The Cleco

Experimental Aircraft Association • Chapter 393 • Concord, CA

Mail to: EAA Chapter 393 P.O. Box 272725 Concord, CA 94527-2725

FEBRUARY 1995

YOUR 1995 OFFICERS

PRESIDENT	Fred Egli 935-7551
VICE PRESIDENT	Lisle Knight 524-2269
SEC/TREASURER	Louis Goodell 682-4198
EDITORS	Ken & Linda McKenzie 283-3119

MEMBERSHIP MEETING

February 22, 1995, (the 4th Wednesday of every month) @ 7:30pm, Old Buchanan Terminal Building, Concord Airport. Please wear your badges to help those of us who have trouble remembering everyone's name. Please bring chairs, since we never seem to have enough.

BOARD MEETING

The board meeting is scheduled for 7:30 p.m., Wednesday, March 1 at Fred Egli's house. If you are interested in attending or have a matter you wish to discuss, please call Fred.

FEBRUARY PROGRAM

For this month's presentation we will have the pleasure of learning about the design aspects that went into the "One Design" project from Dick Rihn. Dick has been highly active in aerobatics for many years, and his son Dan designed and built the One Design to offer the aerobatic pilot an aircraft that met all the requirements necessary for unlimited competition, without leaving their bank account on the runway or mortgaging their house. Dick will show a video on the One Design's capabilities and describe the process for creating this singularly unique aircraft. I do hope you enjoy it.

RAFFLE NEWS

by Larry K. Laughlin

Wow! It is amazing how raffle prizes just kind of flow towards our need, with so little begging on my part. Thank you so much for supporting the raffle. By all means, keep the donations coming, too!

In December, Scott Achelis had an occasion to meet with Eric Schultz, a past member of #393, to do a little TIG welding. Thanks to Scott's asking, Eric was kind enough to donate one hours worth of TIG welding to our raffle, a $30 value. That is exactly the kind of open minded help, I need to work the raffle as a club fund raiser.

As a bonus, Andy Marshalll called me recently and offered to donate several copies of his "Composites" book, a must have for anyone fooling around with this stuff, (more on Andy's donation next month).

Thanks guys for blazing the trail in January. If everyone in the club casually mentioned our monthly raffle to someone they knew that might donate something or if they themselves are in a position to make raffle prizes available to us, we might raise enough money to cover our 1995 newsletter expenses and even more.

** ** REMINDER ** **

Your chapter dues are now due. Renewals not received by March 15, will be dropped from the mailing list.

UNCLASSIFIEDS

FOR SALE: IO-360-A1B (fuel injected, 200hp) for sale "at more than a fair price." Call John M. Agee, M.D. at (916) 484-7038. [Ed. Note: Larry Laughlin says this is a 17 year old Angle Head, Zero Time engine (since NEW), all updated and test run for $14,500]

Varieze: 2 partners looking for a third to provide sweat equity and some cash and to contribute to other completion costs for a very nice Varieze at CCR. Completed to point of taxiing. Call Jim -- days 675-4312 or nights 820-2586, Chris -- days (707) 523-5135 or nights 798-8844 for additional details.

FOR SALE: Lightweight starter for Lycoming engine. Manufactured and STC'ed by Lycoming. New; $450. Call Mike Parker, (510) 685-4809 (leave message).

FOR RENT: Hangar space is available in one of the West Ramp Port-to-Port for building a kit. Contact Barry Burgess, 118 West MacDonald Ave., Richmond, CA 94801. Home (510) 215-2991; Work (510) 532-5242.

Lower Winglets are Needed

[Ed. - This rebuttal to Shirl Dickey's article, "Effects of Lower Winglets on Stall Characteristics" was published in the January-February 1995 issue of Contact!]

... "Apparently the purpose of the article was to answer the concern of his builders regarding his decision to omit lower winglets on his design, after we had determined in flight testing of the Cozy Mark IV that they were necessary to provide roll stability at high angles of attack and aft CGs.

"Curiously, the author suggests that he wants his design to be unstable in roll, because if it were not, he theorizes, it would be susceptible to locked-in deep stalls. ... This is outrageous! A canard aircraft should be designed so that it is stable in all three axises and also not susceptible to deep stalls.

"We showed in our flight testing of the Cozy Mark IV that it is possible to achieve stall resistance without sacrificing stability. We proved conclusively that a canard aircraft (ours) with swept, tapered wings, but without lower winglets, at high angles of attack and aft CGs is susceptible to premature wing tip stall, roll-off, and an uncommanded altitude loss of over 1000 feet. With lower winglets, it was stable in all three axes and wing stall was delayed. We then demonstrated that canard span determines the CG at which a main wing stall can be induced, and canard span can be adjusted such that wing stalls will not occur within the approved CG range (as modified, if necessary) all consider lower winglets mandatory!

