp, a volt-meter and 4-volt lamp—all these will be required at one time or another, and it is far better to carry a good supply than find yourself delayed for hours while trying to procure a substitute.

A complete tyre repair outfit, two inner tubes with valves, one pressure gauge, tyre levers, lifting jack, spare outer cover, double-acting pump, solution and preparation for stopping cuts, complete the list of tools and spares. These should not be carried loosely in the tool-box, as damage will be done to the spares by the continual rattling and knocking against each other. Tool trays with partitions are very useful, the spares may be wrapped in rough cloth and put into the divisions. Oil and oil-cans should be kept in a separate place if possible, as invariably the oil finds its way out of the can. Some motorists of a practical turn of mind possess a workshop, and are thus independent of garages for all small repairs. A certain amount of pleasure is gained in executing minor repairs and adjustments, and a considerable saving in time is effected. The workshop may form part of the motor house or be independent of it. A bench and turning lathe are indispensable, and these should be placed as near a window as possible so that plenty of light will be thrown on the work. A good parallel vice with 3-inch jaws should be fitted on the bench. In addition to the usual kit of tools kept in the bench drawer, a small grindstone, emery wheel, and boring machine will prove very useful. The turning lathe should not be a toy, but one capable of doing good work. It should be fitted with a Cushman chuck and the driving done by foot treadle. All kinds of turning, boring, slotting, drilling, grinding, milling, screw cutting, and even gear cutting may be executed.

Quite a large number of cars are laid up during the winter, so that the opportunity should be taken to completely overhaul the parts requiring attention. In the case of an engine overhaul, all wires, rods, inlet, exhaust and water joints as well as the pump must be first disconnected. Care should be taken to mark or stamp the parts before disconnecting, otherwise trouble may be experienced in re-assembling. All dirt and grease must be removed, the plugs taken out and the holes plugged with corks, and the valve covers removed. If the valves are "pitted" or only partially bearing, they must be ground in with fine emery and fine oil. Turn the valve backwards and forwards on its seat by means of the spindle, which may be attached to a lever. Change the position of the valve occasionally, and grind until the seating and valve has a bright surface all round. The seating and valve must now be thoroughly cleaned, and care should be taken to see that no emery powder is left about. The cylinders may now be removed. This operation should be proceeded with carefully. All dirt and oil can be removed by immersing the cylinders in paraffin, any thick deposit in the combustion chambers being removed with a scraper. If on examination of the piston rings they are found to be "sooted" on some part of the circumference, a leakage is occurring past the rings. If the rings show much sign of wear, they should be renewed. If the piston is loose on its bearing, the pin should be taken out and replaced by a new one made to fit the hole in the connecting rod. The pin must be of shorter length than the diameter of the cylinder. Knocking in the cylinder is often caused by a slack pin in the piston. In another part of the book the operation of taking off the piston rings is described. The piston and rings should then be thoroughly cleaned and every particle of deposit removed. The crank pin brasses may require to be taken up. This operation has been described in another chapter. The gear-box inspection door should be taken off, and the grease removed. If the bearings are much worn, they should be taken up, and the striking forks should not present too much play. If the gear wheels are badly worn, they should be replaced by new wheels. It is seldom that all the gears require renewing. The makers of the car supply gears and spare parts, but care should be taken to describe the type of car, as different types by the same makers are placed on the market every year.

The differential gear and live axle require examination. If the gear and planet wheels have too much play, adjustment may be made by means of the locking ring. All the old grease and oil should be removed and the box replenished with fresh lubricant. The care of chains has already been treated in another part of the book. If excessive play exists in the steering gear, it is very important that this should be remedied at once. If the steering lever pins are much worn, they should be replaced by new ones carefully fitted into the joints. If the holes are not truly circular, they should be "reamered" out before the new pins are fitted. If the steering wheels are not running in parallel lines much wear takes place on the front tyres; this is generally the result of slackness at the joints. A thin waterproof or leather cover to protect the joints from dust and water is very essential, but the presence of this over the joints should not interfere with the regular lubrication of same. The wheel bearing should be cleaned out and new grease put in the caps. Any slight "grating" sound when the wheels are revolving after being jacked up, may be due to the presence of a broken ball. A new ball, the exact size of the other, should be installed in place of the damaged one. The tyres should be carefully looked over and any cuts vulcanized. Water should never be allowed to find its way inside the outer cover, as it rots the canvas. If the tread is badly worn, the tyres may be retreaded. The brakes should be cleaned and adjusted, and any weak springs and slack pins replaced. If the brake leather is much worn it should be renewed. If internal expanding brakes are used, any worn parts should be replaced. An examination of the radiator, pump, and tanks must be made, any leaky joints made good and slackness taken up.

