Part One

Carburettor Operation Principles

Engine fuel and air feed systems

One type of feed system adopted for internal combustion engines is schematically shown in **Fig. 1** where the feed stages are:

a) **Air feed:** air is drawn in by the engine through an air cleaner (or filter).

b) **Fuel feed:** fuel is sucked from tank and delivered to carburation area by an engine-operated mechanical lift pump.

c) **Fuel/air mixture:** is handled by the carburettor which governs the power produced by the engine through its throttle valve.

d) **Mixture delivery to cylinders:** through the intake manifold.

What the carburettor does

The carburettor is assigned the task of blending a combustible mixture of air and fuel in the correct proportions to meet the variable requirements of the engine.
The mixture supplied must have a given **metering** and be as uniformly **blended** as possible.
The **metering** value, or mixture strength α, is given by the weight ratio between the amounts of air and fuel drawn in by the engine. For the normally available gasolines the correct mixture strength, that is, without any excess of either component, consists approximately

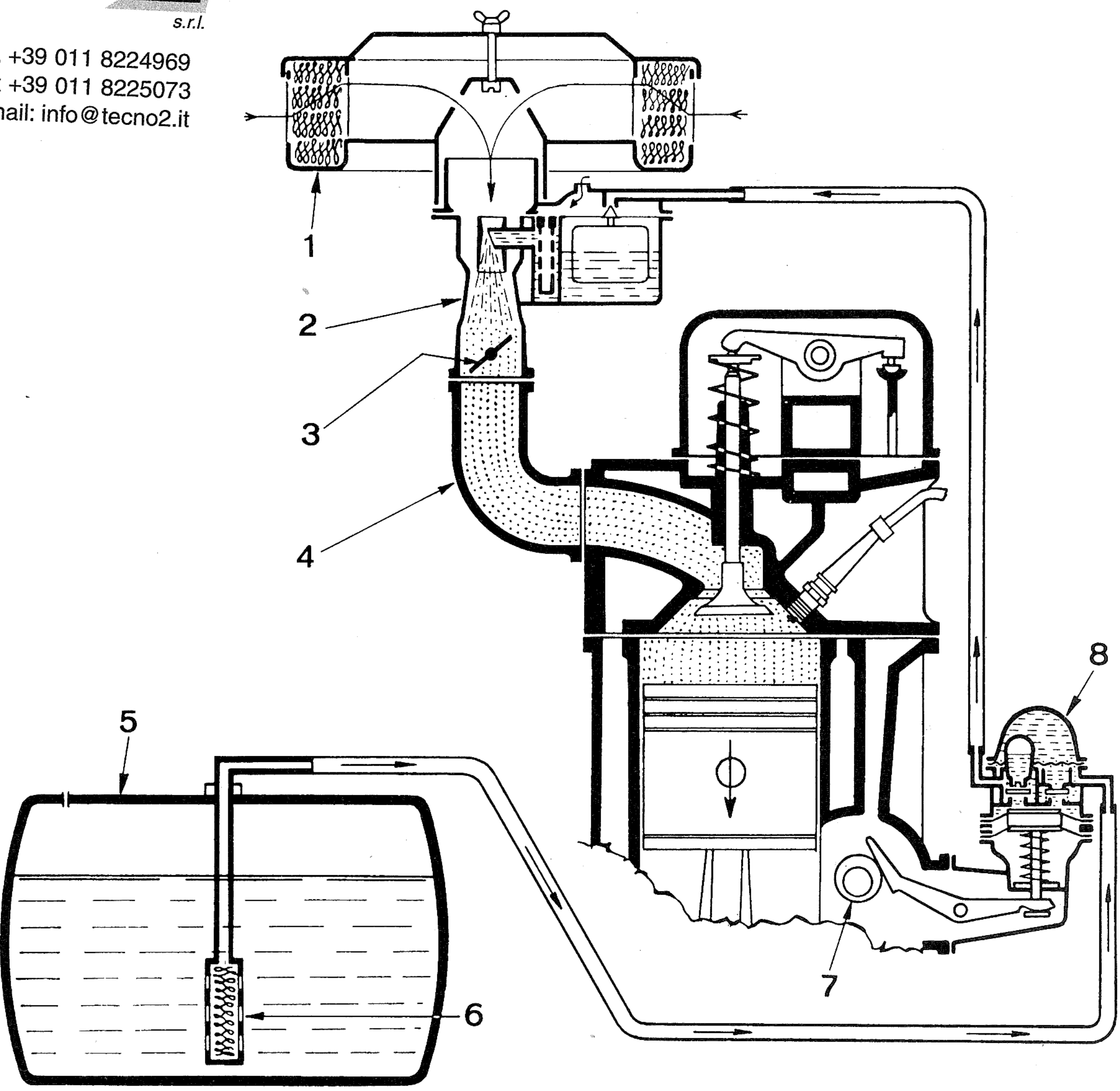

FIG. 1
Engine fuel and air feed system: 1 Air cleaner - 2 Carburettor - 3 Throttle - 4 Intake manifold - 5 Fuel tank - 6 Fuel strainer - 7 Camshaft - 8 Mechanical lift pump.

15 kg of air to **1 kg** of gasoline, briefly known as **strength 15**. Engines may work satisfactorily with strong mixtures (excess fuel) down to around **strength 6** and with lean mixtures (excess air) up to around **strength 18**. By optimum **blend** is intended a mixture in

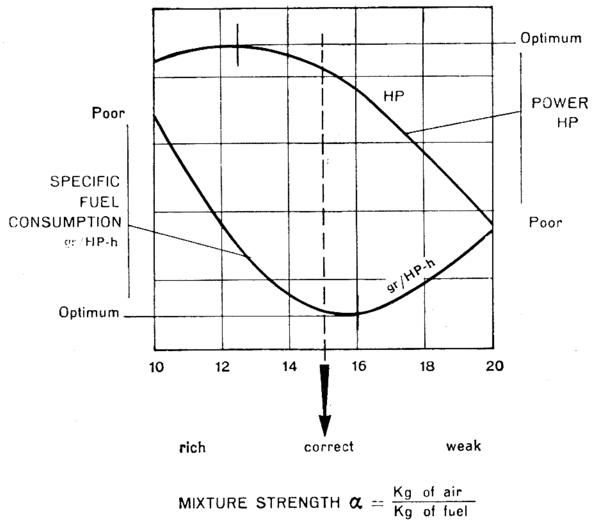

FIG. 2
Influence of mixture strength on engine performance. Maximum power is obtained with a strength of 12-13 and maximum economy (lowest specific consumption) with a strength of 15-16.5.

which air and fuel are as intimately and uniformly coalesced as possible, with the state of fuel changed from liquid into vapour.

Engine mixture metering requirements

Fig. 2 shows the influence of fuel/air mixture strength on the performance of a modern engine, considered at

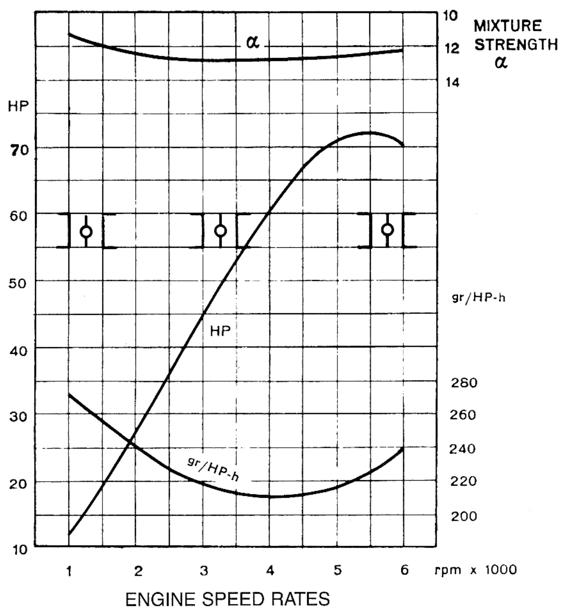

FIG. 3
Full power performance curves: maximum power produced by engine at different rpm rates. From top down: mixture strength, power in HP, carburettor throttle settings and specific fuel consumption in gr/HP-h.

a random point in engine operation under average service range conditions. A slightly strong or rich mixture ratio gives the maximum power obtainable from the engine whereas a slightly lean or weak ratio gives the best economy (low specific fuel consumption).

Engine operation range

An automobile engine operates under the most diverse speed (rpm) rate and power output conditions. Some of the more significant service conditions are discussed below with the aid of Figures 3-4-5.

