Cowl Investigation Part 3

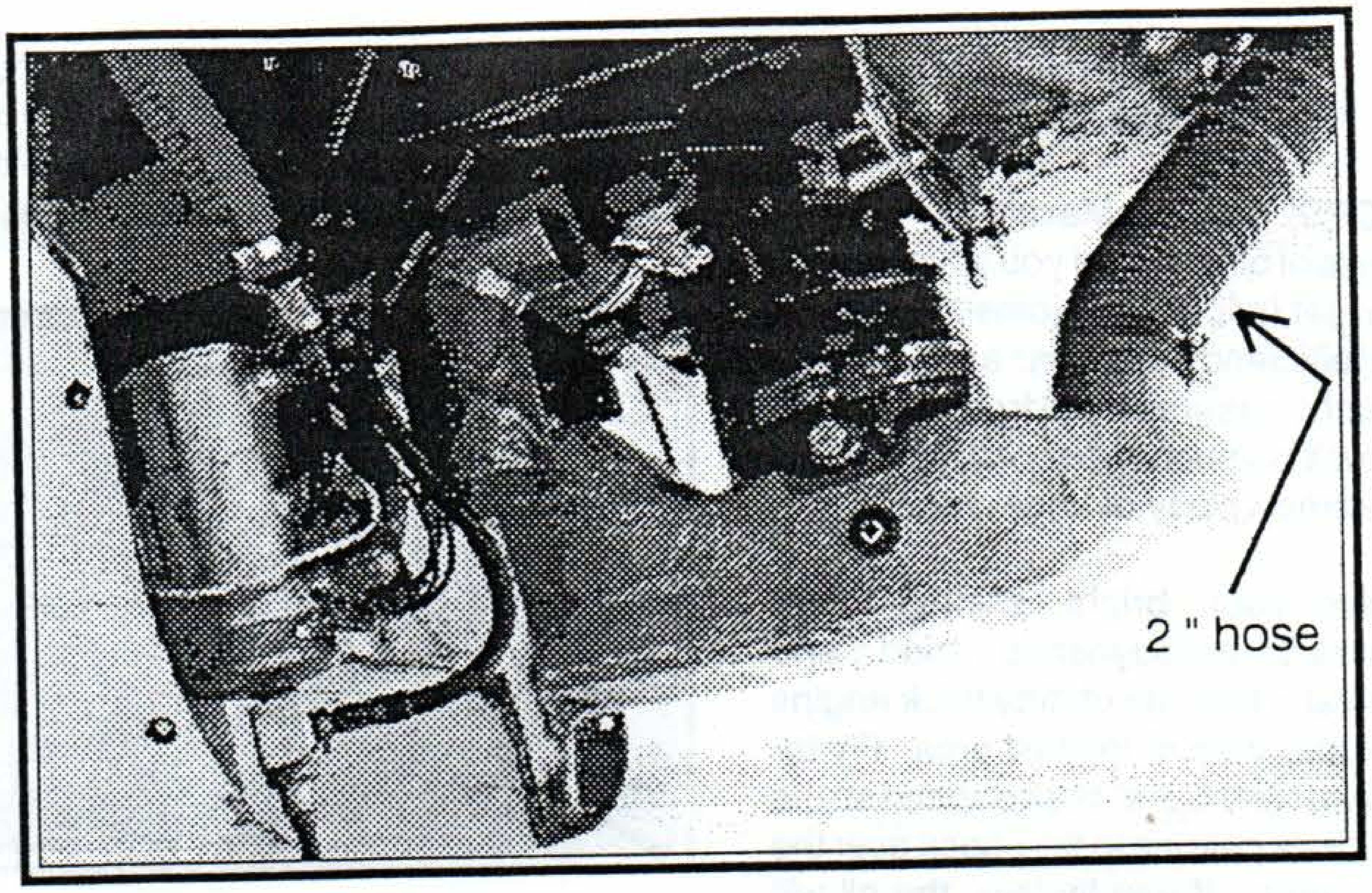
[Pr]evious attempts at increasing speed and efficiency by changing cowl outlet and profile gave pretty meager results. Increases of 2-1/2 knots were hardly worth the effort. The noise reduction was nice but I needed something more. (Isn't greed wonderful?)

My ole pappy used to say, " If your ideas aren't working then use ones that do work." In this case of EZ efficiency I had to see what the gurus were doing and copy that.