"Uncommanded roll-offs with large altitude losses should not be accepted. Perhaps the author should do less theorizing and flight testing.

Nat Puffer, CO-Z Development
2046 North 63rd Place
Mesa, AZ 85205
(602) 981-6401

WARBIRDS ANNOUNCEMENT

Larry Smigla of Vacaville is interested in starting a local chapter of the Warbirds of America. The only prerequisite is that you be a member in good standing in the EAA. If you are interested Larry has provided a questionnaire that needs to be filled out and returned. We will have copies of the questionnaire at the next chapter meeting. You may also request copies from Ken & Linda McKenzie at (510) 283-3119.

MINUTES OF THE JANUARY CHAPTER MEETING

A warm "Thank You" to Will Price for taking notes in my absence. There was no new business. During introductions: Harry Heckman had a good experience with ordering parts from Aircraft Spruce; Lou Ellis announced that the engine is back in his Glasair; Lyle Powell had attended a workshop on engines; Ed Lester spoke of a fuel problem he had experienced after his engine was reinstalled; and Chris Opperman announced plans for an upcoming hangar party. The raffle had seven big winners. Our speaker, George Sparr talked about carbon prepreg and various sandwich materials. He talked about the need for keeping prepreg materials in a freezer at 0°F. After removal from the freezer they have about a two week life.

TREASURERS REPORT

Balance in the Checking account is $906.81; the balance in the Savings account is $2,312.20. As of Feb. 7 the chapter had collected $800.00 in dues.

WELCOME NEW MEMBERS

We would like to extend a warm welcome to our newest members; Ed & Marge Buckner, Mike Diaz and Bruce Milan., who joined Chapter 393 at our January meeting.

OPERATION/MAINTENANCE

Cylinder Choke and the Lycoming Shortcut

Marvel's Mystery, Part III

by Bill Marvel of San Pedro, CA

(with loads of great information, all drawings, and a real education from Bill Scott)

Reprinted from the July / August 1994 *The American Star*

For years, those of us in the AYA with a technical orientation have stressed the importance of keeping cylinder head temperatures down in order to enhance cylinder life in general and exhaust valve health in particular. In fact, as you noted in Part I of this series [Ed. Note - See August 1994 Cleco] of this series, oil cooling and lubrication of the exhaust valve stems is crucial to exhaust valve longevity, *even if* you keep CHT levels in check. However, we now know that, ironically, the very act of keeping CHT levels down in order to enhance exhaust valve life will, in new Lycoming cylinders, contribute to advanced cylinder barrel wear! Here's why.

Cylinder Choke

Take a look at figure 1. The symbolic stars indicate relative temperatures in a cylinder barrel in operation, with the smallest star indicating the coolest temperature and the largest start the hottest. Based on our general understanding that heat causes expansion, it stands to reason that the greater the temperature of a portion of the cylinder the more the steel walls will expand and the greater the cylinder diameter will become. If the cylinder walls started off perfectly parallel, combustion heating would cause cylinder diameter to expand more and more as heat load increased from bottom to top in the cylinder. For this reason, a proper cylinder buildup calls for a gentle tapering of the inside diameter of the cylinder walls from bottom to top so that at normal operating temperature the walls become nearly parallel. This taper of the cylinder inside diameter is called choke.

Insufficient Choke

But just how much taper (choke) should be built into the cylinder barrel at room temperature to offset the uneven heating of the cylinder and the related expansion of its inside diameter? Where should it start? And what results if it is improperly done? Suppose that the taper of the barrel is designed so that the walls become fully parallel at a CHT of 300 degrees and that you normally cruise at a CHT of 400. You can imagine that, in this situation, the operating CHT causes the walls at the upper end of the cylinder to expand beyond parallel, excessively increasing the diameter of the cylinder at its upper end, as shown in figure 2. This results in a tapered cylinder wall surface against which the rings must try to seal, as depicted in figure 3. On each reciprocating stroke in this example, the rings must increase in diameter and expand out as the piston travels towards top dead center (TDC), defined as the uppermost piston position in its motion in the cylinder. Of course, as the piston travels down from TDC towards bottom dead center (BDC) at the cylinder's skirt, the rings are compressed to fit the smaller diameter that exists in the cooler part of the cylinder. This constant changing in diameter of cylinder walls that the rings have to seal against leads to wear in the ring, the cylinder wall and the piston ring groove, which ultimately results in "ring flutter." This phenomenon can occur anywhere in the cylinder barrel as a result of barrels that are not straight and round at operating temperature, or that have a poor surface finish, such as rust or improper honing. Ring flutter can also be triggered near TDC where the piston and rings must change their direction during the reciprocating stroke. To explain it, let's look at the TDC situation in more detail.