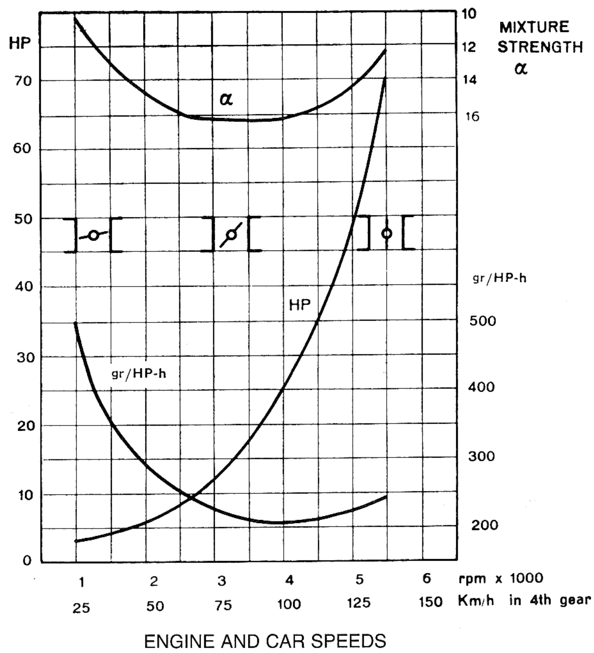

FIG. 4
Part load performance curves: power needed for car operation from lowest to highest road speed, in direct drive on level road. From top down: mixture strength, power in HP, carburettor throttle settings and specific fuel consumption in gr/HP-h.

Fig. 3 - Full power: carburettor throttle is held wide open.

Fig. 4 - Partial power or part load: the throttle is opened progressively. Generally, this condition refers to the power required to move the car at a steady speed on level road, with transmission in direct drive or highest gear ratio, from the lowest to the highest speed. The complete curve - plotted with engine on dynamometric test bench - starts with carburettor throttle in minimum opening position and ends, through progressive setting variations, with throttle wide open.

Fig. 5 - Pick-up or acceleration: the throttle is suddenly set to an opening wider than it had before and the engine must rapidly increase its rotational speed. This is accomplished properly if mixture strength α attains the value needed for full power operation; now, if the specified value is exceeded, pick-up will be poor owing to excessive mixture richness whereas if mixture

strength is below the value specified for optimum part load operation engine "stutter" (or flat spots) will result because of excessive mixture weakness.

Idle (or slow running) speed: throttle is almost totally closed and allows the engine to operate at the minimum speed at which it will keep running but without producing any power for work.

In **Fig. 4** idle speed rates are reached below **1000 rpm** of engine.

In **Fig. 5** the depression (vacuum) and mixture strength curves at part load operation begin at engine idle speed.

As the set of graphs provide the curve patterns for power, throttle setting, specific fuel consumption, mixture strength α and manifold vacuum, a good idea may be had of what the engine requirements actually are. In brief, a strong or rich mixture is needed for full power, pick-up and extreme rpm rates while a lean or weak mixture is needed for best economy at limited power outputs.

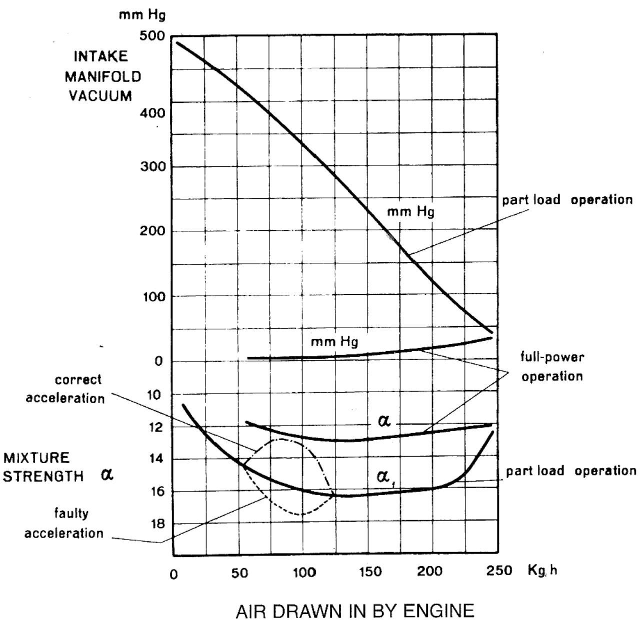

FIG. 5
Mixture strength versus amount of air drawn into the engine, under full and part power curve conditions, with respect to intake manifold vacuum values.
Mixture metering curves are the same as those plotted in Figs. 3 and 4.
Acceleration is best if mixture becomes richer instead of weaker but without exceeding the full power strength ratio otherwise the mixture would be too rich.

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The Simple Spray Carburettor

It is shown in **Fig. 6** and consists of:

– **A fuel bowl or chamber V** in which a float-controlled needle valve keeps the fuel constantly at a level 5-6 mm lower than the fuel in jet **G**.

– **A Venturi D.**

– **A spray tube or nozzle S** through which fuel flows from float chamber to calibrated jet **G**.

– **A throttle F** generally of the butterfly valve type which regulates the amount of fuel/air mixture drawn in by the engine.

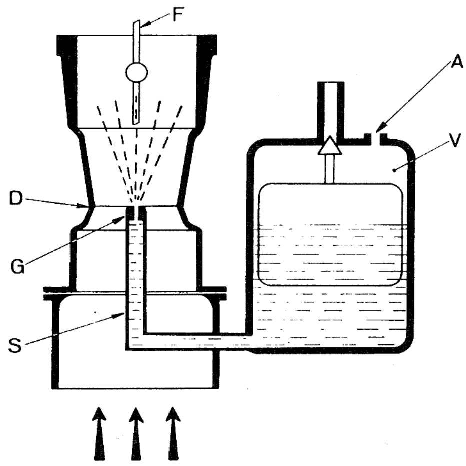

FIG. 6
Simple updraft carburettor - F Throttle - D Venturi - G Fuel jet - S Spray tube - V Fuel bowl or chamber, with float - A Float chamber vent.

The purpose of Venturi **D** is to increase the depression acting on jet **G** to favour the vapourisation of the gasoline sprayed from the jet during engine operation: this occurs because of the physical laws illustrated in **Fig. 7**. The manometer connected to the Venturi restriction indicates the lowest pressure (highest vacuum) referred to the atmosphere: jet **G** is located in this area and delivers fuel sucked from the float chamber which is kept at atmospheric pressure through vent **A**.

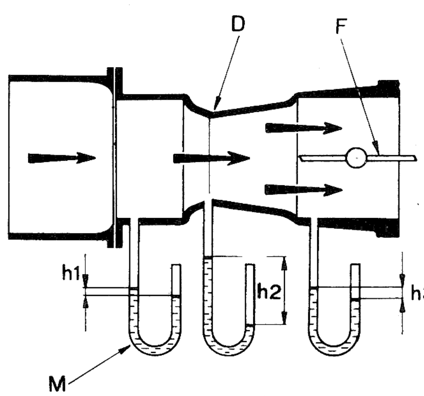

FIG. 7
Depression (vacuum) values along carburettor barrel - F Throttle butterfly valve - D Venturi - M Manometers - h1, h2, h3 Readings.

Fundamental carburettor systems

Carburettor designs may have barrel arrangements different from the simple spray unit of Fig. 6: three basic patterns are shown in **Fig. 8**.

1 - Downdraft (or inverted) carburettor: air enters from the top. It is practically the standard pattern on the majority of current automobiles because it is more accessible and provides better engine feed as the mixture flow is assisted by gravity.

2 - Updraft (or vertical) carburettor: air enters from the bottom. Largely adopted in the past because it avoided admission of fuel in the liquid state to the engine. Abandoned in current applications because it is not easily accessible and fails to ensure proper cold starting and cylinder charge volumetric efficiency.

3 - Sidedraft (or horizontal) carburettor: air enters from the side. Preferred when low under-hood height is a design requirement.

Also used are some intermediate patterns with inclined barrels.

Simple spray carburettor defects

a) Considering the physical laws governing the discontinuous efflux of fluids (both liquid and gaseous) from restricted apertures, it becomes possible to show that as the vacuum in the Venturi increases the amount of fuel issuing from the pilot jet will also increase but at a faster rate than the increase in the air swallowed in by the carburettor. The mixture formed in a simple carburettor becomes noticeably, richer as the engine draws in larger amounts of air; as a net result, the mixture will be correctly proportioned at greater air flow rates but too lean at lower flow rates.

The simple spray carburettor, as considered here, also has the following failings:

b) It does not permit engine operation under no-load conditions as it has no **idle speed or slow running device.**

During this stage, the depression in Venturi is too weak to draw any fuel via spray tube **S - Fig. 6**.

c) It cannot meet sudden engine rpm rate variations as it has no **transition (or progression) orifice system** or **accelerating devices**.

d) It does not allow cold starting of the engine as the depression in Venturi drops still further on account of the lower cranking speed supplied by the starter motor while the engine needs a rich mixture; in other words, it is not equipped with a **starting device or choke**.

All these shortcomings are obviated by special features incorporated in modern carburettors.