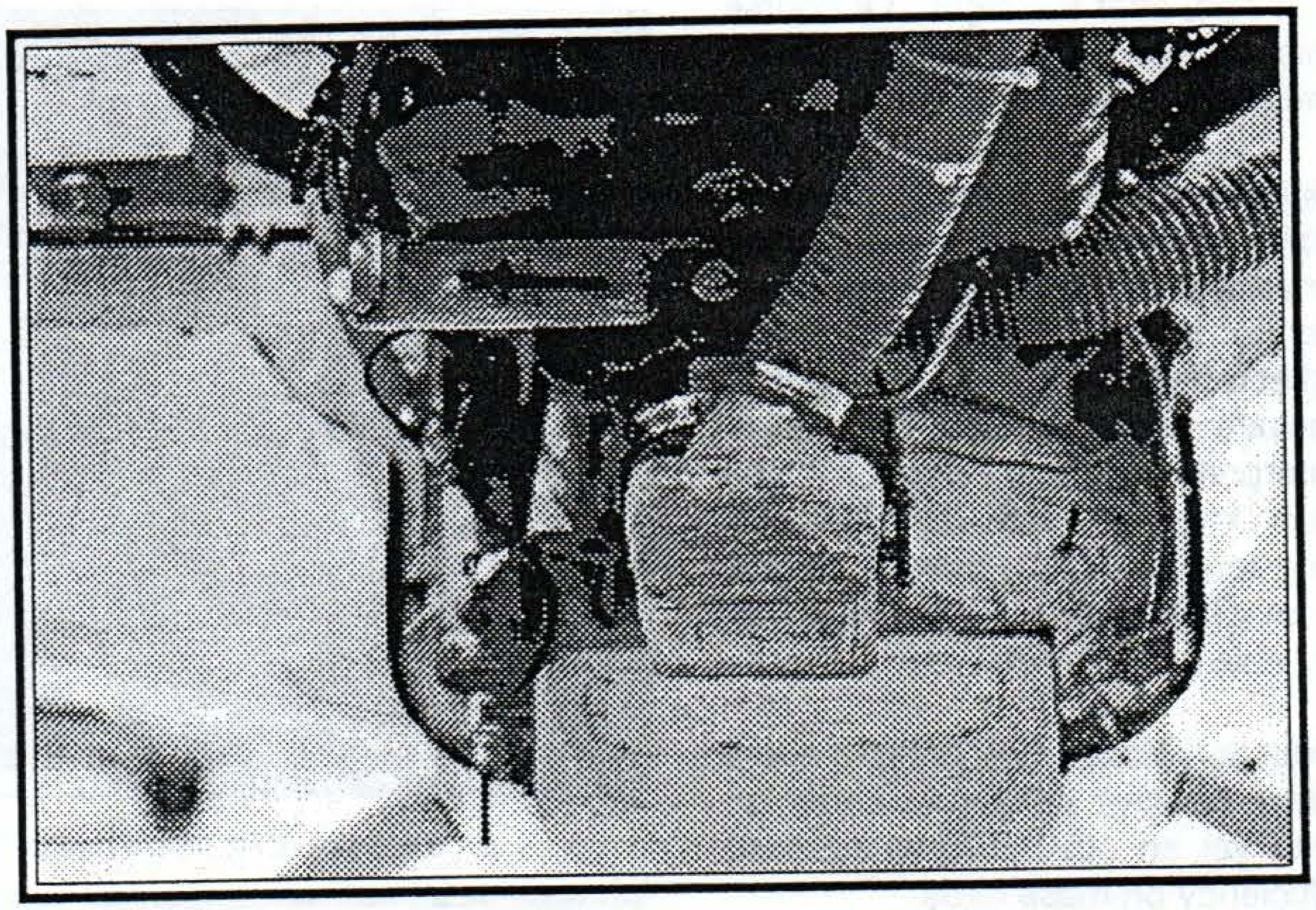
My CHT's on the right side have always run hotter than the left side. I believed this to be the result of the stock air filter to carburetor induction hose deflecting the air to the left side of the cowl. Earlier tests back in November had shown removal of the Amsoil foam filter and all flex duct hoses to have had little effect on CHT but I thought I'd try the idea again.

[T]he November test was with large ramps installed in the lower cowl directing air toward the base of cylinders #3 and #4. Removal of all hoses, filter, and elbow had the following effects on CHTs. #1 did not change from the previous 350° F. #2 increased 19° F from 360° F. #3 dropped slightly from 380° F. #4 dropped 11° F from the earlier 435°F. Because of this previous test I did not expect to see major improvements in CHT when I installed the new carb air box and removed flex duct that appeared to block the path of cooling air to the forward cylinders. I did hope to see a gain in static and top RPM and airspeed as well as rate of climb, however.

