CARBURETTORS

PRINCIPLES OF CARBURATION

IN subsequent sections of the present work the overhaul and repair of specific models of aeroplane carburettors will be dealt with. Basically, all aeroplane carburettors function on the same principles, viz. the correct proportioning of fuel to air for every condition of flight. Before dealing in general with the construction of an aeroplane carburettor, it is perhaps advisable to enumerate and enlarge on the various conditions of running. These are as follows :

(*a*) Starting and slow running.
(*b*) Cruising with maximum fuel economy.
(*c*) Normal sustained full power.
(*d*) Temporary extra power output, such as is used for take-off or in emergency.

Fuel-air Ratios

As regards mixture strength, slow running requires a relatively rich mixture, whilst starting, especially from cold, requires an even richer mixture, which is usually obtained by means of fuel injected by hand pump direct into the induction system.

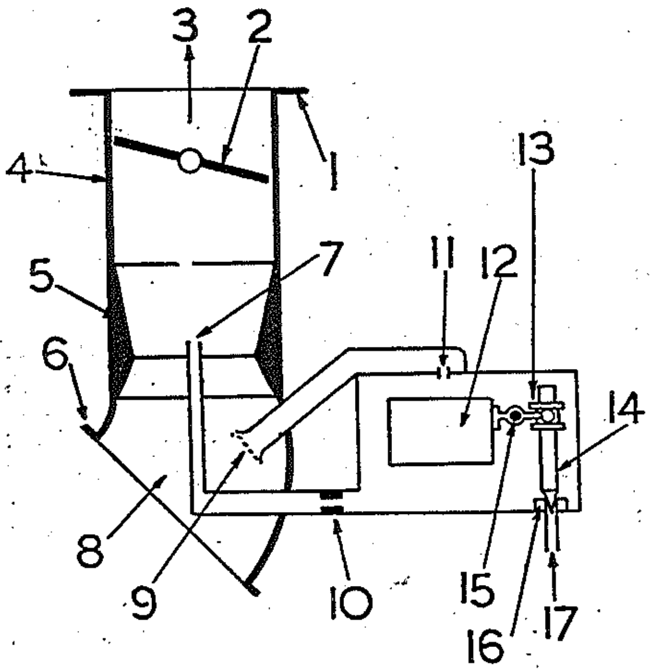
Cruising

Cruising, which forms most of the flying life of an aeroplane, calls for the weakest mixture that the engine will run on safely, and it has been found that by advancing the ignition an additional 10° or so over and above normal ignition advance, that engines can be made to run steadily on ultra-weak mixtures and so aid fuel economy and ensure extended range of the aircraft.

Normal sustained full power calls for a mixture somewhat richer than that used for cruising, together with less ignition advance.

Take-off Conditions

Take-off conditions require an even richer mixture than that for normal power, the extra fuel supplied being used as an internal coolant for the cylinders and so counteracts detonation, which can be rapidly destructive. It will be seen therefore that there are four main mixture strengths to be supplied by the carburettor.



1. Induction flange.
2. Throttle.
3. Direction of mixture to engine.
4. Throttle bore.
5. Choke.
6. Air intake flange.
7. Fuel discharge tube.
8. Air intake.
9. Pressure balance tube.
10. Main jet.
11. Air vent to float chamber.
12. Float.
13. Needle collar.
14. Needle.
15. Float spindle.
16. Needle seating.
17. Fuel connection.

Fig. 1.—A SIMPLE CARBURETTOR

Basic Principles in Design

The mechanical details of aeroplane carburettors are fairly similar. They consist of one or more tubes connected to the engine induction system, in which there is a valve, usually in the form of a disc mounted on a spindle by which the amount of fuel-air mixture passing to the engine can be controlled and thereby the power output. Situated in the tube, which is known as the throttle bore, is also a cone-shaped restriction known as the choke or venturi, and it is into the waist of this choke that the fuel issues.

The proportion of fuel to air passing through the choke is controlled by the main metering system or, as it is commonly known, the jet system of the carburettor, and this is the subject of hundreds of patents, of which only a few exist to-day as technically sound commercial propositions.

The supply of fuel to the jet system is controlled by a float chamber which contains a float and valve mechanism that prevents the fuel from rising above a predetermined level and is similar in principle to a domestic water cistern. In a few designs the fuel supply is controlled by its pressure on a diaphragm.

Fig. 1 shows diagrammatically the principal details of a carburettor.

