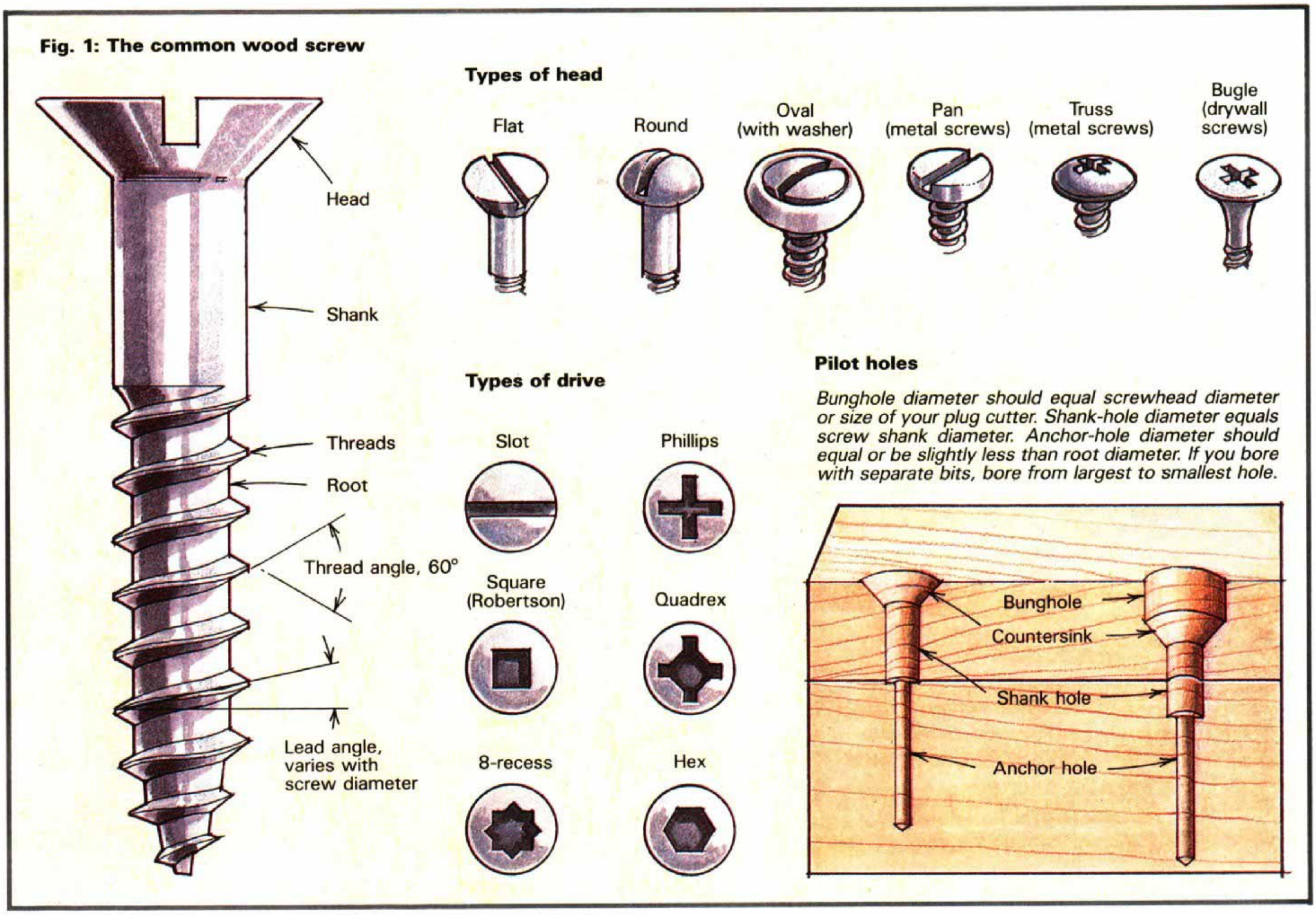
Wood Screws

The basics of the basic fastener

by George Mustoe



One day during my late teens I was struck by the desire to build a small sailboat. The fact that I knew nothing about sailing seemed irrelevant, as did my lack of woodworking expertise. After all, I'd built some barn-lumber shelves for my rock collection just the summer before and, as a foolish adolescent, building a boat didn't sound much more difficult. Within a year my 12 foot craft was sunk in a spring storm and I have few memories of sailing it, but, fifteen years later, I still remember the blisters I got driving hundreds of screws to fasten the plywood hull. Since then I've never had a great fondness for wood screws, but I don't share the disdain of purists who believe that metal fasteners are the devil's tool for capturing the souls of cabinetmakers.

Craftsmen who rely on well-cut joints for their finer projects still find screws handy for reinforcing these joints, as well as for attaching hardware, assembling jigs and bending forms, and making the usual run of utility furniture for home and shop (see figure 2, p. 50). Wood screws have gained even greater importance in recent years because of the increased use of particleboard and plywood, materials that are not suited for traditional joinery.

The basic wood screw consists of a head and a shank, roughly two-thirds of which is threaded. Standard wood screws come in lengths from about ¼ in. to 6 in., and a variety of head configurations, as shown in the drawing. In general, flat-head screws are used flush with the surface or hidden beneath a plug.

Round-head screws can be left visible, and, for a fancier touch, you can use oval-head screws seated in nickel-plated finishing washers. Sheet metal and drywall screws are increasingly used in wood (see box, p. 51). Sheet metal screws have flat or pan heads and drywall screws employ bugle heads, which are self-countersinking in sheetrock, most plywood, and softer woods. The drawing also shows some of the variety of drive configurations available. Square-drive screws are common in Canada, where they're called Robertson screws, after their inventor. A square-drive variant, the Quadrex screw, can be driven with either square or Phillips drivers.

