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Lord Mounts: The Shocking Truth

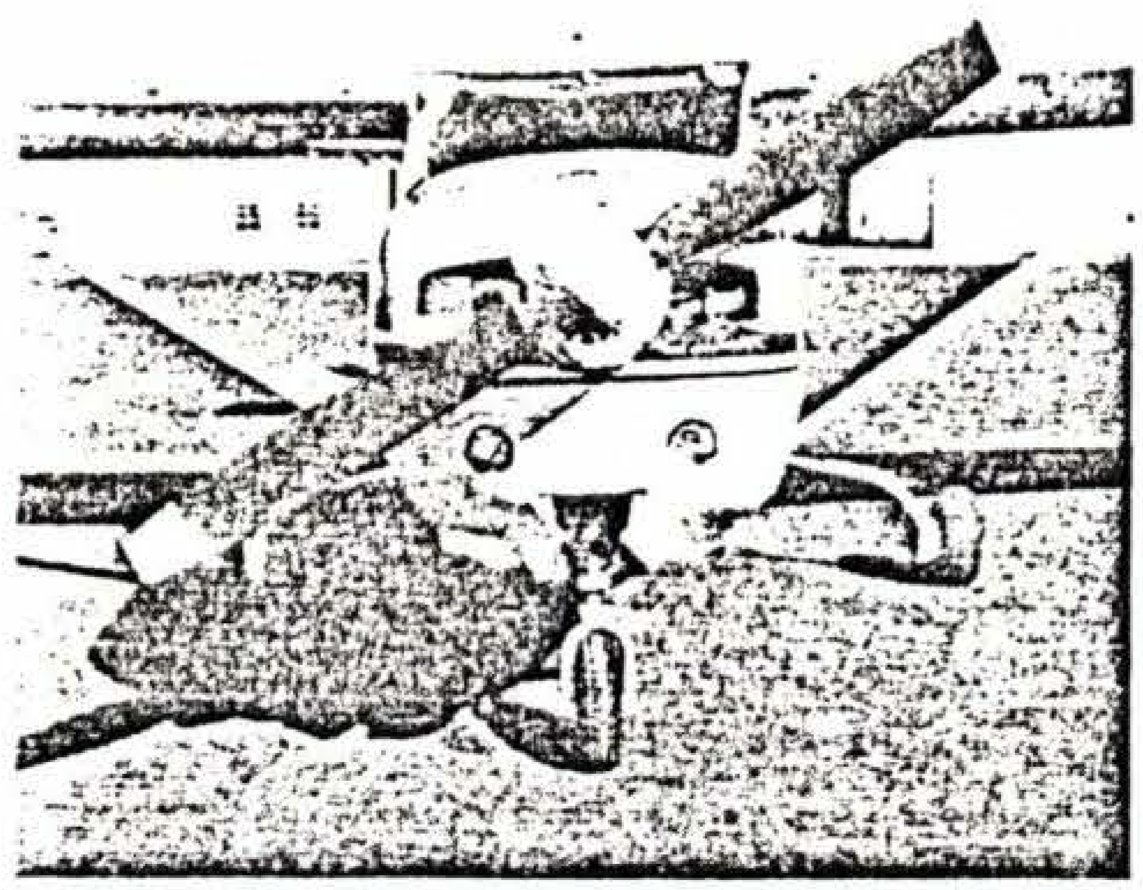
by Norm Bender

Sooner or later, you're going to shop for shock mounts—and when you see the price tag, you'll know how these mounts got their name. A new set of biscuits can require a lot of dough.

By now, everybody knows that—in aviation—most rubber shock mounts are made by Lord Corporation. Shortly after I found out what "Lord mounts" were back in the summer of 1960, I couldn't believe the disparity in prices that prevailed. At that time, the airframe makers' prices (of Beech, Cessna, etc.) were ridiculously low in comparison to the prices quoted by the parts houses. Trouble was, though, very few of the "airframe distributors" kept them on the shelf, and the parts houses got the business by default.

This picture has completely changed through the years, so that now the airframe manufacturers are far outstripping the supply houses in the crazy race that both are putting on to sock the aircraft owner where it bruises most—in the hip pocket. Not only is the price of shock mounts unbelievable, but the crazy-quilt of applications, supersedures, and substitutions that have been promulgated in the past decade has created an even more adverse effect. The principle of mass production is certainly a menace (financially) to designers and engineers, and they have made sure that aircraft shock mounts aren't going to be hazardous to their health.

A look at any parts catalog that lists aircraft engine shock mounts will reveal that the same basic engine will use a multiplicity of mounts, not only in the aircraft of various manufacturers but *within models* of the same manufacturer. The aircraft designers are the culprits: They tell Lord (or Barry Controls, which is now making inroads on what used to be an exclusive market) the specifications for a particular model. There is no consideration for the fact that a shock mount that could well cover the requirement is already in use and in stock at the factory warehouse. The fact, also, that Lord is a quantity-sensitive supplier (i.e., the more you buy, the lower the price) is of no consequence to these designers/engineers. Of course, Lord smiles quite happily, for they have their own staff of designers who rub their hands in glee when a new design is thrown at them.



Spinner/cowl alignment will tell you if mounts are deteriorated.

Spacer Spoof

In many instances, a "new design" goes no further than the spacer that separates the two "biscuits" (or "sandwiches," as Lord calls them). The spacer is probably the most inert part in the entire aircraft, once it is locked in—yet, millions of unnecessary dollars have been spent on dressing this metal spacer in rubber coatings (even in jelly packets) to create an illusion that vibration is effectively dampened. I have no doubt that designers and engineers can spout many expensive words in support of their handiwork, but it's doubtful (in my opinion) that many comparative flight tests with sophisticated vibration recorders were made in support of some of these drawing-board fantasies.

A good illustration of the Spacer Spoof stems from the FAA Parts Manufacturer Approval (PMA) issued to Barry Controls. Barry, which has long been in the "vibration isolator" business (but only recently moved in to challenge Lord in piston aviation) supplies one replacement shock mount kit that covers four (4) Lord mount applications. The four corresponding Lord kits utilize three different types of spacers, at least one of which has a rubberlike coating over the metal. The Barry replacement kit employs a plain metal tubing spacer, cut to proper length. From this, it must be assumed that FAA isn't at all convinced that "rubber coatings" and "jelly blankets" on shock mount spacers contribute to the function of the engine shock mount assembly. So. Can it be that these drawing-board beauties are more satisfying to the monetary taste buds than to the vibrating engine?

In defense of Lord, it should be noted that Barry did not have to kowtow to Wichita designers/engineers in putting their replacement mount kits on the market; they only had to convince the FAA that theirs was a product that would equal or better the original equipment. In criticism of Barry, they have not chosen to pass along much price relief to the owner.

It's interesting to note that Piper selected Barry—probably for the first time in its long association with Lord—to supply shock mounts for their Aerostar 600 series aircraft. Barry P/N 94011-1 (Piper 486-662) uses a plain little old metal tube for a spacer. (The Lord application charts for this aircraft call for their J-9613-9 kit, which uses a heavily coated spacer. In this instance, Barry happens to be about $30 a kit less, at the retail level, than Lord.)

One more point that ought to burst the rubberized/jelly-filled spacer bubble is the fact that at least Piper and Beech make available the "biscuits" as a separate entity, rather than forcing the purchase of a complete kit (with spacers, expensive washers, and other hardware). This can surely be interpreted as meaning that their engineers have no quarrel with the reuse of spacers. This in turn suggests that the spacer is rather insignificant as a functional part.

The point is that millions of aircraft-owner bucks have been channeled into the trash barrel in the belief that complete shock mount kits are needed where in fact the "biscuits" are all that's necessary.

Biscuit Availability

In defense of mechanics, it must be mentioned that the "biscuits" (sans

Norm Bender has sold more small aircraft engines—and Lord mounts for them—than any individual in the world. He is based at Memphis International Airport.

spacers) are not always available, and in many cases the complete kit must therefore be purchased. Supply houses rarely have the biscuits listed and available separately. The airframe people have joined the ranks of the inconsiderate, and (on most aircraft models) they no longer break the shock mounts out as individual component items—you buy the whole kit whether you need it or not. They just can't be bothered. The Lord people will probably be the first to agree that many reusable spacers and expensive washers are relegated to waste—at the aircraft owner's loss.

There is a way to beat the game. Over the years, Norm Bender Inc. has researched the situation, and passed word on to Linda Lou Inc. (our parts arm), to obtain many of the commonly used biscuits as separate items. In other instances, very expensive kits (some costing close to $1,000—for just one engine installation) can be bypassed by buying combinations of much-lower-priced kits, and breaking them down into individual components—either to sell as biscuits only, or reassemble into kits as necessary. A good example is the Piper shock mounts, which covers a great number of their models. Bender bought thousands of these individual biscuits when Piper was retailing them for around $12—and that was just five years ago. Today, Piper asks about $35 for each of these biscuits, and they carry only a token discount (even to distributors). Linda Lou can supply these same mounts to the owner for three bucks *less* than a Piper distributor pays to get them. But you know what? Most Piper dealers and distributors *still buy from Piper*. And you know what else? Many Piper owners buy from these same dealers and distributors at the $35 price (or perhaps even more of a markup). Or, they're told they have to go for the full kit, at even greater cost.

You can see why I buy Lord mounts from Linda Lou!

Poor Maintenance Practices

It is a crying shame, and another travesty to owners wallowing in their naivete, that many—too many—mechanics and repair stations knowingly reuse engine shock mounts at an engine change. There are several reasons for this abandonment of responsibility, the main one being ignorance, which is also the most difficult to counteract. Another is lack of planning in the installation. (This is where the first thought of new shock mounts—and new bolts and nuts—is when the replacement engine is ready to be hung.) New mounts aren't readily available? Heck, let's wipe off the old mounts with a little Angry All and slip 'em back on . . . Who's going to know or care? What does it matter if the engine droops a little at the nose? A couple of washers on the bottom bolts will get that spinner up off the cowl, at least until it's a few hours out of the shop.

You probably think I'm making all this up.

I'll tell you the *biggest* reason (other than ignorance) for people willfully reusing shock mounts, though, which is the *unbelievable cost* of this item—unbelievable even in an industry where costs are passing beyond astronomical, to the realm of fantasy.

Sources:

Barry Controls Div.
Barry Wright Corp.
2323 Valley St.
Burbank, CA 91505
818/843-1000

Aerospace Products Div.
Lord Corporation
1635 W. 12th St.
Erie, PA 16514
814/456-8511

Vibration Isolation Products Corp.
Box 7029
Burbank, CA 91510
818/896-1191

Linda Lou Inc.
Box 30343
Memphis Intl. Airport
Memphis, TN 38130
1-800-824-9912

Too many A&Ps and repair stations are reluctant to spring the shock of the cost of new mounts on their prospective customers. They're afraid (understandably) that the customer will think "ripoff" and take flight. If those old mounts are not concrete-hard, or fatigue-cracked like a 20-year-old AT-6 tire that was surplus to begin with, they just might spring back to life if soaked in lemon juice, or linseed oil, or horse-pee, or some other exotic elixir that will generate erection in the rubber. I'm sorry to say, no way. It just ain't part of the process, son. And the most tragic part of this whole scene is that the naive owner, looking for a way to lessen the

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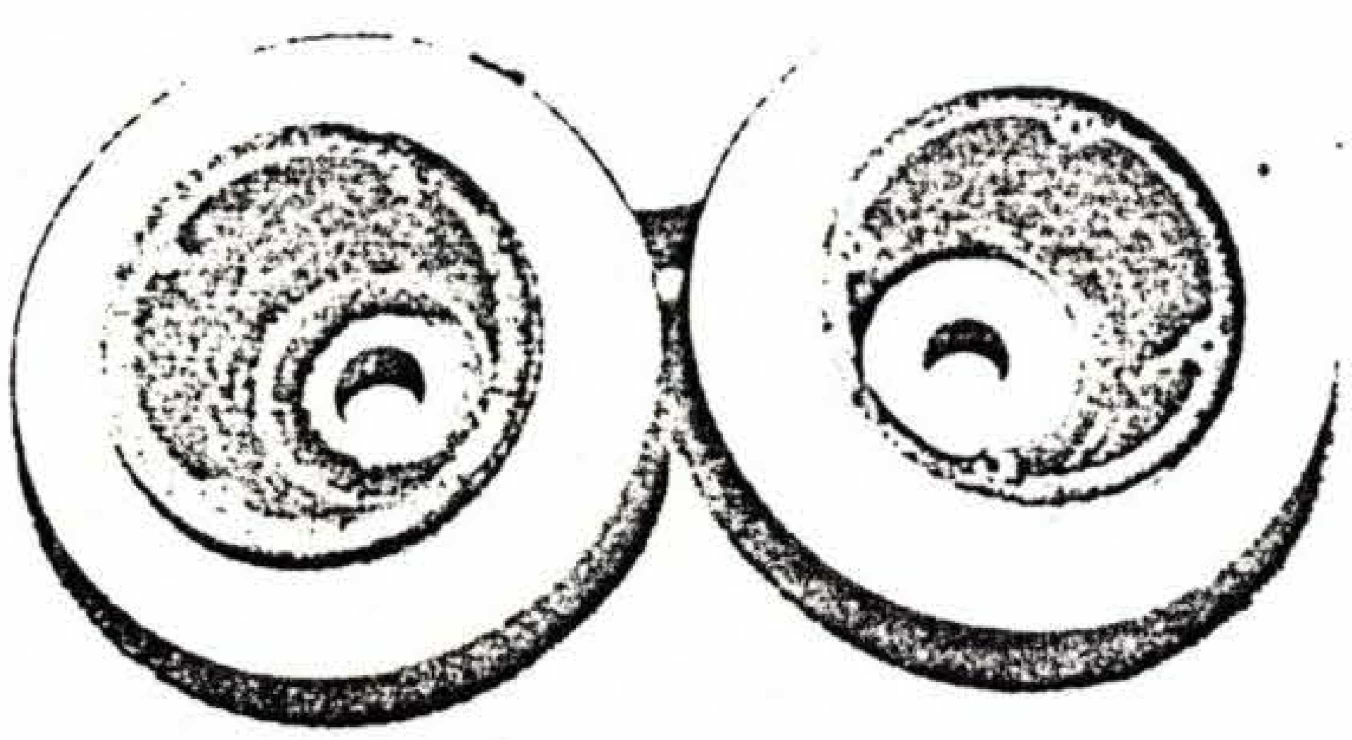
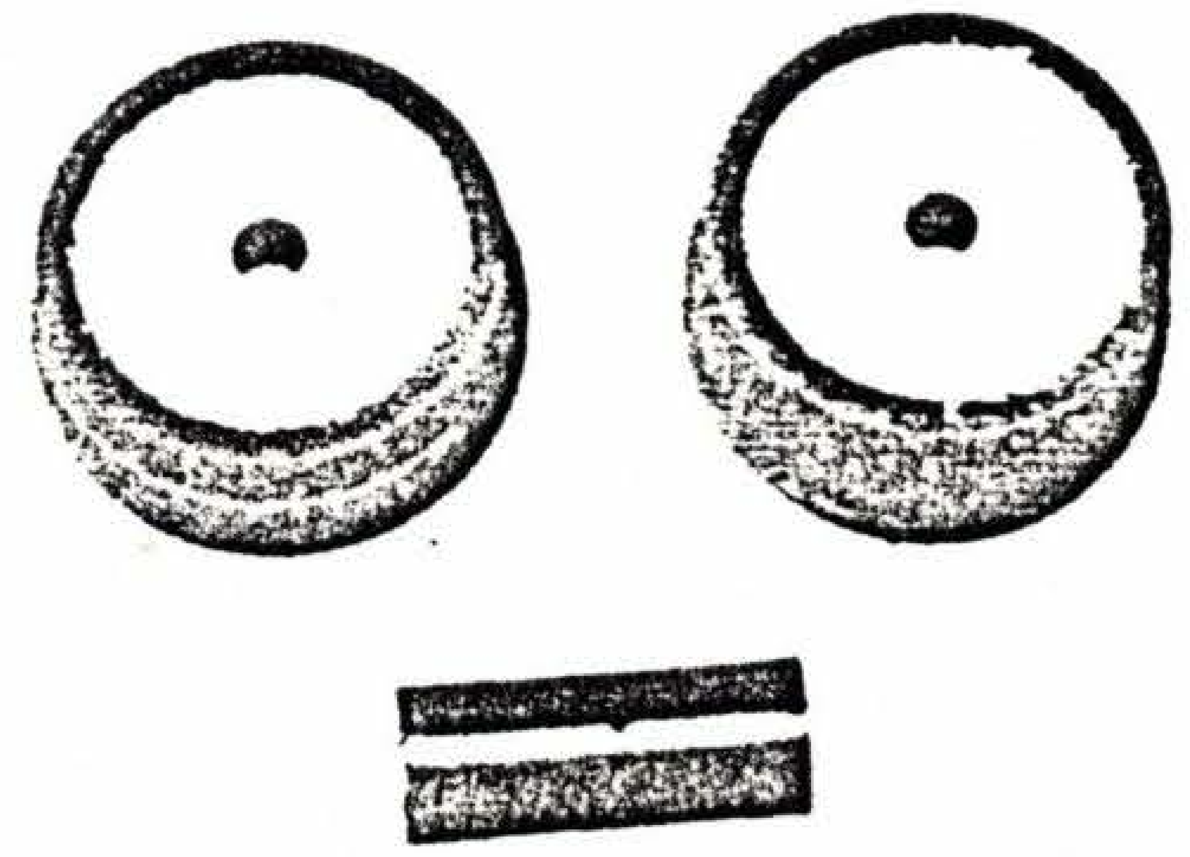


