Chapter 1

Nails, Screws, Bolts, and Other Fasteners

The strength and stability of any structure depend heavily on the fastenings that hold its parts together. One prime advantage of wood as a structural material is the ease with which wood structural parts can be joined together with a wide variety of fastenings—nails, spikes, screws, bolts, lag screws, drift pins, staples, and metal connectors of various types. For utmost rigidity, strength, and service, each type of fastening requires joint designs adapted to the strength properties of wood along and across the grain and to dimensional changes that may occur with changes in moisture content.

Nails

Nails are the most common fasteners used in construction.

Up to the end of the Colonial period, all nails used in the United States were handmade. They were forged on an anvil from nail rods, which were sold in bundles. These nail rods were prepared either by rolling iron into small bars of the required thickness or by the much more common practice of cutting plate iron into strips by means of rolling shears.

Just before the Revolutionary War, the making of nails from these rods was a household industry among New England farmers. The struggle of the Colonies for independence intensified an inventive search for shortcuts to mass production of material entering directly or indirectly into the prosecution of the war. Thus came about the innovation of cut nails made by machinery. With its coming, the household industry of nail making rapidly declined. At the close of the eighteenth century, 23 patents for nailmaking machines had been granted in the United States, and their use had been generally introduced into England, where they were received with enthusiasm.

In France, lightweight nails for carpenter's use were made of wire as early as the days of Napoleon I, but these nails were made by hand with a hammer. The handmade nail was pinched in a vise with a portion projecting. A few blows of a hammer flattened one end into a head. The head was beaten into a countersunk depression in the vise, thus regulating its size and shape. In the United States, wire nails were first made in 1851 or 1852 by William Hersel of New York.

In 1875, Father Goebel, a Catholic priest, arrived from Germany and settled in Covington, Kentucky. There he began the manufacture of wire nails that he had learned in his native land. In 1876, the American Wire and Screw Nail Company was formed under Father Goebel's leadership. As the production and consumption of wire nails increased, the vogue of cut nails, which dominated the market until 1886, declined.

The approved process in the earlier days of the cut-nail industry was as follows. Iron bars, rolled from hematite or magnetic pig, were fagotted, reheated to a white heat, drawn, rolled into sheets of the required width and thickness, and then allowed to cool. The sheet was then cut across its length (its width being usually about a foot) into strips a little wider than the length of the required nail. These plates (heated by being set on their edge on hot coals) were seized in a clamp and fed to the machine, end first. The cutout pieces, slightly tapering, were squeezed and headed up by the machine before going to the trough.

The manufacture of tacks, frequently combined with that of nails, is a distinct branch of the nail industry, affording much room for specialties. Originally it was also a household industry, and was carried on in New England well into the eighteenth century. The wire, pointed on a small anvil, was placed in a pedal-operated vise, which clutched it between jaws furnished with a gauge to regulate the length. A certain portion was left projecting. This portion was beaten with a hammer into a flat head.

Antique pieces of furniture are frequently held together with iron nails that are driven in and countersunk, thus holding quite firmly. These old-time nails were made of foursquare wrought iron and tapered somewhat like a brad but with a head that, when driven in, held with great firmness.

The raw material of the modern wire nail factory is drawn wire, just as it comes from the wire drawing block. The stock is low-carbon Bessemer or basic open-hearth steel. The wire, feeding from a loose reel, passes between straightening rolls into the gripping dies, where it is gripped a short distance from its end, and the nailhead is formed by an upsetting blow from a heading tool. As the header withdraws, the gripping dies loosen, and the straightener carriage pushes the wire forward by an amount equal to the length of the nail. The cutting dies advance from the sides of the frame and clip off the nail, at the same time forming its characteristic chisel point. The gripping dies have already seized the wire again, and an ejector flips the nail out of the way just as the header comes forward and heads the next nail. All these motions are induced by cams and eccentrics on the main shaft of the machine, and the speed of production is at a rate of 150 to 500 complete cycles per minute. At this stage, the nails are covered with a film of drawing lubricant and oil from the nail machine, and their points are frequently adorned with *whiskers*—a name applied to the small diamond-shaped pieces stamped out when the point is formed and which are occasionally found on the finished nail by the customer.