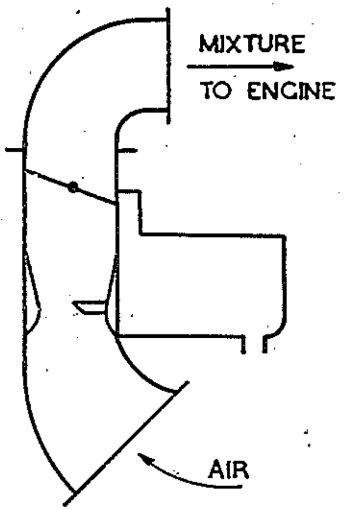


Fig. 2.—VERTICAL CARBURETTOR

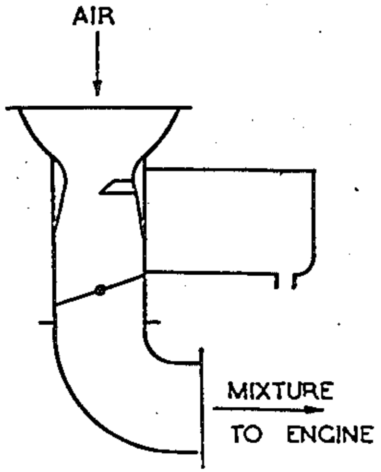


Fig. 3.—DOWN-DRAUGHT CARBURETTOR

In addition, means have to be provided to weaken off the mixture as the engine is flown to high altitudes; otherwise, due to the rarefaction of the air, power is lost through unnecessary richness of the mixture.

Mixture Control for Altitude

Originally manual control of the mixture was left to the skill of the pilot, but to-day carburettors are being built in which the mixture strength is automatically controlled from sea-level to the greatest altitude to which the aeroplane can fly.

In general, present-day aeroplane carburettors are of two types, vertical or down-draught. Horizontal carburettors have been used in this country in the past, but, except for one or two Continental engines, are to-day practically non-existent.

Fig. 2 shows a typical vertical carburettor which is mounted relatively low down on the engine and through which the air enters vertically, picking up fuel on its way to the induction system.

Fig. 3 shows a down-draught model. This is mounted high up on the engine, and in some cases is of assistance in clearing retractable under-carriages, besides having certain technical advantages from the carburation point of view.

Apart from the difference in direction of air flow and the fuel passages for the slow-running system, vertical and down-draught carburettors are basically similar.

Slow-running Systems

Figs. 4A and B show these diagrammatically. In a vertical-type carburettor, the discharge orifice is above the fuel level in the

