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FOR OFFICIAL USE

K5

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Post Office Engineering Department

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Subject

GAS AND PETROL ENGINES

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CORRECTION SLIP TABLE

Serial No. of Slip :	Date of Issue :	Corrections carried in	
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FOR OFFICIAL USE

GAS AND PETROL ENGINES

(K.5)

The following I.P.O.E.E. paper is of kindred interest :—

No. 33.—"Fundamental Principles of Modern Internal Combustion Engines." By P. Dunsheath.

For particulars as to the maintenance of motor cycles, lorries, and Ford cars, reference should be made to the makers' instruction books issued to drivers of each type of vehicle.

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GAS AND PETROL ENGINES

GENERAL DESCRIPTION

The internal combustion engines most generally met with in the Post Office service are single-cylinder machines working on what is commonly known as the "Otto" or 4-cycle system. In this system a working stroke is obtained once in every two revolutions of the crankshaft, thus differing from the steam

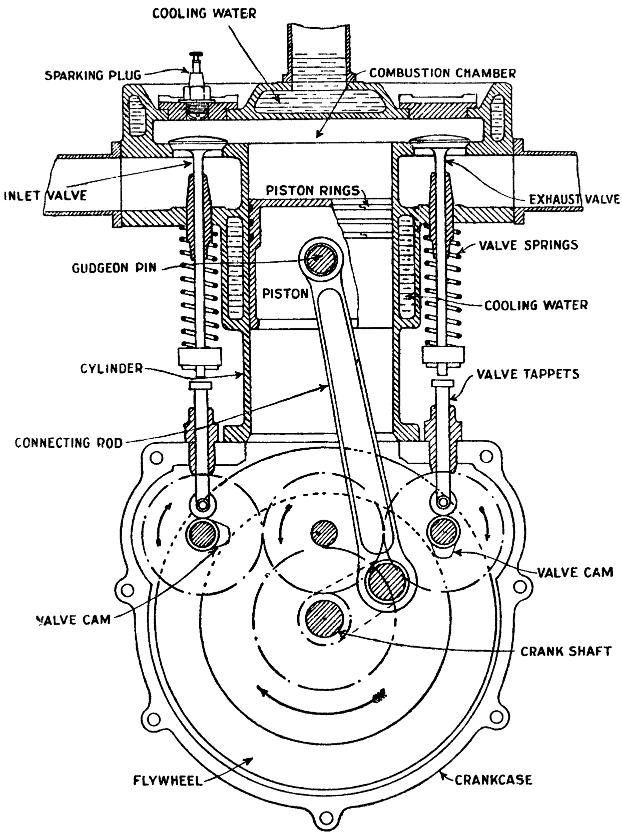


FIG. 1.--GENERAL ARRANGEMENT OF WORKING PARTS.

engine, in which we get a working stroke for each revolution of the crankshaft in a single-acting engine like the Willans and Robinson, or two working strokes for each revolution of the crankshaft in a double-acting engine where steam is admitted on both sides of the piston. It will generally be found that coal gas is used for horizontal engines of moderate speed (*i.e.*, up to about 450 revolutions per minute) with belt drive, and that petrol is employed for small vertical engines running at higher speeds and direct coupled to the machines they are intended to drive. Each type may, however, be designed to use either fuel. Further, each type may consist of several cylinders with pistons working on a common crankshaft, but, for the purposes of this pamphlet, only the single-cylinder unit will be considered.

The working of the two types may be taken as identical as far as the general principles are concerned, and differs only in detail.

Figures 1 and 2 show the general arrangement of a petrol engine and gas engine respectively. In Fig. 1 the valves are, for clearness, shown on separate sides of the cylinder, but they are usually placed side by side on one side of the cylinder and worked off cams on the same shaft. In Fig. 2 the cam shaft is not shown, in order to avoid complicating the diagram; it is worked off the crankshaft by worm or bevel gear and the cams actuate rocker arms which impart the necessary movement to the valves in a manner similar to that shown on the petrol engine diagram.

The engine consists of bed-plate (usually of cast-iron), cylinder with water jacket, piston (of the trunk type fitted with three rings near the head and, in some cases, a fourth fitted at the outward end), connecting rod, crankshaft (running in white metal or phosphor bronze bearings), heavy flywheel, and inlet and exhaust valves held down on the valve seats by springs and actuated by cams mounted on a shaft driven at half the speed of the crankshaft. In the case of gas engines, a third valve is provided to admit the gas to a mixing chamber from which it is then drawn, mixed with air, into the cylinder through the main inlet valve. In the case of petrol engines, a carburettor is employed to control the flow of petrol and to supply a mixture of petrol and air in the form of gas. The gas is sucked into the cylinder through the inlet valve. Finally, an ignition system is required to fire the charge in the cylinder. This, in modern engines of both types, is most commonly effected by the electric magneto machine; but ignition by accumulator and spark coil is sometimes met with and also the hot tube ignition in gas engines of earlier date.

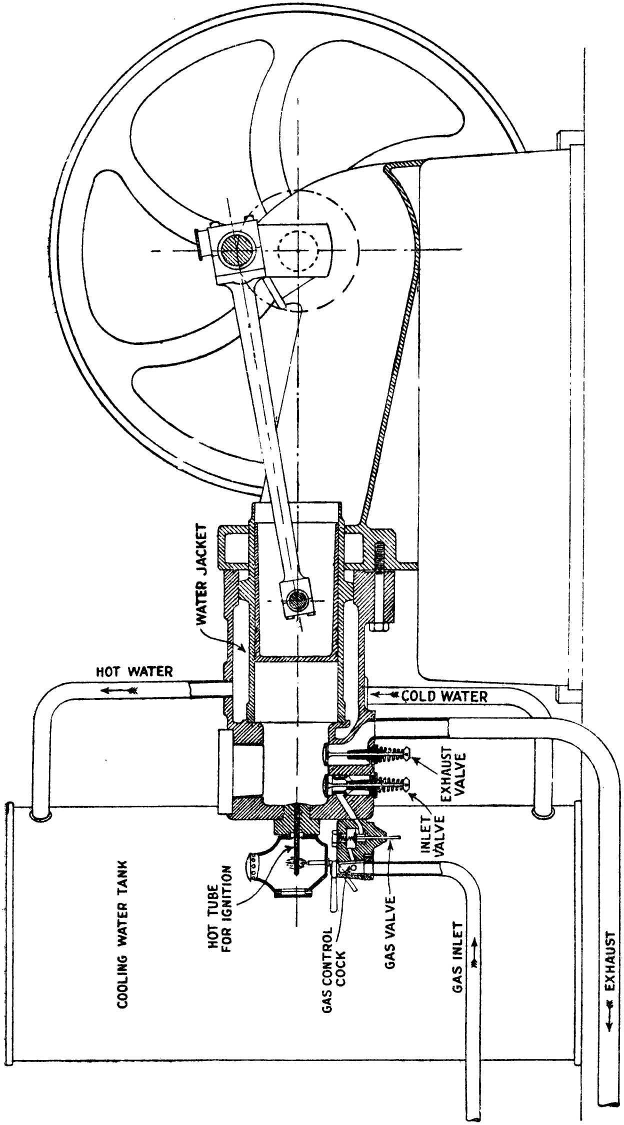


Fig. 2.—General Arrangement of Gas Engine.

