TR250 - TR6 Carburettor Overhaul
Part III – Reinstall, Tune and Troubleshoot

By Nelson Riedel, nriedel@nextek.net
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The first two parts described removing, cleaning and disassembling the carbs and then the overhaul and reassembly. In this part we reinstall the carbs and then tune them. Some troubleshooting hints are at the very end.

Installing the carburettors

The installation of the carbs on the manifold is the reverse of the removal process described at the beginning. Make sure that a spacer with a gasket on each side is fitted between the carb and the manifold with the notches toward the front of the car as shown in the adjacent photo.

The carb throttle linkage, fuel lines, breathing hoses, vacuum hoses and choke cables must be connected. For the choke cable, I tighten the screw to the roughly correct position on the inner cable and then make the final adjustment (cold start valve closed with choke knob pushed in) by moving the outer cover in the clip (unfastened) at the top of the carb.

Tools

Two special tools are needed for work on carbs; a mixture-adjusting tool shown on the left of the photo and the Unisyn used to synchronize multiple carbs on the right of the photo. TRF sells the mixture-adjusting tool for $10 (list) and the Unisyn for $30 (list). Since these are fairly expensive, maybe one can borrow them from a friend for the job and then return them. (A good feature of borrowing and returning the tools is that one won't have the tools to use to wear out the threads of the adjusting screws.)

Adjusting (Tuning) the Carbs:

The carb adjustments are:

- Synchronization
- Mixture
- Idle speed
- Bypass Valve
- Fast Idle speed

Before starting, the following should be done:

1. Verify all the emission breathing hoses are connected and oil filler cap is in place and fuel cap closed.
2. Verify the vacuum hose from the manifold is connected to the brake servo unit (been there, done that).
3. Verify the small vacuum hoses to the distributor and bypass valves (early carbs), etc. are connected.
4. Remove the dampers (don't add oil to the dampers yet).
5. Lift the air valves and verify that they move freely and return to the down position with an audible click.
6. Verify that the throttle shafts turn freely.

Next, start the engine and run it until it is hot. This may require some fiddling with the idle screws to keep it running if the adjustments were changed radically when the carbs were overhauled or if the pervious adjustments were way off. It might be a good idea to verify that the thermostat is operating properly by measuring the fluid in the top of the radiator. It should be in the 160^{o} to 180^{o} F range. The carbs can't be tuned properly if the temperature is well below this.

After the engine is hot, push the choke knob all the way in and make sure that the cold start valve is closed and the fast idle screw is not touching the cold start valve cam. If this is correct there should be a gap as shown in adjacent photo. (This photo was taken after the carbs had been powder coated. It looks like the vent hoses are getting a bit checked.)

Next, verify that the air valves are operating properly. Open the throttle and verify that the valves go up, and then come back down when the throttle is closed. If there is a problem here, remove the top cover and verify that the two holes in the air valve are on the manifold side and verify that the diaphragm is not torn and that it is held firmly to the air valve. When reassembling, make sure the lip on the diaphragm rests flat against the carb body and the little tab is positioned in the matching slot in the body.

Next, adjust the idle screws for an engine speed of about 900 RPM. If it is impossible to reduce the engine idle speed to this level, then something is wrong that must be corrected before proceeding. Clearly, fuel is getting to the engine when the throttle plates should be closed preventing fuel from reaching the engine. First, examine the linkage to make sure nothing is holding the throttle partially open. Another possibility is that one or both the bypass valves are misadjusted or defective. Remove the bypass valves one at a time (slotted head screws) and cover the two holes in the body with duct/masking tape. If this fixes the problem, then examine, repair and adjust the valve for minimum sensitivity (see Part II). If covering the passages to the bypass valves doesn't fix the problem, then there is likely something preventing the throttle plates from closing. Pull the carbs and examine the shaft and throttle plate to make sure that the springs are holding the plates closed. Also, make sure the plate is aligned on the shaft properly such that it completely closes the carb opening. If the plate is misaligned, loosen the screws and work the throttle back and forth until the plate comes into alignment and then retighten the screws.