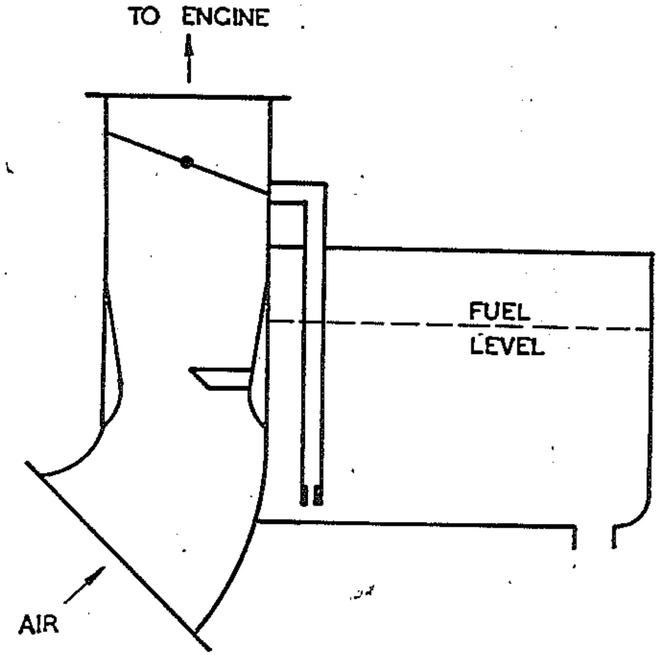


Fig. 4A. — Slow-running system on vertical carburettor

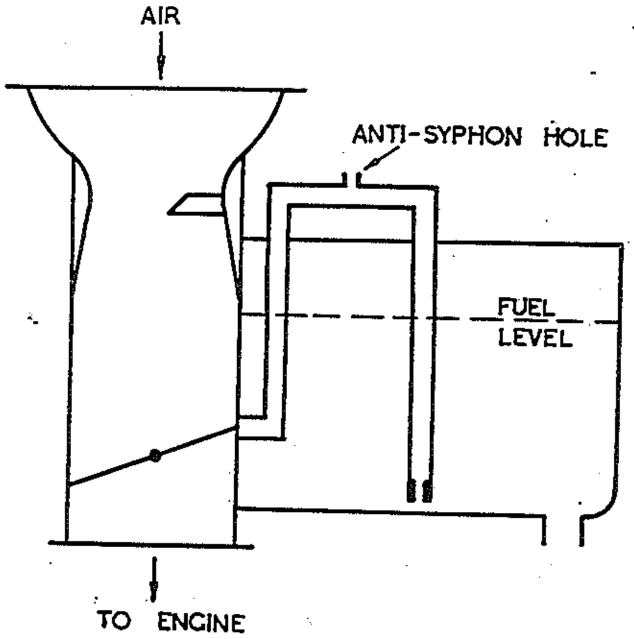


Fig. 4B. — Slow-running system on down-draught carburettor

float chamber, so that when the engine is stopped and suction on the slow-running jet ceases, fuel flow also ceases.

In the case of a down-draught model, it will be seen that the discharge orifice is below the level of fuel in the float chamber, so that once started the fuel would continue to flow by siphoning, and it is therefore necessary to prevent this by first carrying the fuel passages above the normal fuel level and incorporating an air leak known as the anti-siphoning hole.

Wear

This takes place mainly at spindle bearings, linkage pins, and at the float needle and seat, although

by the careful selection of materials the latter have to-day a life of frequently 800 to 1,000 hours running.

Acceleration

Owing to the extremely weak mixture strengths now used, clean and unfailing pick-up when the throttle is opened presents a problem. This at first was overcome by injecting temporarily additional fuel, by means of a simple squirt or pump operated by the pilots' throttle lever, but as engine design progressed and increasingly weaker mixtures came into use, a simple discharge pump failed to give good acceleration and a dual-purpose pump became necessary, it being known as a delayed-action pump, in that it first gave a mass discharge to replace the fuel deposited from the air stream when the throttle was opened and then followed on without a break with a sustained discharge which lasted until the engine reached normal steady-running conditions that the main jet system of the carburettor was able to satisfy.

Finally, it must be remembered that the present-day aeroplane carburettor is a highly scientific instrument, in which only the very best material is used and in which the necessary manufacturing precision ranks with that of the watch-making industry. Such carburettors therefore need careful and intelligent treatment when being stripped and reassembled.

stripping the carburettor for cleaning purposes, it is entirely unnecessary to remove or alter the position of the eccentric pin, and then the power-jet operating position will not alter.

Accelerator Pump

This unit is an entirely straightforward piece of mechanism, the suction valve being situated in the piston itself, and the delivery valve placed on the side of the lower part of the pump body casting. Access to either of these parts is obtained by the removal of the cover plate at the bottom of the pump. The only likely cause of the pump failing to operate will be dirt under either of the valves, in which case they should be removed and carefully blown out. It should not be necessary to remove the valves from the housings for this purpose.

Choke Tube

During assembly of the choke tube, care should be taken to ensure that the countersinking which registers the choke position is exactly opposite the locking screw ; otherwise the delivery from the diffuser will be reduced.

Inspection of Carburettor

Check the float for damage and the float fulcrum pin for wear.
Check the seating of the needle valve for sticking and wear.
Check movement of throttle and angle of throttle lever.
Check the movement of power-jet lever, and check the timing.
Check the range of the mixture lever.
Check linkage for wear.
Examine for leakage at all joints.
Thoroughly wash out all orifices and passages, and be sure they are perfectly clean.
Clean the oil chamber and check the joint for leaks.
Check the jets for capacity on a standard flow-meter.
Check all tab washers for security.
Examine all faces, and make sure that there are no bruises or scores. Faces should be perfectly smooth to ensure a good joint.
Check choke-tube bore and length of delivery pipe, since these affect consumption.
Check the petrol level.
Clean the balance pipe and diffuser.
Wash and thoroughly clean the oil chamber.

CLAUDEL-HOBSON TYPE A.I. 48 CARBURETTOR

FITTED TO GIPSY MAJOR AND GIPSY SIX ENGINES

THE Claudel-Hobson type A.I. 48 carburettors have been designed to operate on high-efficiency aero engines. They are completely pressure balanced, and the available range of mixture control for altitude is enough to meet all requirements up to at least 30,000 ft., but for use in aeroplanes unlikely to attain great altitudes, the percentage of altitude control is cut down by decreasing the area of the slot in the altitude control plug.

This demand for a great range of altitude control calls for extreme care in design and a special altitude control system, in order to avoid any suddenness of action, and to ensure that equal increment of movement of the altitude control lever shall give equal and progressive weakening of the mixture.