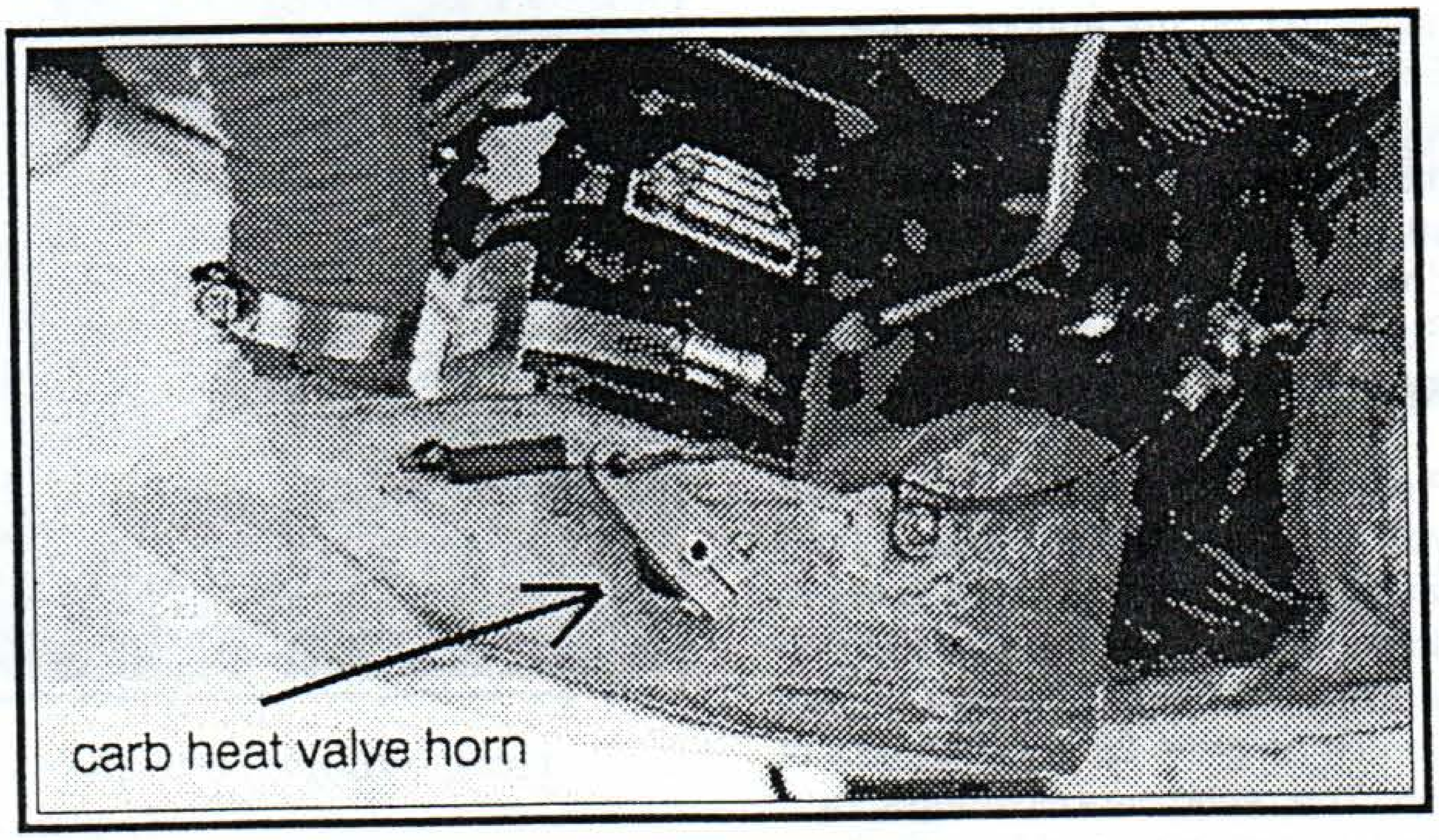
I designed a carb air box that would allow use of my previous carb/cabin heater muff and permit both to function. Since I had only one heat muff I decided to use a design that permitted selection of carb heat or cabin heat, but not both simultaneously.



Heat enters aft of the carb from a muff on the right side exhaust



Note clear path for NACA duct inlet to the cylinders (above) and air box clamp mounting to carb (below)



You Are Invited to a Mazola Oil Party

OOPS! Did I say Mazola oil? I meant mess of oil. Many of you adventurous builder/pilots have joined the quest for efficiency this year as a result of much treasured input from the gurus. Now it is your turn to contribute to the common body of knowledge.

Take your bright shinny, newly painted aerodynamic mod and smear a thin line of dirty thick engine oil upstream of the test area. Fly for at least an hour at cruise speed so the oil has a chance to flow back over the test area. If you fly less, the oil will probably run down off the cowl when you park after the flight. Of course this will happen before you can get the photos taken.

