SPORTPLANE BUILDER...

By Tony Bingelis

ARE YOU USING AIRCRAFT HARDWARE CORRECTLY?

It doesn't take a mental giant to be able to install a bolt in a hole, slip on a nut and torque (that means 'tighten", Wilbur) it. It does, however, take a bit of thought, knowledge, self discipline and skill to do it correctly most of the time, and under different installation limitations.

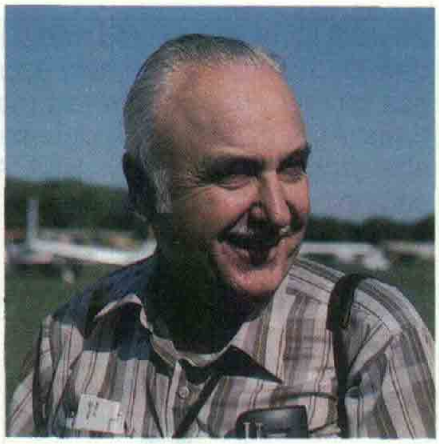
For the most part, I would assume that the folks building and rebuilding warbirds, racers and space shuttles are the most likely group that would use aircraft hardware correctly. I am not as sure about the ultralight, lightplane and other amateur builders as they are as contrasting a group of individuals as they are innovative. For this reason, if for no other, I make this plea.

Please don't even think of putting hardware store nuts and bolts in your aircraft project, even if they don't look like stove bolts. The importance of correctly selecting and correctly using the hardware that will be holding your airplane together deserves your most careful attention. After all, the safe and efficient operation of your aircraft will greatly depend on it.

I am told that the reason some first-time builders use commercial grade hardware is because nobody told them they shouldn't. Well, consider yourself told.

It is quite understandable that a builder who needs a particular sized bolt would be tempted to substitute anything else that would fit. After all, it is mighty convenient to be able to dash off to the hardware store and pick up a few bolts in the correct size just when you need them most. Unfortunately, they simply will not do. Most hardware store bolts have less than half the strength of similar sized aircraft bolts. In addition, they are prone to corrode and weather poorly, even though they are plated. See the difference for yourself . . . place two bolts side by side and compare the aircraft bolt to the hardware store bolt. The aircraft bolt will have a smoother finish and look much better than the commercial example. You will notice, too, that almost all commercial bolts have a coarse thread and you can't find self-locking nuts for them. Of course, there are high quality commercial bolts that have high tensile strengths and could probably be substituted safely.

Even the experienced builder sometimes finds himself without the proper hardware (bolt, etc.). And he, too, may decide to substitute something else for the missing item. He substitutes the needed bolt deliberately, but due to his



knowledge and experience, the substitution is fairly safe, or at least acceptable for a particular use. Not so with an individual who may be a whiz at a podium or among the "software set" but not so comfortable with things mechanical. He might make an unacceptable substitution, when faced with the same problem, simply to get on with his project. Actually, I don't think anyone, regardless of his background, should make substitutions in important structural applications without at least checking with the designer.

Even though it seems that rules are destined to be broken either deliberately or through blissful unawareness (ignorance, I think it's called), rules are useful and can even be important. A few written and unwritten topical rules follow.

As a rule, a bolt assembly generally consists of a bolt, a single washer and a nut. You can get by with a single washer provided the bolt length is correct for that particular location (see Figure 1).

The washer is always placed under the end that will be torqued. In all normal installations this would be under the nut. Does that mean that if you put a washer under the head of the bolt it would be O.K. to torque it? Well, the unwritten rule says it is bad practice to tighten a nut by turning the bolt head (it abrades the cadmium plating and tends to loosen the fit, that's why). Still, there are times when this is necessary.

I am sure most of you have heard of the rule that the bolt head always goes up or faces forward into the slipstream. This concept is based on the notion that if the nut comes off, gravity (or the slipstream) will hold the bolt in place. Using the same reasoning, you would put the head of the bolt on the inboard side of a helicopter rotor head so that centrifugal force would keep it in place.

