

Building Basics

JUST AS THE HUMAN cell is the basic building block of muscles, organs, tissues, and bones that make up the marvel that is the human body, the ubiquitous bolt is the most basic component of an airplane's construction. Like the human cell, without bolts, the airframe would never come to life.

The seemingly endless variety of bolt sizes and shapes can often overwhelm the new builder. Most likely the seemingly endless bins of bolts

All About Bolts

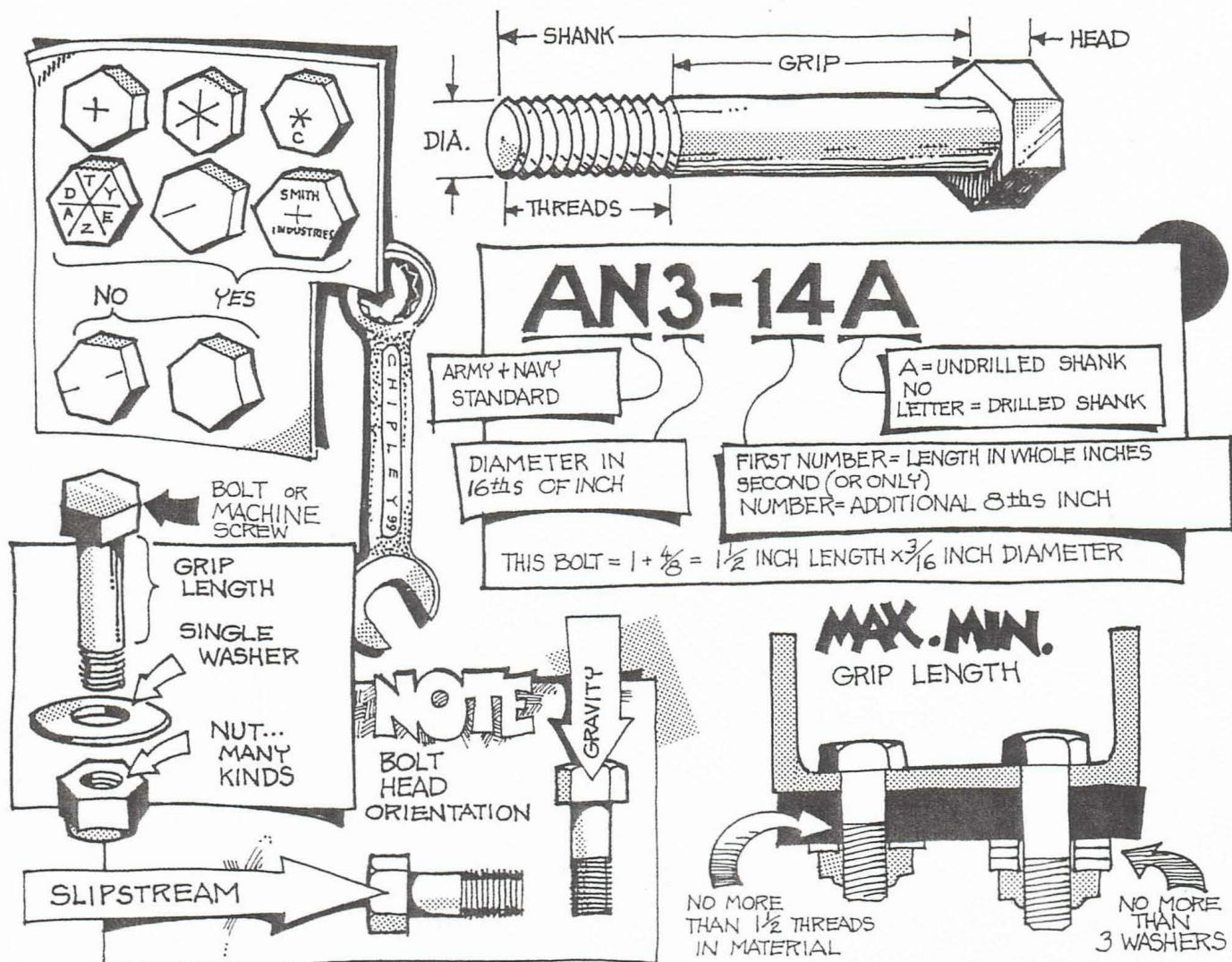
An up-close look at what holds an airplane together

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at your local hardware store have mesmerized you. Speaking of the hardware store, it *is not* the place to purchase the bolts and nuts you need for your aviation project.