Lamps.—A few remarks about the care of the acetylene lamps will not be out of place. The burner is the most vital part, and dust is apt to find its way into the lamp and choke the small outlet holes. A piece of fine wire should always be kept for the purpose of cleaning the gas orifices. Obstruction in the piping leading from the generator to the lamps may be removed by applying the tyre pump to the free end of the pipe. If a burner gives much trouble, it is economy to replace it by a new one immediately. Generally speaking, all acetylene lamps have a little filter pad, through which the gas passes on its way to the burner. This pad or filter arrests any particles of dust. It requires renewal from time to time. The action of acetylene gas on rubber tends to rot it after a time, so that a sharp look-out should be kept for leaks, and spare lengths of tubing inserted. A small quantity of castor oil on the plug of the tap will keep it in easy working condition. If a lamp is badly smashed, it is cheaper in the end to buy spare parts than repair the damage. A bull's-eye fitted on the head lamps greatly adds to the illuminating power.

Lamp covers should always be used in winter or when touring. They keep the lamps free from dust and save much trouble in cleaning. The back lamp ought to be covered, as the back of the car is generally very dusty.

A word as to the generator; in its simplest form the water is arranged to drip directly on the carbide and gas

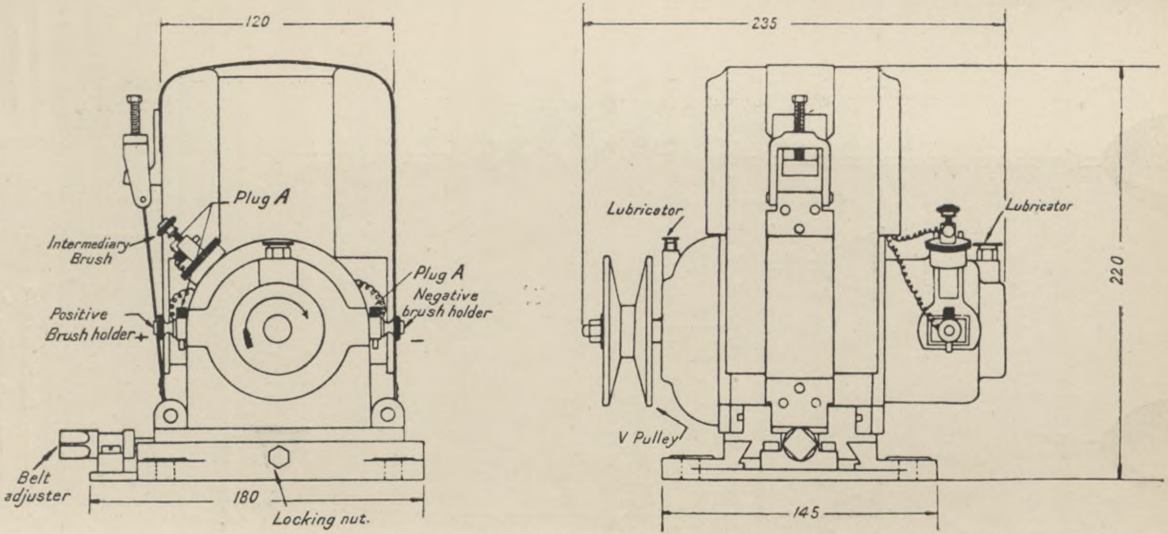

FIG. 16.—Sectional diagrams of the Ducellier dynamo.

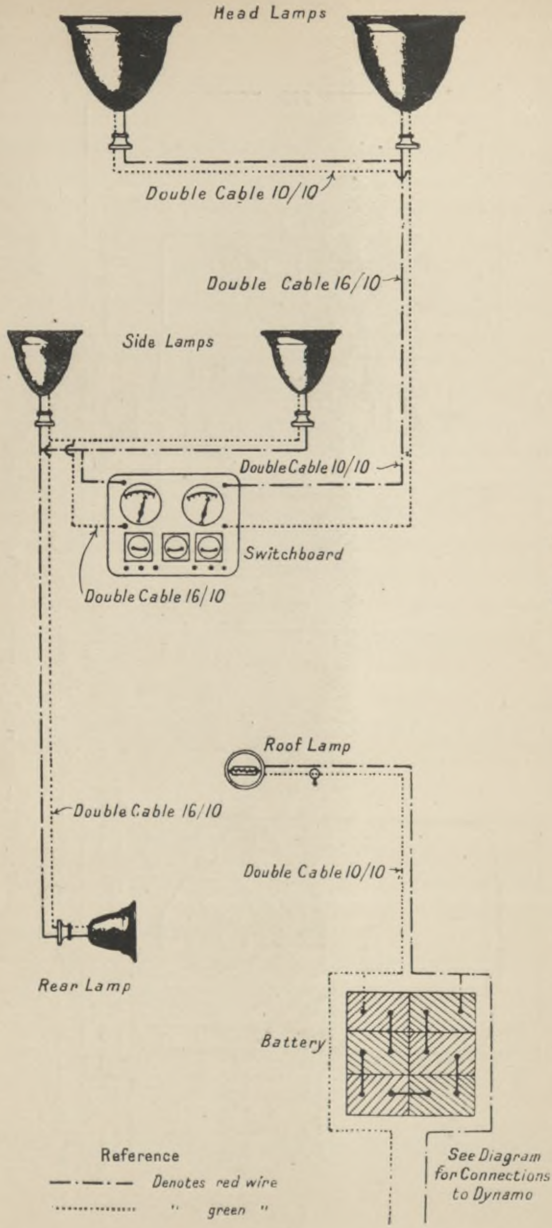
Head Lamps
Double Cable 10/10
Double Cable 16/10
Side Lamps
Double Cable 10/10
Switchboard
Double Cable 16/10
Roof Lamp
Double Cable 16/10
Double Cable 10/10
Rear Lamp
Battery
Reference
Denotes red wire
" green "
See Diagram for Connections to Dynamo