Further, it is essential, for convenience in flying, that for a given position of the altitude control lever, the mixture shall be weakened by the same percentage at all throttle positions. The pilot will then only have to alter the position of his altitude control lever with change of altitude, and not for different throttle positions at the same height.

Because of the amount of altitude control required at great heights, it is imperative that there shall be an interlocking gear, which will shut the altitude control valve when the throttle is closed for a dive, to ensure that the engine will open up again. On engines which are likely to cruise at altitudes at part throttle for long periods, it is necessary for fuel economy that the interlocking gear does not begin to close the altitude control before the half-throttle position. In most cases the interlocking gear is arranged on the engine or aeroplane instead of on the carburettor.

Successive models of this carburettor have had a series of type-indicating letters. The first was known as A.I. 48 A, whilst later models had the last letter of the type number altered to B, C, D, E, etc., each change signifying some detailed modification.

Slow-running Idling Position

In Fig. 2 the carburettor is shown in the slow-running idling condition, the diffuser is inoperative, and petrol is flowing from the slow-running jet. It is then ejected beside the throttle, and via the transverse passage into the centre and other side of the carburettor outlet.

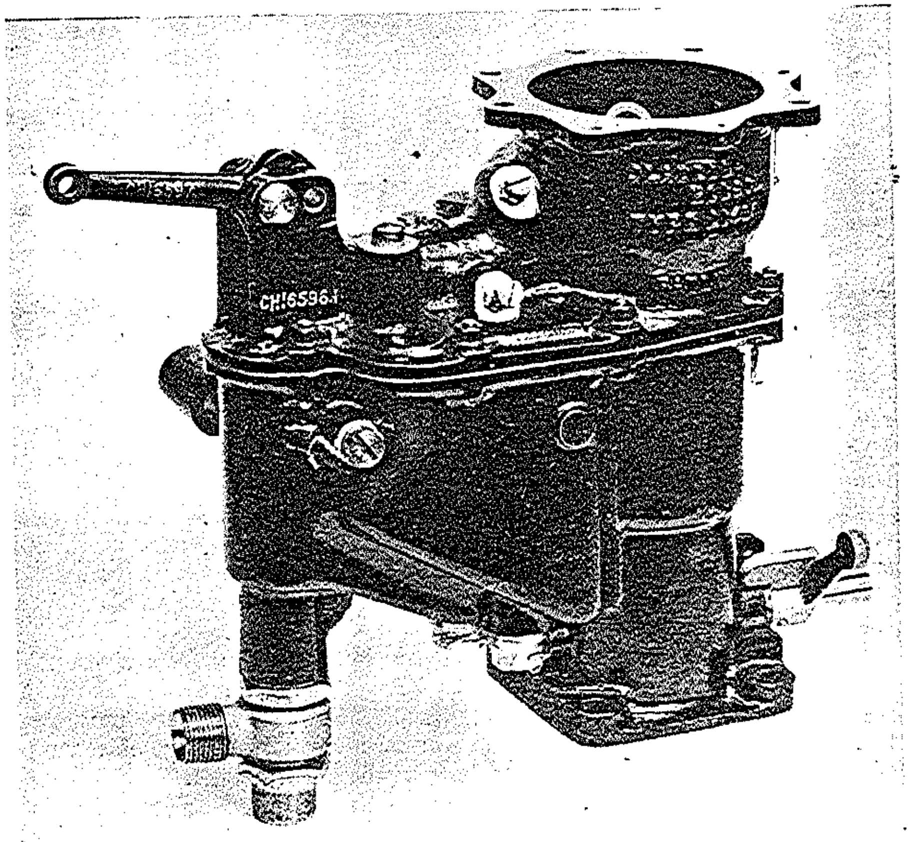


Fig. 1.—The Claudel-Hobson type A.I. 48 carburettor

Small Throttle Opening

In Fig. 3 the throttle is slightly more open, the slow-running and transverse holes are still functioning, and the diffuser beginning to act. It will be noted that the first row of depression holes are uncovered, and air is proceeding via these holes to mix with the petrol and form an emulsion.

Full Throttle

In Fig. 4 the condition is that of full power. The slow-running and transverse passage is out of action. The diffuser is in full action, and all depression holes are uncovered and taking air to mix with the fuel. In addition, the power-jet valve has opened and added petrol to that supplied by the main jet, in order to convert the economical cruising mixture given via the diffuser to the richer mixture necessary for maximum power.

