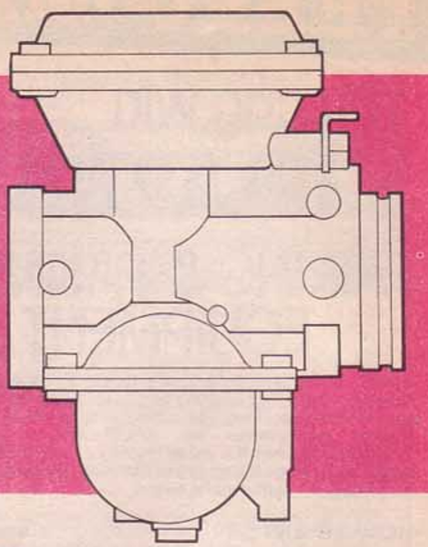
SELF CONTROL



UNDERSTANDING AND TUNING CV CARBS

BECAUSE of tight controls on exhaust emmissions, modern bikes run on fuel/air mixtures weak enough to melt holes in the pistons of us throttle-happy bikers. To prevent this, more and more machines are being fitted with constant vacuum (or constant velocity) carburettors — the carbs with self control.

What carburettors do

The job of any carburettor is to mix the right amount of fuel with the right amount of air, and then to supply the engine with the amount of mixture it needs.

As the piston goes down on its induction stroke it creates a vacuum, which sucks air in from outside through the large tube (choke) which forms the centre of the carburettor. Set into the wall of the choke, usually at the bottom, is a much thinner tube called the needle jet. The vacuum sucks fuel up the needle jet and the air rushing through the choke breaks the liquid up into tiny drops to form the mixture.

The next problem is to make sure that the fuel and air are mixed in the right proportions. At the bottom of the needle jet is a small hole called the main jet, and its size controls the maximum rate at which fuel can flow into the needle jet. The diameter of the choke controls the maximum rate at which air can get into the engine, and the size of the main jet is carefully matched to the choke diameter to give the correct fuel/air ratio at full throttle. But what happens when you don't want to go flat out?

The amount of mixture allowed into the engine controls how fast the engine spins, and therefore the bike's speed. Partially blocking the choke cuts down the amount of air allowed through. This is done with the throttle valve, which slides up and down in the choke and so controls your speed.

A tapered needle is attached to the throttle valve and dangles in the needle jet. When the throttle valve is fully open, only the pointed end of the needle is in the needle jet and so lots of fuel can stream out. But, as the throttle is closed, the thicker part of the needle is pushed into the needle jet and the flow is restricted. So the ratio of fuel to air is always the same, even though the amount of air allowed through changes.

Conventional slide carburettors (which we'll look at in detail next month) have the throttle valve connected directly to the twistgrip by cable. Winding back the twistgrip opens the throttle, air pours in through the choke picking up the right amount of fuel as it goes, the engine spins faster, the bike accelerates. Releasing the twistgrip allows the throttle to close, air can't get through the choke so the engine gets no mixture, the bike slows down. Nice and simple.

So why have CV carbs?

The fuel has to be broken down into tiny droplets and thoroughly mixed with the air if it is going to burn efficiently in the cylinder and supply full power. Since it is the air flowing over the needle jet which breaks up the fuel, it follows that the air must always be moving fast enough to do the job properly.

Slide carbs would be OK if we always opened the throttle smoothly. As the engine revved faster and needed more mixture, the throttle would open and let more air through. The speed (velocity) at which the air moved through the choke would stay the same, because a lot of air going through a big hole moves as fast as a little bit of air going through a small hole.

But we don't always open the throttle smoothly. We sometimes whack the twistgrip against its stop. At first, the engine is still turning slowly and isn't sucking in much mixture. We have opened up the throttle, so there's a big hole with only a little bit of air going through it — the air slows down. Opening the throttle has also lifted the needle, so petrol flows out of the needle jet. The air isn't moving fast enough to break it into tiny droplets, so the engine swallows it in large globs which it can't burn properly.

The result is that the engine gasps, and nasty black puffs of partially-burnt fuel appear in the exhaust. After a few moments' hesitation things usually sort themselves out, as the engine speed picks up and the air gets moving fast enough again — although sometimes the engine will die on you unless you close the throttle and open it again more slowly.

