

SECTION 5, CHAPTER 2

FUEL SYSTEMS AND CARBURATION

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Introduction

1. Gasoline and oil engines, the power units with which we are concerned, convert the potential heat energy contained in the fuel into mechanical work. The principles of operation and broad constructional details of such engines have been dealt with in Chapter 1, but how the fuel is supplied to the engine still needs to be explained in detail. It is only proposed to deal with the gasoline engine in this chapter, information regarding the oil or diesel engine being given later in this Section.

Requirements

2. The fuel used by the engine is in liquid form, therefore, there must be a storage tank and means of delivering the fuel to the engine, the whole layout being known

as the *fuel system*. Having got the fuel to the engine, it must be measured and mixed with air in the correct proportions required to form a combustible mixture for the various engine running conditions. This is done by a *carburettor*; there is an alternative method of measuring the gasoline known as *fuel injection*, but, although it is more accurate than a carburettor, it has only specialized uses at the present and will be ignored in these notes.

Fuel Pipes

3. The fuel is conveyed from the tank to the engine by means of pipes which are usually made of copper, although flexible piping is often used, particularly where movement is likely to occur, such as when the engine is flexibly mounted. When copper

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tubing is used it should always be annealed before being fitted, as this will reduce the risk of fracture; it should also be adequately secured so as to minimize the effects of vibration and, where movement is likely to occur, the pipe should be coiled for one or two turns.

Fuel Filters

4. The most commonly used gasoline filter is the ordinary fine mesh gauze type, which will intercept much foreign matter but cannot be relied on to stop water or the finest grit from reaching the carburettor; some types of filter incorporate a transparent bowl so that any sediment can be seen. Chamois leather is a very satisfactory material for filtering gasoline which may be contaminated; it possesses the property that if it is first moistened with gasoline it will pass gasoline but not water. Dependent upon the fuel system in use, filters may be found fitted in any of the following positions:—

- (a) In the filler neck of the fuel tank.
- (b) At the base of the fuel tank where the main feed pipe is attached.
- (c) Between the fuel tank and the pump.
- (d) Incorporated in the fuel pump.
- (e) In the carburettor where the main feed pipe is attached.

FUEL SYSTEMS

General

5. The type of fuel system to be used in a particular application will be decided after due consideration of such factors as where the fuel tank can be positioned, the positioning of the carburettor, and the run of the feed pipes, etc. Various methods have been used for the supply of fuel, such as:—

- (a) Direct gravity feed.
- (b) Sealing of the fuel tank and maintaining sufficient air pressure in the tank to force the fuel to the carburettor.
- (c) Using the depression in the induction manifold to cause fuel to flow to a device known as the "Autovac", and thence by gravity to the carburettor.
- (d) Finally, the use of diaphragm, gear or plunger type pumps.

The only methods the general engineer is required to know are the "gravity feed" system, and the diaphragm type of pump known as the "A.C. mechanical pump"; (the initials A.C. only indicate a trade name).

Gravity Feed

6. Where it is possible to mount the fuel tank at a certain level or "head" above the carburettor, fuel will flow along the connecting pipe line by gravity. In addition to the use of filters already mentioned, a fuel ON-OFF cock is fitted (Fig. 1); it is also essential that the fuel tank is vented to atmosphere

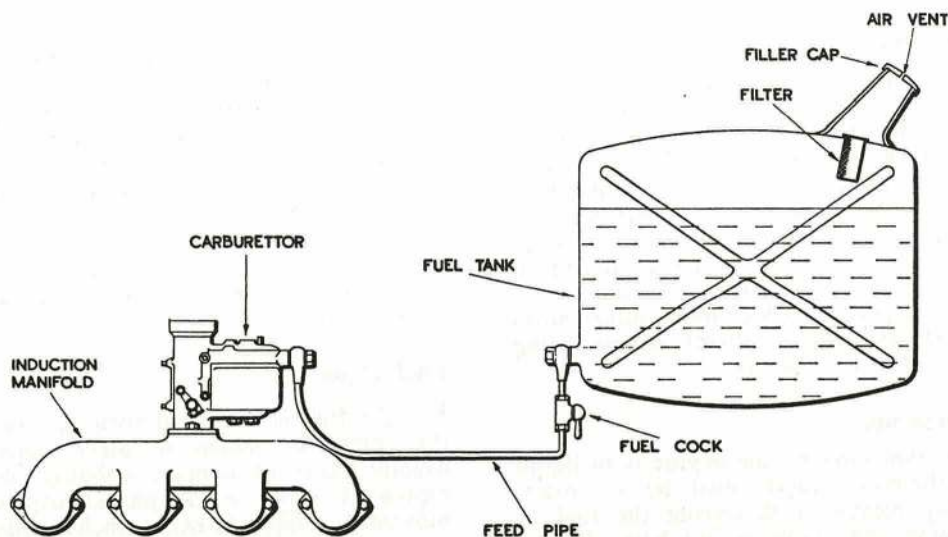


Fig. 1. GRAVITY FEED

this vent usually being incorporated in the filler cap. It will be obvious that when conditions are such that a direct gravity feed can be employed, the system is as simple and reliable as can be obtained.

The A.C. Fuel Pump

7. **General.** A.C. mechanical pumps are now extensively used in fuel systems where it is required to draw fuel from a low level tank and to supply the fuel to the carburettor at a pressure of approximately $2\frac{1}{2}$ pounds per square inch. They are made in various shapes and sizes to suit particular types of engines, but the principle of operation is the same for all models. The pump is secured to the engine, and its rocker arm is operated either directly by an eccentric cam on the camshaft, or by a push rod interposed between the rocker arm and the eccentric cam.

8. **Construction.** The body of the pump consists of two castings, the diaphragm (Fig. 2) fits in between them and is secured by the clamping action provided by the set

screws securing the upper to the lower casing. A return spring fits under the diaphragm, and the diaphragm is connected to the rocker arm link, the rocker arm being kept in contact with the eccentric cam (or push rod) by a light spring. In the upper casing are fitted the inlet and outlet non-return valves, a fine mesh gauze filter, and the top is enclosed by a cover having a cork gasket between it and the upper casing; the securing set screw has a fibre washer fitted under its head. A screw fits into the lower part of the upper casing, and this can be removed when it is required to drain away any sediment from the upper casing. A drain hole is provided at the base of the pump to allow gasoline, should the diaphragm become punctured, to drain away instead of entering the crankcase. On some pumps, provision is also made to enable the diaphragm to be operated by hand for priming.

9. **Operation.** Rotation of the eccentric lifts the rocker arm, thus causing the link to pull the diaphragm downwards and compress the diaphragm spring. This action causes a drop in pressure in the pump chamber,