Shank diameters are measured in gauge sizes from 0 to 24 (a range from 0.060 in. to about 0.372 in.), the difference between successive gauges being 0.013 in. The solid core of the threaded portion is called the root; its diameter is measured from valley to valley of opposing threads. All screws of the same gauge have the same head, shank and root diameters, regardless of their length. Two angles describe the threads. Single threads viewed in cross section have an included angle of 60°, called the "thread angle." Most wood screws, regardless of other differences, have thread angles of 60°. The "lead angle" is the pitch at which the thread winds around the shank. It varies according to the shank diameter, but is much the same on many common screws—the difference between the lead angle of a #2 screw, with 26 threads per inch (tpi) and a #24 screw, with 7 tpi, is a matter of only a few degrees.

Threads are either cut or rolled on the screw blank. In the first process, metal is cut away on a form of metal lathe. In the second, the blank is squashed between two dies to form the threads. A rolling machine can spit out between 200 and 300 screws per minute, while a thread cutter, which must make half a dozen passes by each blank, can produce only a tenth as many. Chances are, however, that the screws you're using (hardened drywall screws excepted) are cut, not rolled. It seems that third-world countries can produce cut-thread screws cheaper than first-worlders can produce rolled screws. If the outside thread diameter equals the shank diameter, it's probably cut; if the shank diameter is smaller, it's probably rolled. There's no difference in performance, though rolled threads are said to be marginally stronger.

For ordinary wood screws the choice of metal is usually determined by the amount of corrosion resistance that's required, or for appearance. Plain steel screws are not seen much anymore, and most steel screws have a thin plating of nickel, cadmium, or zinc chromate. (Unplated steel screws may stain woods containing tanin, such as oak.) Galvanized screws are better for outdoor uses, but the rough zinc coating makes them hard to drive. Brass and bronze screws are weather resistant and their golden color makes them popular whenever screwheads are visible. Aluminum screws are handy for attaching metal molding and where light weight is important. (Don't use aluminum screws in steel, or vice-versa, as any moisture will cause a galvanic reaction that will rot the hole.) Stainless steel screws offer the ultimate protection against corrosion, but they are relatively expensive.

The mechanical properties of the various types of screws are similar enough and screws appear to be so deceptively simple that workers often give little thought to the engineering considerations that go into a well-planned, screwed joint.

