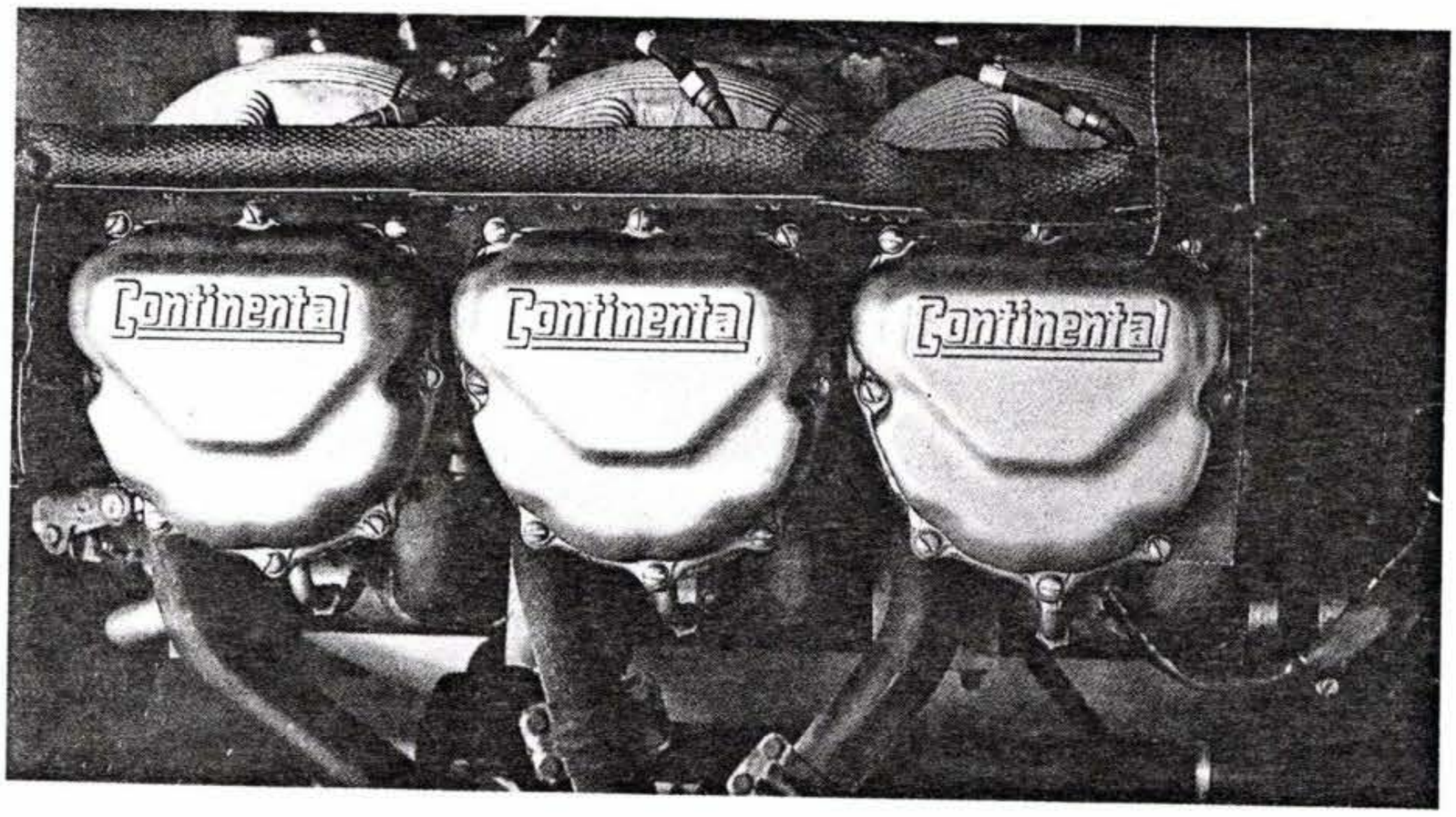
Dodging Installation Grief

Careful planning for that engine installation pays off every time.

BY BILL WELCH



A common six-cylinder Continental installation is seen in this popular lightplane.

Powerplant installations account for much of the grief suffered by aircraft builders, especially those building from scratch or with optional engine installations. Most of the problems can be anticipated by a thoughtful builder willing to take the time for an orderly and methodical preparation before cutting any metal.