On '73 and later carbs it is a good idea to temporarily disconnect the the hoses connected to the float chamber vent ports while the engine is running. The engine speed should not change. An increase in engine speed when the hoses are disconnected indicates that the anti run-on valve is either stuck operated or the there is incorrect wiring or a fault in the electrical circuit causing the valve to be operated. This should be fixed or the hoses left disconnected.

Manifold Vacuum: If one has a vacuum gauge, it's a good idea to measure the vacuum before proceeding. I connect the gauge to the port to the anti run-on valve on the later cars and the port to the brake servo on the earlier models. The hose to the brake servo is harder to get off and requires a reducer to match the gauge hose which is why I use the anti run-on valve port, if provided. The vacuum should read between 17 and 20 inches of mercury (Hg) and be pretty steady. If it is slightly lower, the timing may be too retarded. If it's much lower, like 10 or less something is likely wrong with the valves. If the reading is about correct but not steady, then one can go ahead and tune the carbs to see if that smoothes the operation. If the reading is much below 17, the problem should be fixed before proceeding because tuning the carbs will have little effect on the engine performance.

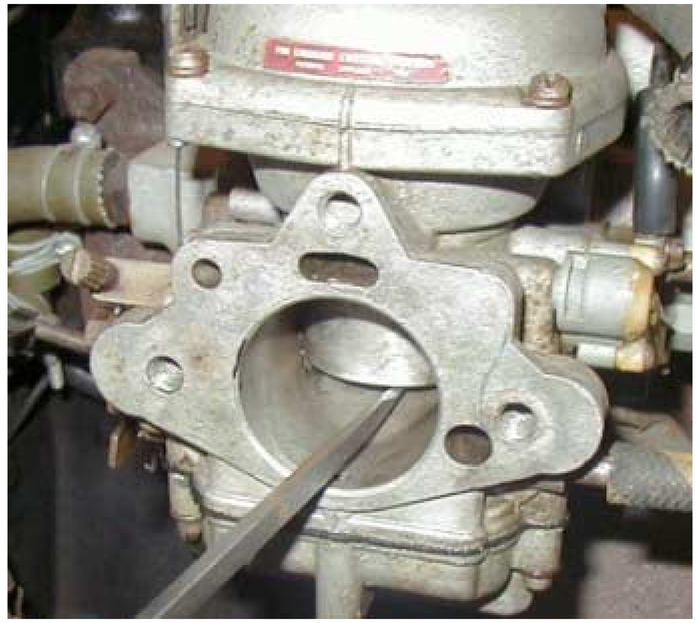
Synchronization: After the idle has been successfully adjusted to about 900 RPM, slacken one of the spring coupling bolts to allow the carbs to work independently and then use the Unisyn to synchronize the two carbs. The Unisyn measures the airflow into the carb. It is placed over the air intake port as shown in the next photo (on a TR250 --- the TR6 hadn't been reassembled at this time). The little red plastic cup in the tube rises in proportion to the amount of air entering the carb. If it doesn't rise at all, the disk in the center of the tool should be rotated clockwise to close the opening somewhat. If the cup goes all the way to the top then the disk should be rotated counterclockwise. The disk should be adjusted such that the cup floats at the calibration mark halfway up the tube. The Unisyn is then moved to the other carb and the idle screw adjusted such that the cup is also at the ¾ mark. Sometimes this process will have to be repeated several times to sync the carbs since adjusting one carb changes the engine speed which in turn changes the airflow through the other carb. The spring coupling screws are tightened after the carbs have been successfully synced.

Crossover: While fooling with the synchronization one observes that the engine can be made to idle properly with one carb completely closed. How is that? First, recall that little cutout section of the bypass valve gasket lets a little fuel through even if the throttle plate is completely closed. However, the major reason this happens is the bridge between the front and back half of the manifold that contains the manifold vacuum ports. The cross sectional area of the bridge is small compared to the carb throat so there is little effect if the carbs are running full open. However, only a few percent of the carb capacity is used at idle and the bridge has adequate capacity for a carb on one side of the bridge to supply the three cylinders on the other side of the bridge.