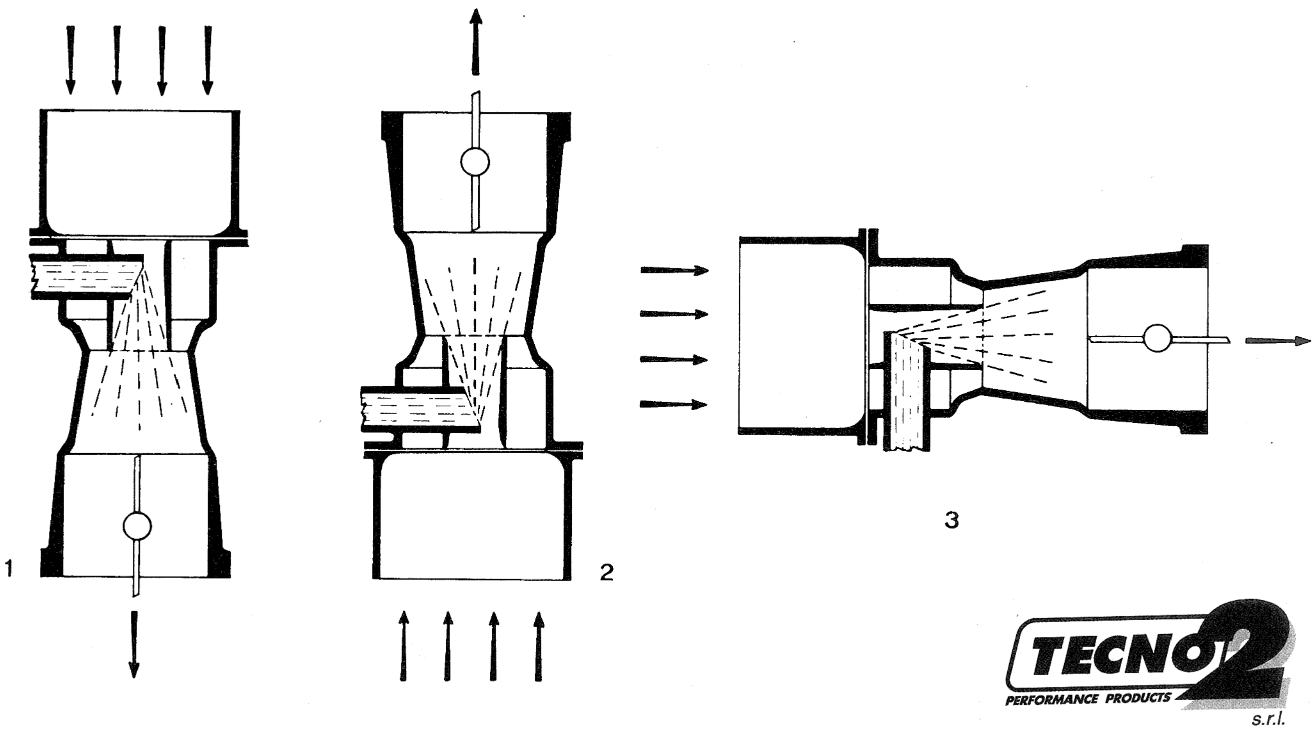

FIG. 8
Carburettor systems - 1 Downdraft - 2 Updraft - 3 Sidedraft.

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The Modern Carburettor

To prevent the mixture strength from enrichening as the demand of engine increases, several provisions have been devised over the past 70 years one of the most suitable of which is the "air bleed correction" system, being automatic and without moving mechanical parts.

a) Air bleed correction

This feature was adopted on Weber carburettors and is illustrated in **Fig. 9**. When a depression is established in the restriction of Venturi **D** it communicates with well **P** through spray tube **S**, fuel is drawn out through jet **G** while outside air, via jet **Gf**, "bleeds" in through the lateral holes in emulsion tube **T**.

As the vacuum becomes stronger, following the increase in engine rpm rate, the fuel issuing from jet **G** is corrected by the increasingly higher "braking" action of the air drawn in through jet **Gf** and the orifices in emulsion tube **T**.

The main advantages of this automatic corrective bleeding action are:

– Better atomisation of fuel because spray tube **S** does not supply only gasoline, as occurs with the simple spray carburettors, but a suitably proportioned fuel/air mixture.

– As may be readily seen, jet **G** is no longer submitted to the full action of the vacuum in Venturi **D** whereby to a given fuel flow rate corresponds a larger sized jet **G**. The advantages offered by this arrangement are twofold: firstly, a larger size jet is easier to make and is less affected by possible impurities in the fuel; secondly, its efflux characteristics contribute to mixture correction improvement.

Also of great importance is the size of spray tube **S** and of the space between emulsion tube **T** and well **P** where the fuel flows: in fact, the reduced size of tube **S** and of the cavity around **T** means stronger resistance to the passage of the mixture, namely, the higher the vacuum in Venturi the higher the resistance or "braking" action. By varying also these two design features, the fuel supply curve can be further corrected thus obtaining the best possible mixture metering for proper engine feed.

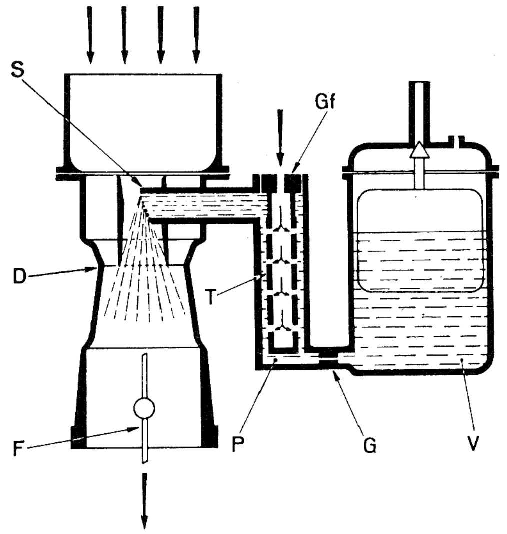

FIG. 9
Air bleed correction - S Spray tube or nozzle - Gf Air bleed jet - T Emulsion tube submerged in well P - G Main fuel jet - V Float chamber - D Venturi - F Throttle.

b) Idle speed (or slow running) device

The idle speed device allows a warm engine to operate at the lowest rpm rate at which it will keep running. Under this condition, the throttle is nearly closed and the degree of vacuum promoted in the Venturi is inadequate to draw out any fuel from the nozzle, owing to the small amount of air breathed in by the engine. Now, going back to **Fig. 5**, it may be seen how the vacuum in induction manifold is higher at lower air flow rates under part-load operation which, as mentioned earlier, at one end approaches the idling speed stage. This low vacuum is therefore exploited for the idling engine feed circuit by connecting the throat area downstream of the throttle to a fuel jet **Gm, Fig. 10**, which is by-passed by an air corrector jet **Gam** that also cuts-out the syphoning action which would otherwise be present.

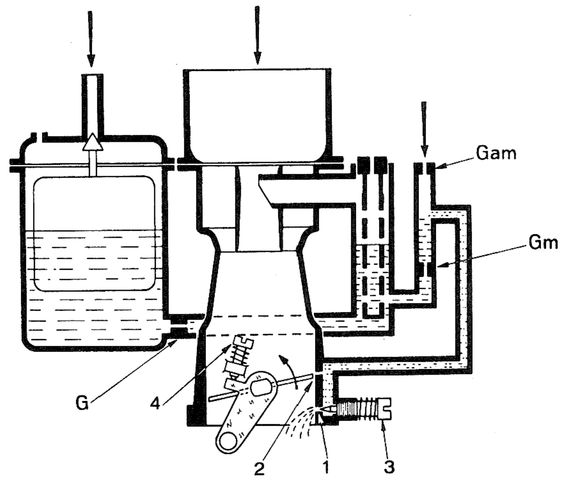

FIG. 10
Idle speed circuit - Gam Idle speed air jet - Gm Idle speed fuel jet - G Main fuel jet - 1 Idle speed mixture orifice - 2 Transition (or progression) orifice - 3 Idle mixture adjusting screw - 4 Throttle setting or idle speed adjusting screw.

The mixture thus formed is drawn in via orifice **1** whose bore is varied by a taper-pointed screw **3**, hence called **"idle mixture adjusting screw"**. During idle the engine breathes the air it needs through the small gap around the throttle valve: This gap is varied by a specially provided **"idle speed adjusting screw" 4**.