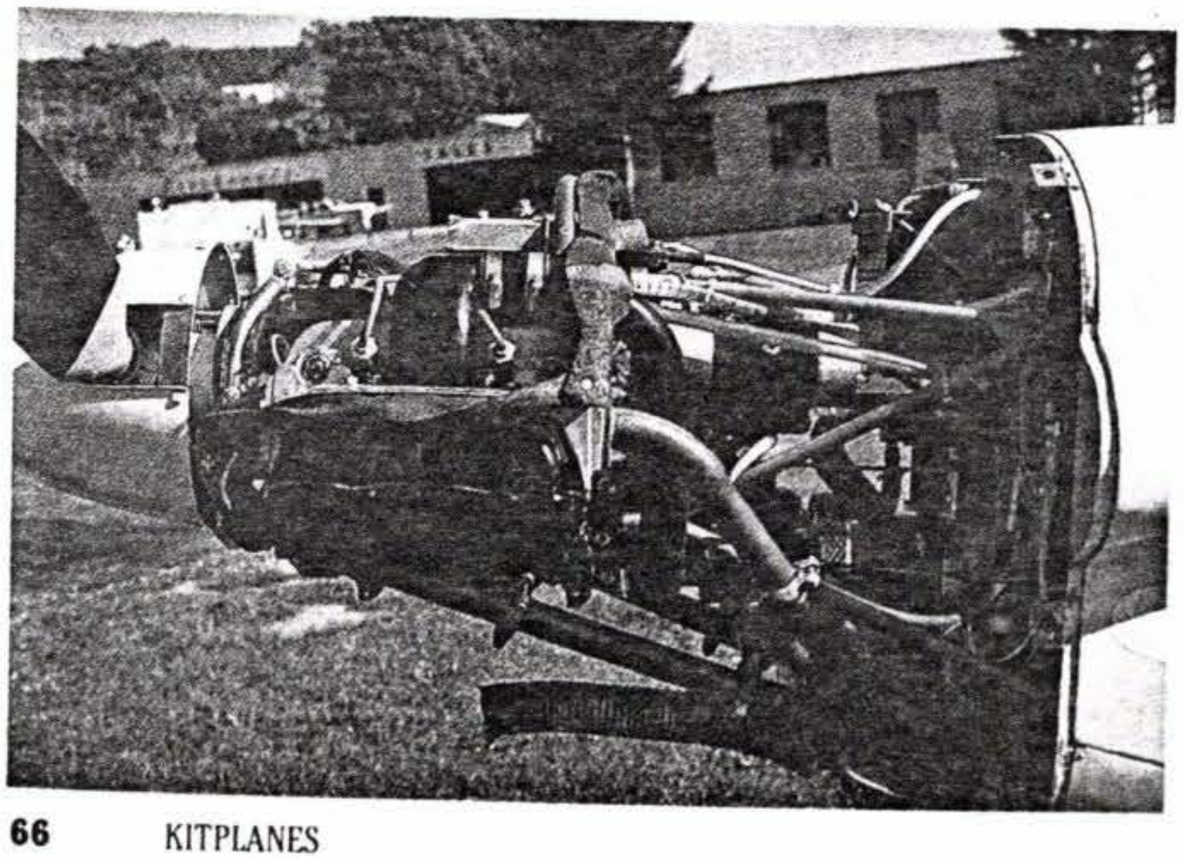
Builders generally tend to take one of two approaches to planning, all on paper or all in the shop. Either will serve, as long as you do the whole job. If you skimp on the planning, you won't skimp on the fixup later. As one former colleague often put it, "We never have time to do it right, but we always have time to do it over."