Note in figure 3 how the compression rings are no longer well supported in the piston ring groove near TDC, with the uppermost ring being worst case. The increased diameter of the cylinder allows the ring to extend well beyond the ends of the piston groove that supports it. Additionally, the face of the ring does not hit the cylinder walls squarely. In this situation the compression rings tend to roll very slightly as they reverse direction at TDC. Figure 4 depicts what results from this ring rolling motion during ring reversal. It causes a radial wear step indent to develop in the cylinder wall at the point where the compression rings rest when the piston is at TDC. As the rings roll and create the indentation, they also wear away the top and bottom surfaces of the piston ring groove. This in turn allows more ring rolling motion, and the cycle worsens. This rolling-ring wear mechanism eventually causes the rings to "hop, skip, and jump" (the essence of ring flutter) across the cylinder walls, producing high wear rates to rings, uneven wear to cylinder barrel and, of course, the possibility of a lot of oil loss through ring blow-by.

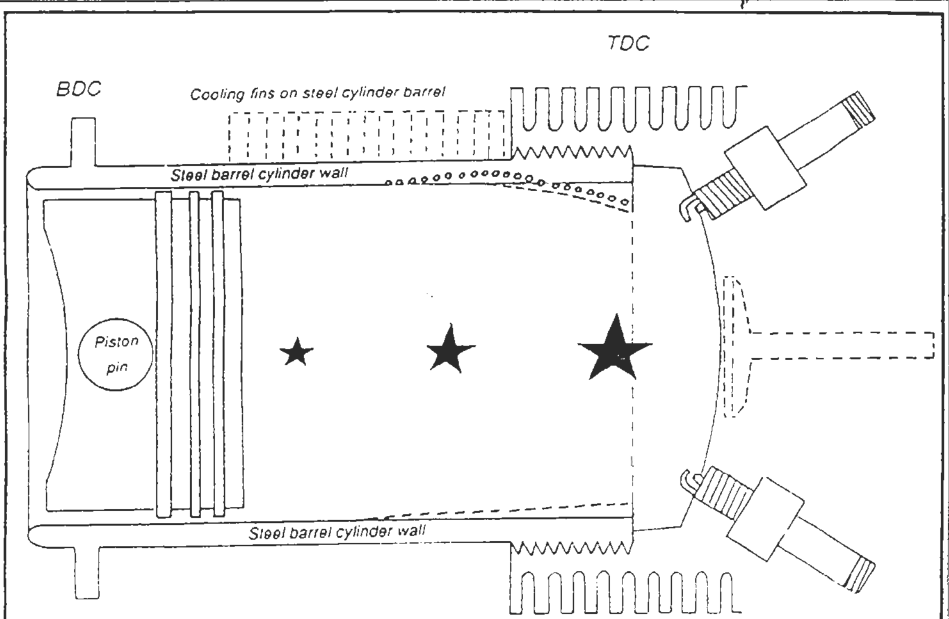

Figure 1

An Interesting Aside

A side point of interest regarding this phenomenon is that a compression test done to a good cylinder should produce the same results regardless of where the piston is on the compression (or power) stroke, as long as both valves are closed. When mechanics doing compression checks can get acceptable

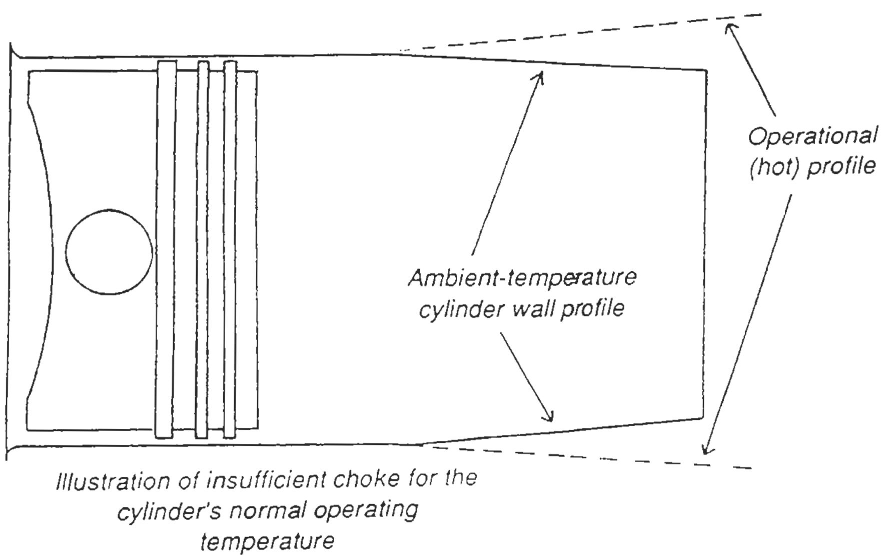

Figure 2

zero at other piston positions on the compression or power strokes in badly worn cylinders. There is no real, set limit for the minimum acceptable compression readings as the prop is moved well off TDC to test the ring's sealing ability with the cylinder wall. However, a compression loss of greater than 15psi or so should at least raise eyebrows.