FIG. 17.

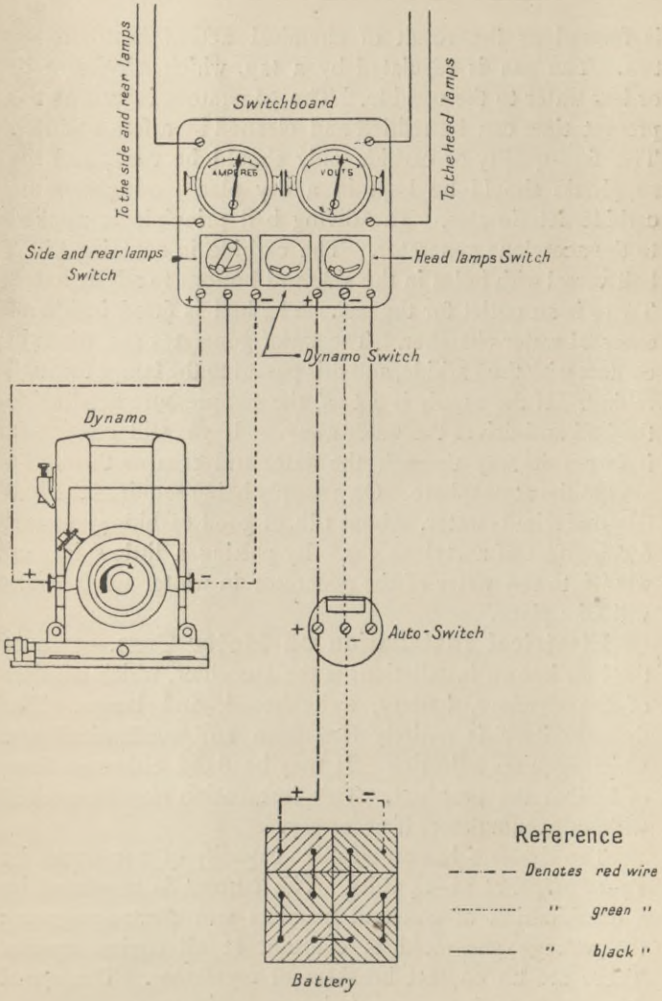
To the side and rear lamps
Switchboard
To the head lamps
AMPERES
VOLTS
Side and rear lamps Switch
Head lamps Switch
Dynamo Switch
Dynamo
Auto-Switch
Battery
Reference
Denotes red wire
" green "
" black "

FIG. 18.

is formed as the result of chemical action between the two. The gas is regulated by a tap, which admits more or less water to the carbide. The generators in use at the present time can be refilled and cleaned in a few minutes. The first quality of carbide only should be used, and the supply tin should be kept in a dry place, otherwise the carbide deteriorates. The diving bell principle is applied to the acetylene generator. The carbide is contained in a bell vessel with holes in the side and bottom to admit water. There is an outlet for the gas. The bell is fitted inside an external water chamber. The water generates gas when in contact with the carbide, and this passes to the lamps through tubing. If the supply is cut off, the gas pressure acts inside the bell and drives the water away. If gas still continues, it forces its way through the water and escapes through a vent to the atmosphere. On a supply being required the bell falls and admits water. About 1 lb. of good carbide generates 6 cubic feet of acetylene gas. By putting a little spirits of wine into the water of the generator in winter no freezing will take place.