Lord mounts, unlike ordinary conical mounts, are hollow inside. The two halves are metal-backed.



Short spacer tube bolts between mount halves. This assembly (for a Cessna T303) costs $110—and you need four per engine.

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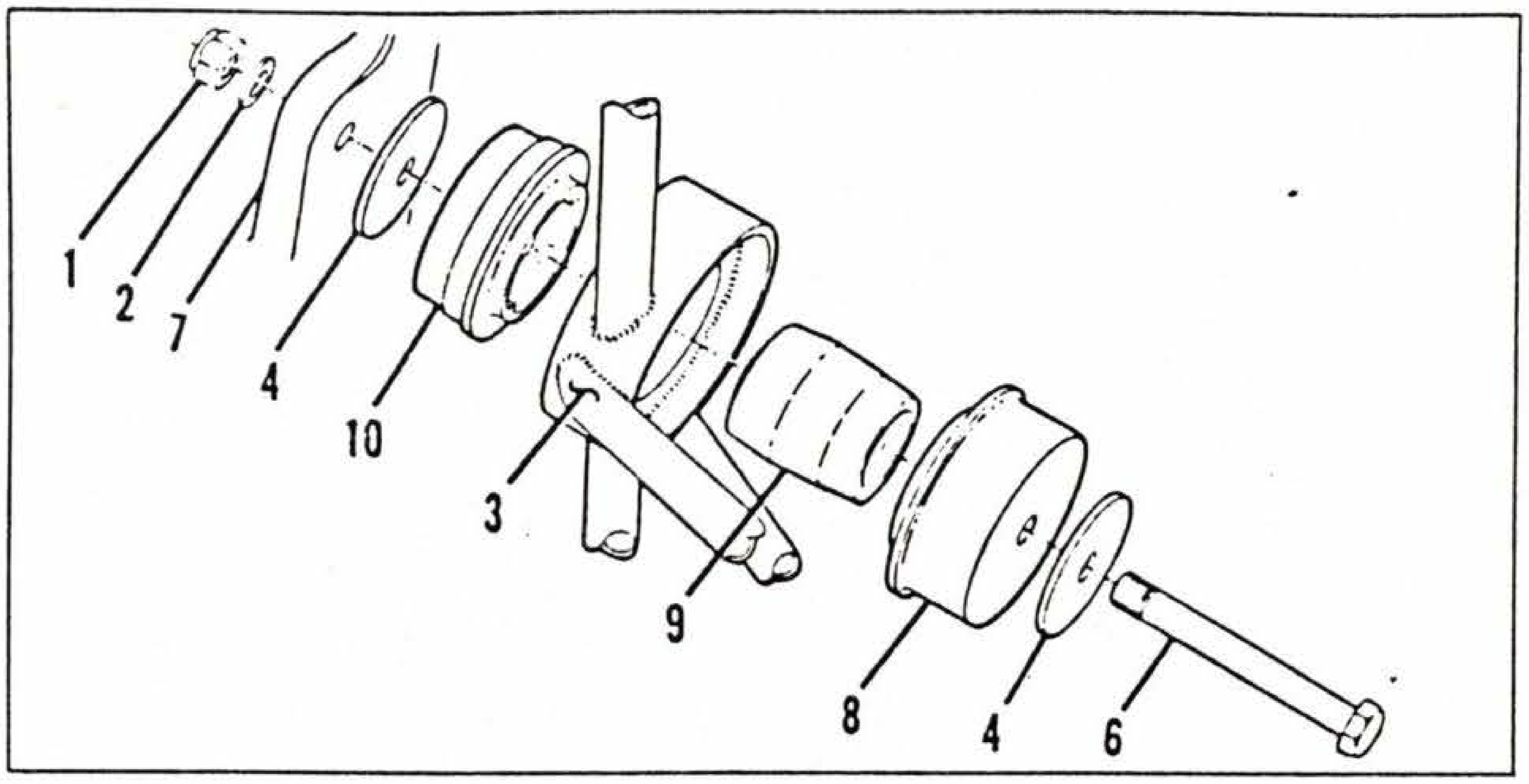
trauma of an already excruciating pressure on the hip pocket, is generally glad to hear this music. If it's good enough for his mechanic, it's good enough for him (or her).

Let's get some facts straight. Once a set of mounts has been installed and torqued into final position, the biscuits quickly begin to take a "set." At the same time, the engine compartment temperatures (and fumes) go to work on the rubber, attacking its resiliency. The vibrations generated by the engine immediately get to their job of destruction. Consequently, once the mounts have been installed and the aircraft operated for a few hours, the mounts should not be reused if they are ever taken out again. In fact, our philosophy is that if the mounts were installed on Tuesday, do not reuse them if they have been in position longer than the following Thursday.

This philosophy is not designed to sell shock mounts for Lord, Barry, or VIP (just as Lycoming's and Continental's TBOs are not for the purpose of selling more engines—in spite of some journalistic inferences to that effect that appear from time to time). Rather, it's our belief that once the mounts have been compressed to their working position and have begun to take a set (under hundreds of pounds of pressure), they probably will not resume their original shape and position once torque is released. And it's just as unlikely that they'll resume their previous position under the same torque values that were applied when they were in virgin status.

Crankshaft centerlines, both horizontal and vertical, are difficult to establish and maintain under the best of conditions. The centerlines drift, or stray, or tend to get cattywampus when shock mounts begin to give up the ghost. The effects of these out-of-line conditions can be numerous, and quite obvious when you know what you're looking at. Many accessory failures have resulted from the loosening of attaching hardware caused by increased tempo of engine vibrations permitted by dying shock mounts. A lot of finger-tingling cockpit vibrations immediately disappear when *new* shock mounts perk a droopy engine back into its upright position.

Every pilot, owner, or operator should *personally* take a look—and lay hands on—the shock mounts of his or her aircraft every few hundred hours



A typical Lord mount installation (for O-320-H) is shown here. When all four mounts point at engine c.g. the installation is dubbed "Dynafocal."

[Many manuals, such as the Beech 35 Shop Manual, recommend periodic rotation of mounts—Ed.], and especially after 1,000 hours. If the mounts begin to show a resemblance to Ronnie Coleman's girlfriend's face after departing Shangri-La, one should heed the message!

Bolts and Nuts

Too few "mechs" in this industry make it a ritual to replace the bolts and nuts that are loosened and removed from high-torque positions, especially if their service life has been long and arduous. This is particularly true of engine shock mount bolts and nuts. Once these bolts have been subjected to the stress and tension they were designed to withstand, they will probably have stretched dimensions and some degree of fatigue. It is a disservice to the owner of an aircraft to reuse this relatively inexpensive hardware when new hardware is available. *Plan ahead* and order new hardware.

Most aircraft manufacturers utilize standard AN or MS nuts and bolts. Beech mostly uses (M), as in Magnafluxed, bolts and nuts. Both Beech and Piper use some special, or funny-looking, nuts, and it is rare that their dealers or distributors can supply these items off the shelf. Consequently, many installations go back together with the *old nuts*, or—if they've been tossed into the garbage pail as soon as they were removed (as is too often the case)—any nut that fits and is on hand might be used. Many aircraft are blithely flitting about the skies with shock mount nuts of the fiber locknut variety—which is hazardous to all concerned.

Linda Lou Inc. can generally supply an engine set of *new bolts and nuts* as specified by the airframe manufacturer (even the exotic bolts that Beech is now listing). Many applications use different length bolts at different engine mount positions. This should be checked before ordering. The parts catalogs, especially in Beech's case, are quite unreliable when calling out the bolt that may actually be installed on the aircraft. Unlike most supply houses, Linda Lou actually has these items on the shelf and can usually ship same day. Not many parts houses can honestly make that claim.

Enough commercializing. Where you buy your parts from is not the important point here. The point is, if you need new parts, act. No one's going to take ultimate responsibility for the situation (under FAR 91.163) but you.

MAINTENANCE TIP OF THE MONTH: HYDRAULIC FLUID TEST

In any piece of gear that uses hydraulic fluid (oleo strut, brake cylinder, etc.) it is essential that the fluid be fresh—not burnt, discolored, or acidic. MIL-H-5606 doesn't "wear out," per se, but it does undergo chemical changes in service. To check your hydraulic fluid to see if it's good, place a small sample of it in a nonmetallic container and stand a piece of polished copper in it. Keep the copper in the fluid for six hours at 70 degrees Fahrenheit (minimum). Then remove the copper and examine it. If pitting, etching, or chemical attack is evident, the fluid is bad and should be discarded.

Oil Fouling: Its Causes and Cures

One of the best engine-trouble-shooting tools in any pilot's (or mechanic's) arsenal is the 7/8-inch deep socket—the kind you use to remove spark plugs. Checking the firing ends of a set of plugs immediately after a flight can give an excellent picture of an engine's state of health, especially if the plugs are arranged by cylinder order in a plug tray. Errant cylinders stand out immediately.

But what does it mean when one or more plugs look like they've been dipped in hot tar? It means the plug in question is oil-fouled, of course, but that doesn't really tell you very much about how it got that way.

Oil wetness on the electrodes of *top-hole* plugs is usually a telltale sign of blowby (from excessive ring wear or barrel wear). In an engine that's burning excessive quantities of oil (a quart an hour or more), this is generally a foolproof way to spot problem jugs.

Oil on *bottom-hole* plugs is not necessarily a sign of trouble, since gravity puts a considerable amount of oil on bottom plugs in normal operation. Also, piston rings (which rotate in normal operation) will sometimes line up in such a way as to slosh oil onto bottom electrodes. Just the brief taxi-in and shutdown period is enough to leave unburned oil on many bottom plugs.

What's worrisome is the consistent finding of wet plugs in *both* locations (top and bottom) in a given cylinder. In a flat engine (horizontal/opposed), this means a jug with blowby and/or compression problems. (Radials are another story: the bottom cylinder is going to be wet almost all the time, and both plugs will show it.)

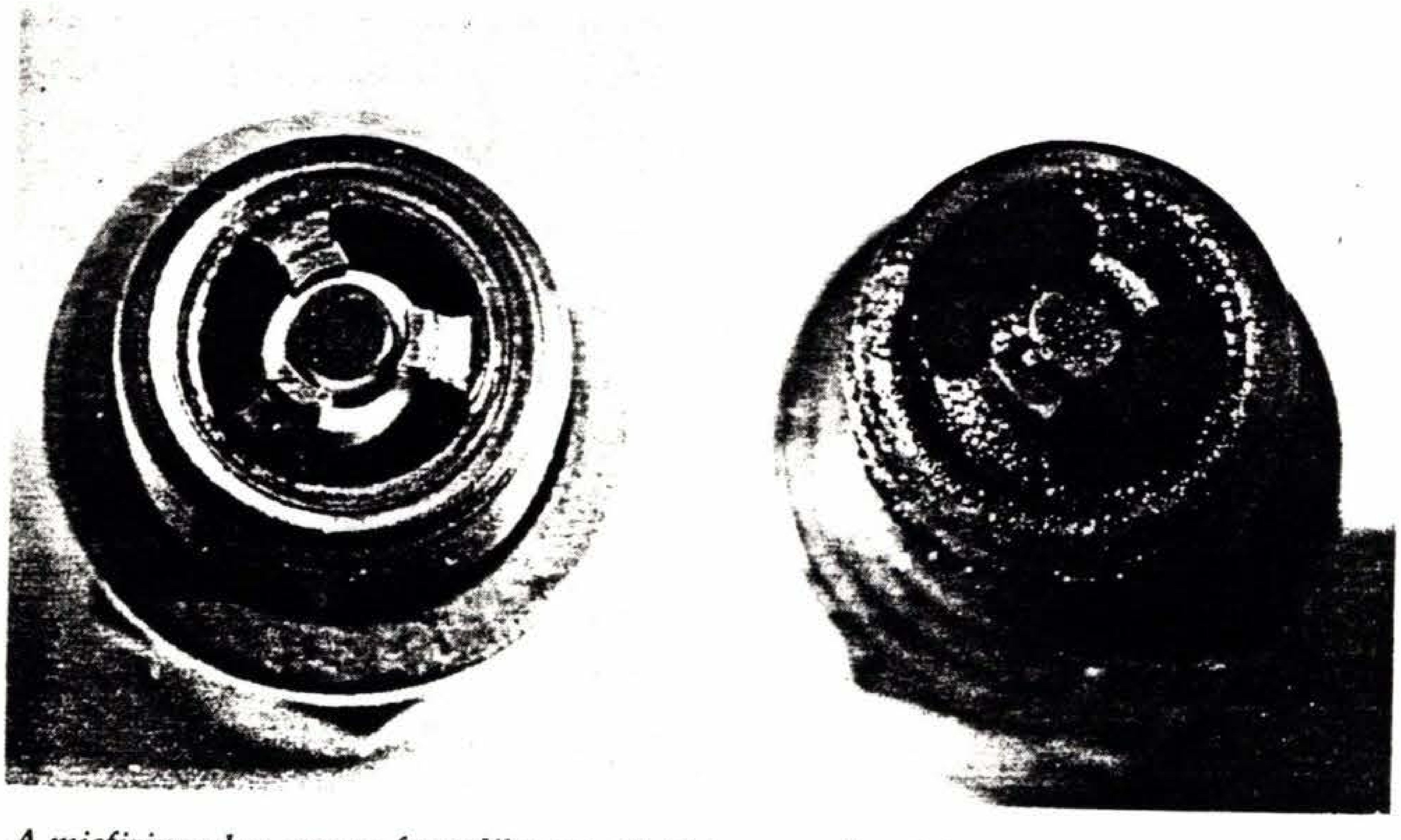
It's important to remember, however, that plugs not only foul out when they get too oily, but *they get oily when they foul out*. Suppose you have a plug that's firing weakly for one reason or another (it needs cleaning; somebody dropped it on the ground; the cigaret spring is corroded; moisture is trapped in the "all-weather" connector). You notice that the engine runs rough during the pretakeoff mag check, when the left mag is selected. You taxi back in, and—lo and behold—the top number-three plug is oily.