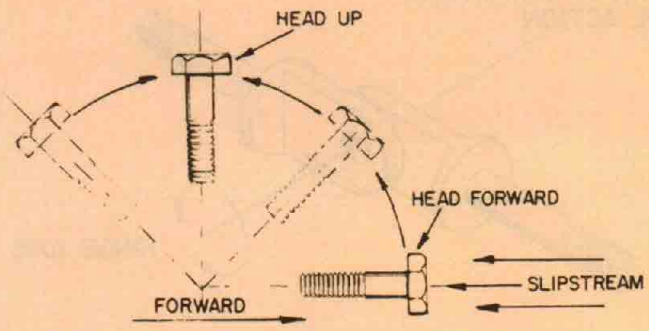
Nice thinking there and I'm sure that the "heads up" and "heads forward" practice is a good one. However, in some installations, it matters little how the bolt is inserted. If the nut comes off, the assembly will fall off, period. You should be aware of this. Sometimes it is absolutely impossible to install a bolt with the head up due to a lack of access or due to some structural peculiarity. So, install the thing head-down and don't worry about it. Just make sure that you use a good self-locking nut, or one that can be safetied in some other manner.

Why do you suppose aircraft manufacturers have a rule against cutting bolts or reworking threads without special permission? Since you are the manufacturer of your airplane what do you think about the practice? Cutting the end of a bolt off is no monumental thing, at worst the end would get rusty. Rethreading the shank, however, could be risky if the bolt were to be used in a highly stressed area or subjected to load reversals.

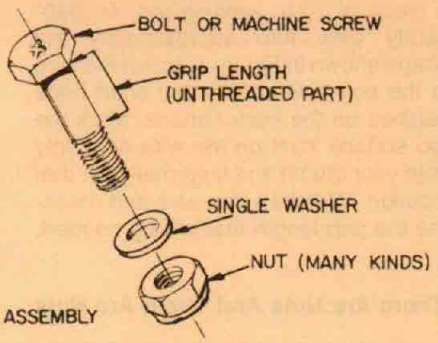
There is a rule about bolt lengths. It says that the bolt should be long enough that no threads bear on the structure or fitting. Other variations of the rule say that no more than 1-1/2 threads shall bear on the structure or fitting. Another way of saying essentially the same thing is to say that the grip length (unthreaded part of the shank) shall equal that of the parts being connected. At any rate, getting the correct bolt length is important.

The catalogs list the various AN (Army/Navy Specification) bolt lengths in 1/8 inch increments so an AN3-7 bolt would be a 3/16" bolt 7/8" long. Don't forget that about 3/8" of that bolt are taken up by threads and the grip length will be considerably shorter than the total length.

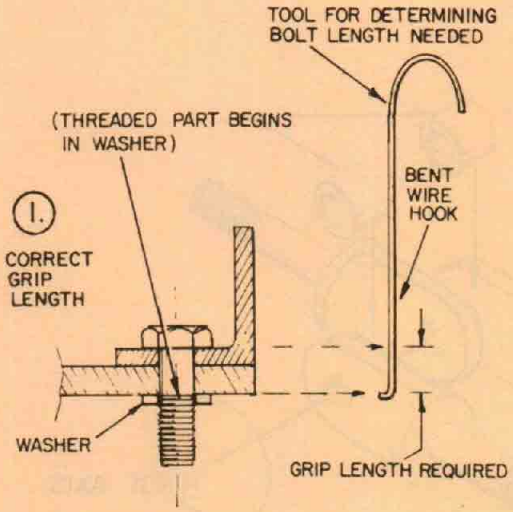
Plans are getting better as the years go by and designers are now doing a fairly good job of calling out the correct bolt sizes and lengths. However, you should check each installation to see that the grip length is correct for your project and that the bolt is not too short. If you can see the edges of the material being bolted together, or if you know the total thickness, arriving at the cor-