Electrical Installation on Motor Cars.—One of the best known installations is the Ducellier, which consists of the dynamo, battery, switchboard, and lamps. The dynamo itself is entirely free from any mechanical part which requires adjusting. It may be fixed either in front or behind the gear-box. This installation may be worked without accumulators if necessary.

The dynamo has an effective capacity of 200 watts, *i.e.* 14–15 amps. at 12–14 volts. The current is regulated by a combination of constant magnets and electro-magnets; the voltage generated is constant at all engine speeds. There are no contact breakers or regulators. The speed does not exceed 2000 revolutions per minute.

When the speed of the dynamo is sufficiently high to commence charging the accumulators, a switch automatically connects the dynamo with the battery, and disconnects it when the reverse action takes place. A coil cuts off the current when the output falls to zero. The battery is one of 12 volts, 60 amps. minimum, and provides the lighting when the engine is stopped.

The switchboard is fitted on the dashboard of the car, and contains the necessary instruments for the perfect working of the installation.

The dynamo is contained in a neat mahogany box, and may be driven by belt, gear, or friction. Fig. 16 shows sectional diagrams of the Ducellier dynamo. Fig. 17 illustrates the wiring from the switchboard to all the lamps, and Fig. 18 gives the wiring from the dynamo to the switchboard, auto-switch, and battery.

Horns.—Many and various are the devices to attract the attention, and some of the latest sounds heard on the streets and roads are a creation in discord. Some horns are operated electrically ; the current from the battery starting a small motor at high speed. A toothed wheel is fixed on the end of the motor shaft and strikes a knob fixed to a steel diaphragm, and the vibration of the diaphragm produces the sound. There are other types of electric horns. The reed horn is extensively used. Occasionally dust finds its way between the reed and tongue. By passing a sheet of paper between tongue and reed a remedy is generally effected. The indiarubber bulb should be keep free from oil, as oil rots the rubber.

Driving.—Practical experience in driving does far more for the beginner than much theoretical instruction, but the principles and practice in the mechanism and management of the motor car require to be carefully studied. The rapid increase of motor cars renders it highly essential that chauffeurs and owners who drive should acquaint themselves with every part of the machine which they control.

Good nerves, a cool head, and a quick judgment in the event of emergency, are very essential to a good driver. The manipulation of the various levers and handles, as well as the adjustment of the different parts, can be picked up quickly by practical experience. Confidence will soon come from knowledge and experience, but the novice should not attempt to run at a high speed until he understands every movement and mechanism. Much careless and reckless driving is indulged in at the present time, and the charges brought against motorists by the public are sometimes only too true. There is a great tendency to increase the speed of the car to its utmost limit. The spirit of speed often runs away with the better judgment of the driver, and cyclists, carters, and pedestrians have no feelings of good-will as the car rushes past accompanied by a cloud of dust. I will not deny the exhilarating sensation of travelling at high speed, but I heartily condemn any attempt at high speed through a village or past cottages on the roadside. Only too often have accidents occurred through this foolish practice. Great care should be taken in turning sharp corners, especially in the country, where the roads have many windings obscured by hedges and banks. In addition to the great risk, there is the damage done to tyres by side-skidding; on the other hand, there is nothing to show except the saving of a few seconds. Cross-roads are another source of danger, and some very serious accidents have occurred due to rushing past at high speed. There is no better controlled vehicle in the whole world than a motor car, provided the brakes and steering gear are in good working order, but often drivers rely too much on this fact. All the judgment, skill, and coolness in driving will not prevent a catastrophe, when great risks are taken; when overtaking cyclists and other cars caution should be exercised. The motor car ought not to be a nuisance to the other users of the roads. Nothing gives me greater pleasure than to sit beside a careful driver, and I know one such man whose courtesy and consideration to others on the road win for him much popularity. The extreme care he exercises in passing children and aged persons proclaims him to be a worthy knight of the road.

The following remarks may be of use to the reader who has been unable to procure the necessary tuition in driving from an expert. After fixing upon a suitable stretch of road, the novice should ascertain if the accumulators are charged and the radiator filled with water and the petrol tank full. Care being taken to use a gauze strainer when filling the petrol tank, otherwise foreign matter or dust may find its way into the supply pipe and choke it. All grease lubricators must be filled, and the lubricating tank should contain the proper amount of oil. The crank chamber, gear-box, and differential gear casing all require oil. The different levers should be studied, including the spark, throttle and air levers.