Bypass Valve Adjustment: Disconnect and plug the vacuum connection to the distributor vacuum retard unit. The idle speed should increase to about 1300 RPM. Turn the bypass valve screw clockwise until the engine speed increases to 2000 - 2500 RPM indicating that the valve is floating. Then turn the bypass screw back (counterclockwise) until the speed returns to 1300 RPM. Use the throttle to rev the engine to about 2500 RPM and then release the throttle and verify that the engine returns to 1300 RPM. If it doesn't, the valve is floating requiring that the adjustment screw be be turned further counterclockwise until the speed drops back to about 1300 RPM. Once the valve is adjusted such that the speed drops back to 1300 after the engine is revved, turn the adjustment an additional half turn counterclockwise to seat the valve. Repeat this adjustment on the second bypass valve.

Mixture Adjustment: The mixture is tested by inserting a long thin screwdriver into the air intake and lifting the air valve as shown in the adjacent photo. The air valve should be lifted approximately 1/4 inch. If the mixture is correct the engine speed should be steady or increase slightly at near the 1/4 inch lift point. If the valve is lifted further, the engine should slow down and possibly stall. If the mixture is too rich, the engine speed will increase maybe 10% or more, and may not tend to slow down till the air valve is lifted much more than 1/4 inch, depending on the richness of the mixture. If the mixture is too lean, the engine speed will decrease and possibly stall. Before each test the throttle should be opened increasing the engine speed to about 2000 RPM for a few seconds to clear all fuel from cabs and manifold.

The mixture can be adjusted on the '70 and later carbs.



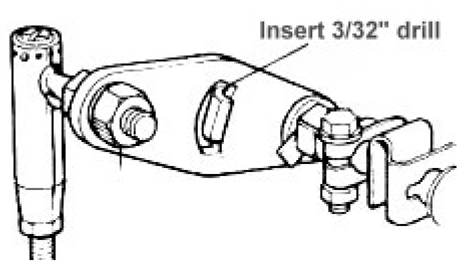
This step is skipped on the earlier carbs with fixed metering needles. The assumption is that the precision design and manufacture of the earlier assembles is such that no adjustment is necessary. This is refuted by the later design improvement that incorporated adjustment capability.

The mixture is set using the mixture-adjusting tool that is inserted into the air valve guide rod after the damper assembly has been removed from the top of the carb. The Allen wrench engages the mixture adjusting screw and is turned to raise or lower the metering needle. The end of the aluminum outer sleeve of the tool is inserted into the end or the air guide with the pin on the sleeve fitting into a slot on the air guide. The knurled knob is grasped firmly before any adjustments are made to prevent the air guide from turning with the mixture adjustment screw. Failure to do this may cause the air valve to turn and tear the diaphragm. The photo shows the tool in position.

Before the adjustments are made one must decide what do to do with the idle trimming screw. If one is comfortable with making the adjustments and then leaving everything alone the screw can be fully closed and forgotten about. If one needs to frequently lift the bonnet and tweak the carbs (possibly due to excess testosterone) then the screw should be set open by one turn. The screw can then be tweaked to satisfy ones primitive impulses. (This screw can be used to make minor idle mixture adjustments on the early fixed needle models.)

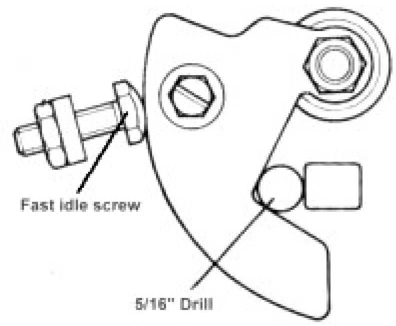
The idle trimming screw is set as desired and then the mixture is checked and adjusted for each carb. I make identical changes to both carbs and then test both. Because of the crossover, it is impossible to isolate the effects on the individual carbs at low rpm. The tests are made with the damper assemblies removed. The mixture-adjusting tool must be removed before testing the mixture. If the carbs test too rich, the screws should be adjusted ½ turn counter clockwise; if it tests too lean the screws should be adjusted ½ turn clockwise. After the adjustments the carbs are tested again and adjusted as required. Remember that the range of the screw adjustment is 3 turns counterclockwise beyond which the screw is may come out of the needle carrier. In practice, one should not go beyond 3 turns counterclockwise from the tight position. As mentioned earlier the carb adjustments are kept identical. These are tweaked later after the road test.