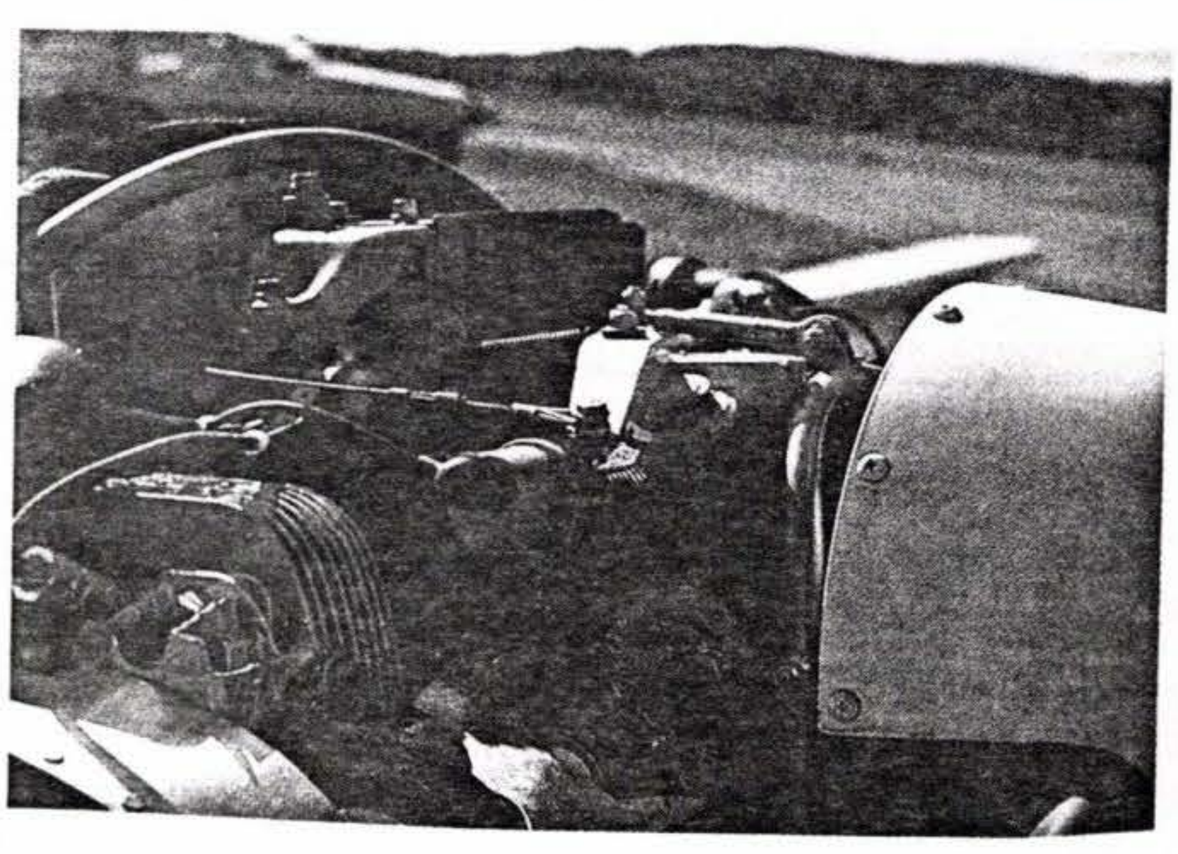
A professional Volkswagen-derivative installation is this Limbach engine (below, left) in the Sportavia RF5-B Sperber—another tightly cowled setup. Note the unusual RF5-B propeller control. The Hoffman three-position prop is operated by bearings on the yoke mounted on the engine. Running only briefly when the control is applied, they bear on a hub plate that lifts the blades off centrifugal stops momentarily to allow positioning according to rpm. To feather the blades, the bearings are held against the stopped propeller plate by an overcenter lever and spring.

At the beginning, what you need most of all is a checklist—a detailed list of all the tasks you must complete to have the engine in the plane and running. That sounds innocuous enough, but most people tend to shortcut it, and that's where the problems start. As innocent a thing as routing the wire for the cylinder head temperature or the oil temperature is fully capable of creating a major crisis if it's neglected until the last moment.

The reason is obvious if you think about it. Virtually nothing you can do in the engine room is without effect on other things in there. This is particularly true for the tightly cowled newer designs that achieve the best performance. You've seen cowls with add-on bumps. Those are the easy ones to solve, if a bit embarrassing. Inside, it's a very different story.

After the physical interference





static rpm are often not available. If the engine is certificated or a model in common use for custom planes, someone can usually provide useful data. If a satisfactory installation is accessible, the engine can be calibrated approximately by exchanging propellers with the known unit.

Direct measurement of power output is awkward for an individual builder to set up, but it can be done. It requires measuring both the torque and the rpm accurately. Manifold pressure is only an indirect measure, and can be used only if the engine is calibrated.