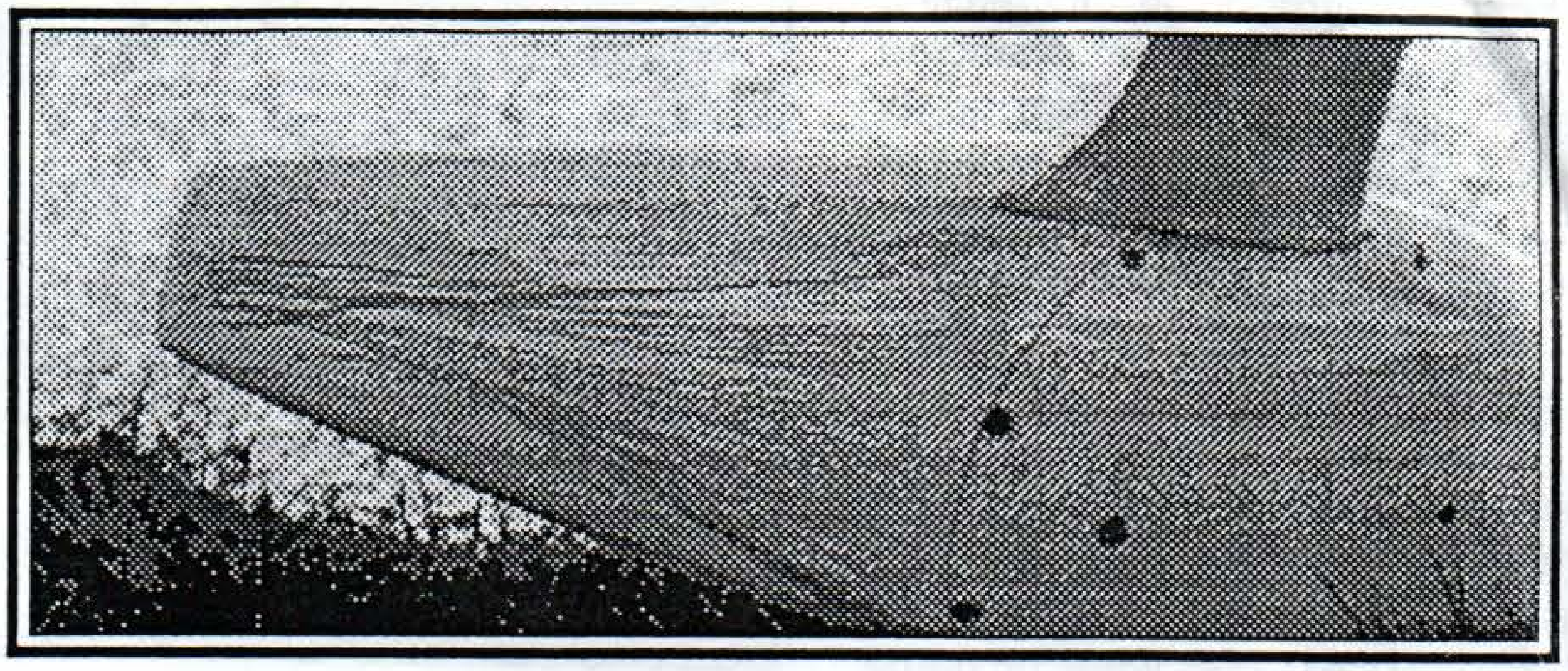
I know you hate to write, so just shoot some photos and put a note in the envelope as to what the photos describe. If you know and understand what is happening in the oil flow field include that too as I don't do well at interpreting other's photos. If you don't know why something is occurring send the photos anyway. Maybe some CSA speed/efficiency guru will be able to explain it.

Your good ideas may just spur some other creative thinker to come up with yet an other way to increase efficiency on these birds.

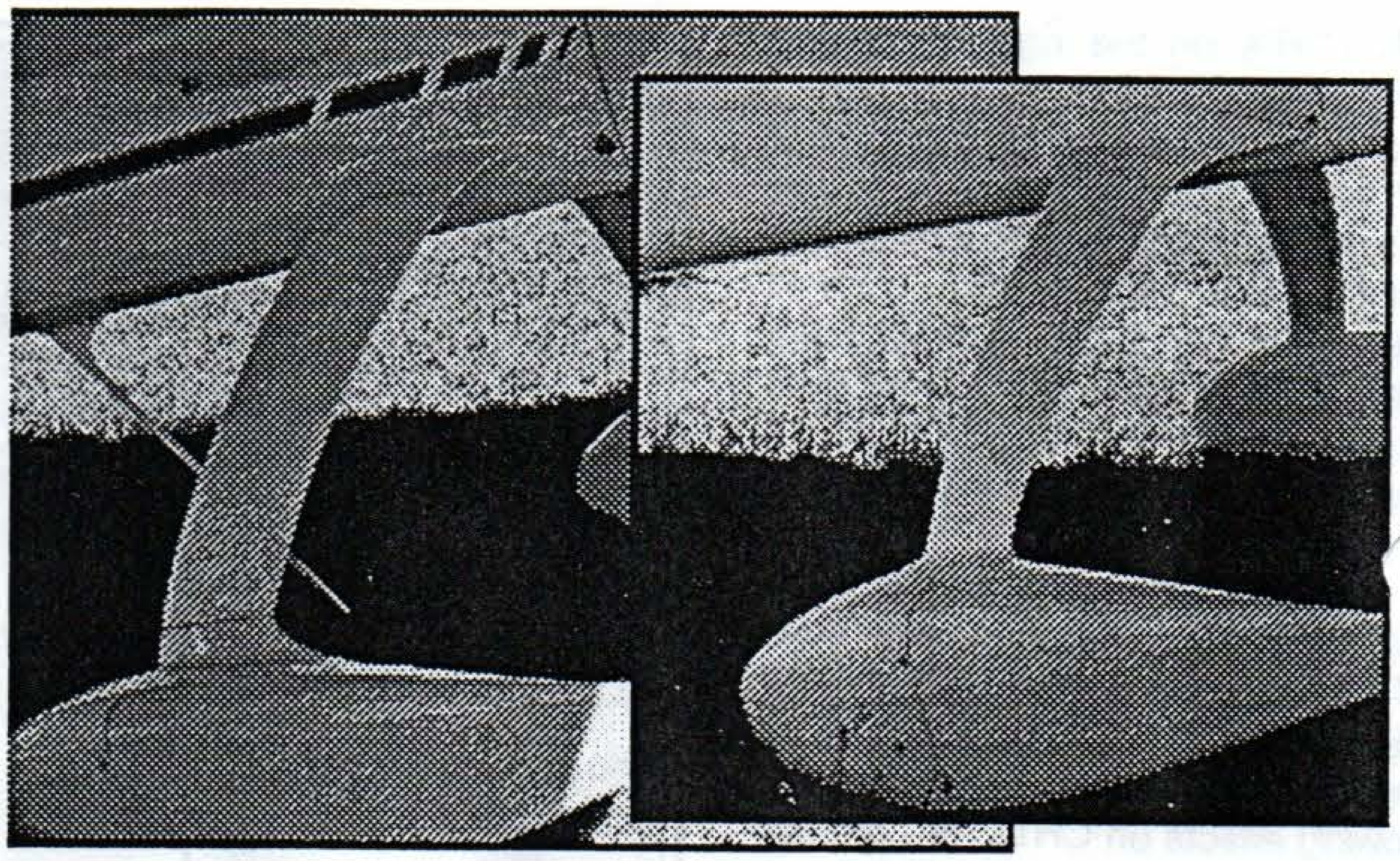
Please remember, your photos must be light to be most effective when reproduced on my antique software. Expose your film for the subject area. It is really easy to shoot a cowl and have the camera meter read the sunset behind the airplane thus under exposing your subject area. Read the camera manual and expose for the subject.