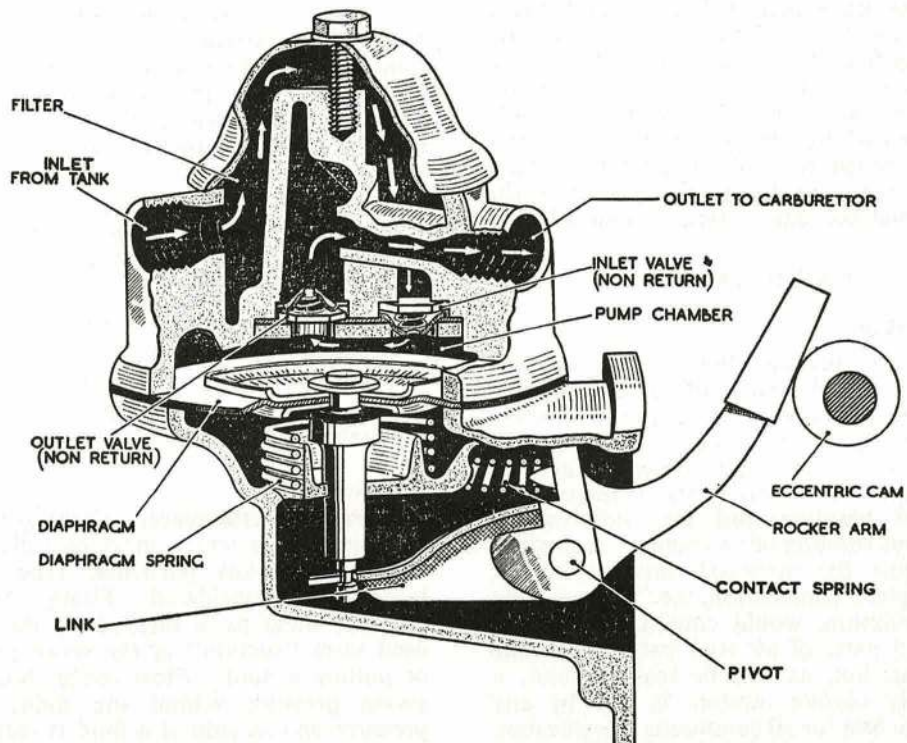


Fig. 2. A.C. FUEL PUMP

therefore, the inlet valve opens and fuel flows from the tank, through the filter and past the valve into the pump chamber. As the high part of the cam passes the rocker arm, the light spring causes the rocker arm to follow the cam, and the diaphragm return spring pushes the diaphragm upwards. This action closes the inlet valve and opens the outlet valve, and the fuel in the pump chamber is forced out and via a pipe line to the carburettor float chamber. Thus there is one inlet and one delivery stroke of the pump for each complete revolution of the eccentric.

10. **Idling.** Because the pump is always capable of supplying more fuel than the carburettor requires, and, as requirements vary considerably with the engine speed and load, the flow of fuel from the pump to the carburettor must be controlled, otherwise, wastage would result; this is the reason for the diaphragm operating lever being made in two parts, i.e. the rocker arm and the link. When the fuel in the carburettor reaches the required level, a needle valve closes and prevents the entry of any more fuel. Continued delivery of fuel by the pump causes a back pressure which pushes the diaphragm down against its spring, thus holding the link away from the rocker arm and allowing the rocker arm to "idle" without working the pump diaphragm. This continues until, when the carburettor requires more fuel, the valve is opened, thus allowing the diaphragm spring to force the diaphragm upwards again and normal pumping action is resumed.

CARBURATION

Introduction

11. In the previous chapter reference was made to the burning of a combustible mixture in the cylinder in order to do work. This mixture is composed of gasoline and air, and the term "*carburation*" is applied to the process of supplying a mixture of vaporized gasoline and air, suitable for continuous running of an engine. A mixture having just the necessary amount of air for complete combustion, i.e. a chemically correct mixture, would consist of approximately 15 parts of air to 1 part of gasoline by weight, but, as will be realised later, a chemically correct mixture is not by any means the best for all conditions of operation. In comparison with a chemically correct mixture, a mixture that contains more

gasoline in proportion to air is said to be "*rich*", and one that contains less gasoline in proportion to air is said to be "*weak*".

12. The normal internal combustion engine is required to work under varying loads and at different speeds. An engine working under load and at a high speed obviously requires more combustible mixture than one that is just idling, therefore provision has to be made to supply the varying quantities to meet the different demands. Also, in order to satisfy the engine's requirements for its various operating phases, in practice, mixture strengths of approximately the following ratios by weight are required:—

(a) **Cold Weather Starting.** A very rich mixture; 4 parts of air to 1 of gasoline.

(b) **Starting and Slow Running.** A rich mixture; 10 parts of air to 1 of gasoline.

(c) **Cruising.** A weak mixture; $16\frac{1}{2}$ parts of air to 1 of gasoline and sometimes 20 to 1.

(d) **High Speed.** A rich mixture; 12 parts of air to 1 of gasoline, progressively enrichening in proportion to rising speed.

13. The component used to provide the combustible mixture for continuous operation of a gasoline engine is known as the carburettor, and the complete process of carburation in modern jet type carburettors may be divided broadly into the following stages:—

(a) Continuous measuring, or metering as it is called, of the gasoline and air in the correct proportions to suit the various needs of the engine.

(b) Atomization or breaking up the gasoline and mixing it uniformly with the air flow.

(c) Vaporization of the liquid gasoline in order to render the mixture more suitable for combustion.

Principles

14. **Pressure Difference.** There are several basic principles which must be fully understood before any particular type of carburettor is considered. Firstly, there is no such thing as is implied by the loosely used term "suction" in the sense of lifting or pulling a fluid. Flow occurs because of excess pressure behind the fluid; if the pressure on one side of a fluid is reduced by some means, whether due to the human lungs or by a piston descending in a cylinder,

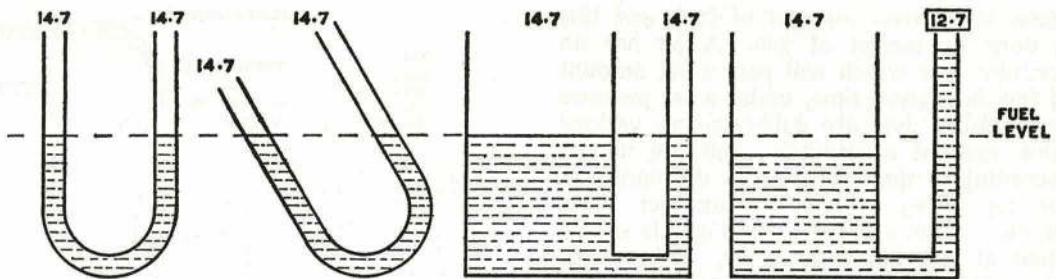


Fig. 3. "U" TUBE PRINCIPLE

the greater pressure on the other side of the fluid causes flow. The reason for flow therefore, is a difference of pressure, and this principle of pressure difference is applied in the action of a carburettor.

15. **"U" Tube.** The second principle involved is concerned with the fuel part of a carburettor. This is the "U" tube principle which is illustrated in Fig. 3, and, as can be seen, despite any difference in the surface area of each leg, so long as the two pressures are the same then the level of liquid in each leg will also be the same. If the pressure on one leg of the "U" tube is reduced, the fluid level will rise in that leg and fall in the other leg, thus a flow of liquid can be achieved.

16. **Venturi.** The third principle concerns the air part of the carburettor, and it is known as the venturi or choke tube principle. It is already known that as the piston descends, air flows from the atmosphere because its pressure is greater than the pressure in the cylinder, therefore, the lesser pressure will extend to any pipe or passage which may be in use to connect the cylinder inlet to atmosphere. This lower pressure can be further reduced by fitting a choke tube (venturi) at some convenient place in the passage. The choke tube is shaped with a waist, so that the entrance to the narrow part is abrupt but the exit is more gradual; this causes the speed of the air flow to increase, and the pressure to decrease still further. In the following paragraphs it will be seen how these principles can be applied in carburettor operation.

Simple Carburettor

17. The action of a carburettor is very similar to that of a scent spray (Fig. 4).

This familiar object consists of a container filled with the required liquid, and fitted with a fine bore tube which extends almost to the bottom of the container, this construction providing to all effects a "U" tube. There is also a hollow rubber ball, connected to a nozzle that is located over the open end of the tube. When the ball is squeezed, the blast of air sent over the tube lowers the pressure, liquid is pushed up the tube by the greater pressure in the container and, on issuing from the tube, is broken up into a very fine spray.



Fig. 4. SCENT SPRAY

18. The carburettor can be conveniently divided into two main parts, the fuel part and the air part. Considering the fuel part first, a device is required which will maintain a constant and predetermined level of fuel. This can be achieved by application of the "U" tube principle in the form of the float chamber, the constant level being maintained by using a float and needle valve mechanism to control the fuel supply (Fig. 5). One of the requirements of a carburettor is to

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meter the correct amount of fuel, and this is done by means of jets. A jet has an accurate hole which will pass a set amount of fuel in a given time, under a set pressure or "head". Jets are calibrated in various sizes, marked accordingly, and are named according to their function in the carburettor, e.g. idling or slow running jet, main jet, etc. Although the jet in Fig. 5 is shown fitted at the discharge point, in practice, jets will normally be found submerged in the carburettor.

