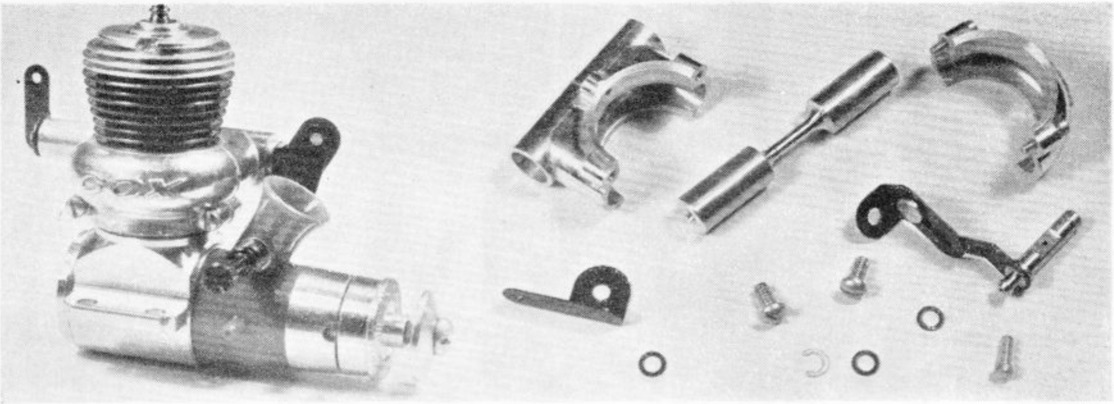


THE HOW AND WHY OF RADIO CONTROL

THROTTLES

by Peter Chinn

BEFORE the late nineteen-fifties, model aircraft engines were rarely provided with any means of altering their speed in flight. There were a few minor exceptions to this (e.g. spark-ignition motors with 2-speed contact-breakers, 2-speed needle-valves and one or two crude forms of intake throttling), but it was not until advanced multi-channel radio-control models came on the scene, that any real progress was made in evolving true throttle-type carburettors for model two-strokes.

There used to be a quite widely held view that it was practically impossible to obtain effective throttling with a model carburettor. Actually, the better examples of the throttles now to be found on R/C engines are, all things considered, very good. Some people seem to think that a 2,500rpm idling speed is poor, but is it? Perhaps it does sound fast compared with the 500-800rpm tick-over of a typical modern car engine but remember that the latter probably delivers its peak power at only about 5,000rpm and is rarely operated for prolonged periods above 3,500 to 4,000rpm, whereas our model R/C engine may peak 2½ or even three times as fast and may regularly operate at full-throttle speeds of around 12,000rpm. In other words, the idling revolutions of a good R/C motor may be between one-quarter and one-fifth of its normal operational speed, compared with one-fifth to one-eighth in the case of the car engine. Considering that the multi-cylinder four-stroke car engine provides much less critical conditions for efficient operation at different throttle openings than does a small single-cylinder two-stroke, we feel that model manufacturers have done quite a good job in getting R/C engines to work as well as do most of the better ones now on the market.

The Problem

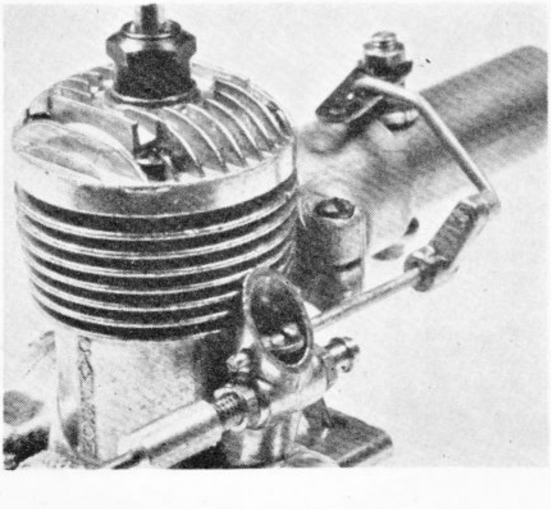
Model aircraft motors, like full-size petrol engines, belong to that group of heat engines developed from, and known collectively as "gas engines." The amount of power that such an engine develops depends, first and foremost, on the quantity of gas that is burned in the cylinder. Therefore, controlling the power output would appear to be quite easy: all that should be required is some sort of valve to regulate the amount of gas admitted to the combustion chamber.

Unfortunately, things are not that simple.