The engine is now ready for starting, but before doing so make sure that the brakes are on and the gears out, *i.e.* the gear lever in the free notch; retard the spark as much as possible. Move the throttle or mixture lever, also the air lever, if one is fitted, to a position on the arc that will give the easiest starting. See that the petrol cock is open so that the petrol flows into the carburetter, and that the carburetter is flooded; this is done by depressing the small spring stud on top of the float chamber. Turn on the lubricators and switch on the current. Push the starting handle in until it engages with the engine shaft, and turn slowly until compression is felt. Always pull the starting handle upwards; if pushed down the engine may "backfire" and the arm or wrist may be injured, so pull against the compression quickly, almost with a jerk. If all these directions are carried out the engine should start. Various self-starting devices are in use, but directions as to their working are supplied by the makers. The spark should now be advanced or retarded, and the air lever and accelerator should also be moved to the best position so that the correct mixture may be ascertained.

It is easy to tell when an engine is getting the proper mixture. There is a "hum" about it which is the sweetest note to the ear of the motorist. Observe if the water circulation is working. By this time the sight feed lubricators will be working drop by drop, the usual speed being about six drops per minute. When seated, put your left foot on the clutch pedal and push; the clutch is now withdrawn and will not return to the engine power until the pedal is released. Still keeping the pedal down, take off the brakes and put the gear lever into the first notch. Raise the foot from the pedal very gently and the car will begin to move away, accelerate slightly and use the steering wheel carefully. Very little movement is required to steer a car. After driving a short distance the speed may be changed by grasping the gear lever, at the same time pressing in the trigger lifter. Withdraw the clutch by pushing down the clutch pedal. Move the gear lever forward into the second notch and release the pedal. If the engine is governed, it will not be necessary to touch the ignition, accelerator, or throttle.

A little practice in changing gears will soon enable the driver to find the right notches without taking his eyes off the road. A few corners should be negotiated so that proper control of the steering wheel may be learned.

Depress the clutch pedal again and put in the third speed gently, being careful not to allow the car to slow down too much. By pressing the brake pedal occasionally the driver will be able to estimate the power of the brake. Use the brake pedal and clutch so that the speed of the car may be varied; this will come in useful when actually driving in towns through crowded traffic. After practising on level roads the driver must acquire the necessary skill in changing gears while going uphill. With a clear road in front, the car may be "let out" on top speed, the gathering momentum of the car being sufficient to carry it a good way uphill on top speed. The throttle will, of course, be open and the accelerator pedal down, then retard the ignition. This is all that can be done. If the car slows down and the engine begins to throb, then a change to the second speed must be effected, remembering to withdraw the clutch. This is rather a difficult operation for beginners, and often the car jerks and grinds before "picking up" again. In the hands of an expert the change of gear can be effected without any appreciable sound or movement. It is not wise to wait until the engine has slowed down before changing gear; there is a certain moment to change, and most motorists know exactly when it occurs. It is a sort of intuition. Some drivers are imbued with the idea that all they have to do is to push and pull various levers and steer the car at top speed over irregular roads. The engine should never be allowed to knock or throb, nor should it be allowed to race.

The sound of the engine will tell the intelligent driver much. If the clutch is out when descending a hill, the driver must be careful not to let it in again until the car is travelling at the same rate as the gear which is in mesh. Reverse driving is rather difficult, and careful manipulation is required. When the car is at a standstill, depress the clutch pedal and slide the gear lever from the free-gear notch into the reverse gear. Before putting in the clutch by releasing the pedal, look behind but keep control of the steering wheel. After some practice it will be only necessary to steer with the left hand, and a constant watch can be kept behind. After a few days at the wheel a new sense will come to the driver, his eye, ear, and hand become educated to distances, speeds, sound, and mechanism.

Never use a cheap or poor oil; efficient lubrication is exceedingly important. Over-lubrication is certainly objectionable, but failure of lubrication is worse. Brakes should be tested periodically; this is of vital importance to the car and its driver. Adjustments should never be put off until a convenient time. The convenient time is now; small defects such as leakage, loose nuts, broken wires, etc., should be attended to before harm is done. It is wise to carry a spare accumulator if the ignition is by accumulator alone; if dual ignition, this is not necessary. Accumulators should be charged every month or so. Before leaving the subject of driving a word might be said concerning accidents. Should an accident occur, give your name and address, also the number of your licence and car, to the police and the injured party. Should any witnesses happen to be on the spot, procure their names and addresses. If possible, get their version of the accident and, after writing down, ask them to sign.

Notes on Touring.—There is no more delightful holiday under the sun than a motor tour, but there is always a risk of trouble unless the outfit on the car is a very complete one. The mechanism and management of the car have been dealt with at some length, and I propose now to deal with the preliminary preparations and precautions with a view to eliminating the worrying delays which sometimes happen to the best of cars when touring. A common fault, but one which is rapidly disappearing, is the inaccessibility to parts requiring adjustment and repair. A car intended for touring should have its mechanism accessible and not "cramped" together—a mass of bolts, screws, and levers. Prospective buyers of cars should particularly note the accessibilty of the working parts requiring adjustment.