One caution is warranted here. Most mechanics generally do not move the prop very far off TDC during compression checks. Accordingly, they may have no idea how much force is generated as the piston is moved well away form top dead center. When you or your mechanic do this test, make sure you chock both main gear, fore and aft, and have a helper who can rapidly release the quick disconnect at the cylinder adapter fitting if the prop forces become more than one can handle.

results only at TDC, and the compression readings fall off rapidly when the piston is moved away from TDC, it is a dead giveaway that this type of wear has occurred. In fact, in cases of really excessive wear the rings can be heard snapping into the radial wear step indent at TDC, at which point the differential compression gauge shows a maximum reading. Those of you who do your own compression checks have undoubtedly experienced this at one time or another. In a good cylinder, there should be no metallic snapping sound during a compression check near TDC. Additionally, the compression readings should remain reasonably constant if the prop is moved to reposition the piston throughout the normal compression and power strokes.

Here's another fact concerning compression checks. When rings do not seal properly with the cylinder wall, oil will leak past them. This will produce an increase in oil consumption, but will also tend to help the rings seal better when compression is tested. In fact, this condition can produce almost perfect compression readings on the cylinder with the worst wear!

It is for these kinds of reasons that a compression check reading must be seen in its proper light. A reading of 80/80 at TDC may in fact be bad news—it could be an indication of excessive wear if that reading falls off drastically when the piston is moved slightly away from TDC. Or, it could mean oil is leaking past worn rings. In general, compression readings must always be taken with a grain of salt and should be tempered with knowledge of oil consumption, total time on the cylinder, usage history and inspection of the lower spark plugs and cylinder walls for oil that would artificially elevate compression results. Bill Scott says it is not uncommon to get a compression reading of 80/80 at TDC and a reading of

Excessive Choke

So much for the discussion of insufficient choke. Now, let's make to opposite assumption. Say the cylinder choke was designed so that the walls become parallel at 450 degrees and your cruise CHT is 350°. There are no subtleties involved here. When the piston reaches TDC, the cylinder diameter is too small as a result of not enough expansion taking place due to cool-running CHTs. The piston and rings are "squashed" into the top of the cylinder. Piston scuffing occurs and the rings eat away the cylinder walls against which they are compressed, and vice versa. Piston, ring and cylinder walls all wear rapidly, and after awhile the choke simply vanishes—gone forever through mechanical abrasion. The final resulting condition is often insufficient choke—which you just read about.