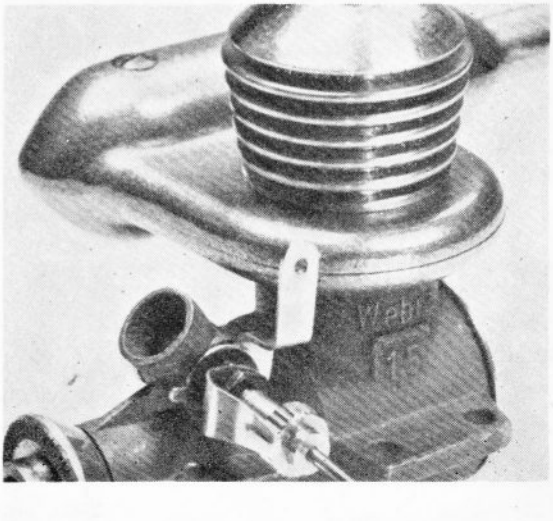
The fuel burned by the modern internal combustion engine is not stored in a gaseous condition. Instead, it is supplied in a liquid

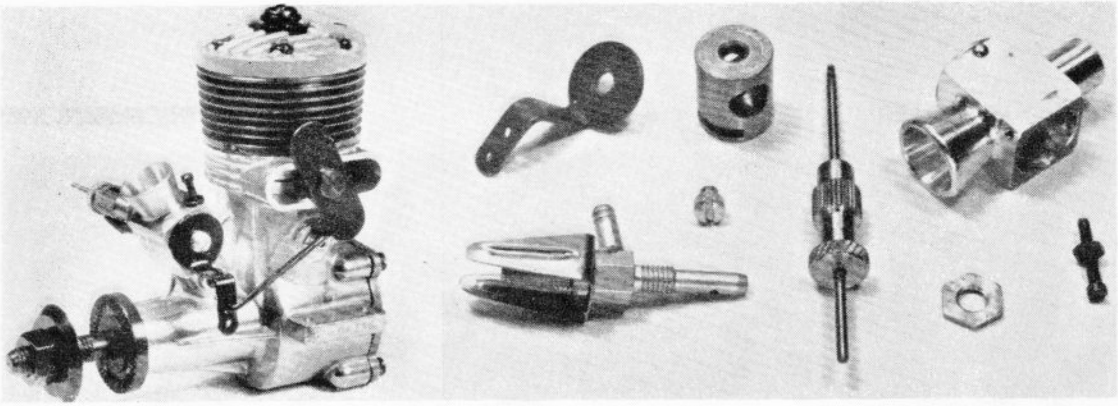
Heading photo shows the Cox Throttle Control conversion for Medallion series engines used plunger type exhaust restrictor coupled to rotating spraybar flattened to act as butterfly valve. Minimum "idling" speed was about half full-throttle speed.

Below: Simple intake butterfly valve to reduce only air supply has limited value as throttle. This example, used on the 1961 low-priced Cameron 15 engine, was linked to similar valve in exhaust extension for slightly better response.



Diesel R/C motors are mostly found only in the under 2.5cc. sizes and do not respond to throttle control as well as their glowplug counterparts. One of the best of the small R/C diesels, however, is the 1.5cc. Webra Record. It has a simple built-in non-adjustable barrel throttle.





One of the first R/C engines to offer a reasonably low idling speed was the K&B Torpedo 45 of 1960. Notched barrel throttle. Later K&B carburettors had addition of simple non-adjustable bleed hole.

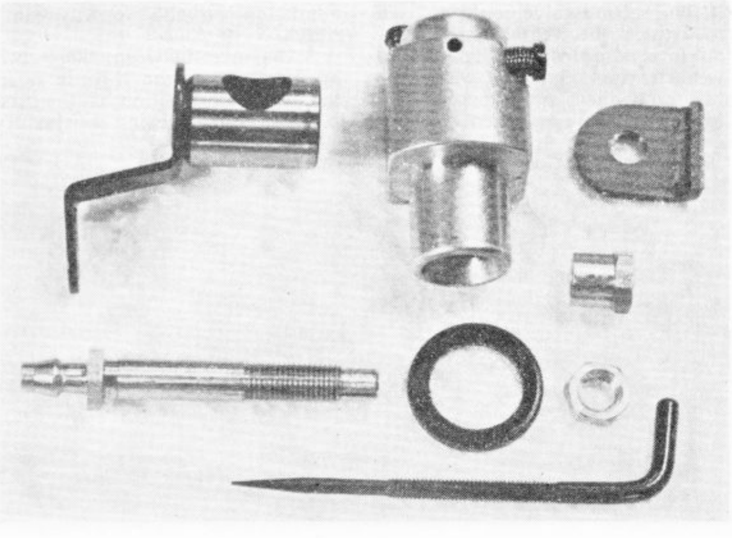
form and then has to be atomised in air to form a gaseous mixture or vapour before entering the cylinder. This mixing is the primary function of the carburettor.