THE OTTO OR 4-CYCLE SYSTEM.

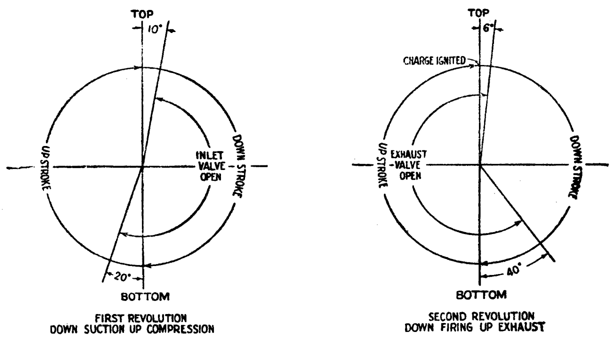
The working of the Otto or 4-cycle system is shown in Fig. 3, and is as follows :—

(1) When the crankshaft is rotated, starting with the crank at the top of its stroke, the inlet valve is opened and a charge of gas and air or petrol vapour is sucked into the cylinder by the action of the descending piston. The exhaust valve is closed on this stroke.

(2) On completion of the down stroke, both valves are closed and the rising piston compresses the charge into the space at the top of the cylinder.

(3) When the crank reaches the top of the stroke both valves are still closed and the charge is ignited by electric spark or hot tube. This is the working stroke.

(4) When the crank reaches the bottom of the stroke the exhaust valve is opened and the products of combustion are discharged to atmosphere through the exhaust valve.



VALVE SETTING DIAGRAM

Fig. 3.

The crankshaft has now completed two revolutions and the process repeats itself as long as the engine is running.

It will be useful here to indicate more accurately the actual setting of the cams which operate the inlet and exhaust valves, as the best results cannot be obtained if these open and shut at the exact top or bottom of the piston travel. The inlet valve is set to open slightly after the crank has turned over the top dead centre (in petrol engines up to 10 degrees) and to shut 20 degrees past the bottom dead centre. The exhaust valve is set to open considerably before the bottom dead centre (up to 40 degrees in a petrol engine) and to close slightly past the top dead centre (about 6 degrees), as shown in Fig 3. Generally

THE FOUR STROKE CYCLE OF OPERATIONS.

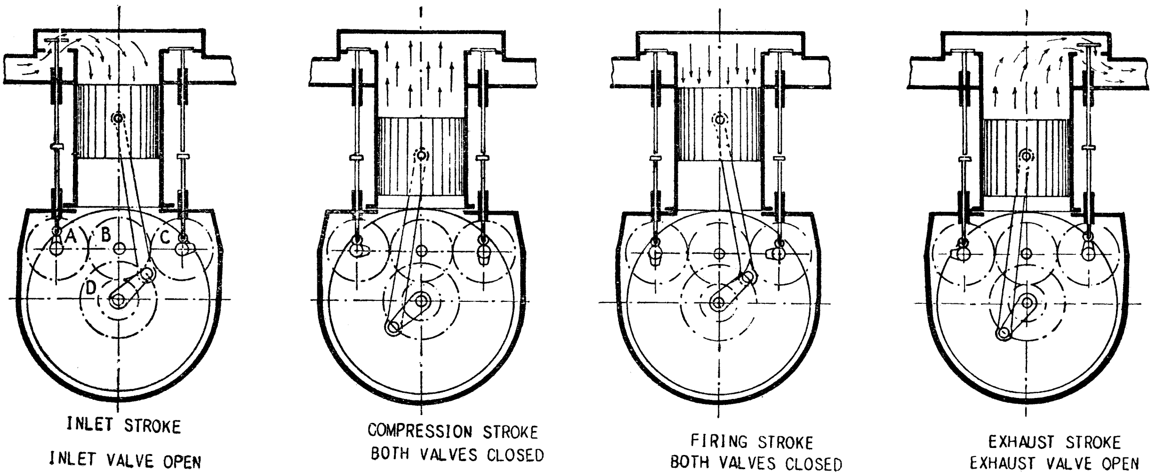


Fig. 4.

speaking: the angles given above decrease with slower running engines and increase with higher speeds.

If electric ignition is employed and means of varying the time at which the spark is produced are provided, the setting should be such that, when the timing device is in its fully retarded position, the spark is produced at the instant when the piston is on the top dead centre, and this is the position when starting the engine. When the engine is running, the timing device is advanced so that the spark is produced before the piston reaches the top of the stroke; this allows for the time taken to fire the charge in order that the explosion may take place on the instant that the piston reaches the top dead centre

Fig. 4 shows the four-stroke cycle of operations. The four circles marked *A*, *B*, *C* and *D* represent toothed gear wheels, *D* being fixed to the crankshaft, *B* being an idle wheel to drive the two wheels *A* and *C* which rotate the cams operating the inlet and exhaust valves respectively. The number of teeth on the idle wheel *B* is immaterial, but the wheels *A* and *C* must have double the number of teeth on wheel *D*, so that the cam shafts make half the number of revolutions made by the crankshaft. The settings of the valves are adjusted by altering the relative positions of these toothed wheels. Where both valves are on the same side of the cylinder, of course, wheels *B* and *C* can be dispensed with and *A* can be driven direct from wheel *D*.

Valve setting on multi-cylinder engines should present no greater difficulties than for single cylinders, as the cams operating the valves are fixed on the cam shaft and cannot be altered in relation to each other; if, therefore, the valves are set for any one cylinder the others will also be correct. A simple method of timing any engine is to mark out the points shown in valve setting diagram (Fig. 3) on the flywheel for any one cylinder and the cams can then be set so as to open and shut the valves at the correct points; care must, however, be taken to make the openings and shuttings of the valves to suit the particular design of engine in use.