The plug could be oily because it was firing intermittently; cold plugs tend to oil up, and the finding of a wet number-three top-hole plug (when cylinder compression is known to be good, and the engine is not burning oil) should tip you off to a possible ignition problem. Before suspecting a cylinder defect, clean the plug and bomb-test it; inspect the terminal well; dress the cigaret spring (with a jeweler's file); and (if possible) check the ignition lead for insulation breakdown.

Among the odd causes for plug oiliness we've seen over the years are:

1. Failure of owners or mechanics to clean the *firing cavity* of a plug (with a vibrator or a sharp instrument) as well as the electrodes themselves. The firing cavity accumulates hard, BB-like globules of lead, and splotchy lead-carbon deposits, over time. Eventually these deposits can cross the ceramic insulator and bridge the grounded and ungrounded sides of the plug. Since the deposits are only weakly conductive, and may form and break off in operation, the result can be an intermittent plug.
2. Plugged injector nozzles (in fuel-injected aircraft). Poor fuel flow to the cylinder causes low combustion pressure and ineffective ring sealing.
3. A burned terminal spring (or ignition wire terminal pin) at the magneto outlet. (Remove the outlet cover plate screws and visually inspect all terminals for burning/corrosion.)
4. A bad ignition wire.
5. Inactivity. (We once wondered why the odd-numbered cylinders on the left engine and the even-numbered cylinders on the right engine of our Cessna 310 would foul plugs so quickly, until one day we pulled plugs "cold"—without running the engines—and watched oil drain out of the bottom spark plug holes in the above-mentioned cylinders. The 310's engines are canted, and during inactive periods, oil flows to the low point in the lowest cylinders.)

The point is: Don't do a top overhaul simply because a few cylinders' plugs look oily. *All* of your bottom plugs will oil up if you idle your engine long enough, and top plugs can get oily for reasons other than blowby. Free your mind before you go troubleshooting. You'll come out way ahead.



A misfiring plug can go from like-new (left) to severely oil-fouled (right) in a matter of hours, or even minutes. If both of a cylinder's plugs look badly oil-fouled, suspect jug problems; if only one plug is oily, suspect ignition problems.

ARTICLE OF THE MONTH

#54F .05

Methods of Safetying

Vibration is a real concern in aircraft maintenance, and there must be some provision for safetying or locking all fasteners to prevent their vibrating loose in flight.

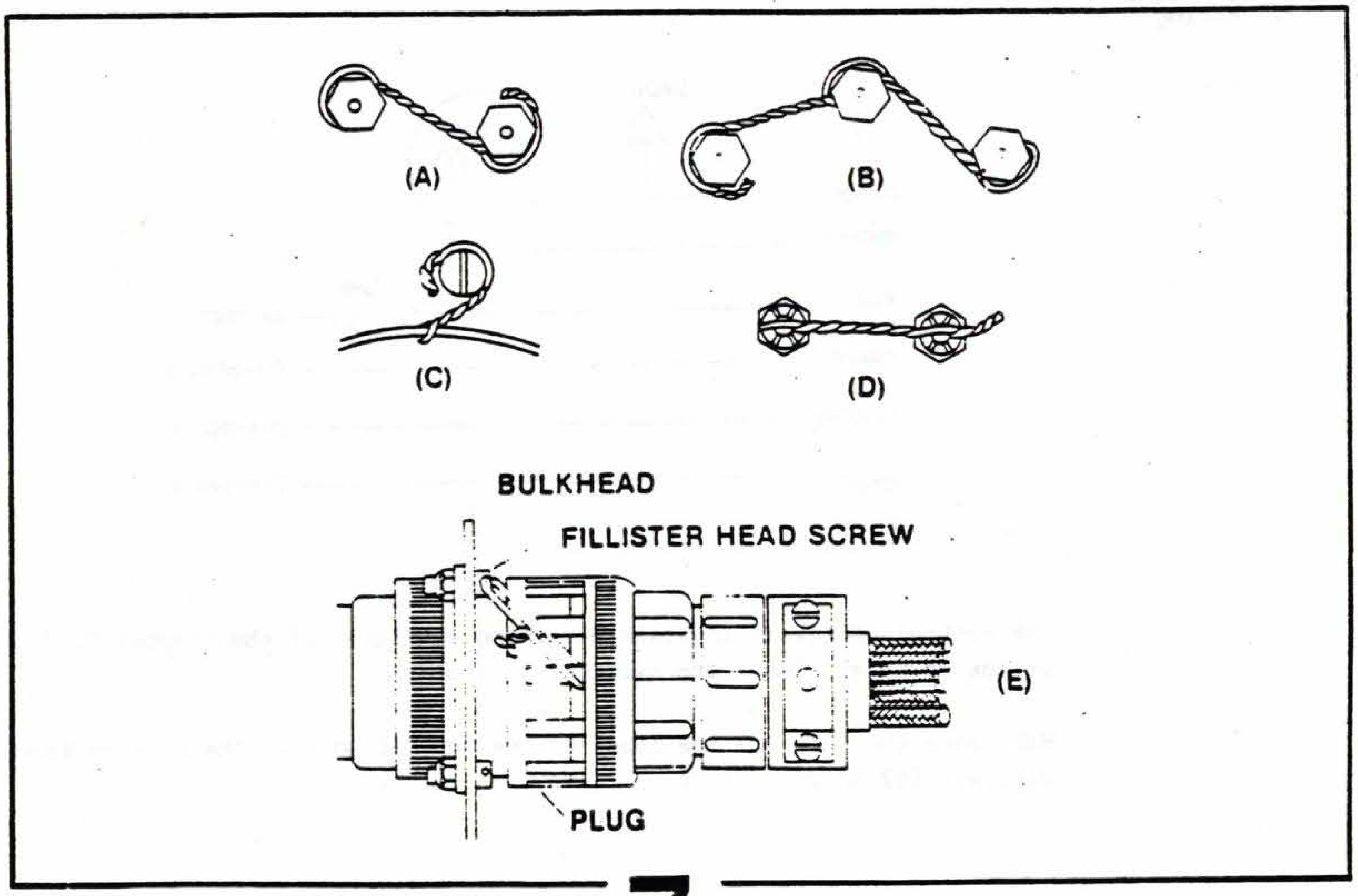
Self-locking nuts are used for the vast majority of applications in modern aircraft construction, but there are still places where safety wire or cotter pins are needed. In Fig. 1 we see some of the typical uses of safety wire. In Fig. 1A we see two drilled-head engine bolts safetied together. The wire should pull the bolt head in the direction of tightening and should be twisted with an even twist to the next bolt. After the end of the wire is passed through the head of the second bolt it is again twisted, this time for about three or four turns, and the wire is cut off. Always bend the ends of the wire back where they cannot cut you when you pass your hand over the bolts.

If there are a number of bolts, such as used to mount a propeller, you may safety them in groups of three. It is usually not a good idea to tie more than three together with one piece of wire, Fig. 1B.

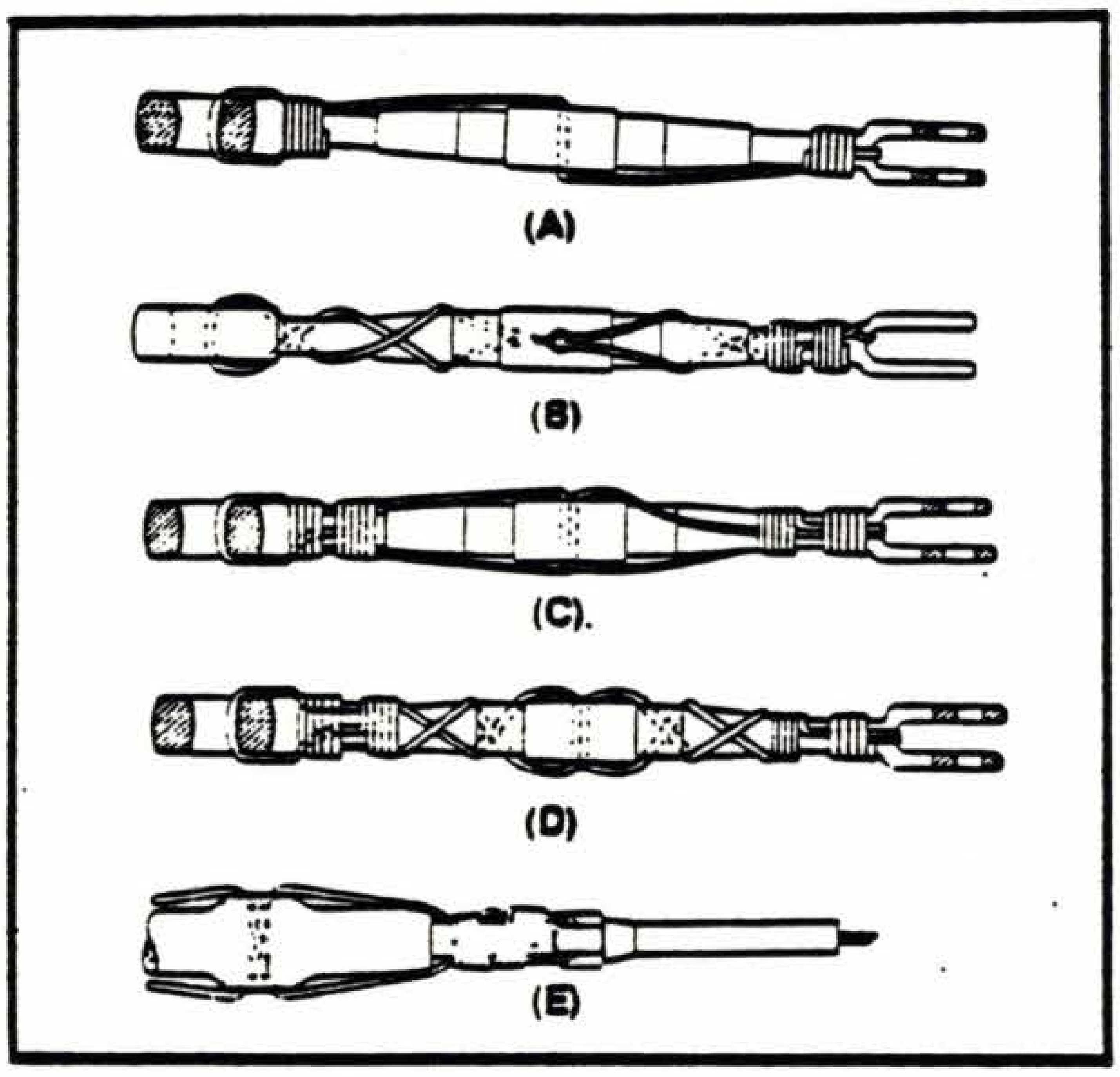
Fillister-head screws are safetied to holes in a housing in much the same manner as the drilled head bolts, Fig. 1C. Remember, anytime safety wire is cut off, the ends should be bent back so they cannot cut your hand.

Studs should not have self-locking nuts used on them nor should drilled studs be safetied with cotter pins, because neither of these safetying methods will prevent the stud backing out of the casting. Fig. 1D shows two drilled studs with castellated nuts safetied together with safety wire. This prevents the nut becoming loose, as well as preventing the stud backing out of the casting.

Electrical connectors can be safetied to drilled-head fillister-head screws. Be sure that the wire pulls the plug in the direction of tightening, Fig. 1E.



Turnbuckles may be safetied in a number of ways. Those used in control systems where the cable is 1/16- or 3/32-inch diameter may be safetied by the single-wrap method, Fig. 2A, using either brass or copper safety wire, 0.040 diameter. Turnbuckles used with 1/8-inch cable may be safetied with a single wrap if 0.040 stainless steel or monel safety wire or 0.057 copper or brass wire is used. Forty-thousandths-inch copper or brass wire may be used if the turnbuckle is double-wrap safetied.

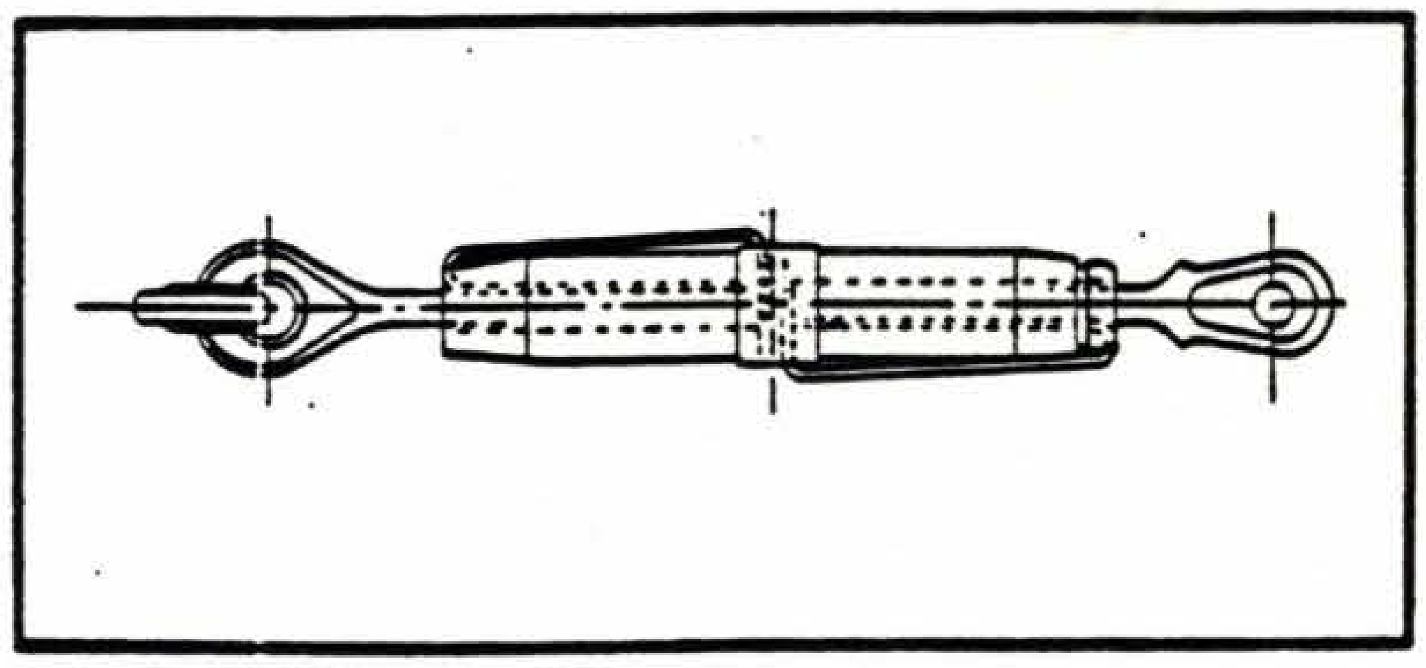


CABLE SIZE	TYPE OF WRAP	WIRE DIAMETER	MATERIAL
1/16	Single	0.040	Brass
1/8	Single	0.040	Stainless Steel
1/8	Double	0.040	Brass
5/32	Single	0.057 (min)	Stainless Steel
5/32	Double	0.051	Brass