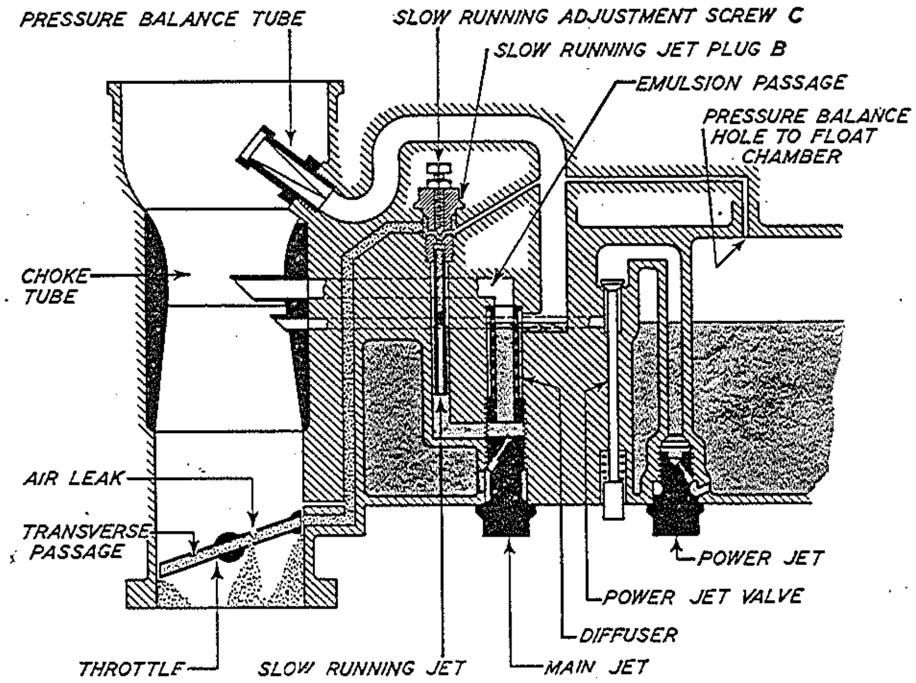


Fig. 2.—Slow-running condition

Altitude Control Operation

In Fig. 5 the carburettor is still shown in full-power condition, but the altitude control cock mixture for control and the connecting passage are shown. It will be seen that the admission of air through the altitude control cock into the emulsion passage will weaken the suction on the jets in proportion to the air admitted through the cock.

It should be clearly understood that this control in no way affects the automaticity of the carburettor, which remains constant—whatever the amount of control given—within the limits of mixture strength on which it is possible to run the engine.

Model " E " differs only from Model " D," in that the slot in the altitude valve is wider, thereby giving greater altitude control.

Models " F," " G," and " H " have an altitude valve of a type which, when operated, throws less strain on the aeroplane controls. It is in the form of a plunger or piston valve, and has an endwise movement, in distinction to the original cone-shaped valve having a rotary movement (*see* Fig. 6).

The action of both types is identical, except that the plunger type has been arranged to give a greater percentage of weakening than could be obtained with the rotary type.

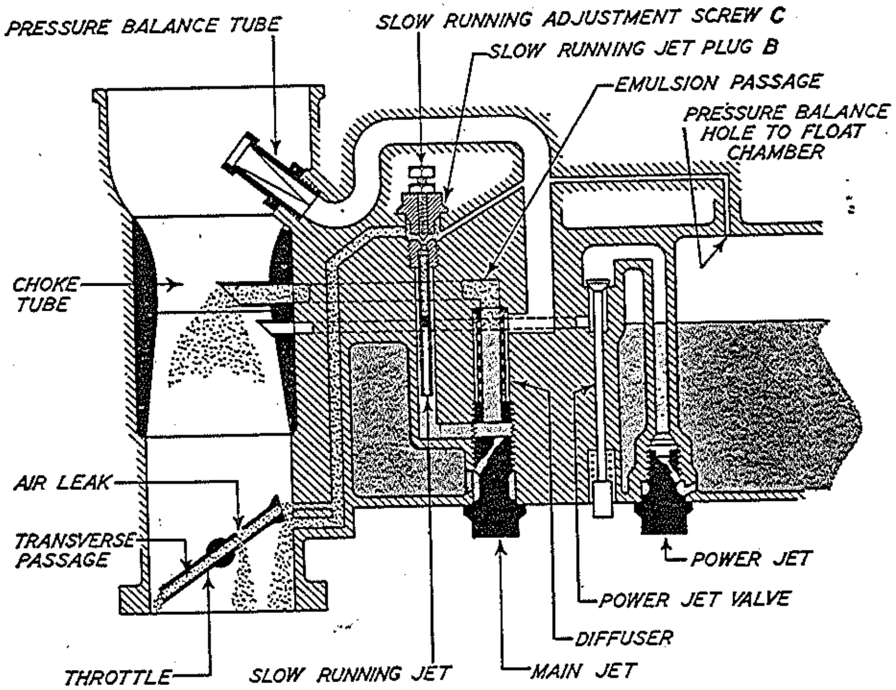


Fig. 3.—Small throttle opening

ADJUSTMENT INSTRUCTIONS

Idling or Slow Running (*see* Fig. 2)