So what we need is a carb which always opens the throttle by just the right amount, no matter what we do. That way, the right amount of fuel will always get broken down into tiny enough droplets because the needle will always be at the right neight and the air will always be flowing over the needle jet at the same speed — a Constant Velocity or CV carburettor.

HOW THE CV CARB WORKS

A CV carb has two throttles. The one that is controlled by the twistgrip is a simple flap, called a butterfly valve, at the engine end of the choke. It is pivoted in the middle so that it can either lie flat when the twistgrip is wound open, or block the end of the choke when the twistgrip is released.

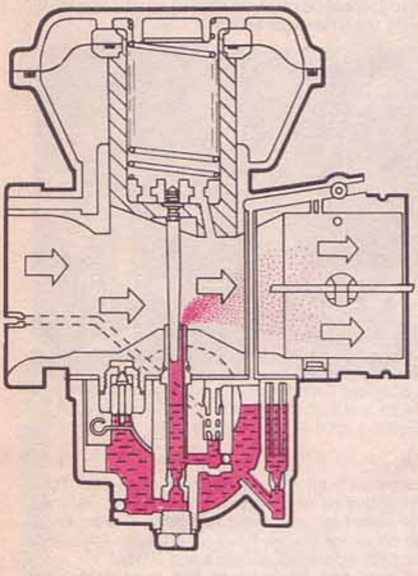
The other throttle is basically a normal throttle slide. The difference is that it isn't connected to the twistgrip cable. Instead, the top of the slide is sealed to the carburettor body by a rubber diaphragm — but it is still free to move up and down in the choke.

When you open the butterfly valve by winding back the twistgrip, the sucking action of the piston creates a vacuum in the choke. The space below the diaphragm is connected by an air jet to the air outside the carburettor, but the space above the diaphragm is connected to the choke by a hole up the middle of the throttle slide. So the vacuum in the choke sucks up the diaphragm, which lifts up the throttle slide.

Air and fuel flow in the CV carb

The throttle slide settles at just the right height so that the air always flows underneath it at the same speed — which is the constant velocity we wanted. If the gap under the throttle slide was too small the engine would have to suck harder to get the amount of mixture it needed, which would create a greater vacuum, which would lift the slide and make the gap bigger. If the gap was too large, the engine wouldn't have to suck very hard at all and so the slide would fall. This is why constant velocity carbs are also sometimes called constant vacuum carbs.

You control the speed of the engine by controlling the amount of mixture which can get past the butterfly valve. But the delicate job of keeping up the air speed over the needle jet is done by the engine. Beautiful, innit?

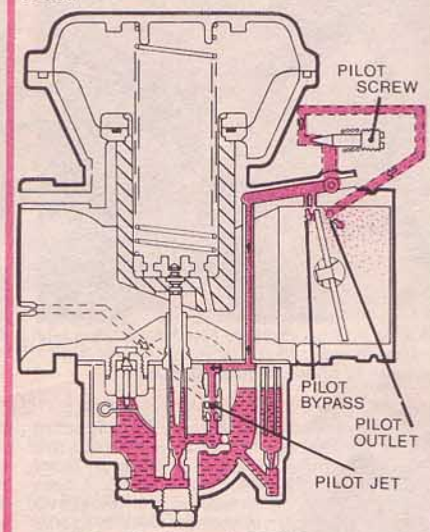


Maximum throttle raises the diaphragm

THE PRIMARY SYSTEM

Just to make things more complicated, engines running at very low speed need a fuel/air mixture which is richer than normal. Since the throttle slide and its needle always supply the ideal mix for normal running, a separate system is needed for idling and low-speed running up to about ⅛ throttle openings.

Some of the fuel supplied to the needle jet by the main jet is diverted to the pilot jet. This is then mixed with air from the pilot air jet, and a rich mixture is fed into the choke on the engine side of the butterfly valve through the pilot outlet. So, even when the throttle is closed, the engine can suck in enough rich mixture to idle. The amount of mixture allowed into the engine is controlled by the pilot screw, which has a pointed end partially blocking the passage supplying the pilot outlet.