Idle Speed Adjustment: Once the mixture has been set, both idle screws are turned in the same direction an equal amount as required to get the idle speed to about 850 RPM. The synchronization should be checked again to make sure it is equal and if not, it should be adjusted.. One bolt in the spring clip for each for each carb is then loosened and a 3/32-inch drill shank placed between the tongue and the slot of the interconnection lever (see sketch). While holding the drill in position tighten the spring coupling bolts on both carbs and then remove the drill.



Next, open the throttle enough for the engine to run at about 1500 RPM and use the Unisyn again verify that the carbs are balanced. If not, the previous step should be repeated until the carbs are balanced at both idle and at about 1500 RPM. (See why this procedure is called tuning?)

Next, pull out the choke knob and insert a 5/16-inch drill between the cam and stop on the cold start valve (see sketch) on one of carbs. The choke knob should be pushed back in enough so the cold start valve spring or the stiff choke inner cable holds the drill in position. Next, slacken the nut on the fast idle screw and then adjust the screw such that it just barely touches the cam. Tighten the nut to secure the adjustment. Repeat the adjustment on the second carb. Start the engine, pull out the choke knob and verify the speed is 1100 to 1300 RPM. Make identical changes to both fast idle screws as necessary to bring the speed into the 1100 to 1300 RPM specification.



Fill the air valve guide rod to within ¼ inch of the top with oil. I prefer SAE 20 3-IN-ONE electric motor oil sold in 8 oz cans. Motor oil is also satisfactory. Install the damper assemblies in the top cover and then raise the air valve with a finger to the maximum up position to force the thimble on the damper assembly (later carbs) into position in the end of the air valve guide rod. Next, clean up the oil expelled from the vent in the top of the carb because you over filled the valve guide.

The final step is to install new filters in the air filter housing and mount the housing to the carb after placing gaskets between the cleaner housing and the carb. I usually affix the gaskets to the air cleaner housing using a small amount of gasket cement to prevent them from falling out when the air filter housing is mounted.

The test drive

The best check of carb tuning is the test drive. The test drive should be such that the engine is at normal temperature for at least the last 10 minutes. During the test drive observe the following:

- Does the engine run pretty well and not misfire when cold without the choke knob pulled? If so, the mixture may be too rich.
- Test the hot engine under load in all gears between 1000 and 3000 RPM. If the engine misfires, then one or both the carbs may be too lean.
- If misfires occur, repeat test with choke knob pulled part way put. If it no longer misfires, then at least one or both of the carbs are very likely set too lean.
- Downshift and decelerate. If the engine backfires or pops under this condition, one of the carbs may be too lean. (A air leaks in the carb or manifold gaskets as well as a faulty bypass valve can also cause this condition.)

After the test run, pull all the spark plugs. Note that the front three are associated with the front carb and the back three with the rear carb. If the end of one of the plugs in the front or rear group looks significantly different than the end the other two, something else is wrong (consider a compression test or an examination the ignition system). If the end of all the plugs in a group of three have a brownish color, then the associated carb is probably adjusted properly. If the plugs are black, the associated carb is probably set too rich. If the plugs have a whitish color, the associated carb may be set too lean. Evaluate all these data and adjust the mixture as appropriate, maybe a half turn at a time. Take another test run of 10 minutes or so. Check for misfires as above. It is necessary to check only one plug in each group after this test run (assuming all the plugs in each group of three looked the same after the first test). Continue to repeat adjustments & test runs as required until good performance is achieved and the plugs look right.

The left plug in the photo is white indicating that associated carb is set too lean. The right plug is black indicating the associated car is set too rich.

The brownish color over the tip and part of the center porcelain on the left plug indicates a carb with proper mixture. The uniform more whitish color of the right plug indicates a carb that the mixture is still a little lean.

Two plugs with the brownish color indicating carbs with a properly adjusted mixture. All the plugs shown are Champion N12Cs.

Anti run-on valve test

Before wrapping up the carb overhauls I usually test the anti run-on valve on '73 and later TR6s. The valve is located below the carbon canister that is secured to the right side of the radiator. The photo on the right shows the valve in my '76. The canister has been lifted away to expose the valve.