In the older type of engine the inlet valve is frequently "automatic"; that is, instead of being actuated by a cam, as explained above, it is fitted with a considerably weaker spring and is opened by the suction produced in the cylinder on the first down stroke of the piston during the four-stroke cycle of valve operation. The valve cannot open on the second down stroke on the third cycle owing to its being held up against the seating by the explosion of the charge. The strength of the spring employed with the automatic valve must be sufficient to prevent the valve from "chattering" on its seating on the one hand, and, on the other hand, not too powerful to prevent the suction in the cylinder from opening it sufficiently to allow a full charge of explosive mixture to enter the cylinder. The automatic inlet valve has practically been superseded in modern practice by the mechanically operated valve, as it has been found that the positive action by means of a cam working against a strong spring is more reliable in operation. The mechanically operated valve has the further advantage that both inlet and outlet valves with their springs can be made interchangeable, thus lessening the number of spares required.

The two stroke or 2-cycle system differs from the 4-cycle system in that an explosion is obtained every revolution and is thus similar in action to a single acting steam engine.

THE TWO STROKE CYCLE OF OPERATIONS

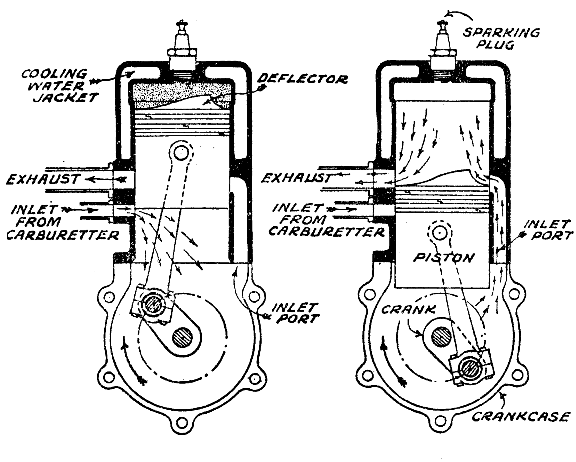


Fig. 4a.

There are no moving valves but the piston uncovers inlet and exhaust ports during its travel. The working is as follows :—

When the piston is nearing the bottom of its travel an inlet port is uncovered allowing a charge of explosive mixture which has been compressed slightly in the crank chamber on the down stroke of the piston, to enter the cylinder : this charge is compressed by the rising piston and exploded in the usual way. This forces the piston down : on its downward path it uncovers an exhaust port and allows the spent gases to escape. This process is repeated each revolution (see Fig. 4a).

The difficulties met with in this type of engine are as follows:

(1) To get sufficient explosive mixture into the cylinder before the commencement of the up or compression stroke of the piston. This is overcome to some extent by making the crank chamber as air-tight as possible and drawing the charge into the crank case where it can be compressed by the piston on the down stroke, and thus force a charge into the cylinder at the beginning of the up stroke.

(2) To get rid of the burnt gases and clear the cylinder before the commencement of the up stroke. A remedy is found in fitting a deflecting head on the piston to guide the gases into the exhaust port.

It will be seen that the 2-cycle engine is considerably simpler to construct than the 4-cycle type owing to the absence of valves and their operating gear, but, owing to the above difficulties of getting a full charge into the cylinder and then completely getting rid of the burnt gases it is generally less efficient and is difficult to design in the larger sizes without introducing complications which outweigh the advantages of this type over the 4-cycle system.

ELECTRIC IGNITION.

For gas engines a low tension magneto machine is commonly used. This form of machine consists of a stationary armature fixed between pole pieces on permanent field-magnets with a soft iron sleeve placed between them which is caused to rotate backwards and forwards, thus cutting the lines of

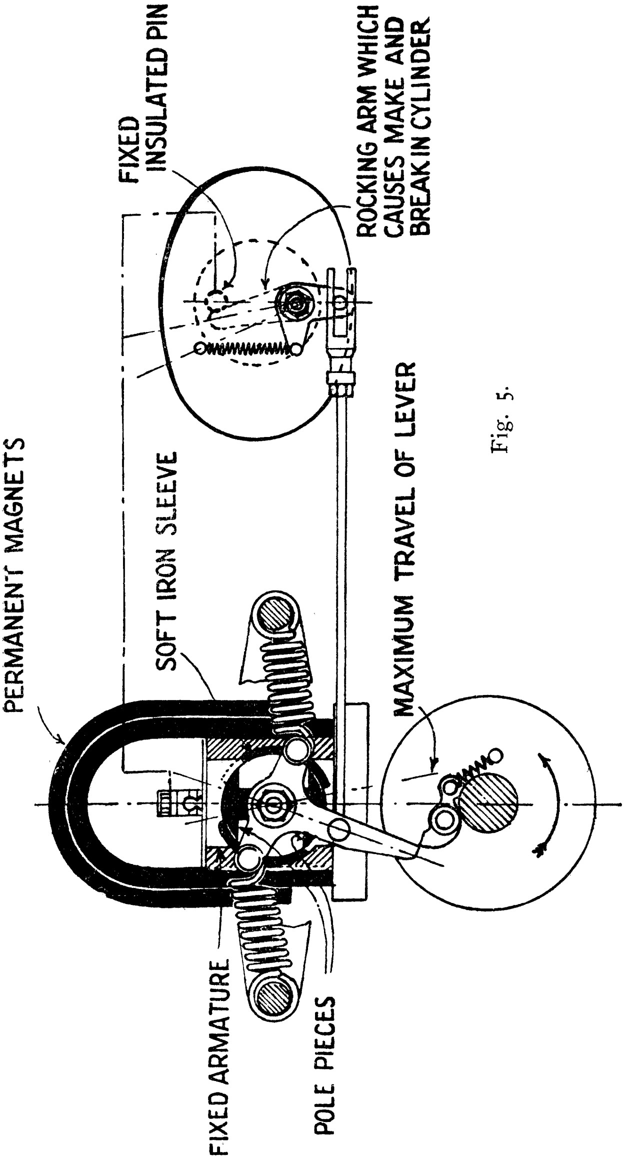

PERMANENT MAGNETS
SOFT IRON SLEEVE
FIXED INSULATED PIN
ROCKING ARM WHICH CAUSES MAKE AND BREAK IN CYLINDER
MAXIMUM TRAVEL OF LEVER
FIXED ARMATURE
POLE PIECES

Fig. 5.

force set up in the field by the permanent magnets and thereby generating a current in the armature. This current flows round the firing circuit and produces a spark when the circuit is broken in the cylinder. The arrangement is shown in Fig. 5.