As the builder of an experimental category airplane, you can legally use hardware-store nuts and bolts in

your project—but with rare exceptions *you should only use approved aircraft hardware*. The reason is simple: hardware-store bolts are made of a low-carbon, mild steel with a tensile strength of about 55,000 psi (pounds per square inch)—pretty weak. Aircraft quality hardware is made from a nickel alloy, corrosion-resistant steel. Heat treating further strengthens aircraft quality hardware to a minimum of 125,000 psi. Brings to mind the



"hefty, hefty, hefty, wimpy, wimpy, wimpy" TV commercial. Hardware is not the place to try to save money on your project, so always go "hefty."

Bolt Standards

Aircraft quality hardware is often called "AN" hardware, which stands for Army/Navy, the two military branches that established the criteria for acceptable aviation hardware way back when. Joining AN in the succeeding years are National Aerospace Standards (NAS) and Military Standards (MS, also called "mil-spec"). However, unless you're building a spacecraft in your workshop, AN hardware suffices for most applications, and the better home-builder's supply sources are well stocked with the AN fasteners.

You can identify an AN bolt by the marking on its head. These markings take many forms, but they do follow some basic rules. A bolt with no markings on the head is a non-certified bolt—the hardware-store wimpy variety.

Other head-codes can be simple asterisks or crossed lines, letter codes identifying the material from which the bolt is made, or even the name of the manufacturer. (See illustration.) These markings typically mean you're looking at a corrosion-resistant steel aircraft bolt.

You'll be dealing with AN bolts from the smallest AN3 (3/16-inch diameter) bolt, to the largest AN20 (1-1/4-inch diameter) bolt. But flipping through the latest Aircraft

Spruce & Specialty catalog, you'll discover additional alpha-numeric designations following the AN number. Although there's no need to memorize the countless bolt codes, there is a method to this cryptic madness. See the accompanying illustration for how to decode an AN bolt designation.

Bolt Vibrations

Airplanes vibrate, and vibration can cause bolts to wiggle loose and no longer fasten thing together. This is a bad thing in any aircraft, so AN bolts have features that allow you to

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prevent them from vibrating free.

Some AN bolts have a hole drilled through their head, shank, or both. Usually, the hole drilled in a bolt's shank is for a cotter pin. If the hole is drilled in the bolt's head, that's where you use safety wire to make sure the bolt won't vibrate loose. On bolts with a drilled head the letter H follows the AN designation. A bolt with a drilled shank has no letter after the alphanumeric AN string. If the bolt is not drilled, the letter A follows the AN code. Typically, you use a lock washer or elastic stop nut

with an undrilled bolt.

Sometimes a designer specifies a close-tolerance bolt. Because standard shank diameters can be off as much as .003 of an inch, in applications where a "perfect" fit is required to minimize wiggle—like a wing attach fitting—you need a close-tolerance bolt. Close-tolerance bolts have a small triangle embossed into the head, and are generally coded AN173 through AN186.

Bolt Grip

You don't need a ruler to learn how long a bolt is. Just look at the code on its head. More important than learning the bolt's length is deciding how long a bolt must be for a particular fastening job. A bolt's length is the length of its shank, and the length isn't always enough information to make the correct selection.

The unthreaded portion of the shank—the grip—is designed to carry shear loads. To securely fasten two things together, the bolt's grip should equal the depth of the hole through which the bolt passes (see illustration).

Sometimes "equal" is just a bit off, and as a general rule you can have no more than 1.5 included in the bolt hole. If more than 1.5 threads extend into the hole, your grip is too short, and you need to get another bolt.

Your bolt's grip is too long if you have to add more than three washers to the bolt before adding the nut. If that's the case, you need to get a bolt with a shorter grip.