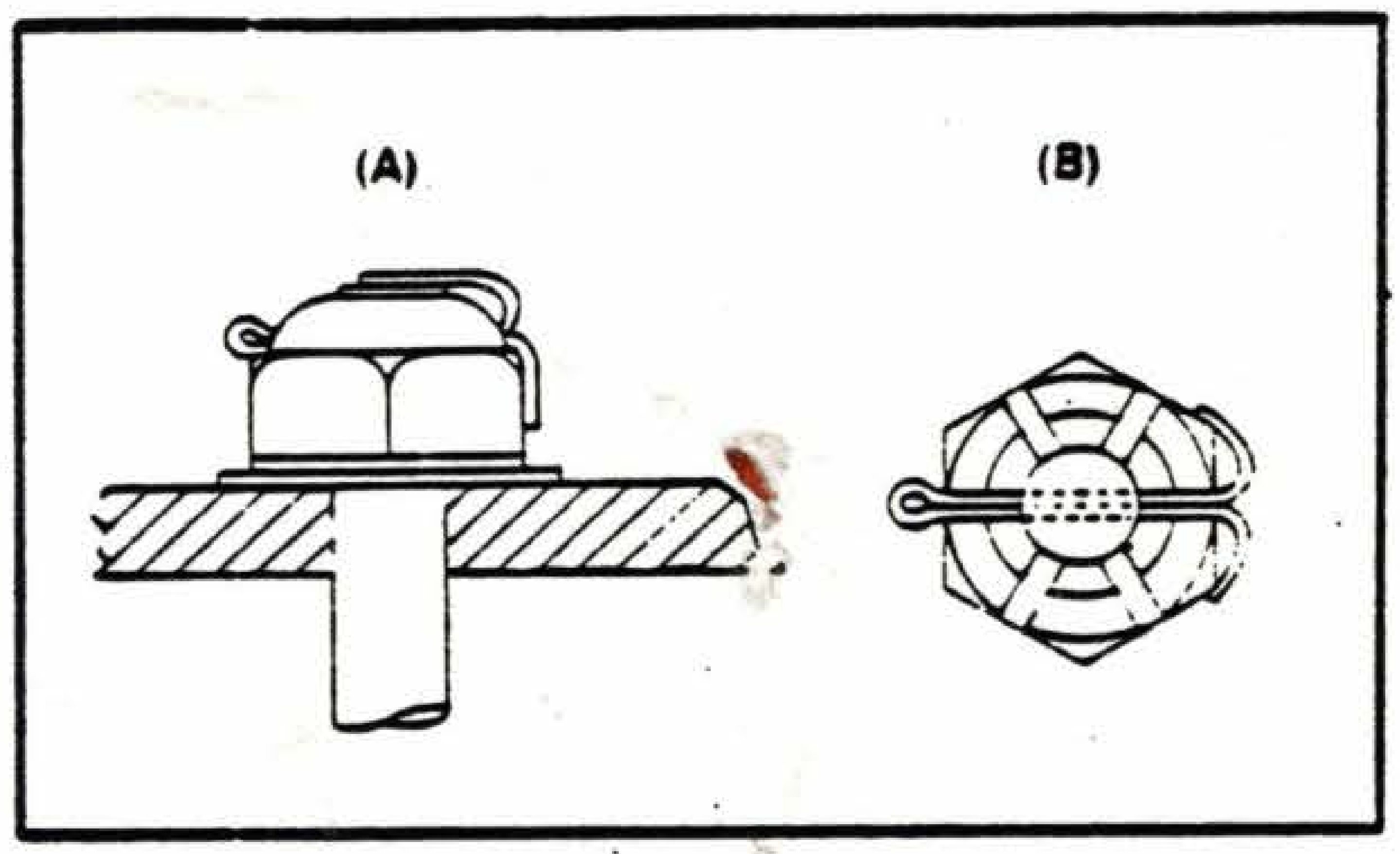
Turnbuckles in 5/32-inch control cable can be double-wrap safetied with 0.040 stainless steel or 0.051 copper or brass, or they may be single wrapped with 0.057 stainless steel wire.

Before safetying a turnbuckle, it must be adjusted to the correct cable tension, and there must not be more than three threads showing on either side of the barrel. Wrap the wire around the turnbuckle in the manner shown in Fig. 2 and finish the safety wiring with at least four turns around the shank of the turnbuckle before it is cut off.

Clip-type locks such as those seen in Fig. 3 may be used in place of safety wire if the turnbuckle barrel is drilled to accommodate this type of clip.



Cotter pins may be used to lock a castellated nut onto a drilled-head bolt by either of the two methods shown in Fig. 4. The method in which



one end of the pin is bent over the top of the bolt is the preferred method. In either method, when the ends of the cotter pin are cut off, be sure that they are bent back so they cannot cut you if you rub your hand over the end of the bolt.

The excerpt for this month's Technical Library was taken from ITP-G, Book 5, Section 1, Aircraft Hardware, published by Aviation Maintenance Publishers. For a free book catalog write: Aviation Maintenance Publishers, P.O. Box 890, Basin, WY 82410.

Light Plane Maintenance™

VOLUME V, NO. 11

NOVEMBER 1983

Engine Break-in After Top Overhaul

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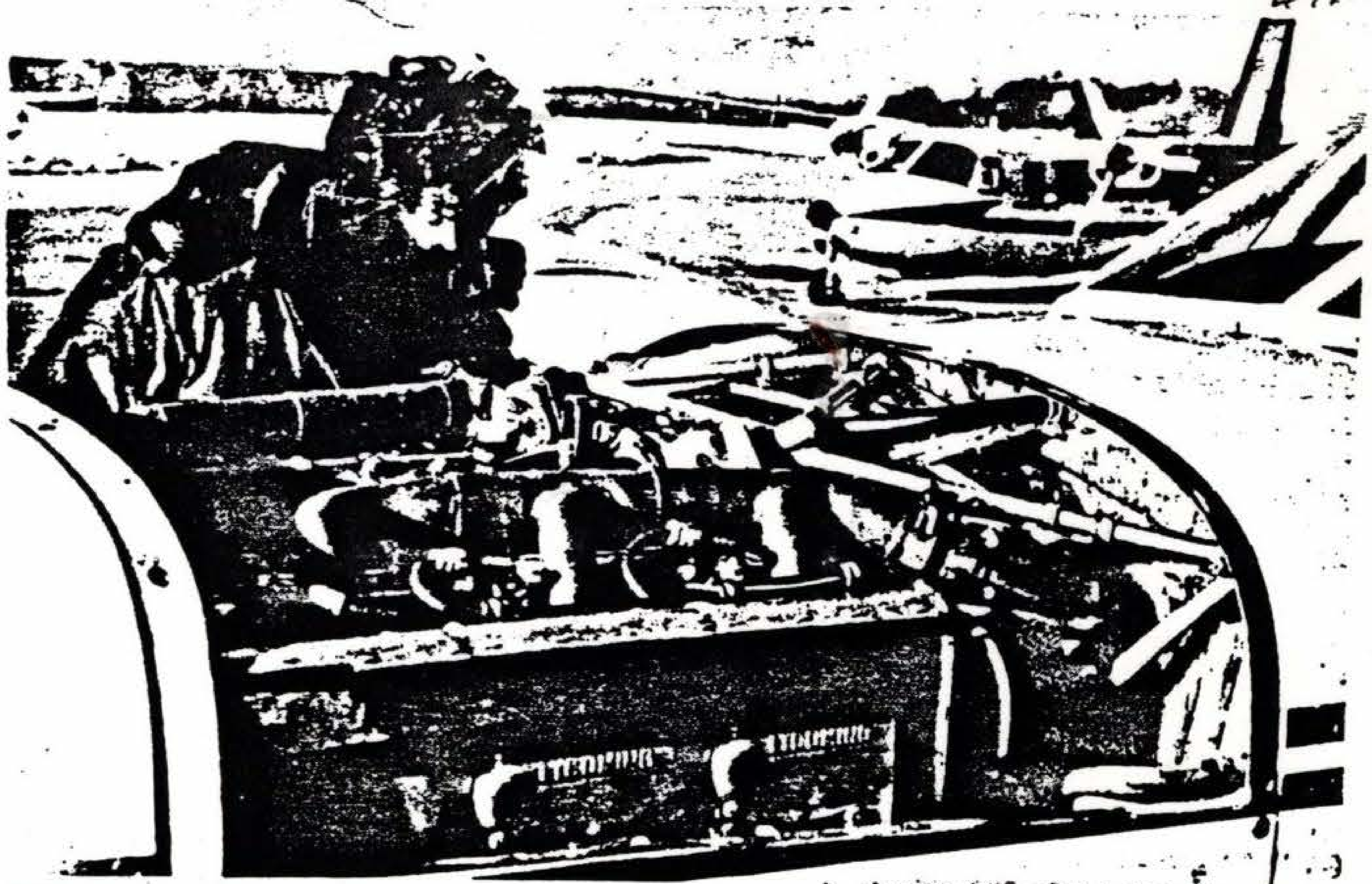
Not everyone is going to own his or her plane long enough to have to break in a new engine, but most of us—sometime, somehow—are going to face the prospect of a top (or partial top) overhaul. The question is: How does one "break in" an aircraft engine after, say, a ring job on two cylinders? Do you switch to mineral oil? Should you keep using ashless dispersant oil, but fly at high power settings? (How high is high? Full throttle? Top-of-the-green?) How long should it take to "seat" a new set of rings? How do you know when an engine has finally broken in?

First things first. Whenever any cylinder is reworked—for valves, guides, barrel deglazing, or whatever—the rings should be 100-percent replaced (with darn few exceptions). And whenever rings are re- [illegible], the new ones need to be broken in. [illegible] effect, you need to break in your engine all over again . . . even if only one cylinder has been reworked.

What exactly is "break-in"? Basically, it's nothing more than the wearing away of the highest high points (microscopic ridges in the metal that look like mountains under magnification) on the surfaces of any two metal pieces that rub together. In a chrome cylinder, you're wearing cast-iron rings against a chrome-surfaced barrel; in a steel jug, you're wearing chrome-faced rings against a steel barrel.

During break-in, the very high pressure on the individual metallic ridges, as they come in contact, effectively ruptures the oil film that separates them. The resulting friction causes the highest ridges to melt and flow (or weld and unweld) in such a way as to conform to each other; the metal parts "seat" to each other. Paradoxically, an oil with anti-scuff agents (or super-high-film-strength lubricants) in it actually interferes with break-in, by preventing metal/metal contact. For this reason, it's important that molybdenum disulfide, zinc dithiophosphate (ZDP), TCP, and other "extreme pressure" or boundary lubrication additives not be used for break-in. (Many shops [illegible]ingly use STP, which contains ZDP, [illegible] buildup oil to coat engine parts on [illegible]sembly. This is probably a bad practice, and may be why some 3 out of 10 aircraft engines fail to break in completely after overhaul.)



With larger engines especially, break-in is a critical process. (Shown here is a Lycoming TIO-540-S1AD in a Piper Turbo Lance. Note unusual top exhaust.) Even if only one cylinder has been topped, it pays to run the engine hard for the first 10 hours. Mineral oil should be discontinued as soon as top spark plug(s) begin to run dry and grey/white.

The oil to use for break-in is straight, unadulterated mineral oil. Texaco mineral oil is said by some mechanics to contain the fewest additives; but Aero Shell in the red can is also an industry favorite.

There are exceptions: Some engines (e.g., Lycoming O-320-H, TO-360-C, and TIO-541 series) must start out on ashless dispersant oil, to ensure adequate lubrication of critical valve and/or turbo parts. (See Lycoming Service Bulletin No. 318, and Service Instruction 1014.)

Merely flying on mineral oil does not

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guarantee good break-in; high cylinder mean effective pressures are also needed to promote rupture of the ring/piston oil film. Translated, that means you have to fly at high power settings.

From the moment a fresh cylinder is put into service, the minute valleys in the surface of the metal begin to fill up with varnish (cooked oil). When the valleys overflow with varnish, the metal acquires a smooth, "glazed" surface, rendering further break-in difficult, if not impossible.

If you think about what's going on, it should be fairly evident that the process of ring seating is actually a race between the countervailing forces of ridge wear-down, on the one hand, and varnish accumulation, on the other. The kinetics of these two processes determine whether you end up with glazed cylinders (and 3-hrs/qt oil consumption), or good ring seating (and dry-running cylinders).

Most aircraft engines have two compression rings, an oil control ring, and (in some cases) a wiper ring below the wrist pin. Optimum oil control depends on proper break-in of all three (or four) rings. But notice what happens when you put a fresh set of rings in service: The top ring, naturally, is exposed to the greatest combustion pressure. The normal pathway for escape of the pressure is for gases to travel *behind* the ring, then down to the next land or groove; then around the inside of *that* ring, and down again. The net effect is that the lower-two compression rings "feels" only about 40 percent as much pressure as the top ring; while the oil-control ring may feel only a *tenth* the pressure of the top ring. Also, there's a corresponding temperature gradient: The top ring runs hot, the second ring a little less so, and so on. What this means, of course, is that the top ring breaks in preferentially over the remaining rings in the set.

The top compression ring is going to break in no matter how you operate the engine (within reason). *But the downstream rings may never break in, if they fail to be exposed to high pressures and temperatures.* This is why overhaulers tell plane owners not to "baby" their engines during break-in—especially low-compression types, which barely produce enough pressure below the top ring to favor good break-in even at 75 percent.

The fact is, if you insist on performing lengthy or repeated ground runs prior to your first post-overhaul flight, you'll only hasten the formation of cylinder varnish, while creating conditions that favor the break-in of your top compression rings *to the exclusion of all other rings*. The country's largest overhaulers recommend the following procedure:

1. Pre-oil the engine before startup, in accordance with manufacturers' recommendations. (If OAT is below freezing, preheat engine and oil.)
2. Keep ground running to a minimum (5 minutes max).
3. Don't cycle the prop.
4. Take off at full power, noting rpm, oil pressure.
5. Leave cowl flaps open. Do not reduce power to below 80 percent.
6. Climb no higher than 5,000 feet. Fly around the airport at *no less than 75 percent power* for an hour.
7. Land and check oil consumption.

How do you know when the engine has broken in? Initial ring seating should occur within the first 15 minutes to two hours. (Thereafter, cylinder head temperatures will stabilize—but remember, your factory CHT is wired to only one cylinder.) Final break-in—signified by stabilized oil consumption—should come in 50 hours.

"If oil consumption hasn't stabilized in 100 hours," says a spokesman for a respected east-coast overhaul shop, "further action—possibly deglazing of the cylinders—is called for."

Not all engines break in at the same rate (chromed jugs take a little longer than steel, for example), nor with the same degree of success. Such engines as the Lycoming O-360-A series with nitrided jugs can be counted on to break in properly, within 50 hours, in a high percentage of cases. On the other hand: "About three out of every ten O-470s we rebuild come back with break-in problems, typically high oil usage," reports one east-coast overhauler. "It has to do with ring design and operator practice, we think."

Overhaulers stress one point over and over again: Owners should not fly at reduced power during break-in. "It's the most frequent problem we have," says one A&P. "Guys are afraid to run at 26-square, or at redline. These engines are built to run wide open. But just try to convince an owner of that."