The working is as follows:—

The soft iron sleeve is connected to a cam on the half speed shaft in such a way that it is slowly moved through approximately ¼ right angle and then released by a trip device. It is then instantaneously brought back to its original position by a stiff spring or springs. This action causes the iron sleeve to cut the lines of force set up by the permanent magnets at a rapid rate, thus giving a strong current independently of the speed of the engine. When the current is at its maximum the cir-

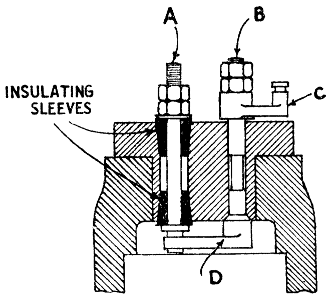


Fig. 6.

cuit is broken by means of a contact breaker inside the head of the cylinder and a vigorous spark is produced. The exact timing of the spark is adjusted by altering the position of the cam on the side shaft which actuates the contact breaker in the cylinder.

The contact breaker just referred to is shown in Fig. 6. It is mounted on the end of the combustion chamber and consists of two parts, *A* and *B*. *A* is a fixed metal pin well insulated from all electrical contact with the engine frame, and *B* is a movable rod with arms *C* and *D*, of which *C* is outside the cylinder and *D* inside. The arm *D* forms the make and break against the pin *A*. The arm *C* is actuated by a lever working on the cam shown in Fig. 5, and rocks the rod *B*, causing arm *D* to break contact with the pin *A* when the spark is required. When the arm *D* is in contact with the pin *A* the electric current flows from *A* through arm *D* to frame or earth and thus back to the earthed terminal of the armature winding, through this winding, and by insulated wire to *A*.

The advantage or employing the iron sleeve type of magneto for gas engines is that the spring rotates the sleeve at the same rate for all engine speeds, and thus produces a strong spark when the engine is being started, whereas the revolving armature type does not produce a spark until considerable speed is attained.

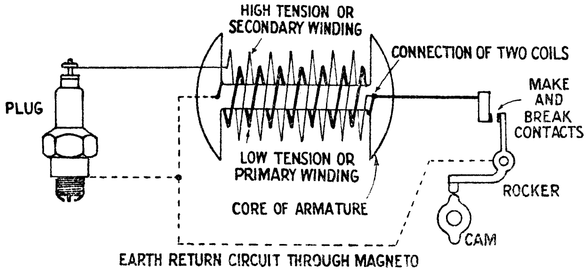


Fig. 7.—Magneto Circuit.

The sleeve type is not suitable for engines which run at high speed, and for petrol engines a magneto machine with a revolving armature is employed. This supplies current at a potential high enough to spark across the points of a sparking plug, and

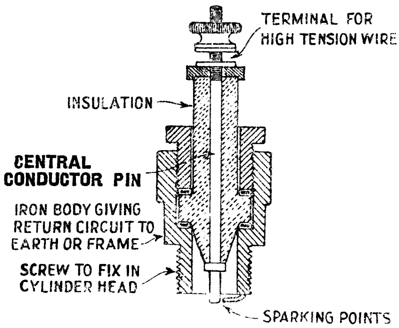


Fig. 8.—Section of Sparking Plug.

does not require a make-and-break device in the cylinder. Fig. 7 shows the general arrangement of the revolving armature type, and Fig. 8 a section of the sparking plug with fixed points. The armature is wound with double windings, one consisting of a small number of turns of thick wire and the other consisting of a large number of turns of very fine wire, thus giving the same effect as a transformer. The volts generated in the low-tension winding are raised in the same ratio as the number of ampère turns in the thick wire to the number of ampère turns in the thin wire. By this means the volts in the secondary winding are brought up to something like 50,000. A condenser is also fitted in shunt with the make-and-break device on the low-tension side to lessen the sparking at the contact points, and thus to reduce the wear on them. The low-tension winding is connected to the frame or "earth" at one end and, at the other end, to a slip ring on the shaft, from which it is collected by a carbon brush and carried to the make-and-break, which controls the time at which the spark takes place. The spark occurs at the instant when the low-tension current is broken. One end of the high-tension coil is connected to earth through the low-tension, and the low-tension coil and the other end is connected to the insulated pin passing down the centre of the sparking plug. When the low-tension current is broken, the current induced in this high-tension coil jumps across the plug points, thus completing the circuit *via* frame or "earth." The timing of the spark is thus controlled on the low-tension winding.

All magnetos run on ball bearings, therefore a few drops of good thin oil after 100 hours running is all that is necessary on the main bearings and an occasional drop on the pivot of the contact-breaker rocker. Certain types are not provided with a lubrication hole. In such cases the bearings have been packed with grease when assembled, and are likely to run for long periods without attention. The contact-breaker mechanism must be kept scrupulously clean. Carbon brush and collector rings should be examined occasionally, care being taken that the former is making firm contact, while the latter should be wiped with a piece of rag soaked in petrol and pushed through the brush opening by means of a pencil. High-tension leads should be scrutinised for cracks in the insulation.

Another form of electric ignition is by means of a small battery and a coil which transforms the low tension current from the battery up to high tension current capable of jumping across the points of the sparking plug. The battery may be either a small accumulator or dry cells, giving a voltage of 4 to 6 volts. A trembler is usually provided on the coil to furnish a quick make and break, and so to increase the intensity of the spark. The arrangement is shown in Fig. 9.

Ignition by means of hot tube may be met with on older types of gas engines. This consists of a metal or porcelain

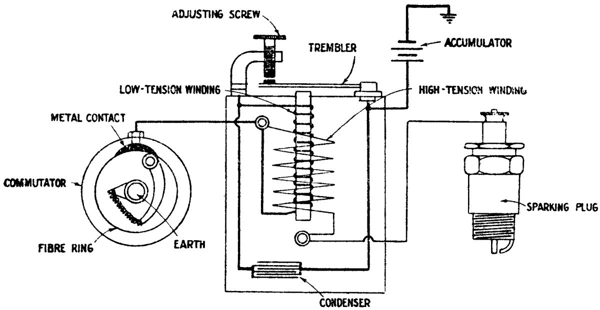


Fig. 9.

tube which projects into the cylinder and is kept at a high temperature by means of a bunsen gas flame or blow lamp. Fig. 10 shows the general arrangement.