Two adjusting screws are thus provided for mixture and speed rate variations ensuring proper idle operation settings. In the more common applications, the idle speed circuit fuel is taken from the main system well at

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a given location which generally is level with the lower holes of emulsion tube – as shown in **Fig. 10** - or, at any rate, downstream of the main or pilot jet.
This arrangement ensures the automatic exclusion of the idle speed circuit feed when it is not needed. For instance, under full power operation – when the depression in well is highest – a **"reversal"** may occur in the idle speed circuit, that is, air enters through orifices **1** and **2**, jet **Gam** and flows to the main well.
In some sports car designs the idle speed circuit is often fed directly from the float chamber; in others, said "reversal" is limited by varying the idle speed system.

c) Acceleration progression

As described so far, the carburettor can operate equally well at both idle and normal speeds, with part- or wide-open throttle. However, if the throttle is opened slightly from its idle setting to rev up the engine, a "stalling" results and engine will stop.
This occurs because the wider gap around throttle lets in a greater amount of air while the mixture issuing from the taper-pointed screw orifice instead of increasing proportionally tends to reduce with the decreasing depression: the engine thus receives an excessively lean mixture, is "starved" and stops.
To ensure a progressive action during acceleration a transition orifice **2** is drilled in carburettor, directly in line with the upper edge of the throttle in its idle speed setting and communicating with the idle mixture duct – **Fig. 11**.
During idle speed operation – **see A, Fig. 11** – the transition orifice being **2** located upstream of the throttle valve where pressure is almost the same as atmospheric, air is introduced into the barrel with the mixture issuing from orifice **1** below.
When the throttle opening is increased – **see B, Fig. 11** – transition orifice **2** will be located partially or totally in the area downstream of the throttle where vacuum is rather high and will thus supply the mixture in parallel with idle speed orifice **1**. If at this point the throttle is further opened the mixture supplied by the idle speed circuit alone would no longer be adequate but, now, the depression acting upon nozzle **S** is sufficient to draw a spray of fuel from it. – **see C, Fig. 11**.
In some cases two or three transition orifices are provided to prolong the progression stage accompanying the opening of the throttle valve.
During these progressive acceleration stages, especially when the throttle is opened suddenly, the shape and the size of emulsion tube **T** – **Fig. 9** – become two extremely important design factors: in fact, with engine idling in tube **T** and in associated well **P** there is a certain amount of fuel whose level, owing to capillary action, is often at the same height as the level in float chamber. When the throttle is opened, even a slight vacuum (a few mm water column) will be sufficient to draw fuel from well **P** and prime the mixture supply from the main circuit.
In brief, there are two systems without moving parts that are generally adopted to ensure smooth engine operation during throttle opening stages:

– One or more transition orifices, and

– A reserve of fuel in well P.

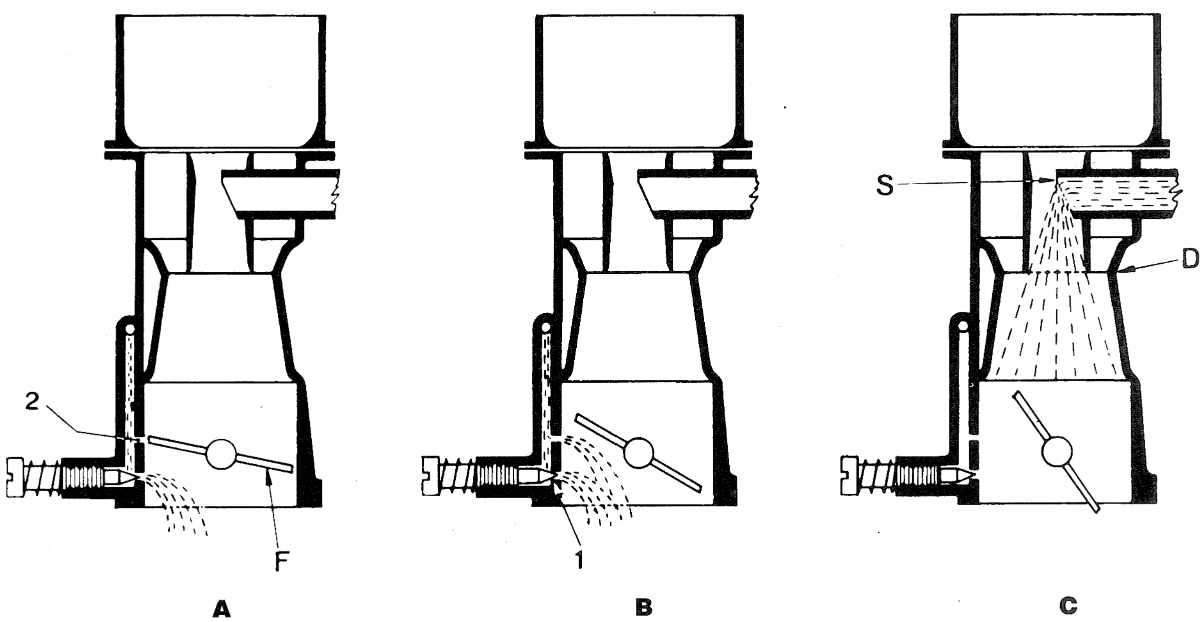

FIG. 11
Transition (or progression) stage - A Idle speed operation - B Transition stage - C Priming of the main circuit and idle speed circuit supply cut-off - 1 Idle mixture orifice - 2 Transition orifice - F Throttle - D Venturi - S Spray nozzle.

In spite of the design features described there are cases in which an accelerating pump must be used to inject an additional amount of fuel at every quick opening of the throttle. Generally, the accelerating pump is incorporated in carburettors when:

– Venturi diameter is greater than 22-24 mm
– A single carburettor feeds many cylinders
– The application is for sports engines.

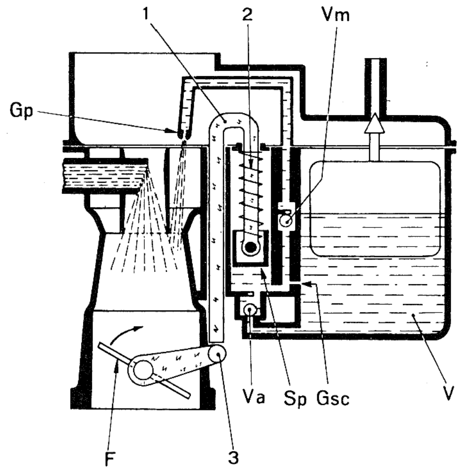

FIG. 12-A
Plunger-type accelerating pump - 1 Pump rod - 2 Spring - 3 Pump control rocker lever - F Throttle - Va Inlet valve - Sp Pump plunger - Gsc Pump drain jet - V Float chamber - Vm Delivery valve - Gp Pump jet.

The quick opening of the throttle may cause a temporary leaning out of the mixture strength as a result of the faster rate at which air is swallowed with respect to the carburettor. This depends on the different densities and circuiting of the two fluids inside the carburettor. Generally, best results are accomplished if the injected fuel is directed against the edge of the throttle valve that does not affect the operation of transition orifices.

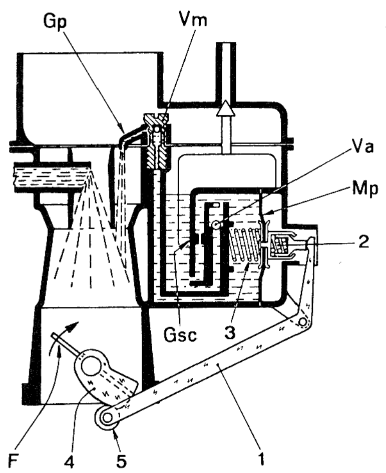

FIG. 12-B
Diaphragm-type accelerating pump - 1 Pump control lever - 2 Pump spring - 3 Diaphragm return spring - 4 Cam lever - 5 Roller - F Throttle - Gsc Pump drain jet - Mp Diaphragm - Va Inlet valve - Vm Delivery valve - Gp Pump jet.

The mechanically-operated pump may be either of the plunger or diaphragm type, **see Fig. 12-A and B**. With the plunger pump – **see Fig. 12-A** – when the throttle is opened plunger **Sp** is pushed down by spring **2** and compresses the fuel beneath it: suction valve **Va** thus closes and the fuel, via delivery valve **Vm** which is lifted from its seat, flows partly through pump jet **Gp** and partly back to float chamber via pump drain jet **Gsc**. When the throttle is closed the plunger travels back up compressing spring **2** and sucks in fuel through valve **Va** and jet **Gsc**. With the other type of pump – **see Fig. 12-B** – a diaphragm replaces the plunger but operation is practically the same. The importance of jets **Gp** and **Gsc** will be explained later on.

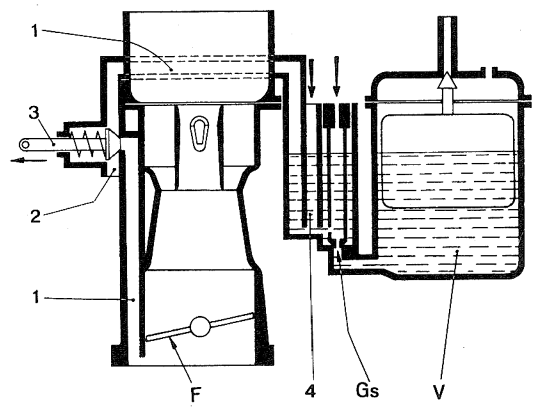

FIG. 13
Simple choke - 1 Starting mixture duct - 2 Starting air jet - 3 Starting valve - 4 Starting reserve well - F Throttle - Ga Starting jet - V Float chamber.

d) Starting device or choke

This device completes the modern automatic carburettor in its simplest form. When a cold engine is started, and especially at low ambient temperatures, the following phenomena take place:

– **Too weak vacuum acting** on jets and developed in intake manifold because the starter-cranked engine turns very slowly, for various reasons, namely, about 70 to 150 rpm.
– **Inadequate mixture supply** from the idle speed circuit and no mixture at all from the main jet, owing to the extremely low vacuum.
– **Fuel condensation** on intake manifold and cylinder walls as a consequence of the low vacuum and temperature. The cylinders receive a lean and poorly blended mixture containing a high percentage of fuel which is still in the liquid state and hence the charge is difficult to ignite.