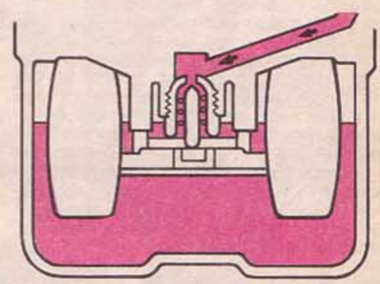
The pilot jet controls tickover

There is also a pilot bypass, which is a small passage linking the pilot mixture supply (before the pilot screw) to the choke (on the carb side of the butterfly valve). When the butterfly valve is closed the engine's vacuum can't reach as far as the bypass, so the mixture for idling must all be sucked past the pilot screw. But, when the butterfly valve is opened slightly, the engine can suck mixture out of the bypass at a rate controlled only by the pilot jet. This supplies an increasing amount of mixture as the engine's speed increases, thus ensuring a smooth changeover from pilot to main jet.

THE FLOAT BOWL

A reservoir of fuel is stored around the main jet in a chamber called the float bowl. Fuel enters from the petrol tank through a valve seat. As the fuel level rises, a float pushes a needle into the valve seat to cut off the supply. As the carb uses up the fuel the float falls, the valve is opened again, and the fuel level in the fuel bowl is restored.

There is also an overflow pipe which empties fuel harmlessly onto the road if the level gets too high. This can happen if the float is punctured, if the float needle doesn't seat properly in the valve, or if the bike is tipped over.



Float height is critical

COLD-START DEVICES

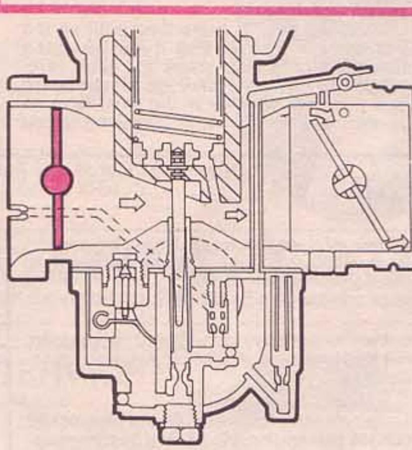
Engines need a richer mixture when they are cold. There are two types of cold-start device — choke valves and starter carburettors.

Choke valves are butterfly valves like the throttle butterfly but are mounted at the other end of the choke, by the mouth of the carb. When you open the throttle butterfly the engine vacuum lifts the throttle slide in the normal way and fuel streams out of the needle jet. But, if the choke valve is closed, the air supply to the carbs is restricted and so the mixture will be rich. Operating the lever on the outside of the carb (sometimes mounted on the handlebars) closes the choke valve, and releasing it opens the choke valve for normal running once the engine has warmed up. This is why the lever is sometimes called "the choke", although its proper name is choke-valve lever or cold-start lever.

Choke valves are simple and crude. The engine will start easily enough, but it won't run very well at larger throttle openings because the choke valve stops it getting enough air.

Starter carburettors are just what their name implies — an extra carb to supply rich mixture while the engine is cold. The starter carb is usually built into the main carb body next to the float bowl.

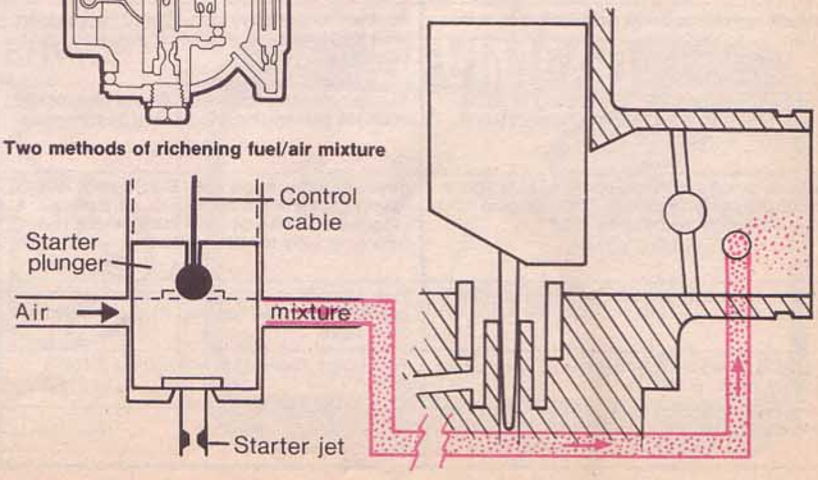
It consists of a plunger which can move up and down in a cylinder when pulled by a control wire connected to the cold-start lever. There is a starter jet at the bottom of the cylinder which allows fuel through from the float bowl. An air passage connects one side of the cylinder to the mouth of the choke, and a mixture passage connects the other side of the cylinder to the engine end of the choke.