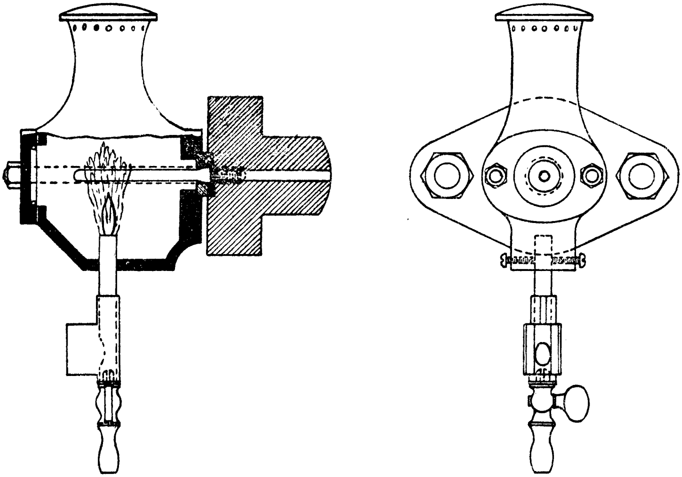


Fig. 10.

The tube may consist of $\frac{1}{4}$ in. gas pipe about 8 in. long, but the life of these is short, and a nickel pipe, though more expensive in first cost, gives a very much longer life and is more satisfactory. The main point to be observed is that the hottest part of the bunsen flame should come in contact with the tube in order to give sufficiently high temperature to ignite the explosive charge. To ensure this the top of the inner blue flame must be kept about $\frac{1}{4}$ in. below the tube. This can be adjusted by varying the gas supply or the amount of air admitted to the bunsen burner. A better method is to maintain a fixed gas supply and to vary the air until the correct height of flame is obtained.

GOVERNING.

Where constant speed is required, a governor must be provided. On gas engines this may be of the *inertia* or *hit and miss* type, or the ordinary *centrifugal* type. On petrol engines, owing to the greater speed at which they are commonly run, the hit and miss type is not suitable.

A simple form of *hit and miss type* governor is shown in Fig. 11, where *V* is the valve which admits the gas, with a hard

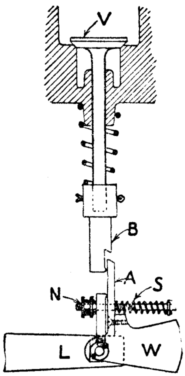


Fig. 11.

steel block *B* fixed on to the bottom end of the valve stem. Below this is mounted an arm *A* fitted on to the end of a lever *L*. which is worked off the cam shaft so that, at normal speeds, the arm *A* lifts the block *B* and the valve *V* once every two revolutions to admit the gas required to form the explosive mixture in the cylinder. The arm *A*, however, is attached to a weight *W* and mounted on the lever *L* by means of a pivot and held in position by a spring *S* in such a way that, when the speed of the engine increases and the lever is therefore given a more sudden upward movement, the weight *W* tends to lag behind and causes the arm *A* to miss the block *B*, so that the valve is not lifted for that particular stroke and an explosive charge is not obtained. This will bring down the speed until a point is reached at which the arm will again lift the gas valve *V*. The tension on the spring is regulated by the milled nuts *N*, and this governs the speed of the engine.

This method of governing is economical of fuel, but gives greater variation from the normal speed than throttle governing actuated by the centrifugal governor, and also throws more strain on the working parts of the engine on that account. This, however, is not important on engines of small horsepower.

On petrol engines the ordinary centrifugal governor is employed, which opens and shuts a butterfly valve in the pipe between the carburettor and the engine.

As stated above, both gas and petrol have to be mixed with air to form an explosive mixture before being drawn into the cylinder. In the case of an engine using coal gas, the gas requires to be mixed with 10 parts of air to 1 of pure gas (vary-

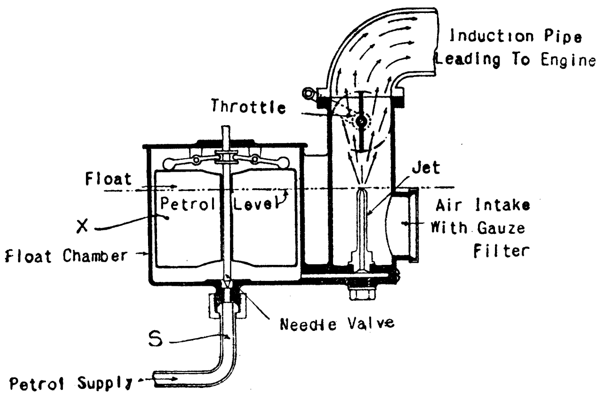


Fig. 12.—Simple Form of Float Carburettor.

ing slightly with different qualities), and this is effected by suitable design of the gas valve and inlet valve and by controlling the pressure of gas by means of a cock on the gas supply pipe.

In the case of petrol, a more elaborate device known as a carburettor is employed. The proportions of air and petrol required are approximately 15 lb. of air to 1 lb. of petrol, which corresponds roughly to 2 volumes of petrol vapour to 100 volumes of charge. A simple form carburettor is shown in Fig. 12. This consists of a float chamber and float to maintain a constant supply of petrol at all loads, and a mixing chamber to provide for the mixture of petrol and air in correct proportions to form petrol vapour. The action is as follows :—

The petrol enters the float chamber by the supply pipe *S* through a small valve-seating. A hollow float is provided which rises with the petrol until it comes up against two weights on the end of rocking levers pivoted on the carburettor cover which engage with a collar on the needle passing through the centre of the float. The float then raises the weights and depresses the needle which terminates in a cone and fits into the small valve-seating at the bottom of the float chamber and so cuts off the supply of petrol. As the petrol gets used up the float falls again, and the weights at the end of the rocking levers raise the needle clear of the valve seating, thus allowing petrol again to enter the float chamber. It will be seen that an automatic means of keeping a constant level of petrol is thus provided. This level is usually adjusted so that the petrol rises to a point just below the top of the jet in the mixing chamber. When the engine is at rest the petrol remains there and there is no waste. When, however, the engine is rotated, the suction produced by the piston during the inlet stroke sucks air through the air intake past the top of the jet and, by reducing the pressure of air above the jet below that in the float chamber, causes the petrol to overflow. It then mixes with the inrushing air and is carried on in the form of vapour past the throttle valve into the cylinder. The supply of petrol vapour to the engine is regulated by varying the opening into the induction pipe by means of the throttle valve. This consists of a metal disc which can be turned through a right angle. It is open in the position shown on the diagram but completely closes the induction pipe when moved at right angles to the position shown. It will be seen that, with the carburettor shown, the entire control is carried out by means of the throttle valve. This is fairly satisfactory in the case of an engine running at constant speed. Where, however, varying speeds are required, as on motor vehicles, it is found that when the engine is running at the higher speeds and air is drawn at greater velocity through the air intake, the amount of petrol drawn through the jet is excessive and out of proportion to requirements. Some means must therefore be provided to alter the proportion of petrol and air supply. This is done either by varying the size of the jet or, more simply, by providing for extra air intakes between the top of the jet and the throttle valve which can be separately controlled by hand or automatically by means of springs set in such a manner that they allow extra air to enter in proportion to the extra suction produced by the engine running at the higher speeds. The best results are obtained when the carburettor is fitted close up to the inlet valve and the induction pipe is kept as short as possible. If the induction pipe is too long the petrol vapour condenses out of the mixture and difficulty is experienced in getting a constant proportion of petrol and air into the cylinder. To facilitate the vapourising of the petrol the body of the mixing chamber is frequently heated either by hot water from the water jacket or by hot air from the exhaust pipe.