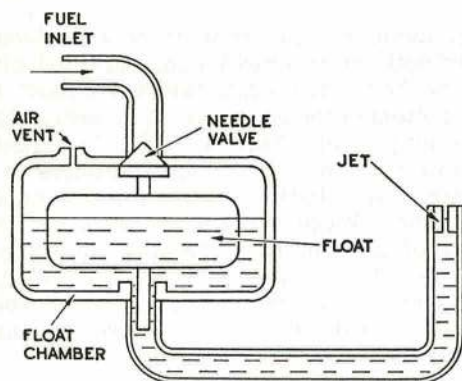


Fig. 5. FUEL PART

19. In order to cause fuel to flow the "U" tube must be subjected to a pressure difference, and this is achieved by the air part of the carburettor. This is known as the mixing chamber, and it comprises the air intake passage, the choke tube, and the throttle valve. The fuel part fits into the air part so that the discharge nozzle is in the narrowest part of the choke tube, i.e. where the air velocity is the greatest and the pressure is the lowest (Fig. 6). Operation of the throttle valve controls the amount of mixture passing to the cylinder, and thus controls the speed of the engine.

20. The simple carburettor as described in the previous paragraphs would be very limited in its performance, and would only be suitable for an engine running at a constant load and speed. It will be seen that if the throttle is almost closed, i.e. for slow running, the point of greatest air velocity will not be around the discharge nozzle but at the edge of the throttle valve, thus, fuel flow will cease and the engine will stop. Also, as the throttle valve is opened and the air flow is increased, the fuel flow increases even more quickly; the consequent enrichen-

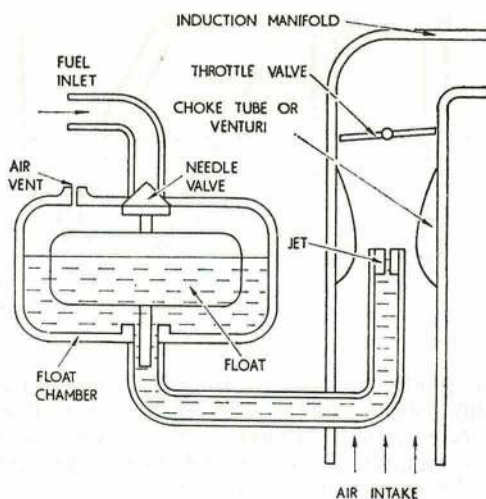


Fig. 6. SIMPLE CARBURETTOR

ing of the mixture must be corrected. These are not the only reasons, but are sufficient to show that if an engine is required to operate over a wide range of speeds and loads, then the simple carburettor requires a certain amount of modification.

Air Flow

21. The air flow into the simple carburettor shown in Fig. 6 is in an upward direction, but in actual practice it will be found that carburettors are designated as updraught, downdraught, or horizontal draught, according to the direction of the air flow. The most widely used flow is the downdraught type, the reason for this being that the power obtained is dependent upon the weight of mixture got into the cylinder, and it is much easier for the air to flow downwards, aided by gravity, than it is to flow upwards or horizontally.

22. The second requirement of a carburettor (para. 13), is to atomize or break up the gasoline and mix it uniformly with the air flow. It has already been shown that the spraying action of a carburettor helps to achieve this object, and the design of the spray devices in particular carburettors is such as to further this aim. Also, when particular carburettors are being considered later in this chapter, it will be noted that, for a definite reason, air is bled into the gasoline stream before it even reaches the discharge point, and this air also atomizes the gasoline to a high degree.

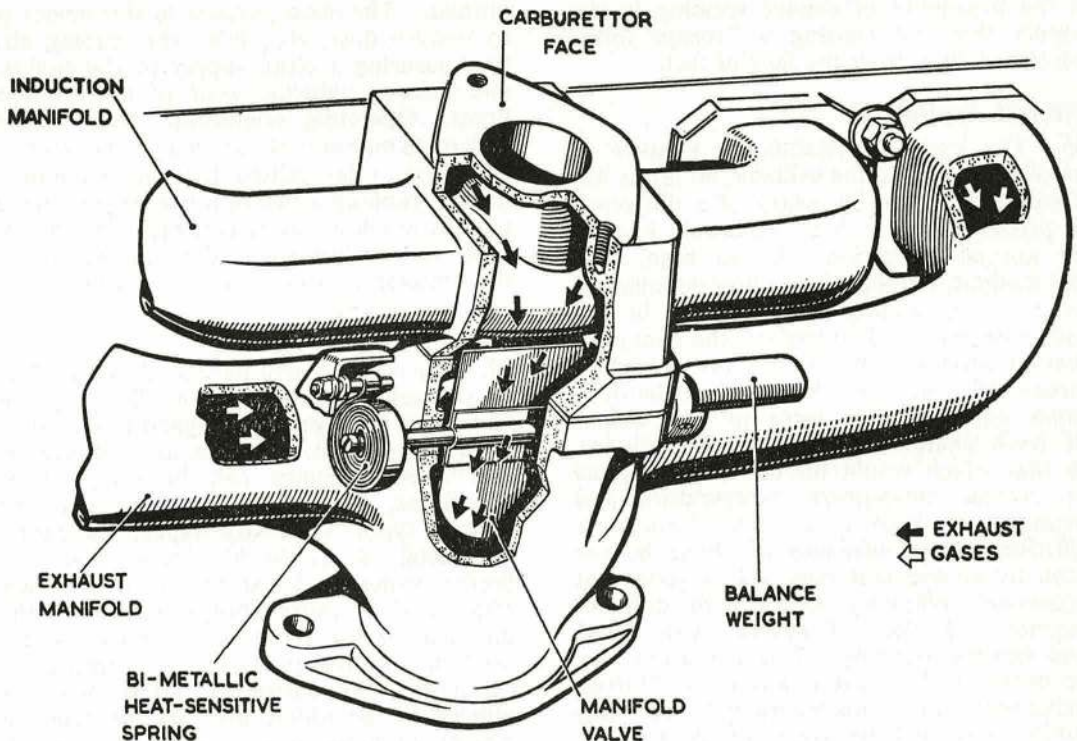


Fig. 7. EXHAUST GAS HEATING

Vaporization

23. The last function of the carburation process (para. 13), is to vaporize the liquid gasoline in order to render the mixture more suitable for combustion. The minute globules of gasoline in the mixture produced by the carburettor are still in liquid form, with the liability that they might be deposited in the inlet manifold. The easiest way to vaporize a liquid is by the application of heat, and so the carburettor is usually situated in a warm place on the engine. In some instances warm air is supplied to the air intake, and in other applications the inlet manifold is provided with channels or jacketed to allow of the passage of hot water or hot exhaust gases; a typical application making use of the heat of the hot exhaust gases is shown in Fig. 7, and it should be noted that the heat supply is automatically controlled.

24. A simple method of supplying heat for vaporization is by bolting the inlet manifold to the exhaust manifold in such a way that heat is transferred by conduction; the place

at which the extra heat is applied is known as the "hot spot" (Fig. 8). It must be borne in mind that heat must not be applied excessively, because too much heat would cause trouble. The hotter the mixture the less dense and lighter it is, therefore, less power is obtained; also, if the fuel supply to the carburettor gets too hot, then there

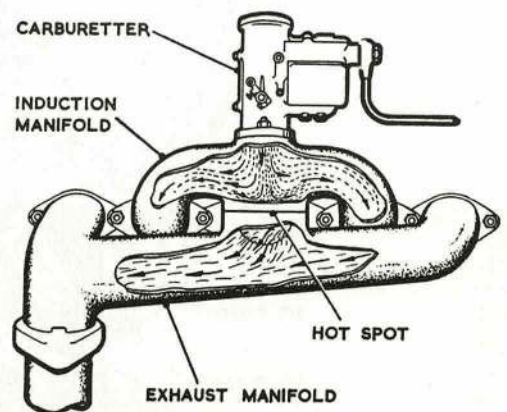


Fig. 8. HOT SPOT

is the possibility of vapour forming in the supply line and causing a "vapour lock" which would prevent the flow of fuel.