Screwed joints must withstand lateral shearing forces as well as the direct pull of tensile loads. Tensile loads are resisted by the force of the screw threads acting against the head. Lateral loads involve a different type of holding power, namely the friction of the wood surfaces that are being pressed together by the clamping action of the screw. When the surfaces are also glued, the joint's holding power is greatly increased.

The most serious mechanical limitation of wood screws is that they focus stress on a very small area of the joint. This effect is minimized by making sure screws penetrate far enough and are spaced closely enough to distribute their holding power. Several medium-size screws, say #8 or #10, spaced 4 in. to 6 in. apart will be stronger than huge screws placed at 1 ft. intervals. More penetration means more strength. A handy rule of thumb for screw length is that, where possible, the entire threaded portion of the screw should penetrate the piece.

The strength of screwed joints is highly variable according to the size and spacing of the screws, the type of wood, and the grain direction. Withdrawal strength (tensile load), for example, varies according to how deep the screw is inserted and the shear strength of the wood. A #10 wood screw inserted ½ in. into face grain will resist withdrawal up to 678 lb. in maple, but only 346 lb. in yellow poplar. Inserted 1 in., the values rise to 1,400 lb. and 711 lb., respectively. The holding power in any species is about 50% less for endgrain, so screw length should be increased about one and a half times to compensate.

Screws must be kept snug if they are to perform properly. This is a problem particularly with chairs and other solid wood furniture where wood shrinkage, severe overloading or merely the rigors of daily use can cause joints to open up so that the screws are no longer able to maintain pressure between the adjacent wood surfaces. Instead of being distributed evenly over the joint, the loading falls on the shank of the screw. If the screw loosens, it may pull out. More likely, the joint will fail when the wood around the screw tears out or splits.

The strength of the screw metal is not very important in determining the final strength of the joint, for even the softest metals are much stronger than the wood they penetrate. When screws do break during driving, it's almost always because the pilot hole is too small. In effect, you shear off the screw—proof that the lateral strength of a screw is much less than its tensile strength.

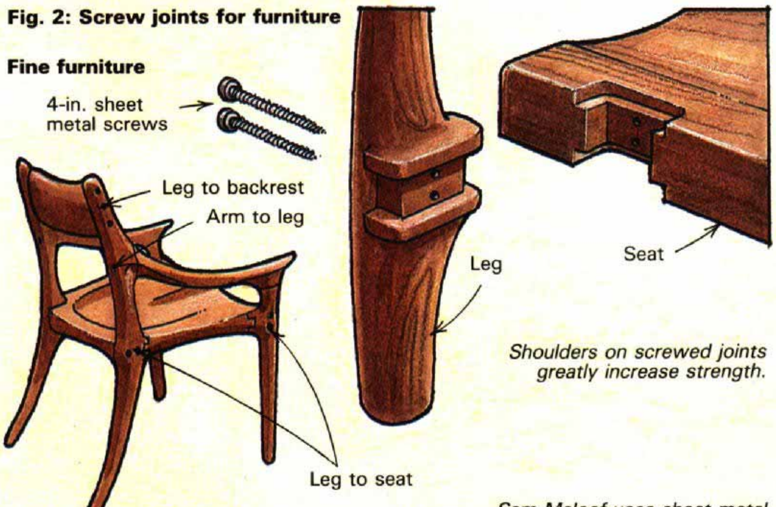
Screwed joints don't allow wood movement to take place, so screws cause problems when used to attach solid wood panels to cabinet carcases, or in other situations where humidity changes would cause expansion or contraction along the joint. Several methods of allowing for movement when attaching tabletops or panels with screws are shown in figure 2.

Most screwdriving problems are related to the pilot hole. In fact, the pilot hole consists of several concentric holes, as shown in the drawing on the facing page. The plug or bunghole (or countersink, if a flat-head screw isn't to be hidden) should be at least the diameter of the screwhead or of your plug cutter. The shank clearance hole should be the same diameter as the unthreaded portion of the screw's shank. This allows the shank to slide through the wood without binding so the two pieces are drawn together as the screw is tightened.