Please send two photos of each area you find interesting. One photo should be just far enough away to show what part of the airplane you are investigating. The bottom two photos on page 28 are examples of this. Then send me a close-up shot of the interesting area of investigation, similar to the top photo on this page.

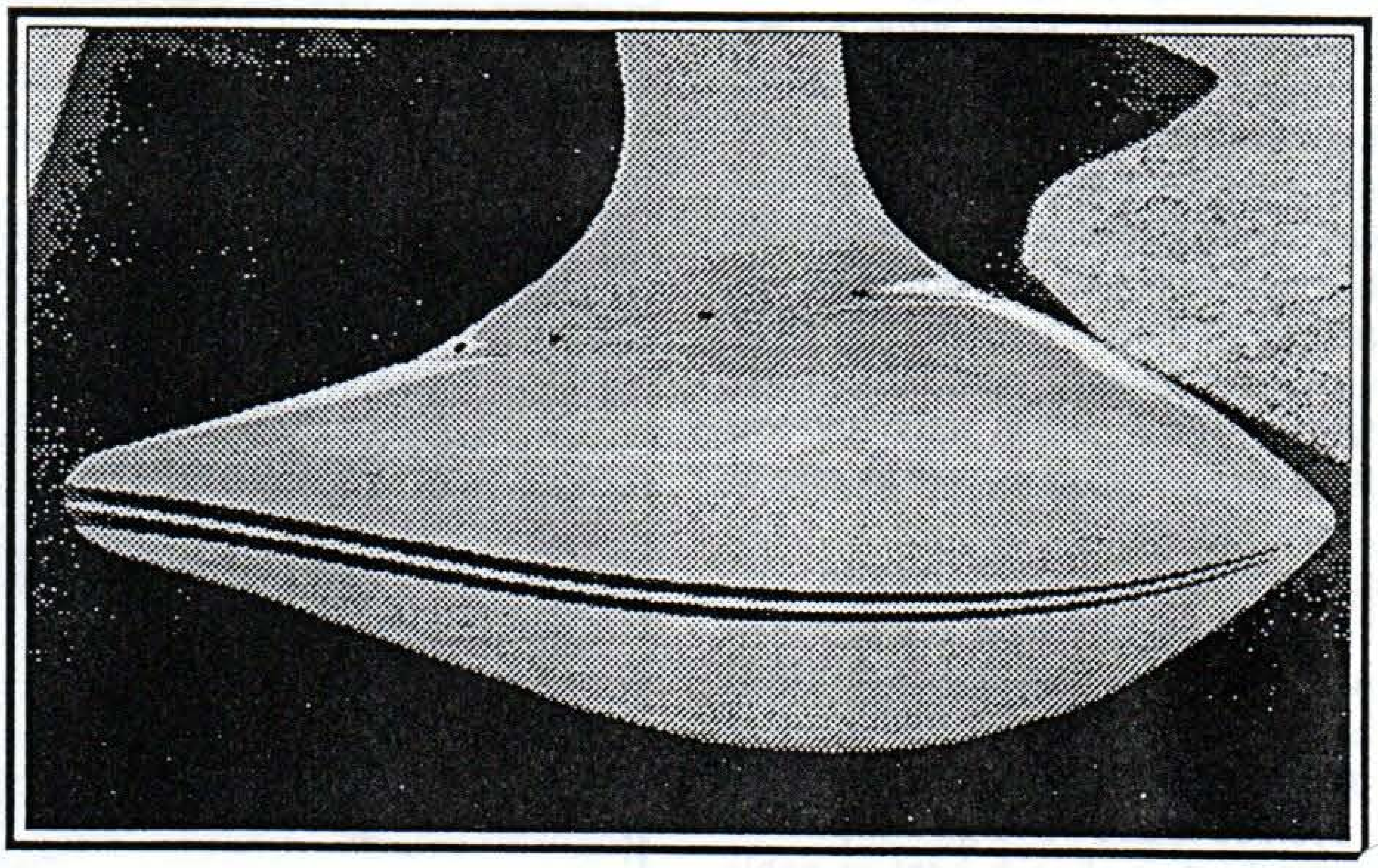
For this first oil flow investigation I plan to limit study to wheel pants, landing gear and cowling. If you find something interesting on an other part of the airplane please send that too as the field is wide open. I would hate to miss a chance to go Mach on 4 gph because I put a limit on you.