Normal Aspiration

25. The basis of obtaining a mixture of gasoline and air in the cylinder, so far as has been described, is by means of a difference in pressures, or, as it is commonly known, by normal aspiration. At no time, with this method, will the mixture flow be sufficient to maintain atmospheric pressure in the induction manifold, therefore, the charge of fuel/air mixture obtained on the induction stroke must inevitably be less than the optimum amount. The ratio of the weight of fresh charge obtained in the cylinder, to that which would fill the swept volume at normal atmospheric temperature and pressure is known as the "*volumetric efficiency*". An efficiency of about 80 per cent. for an engine is regarded as good, but volumetric efficiency varies with different engines and also, of course, with speed and throttle opening. This deficiency can be overcome by what is known as "forced induction" or "supercharging" but this subject is beyond the scope of these notes.

Air Cleaners

26. The fitting of some form of air filter or cleaner to the carburettor air intake is

normal. The main purpose of this device is to remove dust, etc., from the ingoing air, thus ensuring a clean supply to the engine, and thereby reducing wear of the cylinder bores. Operating conditions, with regard to foreign matter in the air, vary considerably, but when it is realized that in one hour's normal running a twelve horse power engine uses as much air as is contained in a good-sized room, then some idea can be got of the amount of dust, etc., that might pass into the engine.

27. Air cleaners also have a silencing effect on the noise caused by the air flow, and, in fact, some are specially designed to eliminate all trace of what is known as "carburettor roar". Air cleaners can be classified as dry filters, centrifugal separators and the washer types. The dry types use fabric or special felt as the filtering element, deflector vanes and catchment louvres are often used to cause abrupt changes in the direction of the air stream and consequent deposition of foreign matter in the centrifugal extractor, and oil-wetted metal wool is utilized in the widely used washer types, a typical example being shown at Fig. 9. With this type, the air passes down the annular space to the right-angle turn at the restricted gap, thus impinging at high velocity on the surface of the oil bath, where most

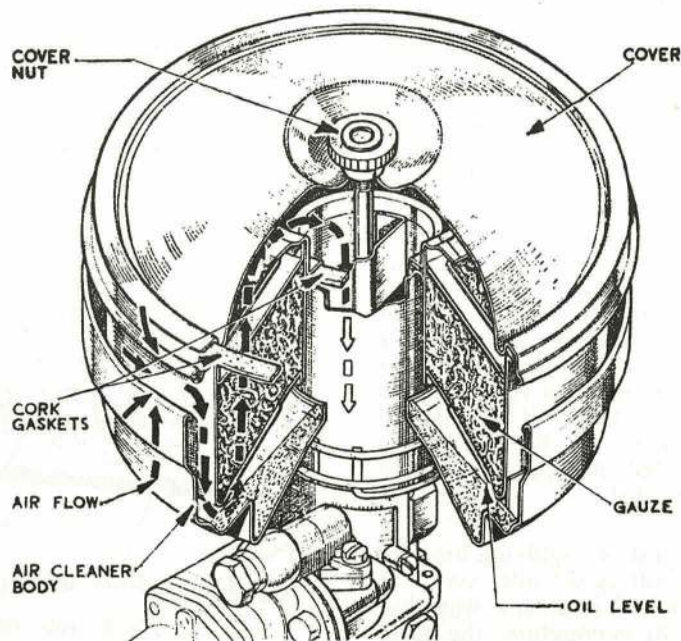


Fig. 9. TYPICAL AIR CLEANER

of the heavier particles are deposited and sink to the bottom as sludge. The air then passes through the oil-wetted metal wool, which traps the finer particles, before passing down the vertical intake.

Practical Carburettors

28. Just as was seen in Chapter 1 that practical engines were far more complex than the simple power unit, with much variation in the design and manufacture of the parts employed, so a diversity of detail will be found in practical carburettors. As has already been seen, the principle of the spray carburettor is quite simple, but to make this carburettor so that it is able to supply an engine over its full range of working conditions necessitates considerable modification. Much could be written about satisfying the requirements of a carburettor, which is, of course, beyond the scope of these notes, but a brief consideration of the problems involved will aid understanding of what is required.

29. It has already been stated that the throttle valve controls the amount of mixture entering the engine, thus controlling the speed and power output. If the throttle is opened fairly quickly the air flow immediately increases, but gasoline is much heavier than air and the tendency is, at first, for the fuel flow to lag behind the air flow, thus giving a weak mixture which may cause stalling of the engine or hesitation (flat spot); this can be overcome by providing a temporary additional supply of gasoline as the throttle is opened.

30. When the engine is required to run slowly the throttle is almost closed, thus, the velocity of the air flow past the discharge point will be low, and the pressure difference insufficient to cause a flow of fuel. This can be overcome in either one of two ways, each of which introduces further trouble. Firstly, if the choke tube is made small enough to speed up the air flow sufficiently to cause fuel to flow, then it will be too small to pass the required amount of air for larger throttle openings. Secondly, just as it is more difficult to drink lemonade out of a glass with a $\frac{1}{2}$ " bore glass tube than it is with the usual straw, the fuel flow could be made easier by using a smaller jet, but this would not be capable of supplying sufficient gasoline for high engine speeds.

These difficulties are usually overcome by choosing a suitably sized main jet and choke tube for large throttle openings, and providing what is virtually another simple carburettor for slow running.

31. Also, as stated previously (para. 20), because fuel flow increases at a greater rate than increased air flow, inherent in the design of the carburettor unless it is of the "constant vacuum" type, the mixture strength must be corrected or "compensated" as it is more commonly known, so that sensibly constant proportions are maintained throughout the cruising range. This is usually done either by incorporating compensator jets, or by "bleeding" devices whereby the main jet is progressively partly relieved of the pressure difference with increased throttle opening.

32. Further, the results of theory and research have shown that the chemically correct mixture is not the best for economy or for power. For economy, weak mixtures down to 20 or more to 1 are desirable, provided such weak mixtures can be properly distributed, ignited and burned, while mixtures that are 12 to 15 per cent. rich are required for power and acceleration.

33. Carburettors designed to give continuous running of an engine can be classified broadly under two main headings, "constant choke" or "static" types, and "constant vacuum" types. Constant vacuum types are essentially instruments in which the jet and air orifices are variable, whilst the constant choke types have a fixed choke and fixed dimensioned jets, and they are often referred to as multi-jet carburettors. Two fixed choke carburettor manufacturers, i.e. "Zenith" and "Solex", produce many different models which vary according to the size and particular applications of the engines concerned; the following paragraphs give information about some of the methods used by these manufacturers to satisfy carburation requirements.