The idling or slow-running jet feeds the slow-running mixture to two holes situated in the side of the carburettor body adjacent to the edge of the butterfly throttle. The feature of the slow running in this carburettor is the use of a passage situated in the throttle, which registers in the closed position with one slow-running hole. It will be seen that the mixture is drawn, not only past the edge of the throttle when the latter is a little way open, but is also drawn through the passage in the throttle, or as it is styled, the "transverse hole," and a portion of the mixture emerges from the throttle adjacent to the other side of the carburettor bore. There is a further small hole in the centre of the throttle through which emerges another portion of the slow-running mixture, and it will be seen that by this means the mixture is not fed entirely to one side of the induction system, but more or less evenly throughout the whole area. Also due to the fact that the depression increases on the transverse hole throughout the early part of the throttle movement, the "flat spot"—which is often prevalent on other types of butterfly throttle carburettors —is obviated.

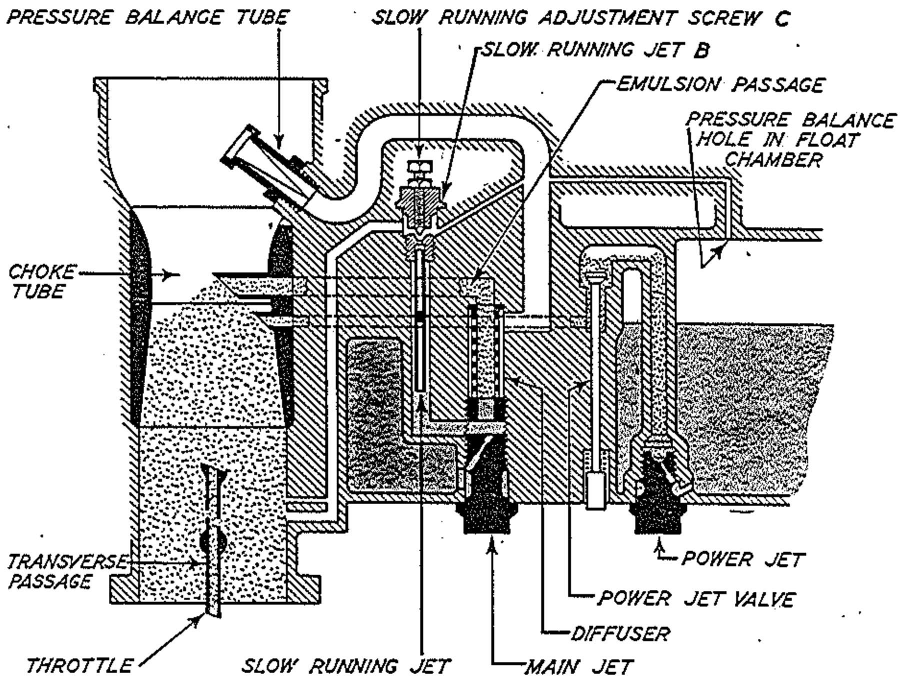


Fig. 4.—Full-throttle condition

During "tick-over," fuel issues from the hole opposite the throttle, air entering the hole on the intake side of the throttle mixing with it. As the throttle is opened, this second hole comes under suction and feeds fuel also, being an additional means for preventing any "flat-spot" while the main jet is coming into action. The size of these two holes must not be altered when once fixed by the engine makers.

The adjustment of the slow-running mixture is carried out by means of a change of jet and the admission of a certain quantity of mixture which is controlled by the adjustment screw C (*see* Figs. 2 and 3).

Models "A," "B," and "C" were fitted with a slow-running system, in which the *quantity* of mixture for "tick-over" was adjustable by means of a screw and locknut standing up on top of the slow-running jet. Turning this screw in a clockwise direction shuts off the amount of fuel and gives a *weaker* slow-running mixture.