The Lycoming Shortcut

Ideally, you would like to have a choke machined in each

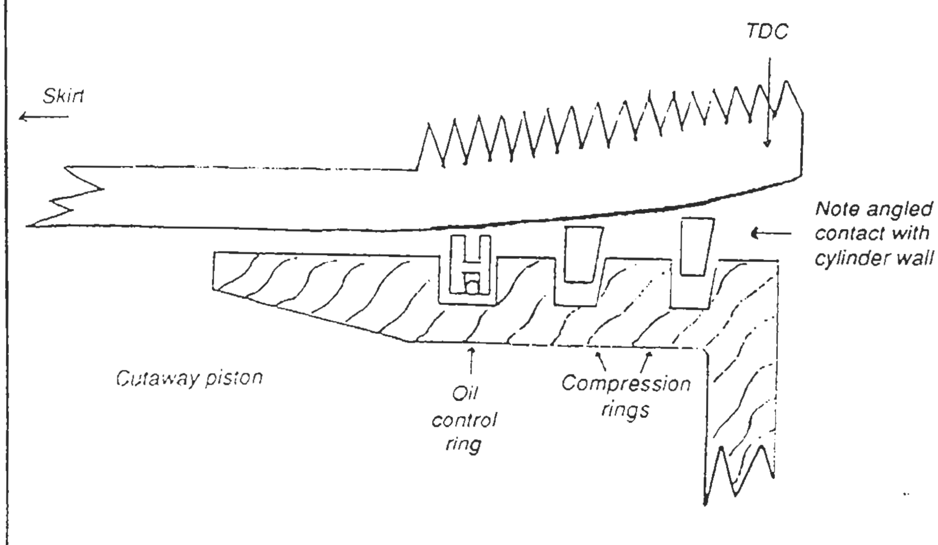

Figure 3

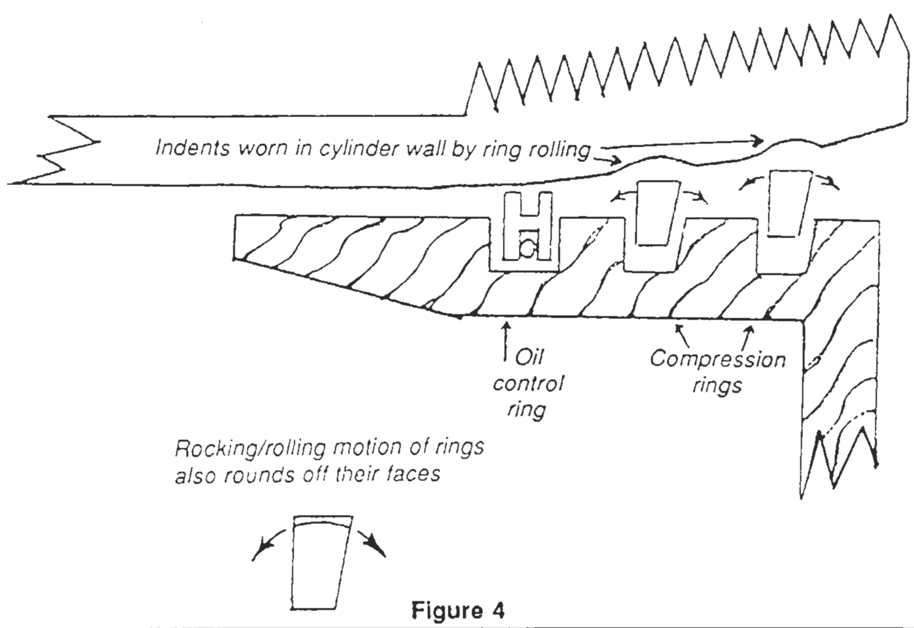

Figure 4

cylinder walls during operation with the Lycoming choke. Because the choke starts far up the barrel, the cylinder walls below the choked area expand beyond parallel due to the high heat level there. In contrast, because of the large amount of choke (.010 inches), the top of the cylinder never does attain the parallel-walls condition, because our CHTs do not run hot enough. Bill Scott believes that Lycoming made a mistake in its original decision as to the amount of choke required in its high-compression engines, such as the O-360 in the Tiger, the O-320 in the Cougar and the O-235 in the AA1C. The amount of choke placed in the cylinders by Lycoming is optimized for operation at the redline temperature of 500°F, which is rarely achieved and would trike terror in the heart and wallet of any pilot who saw such a reading on the CHT gauge. Most aircraft engines spend 97% of their life at cruise power with 350ish CHTs. The result is that, at cruise power and corresponding lower CHTs, a new Lycoming cylinder is not fully expanded and therefore the rings are constantly running on uneven cylinder walls and slamming into the remaining choke on the compression and exhaust strokes. In doing so, the rings are compressed to fit inside the smaller cylinder diameter, causing rapid wear to the cylinder walls, rings and pistons.

cylinder that corresponded to the usual cruise CHT of that particular cylinder. Pilots with multiple CHT systems in their aircraft could actually tell a cylinder shop what cruise temperature was generally associated with each cylinder. But in truth, most of our engines operate in the 330- to 390 degree range of CHT in cruise and Bill's experience tells us that a choke (diameter reduction) of about .007 inches works fine for this temperature range. Generally, it would be preferable to machine this choke profile into the cylinder barrel starting about half way up from the bottom with the smallest diameter occurring at the top, at the cylinder head. Such a profile appears as the *lower* dashed line if figure 1.

Lycoming does not, however, do it that way. During their cylinder buildup, the steel barrel with male threads on its outside diameter is screwed into female threads in the cast aluminum cylinder head. The latter is manufactured with a slightly smaller diameter than the barrel being screwed into it. This results in a nice, tight thread joint to hold the cylinder head on with no leakage. In addition, due to the tight fit of the barrel into the cylinder head, a slight reduction in the cylinder's inside diameter takes place. This diameter reduction exists about 1.25 to 1.5 inches of travel before TDC, and is the only choke provided. The barrel diameter reduction is about .010 inches and occurs only at the very top end of the barrel. This profile is shown in figure 1 by the *upper* dashed line. In short, Lycoming's choke occurs over a smaller distance and is of greater taper than preferable. This results in some very interesting geometry when the cylinder is in operation, as you'll see in the next paragraph.