ZENITH

Model 24T-2

34. This carburettor (Fig. 10) is used on some small air cooled engines; it is of fairly simple design having one principal jet, a slow running jet and an air jet. The carburettor consists of two main castings, the
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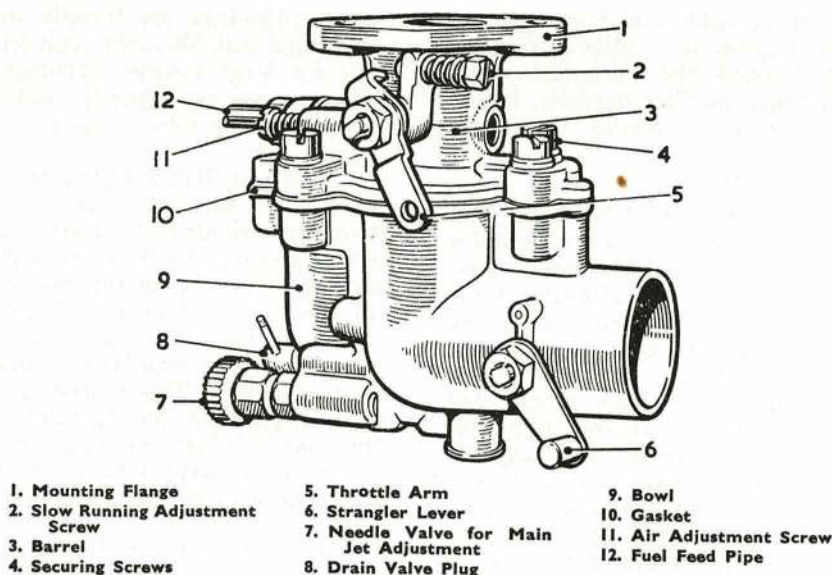


Fig. 10. ZENITH 24T-2

upper or barrel portion being secured to the lower bowl portion by five screws; the flange on the upper portion is for connection to the induction manifold. The float chamber contains a normal type float and a combined needle seating valve, the correct fuel level being automatically provided by the position of the needle seating which is usually fitted with one washer; two washers may be used if it is desired for any reason to lower the fuel level in the float chamber. A flap valve strangler is fitted in the air intake to facilitate starting the engine when cold, and it is usually operated by a push-pull control.

35. Gasoline enters the float chamber through a gauze filter and past the needle valve. The lower end of the needle rests in a small depression in the centre of the top of the float, and is raised with the float as the chamber fills with gasoline, to maintain the required fuel level. From the float chamber, which is open to atmospheric pressure, fuel passes through the principal or main jet to the main jet tube and slow running jet, to the same level as in the float chamber.

36. **Slow Running.** When the throttle valve is closed at engine idling speed, the low pressure at the slow running orifice causes fuel from the slow running jet (Fig. 11) and air, the amount of air being regulated

by the air adjustment screw, to pass through the slow running orifice and so to the engine. As the throttle is opened, the lesser pressure or depression above the throttle valve rapidly decreases. So that an over-weak mixture, which would tend to cause a "flat spot", does not result before the main supply takes over, a progressive orifice, located immediately beneath the throttle valve in the closed position and fed from the slow running jet, is used. Thus, immediately the throttle starts to open, the resultant depression between the edge of the throttle and the carburettor body is felt on the progressive orifice, causing additional fuel to be supplied by the slow running jet. This supply decreases as the throttle is opened further, by which time, however, the main carburettor is operating.

37. **Mixture Control.** When the throttle valve is opened, fuel will flow from the main jet tube by reason of the lesser pressure existing at its discharge point. Suitable air bleeding is provided (Fig. 11) to atomise the fuel and to prevent enrichening of the mixture as the throttle valve is opened further. This air bleeding to the main jet system is controlled by the air jet which is supplied from the main air intake, the air then passing via a series of holes to the discharge tube. As the engine speed increases the level of fuel in the discharge tube falls, progressively uncovering the series of holes down the tube;

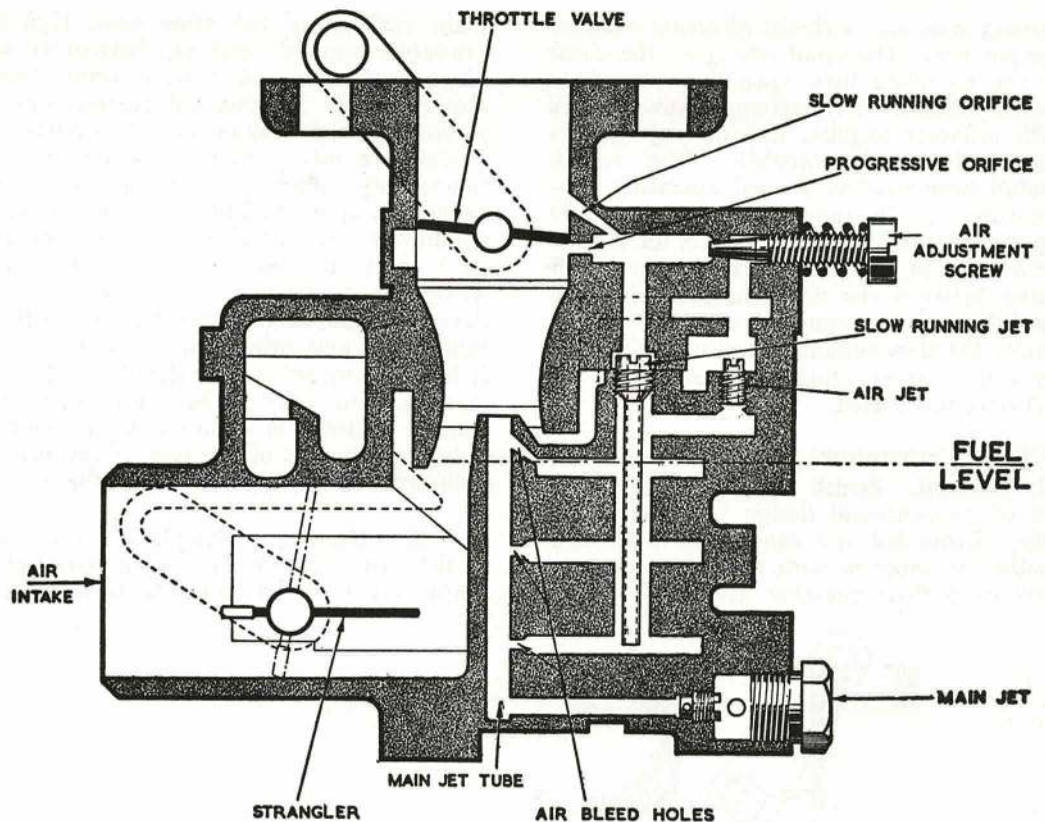


Fig. 11. TYPE 24T-2 (Diagrammatic)

the bleed air will not only partly relieve the depression and thus keep the mixture strength correct, it will also atomize the liquid fuel to a large extent.

38. Main or Principal Jet. The carburettor is provided with an adjustable main jet (Fig. 12) which is set and sealed by the engine makers, and provides the correct mixture strength for all operating conditions up to an altitude above sea level of about 3,000 feet. Normally no adjustment of this setting

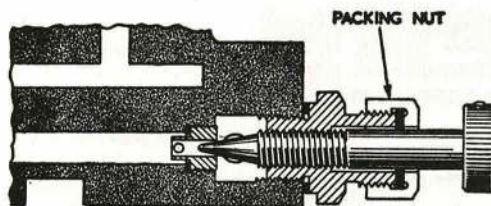


Fig. 12. ADJUSTABLE MAIN JET

should be necessary, but, if the engine is operated at a higher altitude than 3,000 feet, it may be necessary to correct symptoms of rich mixture and possible loss of power. This is done by breaking the seal, slackening the packing nut, and turning the needle valve adjuster in a clockwise direction, a quarter of a turn at a time, pausing between each adjustment to observe the effect on the engine running. When, by trial and error, the best setting is obtained, the adjuster should be locked by tightening the packing nut, and resealed against further movement.

39. Air Adjustment Screw. If difficulty is experienced in starting the engine, the cause may be an incorrect mixture strength from the slow running tube. When adjusting the starting or slow running mixture strength it will be necessary to control the throttle opening by hand, thereby rendering the engine governor inoperative. Turning the air adjustment screw in a clockwise direction richens the slow running (idling) mixture;

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turning in an anticlockwise direction weakens the mixture. The usual setting for the screw is one complete turn open from the fully closed position. This setting, however, varies with different engines, and all adjustments should be made carefully. The engine should have reached normal operating temperature, and be running at about 500/600 r.p.m.; turn the screw a quarter of a turn at a time in the estimated direction, and pause between the adjustments to observe the effect of the changed mixture. When setting the slow running speed of the engine, the slow running adjustment screw (Fig. 10) will have to be used.