Two methods of richening fuel/air mixture

When the starter carb isn't being used the plunger sits at the bottom of the cylinder, blocking the fuel supply from the starter jet. Operating the cold-start lever pulls the plunger to the top of the cylinder. Engine vacuum sucks air through the air passage and fuel through the starter jet. The fuel is broken up by the air flowing over the jet, and a rich mixture is fed to the engine through the mixture passage.

Since air can still flow freely through the choke, the throttle butterfly and slide valve can be used in the normal way. So the engine will run quite well at higher speeds even when cold.



TUNING AND BALANCING

On multi-cylinder bikes (except single-carb twins) it is vital that each throttle butterfly valve opens at the same time and by the same amounts, otherwise you'll have the cylinders fighting each other. It is only necessary to get this sychronisation right at tickover speed since they always move together if they start moving together.

The throttle stop screw prevents the throttle butterflies from closing completely, and so controls tickover speed. But the mixture at tickover speed is controlled by the pilot screws, so these must be set first. The pictures that follow are of a twin-carb bike (a Kawasaki Z250), but the sequence is the same for any number of carbs.

Before starting, spark plugs and contact breaker points should be cleaned and set to the correct gaps, and ignition timing should be accurately adjusted. It is also important that none of the carburettor passages and jets are blocked. All cables, slides, and valves should move freely — and the cold-start device must be returning fully (check that it isn't sticking and that its cable, if it has one, has some slack).

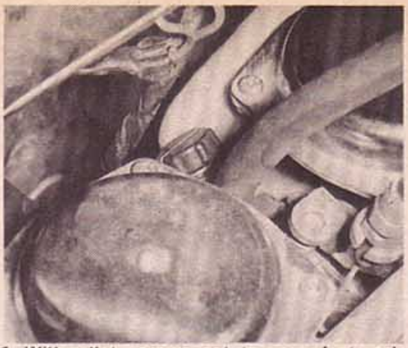
First slacken off all throttle cables. Turn the pilot screws (one on each carb) gently clockwise until they just seat, and then turn each one anti-clockwise by the same amount. It will usually be 1-1½ turns, but check with your handbook for the manufacturer's recommendation.

Take the bike for a few spins around the block to get it fully warmed up, and then turn the throttle-stop screw anti-clockwise until the bike just ticks over. Most bikes have just one throttle-stop screw to control all the carbs. If your bike has a separate one for each carb, adjust them all by the same amount.

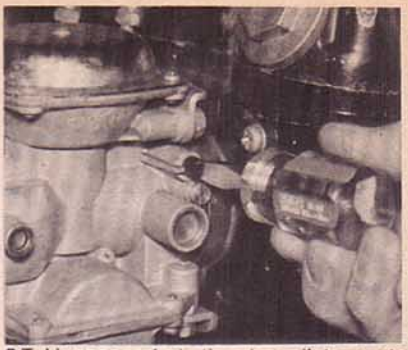
Taking one carb at a time, turn the pilot screw first one way and then the other until you find the point at which the engine ticks over fastest. Only move the screw by about ⅛ turn at a time, and give the engine revs a few seconds to settle down before deciding whether or not you have found the best setting.

When the best positions have been found for all of the pilot screws, set the engine to tick over at the speed recommended in the handbook by turning the throttle-stop screw.