If the car has been running a season, the connecting rod brasses may require to be taken up. Take each connecting rod and bring them alternately to the bottom dead centre, and move it up and down. If there is any appreciable "slack," it should be taken up by filing the edges of the brasses with a flat smooth file. By working the brasses on the crank pin the exact amount to file off will be ascertained; after adjusting all the brasses and tightening the nuts, lubricate and give the engine a turn by hand to make sure there is no "binding" or "gripping" at the crank pins. The valves also require attention when they are badly pitted. They should be turned up true in the lathe. In another part of the book the operation of grinding in the valves is treated. A thorough examination of the gearing may prevent trouble in this quarter later on. If the wear on the sides of the teeth is excessive they should be renewed, but as a rule the gears will run well until a quarter of the tooth face is exceeded. The brasses in the gear-box may require to be taken up. The carburetter should be carefully examined and cleaned out. The float must have no petrol inside it. By lifting the needle valve and turning on the petrol tap the petrol should flow quickly into the float chamber. The needle valve may require a little grinding. This necessitates careful handling. The grinding in should be done with a little knife polish or very fine emery. In the Longuemare type the spray cone may be removed and the cuts cleaned. Sometimes missing is caused by a partially blocked petrol pipe; a remedy is effected by removing the joint at the carburetter and blowing through the pipe into the tank by the tyre pump. A speck of dust in the spray nozzle is enough to block the supply for a time. Alternate missing is often caused by this. The jet should then be thoroughly cleaned and washed with petrol, at the same time cleaning the passages.

The steering gear must be looked over and all parts secured by nuts and pins. If the type is the worm and quadrant, adjustment may be made, if required, by making the worm work deeper into the gear teeth. If the quick thread and nut type is used, the nut halves should be brought closer together. The steering gear should be examined periodically, as wear and tear soon reduces the working parts, and much "backlash" takes away from the pleasure of driving. If the clutch leather is much worn it should be replaced before starting out. In making brake adjustments care must be exercised to take up wear equally on both sides; if this is not attended to, the car will tend to turn on the application of the brakes. A compensating device is fitted to a large number of cars, so that equal adjusting of each brake is not necessary. Any "slack" in the wheel bearings should be taken up. The radiator pipes and tanks should be flushed out with fresh water. Rain water is best for the radiator and cylinder jackets.

Tyre troubles come at the most unexpected times, and it behoves the motorist to carry a full rig-out of tyre tools and spares. When a tyre punctures, jack up the wheel and take out the inner tube; if it is a small puncture, the inner tube will be replaced by a spare one. Before putting in the inner tube, feel round the inside of the outer cover, as a nail may have found its way into the cover, and if not removed it will pierce the new tube; dust with a little French chalk, replace the tube and outer cover and inflate the tyre. If the cut or hole in the outer cover is large, a patch should be put on, previously cleaning the puncture with petrol and allowing the cut to become dry before applying the solution. If the cut or burst is an exceptionally large one, a gaiter should be fixed on the tyre. The tyre must be in a deflated condition before the gaiter is put on; when it is blown up the gaiter will fit closely around the tyre. The gaiter should be a little forward of the cut so as to allow for shifting in an opposite direction to which the wheel is travelling. The tyre repair outfit should comprise the following: one complete valve, two or more inner tubes and an outer cover, three tyre levers, canvas and rubber patches, one tin of French chalk, one vulcanizer, two gaiters, one tin solution, a sponge and piece of sandpaper. One non-skid is quite sufficient. Tyres are easily cut in wet weather, so that the car should proceed slowly over rough parts of the road. When driving in town, studiously avoid tram rails. Not a few tyres have been cut by the sharp edge of the rail in wet weather.

A waterproof cover for the car should be carried, as often accommodation is not available in out-of-the-way places visited by motorists. Spanners to fit all nuts, screw-driver, hammer, files, pliers, spare bolts, nuts, springs, screws, etc., form part of the tourist's outfit.

If night driving is indulged in, a sharp look-out must be kept, as the head lamps' powerful rays in front of the car often make it difficult to discern distance and objects on the road. The wind screen should be kept down if possible, so that any reflection which might be caused by the glass does not interfere with the vision of the driver. Continual gazing at the bright patch on the road soon strains the eyes, and I have frequently pulled up quickly, imagining that I was running into a wall. Another temptation assails the night driver—that is, to steer the car on to the bank. It is often very difficult to distinguish one's position, especially when travelling fast. Fifteen miles an hour is quite good speed for night driving. An electric flash lamp is handy for reading road signs. A constant watch should be kept for automobile signs. It is difficult to distinguish them in the dark unless very powerful head lights or a search light is used. Every good motorist cultivates and acquires a feeling of good-will towards his car. An engine should never be abused. Every care and consideration for the mechanism means that better results are got, and no one knows this better than the touring motorist.