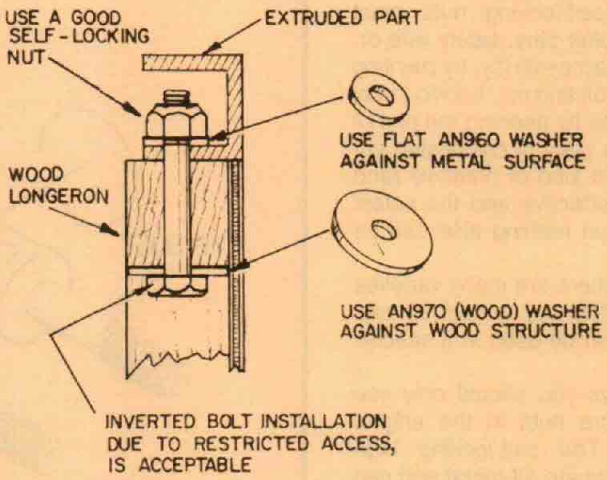


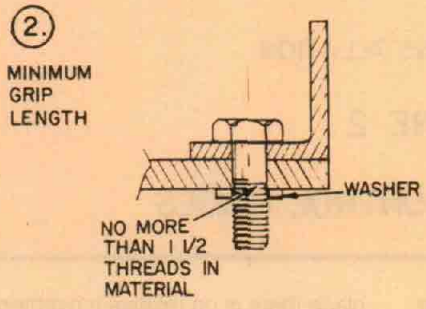
BOLT INSTALLATION BASICS

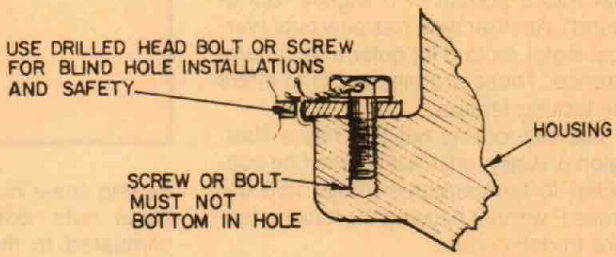


NORMAL BOLT ASSEMBLY









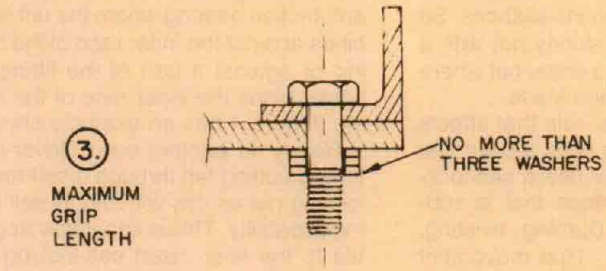


FIGURE 1.

STRUCTURAL BOLTS & MACHINE SCREWS
(INSTALLATION BASICS)

rect bolt length is easy. There are places, however, where you don't know exactly how long a bolt you will need unless you try two or three. Here's an easier way.

Make and use your own grip measuring tool. Bend this handy gadget out of a piece of 1/16" welding rod, or .040" safety wire, into approximately the shape shown in Figure 1. Insert the wire in the bolt hole so that the short hook catches on the back surface. Mark the top surface level on the wire or simply hold your thumb and fingernail over that location. Withdraw the wire and measure the grip length that will be needed.

There Are Nuts And There Are Nuts

I don't know what that means but, you guessed it, there are written and unwritten rules regarding the use of nuts.

It is said that all nuts, with the exception of safety (self-locking) nuts, must be locked by cotter pins, safety wire or, if because of inaccessibility, by painting the end of the bolt and nut. Locking may also be achieved by peening the end of the bolt when a plain or castellated nut is used. Sounds kind of primitive (and it is), but it is effective and the safest thing to do when nothing else can be done.

Fortunately, there are many varieties of nuts and often any one of several kinds of nuts can be used in a specific installation.

One rule says you should only use high temperature nuts in the engine compartment. The self-locking high temperature nuts are all-metal and can withstand temperatures of 450 degrees F and higher. Most of these nuts obtain their locking capability from threads that are slightly out of phase with the basic threads. Other types feature a basic nut that has a portion of it slightly "out of round". Another type has saw cuts (vertical slots) around its outer end circumference. These are pinched in to effect the locking feature.

The self-locking nut that has a fiber/nylon (usually red) insert cannot be subjected to temperatures above 250 degrees F without causing the locking feature to deteriorate.

Obviously, it is all right to use a high temperature type self-locking nut anywhere in the aircraft . . . even if it doesn't get hot there. Right? However, you had better keep the fiber insert type of self-locking nut out of the engine compartment. That is a pretty clear cut rule but if you knew where the temperatures were moderate enough you could still use the fiber nut there with confidence, but why waste time running studies and tests? Use the high temperature type nuts in the engine compartment and be done with it.