To ensure prompt starts and smooth operation during engine warm up the carburettor must supply a rich mixture and this is obtained by a special device known as the **"choke"**. Once the engine reaches its normal rated operation temperature the choke must be excluded.

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Manual choke of the auxiliary carburettor type

This starting device consists of an auxiliary carburation unit fed directly from the float chamber and which is cut-in or out, with throttle set in idle speed position, by a separate hand control. As shown in **Fig. 13**, when valve **3** is opened the depression present downstream of the throttle communicates with fuel reserve well **4** - via duct **1** - and hence with jet **Gs**. The mixture supplied by this circuit and leaned out by the air entering through jet **2**, allows engine to start and rev-up to an adequate power during the warming up stage.
This type of starting device is provided with a simple blanking valve but the system may be improved by adopting a progressive-action valve which permits the desirable "graduation" in choke operation.

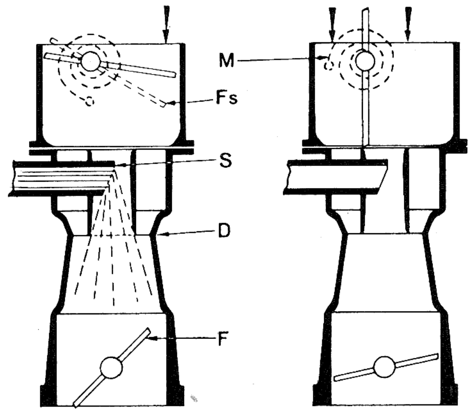

FIG. 14
Offset shutter (or strangler) valve choke - Fs Choke valve - S Spray nozzle - D Venturi - F Throttle valve - M Calibrated spring.

Manual choke of the shutter valve type

With this system **(see Fig. 14)** the auxiliary carburettor described earlier is replaced by a shutter (or strangler) valve **Fs** positioned offset with respect to barrel centreline and upstream of Venturi **D**. During the starting stage – **Fig. 14-A** – shutter valve is closed while throttle valve **F** is slightly open – **fast idle position** – through a lever linkage control. As will be readily apparent, the vacuum produced by the cranked engine is no longer confined to the area downstream of throttle **F** as occurred in the previously described system but now influences the whole area beneath shutter valve, including Venturi **D** and nozzle **S**. Once engine has started, the vacuum around nozzle **S** increases and the resulting mixture would be excessively rich but at the same time also the force tending to open shutter valve **Fs** increases; this is why the latter valve is not rigidly connected to choke control lever linkage but through the intermediary of a calibrated spring **M** so that valve **Fs** may open to keep the depression at the specified value. Once engine is warm, shutter valve **Fs** must be set back to its vertical position – **Fig. 14-B** – namely, the "choke" control must be excluded.

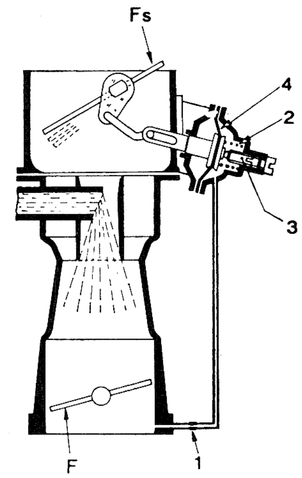

FIG. 15
Pneumatic overchoking or antiflooding device - 1 Limiter jet on vacuum channel - 2 Diaphragm return spring - 3 Adjusting screws - 4 Diaphragm - Fs Choke Valve - F Throttle valve.

For improved engine warm-up operation also a **pneumatic overchoking or antiflooding device – Fig. 15** – is sometimes used. The vacuum downstream of throttle **F** increases once engine has started and by acting on diaphragm **A** it overcomes the resistance of spring **2**; as a result, valve **Fs** opens against the opposing action of the choke spring (not shown) to a position governed by the setting of adjusting screw **3**. As long as the engine keeps running, shutter valve **Fs** may open further but cannot close.
One other shutter valve type of choke is shown in **Fig. 16**; during engine starting strangler **Fs** remains shut as its plate incorporates a poppet valve **1** which governs the amount of incoming air according to engine requirements.
Over the auxiliary carburettor arrangement the shutter valve choke offers the advantage of obtaining prompter starts and higher power outputs from the engine at low temperature.

Automatic choke

To make driving easier, prevent misuse and avoid leaving the choke in even after the engine has reached its rated operation temperature, some carburettors have been fitted with an automatic choke which is independent of driver's will.
The automatic choke control, also shown in the colour chart, is ensured via a temperature-sensitive element (bi-metal spring or expanding capsule) which, with engine cold, takes care of inserting the choke, be the latter of the auxiliary carburettor or offset shutter valve type.

Choke cut-out is controlled by the heating of the temperature-sensitive element: it receives heat from exhaust manifold heated air, engine cooling system water or an electric resistor wired to the ignition circuit. The only action which the driver is normally called upon to take for choke insertion is to depress fully and release the accelerator pedal before starting the engine; for this reason, controls of this kind are often

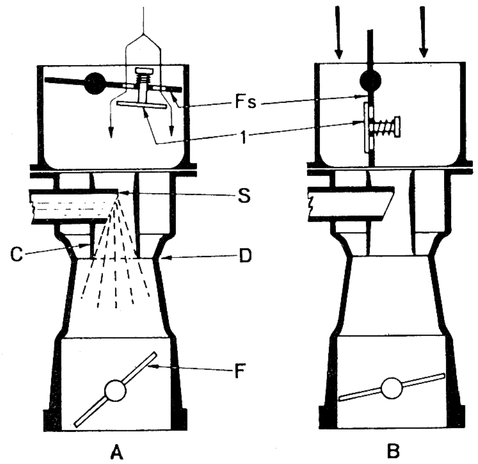

FIG. 16
Offset shutter with incorporated poppet valve type choke - 1 Anti-flooding poppet valve - Fs Shutter - S Spray nozzle - C Auxiliary (or secondary) Venturi - D Main (or primary) Venturi - F Throttle valve - A Choke in operation - B Choke excluded.

referred to as **semi-automatic**.
Referring to the schematic representation of parts involved in **Fig. 17** a description is given in the following paragraphs of the choke insertion, starting, acceleration and choke disinsertion stages.
Choke insertion - with engine cold, bi-metal spring **B** shifts pin **1** and lever **2**, in one with lever **3**, thus moving offset shutter valve **Fs** into closed position: this action occurs when the driver, before starting, depresses fully and then releases the accelerator pedal. This preliminary action by the driver is indispensable to move away from cam **4** screw **5** (carried on lever **6**) via rod **7** connected to accelerator lever **8**: in fact, unless screw **5** is moved out of the way, bi-metal spring **B** cannot rotate lever **3** which drags along also fast idle cam **4** through spring **9**. Before starting the engine, shutter valve **Fs** must be closed and screw **5** must rest against cam **4** to give throttle **F** the pre-set **fast idle** opening.
Starting and acceleration - Once engine has started, the vacuum beneath throttle **F** increases and gains enough force to shift diaphragm **D** and rod **10** the amount allowed by the setting of the mixture weakening screw **11 – pneumatic antiflooding;** the shift of rod **10** causes a partial opening of shutter valve **Fs** to suitably proportion mixture strength to engine warm-up requirements, by overcoming the force of spring **M** and bi-metal spring **B**. If the accelerator pedal is pressed lightly and enough to move screw **5** away from cam **4** the latter – via spring **9** – will be turned through the same angle which the shift of rod **10** had earlier caused lever **3** to make. In case accelerator pedal is released, screw **5** will abut against cam **4** in another location, the cam now being set for a reduction in fast idle rate. Should the accelerator pedal be depressed more forcibly, the vacuum beneath throttle **F** will decrease, spring **M** sets back rod **10** and the opening of shutter valve **Fs** will be governed by bi-metal spring **B** alone. Should the starting be prevented by an excessively rich mixture, by depressing accelerator pedal fully in throttle **F** will open completely and, through rod **7** and the lug on lever **6**, it will rotate cam **4** and lever **3** thus causing shutter valve **Fs** to open of a given amount: at this point, by cranking with the starter motor it will be possible to lean out the mixture first and then repeat the starting operation as described above.
Choke disinsertion - With engine running, the heat produced by heater **R** is conveyed to bi-metal spring **B** which gradually deforms and reduces the force tending to keep shutter valve **Fs** closed: this reduces mixture richness and the fast idle rate. Once the rated temperature is reached, bi-metal spring **B** positions shutter valve **Fs** vertical and rotates cam **4** until it no longer contacts screw **5**: throttle **F** may thus return to its normal idle speed setting governed by idle speed adjusting screw **12**.