The first test is to verify valve operation. Disconnect the two wires at the top of the valve. Use a clip lead to connect one of the valve terminals to ground. Then, with the engine running, connect the second terminal via a clip lead to the positive battery terminal. There should be an audible click as the clip lead is touched against the battery terminal. If not, connect the clip lead to the positive battery terminal and then use a voltmeter to verify there is 12 volts across the valve terminals. If not, fix the clip leads. If there is 12 volts across the terminals and the valve doesn't operate, it is defective and must be replaced.

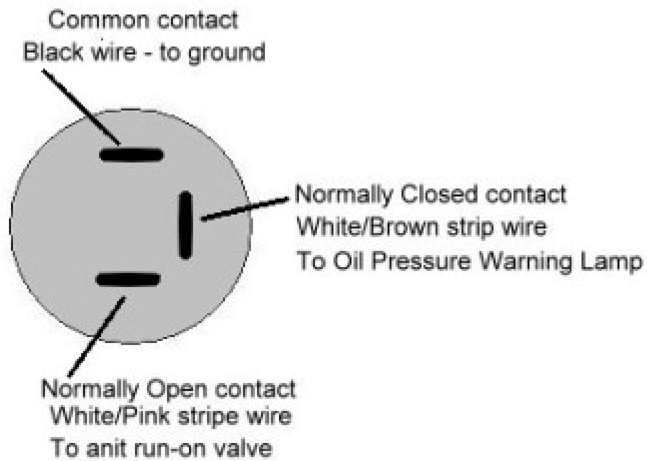
If the valve operates with a click, the engine speed should increase slightly (as the mixture leans) and then stop. If the engine doesn't stop, then check the hoses from the carb vents to the valve and from the valve to the intake manifold. If the hoses are in order, disconnect the hoses from the carb vent and put a finger over the end of each hose and see if there is very slight suction when the valve is open. If there is no suction, then the valve is not functioning properly and probably needs to be replaced.

If there is suction at the end of the hoses that connect to the carbs and the engine continues to run after the valve is operated (with hoses connected to the carbs), then the vent valves may be defective or misadjusted. See the discussion on adjusting these valves near the end of Part II.

After the valve is verified to operate properly with clip leads, normal operation should be verified by listening for the valve operation when the ignition of the running engine is turned off. There should be a click when the ignition is turned off as the valve operates and a second click a few seconds later when the oil pressure drops. If the valve clicks are not heard, the electrical circuit probably has a fault. The white with pink stripe wire at the valve connects to the oil pressure switch which should ground the wire when the engine has oil pressure. The brown with red stripe wire should have 12 volts on it when the ignition is off.

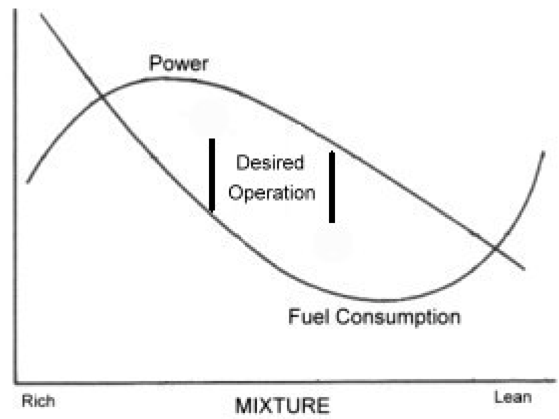
The 12 volt side can be checked by removing the white/pink stripe wire and leaving the brown/red strip wire connected. Then, with the ignition off, use a clip lead to ground the terminal where the white/pink strip wire normally goes. The valve should operate when the terminal is grounded. If it doesn't, then the fault is in the wiring between the valve and the ignition switch.

The ground side can be checked by removing the brown/red stripe wire and leaving the white/pink strip wire connected. Then, with the engine running, use a clip lead to connect 12 volts from the positive battery terminal to the valve terminal where the brown/red strip wire normally goes. The valve should operate when the 12 volts is connected. If it doesn't, then the fault is in the wiring between the valve and the oil pressure switch. This is the most likely source of the problem since the wires at the oil pressure switch are easily disconnected and none of the documentation I've see shows the terminal configuration of the switch. The terminal arrangement for the switch on my '76 is shown in the sketch on the right. If the wires are connected properly, use normal electrical troubleshooting techniques to determine whether the fault is in the wire between the the switch and valve or in the the switch.