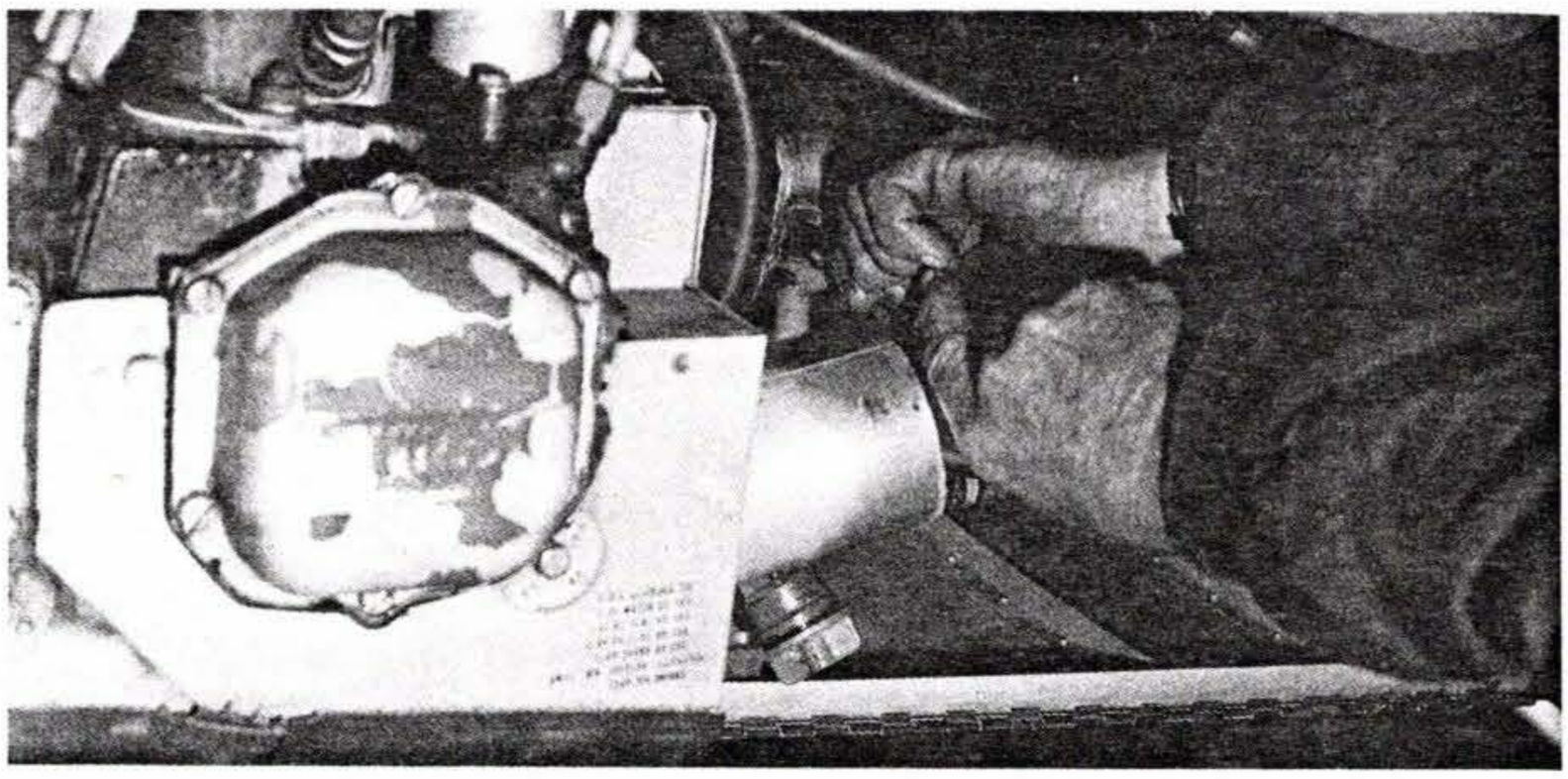
Regardless of how it is measured, if the power output of any engine is below expectations, the same checklist of potential causes is appropriate. One of the first items to suspect is the ignition timing and spark intensity. Nothing can be taken for granted when an engine misbehaves. Sometimes unintentional grounds can bleed off the spark discharge, even from a seemingly flawless harness. There have been cases of switched leads causing low output by grossly mistiming the ignition of two cylinders.

Fuel supply is equally suspect, but often produces characteristic symptoms of lean mixture (no soot, burned spark plugs, high temperatures). But don't overlook excessive fuel—a high fuel pressure or malfunctioning carburetor can produce excessively rich mixture. Again, the symptoms may be visible, in this case as sooty deposits and fouled plugs. If the problem is concentrated in one or two cylinders, the individual cylinder temperatures—and examination of the exhaust stacks—may offer the necessary clues. One common problem is uneven mixture distribution among the cylinders. This may be caused by a modified induction manifold or pipes that are not balanced. In that case, a critical review of the whole induction system is in order. Sometimes the only feasible solution is to introduce turbulence deliberately, but at some loss of manifold pressure and volumetric efficiency.