These oily nails (in lots of 500 to 5000 pounds) are shaken with sawdust in tumbling barrels from which they emerge bright, clean, and free of their whiskers, ready for weighing, packing, and shipping.

The Penny System

This method of designating nails originated in England. Two explanations are offered as to how this interesting designation came about. One is that the six penny, four penny, ten penny, and so on, nails derived their names from the fact that 100 nails cost six pence, four pence, and so on. The other explanation, which is the more probable of the two, is that 1000 ten-penny nails, for instance, weighed ten pounds. The ancient, as well as the modern, abbreviation for penny is *d*, being the first letter of the Roman coin denarius. The same abbreviation in early history was used for the English pound in weight. The word *penny* has persisted as a term in the nail industry.

Nail Characteristics

Nails are the carpenter's most useful fastener, and a great variety of types and sizes are available to meet the demands of the industry. One manufacturer claims to produce more than 10,000 types and sizes. Figure 1-1 shows some common types.

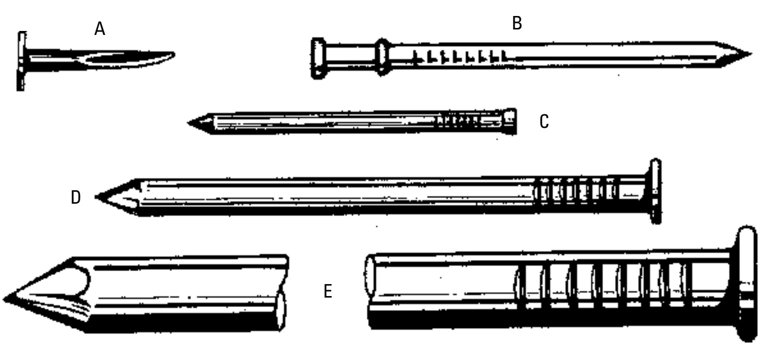


Figure 1-1 Various nails grouped as to general size: (A) tack, (B) sprig or dowel pin, (C) brad, (D) nail, and (E) spike.

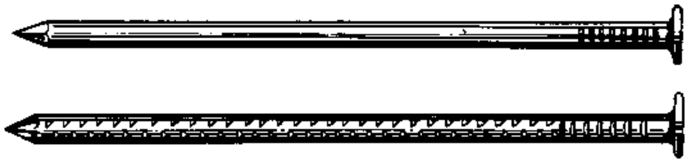


Figure 1-2 Smooth and barbed box nails, lbd size (shown full size). Note the sharp point and thin, flat head.

Nails also have a variety of characteristics, including different points, shanks, finishes, and material (see Figure 1-2). The following shapes of points are available:

- Common blunt pyramidal
- Long sharp
- Chisel-shaped
- Blunt or shooker
- Side-sloped
- Duckbill or clincher

The heads may be

- Flat
- Oval or oval countersunk
- Round
- Double-headed

Each of the features or characteristics makes the nail better suited for the job at hand. For example, galvanized nails are weather-resistant, double-headed nails are good for framing where they can be installed temporarily with the second head exposed for easy pulling, and barbed nails are good when extra holding power is required.

Tacks

Tacks are small, sharp-pointed nails that usually have tapering sides and a thin, flat head. The regular lengths of tacks range from $^1/_8$ to $1^1/_8$ inches. The regular sizes are designated in ounces, according to Table 1-1. Tacks are usually used to secure carpet or fabric.

Brads

Brads are small slender nails with small deep heads (see Figure 1-3). Sometimes, instead of having a head, they have a projection on one side. There are several varieties adapted to many different

Table 1-1 Wire Tacks

Size (oz)	Length (in)	No. per Pound	Size (oz)	Length (in)	No. per Pound	Size (oz)	Length (in)	No. per Pound
1	1/8	16,000	4	7/16	4000	14	13/16	1143
1 1/2	3/16	10,666	6	9/16	2666	16	7/8	1000
2	1/4	8000	8	5/8	2000	18	15/16	888
2 1/2	5/16	6400	10	11/16	1600	20	1	800
3	3/8	5333	12	3/4	1333	22	1 1/16	727
						24	1 1/8	666

requirements. Brad sizes start at about 1/2 inch and end at 1 1/2 inches. Beyond this size they are called *finishing nails*.