Thermodynamics Always Win

The heat loading on the cylinder as shown in figure 1 is a fact of nature. The closer to the head you get, the hotter the metal becomes because the piston and rings mask the lower part of the barrel from combustion heat until the piston reaches BDC. You can't have it any other way. And that leads to the punch line. Note the choke profile shown at the top of figure 1, as designated by the small circles. This depicts the general shape of the

And this leads us to the ultimate irony in the saga of my new engine. In my two problem cylinders the choke was almost gone, with only .003 inches of choke remaining and all of that in the last ⅜ inch of ring travel. Why? Because in diligently keeping the CHTs in the 350 to 375 degree range for exhaust valve longevity, I was running the engine too cool for cylinder barrel longevity with the Lycoming choke!

The best way to describe Lycoming's choke is simply to quote Bill Scott. "Lycoming has come up with a choke that is inappropriate for their high-compression engines. Because it occurs over so short a distance in the barrel, the choke misses an area of the cylinder wall below it that needs taper. And because there is so much choke, the walls do not become fully parallel until an abnormally high CHT is reached. This choke profile simply cannot do what a choke is intended to do." And that is yet another reason why I opted not to take Lycoming up on their new-cylinder offer. By having Bill rework two of my cylinders to a more appropriate choke for my CHTs, I am able to test them against two original Lycoming cylinders still on the engine. In this manner I can continue to learn first hand what does and does not work right in these engines.

My Cylinders—Before and After

Upon visual inspection, the two cylinders I sent to Bill Scott at Precision Engine (phone 901-967-0316) looked quite normal, with one exception. As expected, they showed a nice blue-gray color on the inside of the barrel except for a ¾-inch-wide shiny steel abraded band in the cylinder ½ or so inches from TDC. This corresponded to the worn-away ramp area of the Lycoming choke, which, again, is a diameter reduction of about .010 inches and occurs only in the last inch or so of ring travel before TDC. As discussed previously, with almost no choke left, ring flutter and rolling were occurring, a fact confirmed by two ⅛-inch-wide bands in the cylinder walls corresponding to the reversal points of the two compression rings and the already widening ring grooves in the aluminum piston.

What Bill did to repair this damage is depicted in figure 5. The top four diagrams in that figure show both Lycoming's choke and my worn-out cylinder choke at room temperature and at operating temperature. The bottom two diagrams of the figure show the design of the repair itself. Bill Scott reworked the two cylinders by decreasing the amount of choke at top dead center and by increasing barrel diameter at the skirt, which allowed him to start the ramp of the choke lower in the cylinder, where it should be. As mentioned previously, this more-gradual choke better counteracts the expansion of the cylinder barrel in relationship to the amount of time the cylinder wall is subjected to combustion heat at various stations of piston and ring travel. Lycoming could change the profile of the choke they provide by not relying on barrel pinch in the cylinder head alone to provide choke. By starting out with a barrel that was lightly smaller in diameter, they could screw the barrel into the head, grind the optimal choke profile in the cylinder barrel, and then hone it for ring finish. Why they choose not to do this is unknown. My guess is to save money (theirs, not yours).