There have been reports of erratic results with some of the accessories on the builders' market, particularly with the simplest of fuel-handling devices in which little provision has been made for varying conditions.

Among the more obscure causes of inadequate fuel supply are the use of a pressure carburetor in a gravity system, of more often, hidden restrictions in the fuel system. A bit of trash lodged at a critical spot, or sludge accumulated from improper sealants or other contaminants in a tank can be hard to detect. Even a little water can turn up unexpectedly at the wrong place to obstruct fuel flow. Aircraft attitude in a climb or maneuvers can produce similar effects intermittently, especially if the tank outlet is subject to unporting. Insufficient baffling in a tank can allow this when sloshing is induced by flight maneuvering.

On rare occasions the valve timing can be improperly set up, usually when the assembler misses a subtle indicator such as tiny punch marks on the ends of gear teeth. Typical symptoms include backfiring or afterfiring—after the ignition and



Access is an important part of installation planning. Here an air duct has been removed (right) to service a magneto.

Figure 1. Propeller maximum efficiency.

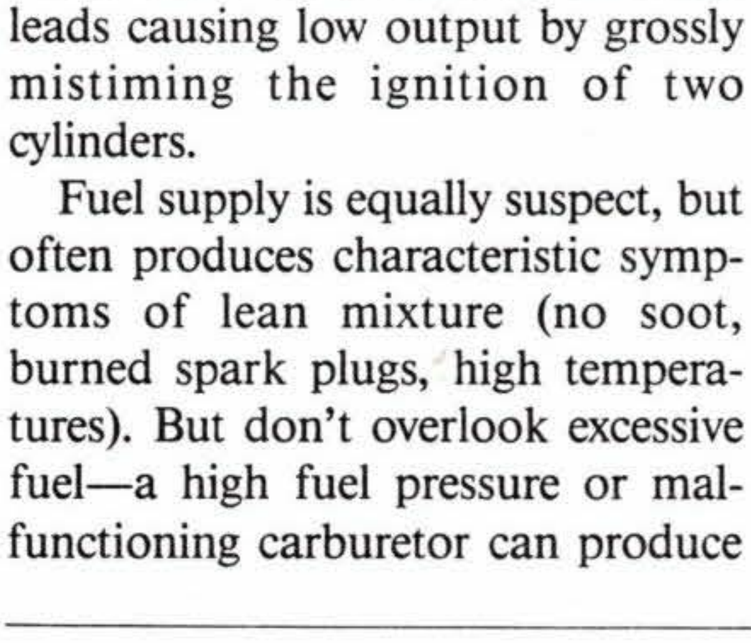


Figure 2. Propeller efficiency off design condition.