The Motor House should be dry and plenty of ground space available. The floor should be of cement, but stone flags serve equally as well. A pit for working underneath the car is almost necessary, and should measure 9 feet by 3 feet by 3 feet 6 inches deep. The pit may be cemented or lined with glazed brick. It should also be covered with stout planking to prevent accident when driving in at night. Very often an old stable and coach house has to serve the purpose of a motor house. Some alterations are generally required, but these can usually be effected by a joiner or carpenter. A bench and cupboards for accessories should be installed, and water must be laid on and the necessary hose provided. The car may be washed outside or inside. If space does not permit inside, a light roof jutting out from the building should be arranged for. The motor house ought to be heated in some way, as damp soon rusts the tools and tarnishes the bright parts of the car. Oil drip pans should be placed under the car. This keeps the floor clean and the tyres free from oil. A few wall plugs round the motor house for connection to an electric hand lamp prove very handy.

Sometimes petrol fumes find their way into the pit. By removing the planking and violently agitating the air, this danger may be removed. To extinguish ignited petrol, throw sand or earth over it, or use a chemical extinguisher. Dust or mud should never be wiped or brushed off. Washing is the proper and only way to keep the varnish on the bodywork in good condition. The water should issue from a hose fitted with a tap at the working end. Plenty of water may be used, but it should have very little velocity. A sponge may be used for the bodywork and a spoke brush for the wheels, and the finishing off with chamois or silk cloths. The brass or nickel portions should be cleaned daily. A good quality of plate or metal polish should be used. The leather upholstery may be washed with soap and water occasionally. The hood, if made of leather should be treated with a good harness polish.

CHAPTER VI

MOTOR CAR DUTY AND LAW

Motor Car Duty: The New Taxation, and how it is Computed

* In connection with the alterations in duties on motor vehicles under the Finance (1909–10) Act, 1910, in England and Wales, the Postmaster-General announces that the new licences for motor vehicles authorized by the above Act are available for issue at money order offices in England and Wales from September 1. The duty on licences for motor cars is to be calculated, as from January 1, 1910, on the horse-power, instead of, as formerly, on the weight, of the car.

Licences for motor vehicles taken out for the current year, 1910, under the old regulations, ceased to have effect on June 30, 1910, and new licences at the new rates of duty must be taken out as soon as possible. The old licences should be presented at the post office when application is being made for the new licence, and, if the new licence is taken out in the same county or county borough as that in which the old licence was issued, allowance will then be made for the duty previously paid for the year 1910. If the amount already paid exceeds the duty payable at the new rates, the excess will be refunded to the licensee.

Medical practitioners who keep a motor vehicle or

* By kind permission of *The Car Illustrated.*

vehicles for the purpose of their profession are entitled to a reduction of one-half of the duty, provided that they have previously satisfied the licensing authority (*i.e.* the county or county borough council) that they are entitled to the reduction. A special form of declaration is provided for the use of medical practitioners.

METHOD OF RATING

The method adopted by the Royal Automobile Club for the rating of motor cars is as follows:—

(*a*) *For Petrol Cars driven directly or indirectly by Internal Combustion Engines.*—The rating of one working cylinder of the engine is calculated as follows:—The internal diameter of the cylinder measured in inches is multiplied by itself (*i.e.* squared), and the product divided by 2·5. If the diameter is in millimetres, the figure 1613 is used instead of 2·5.

For engines with more than one cylinder, the rating, calculated as above, is multiplied by the number of cylinders.

(*b*) *For Steam Cars.*—The same calculation is carried out, with the exception that the rating is calculated for each cylinder separately when they are of different diameters, and the products added together, the result being the rating of the whole engine.

In the case of double-acting engines this result is multiplied by two.

(*c*) *For Electric Motors.*—All motor cars driven by electricity stored in the cars themselves are rated as equivalent to 15 R.A.C. rating.

(*d*) *Two-stroke and Two-piston per Cylinder Engines.*—The rating of these are calculated as under (*a*).

The horse-power for taxation purposes is calculated in the manner already shown, except that in the case of engines of the two-piston-per-cylinder type the constant 1·6 is used instead of the constant 2·5.

The Treasury Regulations make no provision for calculating the horse-power when the bore is in millimetres, but the method described under (*a*) gives the result with sufficient accuracy unless the rating is very near indeed to the division of two classes. 1612·9 should then be taken instead of 1613.

Appended are the regulations made by the Treasury for the purposes of Section 86 (2) of the Finance (1909–10) Act, 1910 (10 Edw. VII. c. 8).