Some Continental factory reps even recommend leaving the throttle firewalled on climbout, and reducing prop rpm only. (This is for low-compression, normally aspirated models.)

"Basically, you can operate your manifold pressure and rpm anywhere where there's not a red line on the gauges," remarked one engine man. "Frankly, I wish more pilots would take this to heart." □

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Top Overhaul Facts and Fiction

By Kas Thomas

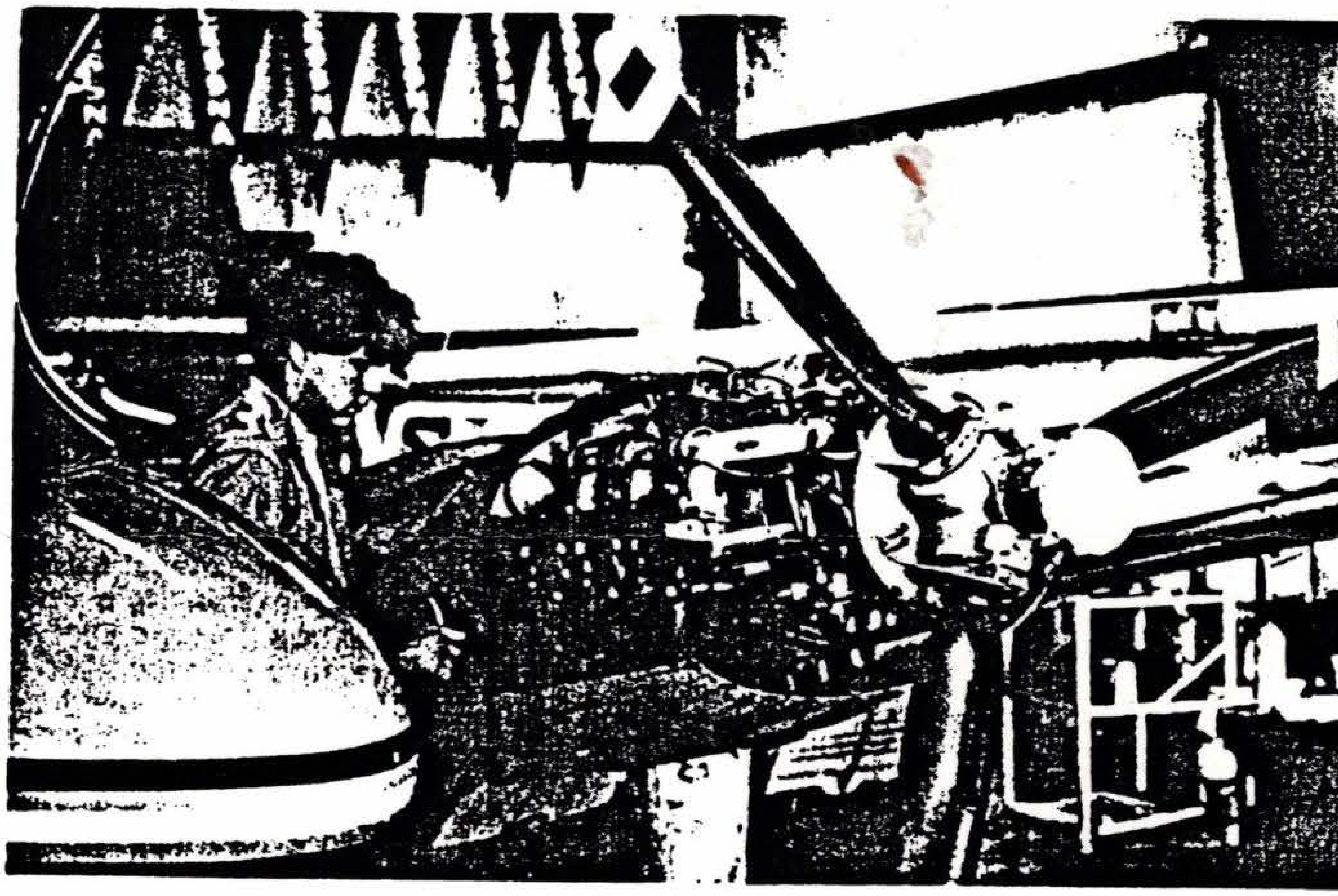
The "top overhaul" is to aircraft maintenance what the coronary bypass is to medicine: a costly, controversial procedure designed to prolong life or forestall the inevitable, depending on your point of view. The cost is high, the outcome uncertain. To be sure, the top overhaul (or "ring and valve job," in automotive parlance) has its place in aircraft maintenance. But it's also one of the most oversold procedures in aviation. Got a low jug? "Let's top it," the mechanic says. On inspection, the cylinder is beyond limits. Want to grind it oversize? Okay. "But if we grind *one* jug oversize, you really should do the others, too." (Another famous sales pitch: "You know, there really isn't that much additional labor to do all four cylinders, as opposed to just one . . .")

Some operators are doing top overhauls prematurely, and there's little doubt that many of these are a waste of money. But some operators are utilizing the top overhaul as part of a carefully considered game plan for extending TBO (time between major overhauls). The market for the "TBO-extension" top overhaul, in fact, seems to be growing rapidly. Many of the questions we get in the mail—and on the phone—these days run along the lines of: "Should I major the engine at the factory-recommended TBO, or should I top it now and try for TBO-plus-400?" And: "If I top it, when should I top it?" "What should a decent top consist of?" "Who should do the work?" "How should the engine be broken in?"

These are not easy questions. They're a bit harder when you're cheek-to-jowl with Mr. Goodwrench, however. It's best to have the answers in advance.

Definition of Terms

The term "top overhaul" means many different things to many different people. In some quarters it means pulling the cylinders off, inspecting them, repairing them as needed, and putting them right back in service with as few new parts as possible. To some, it means a complete ring and valve job, to new limits, for every cylinder. To still others, it means reworking just the jugs that need to be reworked. (Everybody agrees on one thing, which is that the word "top" in "top overhaul" refers to the cylinders and reciprocating parts of an engine, as opposed to the "bottom end," which consists of the crankshaft, camshaft, crankcase, main bearings, oil sump, oil pump, and gear train.)



PHOTOGRAPHY BY THE AUTHOR

Because of the higher operating temperatures, turbocharged engines—such as the Seneca's Continental TSIO-360—need more top-end attention.

Broadly speaking, then, a "top overhaul" can be considered any operation that results in removal of one or more cylinders and the refurbishment (if not the actual replacement) of worn top-end components. As such, it has its counterpart in the turbine "hot section" inspection,

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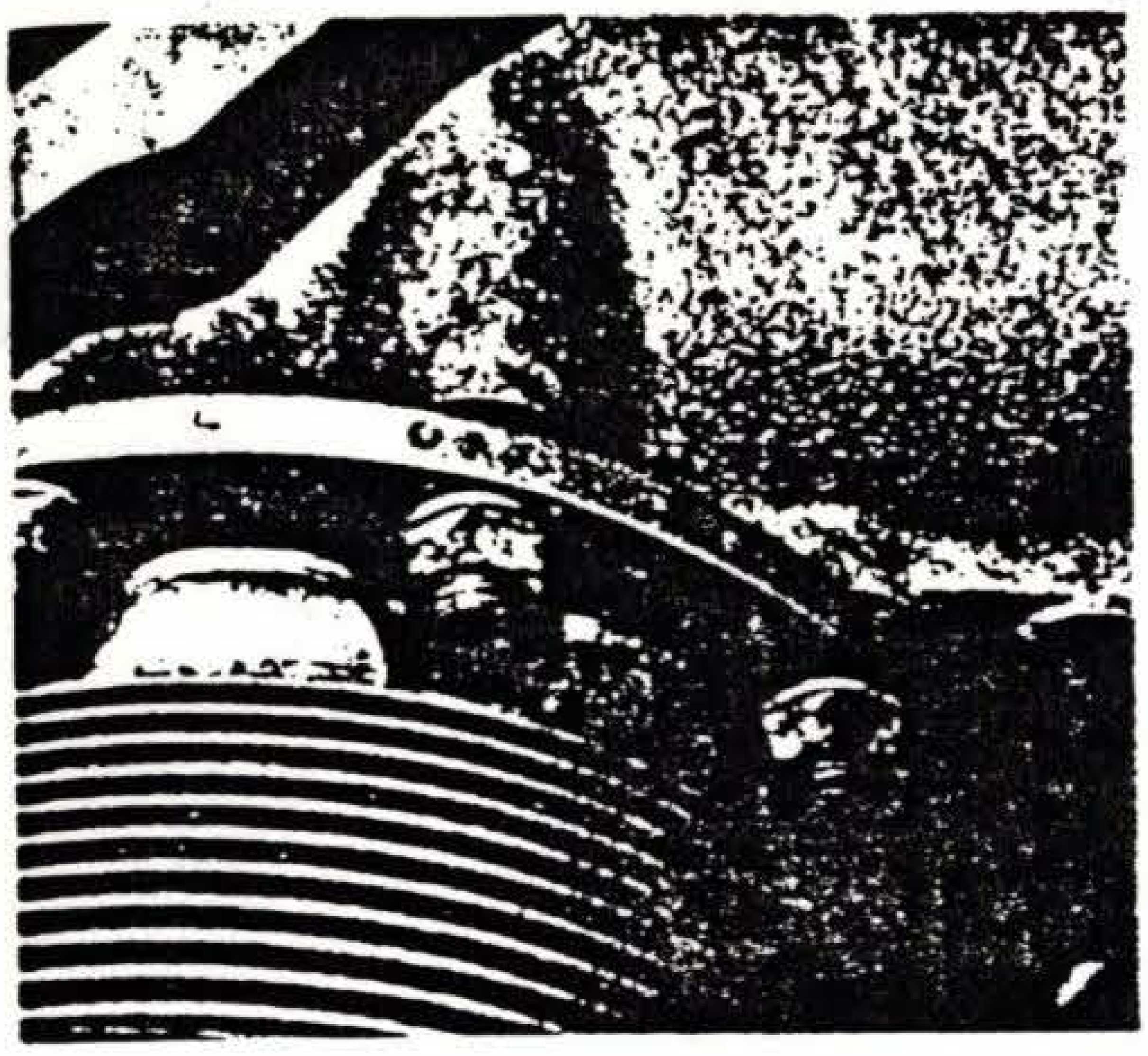

This barrel has been stamped '015' at the base to indicate oversize status.

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which for most jet engines is a required event each 1,200 hours or so. Turbine engines are enormously expensive to overhaul—$60,000 for even the smallest Garrett—and to have to tear one down every 2,000 hours would be unthinkable. Since most of the wear and tear occurs in the hot parts of the engine, it only stands to reason that the "hot section" should be inspected between major-overhauls, and the TBO extended to some fairly high value based on the results of previous hot-section inspections.

The same line of reasoning can be applied to piston engines. The highest temperatures (and the most wear) occurs in a piston engine's "top end": the cylinder barrels, pistons, rings, valves, guides, rocker bushings, etc. By inspecting and/or refurbishing the piston engine's "hot section" at regular intervals, it ought to be possible to raise the average piston engine's TBO. With the exception of the camshaft and accessory gearing, there is not much on the "bottom end" of the typical O-360 or O-470 (or IO-520, etc.) that bears looking at much oftener than 2,400 hours, especially if the engine in question is being flown daily.

Many operators have used this approach to score big TBO gains. In a previous story (September 1983 LPM) we mentioned the case of the California-based Cessna 421 operator whose Continental GTSIO-520-D engines—nominal TBO:1,200 hours—went all the way to 2,350 hours before being majored, thanks to scrupulous top-end renewal at 650 and 1,350 hours (and good operator technique, of course). We're also aware of a Part 135 operator who has obtained FAA approval for 3,000-hour TBOs on Continental IO-520s based on mandatory top overhauls at 1,500 hours. (FAA-sanctioned TBO extensions of 200 to 300 hours for air-taxi operators are extremely common, even without mandatory top overhauls.)

Overall Economics

The economics of performing a top (or partial top—i.e., a top-overhaul of two or three cylinders) as a preliminary to TBO-busting are worth pondering carefully, particularly if the engine in question is already nearing TBO. There's a rule of thumb for this, fortunately. Consider what has to happen in order for a $4,000 top overhaul to be cost-effective in the case of an engine that is nearing TBO and costs $8,000 to major. Obviously, for the top overhaul to be worthwhile, a TBO extension of 50 percent (4,000 divided by 8,000) must be achieved—e.g., your O-320 would have to go to 3,000 hours (vs. the factory TBO of 2,000), and at that point, you would simply have broken even on the top overhaul. (It will have just paid for itself in terms of forestalling the major.)

But let's look at the case of the Turbo Saratoga owner who—when the time comes—is planning not to overhaul, but to buy a factory zero-time rebuilt Lycoming TIO-540-S1AD at a cost of $23,000. In this instance, a top overhaul billing out at $4,000 will be cost-effective if a mere 17-percent TBO extension can be achieved. Since the factory TBO is 1,800 hours, this puts the break-even point at 2,106 hours—by no means an impossible goal.

One conclusion is clear. If your engine has a low TBO or is expensive to major (or you intend to spend a great deal of money on a replacement engine from the factory), a late-in-the-TBO-cycle top overhaul is more apt to be cost-effective than if your engine is a cheap one to overhaul and carries a high TBO.

Lycoming top-end parts are more expensive, generally, than Continental parts (Lycoming's sodium-filled exhaust valves, in particular, cost double or triple what most Continental valves do), and Lycoming engines tend to have generous TBOs, which might suggest that a top-overhaul (for TBO-extension purposes) would more often be cost-effective for Continental owners than for Lycoming owners. This may be true to some extent, but labor is usually a bigger factor, overall, than parts in the top-overhaul bottom line. So essentially the same rules apply to Lycoming as well as Continental owners.

With turbocharged engines, additional considerations apply. Will the turbo, wastegate, controllers, etc. (which may be in fine shape now) make it to the new target TBO? If not, how will the replacement of these items affect the payback picture?

Then too, of course, there are the normal accessories—magnetos, alternator, prop governor, starter adaptor and motor, vacuum pump, etc., all of which are normally replaced at major overhaul time. One or more of these accessories will likely need replacing somewhere down the TBO line, if not at the time of the top overhaul. Performing a top overhaul doesn't allow you to defer *all* decision-making with regard to life-limited components.

Prophylaxis vs. Repair

There may be special circumstances under which a top overhaul performed pre-

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emptively (prophylactically) is warranted—for example, if you are running a Part 135 operation and have a TBO waiver from FAA requiring you to top your engines every 1,000 hours—but generally speaking, for most operators, top overhauls should not be done on a time schedule. They should be done when top-end components are in definite need of inspection and/or repair, as evidenced by the presence of clear-cut distress symptoms.