In order to obtain a combustible mixture, the proportion of liquid fuel (whether it be petrol, or an alcohol or ether-hydrocarbon base model engine fuel) to air, must be held to within fairly narrow limits. Therefore, the carburettor must be able to correctly meter the quantity of fuel required according to the volume of air being taken in.

This is easy enough with a "one-speed" engine, such as a stationary engine designed to run at a steady speed under a fixed load and, therefore, to consume air at a steady rate. It is also fairly simple with a non-throttle-equipped model engine, since all that is required here is that the amount of fuel released is appropriate to the operating speed of the engine which, of course, is a function of the propeller size used. Invariably, even the simplest model engines are fitted with a needle-valve to enable the flow of fuel to be adjusted to meet these requirements. The needle-valve also makes it possible to compensate for other variables, such as fuel tank height (which affects fuel delivery pressure, as model engines do not use float chambers), different fuels and varying atmospheric conditions.

The real problem arises when we start to alter the rate of air flow through the carburettor in order to control the engine's power output. This is because, whereas air is compressible, the liquid fuel is not and, in consequence, as depression, or suction, increases (e.g. with increased rpm) there will tend to be a disproportionately greater flow of fuel, resulting in an excessively rich mixture.

All full-size carburettors incorporate a means of compensating these tendencies, either in the form of a manual extra air control or (far more commonly) an automatic device for reducing fuel flow at large depressions. This is generally achieved by incorporating two or more jets with airbleeds, or as in the case of the S.U. carburettor, a suction controlled piston which not only controls effective fuel jet size but also actually alters the choke area so as to maintain more constant depression. Modern automobile carburettors also incorporate accelerating pumps or other devices to allow temporary enrichment and prevent the mixture becoming too weak when the throttle is suddenly opened for maximum acceleration.



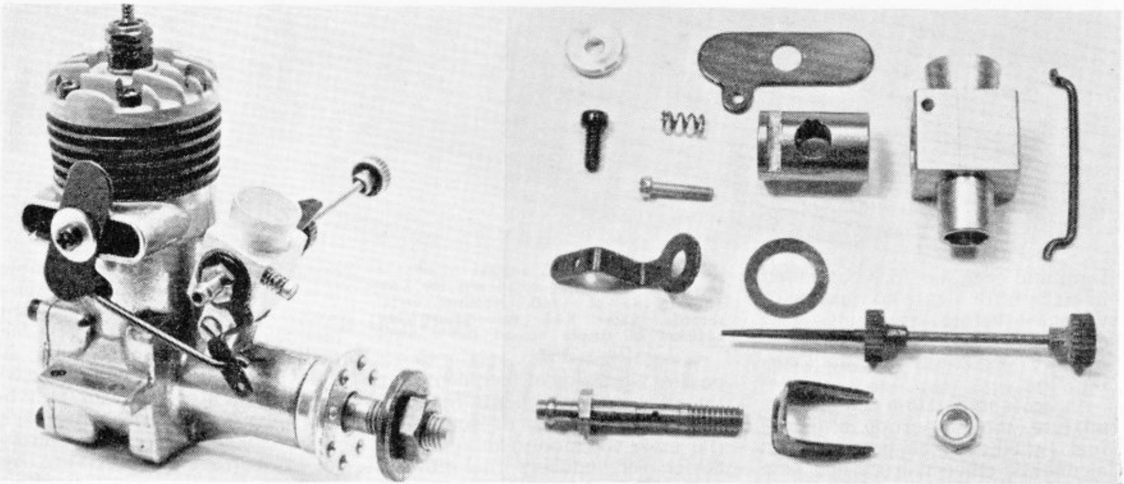
Parts of the Super-Tigre Type B.19/2 carburettor as fitted to current 2.5cc. and 3.6cc. Super-Tigre R/C engines. Carb is of plain barrel type with adjustable airbleed.