Don't get into the habit of hack-sawing AN bolts to the proper length. This invites corrosion by exposing un-plated steel to the elements, and cutting and rethreading AN bolts weakens them.

It may not always be possible or practical, but when installing a bolt, it's always best to have the head of the bolt up or facing into the slipstream (see illustration). That way, if a nut inadvertently becomes loose or

Glossary

AN—Indicates an aircraft-quality piece of hardware. Stands for Army/Navy, the two service branches that first established criteria for aircraft-standard hardware.

Head—The hexagonal portion of the bolt over which the wrench fits.

Grip—The unthreaded portion of the shank.

Shank—The portion of the bolt designed to fit into the hole in the material. The length of an aircraft bolt is measured from under the head to the end of the shank.

Torque—The pressure applied to tighten the nut onto the bolt.

falls off, gravity, inertia, or air pressure might just hold the bolt in place until you can replace the errant nut.

Nuts & Washers

The nut's sole purpose is to prevent the bolt from separating from its fitting or fastened material and to add pressure to keep the bolted components from "working" against one another. And like bolts, an ordinary

nut won't do for aviation because of vibration and the high stress loads the fasteners must endure. AN nuts are categorized by the methods of security: self-locking, or stop nuts; nuts in conjunction with lock washers; or by external safetying—a cotter pin or safety wire.

The self-locking nut is the most common type used in aircraft construction. It has an elastic fiber or

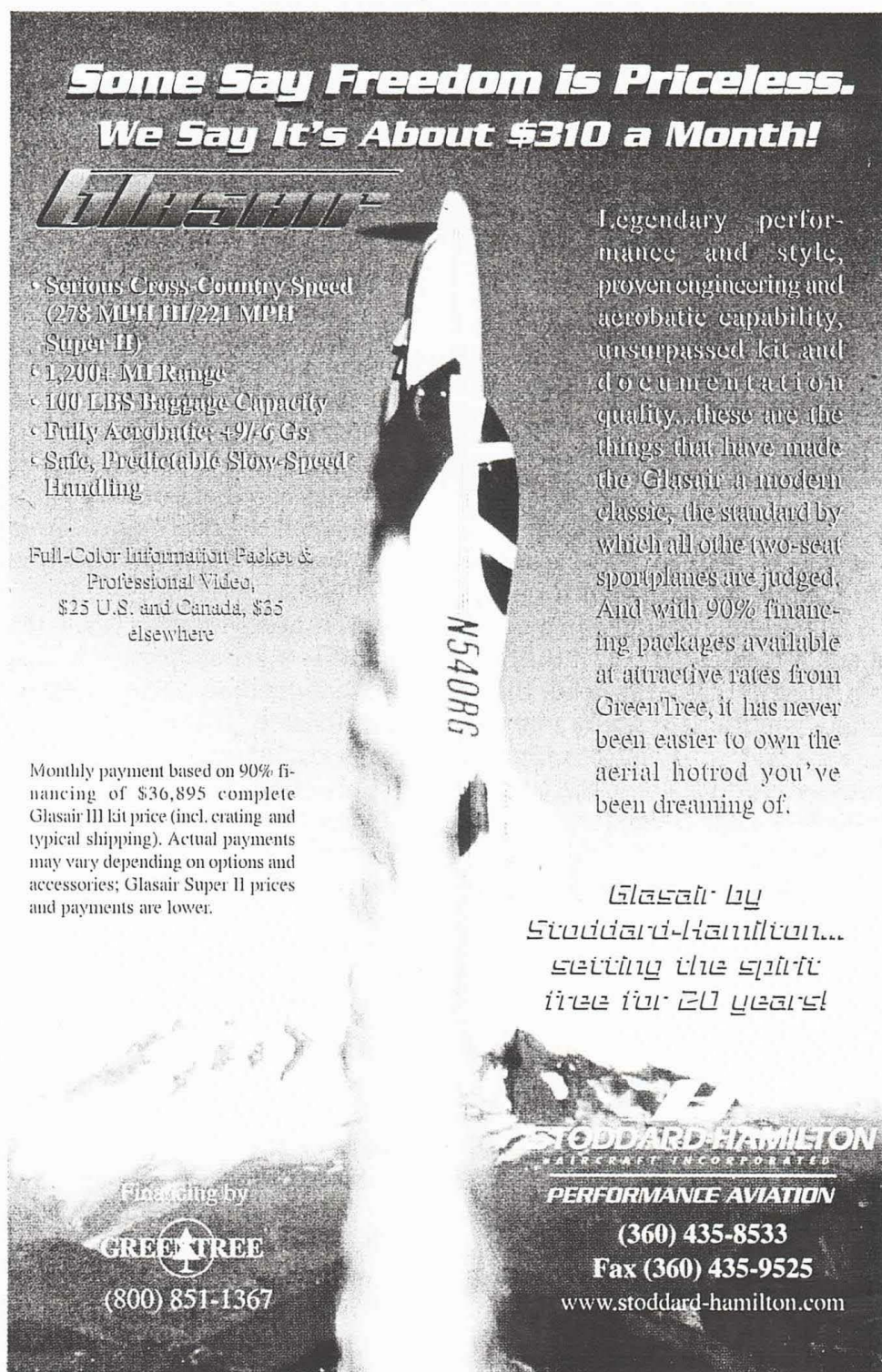
plastic insert that provides friction against the bolt's threads, resisting vibration. If you want proof of their gripping power, try turning the nut with your fingers. You'll get it started, but when the threads bite into the insert, you'll be looking for a wrench (unless you're Superman). If you can turn a self-locking nut on by hand—trash it. You can reuse self-locking nuts, but when they lose their gripping power, they are worthless—and unsafe.