More on Mixture

The desired mixture is the one that produces maximum power with minimum fuel consumption The sketch on the right shows that there is a tradeoff between power and consumption. It should be noted that a too rich or too lean mixture produces both decreased power and increased consumption. The range of mixture shown in the graph represents more than doubling of the air to fuel ratio. The desired operation area represents about a 25% change in the air to fuel ratio. An overly rich mixture causes poor economy, some power loss and excess emissions. The overly lean mixture also causes poor economy, considerable power loss and probably excess emissions too. The overly rich mixture is easily recognized by black exhaust gases (black bumper) and black spark plugs. The overly lean mixture is recognized by engine misfires under load and white spark plugs.



It's natural to try to relate the graph to the needle adjustment. Dick Taylor passed on a couple calculations of the effect of the needle adjustments that I found really interesting. Some time later I ran across the specs of the B1AF needle and was able to enter the data into spread sheet and calculate the open area between the jet and the need at various needle depths. (The jet diameter is 0.10 inches.) The amount of fuel delivered is proportional to this open area. I assume (but don't know for sure) that the proportion is direct; if the area is doubled, the fuel delivered is doubled, etc. Recall that the maximum needle adjustment is a little over 3 turns or a little over 0.01 inch --- roughly one step in the chart below.

Needle (B1AF) and Jet Geometry			
Distance from needle top (inches)	Needle diameter (inches)	Open area between needle and jet (sq inches)	Open area (percent of maximum)
0.000	0.0951	0.0030	19%
0.125	0.0942	0.0035	22%
0.250	0.0923	0.0046	29%
0.375	0.0897	0.0061	28%
0.500	0.0864	0.0080	49%
0.625	0.0835	0.0095	59%
0.750	0.0798	0.0114	70%
0.875	0.0771	0.0127	79%
1.000	0.0749	0.0138	85%
1.125	0.0731	0.0146	90%

1.250	0.0712	0.0155	96%
1.375	0.0695	0.0162	100%
1.500	0.0695	0.0162	100%

The next thought was --- where does it run at idle? The needle in my '76 is around the 3/8 inch height (+ or -) at idle. My guess is that carb runs at about 3/4 inch needle height when cruising at 70 mph on the level.

My '76 TR6 seems to be running great. It is a bit non standard. The head is from a '73 and the air pump, exhaust air injection and EGR valve have been removed. The compression measures between 150 and 160 psi on all cylinders. The carbs are original with original throttle shafts, bushes, needles and jets. My guess is that they have a total service of about 75K miles. These carbs have been completely disassembled in the last few months and powder coated. As far as I can tell, they are in like new condition. The ignition is standard points with 6 volt coil. The timing is set at TDC with retard unit connected. There is a slight ping at around 2000 RPM when under heavy load using 89 octane fuel (at ~ 1,000 ft above sea level).

I did a set of short test runs in the '76 at various mixture settings. All tests were made with the dampers removed and with the exception of the first run, with the idle screws unchanged. Each test run is seven miles over a country road. The middle part is straight and flat where I get up to ~ 70 mph and then turn around and head back. The first part is winding and down hill and of course uphill on the return where the engine can be loaded at low RPM. The mixture setting is based on the number of turns from the full up setting. For example, 0 is all the way up (screw tight), -1 is down one turn, etc. Small spacers were fabricated and placed under the adjustment screw to allow the needle to be raised above the normal maximum up (0) setting. One of the spacers is shown in the next photo. The spacer OD is .370 inches and the ID 0.313 inches. This allows the spacer to rest on the shoulder that the bottom of the adjustment screw normally rests and the ID is large enough for the needle carrier to pass. The sleeve is 0.065 inch high but when rested on the rounded top edge of the shoulder raises the maximum height about 0.070 inch or about 2 turns above the 0 position.

The test results are shown in the next chart The plug color refers to the major color of the darker half of the plug tip. About half of each plug was pretty white and the other half changed color with the mixture. Number 2 and 5 plug plugs were pulled and checked after each test run. In all cases the plugs were nearly identical.