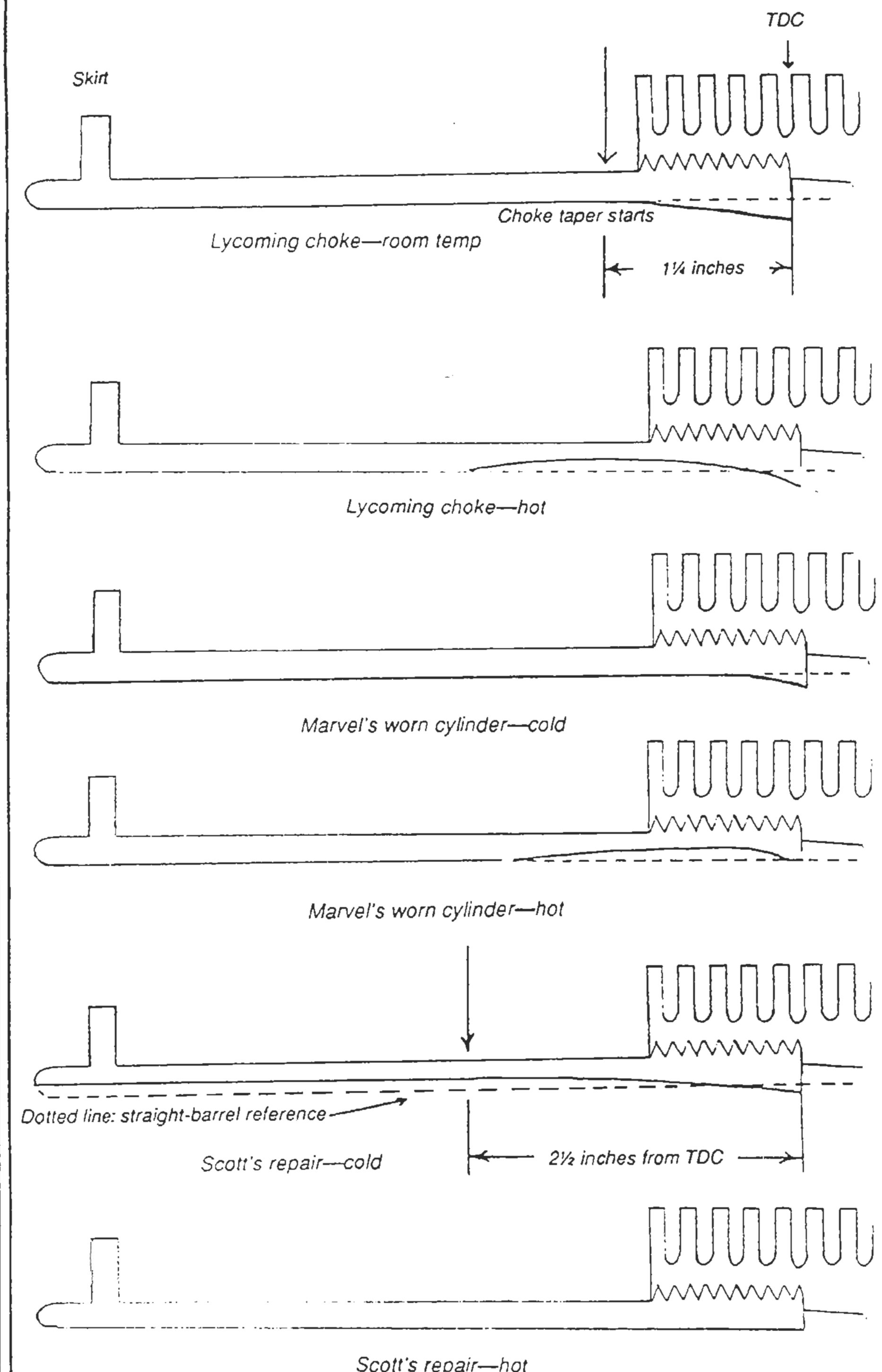

Figure 5

AYA Low Compression Cylinders

The AA1, -1A, AA5 and AA5A aircraft all have low-compression engines and feature plain steel barrels (meaning no surface hardening) that have no choke built into them at room temperature. Of course, these cylinders do not have parallel walls at operating temperature, but the theory is that, since they produce less power, and therefore less heat than do high-compression engines, they will run OK in their less-demanding life. This holds some truth for the AA5 and -5A but it isn't true for the AA1, -1A and -1B, which suffer from both the lack of choke and the contributing factor of a poorly-designed baffling system that increases CHT levels unnecessarily. Bill Scott reports that when these straight-barrel cylinders are chromed, it is *imperative* that the chrome shop build in a proper choke profile, as if they were high-compression cylinders (and that you independently confirm it prior to reinstallation). The reason will be explained momentarily; it has to do with ring tension.

AYA High-Compression Cylinders

The AA1c, AA5B and GA7 aircraft have high-compression engines, and thus generate more heat than their low-compression counterparts. Lycoming provides choked, nitrided cylinders for these applications (the wear surface of the barrel is hardened by the nitriding process). Lycoming warns that these cylinders should not be bored oversize when their barrels are worn. The reason is that the nitriding process hardens the surface of the barrel to only a shallow depth. In the process of oversizing the cylinder barrel to fit an oversize piston, the nitrided surface may be completely removed in places, since it does not harden the surface to a uniform depth as a result of inconsistencies in the hardening process. Oversizing could result in uneven wear to the barrel, due to the rings' running on alternating soft and hard steel spots in the cylinder, setting up the "hop, skip, and jump" characteristic of ring flutter. Bill has seen quite a few Tiger engines that had oversized cylinders installed by brand-name overhaul shops having an STC to do so. However, in most cases, he reports, the compression will drop and rings will be worn out at 400 to 500 hours.

Ring Tension

A piston ring's ability to spring out and expand against the cylinder walls is called ring tension. It is a function of both the metallurgy of the ring material itself and the high cylinder pressure behind the rings. Note in figure 6 that the rings are wedge-shaped, a design feature that allows high pressure gases, shown by the stars, to move behind the rings and push them radially outward to effect a seal with the cylinder barrel. An extremely important point here is that there are two distinctly different ring materials in use in our engines and these have a pronounced bearing on how well the rings seal.