The hole through the petrol jet is of very small dimensions, and great care must be taken that no dirt or water gets into the petrol. All petrol should be filtered through a wire gauze strainer of small mesh before being put into the supply tank and, in addition, a small strainer, shown in Fig. 13, is usually fitted between the tank and the carburettor. This should be cleaned at regular intervals.

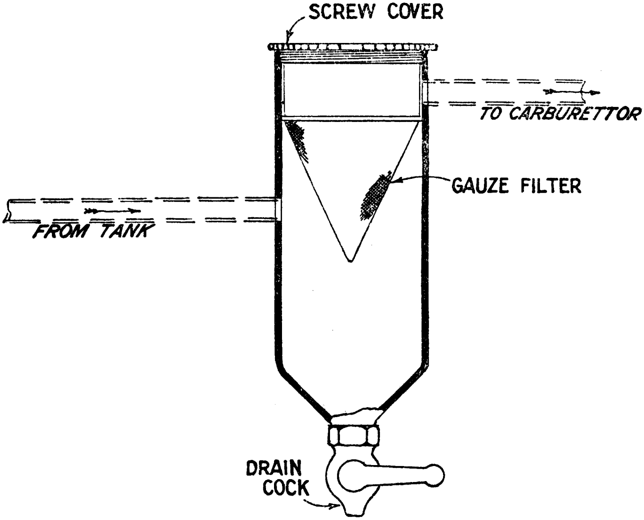


Fig. 13.

PARAFFIN ENGINES.

Paraffin oil also is used as fuel for internal combustion engines in a similar manner to gas and petrol, the only alteration required being the use of a special form of vapouriser to reduce the paraffin to vapour before being mixed with air to form an explosive mixture.

To produce a satisfactory oil engine the only difficulty is to devise a reliable vapouriser, as the heat supplied to the chamber must be able to vapourise the oil but must not be sufficient to decompose it. This heat must be provided either by the exhaust heat of the engine or by some external means such as a blow lamp. In some cases both of these methods are employed, the blow lamp being used only until the engine has had time to warm up. In the Diesel engine, in which heavy oil is made use of, the engine is worked at a higher compression than engines designed for oil, gas or petrol. The fuel is then injected direct into the cylinder at the top of the compression stroke, at which point sufficient heat is generated in the cylinder to fire the charge without any separate ignition device. Owing to the greatly increased weight of flywheel and moving parts necessary to work with the increased compression, this type of engine is not commonly used in the smaller sizes.

With a device used in the Hornsby engines the oil is pumped through a spraying nipple into the vapouriser, which is kept at a suitable temperature whilst the cylinder is being filled with air on the suction stroke. On the following compression stroke air is driven into the vapouriser, which communicates with the cylinder, through a narrow neck and mixes with the oil vapour. As the pressure is increased, due to the compression in the cylinder, the charge becomes increasingly explosive until, at the completion of the stroke, the proper proportions of air and oil vapour are obtained. The mixture is then fired by the temperature of the vapouriser and the heat of compression in the cylinder. The ignition is thus automatic, and after the engine has reached a working temperature no separate heating lamp is required. A blow lamp must, however, be provided to raise the vapouriser to a suitable temperature at starting. When hot tube ignition is employed, the lamp utilised for keeping the tube at the necessary temperature is also employed for heating a chamber in which the oil is vapourised, of which there are several types.

A carburettor, very similar to that used for petrol, can be used, but considerable heat is required to vapourise paraffin, and exhaust jacketing of the body of the carburettor must be arranged for. The paraffin may also be passed through a spiral tube inside a casing carrying exhaust gases. Petrol must be used for starting. This necessitates a small auxiliary tank, in addition to the main paraffin tank, and a 3-way cock being provided to allow the paraffin supply to be turned on as soon as the engine is working. The inlet piping must be as short as possible, otherwise the paraffin will condense on the pipe and the mixture will become irregular ; arrangements must also be made for more air than is required for petrol in order to ensure complete combustion.

Paraffin is quite satisfactory as a fuel provided the load is fairly constant, but where a very varying load, such as is found on motor vehicles, is met with, the difficulty of obtaining a correct mixture prevents its being generally suitable.

Benzole is another fuel which can be used in internal combustion engines. It is obtained from the distillation of coal and is a by-product from gas and coke ovens. The specific gravity of benzole is higher than that of petrol, but the ordinary petrol carburettor is quite satisfactory for its use, although extra air may have to be arranged for in some cases.

MAINTENANCE.

Lubrication.—*Only oil capable of withstanding the heat of the explosion must be used to lubricate the cylinder walls.* Mineral oils of high flash point and high viscosity are most suitable. In vertical engines the splash system, by which the crank webs throw up the oil from the bottom of the crank chamber to the cylinder walls and connecting rod bearings, is most common. With this system care must be taken to see that the correct level is maintained in the crank chamber. In gas engines of the horizontal type lubrication is by means of sight feed lubricators, and the correct setting of these must be accurately maintained.

Loss of power.—The chief causes of the engine failing to maintain its power are (1) *Loss of compression in the cylinder,* (2) *Faulty Ignition,* (3) *Overheating of the Engine.*

(1) *Loss of compression in the cylinder* may be due to:

(a) The valves not working properly, caused by the cams not being set correctly owing to wear or incorrect assembling. If this is the case the setting must be corrected by the valve.