The anchor hole is drilled the same diameter or slightly smaller than the screw's root diameter. If the anchor hole is too large in diameter, the holding power is reduced and the screw is likely to strip out of the hole. Too narrow and you're in for some hard driving and the possibility of a broken screw or split lumber. Some wood technologists recommend that anchor holes be 70% of root diameter, larger for denser woods, and

Fig. 2: Screw joints for furniture

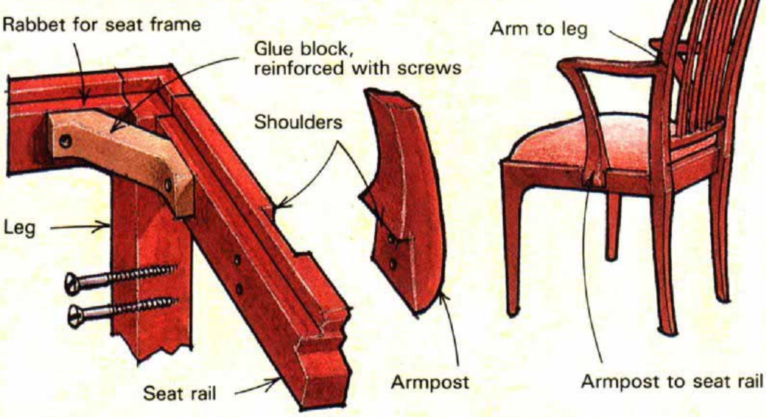
Fine furniture



Shoulders on screwed joints greatly increase strength.

Sam Maloof uses sheet metal screws to reinforce crucial joints in his chairs. Joints are glued and clamped, then screwed.

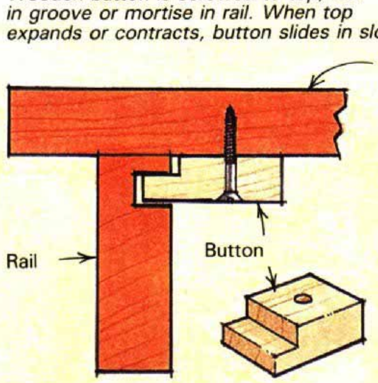
Traditional chairmakers also reinforced joints with screws.

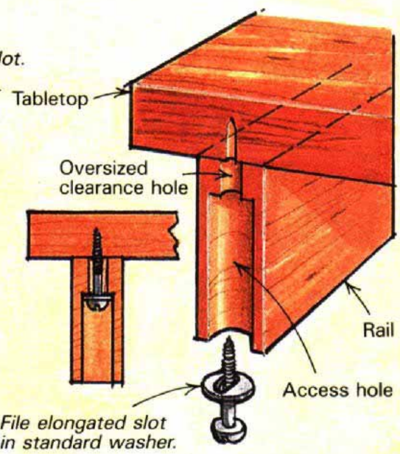


To fix a tabletop to its base and allow for wood movement, you can use buttons (below left) or slot screw (below right).

Top is screwed to rails through a slotted washer in which screw can slide as top expands and contracts.

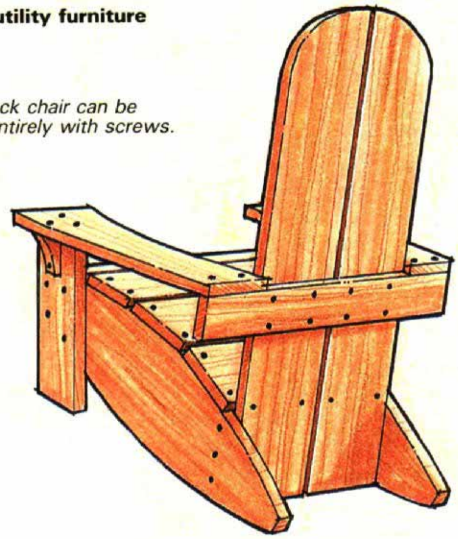
Wooden button is screwed to top, fits in groove or mortise in rail. When top expands or contracts, button slides in slot.