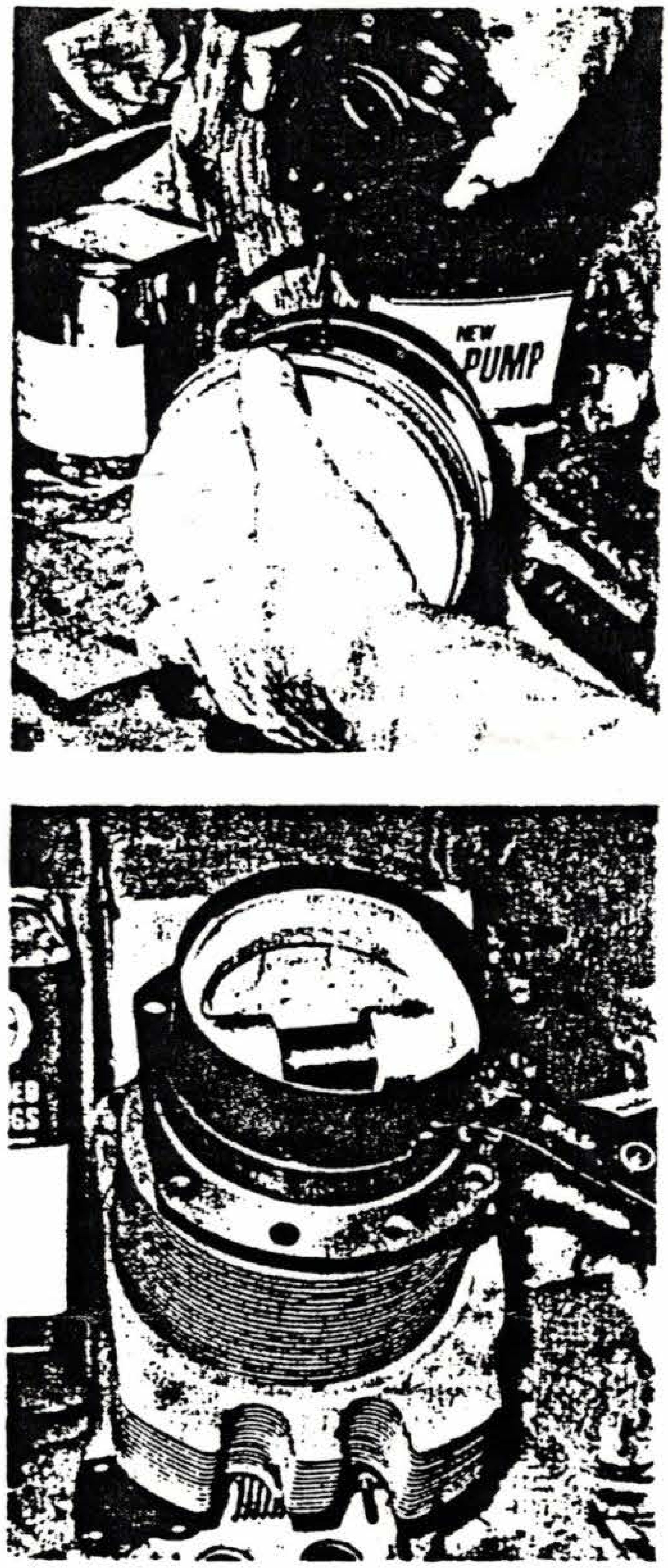
By a "clear-cut symptom," we don't mean cylinder compression in the sixties. In our opinion, far too many owners are being bamboozled into taking cylinders off simply on the basis of "poor compression," which most mechanics erroneously define as 60/80 (see "A Pilot's Guide to Compression Testing," November '82 LPM; reprints $3.00). There is no FAA rule requiring cylinders to be removed when differential compression goes below 60/80. (If your A&P disagrees with this, ask him to produce the regulation.) FAA Advisory Circular 43.13-1A does contain guidelines for compression testing, but AC 43.13.-1A is *advisory only* and does not carry the force of law. Likewise, manufacturers' bulletins are *advisory*, not mandatory, except that they may require the use of special tools per Federal Aviation Regulation 43.13, paragraph (a). On compression scores, the regulations are silent. And rightfully so.

Space won't permit us to recount the litany of compression-score myths here. We still shake our heads, though, when we read the line about "compression 75 percent of new" in the Price Digest Bluebook description of "average" plane condition. Compression in a new engine is never 80/80, and seldom 78/80. Therefore "75 percent of new" implies something below 60/80.) The important thing to remember is that most "20/80" and "30/80" cylinders fly in to the shop where they're eventually removed, so low compression is not really a safety-of-flight concern. Certainly, 60/80 doesn't qualify as dangerously low compression.

How low is low? Some years ago, Teledyne Continental issued a bulletin to Tiara engine operators (M76-18, Rev. 1) stating that compressions as low as 60/80 "are common readings for new engines," and a "limit reading of down to 55/80 is permissible."

The Pasadena, California Police Department operates a small fleet of Enstrom F-28C helicopters powered by Lycoming HIO-360-E1AD engines (with Rajay turbos); and PPD's resident IA-A&P doesn't begin to consider a low jug a problem until it goes below 55/80. If a cylinder is between 55/80 and 60/80, it will be continued in service and monitored every five to ten hours.

We agree with these guidelines. Even if a jug shows up 40/80, it should not be pulled indiscriminately (unless the engine shows other signs of distress). Before pulling a jug on compression alone, its valves should be staked (see AC 43.13-1A) and the



During buildup, parts should be coated with heavyweight mineral oil (top). A ring compressor is used (bottom) to fit the piston/ring assembly to the barrel before installing both on engine.

rings oiled, and compression measured a second and third time, using a different test rig, before condemning the cylinder as defective.

High oil consumption (one quart per hour) *might* be a good reason to top an engine—if other distress signs are evident (e.g., poor power output, wet spark plugs, low compression). But even oil wetness on top-hole spark plugs—a classical indication of advanced barrel and/or ring wear—doesn't *necessarily* mean you're looking at a top overhaul for the associated jug(s). In a fuel-injected engine, wet plugs (possibly accompanied by degraded performance and a rise in oil usage) can simply mean clogged injector nozzles. "A typical complaint from the field," one Lycoming official notes, "will be reported to us at the factory as a loss of power and the cylinders pumping oil. It is typically caused by a dirty or restricted fuel nozzle. The oil residue is a result of insufficient fuel causing low combustion pressures, which prevent the piston rings from doing their job efficiently. Without proper combustion pressures, we do not have sufficient pressure on the compression ring, which allows the oil to leak past."

The main thing to remember is that when deciding on the need for a top overhaul, trouble symptoms—not Hobbs time—should be your main concern; and no *one* indication of cylinder health should be relied on totally for making the "top" decision (unless, of course, there's a gaping hole in the side of a cylinder). Look at the total picture. Cross-compare different indicators—compression, oil analysis, spark plug deposits, engine vibration, oil consumption, etc.—and *monitor trends*; don't fixate on individual data points. If damage to piston crowns, valves, valve seats, cylinder heads, or cylinder walls is suspected, remember that these areas can be checked without removing the cylinder(s), through borescoping. (Also, valve-to-guide clearances can be monitored from the rocker box end using the techniques described in Lycoming Service Instruction S.I. 1088.) In short, don't pull a jug unless the handwriting on the wall is legible, and inescapable.

Cutting Corners

Once the decision has been made to pull a cylinder, don't scrimp or cut corners. Have the jug checked out thoroughly, especially if it's an oldie (more than 1,800 hours TT). If your A&P isn't equipped to perform detailed cleaning, inspection, and repair work on cylinders, have your errant jug(s) shipped to a properly qualified FAA Repair Station (ECI, Schneck, Van Dusen, Piedmont). That way, if special repairs are needed, they can be made on-site in minimum time. Don't expect your local mechanic to be able to weld head cracks or grind barrels oversize.

Avoid doing a "quick-and-dirty" ring job in the field to correct low compression or high oil consumption. If a preliminary dimensional check of your cylinders for bore, out-of-round, step wear, choke, etc. shows the jug(s) to be within service limits, but not within new limits, stop and ask yourself a few hard questions. What is your goal for the top overhaul? If it's merely to improve compression, you may be justified in fitting new rings to the cylinder, honing it, and putting it back in service essentially unchanged. Likewise, if all that's wrong with your jugs is glazed barrels, go ahead and hone them to break the glaze, then put them back in service (with new rings, if more than 50 hours old). If on the other hand you're trying to eliminate oil consumption in a large Continental, or continue an engine past TBO (to the point where the top overhaul will pay for itself), you should definitely bring the cylinder back to new limits. That will usually mean an oversize grind or chroming the barrel;

replacing the exhaust valve guide (and the valve, if it's deformed); fitting all-new rings; and possibly replacing the piston itself, if lands are worn or sideplay in the barrel has grown.

If the exhaust valve to guide side play is at all sloppy (consult your Table of Limits), don't expect the jug to make TBO-plus without replacing the guide. Take this opportunity to upgrade to the latest applicable guide and valve P/Ns. (Consult the latest revision of Lycoming Service Instruction No. 1037 or Continental M82-6, as applicable.) But be sure your shop *hones the guides* to proper finish before putting valves in them. Lycoming S.I. No. 1200C specifies a 30-micro-inch (RMS) surface crosshatch on the guide I.D. for best service life. Many A&Ps aren't even aware of this.

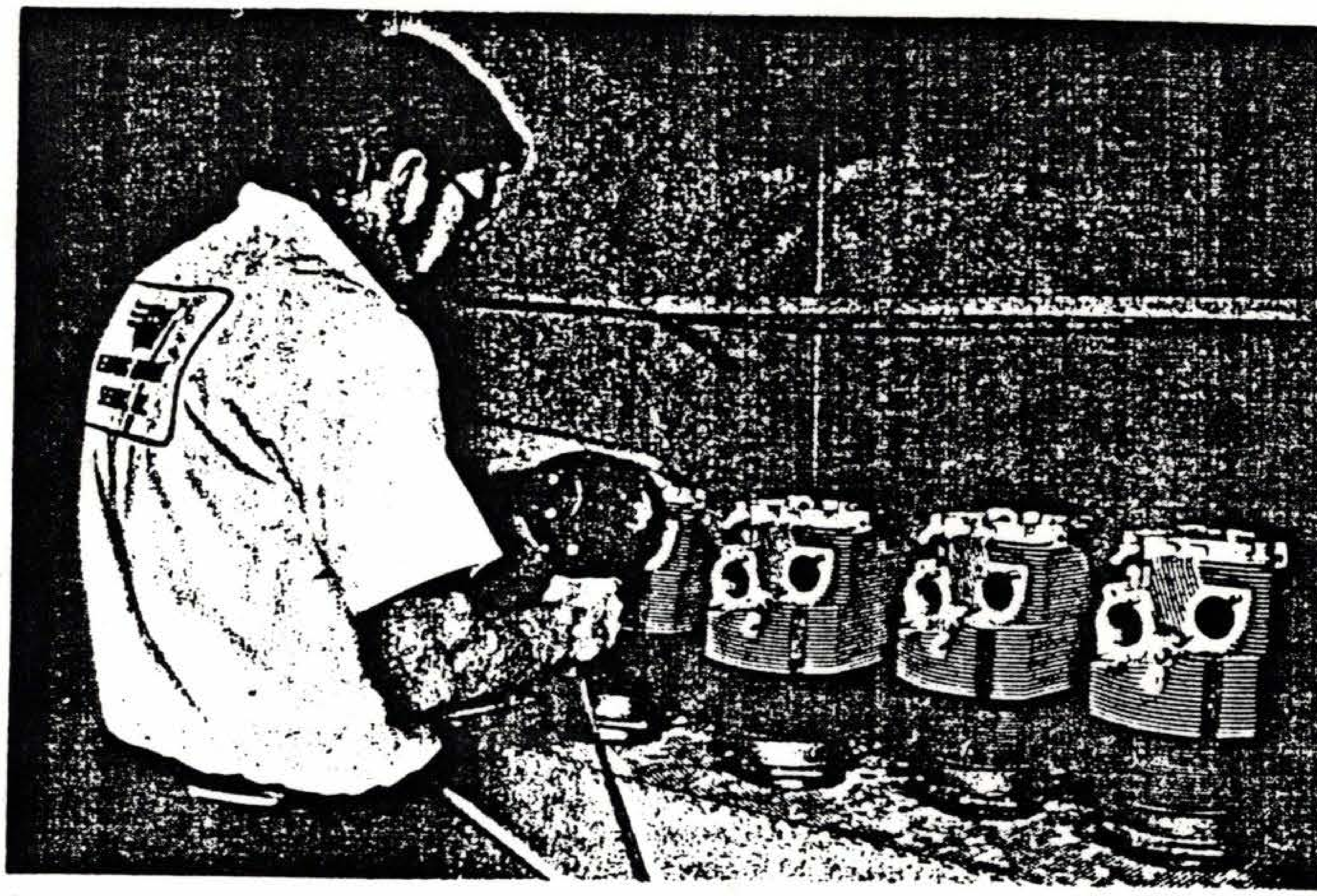
Cylinder honing is another gray area for many mechanics. "Honing is critical for break-in," a Continental engineer told us. "And not many mechanics know how to do it right. The scratches in the barrel bore should be crossed, with lines running at an angle of 22 to 32 degrees with the end of the barrel. These scratches must be wet-cut uniformly in both directions. The final pattern must be clean cut, not sharp, and totally free of torn or folded metal. All of this is spelled out in Service Bulletin M73-13, Revision 1." Also spelled out in that bulletin is a requirement for the final hone to finish out at 15 to 30 micro-inches (except at the extreme ends of the barrel, where 45 micro-inches is acceptable). According to Continental, it is okay to run figure-eights around the barrel I.D. with 200-grit sandpaper after honing to ensure removal of ridges and torn metal.

Very important: If the cylinder is to be oven-heated for valve guide replacement (or other repair operations), be sure honing is done *after*—never before—oven treatment, since otherwise residues from the kerosene-type oils used in the honing process will cook down to form varnish during the heating up of the barrel(s), thereby glazing the cylinders and preventing proper break-in.

Chrome vs. Oversize

Suppose your barrels are scored (from too many cold starts without a preheat). Or suppose your rings have stuck (or begun to stick), creating a nasty wear step on the barrel I.D. at the top of ring travel. Or suppose your jugs are okay for I.D. and out-of-round, but can't be cleaned up while also maintaining the proper choke contour. (That is, if you regrind to restore taper, you no longer meet service limits for bore diameter.) The latter is not an uncommon problem in certain large Continentals. "If you take a cylinder off a Pressurized Centurion after 800 hours," one engine man told us flatly, "you can be damn sure the choke will be gone, and the cylinder can't be returned to service."

The next step is usually to grind oversize, or chrome the barrel. Which should you do?



Cylinders are cleaned up prior to checking for choke, bore, step wear, and out-of-round. A thorough top will also include dye-penetrant inspection for cracks.

The answer is easy if you own a late-model Lycoming. All current production Lycoming engines except O-235-C, O-320-A/C/E, and IO-320-A or C employ nitrided (surface hardened) barrels. And nitrided barrels *cannot* be ground oversize, except for O-360-B and D and O-540-B barrels, which can be ground .010" over. (For more information, refer to Lycoming Service Instruction No. 1047 and the *Direct Drive Overhaul Manual.*)

Barring the above caveat, Lycoming operators with standard steel jugs actually enjoy a somewhat greater flexibility than Continental owners when it comes to oversize grinding, since standard-steel Lycoming barrels can be ground .010-inch oversize *or* .020-inch oversize (Lycoming supplies rings and pistons in both oversizes), whereas Continental jugs can be ground .015-over only. If you see green paint on a Lycoming jug, it means the jug is .010-over. Yellow paint at the base of the cylinder signifies .020-over. Orange paint in the hold-down area means the cylinder has been chromed. (Continental jugs that have been ground .015-over are not color-keyed but have ".015" impression-stamped into the cylinder hold-down flange—and written in the logbooks.)