V-Type Carburettors

40. **General.** Zenith V-type carburettors are of conventional design in which a jet tube, surrounded by a choke tube to act as a venturi, is supplied with fuel to a constant level by a float chamber assembly. Three

main variants of the same basic type are available, namely, vertical, horizontal and downdraught, to suit various installational requirements. Various refinements, one or several of which may be fitted to a particular model, are incorporated to ensure correct functioning under a variety of conditions dependent upon the engine and its operating conditions. In particular, many models have fully or semi-automatic stranglers, whilst one model has an automatic starting device; further, some models have an acceleration pump and others an economy device. It is not proposed to give details of all these features, but only those with which the general engineer is required to be familiar. A typical example of this type of carburettor is shown in diagrammatic form in Fig. 13.

41. **Slow Running.** This phase of operation is the same as for the 24T-2 carburettor (para. 36), i.e., fuel from the slow running

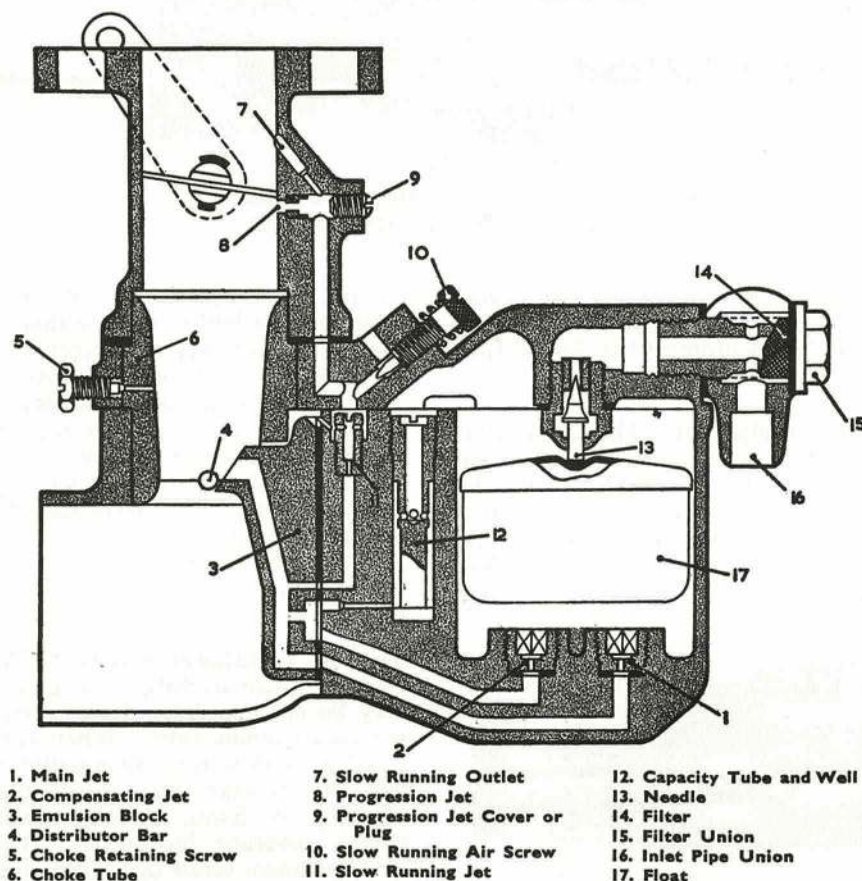


Fig. 13. ZENITH CARBURETTOR. General Arrangement

jet (11) and air regulated by the slow running air screw (10) supply the mixture which passes via the slow running outlet (7) to the engine; prevention of a flat spot when the throttle valve is opened is taken care of by the progression jet (8). Adjustment of the mixture strength is again done by means of the slow running air screw (10), therefore, it is usually referred to as the "quality screw".

42. Compensation. The following method of keeping the mixture strength constant throughout the main range is widely used on Zenith carburetors, and is commonly known as the "Baverey" method; the system is shown diagrammatically at Fig. 14. It will be seen that fuel for the combustible mixture is supplied by two sources, the main jet and the compensating jet. The main

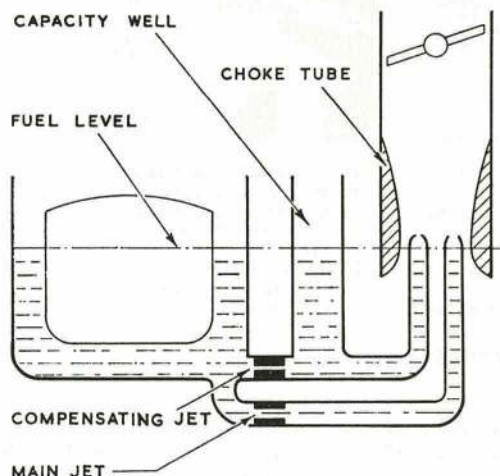


Fig. 14. COMPENSATION PRINCIPLE

jet is fed directly from the float chamber and will supply, as has been stated previously, an increasingly rich mixture as the throttle valve is opened. The compensating jet, on the other hand, discharges into a well which is open to atmospheric pressure, therefore, opening the throttle causes fuel to flow from the well to the discharge point, the level in the well falls and, in fact, the well is emptied at quite a small depression. The flow from the compensating jet is thus at its maximum and thereafter remains constant, no matter how great the depression at the choke may become. Further increase in the depression and, of course, increased air flow, means that the part of

the mixture formed by the fuel which passes through the compensating jet will become progressively weaker. Thus a balance is obtained between the progressive richening of the main jet and the progressive weakening of the compensating jet, and, providing that suitably sized main and compensating jets are used then the strength of the combined mixture remains appreciably constant.

43. This principle can be applied to the carburettor shown in Fig. 13; it will be seen that here the compensating jet and the main jet both feed into a common discharge passage in the emulsion block. Thus, when the capacity well is emptied of fuel, the air bleed or leak effect will also be felt on the main jet. This effect is taken care of by the designer by such things as the size and characteristics of the communicating holes, etc., and thus the finished product gives the desired combustible mixture. It should also be noted that the fuel/air mixture from the compensating jet will break up the main jet fuel which it meets in the emulsion block, thus aiding atomization. The purpose of the distributor bar (4) is to ensure even distribution of the mixture in the choke tube, the theory being that the incoming air strikes the bar and causes a lesser pressure along its length, so that when the fuel/air mixture from the emulsion block nozzle strikes the bar it tends to run along it and then proceed, evenly distributed across the choke, past the throttle valve and into the induction manifold.

SOLEX

Introduction

44. Many models are produced by Solex in horizontal, vertical and downdraught patterns to suit individual design requirements. They all operate over the main range on the same principle of air bleed compensation, i.e. the automatic correction of the proportions of air and gasoline in the combustible mixture over a wide range of engine speeds. Further devices are incorporated in various models to satisfy varied requirements, such as, the "bi-starter", "zero" starter for use in arctic conditions, "accelerator pump and economy" device, "governor", etc.; description in the following paragraphs is limited to those devices with which the general engineer is required to be familiar.