Mixture Tests					
Adjustment Screw Setting (Turns)	Idle RPM	Plug Color	Air Valve Piston Lift Test	Exhaust	Other
+2.0	stalled	Black	speedup - never stall	No Popping	Ran Great
+1.0	500	Dark brown	speed up - never stall	No Popping	Ran Great
0	700	Brown	speed up -never stall	Mild Popping	Ran Great
-0.5	750	Light Brown	slight speedup - stall	More Popping	Ran Great
-1	800	Tan	no speedup - stall	Much Popping	Ran Great
-2	800	Tan	no speedup - stall	Much Popping	Misfire under load
-3	700	Tan	no speedup - stall	Much Popping	Misfire under load

The air valve lift test refers to what happens when the air valve is slowly raised about 1/4 inch and then raised to full up. For the richer settings, the the engine speed increases when it was raised about 1/4 inch and continued to run (rather poorly) as it was raised to full up. The likely explanation is that the other carb is supplying enough fuel to keep it running.

I ran another test of operating the anti run-on valve when it was idling. In all cases except the -2 and -3 setting, the speed increased before it stalled. It stalled with no speed increase in the leanest two tests. For the cases where the speed increases, the mixture at idle is richer than peak power on the curve. As the depression in the float chamber increases after the valve operates, the mixture leans. The speedup indicates that more power is generated at a leaner mixture.

There was a significant increase in the exhaust popping as the mixture was leaned. The exhaust is a stainless dual sport system with several leaks. I plan to remove the exhaust manifold for powder coating in the near future. An attempt will be made to fix the leaks in the pipes when the system is put back together. This will be updated after the pipes are fixed.

Apparently the carb design is such that it runs richer at idle than when the throttle is opened further ---- possibly to insure a smooth idle.

I did a ~ 125 mile test drive on highways and country roads at the +1 setting and measured a 23.2 mpg performance.

After all these tests I decided to use the -0.5 turn setting -- until I tweak it the next time. I also adjusted the timing to 4 degrees ATDC to eliminate the occasional pining with the 89 octane fuel. A subsequent test drive showed 26.7 mpg economy.

Note that it was impossible to adjust the carbs rich enough to turn the plugs black without using the little spacers. That would probably not be the case if the needle and jet were worn making the open area between the needle and jet larger. It is also worth noting that it appears the standard carbs can supply sufficient fuel to reach the maximum point on the power curve, and if one uses the little sleeves, sufficient fuel can be supplied to exceed the maximum power point. I guess that means it is a waste of money to replace the carbs on a standard engine with carbs that supply more fuel --- you loose power and economy really goes to pot.

Dick Taylor suggested several alternatives to the little spacer to achieve a richer mixture. One is to push the jet down about a tenth of an inch. Another is to carefully file a flat on one side of the needle. Dick suggests reducing the diameter measured to the flat by .002 inches from the thickest part to about the middle of the needle.

Note: after this note was written I built an air/fuel monitor and used it to check out carb mixture. This work is described in the accompanying notes. The mixture measurements are in the note Using Air/Fuel Monitor. While that note provides considerable additional information, the conclusion is that the best carb setting is between 1/2 and 1 turn below the maximum up position, the same as found above.

The main thing leaned from these tests is that no matter how badly the carb mixture settings are screwed up, the car runs pretty well. A corollary is that no matter how the carbs are adjusted, a screwed up engine probably can't be made to run well.

Troubleshooting:

The following are some trouble shooting hints:

Possible causes of poor idle quality:

- improper synchronization
- air leaks around manifold
- air leaks around throttle shaft
- temperature compensator stuck open
- damaged diaphragm
- stuck or binding air valve
- misadjusted float
- incorrect timing
- misadjusted idle trim screw

Possible causes of poor engine braking:

- misadjusted or defective bypass valve
- defective ignition retard unit

Possible cause of run-on (dieseling):

- defective anti run-on valve
- fuel octane too low for engine compression

Possible cause of exhaust popping:

- misadjusted or defective bypass valve
- exhaust system leaks
- too lean mixture

Possible cause of poor performance at high temperature:

- misadjusted, stuck or defective temperature compensators
- carb tuned at too low temperature because of defective thermostat