The decision whether to chrome or go oversize is often a tough one; many factors must be considered. Are rings readily available? Chrome cylinders require special rings—namely, non-chromed, cast-iron rings—and supply problems are not uncommon. (For example, until recently there were no aftermarket suppliers of chrome-cylinder ring sets for O-235 Lycomings, and the Lycoming factory's inventory of these rings was low, leaving some customers grounded for an entire season while overhaulers waited for rings to become available.) Oversize rings are also occasionally hard to get for certain engines. Ditto for oversize pistons, which are not sold in great volume and therefore are priced higher than the corresponding normal-size pistons.

New pistons are required when an oversize grind is done, whereas when cylinders are chromed back to normal (new) dimensions, old pistons can be reused. But it is often the case that pistons must be replaced anyway, due to normal wear. (Piston replacement is not a bad idea, also, if TBO-busting is being contemplated.) The picture is further clouded by the fact that most shops will tell you that if one jug is ground oversize, its opposite mate should

(Continued on next page)

MAINTENANCE TIP OF THE MONTH: REPAIR KIT IN A TUBE

Most mechanics agree that one of the handiest "hand tools" around is a tube of RTV (silicon rubber in a tube) sealant—the kind that squeezes like toothpaste, sets in 10 minutes, and cures to a tough, resilient rubber in 24 hours. We've used (or seen A&Ps use) this stuff to make field repairs of broken insulation rubber on ignition lead elbows, "glue" chafing wires together (the joint can later be cut apart), protect ignition wires from cylinder fins—even fix leaks along airbox seams. (Apply RTV from the *outside* of the airbox.) Special high-temp (and fuel-resistant) RTV formulas are available, too. For $7.95 (roughly) per tube, it's quite a "tool."

(Continued from previous page)

be ground over as well, to maintain dynamic balance. (The Avco Lycoming *Direct Drive Overhaul Manual* recommends oversizing cylinders and pistons in pairs for this reason.) So while the chroming operation usually costs a minimum of $175 per cylinder, versus only $50 or so to grind a jug oversize, the price disparity between the two operations is mooted by considerations involving pistons, rings, and further work on other cylinders. If only one jug is bad, the most cost-effective solution may just be to replace the cylinder assembly with a new one.

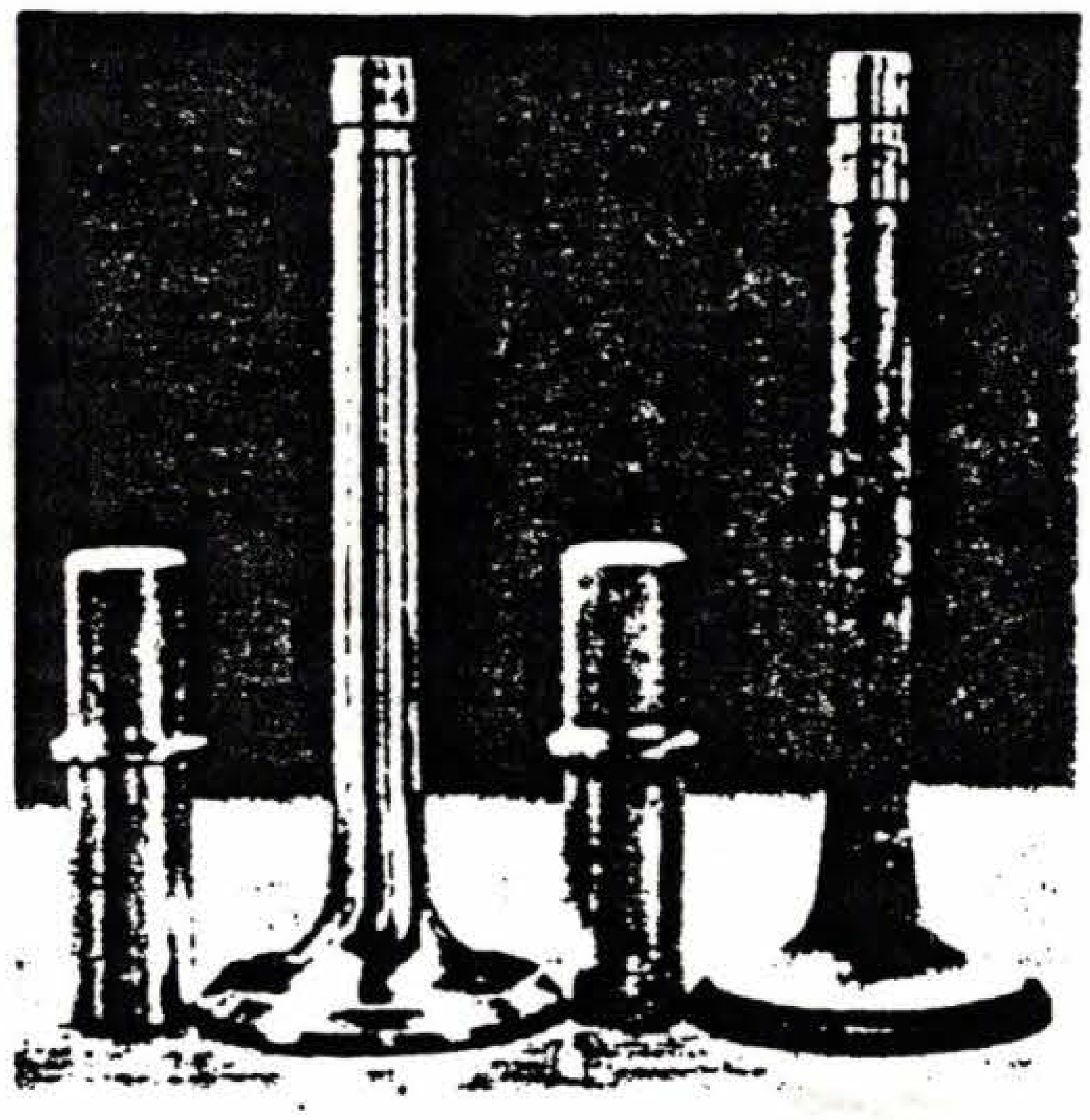
Do all cylinders have to be chromed at once? No. There is no reason why chromed cylinders can't be mixed with steel cylinders on the same engine. ("It's done all the time," a spokesman for a major east-coast overhaul shop told us.) The important thing is not to mix chrome rings with non-chrome rings.

As for oversize grinding: We disagree with those who maintain that cylinders *must* be ground oversize in pairs, to maintain balance. Dynamic balance has less to do with the mass difference between oversize and standard pistons than it has to do with the combustion forces acting on opposite sides of the crank. (Uneven compression will cause worse vibration than unbalanced pistons.) Proof of the pudding is that when oversize and standard cylinders are mixed on the same engine, no difference is discernible in the cockpit. We know, because two years ago we had Mattituck install five oversize O-470-S pistons in our O-470-R Skylane in the course of a top overhaul—and if you hadn't read the logbook entry, you'd never have known that the engine contained one standard 'R' cylinder.

In general, we're in favor of doing the least work possible, even if it means mixing chrome, standard, and/or oversize jugs on the same engine. There is no benefit to be gained from pulling jugs that don't need to be pulled. Of course, if cost is no object, go ahead and put your A&P's kids through college. But if cost is no object, you're in the minority.

Break-In

If we were forced to take sides in the chrome-vs.-oversize debate, at least where top overhauls are concerned, we'd probably choose oversize grinding as our initial preference. The reason is that steel cylinders (properly honed) give more predictable break-in than chromed jugs, on the whole. Because of its inherent hardness, chrome is a more difficult surface to "seat in to" for rings, and unless ring seating is done in a test cell, break-in is a hit-or-miss affair—definitely best left to the overhauling agency, if at all possible. (Also, cylinder chroming is still something of an art, and if not done well, oil control is [illegible]. When chroming is being considered we recommend sticking with an established firm such as Engine Components Inc. or Schneck.) If you own a GTSIO-520,



Valve stem wear is rarely as advanced as shown here (on the right), but exhaust valve to guide clearance is an important parameter to watch.

chroming is no longer recommended by the factory; see Continental Service Bulletin M85-8, dated July 3, 1985.

If your overhauler will guarantee break-in of chromed cylinders, fine. Properly broken in, chromed cylinders will last a good deal longer than steel cylinders (because of chrome's hardness); and for operators who fly infrequently or are based near the coast, chrome offers vastly reduced corrosion potential. Most overhaulers, however, will not guarantee break-in on their chromed cylinders unless the engine is removed from the airplane and run in a test stand. The "in-the-airplane" break-in record of chromed jugs is not particularly good.

With steel cylinders (standard or oversize), it is important to begin the break-in as soon as possible after the cylinders are mounted on the engine, since polished (or honed) steel surfaces very quickly turn to rust unless inhibited with corrosion-preventive oil. During the break-in process, the microscopic hills and valleys in the honed barrel metal fill with varnish and combustion products to form—in effect—a protective coating which helps slow the rapid corrosion that otherwise affects new cylinders. It's essential to start this process as soon as the plane leaves the shop.

Mineral oil will not hurt your other cylinders, so if you're breaking in an engine with only one or two "topped" jugs, go ahead and put straight mineral oil in the sump for at least the first 25 hours. (Note: Phillips makes a 20W-50 mineral oil for break-in. Ask your dealer or jobber about it.) Don't ground-run the engine any more than necessary; and on the day of the first flight, don't cycle the constant-speed prop. (It lugs the engine and encourages scuffing.) After a brief warmup and mag check, slowly bring the throttle all the way in and take off. Keep the climbout shallow, and unless your engine comes with a 5-minute power restriction, don't reduce power after takeoff. Keep the rpm and manifold pressure up. "Babying" the engine at this point is a sure way to flub the break-in.

Will using an ashless dispersant oil automatically ruin your chances for a good break-in? No; it only lowers your chances. (Some engines, such as the Lycoming O-320-H and TIO-541-E, are *required* to run on ashless dispersant oil from the moment they're put in service.) You can put ashless dispersant oil in your freshly topped engine if you want to. Break-in simply won't be as predictable.

Little-Known Facts

Some little-known facts that you might want to consider when top-overhauling your engine:

1. Chromed cylinders can be rechromed.
2. New barrels can be put on old cylinder heads, and vice versa (see "The Engine Clinic," p. 13 of this issue.)
3. A common mistake in field overhauls is installing piston rings upside-down. Even if a ring looks symmetrical, it should be installed with the part-number side *up*.
4. Pistons should not be cleaned in soap or detergent solutions. (Cast aluminum is porous and will retain soap residue. Later, the soap will combine with the mineral oil in the engine to create foam, which interferes with lubrication.)
5. Many shops use STP cut with mineral oil for an all-purpose parts lube during buildup, even though STP contains an antiwear additive that may hinder break-in.
6. Failure to mask the underside of the cylinder hold-down flange prior to painting the base area with orange, yellow, or green paint (to indicate the barrel type) is a major cause of inflight cylinder loss. A thin paint film under the base flange will cause torque to be lost on hold-down bolts, resulting in the studs shearing under high load. The same goes for RTV-type sealants, which should never be used under cylinder hold-down flanges.
7. Connecting rods and crankshaft dynamic counterweights can be serviced during a top overhaul. If you wish to rebush rods or counterweights, or replace connecting rod bolts, now's a good time to do it.
8. It *is* often necessary to remove the entire exhaust system (and/or intake system) from an engine in order to get just one cylinder off; your A&P isn't pulling your leg.
9. Cessna's labor flat-rate book says to allow six hours' removal/installation time to remove the first cylinder from a six-cylinder engine, then three hours additional for each cylinder after that.
10. Top overhaul kits containing gasket sets, ring sets, etc. for most popular engine models are available at nominal cost ($300 up) from El Reno Aviation, P.O. Box 760, El Reno, OK 73036 (phone 405/262-2387). Send for a price sheet (specify engine type)—and say you read it in LPM.

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Twenty Questions to Ask Your Overhauler

by Kas Thomas

We get a wide variety of inquiries (written and phoned) here at Editorial Headquarters, but the most frequently asked questions have to do with engine overhauls. Who should I take my engine to? Should I go for a new-limits job, or a factory reman? Should I go with chromed cylinders, or grind oversize? How long will it take? How will I know if I got a good deal?

The last question is perhaps the hardest for most operators to get a handle on. The best deal on an overhaul isn't necessarily the cheapest deal (nearly everybody agrees on that), but slogging through the murky waters of overhaulers' hype isn't easy. Far too easy to get mud on your Raybans.

In the interest of keeping readers out of trouble (and keeping our phone bill down), we've put together a checklist of sorts to aid operators in getting the best possible overhaul for the least possible money, with the least possble Rolaids consumption.

Try these questions out on your overhauler (put them in writing and send them off in letter form to any overhaulers you're seriously considering doing business with) and see what you get for a response:

1. What kind of engine do you specialize in? (Or: How many engines of my make and model did you overhaul last year?) Generally speaking, you don't want to take your P-Navajo's Lycoming TIGO-541-E1As to a shop that's never seen anything bigger than an O-200. Find out what the shop's specialty is (Lycoming fours; geared Continentals; round engines; or whatever) and be sure they've done your type of engine before. If they claim they specialize in "all types of engines," be wary.

2. Do you overhaul to new limits, or service limits? Most shops now *claim* to overhaul to new limits, but you can cut through the B.S. by asking for a few simple dimensions. The proper "new limits" bore for a 320-, 360-, or 540-series Lycoming cylinder, for example, is 5.125 inches plus .002, minus .005. (The Lycoming "Service Table of Limits" limit of 5.1305-in. is a *service* limit.) Ask about ring gaps and side clearances, and whether pistons are customarily thrown away and replaced with new. If the shop is in the habit of reusing pistons, as yourself—and them—how they obtain new-limit ring fits with worn piston lands.

3. Do you reuse exhaust valves? The answer here should be a firm no. (Lycoming no longer allows the recycling of Inconel valves. See this month's Q&A.)

4. How much choke do you put in reground cylinders? This is particularly important for O-470 and IO-520 Continental owners. Look for an answer in the .005 to .008-in. range. Anything less than that is an invitation to a top overhaul 500 hours post-major.