Models "D" and onwards have had the slow-running adjustment moved to the top of the float chamber—on the opposite side of the carburettor—and it no longer adjusts the slow-running mixture by varying the *quantity*. Adjustment of the screw admits more or less air to the slow-running system, thereby altering its richness or *quality*. Turning the screw in a clockwise direction shuts off the air, and gives a *richer*

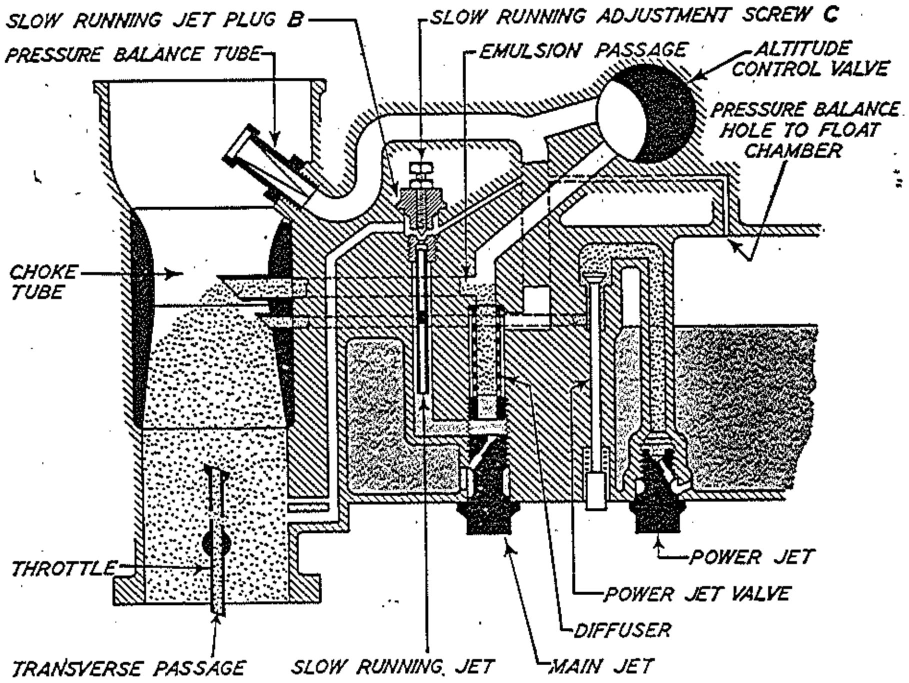


Fig. 5.—Altitude control operation (models A, B, C, D, and E)

mixture, being the reverse action to that of the models "A," "B," and "C."

Particular care must be taken not to confuse the slow-running adjusting screw with the altitude valve compensating screw. The latter is set and sealed by the makers, and is the screw nearest the altitude valve.

Note.—At no time should it be necessary to adjust the slow-running screw to the richest possible position, as such a setting indicates (1) air leaks in the induction system, either at joints or valve guides; (2) slow-running jet too small or partially choked. On a new or reconditioned engine, the screw should always be at least a few turns from the "full rich" position when correctly set for good "tick-over," so as to allow a margin for future adjustment as the engine wears.

Should at any time the slow-running mixture appear to become over-rich for no obvious reason, such as flooding or readjustment of the slow-running screw, the drain hole to be found at the bottom rear end of each induction pipe should be examined, in case it has become wholly or partially choked. Whilst "ticking over," air is drawn through these drain holes (one on the four-cylinder engines, and two on the six-cylinder engines), and any obstruction will cause slower "tick-over" and overrich slow-running mixture.

Action of Diffuser and Choke Tube—Small Throttle Opening

As will be seen by reference to Fig. 3, the mixture is drawn through the emulsion passage in the body of the carburettor and into the choke tube.

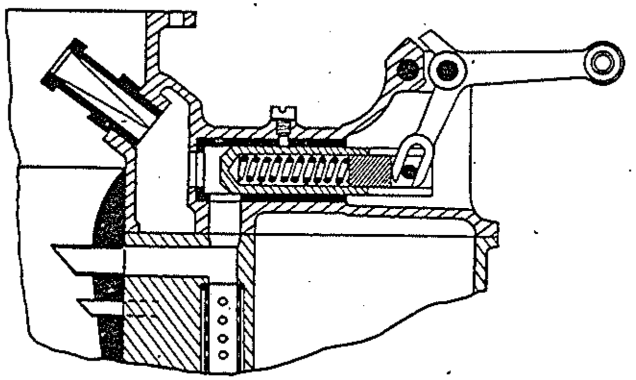


Fig. 6.—Altitude valve fitted to models F, G, and H

The control of the quality of the main mixture supplied is carried out by means of a change of the main jet. This latter adjustment can be made by simply removing the main jet, *which is integral with the external plug*, from the bottom of the carburettor, no other dismantling of parts being necessary.

Control of the amount of air supplied to the diffuser is carried out by means of the diffuser air nipple. This can be varied in size to give a richer or weaker mixture at the larger throttle openings, but in most cases the carburettor is supplied with a suitable nipple, and only in exceptional circumstances will it be necessary for the size of this to be altered. If this is found necessary, a larger nipple should be used to weaken the mixture at full throttle, whereas a smaller one should be used to enrich the mixture at full throttle.