The Lords Commissioners of His Majesty's Treasury, in pursuance of Section 86 (2) of the Finance (1909–10) Act, 1910, and of Section 2 of the Rules Publication Act, 1893, hereby certify that on account of urgency the following regulations should come into immediate operation, and accordingly make the following regulations to come into operation forthwith as provisional regulations :—

1. For the purposes of these regulations the horse-power of any motor car deriving its motive power wholly from a steam, internal combustion or other engine, worked by a cylinder or cylinders, shall be taken to be :—

(*a*) in the case of a single-cylinder engine the horse-power attributable to the cylinder of the engine :

(*b*) in the case of an engine having two or more cylinders the sum of the horse-powers attributable to the separate cylinders.

2. The horse-power attributable to any cylinder shall be deemed to be proportional to the square of the internal diameter of such cylinder measured in inches, and shall be determined according to the number of square inches contained in such square, the unit being taken to be :—

(*a*) in the case of a single-acting cylinder having a single piston, one horse-power for every $2\frac{1}{2}$ square inches;

(*b*) in the case of a single-acting cylinder having two pistons, one horse-power for every $1\frac{3}{5}$ square inches;

(*c*) in the case of a double-acting cylinder having a single piston, one horse-power for every $1\frac{1}{4}$ square inches.

3. Any motor car deriving its motive power or any part of its motive power otherwise than from an engine worked by a cylinder or cylinders, shall be deemed to be of a horse-power exceeding twelve but not exceeding fifteen, provided that, where the motive power is derived in part from an engine worked by a cylinder or cylinders, the horse-power of the car shall not be deemed to be less than the horse-power attributable to the cylinder or cylinders of such engine.

4. Where it appears that, in consequence of the exceptional design or construction of the engine of any motor car, the horse-power as calculated under the foregoing rules is substantially less than the power which the engine is actually capable of developing, the horse-power of the car shall for the purposes of these regulations be taken to be the same as that of a car of equal efficiency deriving its motive power from a cylinder engine of the ordinary type.

5. In measuring cylinders and calculating horse-power, fractions of an inch and fractions of a unit of horse-power are to be taken into account.

The subjoined table, published by the Royal Automobile Club in its useful handbook "Table of Motor Cars Manufactured during the Years 1908–1910 inclusive" gives at a glance the rate of taxation and the cylinder dimensions :—

RATING AND TAXATION OF MOTOR CARS.

Classification (R.A.C. Rating).	Tax. £	s.	d.	* Greatest cylinder diameter allowable for engines with different numbers of cylinders. 1 cyl.	2 cyl.	3 cyl.	4 cyl.	6 cyl.
Not exceeding 6½ h.p.	2	2	0	4·03 in. or 102·36 mm.	2·85 in. or 72·39 mm.	—	—	—
Over 6½ h.p. to 12 h.p.	3	3	0	5·47 in. or 139·12 mm.	3·87 in. or 98·36 mm.	3·16 in. or 80·31 mm.	2·73 in. or 69·55 mm.	—
Over 12 h.p. to 16 h.p.	4	4	0	6·32 in. or 160·63 mm.	4·47 in. or 113·58 mm.	3·65 in. or 92·74 mm.	3·16 in. or 80·31 mm.	2·58 in. or 65·57 mm.
Over 16 h.p. to 26 h.p.	6	6	0	—	5·70 in. or 144·79 mm.	4·65 in. or 118·22 mm.	4·03 in. or 102·38 mm.	3·29 in. or 83·60 mm.
Over 26 h.p. to 33 h.p.	8	8	0	—	—	—	4·54 in. or 115·34 mm.	3·70 in. or 94·18 mm.
Over 33 h.p. to 40 h.p.	10	10	0	—	—	—	5·00 in. or 129·99 mm.	4·08 in. or 103·69 mm.
Over 40 h.p. to 60 h.p.	21	0	0	—	—	—	6·12 in. or 155·53 mm.	5·00 in. or 126·99 mm.
Over 60 h.p. . .	42	0	0	Any engine with cylinders greater than the limit for the £21 tax.				

* This does not apply to engines with two pistons per cylinder, or to steam engines (unless the latter are single-acting and have equal size cylinders). The tax on motor bicycles or tricycles is £1.

Motor Car Law.—The speed limit in Great Britain is twenty miles per hour, except in those villages and towns where the speed must be reduced to ten miles per hour. (Hyde Park, London, twelve miles per hour.)

The red triangle road-sign signifies danger, such as school, a dangerous turn, cross-roads, or steep descent.

In traffic, the driver should hold up his hand to signal that the car is about to stop. When turning to the right, the right arm should be held straight out horizontally. When turning to the left, the driver should wave his hand for the traffic to pass him.

Should a man be leading a horse, pass him so that he is between the car and the horse.

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THE END

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