Come to the party dressed like this



I can't wait to see these "Great Legs" oiled up!



Herb Sanders' new pants will want to come to the "Mess a oil" party

The extra induction hoses were removed and the air box was fitted with a Bracket foam air filter having just over 16 square inches of surface area. A traditional throttle style valve was fabricated using silicone baffle seal material to cushion the edges of the valve. This is the way the stock carb heat valve is done. Due to close proximity of the cowl bottom, my carb air box is only about 2-1/2" high at the carb inlet. That allowed me only about 9 square inches of cross section at the carb air box valve.

The new carb air box mounts to the bottom of the carb with two fiberglass straps that go up the front and back of the carb body and are secured with a screw type hose clamp. I did not want to have unsafetyed bolts inside the induction system to come loose and go through the engine. The clamp method has worked well so far. I have not seen any loosening or slipping of the box. (photo p. 26)

The carb heat inlet is in the aft portion of the air box and is fed through a 2" flex duct that comes from the heat muff. The duct is arranged to prevent obstruction of cooling air traveling to the cylinders.

I installed my original stock baseline cowl with the 3/4" clearance from the prop to the rounded aft edge of the cowl. I wanted to be sure I was just testing the effects of induction system change and nothing else. Flight tests confirmed that relative CHTs changed little. Number 2 and 4 cylinders were still the hottest. As in the November tests, removal of the flex ducting did nothing to drop CHTs on the right side. If anything changed at all it seems the temperatures were higher. The OAT had increased 20°F. But the average CHT increase was close to 35° F. Power and mixture were very similar on the runs. I don't know why the temperatures increased more than the OAT increase.

Performance was enhanced a noticeable amount. Full throttle RPM, after a 200' roll at 2,000' density altitude, was up to 2440 RPM while it usually is about 2360. Charlie Airesman says a K & N filter would offer less restriction and give even more power. The rate of climb increased several hundred fpm. I don't have good history on rate of climb but I was able to keep an honest 1000 fpm at 100+ kts IAS to 8,500' MSL (10,500' density altitude).

Full throttle at 8,500' pressure altitude (10,500' density altitude) gave 2880 RPM compared to the previous induction system that allowed 2780 RPM. The 100 RPM gain increased top TAS to 165 kts from the previous 158.5 kts. Unfortunately CHTs were also increased considerably. Many builders have reported such increases so it seems a waste of time for anyone, especially O-235 powered, to build the original filter on the firewall carb air system.

The next test was to determine the effect of a cowl profile change to reduce drag. I decided to add a boat tail to my modification cowl. The inside shape remained the same. I merely added foam to the outside and carved a boat tail shape.

Charlie Airesman said to make the cowl sides and bottom come in at the same rate to keep the air flow straight. If the boat tail is carried all the way back and not brought up toward the prop, efficiency is lost. It should be remembered that the maximum angle of closure for a flat surface is 7 degrees.

The lower cowl surface is curved, however, and I have not been able to determine what effect that has on maximum closure angle. I decided to stick to the 7 degrees as measured from the firewall to the aft end of the lower cowl. Such a shallow angle would not permit cowl sides to meet forward of the prop unless I installed a prop extension longer than my present 6". The O-235 has a thin crankshaft flange so I was uncomfortable doing that.

I decided to construct a flat trailing edge and keep the cowl sides shorter while trying to keep the 7 degree angle. (Subsequent oil flow flight tests, photo p. 28, show fairly constant oil stream width thus indicating air flow is not slowing down very much. That leads me to believe the curving angle is not excessive which would cause drag by disruption of the air flow).

If memory serves me correctly, Klaus said airfoil trailing edges can be up to 3% of the chord and not have a big drag effect. I decided to apply that rule to my cowl and computation showed the maximum dimension of the trailing edge to be about 1". I made my trailing edge 5/8" wide with square edge intersection to the cowl sides. I learned from previous cowl trailing edge flight tests that round trailing edges were high in drag and noise. They also seemed to disturb the air going into the prop, thus decreasing efficiency.

Finally, the modification cowl with boat tail addition was ready for flight test. This was a rough test as the surface finish was not completely filled and perfectly smooth. Perhaps an extra knot may have been had with another 10 hours of work but I was anxious to see what the rough results would be.