From the foregoing it will be appreciated that the modern carburettor has to be quite a complex instrument in order to perform all its tasks properly. Yet, in many ways, a radio-controlled model aircraft carburettor has to support combustion under even more critical conditions. For example, it is expected to perform through a wide variety of attitudes and manoeuvres which affect fuel delivery pressure. Secondly, its fuel, being mixed with a heavy concentration of lubricant, may be less volatile and is therefore likely to be less readily ignited. Thirdly, all two-stroke motors are inherently less flexible than four-stroke engines due to the poor scavenging of exhaust gases that occurs at small throttle openings and which tends to cause misfiring at low speeds through charge dilution. (This is the cause of the familiar irregular "popping" exhaust note of a two-stroke motorcycle on the over-run.)

In these circumstances, the fact that model R/C carburettors work as well as they do is all the more remarkable.

Intake flaps

Among the earliest and certainly the crudest forms of carburettor "throttle" used on model engines were simple pivoted flaps and butterfly valves in the mouth of the air intake. These, and all subsequent methods of reducing only



Simple barrel throttle (with, in this instance, coupled exhaust restrictor) as used on McCoy 19 R/C engine. Notched barrel and spraybar type needle-valve assembly.

the air supply to the engine, have very limited effectiveness as throttles.

Generally speaking, one cannot expect to achieve an "idling" speed of less than half the "full-throttle" speed with such devices. This is because any attempt to achieve a lower speed by almost completely cutting off the air, only results in the effects of the engine's suction being transferred to the fuel jet (as occurs when one is choking the engine prior to starting) thereby causing an excessively rich mixture on which the engine will not continue to run.

Twin coupled butterfly valves

An improvement on the single flap was the twin coupled butterfly valve layout: i.e. one valve in front of the fuel jet and one behind it. The second valve could be used to reduce the actual amount of mixture admitted (and tending to weaken the mixture), while the first controlled air admission (allowing it to be enrichened as required). The main objection to this system was that the butterfly valves usually tended to be poorly fitting, subject to air leakage around their spindles and difficult to adjust.

The barrel throttle

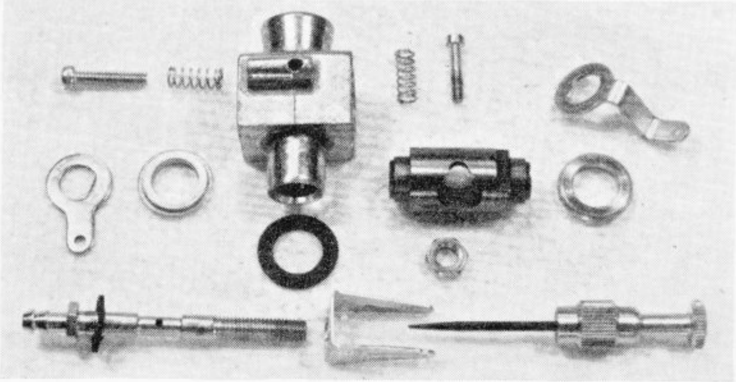
The barrel throttle with concentric fuel jet was obviously a better solution. In this, the barrel is in the form of a solid cylinder of steel, brass or alloy, located transversely in the carburettor choke tube and bored through diametrically to line up with it. The barrel is usually drilled axially to take a spraybar or jet tube so that fuel is discharged into its centre. Rotating the barrel reduces air admission on the "upstream" side and mixture admission on the "downstream" side.

A balance between these two openings when the throttle is in the "closed" position is the first essential when seeking satisfactory low speed operation. If the openings are identical in area, there is generally a tendency for the engine to run too rich before a satisfactory idling speed has been reached, due to too much suction being exerted at the fuel jet.

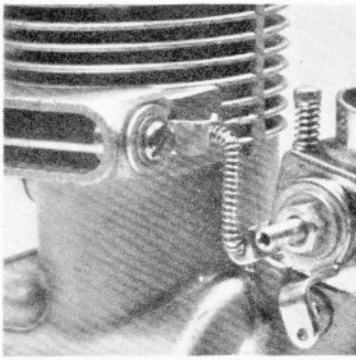
Notched barrels

This excess suction can be eliminated by making the "upstream" opening larger or by filing a small notch in the barrel, so that proportionately more air is admitted for any given throttle opening. The notched barrel system has been seen on several American engines, including K&B, McCoy and early Veco models. Its disadvantage is that it may cause mixture to be too weak at intermediate speeds and, for optimum results, the size of the notch may be fairly critical. A few years ago, contest modellers using engines having this type of throttle, were in the habit of individually "tailoring" the notch on each engine to achieve more reliable operation.