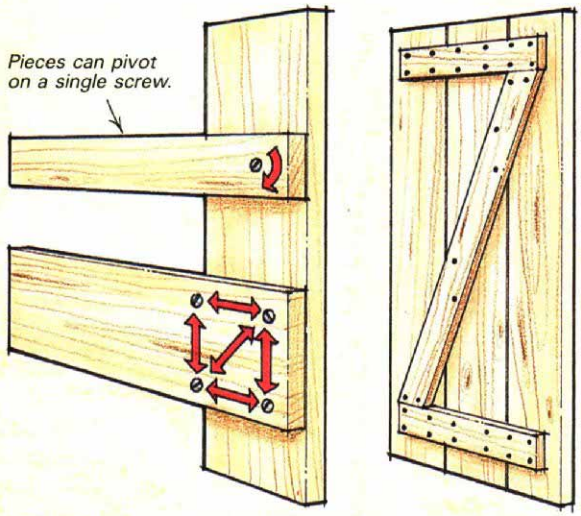


Screws in utility furniture

An Adirondack chair can be assembled entirely with screws.

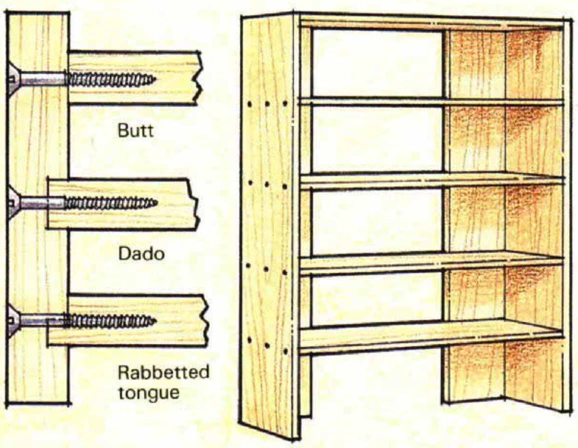


Flat panels for doors, tabletops and carcase sides can be quickly made with screwed battens. Screwing pattern shown here makes no allowance for wood movement, but provides for maximum strength through triangulation.



Screws in rectangular pattern resist racking through triangulation of forces between any combination of three screws.

For simple carcases, like this bookcase, screws can provide the primary joint (butt joint), or can reinforce stronger, shouldered joints (dado and tongue).



Wide back battens screwed to carcase top, sides and shelves triangulates the structure and makes it rigid. A full back of thin plywood or Masonite will do the same.

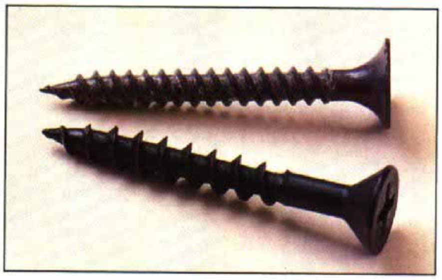
Drywall screws: who needs pilot holes?

by Paul Bertorelli

My hatred of the common wood screw has nothing to do with the purist's view that wood ought not be defiled by metal. Except for dowels, I'll stoop to any method of fastening wood, so long as it gets the job done in a hurry. What I can't stand is rummaging around my drill box for the right pilot bits (usually burned and dull) and my drill's extension cord (upstairs running the fan), only to discover that I've lost the chuck key again.

I had just about resigned myself to common wood screws and their attendant paraphernalia when a friend introduced me to drywall screws six years ago. These case-hardened screws are engineered to penetrate drywall, wood and thin metal without a pilot hole. They were developed during the 1960s when metal framing began displacing wooden studs in commercial buildings. Before long, cabinet and furniture shops discovered how effective they are for woodworking. These days, they are often available in the local hardware store along with low-cost power driving attachments for electric drills.