Flight tests showed the same initial static RPM that I had with the previous cowl version where I installed the new carb air box. Rate of climb seemed to be down about 50 fpm from the previous version but it was too close to call accurately.

The low altitude test, 2000' pressure altitude @ 70% power, showed similar speed power relationship and even the CHTs were very similar. The dB meter was not available for the test so I can not comment on possible noise change.

The full throttle 8,500' pressure altitude (10,500 density altitude) test showed 164-1/2 kt TAS with a 2890 RPM top speed. Speeds and temperatures seemed very close to the original cowl. At this point I can not

23C554

make a decision as to which cowl has the edge on performance.

Oil flow still indicates disruption around the exhaust outlets and perhaps the 4 pipe exit inside the cowl, as recommended by Charlie, Gary, and Klaus is called for to get further performance gains.

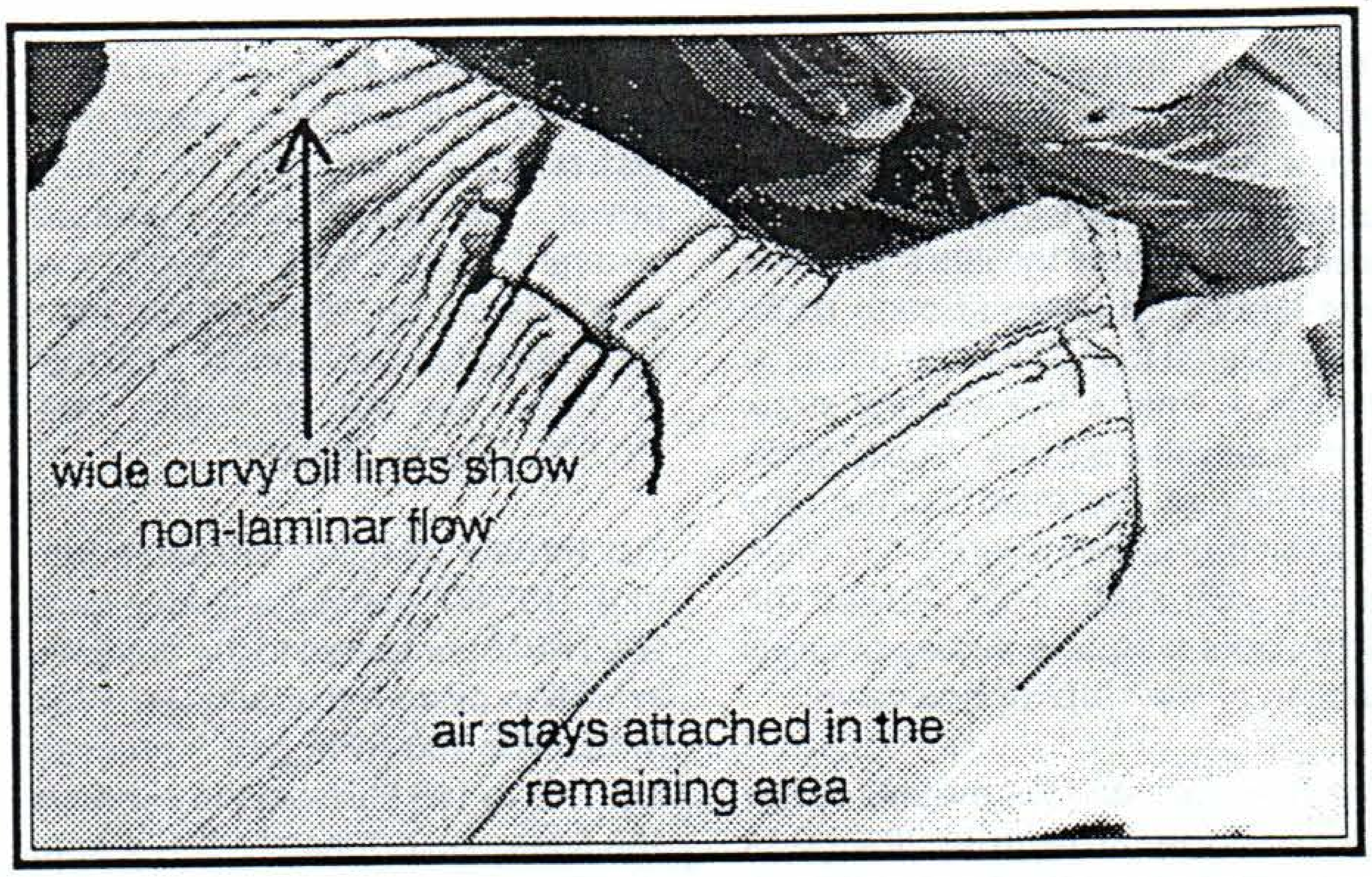
It appears the air flow on the rear end of the boat tail is effected by the prop's rotation. The right side seems to have air flow pulled to the right and away from the right surface. It is strange that pulling effect is not visible on oil flow on the original cowl. See Jan 95 page 25 issue photo. Perhaps there is another reason for the apparent non-laminar flow on the right aft end of the cowl.