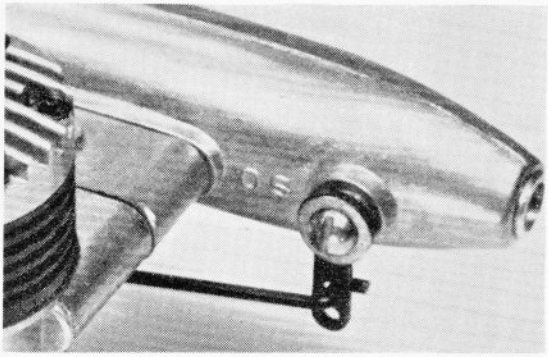
The best way to do this is on a "cut and try" basis, dismantling the carburettor and removing only a few filings at a time, then reassembling and testing the engine to determine its effect; repeating the process until no further improvement is obtained. If a little too much metal should be removed, the situation can usually be retrieved by filing the diametrically opposite edge of the barrel on the "downstream" side. This is apt to be a somewhat tedious and lengthy process.



Veco 45 engine introduced in 1962 had orthodox notched barrel throttle. Later models and early Veco 50 1967-68) had addition of adjustable airbleed as shown here.



Veco 61 engine of 1966-68 used "Automix" principle with addition of adjustable airbleed. Latest Veco 61 and 50 models now fitted with new Perry carburettor.



Coupled exhaust baffles, as fitted to most R/C engines, usually have to be discarded when silencers are added, but a special R/C type silencer incorporating its own coupled baffle is available for most O.S. engines. Shown is O.S.15 engine.

Air bleed systems

Instead of a notched barrel, a bleed hole may be drilled through the carburettor body so that extra air can enter the barrel when this is almost closed. Certain K&B models have this feature.

A further improvement is to use a larger diameter bleed hole and to control its effective area by means of a screw. The screw usually enters from the side and when fully screwed in may blank off the hole completely or almost completely. This normally gives a wide range of control over idling mixture strength and is used by a large number of popular R/C engines including most O.S.-Max and Enya engines, plus some Merco, Super-Tigre, Veco and Webra models.

One thing that has sometimes been overlooked by designers is the importance of locating the bleed hole properly. If it opens too soon after the throttle begins to close, it may tend to make the mixture too weak at part throttle settings, resulting in a "flat spot" above the idling position and a tendency for the engine to cut if the throttle is opened suddenly. It is difficult, however, to make any hard and fast rule as regards the exact point at which the airbleed should open, since it is not only dependent on the design of the carburettor but is also affected by the characteristics of individual engine types. This is a problem best resolved by practical experiment during the design and development stage.

When the throttle is closed to the normal idle position, the barrel will usually be about 1/16in. open when viewed through the intake. Obviously, this varies a little according to the size of the engine and the design of the carburettor, but the objective is an idling speed of not more than 3,000rpm on the recommended prop size—for example, an 11 x 7 or 11 x 7½ on a typical 10cc engine. On 12 inch or larger diameter, a slightly lower idle (e.g. 2,500rpm) may be expected.

As most modellers do not possess any means of accurately measuring engine rpm, the acceptable idling speed may be said to be that at which thrust is below the rolling resistance of the model—i.e. at which the model will not only remain stationary, but will come to rest, with the engine running, after landing.

General adjustment

Setting up an adjustable airbleed type throttle system is fairly straightforward.

The engine is started and the needle-valve set with the throttle wide open. (The ideal needle setting for the best overall performance in flight is usually a $\frac{1}{8}$ to $\frac{1}{4}$ turn on the rich side of the setting at which the engine runs fastest on a full tank.) Carefully note this setting.

Now throttle down to a reasonable idling speed. If the engine runs rich, open the airbleed screw until it is OK. If, on the other hand, it is too weak, close the airbleed.