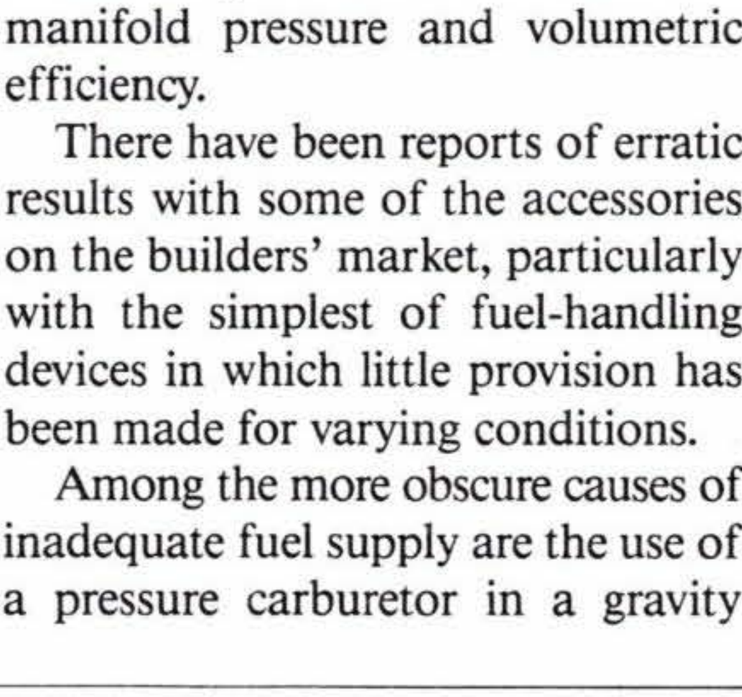
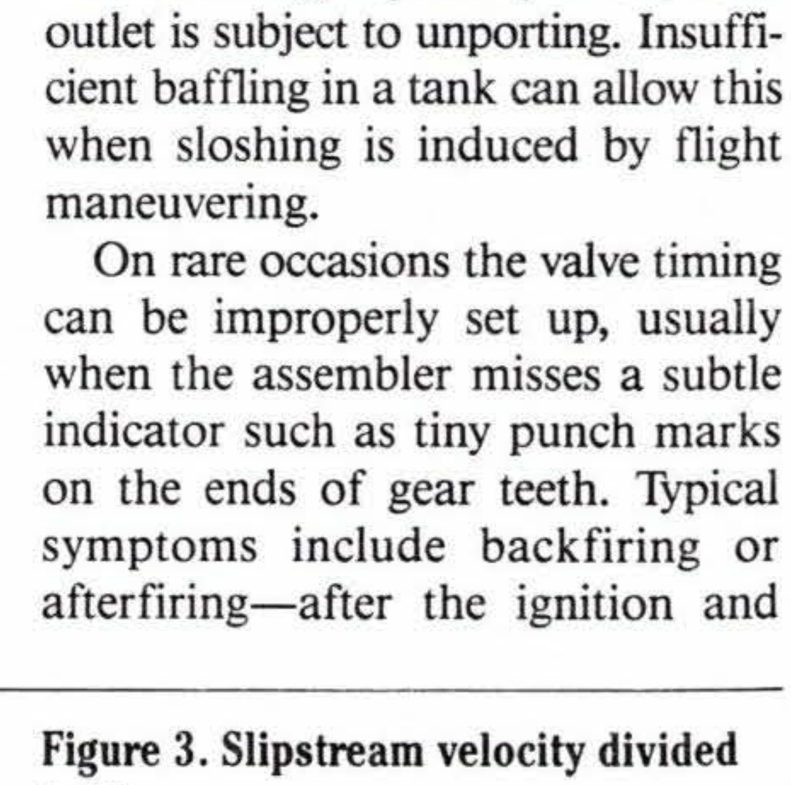
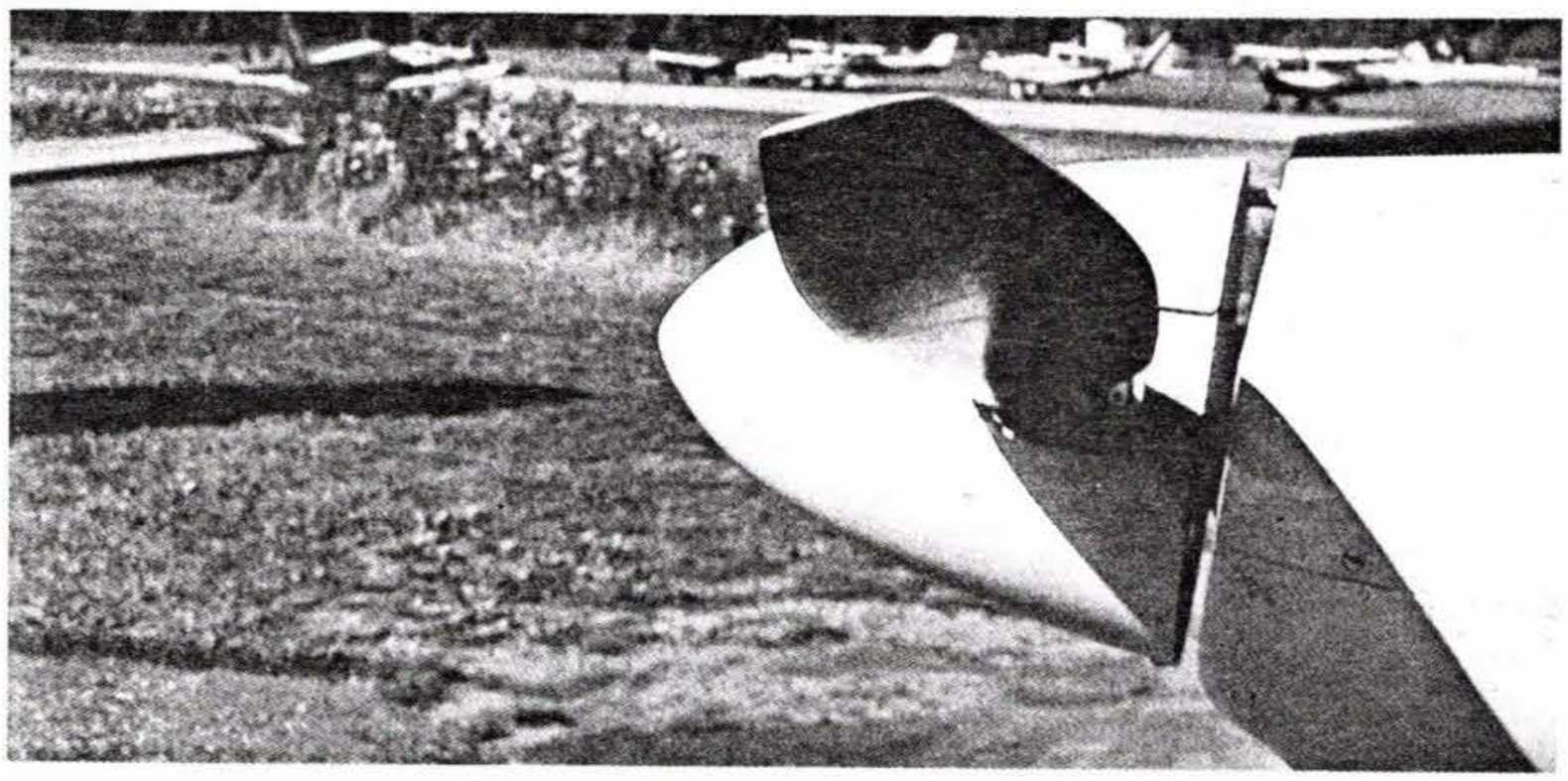