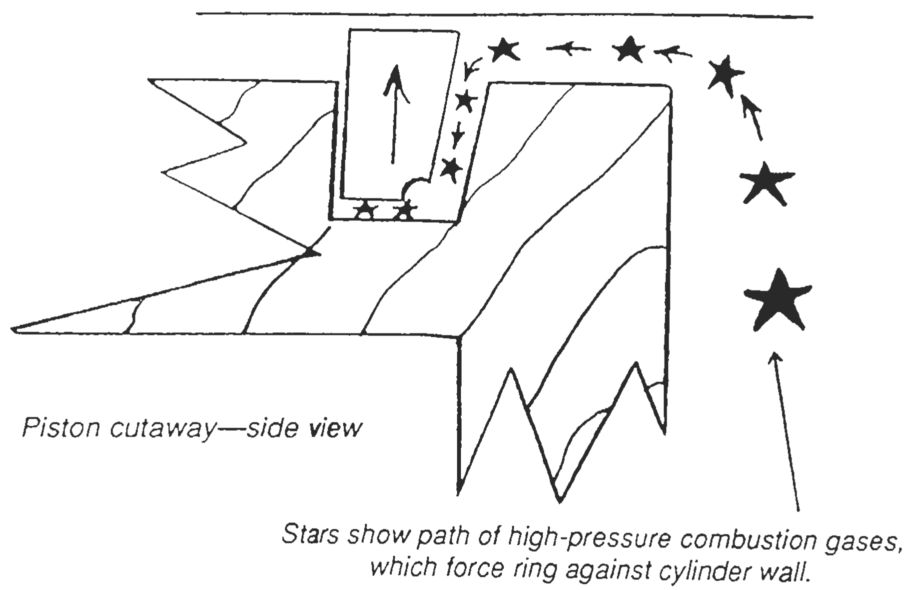

Figure 6

In new Lycoming cylinders, chrome-faced steel rings are used for both the plain steel and nitrided applications. These rings are extremely strong and springy and seat very tight against the cylinder walls, even with no combustion pressure aiding them. Accordingly, they are quite forgiving of advanced wear and tend to hold up well in service even in situations where the choke profile is completely worn out.

In contrast, chromed cylinders on all engines require the use of a soft, cast iron ring. This material is very flexible and relies almost entirely on cylinder pressure to create the seal with the cylinder walls. Because of this fact, these rings require a very good choke profile in order to seal properly. They are not at all tolerant of advanced barrel wear and will not hold up long in such a situation. If a chrome cylinder with no choke or an improper choke is installed on an engine, it is a virtual guarantee that there will be high oil consumption in that cylinder from the start. In fact, Bill Scott believes that the commonly acknowledged higher oil consumption in chrome engines is caused by improper attention to choke profile and is not inherent in the nature of the chrome material itself.

So the point to remember is that the inherent low ring tension of cast iron rings that operate on chrome cylinder walls will, without proper choke, result in high oil consumption for the life of the engine, along with a premature top overhaul(s).

What You Should Know

Much of this article has been oriented toward technical details intended to explain what happened in my cylinders and why. You don't need to know all of it to make sure that you get your money's worth from whoever does your engine work. You do need to know a few things, however.

One was just said. Don't allow anyone to put oversize cylinders on an AA5B, AA1C or GA7 engine. They won't last.

Another is to make sure your overhaul shop uses chrome-faced steel rings on plain steel or nitrided barrels and cast iron rings on chrome barrels. Simple as it sounds, incorrect ring use is a recurring problem. You will not believe the damage that can be done by putting chrome rings on chrome cylinders. They literally rip deep grooves in the cylinder walls.

Third, and certainly most important, is to have the choke profile of each cylinder *independently* checked by someone who has the knowledge and tools to do so. The reason for doing this to new Lycoming cylinders has already been explained. They need choke work right out of the box. But in addition, Bill Scott has to reject some 25% of the just-chromed or Cermicromed cylinders he receives back from his best vendors. He reports that even with proper instructions and prints, many vendors send back cylinders with improper choke profiles or none at all. In some cases, worn out cylinders with poor profiles are back with the same profile under a new layer of chrome! As explained earlier, such a jug will get you high oil consumption from square one no matter what you do to prevent it. The tragedy is that you won't ever suspect poor choke as the problem. You'll probably blame it on those "hot-running" Grummans.

Out of curiosity, I asked my well-respected IA if he checks the choke profiles of cylinders he receives back from vendors for customers airplanes before reinstalling them. He response was no, that he expected the yellow-tagged cylinder to fully ready to install upon receipt, meeting all specs. Don't let this mistake be made on your airplane and paid for out of your wallet. Have the cylinder choke checked independently of the people who overhaul the cylinder.

The Cleco

Experimental Aircraft Association
Chapter 393
P.O. Box 272725
Concord, CA 94527-2725

(9)Dues Due , 2/28/95

Bob Belshe
122 Fairfield PL.
Moraga , Ca. 94556