(A.L. 8, Dec. 60)

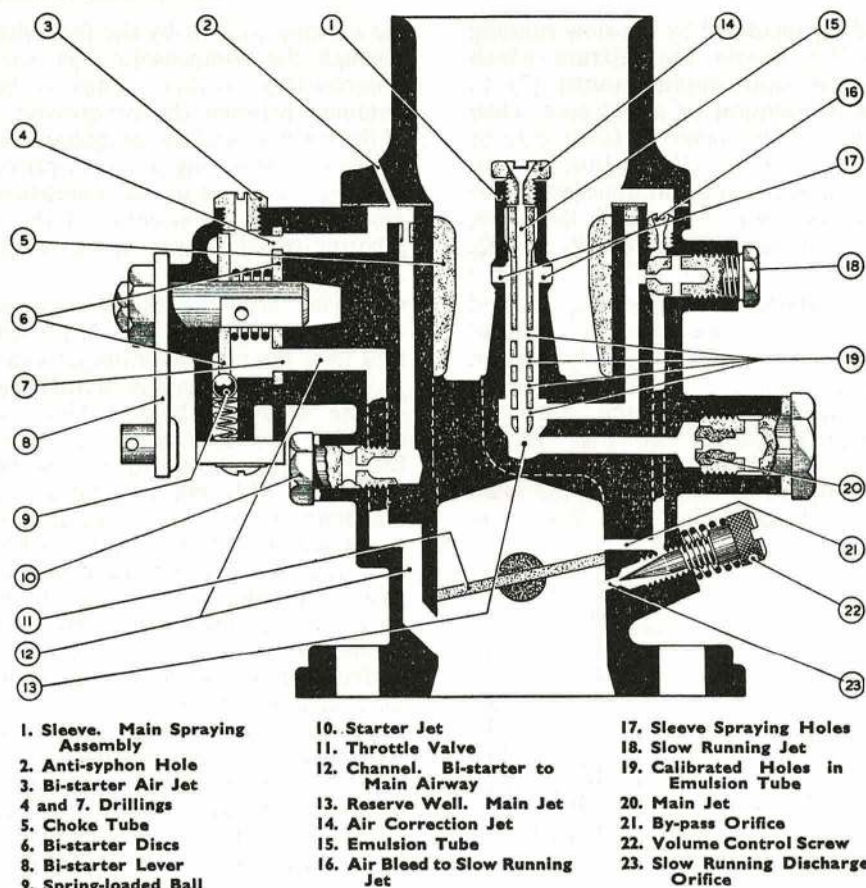


Fig. 15. SOLEX CARBURETTOR

A typical example of a Solex carburettor is shown in diagrammatic form at Fig. 15.

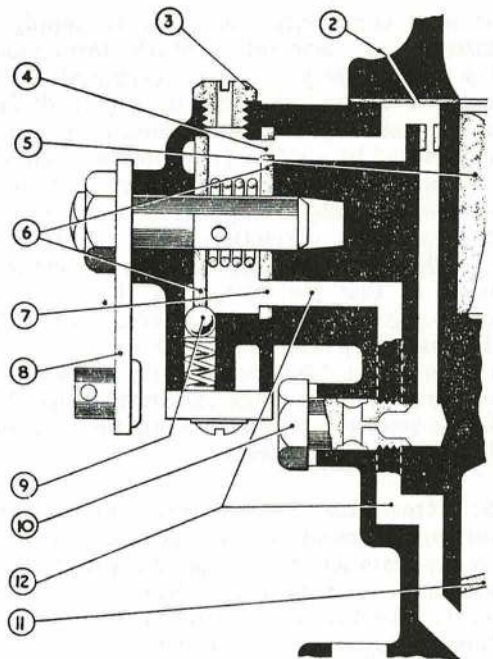
Bi-Starter

45. This device (Fig. 16) is fitted to provide a very rich mixture when starting a cold engine, and is, in fact, a small auxiliary carburettor. It consists of a mixing chamber in which there are two discs (6) keyed to a spindle that is operated by a lever (8). The outer disc, in conjunction with a spring-loaded ball (9), locates the effective position of the inner disc; the inner disc is a disc-valve, with a number of suitably arranged drillings, two of which (4) and (7) are shown.

46. The bi-starter is put into operation when the lever (8) is fully operated to rotate the disc-valve so that the drillings (4) and (7) register with the channels as shown (Fig. 16). When the throttle valve (11) is fully

closed and the engine is turned, the strong depression on the engine side of the throttle is felt throughout channel (12), in the mixing chamber, and in the channel communicating with the starter jet (10). Thus, air flows via the air jet and gasoline from the starter jet (10) to form a rich mixture in the mixing chamber, which then passes along channel (12) and so out into the passage to the induction manifold.

47. Provision is made for the bi-starter to provide a weaker mixture to enable a cold engine, after starting, to be run without the danger of over-choking. When the lever (8) is returned to an intermediate position, the spring-loaded ball (9) locates the disc-valve so that a smaller drilling registers with the channel communicating with the starter jet (10); this action provides proportionately less gasoline and so reduces the mixture strength.



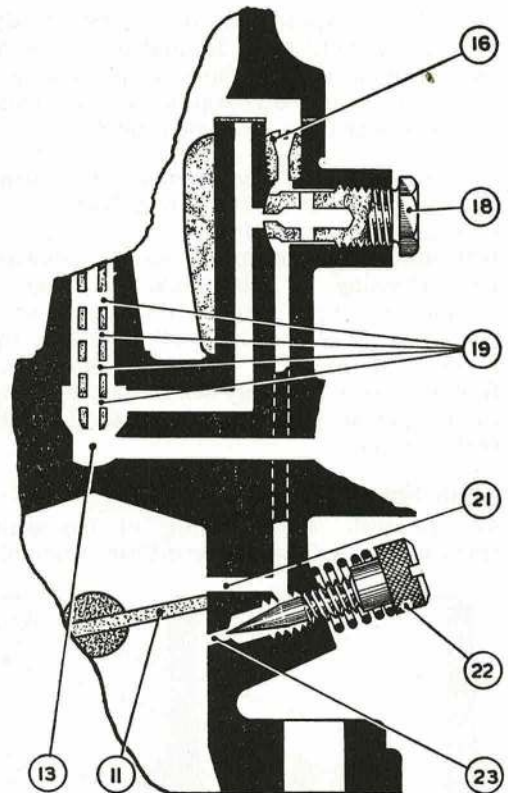
- | | |
|-----------------------|--|
| 2. Anti-syphon Hole | 9. Spring-loaded Ball |
| 3. Bi-starter Air Jet | 10. Starter Jet |
| 4 and 7. Drillings | 11. Butterfly Throttle |
| 5. Choke Tube | 12. Channel. Bi-starter to Main Airway |
| 6. Bi-starter Discs | |
| 8. Bi-starter Lever | |

Fig. 16. BI-STARTER

48. When the engine has warmed up sufficiently that assistance from the bi-starter is no longer required, the lever (8) must be returned to the "off" position so that the drillings in the disc-valve cease to register with the channels, the bi-starter being then isolated from the induction manifold. The tendency of the fuel to continue to flow after the bi-starter is put out of operation is prevented by the anti-syphon hole (2); its function is to break down the depression in the starter channels when the bi-starter is put out of action.

Slow Running

49. **General.** The slow running or idling system is fitted to enable the engine to run slowly; it is shown diagrammatically at Fig. 17. It will be seen that the slow running jet (pilot jet) (18) is supplied with gasoline from the main jet or diffuser well (13), and air from the air bleed (16); the slow running (23) and by-pass (21) holes (orifices) are also connected by a channel to the slow



- | | |
|-----------------------------------|---------------------------------------|
| 11. Throttle Valve | 19. Calibrated Holes in Emulsion Tube |
| 13. Reserve Well. Main Jet | 21. By-pass Orifice |
| 16. Air Bleed to Slow Running Jet | 22. Volume Control Screw |
| 18. Slow Running Jet | 23. Slow Running Discharge Orifice |

Fig. 17. SLOW RUNNING SYSTEM

running jet (18). The function of the by-pass orifice (21) will be found to be that performed by the progressive orifice on the Zenith carburettor.