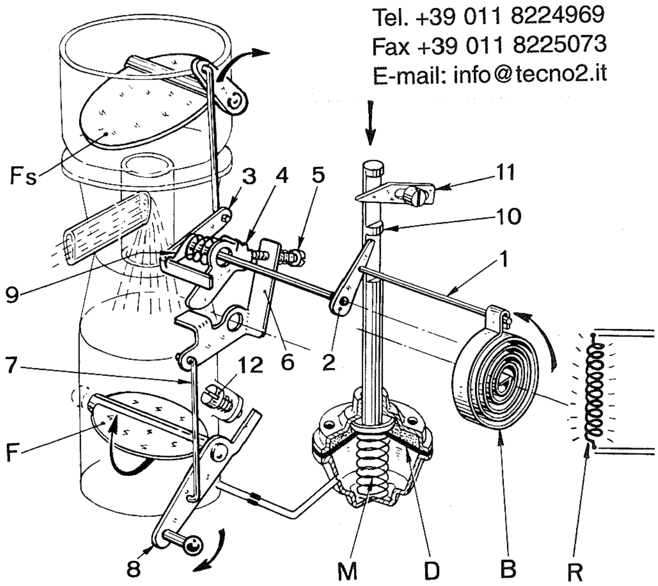

FIG. 17
Automatic choke schematic diagram - 1 Pin - 2 Lever - 3 Lever rigidly connected to lever - 2 - 4 Fast idle cam - 5 Fast idle setting screw - 6 Fast idle lever - 7 Tie rod - 8 Accelerator lever - 9 Spring, connecting cam 4 with lever 3 - 10 Pneumatic anti-flooding device control rod - 11 Anti-flooding control rod travel adjusting screw - 12 Idle speed adjusting screw - Fs Shutter (or strangler) valve - F Main throttle valve - M Spring, diaphragm D - B Bi-metal thermostatic spring - R Heater.

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Modern Carburettor Features

Some basic carburettor devices have been described in the preceding paragraphs but there are also a few other particular systems which have found wide application in current automotive engineering and are worth being illustrated.

Auxiliary (or secondary) Venturi

The purpose of this second Venturi is to boost the depression existing in the main or primary Venturi and to improve the mixing of fuel with the incoming air. In some of the earlier illustrations this device is represented as a small Venturi surrounding spray nozzle **S** – for instance, **Fig. 16** – with its lower edge terminating in the narrower section (or striction) of the main Venturi **D**.

Multi-barrel carburettors

To improve engine performance at full power, the trend in automotive design is to adopt more than one carburettor on the same engine so that each carburettor or barrel feeds a limited number of cylinders, or even a single cylinder: in this way, volumetric efficiency (or combustion chamber charge) is improved with the added advantage that the fuel feed to each cylinder, or group of cylinders, is unaffected by the intake stroke of the others, thus ensuring a more uniformly blended mixture distribution.
This same result could be achieved by adopting a number of **single-barrelled** carburettors but for evident reasons of simplicity and control positiveness, the carburettors with **two or more barrels** (or throats) incorporated in a single body casting are preferred, often having a single constant-level float chamber in common for fuel supply. An important feature is the method adopted for the opening control of the throttles which may be either of the **differential** or the **synchronised** type. The direct type **(mechanical) differential control** is shown in **Fig. 18**: accelerator lever **A** is integral with the throttle **F1** which is opened first (hence, **primary throttle**) and when its opening reaches 2/3 the maximum setting, intermediate lever **L** begins to open throttle **F2 (secondary)** and completes the opening within the remaining part of its travel.
The primary barrel – often smaller than the secondary in diameter – is adjusted to provide an economic mixture strength for part-load operation whereas the secondary barrel is adjusted for full power and acceleration performance.
The secondary barrel control may also be of the **pneumatic** type, that is, obtained through a diaphragm actuated by the vacuum by-passed from the primary throat. - **Fig. 19**.
Upon opening of the primary throttle **F1** the vacuum in main Venturi **D** is ducted to the chamber of diaphragm **P** through passage **1**. If throttle **F1** is totally open, lever **L1** is lowered and frees lever **L2** which is connected (via a link rod) with diaphragm **P**: in this case, the vacuum acting on the diaphragm and opposed by spring **M**, opens throttle **F2** gradually and in accordance with the amount of air drawn in by the engine. Upon closing of throttle **F1** the lever linkage shown ensures the prompt closing of throttle **F2**. This type of pneumatic control finds wider application on engines which have the possibility of operating, at full power, over a wide rpm rate range.

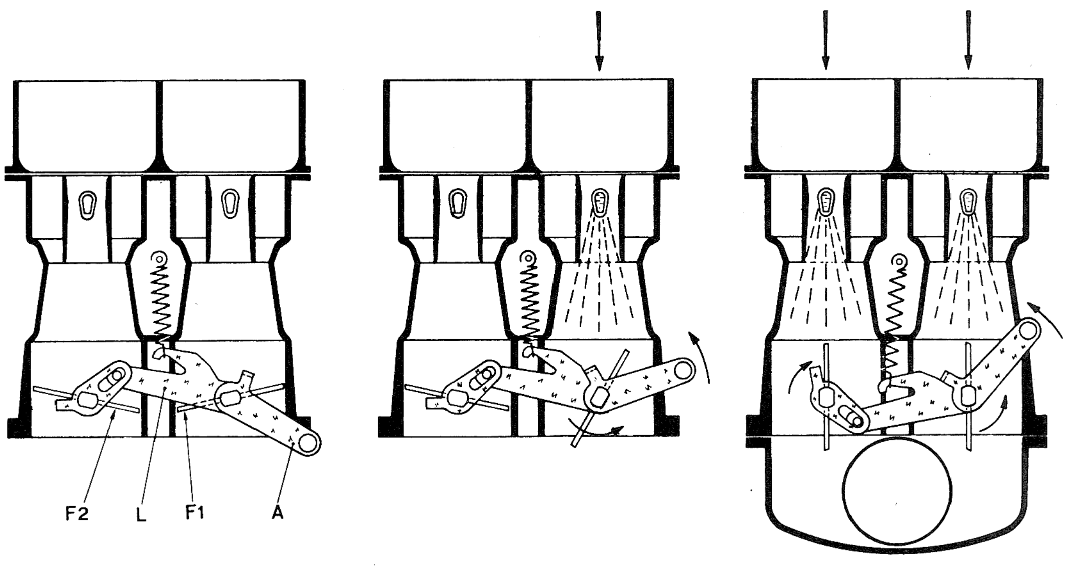

FIG. 18
Mechanically-controlled differential opening of the throttles - A Accelerator lever integral with primary throttle F1 - L Intermediate lever for control of secondary throttle F2.

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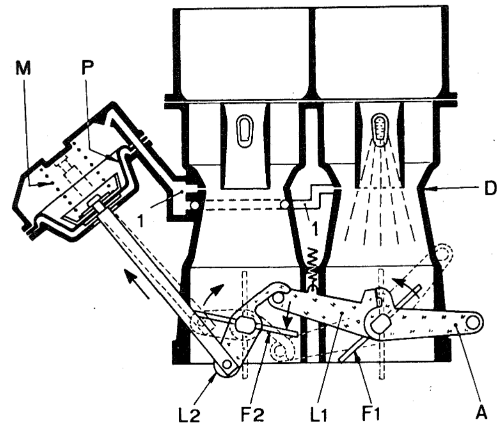

FIG. 19
Pneumatically-controlled differential opening of the throttles - 1 Vacuum duct interconnecting main Venturi D and diaphragm P - M Spring - A Accelerator lever integral with primary throttle F1 - L1 Intermediate lever for control of secondary throttle F2 - L2 Lever integral with throttle F2 and actuated by diaphragm P.

The intake manifold used in conjunction with differential carburettors has a single cavity into which arrive the two carburettor ducts.
The **synchronised control** may be obtained by fitting the throttle valves on the same spindle or on separate spindles interconnected by two identical toothed sectors. To ensure best engines performance, the opening angles of the two throttles must be the same at all times, whatever the position of the accelerator. The synchronised control is usually adopted when each carburettor barrel feeds one cylinder or a group of cylinders, independently of the others. In this case the intake manifold is provided with a separate tubing for each carburettor barrel, connected to the cylinder or group of cylinders involved. At times the separation of the ducts is limited by a common channelling known as the **"compensating type"**.