Drywall screws more closely resemble self-tapping sheet metal screws than regular wood screws. They have a straight shank that terminates in a needle-sharp gimlet point capable of penetrating light metal and wood under power driving. Usually, the shank is threaded right up to the base of the head, but some drywall-type screws have partially unthreaded shanks. Most drywall screws have double lead, which means that two threads wrap their way around the shank rather than just one. The angle at which each of these threads climbs the shank is double that of an equivalent conventional wood screw, so double-lead screws drive faster. Some manufacturers say they have marginally greater withdrawal strength than single leads, but the difference rarely matters in woodworking applications.



For speed and holding power, drywall screws are hard to beat. Top screw has a double-lead, fully-threaded shank. Bottom screw has single-lead threads.

The threads themselves are deeper than those of a conventional wood screw, that is, their height represents a greater proportion of the root diameter. Deep threads are why drywall screws work so well without a pilot hole. They bite hard and forcefully pull the screw into the wood, displacing the, wood and compressing it rather than actually boring a hole as a pilot bit does. With all that compressed wood crammed into the threads, drywall screws are supposed to be very resistant to stripping, especially in plywood and particleboard where conventional screws don't hold nearly as well. Despite this forceful entry, these screws don't seem to cause much splitting when driven in hardwood, at least in my experience.

Drywall screws aren't available in as many varieties as are conventional screws. The most common sizes are #6 and #8 in lengths from ¾ in. up to 3 in. Some suppliers sell larger and smaller sizes, but I've found that a box each of #8 Phillips head in 1¼-in. and 2-in. lengths covers virtually all of my needs.

Drywall screws have bugle heads, their undersides gently radiused rather than sharply angled like a regular flat head. In softwood, some hardwoods and plywood, a bugle head will neatly countersink itself. In meaner woods, you may have to help the screw along with a countersink before driving, and a single-diameter pilot hole makes driving easier. But in most applications, you don't need a pilot hole at all.

My weapon of choice for driving drywall screws in wood is a Makita electric screwdriver fitted with a Phillips bit in a magnetic holder. Simply snap on a screw, jab the point into the wood and pull the trigger. You can drive these screws by hand but frankly, I don't see the point of it. One of the reasons they are case-hardened is to stand up to punishing torque of power driving. In six years, I can only remember snapping one.

I pop in a drywall screw anywhere a regular screw might go. For utility shelving out of plywood, for example, I just butt join the parts with four or five screws across a shelf 10 in. wide. Glued carcase joints can be pulled home with a few drywall screws and the screws left in for additional strength. Conventional screws are too wimpy for that kind of barbarism. If I want a neater job I either do a quick countersink or use a brad-point drill fitted with a depth stop to bore a bunghole.

The only thing I don't really understand about drywall screws is why they haven't driven conventional wood screws into complete oblivion. Perhaps it's nostalgia. I've got a couple of dozen boxes of old-style wood screws gathering dust in my shop. I guess I'm saving them for something, but I can't imagine what it might be.

Paul Bertorelli is editor of Fine Woodworking *magazine.*

most screw manufacturers give away charts listing optimum drill sizes. But it's easy to select the proper drill bits just by holding them up against the screw to compare diameters. It's a wise idea to drill a pilot hole in a piece of scrap lumber to test the anchor hole fit, though. Leave the anchor hole shallow so that the leading two or three threads penetrate solid wood.

A small dab of tallow, soap, beeswax or paraffin makes insertion easier, but lubrication won't be necessary if the proper size pilot hole is used. Try to resist the urge to give that final jerk, which can twist off the screw. If a reluctant screw won't turn quite as far as you'd like, try striking the screwdriver one sharp, downward blow with a mallet. The compression will usually create just enough slack so that the screw can be rotated another one-half turn. You'll also avoid marred screwheads and gouged work by using a driver that fits the screwhead snugly.

To make pilot holes for bunged screws, three different bits are needed: one for the anchor hole, one for the clearance hole and one for the bunghole. This explains why so many impatient workers end up trying to use brute force to make a screw fit into a single hole. If you use more than an occasional screw, it's worth the expense to buy a set of pilot-hole bits, which drill stair-stepped or tapered holes in a single operation, including the countersink or plug hole.