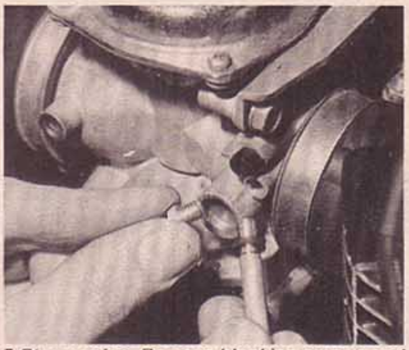
Stop the engine and connect up your vacuum gauges. There is usually a hole provided for this purpose somewhere near the carb/engine manifold. Remove the blanking screw and screw in the vacuum-gauge adaptors. Re-start the engine.



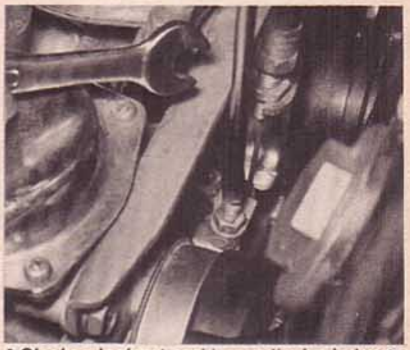
1 With pilot screws set to manufacturer's recommendation, turn throttle-stop screw until engine just ticks over



2 Taking one carb at a time, turn pilot screw to find fastest tickover. Now set correct tickover with throttle-stop screw



3 Stop engine. Remove blanking screws and screw in vacuum gauge adaptors. Re-start engine to check vacuum gauges



4 Slacken locknut and turn adjuster between carbs until both gauges give same reading. Tighten locknuts when correct

We have used a GT Mercury Carb Synchro Tuner to balance the carbs in the pictures. Imported from America exclusively by Read Titan of Leytonstone, East London, it uses mercury columns instead of dial gauges to give a measure of the vacuum. Despite its silly name it works very well, and can handle up to six carbs for a fraction of the cost of dial gauges.

Adjust the throttle butterflies until all the carbs give the same reading. If your bike has a separate throttle-stop screw for each carb, use these to adjust the readings. Most modern twins (like the Kwacker in the pics) have an adjuster, with a locknut, in between the two carbs as well as a throttle-stop screw. Turn the adjuster one way or the other to balance the readings and then retighten the locknut. All other machines have an adjuster (possibly a cable adjuster) above each carb.

Reset the tickover to the manufacturer's recommendation, if necessary, by using the throttle-stop screw for each carb, turn each one by *exactly* the same amount.

Finally, take up the slack in the throttle cable. Bikes like the Z250 have two throttle cables — one to open the butterfly and one to close it — but this doesn't affect the balance because they work on all the carbs at once.

NEIL MILLEN

FAULT-FINDING CHART

NB Chart assumes that fault is not cured by correct adjustment and balancing

SYMPTOMS	FAULT	CURE
With a warm engine, tickover is smoother if cold-start is used	Fuel/air mixture too weak. Could be a worn piston valve, an air leak, a blocked pilot jet or mixture passage	Replace worn piston. Check all carb manifolds, and hoses, and air filter housing for leaks. Clean passages and pilot jet with petrol and blow through with an air line
Exhaust smoke is black and/or tickover is rough	Fuel/air mixture too rich. Could be clogged pilot jet bleed hole or pilot air passage, loose pilot jet	Tighten pilot jet. Clean passages with petrol and blow through with air line
Engine overheats and spark plug is white, acceleration is poor, engine runs better if cold-start is used	Fuel/air mixture too weak. Could be blocked main jet, blocked needle jet, or a dusty needle	Clean jets and needle with petrol, and blow out jets
Exhaust smoke is black, spark plug is sooty, top speed performance is down, engine runs more smoothly without air filter	Fuel/air mixture too rich. Could be a loose main or needle jet, a blocked air passage, a clogged air filter, or cold-start device not returning fully to off position	Tighten jets. Clean air jets and passages with petrol and blow through. Clean or replace air filter. Adjust cold-start cable to give correct freeplay and/or clean sticking cold-start mechanism
Engine hesitates, or cuts out when throttle is opened wide	Fuel starvation. Could be blocked tank cap breather, clogged fuel tap filter, or sticking float valve	Clear tank breather. Clean fuel tap filter. Clean float valve mechanism
Engine is slow to respond to throttle and won't rev very high	Punctured diaphragm or sticking throttle slide	Replace diaphragm. Clean slide and carb wall
Carb overflowing	Badly seated float valve	Clean or replace valve and seat