Full Throttle—Power Jet

The Claudel-Hobson power jet (Fig. 4) supplies a small amount of petrol at full throttle only. By this means the mixture strength throughout the cruising range can be maintained at an economical proportion, whilst maximum power is obtained at full throttle where it is desired.

The power jet is situated in the bottom of the carburettor adjacent to the main jet, and is removed in a precisely similar manner to the latter. The control of the supply is carried out by means of a small valve situated in the top of the carburettor and operated by a cam on the end of the throttle spindle. The operation is clearly shown in the diagram.

Throughout all the range of these carburettors, the jets are flow calibrated, and the numbers represent the cubic centimetres of petrol which they pass on a recognised standard measuring instrument, and it is advisable not to interfere with these in any way, but to replace with others which give the required flow. Although the main and power jets are similar in appearance, it is not possible to use either jet in the reverse position, and care should be taken to see that these are correctly replaced.

Float Mechanism

The conventional type of needle valve is adopted, but the use of a float with a very much increased leverage gives greater power of resistance to the petrol head than with other types, and flooding is not likely to occur under normal circumstances. Petrol level is set 19–21 mm. from top of float chamber when tested at a pressure of ½ lb. per sq. inch (18-in. head of fuel), measured from the actual needle seating.

ADJUSTMENTS AND MAINTENANCE

It may be taken as a definite rule that carburettors supplied by engine makers with or for their engines have jets, diffusers, etc., the sizes of which have been decided upon after exhaustive experiments. It is highly desirable that no alteration shall be made except on their explicit instructions, although for use in the tropics one or two sizes smaller main jets are sometimes permissible.

Practically all that can go wrong with the carburettor in service is either a choked jet through dirt or water, or flooding caused by dirt or wear of the needle after long-continued service.

Care must be taken, when dismantling the carburettor, that the joint washer is not broken, as any leak into the float chamber alters the functioning of the carburettor.

Rebuilding

Care must be taken, when removing and replacing the float, not to damage the varnish, otherwise the float will become petrol logged.

The float must be assembled the correct way up—i.e. with the portion that enters the collar of the needle lower than the fulcrum pin hole.

When a needle valve is badly worn, it should not be ground in, but should be replaced complete with a new needle seat.

A check should be made that the choke tube is held tightly in the bottom half, and that the locking screw is located in the hole in the choke and is tight.

Altitude Valve on Types A to E

This should be taken out after long storage, to remove any possible trace of corrosion, but when fitted again must be perfectly airtight. This can be tested by reversing the top half and pouring petrol into the inlet hole to the valve, past which there should be no leak.

It is permissible to lap this valve in with a very fine abrasive, such as metal-polish paste; anything coarser than this will spoil the seating.

The pressure balance tube should be blown out occasionally.

One further point should be emphasised. Even a minor alteration to the air intake, as designed by the engine makers, can cause quite disproportionate alterations in carburation.

CLAUDEL-HOBSON TYPE A.I.T. 87 M.A. CARBURETTOR

AS FITTED TO THE TIGER VIII ENGINE

HIGH duty supercharged engines make very exacting demands on the carburettor. High speeds require adequate pressure balance to the float chamber and appropriate air-intake design to prevent alteration to the mixture concurring with changes in aeroplane speed. When once the design of the air intake has been determined in conjunction with engine tests, its shape should on no account be altered or the performance of the engine may be seriously affected.

Economy and Power

Provision for economical cruising consumption, combined with the ability to get maximum power, is made in these carburettors by the adoption of the power-jet principle, which ensures the utmost economy under cruising conditions, and still renders full power available as the throttle approaches its open position.

Slow Running

This requirement is catered for by the special slow-running system incorporating the transverse passage in the butterfly throttle, which both obviates a flat spot and provides a three-point spray to minimise build-up difficulties.

A slow-running cut-out is provided to ensure that the engine stops immediately after it is switched off.

Acceleration

A delayed-action acceleration pump is provided to enable the engine to accelerate on weak mixtures for cruising.

Additional Power for Take-off

To overcome the known difficulty met with in highly supercharged engines in leaving the ground, an arrangement is incorporated in the carburettor by which an extra jet is brought into play in synchronisation with the boost control, and this allows extra horse-power to be available for take-off purposes without causing detonation or overheating.

Mixture Control

The mixture control on these carburettors is completely automatic, and gives correct mixture strength from sea-level to the machine ceiling.