The same kind of reasoning is applied to shear nuts. You have self-locking shear nuts and you have castle shear nuts. Both are very thin when compared to the regular nuts. Shear nuts should never be used for other than shear applications. Regular self-locking or Castle nuts may be used for both shear and tension installations. So you can replace that skinny nut with a fat one but do not use a shear nut where it is subjected to tension loads.

There is still another rule that affects the use of self-locking nuts. It says that you should never ever use a self-locking nut next to a surface that is subjected to movement (turning, twisting, rotating or whatever). That movement under a self-locking nut could ultimately cause it to loosen and fall off. You can, however, use self-locking nuts any place there is no relative movement between the nut and the part to which it is attached.

For example, you can use self-locking nuts in a pulley installation, in a rod end bearing installation or against an anti-friction bearing where the nut tightly binds against the inner race of the bearing or against a part of the fitting that tightly binds the inner race of the bearing. Figure 4 has an example shown.

Ready for another one? Never run a thread cutting tap through a self-locking locking nut as this will ruin its self-locking capability. This is especially applicable to the fiber insert self-locking nuts used with machine screws.

Often safety nuts are very difficult to torque onto a machine screw because

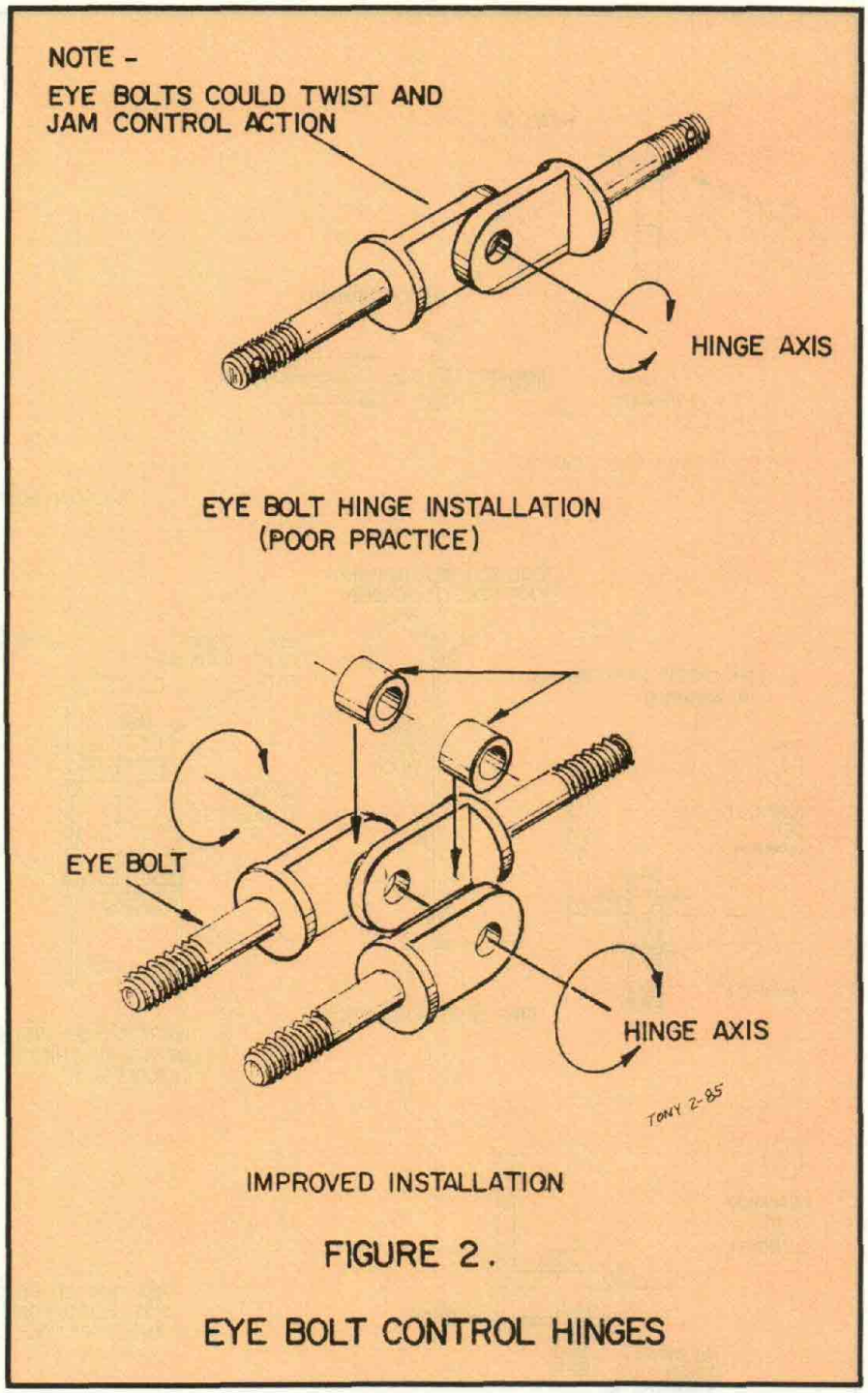


FIGURE 2.

EYE BOLT CONTROL HINGES

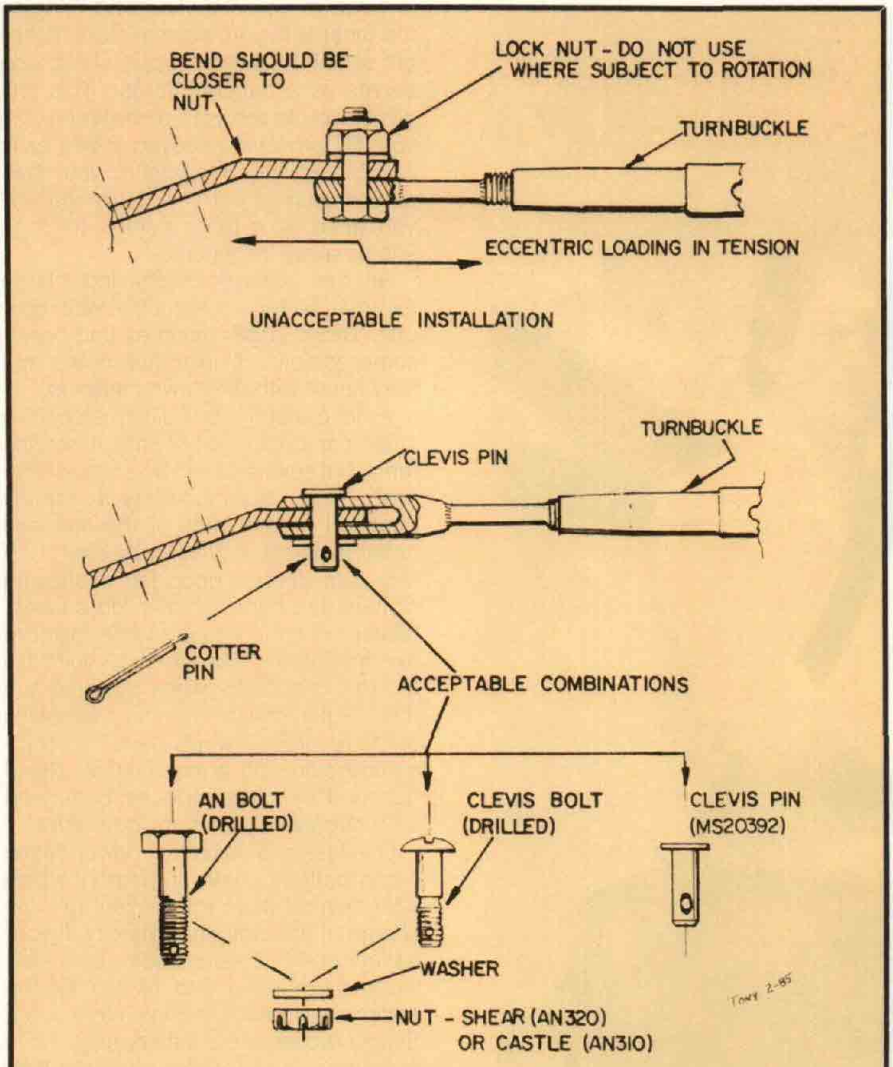


FIGURE 3.