(b) The escape of gases past the valve faces due to wear. This is most likely to occur in the case of the exhaust valve which becomes pitted or scored by the passage of the hot exhaust gases. If this is suspected the cover in the engine over the exhaust valve must be removed and the valve taken out by extracting the cotter pin below the spring which holds it down on to the seating. The valve can then be withdrawn. The valve face and seating should then be examined and, if either is found to be pitted or worn, the valve must be ground on to the seating by smearing the face with a mixture of fine emery and oil and rotating the valve backwards and forwards by means of a screwdriver or similar tool until both valve face and seating present a perfectly bright surface. All trace of emery must then be removed and special care taken to prevent any reaching the cylinder walls. The valve may then be replaced, care being taken that the cover joint is perfectly air-tight. The same procedure should be carried out in the case of the inlet valve if this be faulty.

(c) Escape of gases past the piston rings. This may be caused by (i) wear of the cylinder walls, but is not likely to take place unless the engine has been in use for a long period or the walls have been scored by defective lubrication; (ii) carbon deposit on the piston rings. The piston must be removed and the rings taken off and thoroughly cleaned and all carbon deposit removed from the rings. Great care must be taken in removing the rings, but it will be found that it is possible to expand them sufficiently to enable them to be drawn off over the end of the piston.

When replacing the rings their joints must be so placed that they are out of line with each other in order to prevent a path being found for the passage of the hot gases. There are usually three rings. The piston rings should not require frequent cleaning and, if this is found to be necessary, it is an indication that the lubricating oil used is unsuitable.

(d) Loss of power may be due to the formation of carbon deposit on the top of the cylinder and in the combustion chamber. When this takes place, portions of the deposit get red hot and ignite the charge before the proper time. This causes knocking and loss of power, and puts increased strain on the working parts owing to the explosion taking place before the piston reaches the top dead centre of the stroke. The deposit of carbon is aggravated by excessive lubrication or by slack piston rings allowing the oil to pass into the combustion chamber. If the formation of carbon deposit is suspected the cylinder must be taken down and scraped thoroughly clean.

(2) *Faulty Ignition.*

(a) Low-Tension Magneto.—See that connections of the wires to earth and the insulated pin are good, and that the rocker arm which breaks the current in the cylinder is working freely.

(b) High-Tension Magneto.—The sparking plug should first be inspected. The fault may be due to the porcelain insulation being cracked or punctured or the points may be covered with carbon deposit. In the first case the plug must be changed, and in the second the points must be carefully cleaned. The gap between the points may also be too small or too large; the correct spacing is about 1/50th inch.

The contact points on the distributor marked " make and break " (Fig. 5) are liable to get pitted and burnt, and care must be taken to keep the two surfaces of the points smooth and parallel to each other; the contact points should be adjusted to open 1/32nd of an inch.

The low-tension current is collected from the end of the spindle by means of a carbon brush held down by a spiral spring. The carbon brush must be kept clean and free from oil and care taken to see that it does not become clogged up, and thus fail to make contact with the spindle.

(c) Battery and Coil High-Tension Ignition.—Examine sparking plug as in 2 (b). Test accumulator or dry battery. The first should not be allowed to fall below 4 volts. The trembler on the trembler coil may require adjustment. To do this, unscrew the locking ring and adjust the movable point until a continuous buzz with a clear note is maintained while the current is switched on ; then lock in position by means of the locking ring. The trembler contacts are made of platinum similarly to those on the high-tension magneto "make and break." These must be kept smooth and flat on the face and parallel to each other. When necessary, a smooth file must be used to remove the pitting which will be found to occur, but as little metal as possible should be removed.

The sparking plug can be tested by taking it out of the engine and laying it on the top of the cylinder so that the outer casing makes a good connection to earth. If the engine be then turned by hand a spark should be produced in the same way as if it were fixed in the cylinder.

(3) *Overheating of the Engine.*

This may be due to faulty circulation causing the water in the cooling system to become too hot either through pump failure or a deposit in the circulating water pipes. Both of these should therefore be inspected at regular intervals. The heat of the circulating water pipes on leaving the water jacket should be such that the hand can grasp the pipe without discomfort.

Where the cooling water tanks and engine are in an exposed position, frost must be guarded against during the winter months, or a cracked water jacket or broken cylinder will be the result. Either the water must be completely drained off from the system when not in use, or an anti-freezing mixture must be employed in the circulation. There are several of these, the most satisfactory being a mixture of water and glycerine—30 per cent. of glycerine will stand any frost likely to be met with in this country. The advantage of glycerine over alcohol, which is sometimes used, is that the wastage is slight, and any make-up required due to evaporation can be effected by the addition of water only.

Possible causes of faults are shown in the following charts (Figs. 14, 15 and 16), which have been compiled to suit an engine with high-tension magneto ignition. No difficulty should be experienced in making the necessary modifications for other methods of ignition.

POSSIBLE CAUSES OF FAULTS.

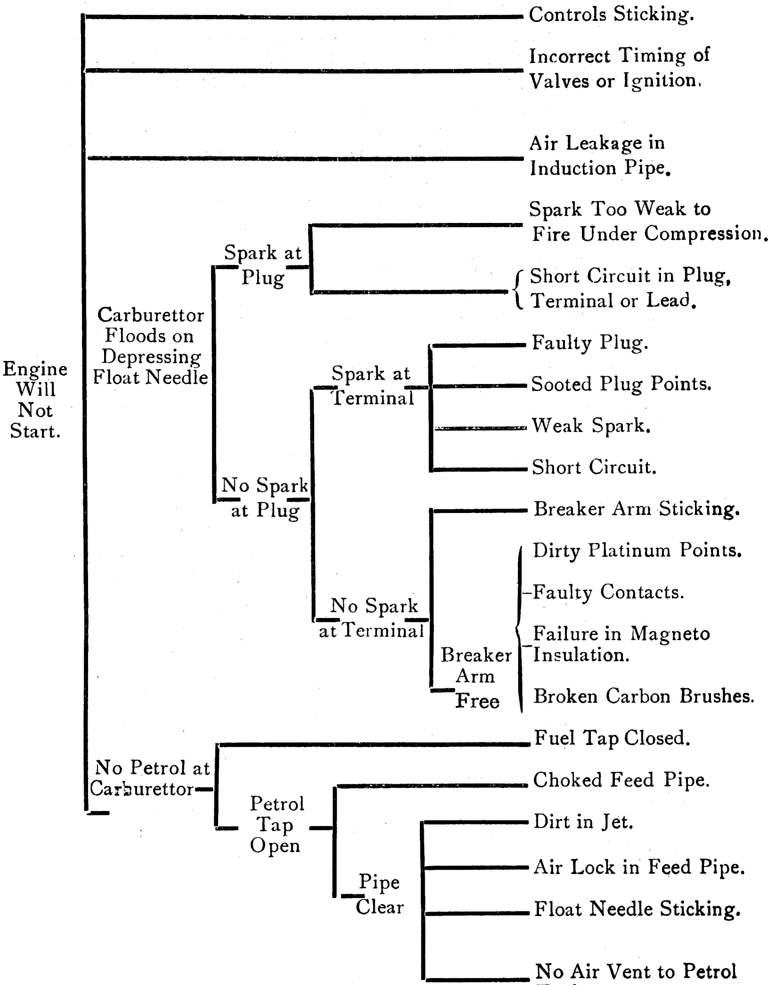


Fig. 14.