5. What style piston-pin plug do you use (Lycoming)? There are three different types of Lycoming wrist-pin plugs in service: the P/N 60828 aluminum plug, P/N 72198 aluminum-bronze, and the LW-11775 "doweled" plug (see Q&A, January '85 for a complete discussion). The plugs are interchangeable and are used in a wide variety of Lycoming models, but the various P/N plugs have widely differing failure rates. *You want the doweled plug, in conjunction with heavy-walled P/N 14077 or -14078 wrist pins.*

6. What style valve guide do you use? This is a rather lengthy discussion unto itself, but the essence of it is, Lycoming and Continental have each made major changes in exhaust valve and guide materials over the last few years, and generally speaking, you now want your high-output Lycoming or Continental to have Nimonic valves in cast-iron (Ni-resist) guides. (Continental's latest exhaust valve for -470 and -520 engines is P/N 646286.) Nitralloy guides have proven somewhat unpredictable for Continental owners; ask your shop what their experience has been (bear in mind that

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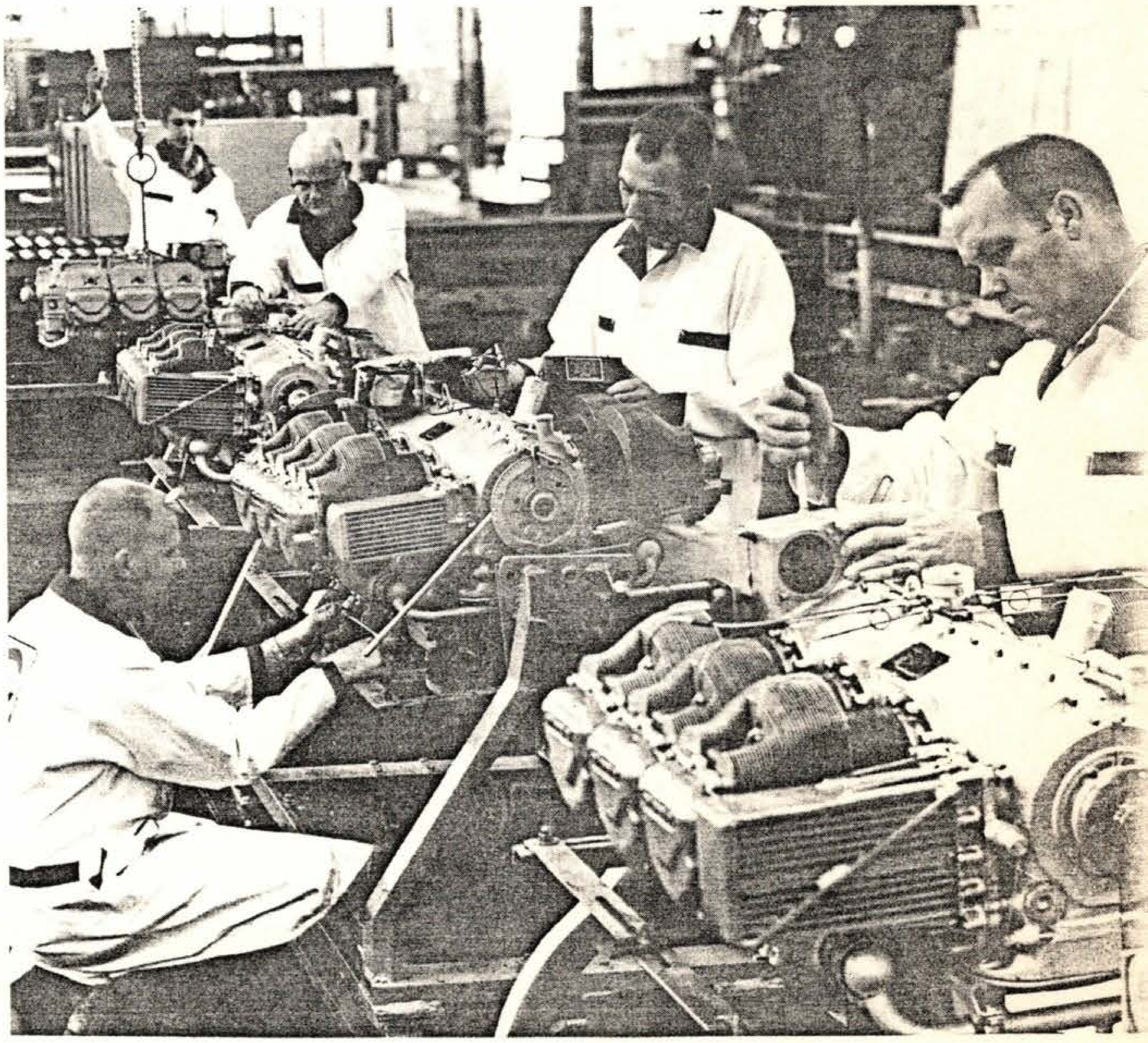

Crank, cam, and lifter regrinding can add extra cost to an overhaul. If grinding is needed, who pays for nitriding? Dynamic balancing? (Who warrants the reground parts?) Get answers in writing, ahead of time.

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you have to replace your exhaust lifters with special high-oil-flow variants), and if you decide to go the nitralloy-guide route, be sure you're getting the latest part number (P/N 648014 is current).

7. Do you substitute PMA parts for genuine factory parts? What's my price savings with parts by Superior, Precision, or ECI? This is a sore point, admittedly, because most overhaul shops *do* use PMA (Parts Manufacturer Approval) parts—aftermarket valves, guides, pistons, rings, etc. (which are often half the cost of Lycoming or Continental equivalents)—and most shops *do not* want owners knowing about it, because the cost saving, by and large, isn't passed on to the customer. (Ask for a basic price quote on your engine. Then ask for a breakdown into two price quotes based on the use of genuine factory parts or PMA parts.) FAA-PMA parts are generally just as good as—and in some cases slightly better than—factory original parts. But you're the customer, and you should know what you're getting (or not getting), so you can meaningfully compare price quotes from other overhaulers.

8. Do cylinders and valve guides come with proper micro-inch honed finish? Honing was discussed in the April '87 issue of *LPM*; ask for actual micro-inch RMS numbers (answers should be in the 25-40 micro-inch range), and ask if valve guides are honed (to 30 micro-inches RMS) per Lycoming Service Instruction No. 1200A.

9. Who does your crank regrinding? Does it cost extra? Does it include dynamic balancing? Most shops send cranks out for grinding; you want to know that the regrinder has been around awhile, specializes in crank grinding, and is an FAA-certified Repair Station. (AEA in Dallas and ECI in San Antonio are two of the better-known names in this field.) If your overhauler tells you that the customer must guarantee the crank to be serviceable, what does that mean, exactly? Does that mean it must be regrindable, but the customer pays for any needed regrinding? Does it mean the overhauler pays for regrinding? What about nitriding? Counterweight reconditioning? Magnafluxing? Ultrasound? What if (horror of horrors) your crank is unrepairable? Get it all in writing ahead of time.

10. Will my camshaft be reground? (Lifters?) By whom? Who pays if the cam is found to be worn beyond repair? Who pays if reconditioned lifters start tearing up a cam lobe in 100 hours? Again, get it in writing.

11. What accessories are included in the overhaul price? Who certifies

Horsepower Upgrading: Weighing the Pros & Cons

There's an old saying in hot-rod circles that "there's no substitute for cubic inches." You can fool with camming, timing, tuning, and porting until you're blue in the face (or until your valves are blue in the face, as the case may be), but if what you really need is raw power, you'd best get a bigger engine.

Many plane-owners openly lust for thrust but are unable or unwilling to trade up. (Once you're comfortable with a given cockpit, it's difficult to let go—especially if you've dumped so much green into paint and panel appointments over the years that you can't justify selling the plane.) As major-overhaul time approaches, the natural temptation is to keep one's present airframe and invest in a horsepower upgrade.

Skyhawk owner (and *Aviation Safety* contributor) Brian Weiss states the case for extra ponies: "I fly my 172 up and down California, and it's got adequate performance, considering I fly solo or lightly loaded much of the time. But I could definitely use some extra rate-of-climb on hot days at high altitude. It's embarrassing when ATC clears you to eleven thousand feet from nine, and asks you ten minutes later if you think you're going to make it."

Weiss loves the plane's existing 160-hp Lycoming ("The O-320-D2J is a solid workhorse," he maintains), but as the original engine edged past 2,000 hours (it's now at 2,300), he began to weigh the trade-offs involved in a 180-hp conversion. "I decided on the Penn Yan conversion," Brian explains, "not because of price—the Avcon 180-hp conversion is about the same—but because the Penn Yan mod uses a fixed-pitched prop rather than a constant-speed. I have two partners in my airplane, neither of whom flies much, so a more complex airplane would not have been a good idea. It wouldn't have encouraged their flying more, and it certainly wouldn't have lowered the plane's maintenance. But thanks to the efficiency of the Sensenich prop"—the 172's original prop is a McCauley—"the performance increase with the Penn Yan mod is about equal to the Avcon conversion. So I'm going with Penn Yan."

them? Generally, the overhaul price includes the cost of reconditioned-exchange starter, magnetos, harness, carburetor or injector, fuel pumps, and alternator. (Vacuum pumps may or may not be included as well.) Find out for sure whether your carb or injector is to be overhauled, or merely bench-calibrated and yellow-tagged. (Lowball overhaulers generally do not include the cost of a complete Bendix fuel-injector overhaul in their prices.) Who warrantees the accessories?

12. Can I have fine-wire spark plugs at no extra cost? Use this as a bargaining chip as shop-selection time draws near.

13. Who does your cylinder chroming? Can I opt for an oversize grind instead? Chroming isn't something that should be entrusted to just anyone. You want a major shop (such as Schneck or ECI) to do any chrome-plating; otherwise you should opt for an oversize grind, if possible. (Unfortunately, this is not an option for some Lycoming owners; Avco does not allow regrinding of most nitrided jugs.)

14. Will I get to keep my cylinders, or is there a chance they'll be exchanged for somebody else's? To each his own. We prefer to hold onto (and repair) our own cylinders, if possible; we don't want anybody else's recycled junk. (You don't know where it's been.)

15. Will I get a written logbook record indicating compliance with applicable service bulletins by number? The answer better be "yes."

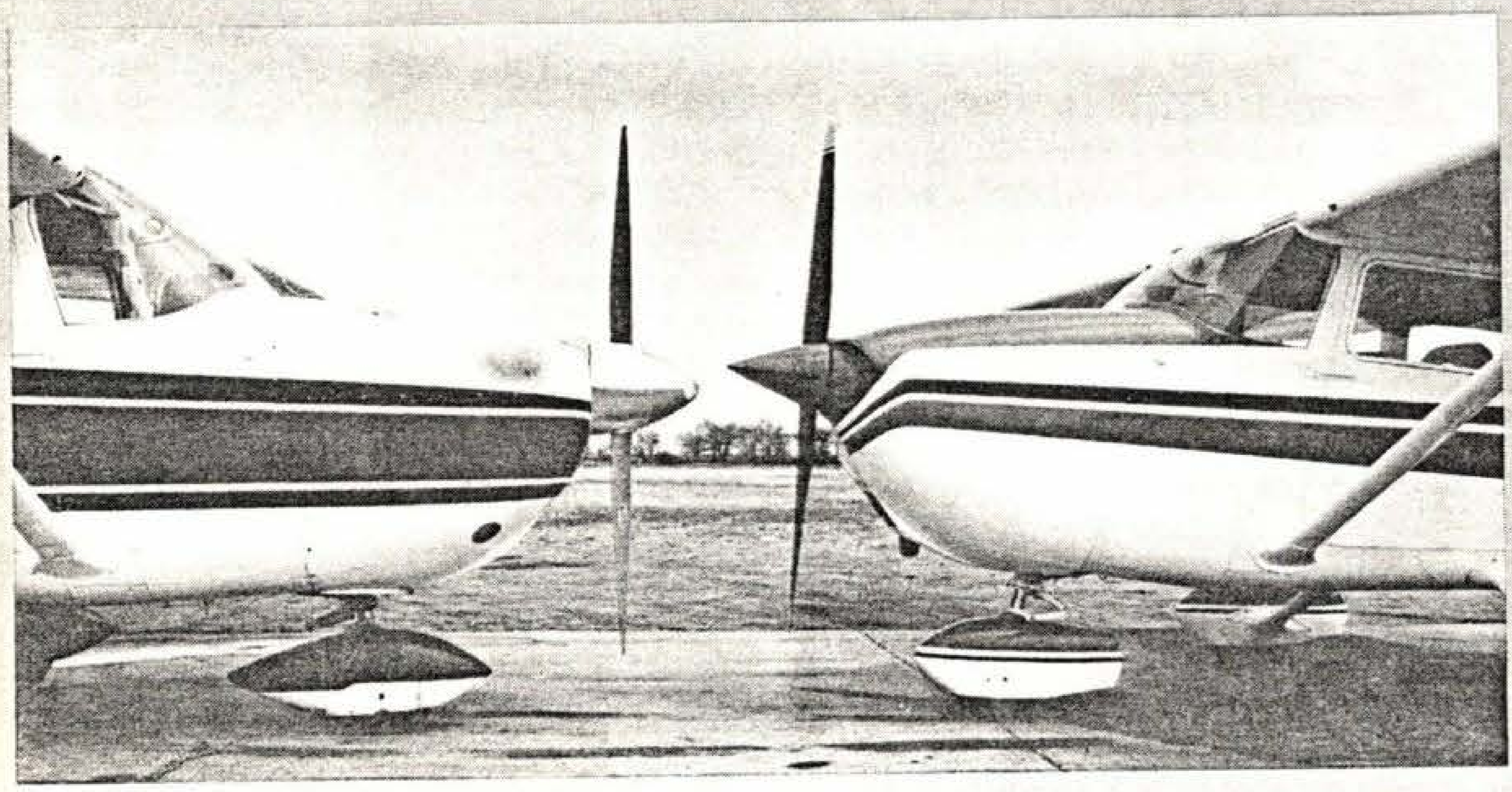
16. Who pays if a cylinder cracks after 100 hours? Answer: They do.

17. Who pays if the crankcase starts leaking oil at a parting line or through-stud? Effective repairs can get hairy; you want some assurance that a leaker will be fixed at no cost to you.

18. How do you run-in your engines, what break-in oil do you use, and what are your limits for oil consumption? The answers should be: On a fully instrumented test stand per the manufacturer's published run-in procedure; Shell red-can 50-weight or equivalent; and one quart in three hours, tops.

19. What happens if my engine is still using a quart of oil every two or three hours after a 50-hour break-in period? The answer you're looking for is: "We'll do whatever is necessary to correct an oil-consumption problem." That means deglazing defective cylinders free of charge, replacing any that have cracks, and replacing the replacements if *they* don't break in in 50 hours.

20. Is your warranty equivalent to a factory warranty? You want pro-rata protection to TBO, with an initial 6-month, 240-hour non-pro-ratafied satisfaction guarantee. Have them send you a copy of their present written warranty. Read it and see how it compares to the factory's Rare-Metal Medallion warranty; it should stand up pretty well.



Adding 20 horsepower to the 172 is worthwhile if you need ROC performance.

Weiss is based in Santa Monica, CA (on the opposite coast from Penn Yan); he will have Victor Aviation perform the conversion using a Penn Yan STC'd kit. "The kit cost if you supply your own engine is $2,495," Weiss elaborates, "and that includes a new Sensenich prop along with the STC paperwork. Victor was able to steer me onto a used O-360-A4K"—for which Weiss paid $4,600—"and I'm going to sell my O-320-D2J through an ad in Trade-A-Plane, or however I can."

After overhauling the O-360, Weiss expects to have "maybe five grand more" in the total conversion than he would ordinarily have put into a firewall-forward new-limits overhaul of the existing powerplant.

"You hear a lot of people complain about how much the 180-horse conversion costs," Weiss remarks. "But I disagree. You're paying money, but you're getting something in return. You know, a guy'll spend a couple grand to pick up a couple knots of airspeed—you see people putting money into flap gap seals and wheel pants and stuff—just to gain a knot or two of cruise speed per thousand dollars. That's considered acceptable by a lot of people.

"Me? I'd rather put five grand into a conversion that's going to give me a 150-pound gross weight increase, a four or five thousand foot increase in service ceiling, and a noticeable boost in rate-of-climb, *plus* a knot or two of extra cruise speed. These are all things that I don't have to strain my eyes to see. I end up with *better*-than-new performance, and a plane that's still simple to fly and maintain."

Weiss compares his situation to that of a friend of his on the field, also a Skyhawk owner (until recently): "This guy, rather than upgrade his old 172, bought a used Cessna 210 that—it turns out—needed a lot of work. And in the past year, he's spent bundles of money—money with lots of zeros after it" (laughter) "and now he's in debt, struggling to keep up with the plane.

"I'd rather keep within the concept of the 172," Weiss summarizes, "and continuously refurbish and upgrade a plane that I *know* I can afford to fly. The plane fits my mission, and until or unless the mission changes, I can't see buying anything else."