The only other noteworthy item to report is that my large internal ramps to direct air flow to forward cylinders may be blocking total airflow though the cowl. The modification cowl has no internal ramps and temperatures for all cylinders usually run about 15° lower than the cowl with the internal ramps. In addition, oil flow tests show air spilling out of the NACA duct on the cowl with the internal ramps while I saw no such event on the modification cowl without internal ramps.

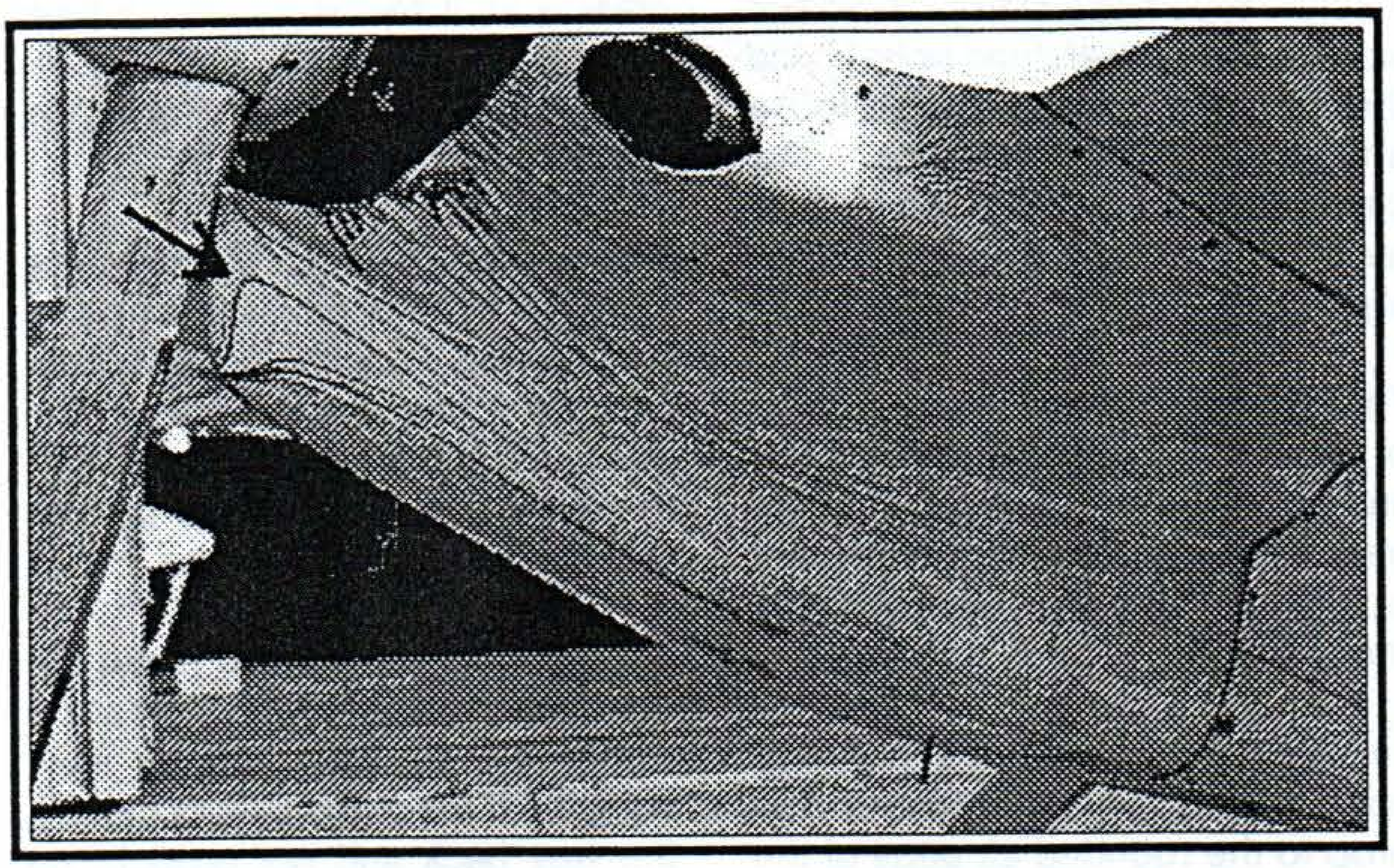
I made one final change on the stock cowl with the internal ramps. I installed fiberglass fences along the straight parts of the NACA inlet duct just before the air goes into the lower cowling. The fences stuck about 1" above the duct sides and were installed to prevent air from spilling out of the duct. I hoped the air would enter the cowl and lower CHTs.

That did not happen. The CHTs are still hotter on the right side but the "delta P"s are all the same - 67 mph. Perhaps the air is now spilling out below the NACA lip and going straight back under the lower cowl. I didn't take time to oil flow it.

While looking at oil flow photos of the landing gear and wheel pant I saw . . OOPS - gotta look into that for the October issue.



Note laminar flow except near outlet



Interesting oil flow appears effected by prop rotation