Mixture strength control devices

As described earlier **(see Figs. 3-4-5)** for maximum engine efficiency and best use of the fuel, the mixture

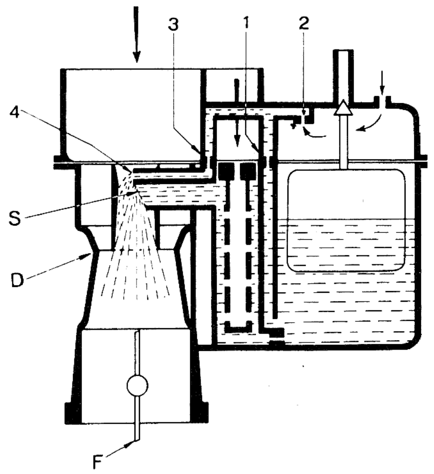

FIG. 20
Mixture enriching circuit (overfeed) - 1 Fuel jet - 2 Emulsion air jet - 3 Overfeeding device mixture jet - 4 Mixture channel in auxiliary Venturi - S Spray nozzle - D Main Venturi - F Main throttle.

strength must be proportioned to engine requirements established by both laboratory and road tests.
With wide open throttle the mixture must be slightly rich for maximum power and good engine life, whereas with part-open throttle, hence part power, the mixture may be leaned out with all the ensuing advantages of greater economy and exhaust gas toxicity reduction.
If a carburettor barrel supplies fuel to just one or two cylinders, the fluctuations in incoming air flow rate already produce the necessary weakening in mixture strength during part-throttle operation. But often it

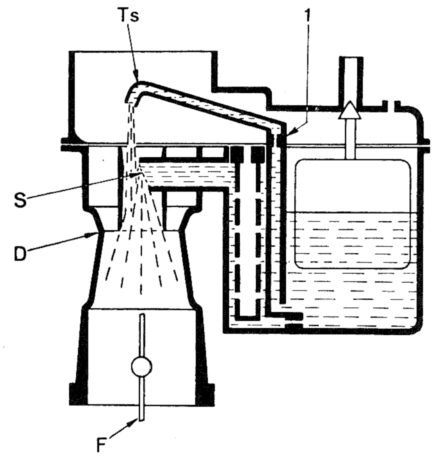

FIG. 21
Mixture enriching circuit - 1 Fuel jet - Ts Fuel spray tube - S Main spray nozzle - D Main Venturi - F Main throttle.

becomes necessary to provide the carburettor with additional devices for the special purpose of adapting it to engine demands under any and all conditions.
One such arrangement – called **overfeeding device** – consisting of a mixture control system without moving parts is shown in **Fig. 20**.
It is a separate circuit, in parallel with and independent of the main circuit, consisting of a fuel jet **1**, an air jet **2** and a mixture jet **3**. The fuel, drawn from the bowl and metered by jet **1**, emulsifies with the air coming in through jet **2** and the mixture thus formed – via calibrated bush **3** – is sprayed into channel **4** in auxiliary Venturi, just above nozzle **S**. The supply from this circuit serves mainly to enrichen the mixture to offset the greater amounts of air flowing both when throttle is partially or totally open.
Another quite similar system is shown in **Fig. 21**: in this case, however, there is no emulsioning air and the supply of fuel takes place through a special spray tube **Ts. Fig. 22** shows a system adopted to weaken the mixture under part-open throttle conditions. It consists of a valve **Vsm** operated by the throttle spindle and serves to blank – at wide-open throttle – an additional air outlet in the carburettor main feed circuit.
At part-open throttle, instead, there is an addition of air (left, see arrows) in the well located below air corrector jet **Gf**, valve **Vsm** being open.
Fig. 23 (**A** and **B**) shows a special valve, in two

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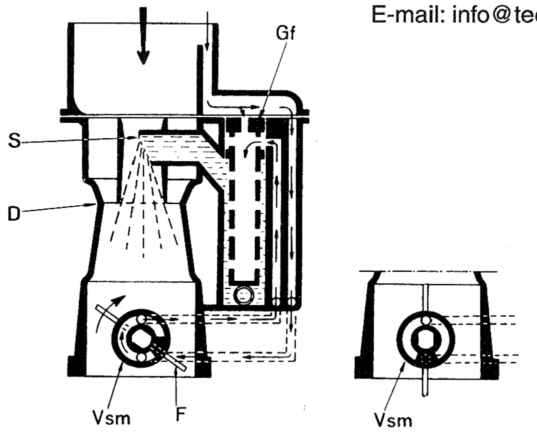

FIG. 22
Mixture weakening circuit - Gf Main air bleed correction jet - S Main spray nozzle - D Main Venturi - Vsm Rotary valve incorporated with main throttle F.

versions for mixture enrichment control either when the throttle is part-open (see **A**) or wide-open (see **B**). Control is by the vacuum existing in the intake manifold.
Fig. 23-A, part-load mixture enrichment: the vacuum, ducted from orifice 1 beneath the throttle, arrives in the chamber above diaphragm **2** which is lifted against the action of spring **3**.
The fuel drawn from bowl **V** flows through the valve seat (see arrows) is metered by jet **4** and then issues via the channel above spray nozzle **S**.
With wide-open throttle, the depression is not strong enough to overcome the force of spring **3** and the valve remains closed **(position shown by the chain-dotted outline)**.
Fig. 23-B, full power mixture enrichment: the vacuum action is the same as described above but valve operation is reversed. At part-open throttle, diaphragm **2** is in raised position, as shown, and the valve is in this case closed thus preventing any passage of fuel. With wide-open throttle the vacuum cannot keep the diaphragm **2** raised and thus the valve remains open (position shown by the chain-dotted outline).

Fig. 24 shows a mechanically-operated full-power mixture enrichment system. With wide-open throttle, the plunger of accelerating pump **Sp** is at bottom stroke and causes taper valve **Vp** to remain open. Via valve **Vp** the fuel from pump barrel arrives at jet **Gpp** thus providing a supply in parallel with main jet **G**. With part-open throttle, as shown in the figure, valve **Vp** remains closed and no additional supply of fuel is had. A similar circuit may also be adopted for the diaphragm-type accelerating pump.

Dust-proof carburettors

Current practice is to connect all air inlets and outlets of the carburettor – such as air bleed jets, float chamber

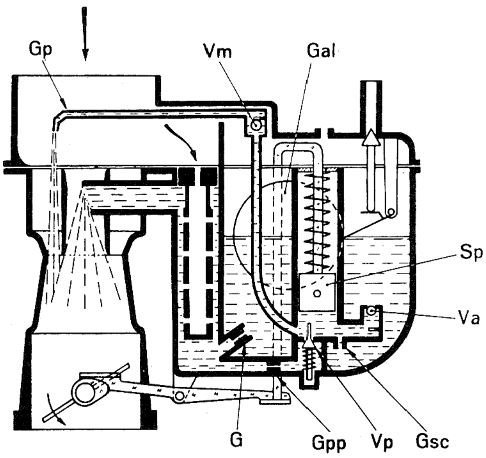

FIG. 24
Full-power mixture enrichment system - Gp Pump jet - Vm Delivery valve - Gal Float - Sp Pump plunger - Va Intake valve - Gsc Pump drain jet - Vp Full power valve - Gpp Full-power fuel jet - G Main fuel jet.

vents, choke air jet, etc. – to the “clean” side of the air cleaner: this leads to advantages in carburettor interior cleanliness, silent running, less influence of filter dust build-up on fuel consumption, air pollution, etc. There are, however, also two notable drawbacks: starting

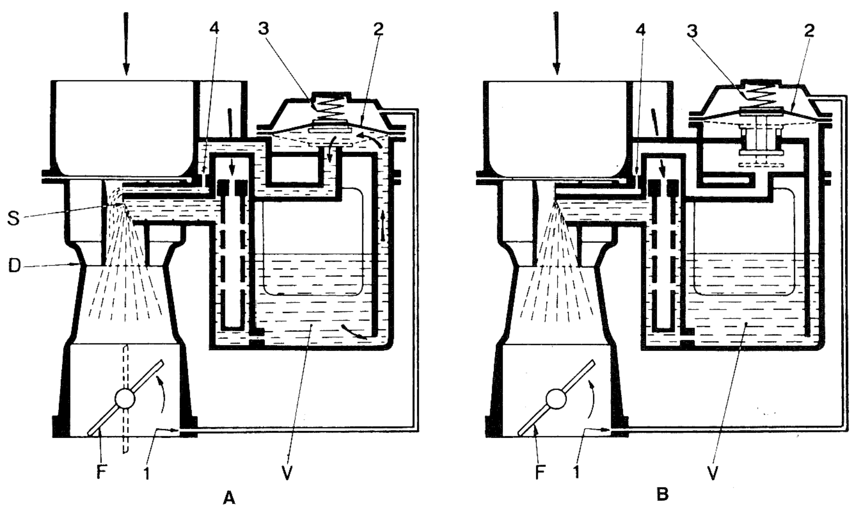

FIG. 23
Mixture enrichment valve for part-load (A) or full-power (B) operation: 1 Vacuum intake - 2 Diaphragm - 3 Reaction spring - 4 Fuel jet - S Spray nozzle - D Main Venturi - F Main throttle - V Constant-level float chamber.

difficulties when engine is hot due to an accumulation of evaporated fuel (percolation) and the engine "hunting" effects – rather complex and not utilisable to the best advantage in all cases – on mixture strength. For this reason the fully dustproof carburettor cannot be adopted in some applications.