On paper, this sounds extremely

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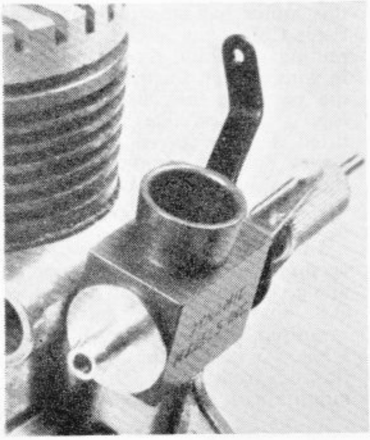
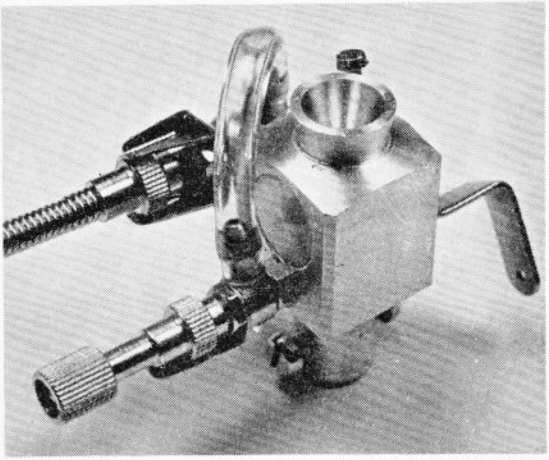


The Johnson "Automix" was the first commercially produced carburettor to use a variable fuel jet to control mixture strength. Seen here on Johnson JRC.36.

Earlier attempts by manufacturers to provide more sophisticated throttle systems were not always popular, due to users' lack of understanding of basic carburation problems. This Enya carburettor, introduced in 1962 on Enya 35-11 and 45 had separate idling needle-valve and jet and automatic mid-range metering. Worked well when adjusted properly.



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simple. The snag is that it is not always so easy to decide whether the engine is idling rich or lean, since it is quite likely to stop in either case. A quick way of checking is to use the needle-valve to temporarily achieve the correct idle mixture. Having done this, one returns the needle to its correct full throttle position and the airbleed is then gradually turned in the required direction until a satisfactory idle is obtained.

With most engines it is preferable to make final throttle adjustments with the fuel tank no more than ¼ full. The idea here is to avoid the risk of the idle mixture being too lean towards the end of the flight, during tail-slides and spins and for landing. It may mean that the engine will tend to idle rather rich on a full tank but this may be more readily tolerated as the idle is then required only for taxying prior to flight. It may be necessary to make minor re-adjustments to achieve a compromise here.

Variable jet systems

A good airbleed type throttle, properly adjusted, can be very reliable. It has, however, one theoretical disadvantage, namely, its fixed jet size.

The fixed jet works well so long as fuel suction is primarily dependent on the depression created by the high speed flow of air through the carburettor choke or venturi. However, as we have seen, when the air inlet is drastically obstructed (i.e. during idling) the suction created in the engine crank chamber (which is a very efficient pump even at the lowest speeds) tends to draw an increasingly excessive amount of fuel from the jet and it is to reduce this strong suction, as well as to dilute the charge, that we feed in more air via the airbleed.

To have to partially destroy suction in this way is a pity because it is when the engine is idling and especially when the fuel level is low and model attitude is changing, that we really need to have a steady high pressure supply of fuel.

The obvious way of achieving this, therefore, is to maintain maximum fuel *pressure* but to reduce the *quantity* of fuel metered through the jet.

Such is the purpose of the variable area jet orifice.

Johnson Automix Carburettor

The first of the variable jet systems to gain favour with R/C modellers was the American Johnson "Automix." Outwardly, this looked much the same as any other barrel throttle unit, but instead of having only semi-rotary movement, the throttle barrel described a helical path—i.e. it also moved sideways into the carburettor body as it rotated towards the idling position. The barrel carried with it the needle-valve, whereas the spraybar was fixed in the carburettor body. In other words, as the throttle moved towards the idle position, the needle-valve also closed slightly reducing the amount of fuel passing through the spraybar hole.

The system worked quite well, its only disadvantage being that it was not possible to adjust the idling mixture independently. The manufacturer subsequently made available alternative needles having different tapers so that weaker or richer idle mixtures could be obtained.

To give more precise control over the idling mixture, some keen R/C modellers added airbleeds to the Johnson Automix and this combination of variable jet and airbleed was subsequently seen in commercial form in the original Veco 61 carburettor. The Veco 61 carburettor could, in fact, be assembled to work either as a normal airbleed type, or airbleed-plus-variable jet type.

(To be concluded)