- Engine Runs Badly
  - Lacks Power
    - Constantly
      - Controls out of order.
      - Controls in Order
        - Poor Compression.
        - Valves Need Grinding.
        - Valve Spring Weak.
        - Stretched Exhaust Valve.
        - Choked Silencer.
        - Incorrect Valve Timing.
        - Ignition too far Retarded.
        - Engine Overloaded.
        - Bad Air Adjustment.
        - Obstruction in Supply Pipe.
        - Excessive Carbon Deposit in Cylinder.
    - At Intervals
      - Partial Obstruction of Petrol.
      - Sticking Valve.
      - Carburettor out of Order.
  - Engine Knocks
    - Pre-Ignition.
    - Overheating.
  - Misses Fire
    - Spark Irregular
      - Sooted Plug.
      - Dirty Contact Breaker Points.
      - Occasional Short Circuit.
    - Spark Regular
      - Mixture too Weak.
      - Water in Petrol.
      - Starved Carburettor.
      - No Air Vent to Petrol Tank.

Fig. 15.

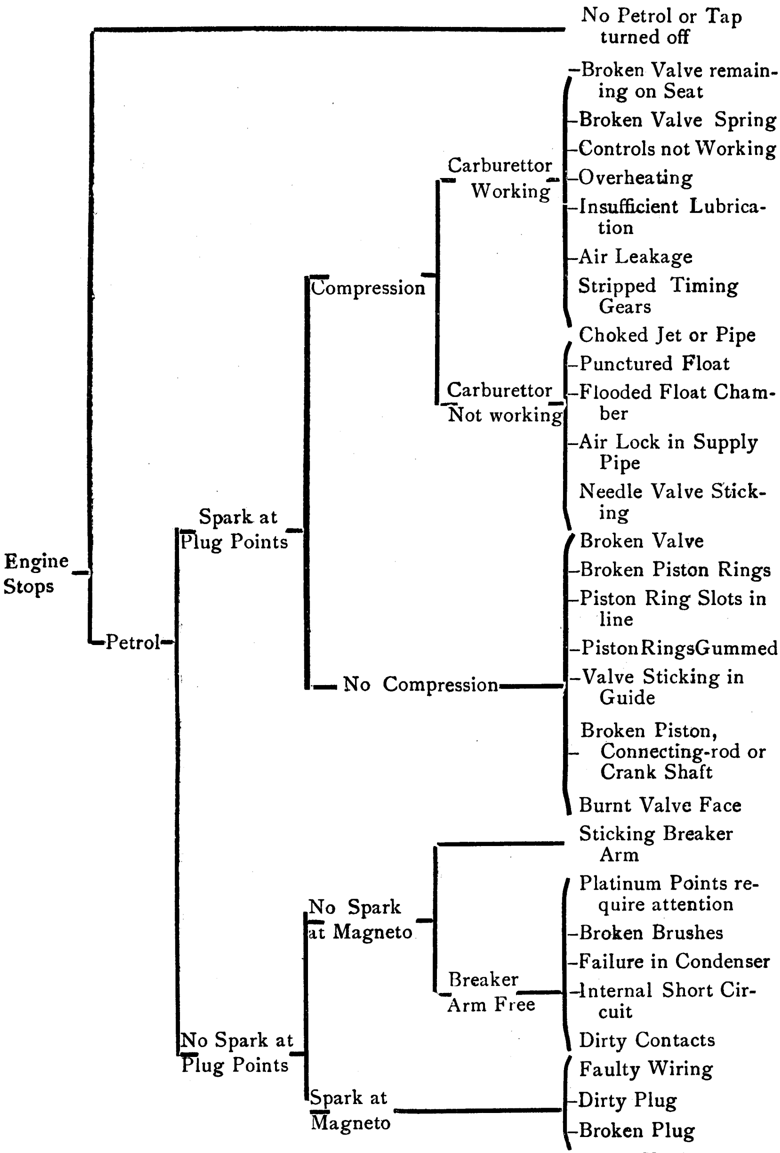


Fig. 16.

(27928) Wt. 1738/3?0/409 1875 9/35 Hw. G.344 (T.S. 8)

LIST OF
Technical Pamphlets for Workmen
(Continued)

GROUP D—*continued.*

18. Distribution Cases, M.D.F. and I.D.F.
19. Cord Repairs.
20. Superposed Circuits. Transformers. Bridging Coils and Retardation Coils.
21. Call Offices.
22. Units. Amplifying. (*Not on sale.*)

GROUP E.

1. Automatic Telephony: Step by Step Systems.
2. Automatic Telephony: Coded Call Indicator (C.C.I.) Working.
3. Automatic Telephony: Keysending "B" positions.

GROUP F.

1. Subscribers' Apparatus. Common Battery System.
2. Subscribers' Apparatus, C.B.S. Part I—C.B.S. No. 1 System.
3. Subscribers' Apparatus. Magneto.
4. Private Branch Exchanges—Common Battery System.
5. Private Branch Exchange—C.B. Multiple No. 9.
6. Private Branch Exchanges—Magneto.
7. House Telephone Systems.
8. Wiring of Subscribers' Premises.

GROUP G.

1. Maintenance of Secondary Cells.
2. Power Plant for Telegraph and Telephone Purposes.
3. Maintenance of Power Plant for Telegraph and Telephone Purposes.
4. Telegraph Battery Power Distribution Boards.

GROUP H.

1. Open Line Construction, Part I.
2. Open Line Construction, Part II.
3. Open Line Maintenance.
4. Underground Construction. Part I—Conduits.
5. Underground Construction, Part II—Cables.
6. Underground Maintenance.
7. Cable Balancing.
8. Power Circuit Guarding.
9. Electrolytic Action on Cable Sheaths, etc.
10. Constants of Conductors used for Telegraph and Telephone Purposes.

GROUP I.

1. Submarine Cables.

GROUP K.

1. Electric Lighting.
2. Lifts.
3. Heating Systems.
4. Pneumatic Tube Systems.
5. Gas and Petrol Engines.