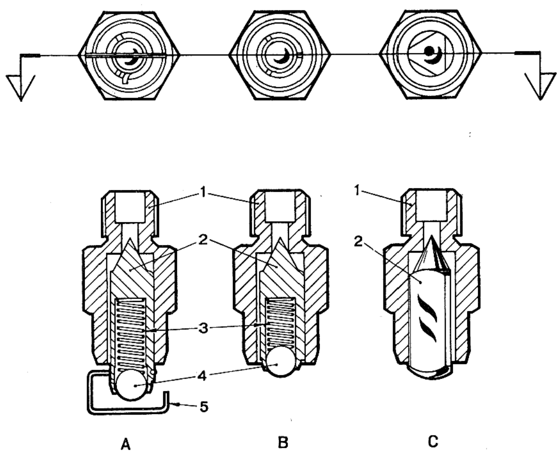

FIG. 25
Needle valve spring damper - 1 Needle valve seat - 2 Needle valve - 3 Damper spring - 4 Damper ball - 5 Needle valve drive hook.

Needle-valve spring dampers

To improve the maintenance of the correct fuel level in float chamber, a spring-dampened type of needle valve has found wide application – **see Fig. 25**.
This arrangement proves beneficial with carburettors subject to marked vibrations, on engines with few cylinders and high rpm rates.
In **A** and **B (Fig. 25)** are two sections of the needle valve showing its incorporated damper consisting of a spring and ball. A solid needle is shown in **C**.
Sometimes it is better to have the needle controlled directly by the float to prevent "bindings" resulting from impurities or gums in the fuel. With some designs, the taper seat of the needle valve is made of a non-metallic material, for instance, synthetic rubber.

Idle shut off solenoid

A solenoid incorporated into the idle circuit to cut off fuel flow when the ignition is switched off. Its only purpose is to prevent the engine from running on. Sometimes the solenoid pin operates upon the jet, sometimes it is located elsewhere in the circuit.

Slot progression

Very late carburettors have a slot to provide progression onto main circuit instead of a series of holes. This gives finer control over mixture strength.

Anti-stall device

Also referred to as low vacuum enrichment or 'LOVE' device; a vacuum controlled accelerator pump. At idle, if manifold depression drops below a certain point, the spring behind a diaphragm will overcome the vacuum and inject a pulse of fuel to prevent stalling.

Throttle kicker

Provides an increase in idle speed under specific load conditions. For example air conditioning, auto transmission, power steering. This is obviously not necessary if a stepper motor is fitted to the carburettor.

Float chamber vent solenoid

This solenoid is fitted into the carburettor's top cover. During normal driving conditions the carburettor is vented into the air cleaner (referred to as 'internal

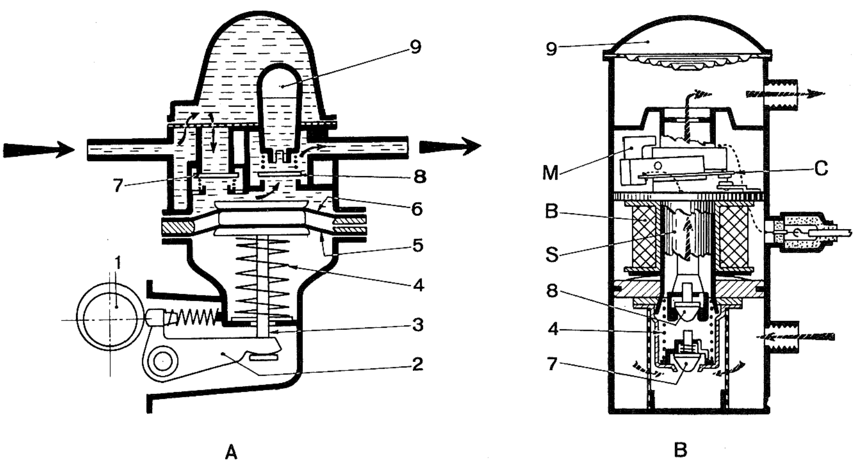

FIG. 26
Fuel feed (or lift) pumps, mechanical (A) and electrical (B).
1 Camshaft - 2 Rocker arm - 3 Rod - 4 Fuel delivery pressure adjusting spring - 5 Sealing diaphragm - 6 Pumping diaphragm - 7 Intake valve - 8 Delivery valve - 9 Air chamber - M Permanent magnet - C Contacts - B Coil - S Plunger.

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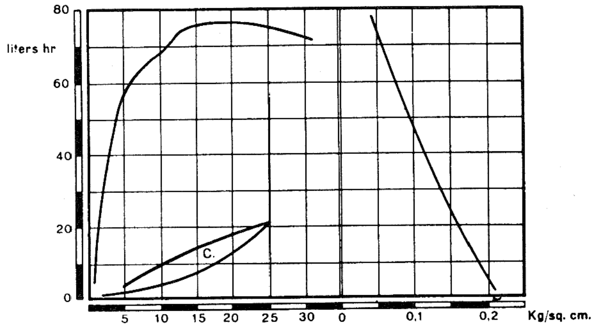

camshaft rpm x 100

DELIVERY PRESSURE
at 2000 rpm (constant)

FIG. 27
Mechanical pump performance curves - Left: fuel pump free delivery rate (top), engine consumption C under part- and full-loads (bottom). Right: delivery pressure pattern versus flow rate variations at 2000 rpm (constant) of camshaft.

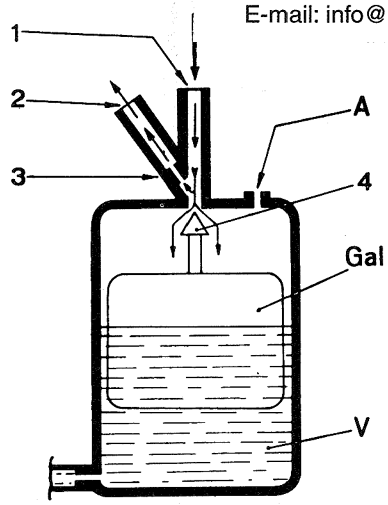

FIG. 28
Schematic fuel re-circulation system - 1 Fuel arrival from pump - 2 Fuel return to tank - 3 Striction - 4 Needle valve - A Float chamber vent - Gal Float - V Bowl or float chamber.

venting'). When the vehicle is stationary, after reaching full operating temperature, the solenoid opens an external vent to reduce the build-up of vapour which would cause hot starting problems.

Stepper motor

A 4-phase electronic motor which controls the throttle position at idle, and therefore engine speed, under all circumstances.

Main Functions –
- Control the engine speed during warm-up period.
- Control of engine speed under all conditions of load, ie with headlights, wiper motors, air conditioning, heater, radio, on, etc.
- Complete closure of throttle during deceleration for maximum economy and minimum emissions.
- When the engine is turned off the plunger retracts completely to prevent running on.
- During hot soak the plunger extends fully to vent the inlet manifold.
- The Stepper Motor is controlled directly by the electronic control unit (ECU) which is receiving inputs from sensors in the engine.

Fuel feed system

For space and safety requirements, in current design feed systems the fuel is sent from tank to carburettor by an engine-driven mechanical pump – **Fig. 26-A** – or an electric pump – **Fig. 26-B** – located in proximity of the fuel tank.
Referring to **Fig. 26-A**, cam **1** actuates – via rocker **2** and rod **3** – the plates holding diaphragms **5/6**: diaphragm **5** provides fuel tightness on engine side while diaphragm **6** pumps the fuel. In the figure, the pump is shown during the **delivery stage** with intake valve **7** closed and delivery valve **8** open: air chamber **9** serves to stabilise the flow rate. Upon further rotation, camshaft **1** causes the lowering of the diaphragms, this in turn closes the delivery valve and opens the intake valve for the arrival of new fuel from the tank. Spring **4** is rated to establish the maximum delivery pressure value, also known as **self-regulating pressure (0.2-0.3 kg/sq.cm.)**.
Fig. 26-B shows an electric pump; item numeration is the same for equivalent parts in **A** and **B**. During the delivery stage, plunger **S** travels upward under the action of spring **4**, magnet **M** causes contact **C** to "make", thus supplying battery current to coil **B**. The magnetic circuit pulls down plunger **S** (intake stroke) but also causes contact **C** to "break" this way, spring **4** again pushes up plunger **S** for a new delivery stroke.
Fig. 27 is a graph showing the flow rate delivery pressure data versus engine rpm – referred to a mechanically-operated fuel feed pump – and consumption curve **C** of the engine on which the pump tested was used. In addition to ensuring a fuel delivery always greater than the amount used up by the engine, the lift pump must provide the following:
- **Quick priming** at low engine rpm (starting stage)
- **Delivery pressure** within the specified limits
- **Effective heat insulation** for satisfactory operation during the hot season
- **Silent running**.

To prevent the disadvantages ensuing from the overheating of mechanical pumps, the system shown in **Fig. 28** is sometimes adopted: this type of circuit serves to send the fuel vapours produced in pump or lines back to the fuel tank.