Figure 3. Slipstream velocity divided by V.



ILLUSTRATIONS BILL WELCH



Here is the feathered Hoffmann propeller.

fuel systems have been proven innocent. This is one you don't want to believe and must treat with caution because of the work involved in checking it out. Some engines require frequent resetting of the tappet clearances, and some rocker retention systems have been known to let the rockers drift out of position on their shafts.

Another puzzling difficulty is with the rigging of engine or prop controls. On occasion, a control will provide the required throw under static conditions, but restrict it in actual operation. Remember that an engine moves on its mounts under load. Both torque and thrust can displace the whole installation enough to affect control motion or strain fuel or oil lines that aren't suitably routed or secured.

Sometimes a fresh engine is tight enough to limit power output until it has been run sufficiently to wear in gears, bearings and piston rings. The cure for that is simple, just running it, preferably with straight mineral oil, watching temperatures carefully and changing the oil frequently.

The oil should always be examined during the first few hours of operation, and when any problems occur, as there are several internal conditions that reveal themselves in the content of engine oil. Normally some trash will show up on the screen or filter of a fresh engine. The kind of material indicates the source, and most of the metals in an engine can be identified with a hand glass and a magnet.

One source of help a builder should never hesitate to call on is the experienced mechanic. It's usually worth the cost of a sharp mechanic's time to get the benefit of many previous bouts with misbehaving engines. Cliff Sadler, who managed Danbury Airport for many years and ran a repair service there, could often pinpoint a trouble by listening to the engine as it was run up. Many mechanics, including Cliff's son Dale, use that technique to ferret out the tough ones.

Low power output can be due to something outside the engine. One example was a propeller of inappropriate design for the engine and airplane. With a certificated prop of the same pitch and diameter, the engine developed its normal power, but with the custom prop it failed to produce the necessary output. The difference was in the blade width, much wider in the custom propeller, causing much greater blade profile drag that bogged the engine down and prevented it reaching its normal rpm. The propeller would have been suitable for a more powerful engine rated at the same rpm and airspeed.

Even the fuel or oil put into an engine can limit the power. Two-stroke engines are especially sensitive to fuel grade, mix ratio if the oil is combined with the fuel, and the condition of the fuel itself. Gasoline does age and weather. Octane rating can change significantly in fuel stored for long periods. The FAA investigated this in connection with automotive fuels used under STCs and found some major changes in fuel properties under poor storage conditions and for some types of fuel.

The very best insurance for your project is careful planning, and generous consultation with others. □