TURNBUCKLE INSTALLATIONS (TYPICAL)

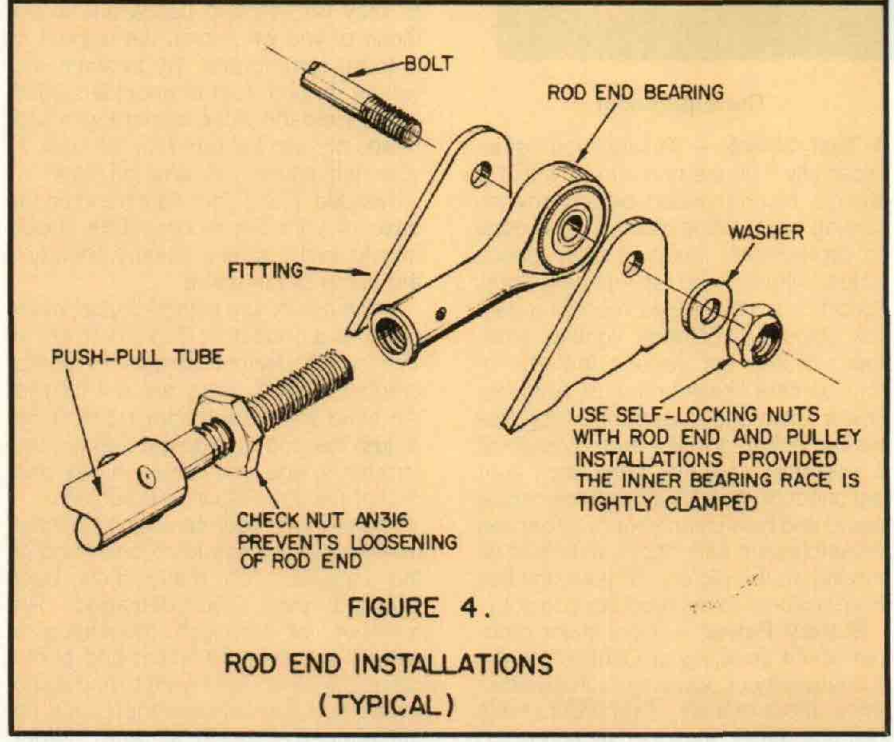


FIGURE 4.

ROD END INSTALLATIONS (TYPICAL)

they have to be turned with a screw driver. A screw driver cannot deliver the twisting force possible with a wrench on a hex head bolt. Some builders solve the difficulty by running a tap through the nut. Wrong, wrong. Of course, if you only need a nut and the self-locking feature is unimportant . . . but why not do it right?

Some people will tell you (more rules) that you shouldn't ever reuse a self-locking nut. Others say don't reuse one more than twice. (Saw a manufacturer's claim, somewhere, saying their nut was good enough for 50 reuses!) Pray tell, how would you know how many times it has already been used? So far, we don't have to keep a Nut Log Book.

My own rule is simple. Don't reuse any self-locking nut but if you do, make sure that it will not spin on all the way just using your fingers. In other words, make sure that the locking resistance of the nut is still effective. Alas, I just learned that there is an all-metal self locking nut that can be spun on by hand and the self locking feature does not engage until it is torqued with a wrench. Now what? I guess I'll just have to know what kind of nuts I am working with.

Here is another reminder about self-locking fiber nuts (reminders are sort of rules, too). Do not make a habit of using a self-locking fiber insert type of nut on a drilled bolt smaller than 5/16" in diameter. If you do use a drilled bolt, be sure that there are no burrs arond the cotter pin hole that could tear into the elastic insert. Maybe they make too much of this rule but then again, who wants to drive around with slashed tires even if they do hold air?

Let me give you one more and then I'll quit.

Inspectors and EAA Designees like to point out casually that that bolt is too long or that this one is too short, simply by looking at the nut. The rule they go by is one that says, when more than 3 threads are showing outside the nut the bolt may be too long. If the bolt is too long, the nut may not even be securing the bolt. (The nut has merely bottomed against the shank.)

But, wait, sometimes even one's eyes can be fooled. Some of the newer types of aerospace nuts appearing on the market are much smaller than the standard self-locking nuts. Using these can result in many more of the bolt threads being visible beyond the nut. This gives the erroneous impression that the bolt is too long.

Just proves that you can't believe everything you see or hear . . . you've got to think, too.

End of Sermon.

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