50. **Operation.** With the throttle valve (11) in the closed position, the induction depression is felt on the slow running discharge hole (23), causing fuel from the slow running jet (18) and air metered by the air bleed (16) to flow through the channel and, with the air bleed from the by-pass orifice (21), to pass the volume control screw (22) before issuing from the slow running hole (23) and thence to the induction manifold. Besides being an air bleed when the throttle valve is in the closed position, the by-pass hole (21) will, on the throttle (11) being

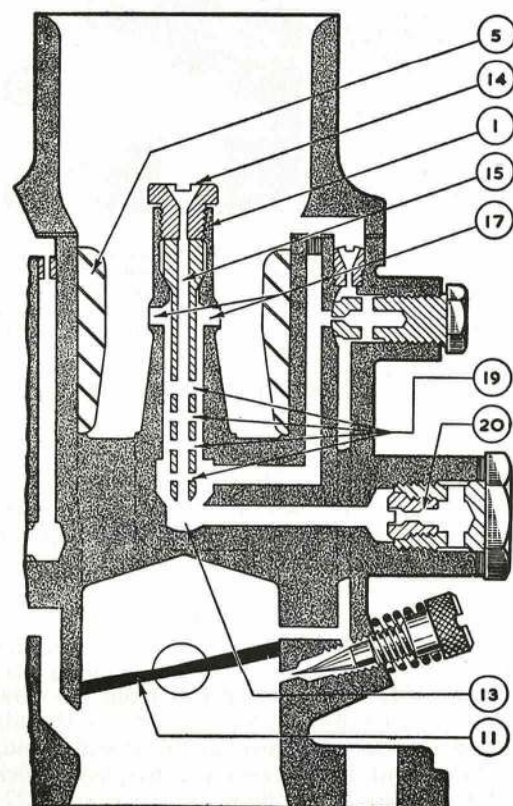
(A.L. 8, Dec. 60)

opened, be exposed to the induction depression (Zenith, para. 36) and thus serve as an additional delivery hole, so preventing a flat spot in the carburation as the main jet takes over from the slow running jet.

51. Adjustment. The amount of mixture issuing from the slow running hole (23) is controlled by the setting of the volume control screw (22); turning the screw clockwise, i.e. "screwing in", decreases the quantity of mixture, and turning the screw anti-clockwise, or "screwing out", increases the quantity of mixture. Thus it is usually referred to as a "quantity screw", as opposed to the quality screw that is used on Zenith carburetors.

Main Spray Assembly

52. General. The function of the main spray assembly (Fig. 18) or diffuser assembly



- | | |
|-----------------------------------|---------------------------------------|
| 1. Sleeve. Main Spraying Assembly | 15. Emulsion Tube |
| 5. Choke Tube | 17. Sleeve Spraying Holes |
| 11. Throttle Valve | 19. Calibrated Holes in Emulsion Tube |
| 13. Reserve Well. Main Jet | 20. Main Jet |
| 14. Air Correction Jet | |

Fig. 18. MAIN SPRAY ASSEMBLY

as it is commonly known, is to supply a mixture of constant strength throughout the main range of the carburettor. It consists of an emulsion tube (15) drilled with a series of calibrated holes (19), which is enclosed by a sleeve (1) drilled with spraying holes (17) around its waist. The top of the assembly is capped by a screwed-in calibrated air correction jet (14), and the complete assembly fits into the carburettor body so that the bottom of the emulsion tube registers with the reserve well (13). The assembly is supplied with gasoline from the main jet (20), so that the static level of the fuel is above the calibrated holes (19) in the emulsion tube and below the spraying holes (17) in the sleeve.

53. Operation. For normal running the mixture is composed of gasoline supplied by the main jet (20) and air passing through the choke tube (5); the tendency of the main jet to enrich the mixture with increased throttle opening is corrected by the action of the diffuser assembly in the following way. When the throttle (11) is opened, the depression in the choke tube (5) causes fuel to flow out of the spray holes (17) in the diffuser assembly and, as the depression increases, the level of the fuel in the diffuser falls and progressively uncovers the calibrated holes (19) in the emulsion tube. Thus, air passing through the air correction jet (14) can then pass through any holes (19) that are uncovered and, besides mixing with and breaking up the liquid fuel, will partly break down the depression and correct the strength of the mixture. Progressive opening of the throttle progressively causes more of the series of calibrated holes (19) in the emulsion tube to be uncovered, and by this means a correctly proportioned mixture is achieved throughout the main range of carburation.

The Governor

54. General. The purpose of the governor unit is to limit the maximum speed of the engine. It is set correctly for the particular type of engine by the makers, who then seal the unit to prevent it being tampered with; normally, only if the spring breaks will it be necessary to dismantle the unit. The governor (Fig. 19) is operated by the action of the mixture stream on the specially shaped offset throttle valve (1). The throttle valve has an inclined face which confronts the

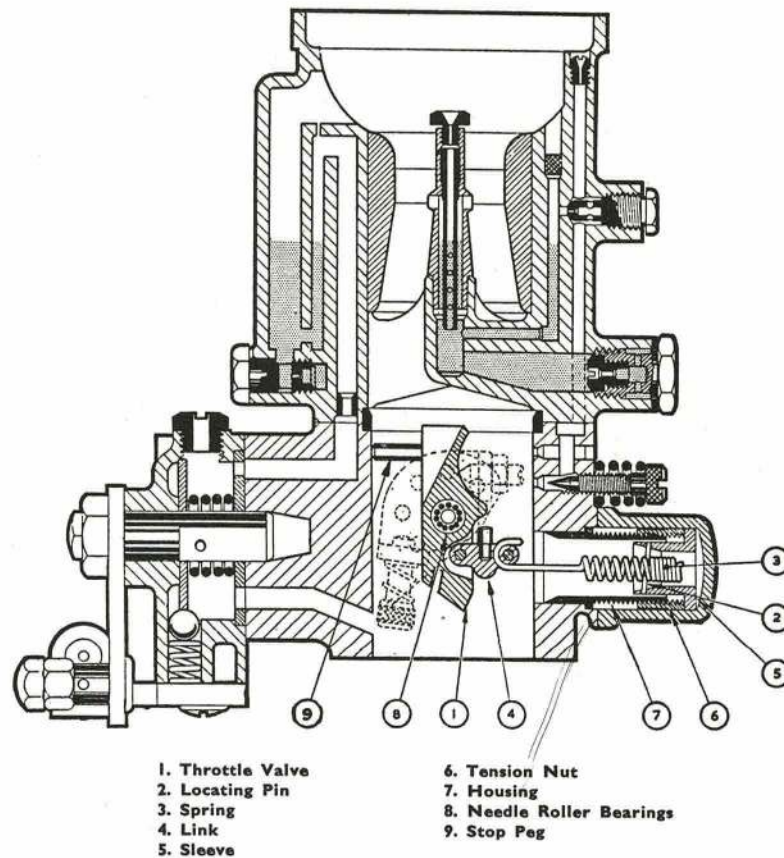


Fig. 19. GOVERNOR UNIT

incoming stream, so that as the mixture speed through the carburettor intake increases it tends to close the valve. This force is resisted by a spring (3) anchored at one end by a link (4) attached to the throttle valve, and located at the other end by a pin (2) passing through the coils of the spring. The governor sleeve (5) has no lateral fixing devices, but the inner face of the hexagon abuts against the outer end of the tension nut (6) which screws on to the housing (7); the tension of the spring can be altered by screwing the tension nut (6) in or out. Furthermore, by rotating the sleeve a lesser or greater number of coils are brought into action, thus varying the rate of the spring. A means is therefore provided to adjust the torque caused by the spring on the throttle in both the closed and open positions. To ensure freedom of movement of the throttle valve on its spindle it is mounted on needle roller bearings (8),

it is therefore free to react to the closing force of the mixture stream impinging on its inclined face and to the opening torque of the spring, both of which must be balanced to ensure correct governing. It will be seen that the throttle valve is also fitted with a full open stop peg (9). To run at speeds lower than the governed maximum, the throttle is closed by the usual action of the control lever and a simple drive of "dog" formation.

55. Operation. Operation of the control moves the stop on the spindle, and the tension of the spring opens the throttle valve in action with the stop. At governed speed, the pressure of the mixture against the larger portion of the throttle valve equals the tension of the spring, therefore, further movement of the operating control will merely move the stop away from the valve, thus having no effect on engine speed.

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