Three styles of pilot-hole bits are commonly available, either

Pilot bits, another view

by Michael Podmaniczky

As George Mustoe has pointed out, the job of properly boring pilot holes for a screw requires three different-size drill bits, one each for anchor, clearance and recess (the bunghole, to a boatbuilder). Boring three separate holes takes time, an important factor to the professional, so various "step" bits were developed. They are indeed faster, but have serious drawbacks. Adjustment is minimal or absent, and waste clearance is ineffective. Tapered bits, for example, cut along their full length, making thorn prone to overheating, and they are difficult and expensive to sharpen. More often than not, step bits produce burned wood, dull bits and oversized bungholes from the repeated plunging necessary to clear the waste. If time isn't your main concern, there's a better way to do the job.

Decide on the screw sizes you most commonly use: probably #6, #8, #10 and maybe #12. Trot down to the hardware store and buy four ***good*** twist bits to match each screw size: two anchors (one each for hard and soft wood), one for shank clearance and one for countersinking and bungholes. This last bit should allow for the smallest-size bung possible, and should be ground to match the shape of the underside of the screw head. To ensure a very tight bung fit, I've also had the diameters of the bung bits professionally ground a few thousandths undersize. If you're feeling flush, buy brad-point bits as well for countersinking round-head screws—they produce a flat bedding surface for the screw head.

Mount all of these bits in a nicely finished block of wood, stand it on the shelf over your workbench and you are ready for anything.

Michael Podmaniczky of Williamstown, Mass., is a contributing editor to Fine Woodworking.

Pilot bits range in sophistication from the one-piece, non-adjustable bit at bottom right to the three-piece tapered twist drill with countersink/bunghole and depth collar at top right. Between is a two-piece rig consisting of a common twist bit and a countersink/bunghole cutter. From left are a brad point twist bit, two plug cutters and a Vix pilot bit, which centers a twist bit in hardware holes—hinges, locks, strike plates and so on.

as individual bits or in sets that cover the most common screw sizes (examples are shown in the photo at left). The least expensive kinds are single-piece flat or half-round steel bits. Their limitation is complete lack of adjustability—a #12 bit, for example, might work great for a 2-in.-long screw, but poorly for longer or shorter sizes. For only a little more money, you can buy pilot bits having an adjustable cutting sleeve. With these, the shank hole depth remains constant, but you can vary the depth of the anchor hole. Some of these adjustable bits have flat cutters, but the best ones use a twist drill for the anchor hole. A set of four costs about $7. Tapered twist bits cut both anchor and shank holes at the same time with exceptional accuracy, and they stay sharp longer than the other two types. Each screw size requires a bit, a matching countersink/bung borer, and a collar depth stop. A set of seven can cost from $50 to $70. They're worth the cost if you use a lot of screws, especially when working with very hard wood.

George Mustoe, a geologist and woodworker, lives in Bellingham, Wash.

Sources of supply

A wide variety of screws, pilot bits and screwdrivers are generally available at hardware stores. Here are some other sources:

Screws—Reed and Prince, one of the largest screw manufacturers in the country, doesn't sell small quantities direct; to find the distributor nearest you, write to Judy Hogan, Reed and Prince, 1 Duncan Avenue, Worcester, MA 01603, or phone (800) 225-7260. Trend-Lines (375 Beacham St., Chelsea, MA 02150) carries a good selection of wood and drywall screws. Parker-Kalon (395 Roberts Road, Campbellsville, KY 42718) makes a drill-point drywall screw for use in heavier metals, and Woodshop Machines (70 Regional Drive, Concord, NH 03301) sells Quadrex screws. Write for information.

Tools—Pilot bits, brad-point bits, power-drive bits, plug cutters, and a variety of hand and power drivers are carried by Garrett Wade Co. (161 Avenue of the Americas, New York, NY 10013), Woodcraft (41 Atlantic Ave., P.O. Box 4000, Woburn, MA 01888), and Trend-Lines (see above).