There is an all-metal variety of self-locking or "stop nuts." They have a manufactured distortion that provides friction similar to the elastic insert. You primarily use all-metal stop nuts forward of the firewall because self-locking nuts with elastic inserts are only rated to 250°F.

You use an AN castle nut with a drilled-shank AN bolt. To safety the two, you pass a cotter pin through the "notches" in the castle (see illustration). Generally, you don't use nuts with drilled-head AN bolts. They screw into a tapped receiver of some sort, like the prop flange on an engine, and you pass safety wire through the head to keep it from vibrating out.

The lock washer is least common type of safetying. You must use it in conjunction with an AN flat washer, and combined it adds weight and complexity to the assembly.

The primary purpose of a washer is to spread the compression forces of the tightened nut and bolt combination over a wider area of the material to which it's being attached, and to protect the material from the tightening nut. The AN960 is most common washer. The number following the dash in the designation indicates the size of the bolt for which they're designed. Common AN washers come in a regular thickness, or a thinner version—typically used as a shim along with a castle nut—designated by an L for light, after the AN code string.



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Putting it all together

Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair, FAA Advisory Circular AC 43.13, lists the various “torques” for given bolts and applications. If you don’t have a torque wrench, a good rule of thumb is to just tighten them until they’re good and snug, but not over tightened. Hercules need not visit your workshop to torque your fittings.

You can also approximate the torque you’re putting on a nut by estimating the pounds of pressure you’re applying to the wrench along with the length of the wrench. For example, if AC 43.13 specifies 25 inch-pounds for an AN3 bolt, and you’re using a 6 inch wrench, applying about 4 pounds of pressure to the end of the wrench yields approximately 24 inch-pounds of torque ($4 \times 6 = 24$).

Obviously, there’s a lot more to learn about aviation hardware, and the Sources box suggests a few of them.

Sources

To learn more about aircraft bolts, these resources were the references for this article. If they are available from EAA, their item number and price are in brackets. To order, call 800/843-3612.

***Sportplane Construction Techniques* by Tony Bingelis
[F01395—\$24.95]**

***Kitplane Construction, Second Edition*, by Ron Wanttaja
[F00580—\$29.95]**

***Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair, FAA Advisory Circular 43.13*
[F00191—\$18.95]**

**Aircraft Spruce & Specialty catalog, 1-800-824-1930, or
www.aircraft-spruce.com**