Nails

The term nails is popularly applied to all kinds of nails except extreme sizes (such as tacks, brads, and spikes). Broadly speaking, however, it includes all of these. The most generally used are called

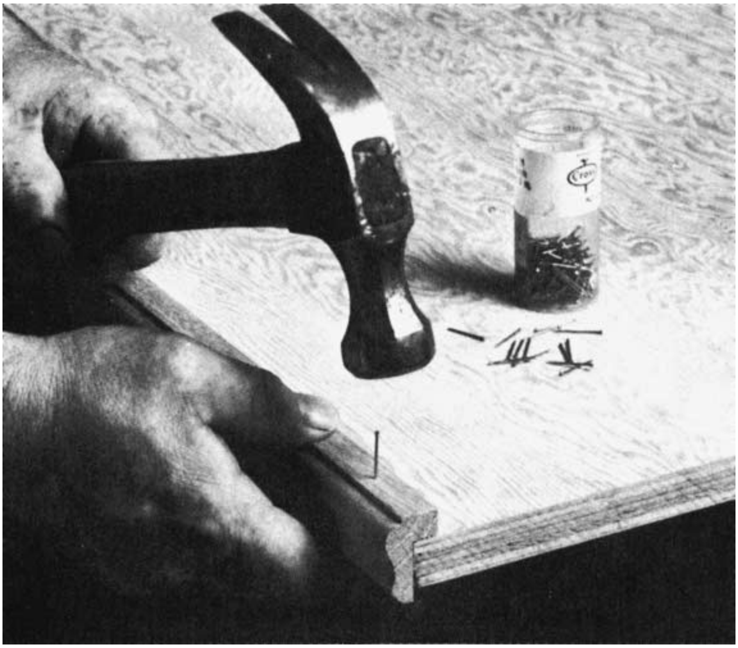


Figure 1-3 Brads are small nails. They are used to attach thin strips of wood such as moldings. *(Courtesy of The American Plywood Assn.)*

common nails, and are regularly made in sizes from 1 inch (2d) to 6 inch (60d), as shown in Table 1-2 (see Figures 1-4 through 1-8).

Table 1-2 Common Nails

	Plain			Coated		
Size	**Length in.**	**Gauge No.**	**No. per Pound**	**Length in.**	**Gauge No.**	**Per 50-Pound Box**
2d	1	15	876	1	16	43,800
3d	$1^1/_4$	14	568	$1^1/_8$	$15^1/_2$	28,400
4d	$1^1/_2$	$12^1/_2$	316	$1^3/_8$	14	15,800
5d	$1^3/_4$	$12^1/_2$	271	$1^5/_8$	$13^1/_2$	13,500
6d	2	$11^1/_2$	181	$1^7/_8$	13	9000
7d	$2^1/_4$	$11^1/_2$	161	$2^1/_8$	$12^1/_2$	8000
8d	$2^1/_2$	$10^1/_4$	106	$2^3/_8$	$11^1/_2$	5300
9d	$2^3/_4$	$10^1/_4$	96	$2^5/_8$	$11^1/_2$	4800
10d	3	9	69	$2^7/_8$	11	3400
12d	$3^1/_4$	9	63	$3^1/_8$	10	3100
16d	$3^1/_2$	8	49	$3^1/_4$	9	2400
20d	4	6	31	$3^3/_4$	7	1500
30d	$4^1/_2$	5	24	$4^1/_4$	6	1200
40d	5	4	18	$4^3/_4$	5	900
50d	$5^1/_2$	3	14	$5^1/_4$	4	700
60d	6	2	11	$5^3/_4$	3	500

Spikes

You can think of a *spike* as an extra large nail, sometimes quite a bit larger. Generally, spikes range from 3 to 12 inches long and are thicker than common nails. Point style varies, but a spike is normally straight for ordinary uses (such as securing a gutter). However, a spike can also be curved or serrated, or cleft to make extracting or drawing it out very difficult. Spikes in larger sizes are used to secure rails to ties, in the building of docks, and for other large-scale projects.

If you have a very large job to do, it is well to know the holding power of nails (see Table 1-3). In most instances, this information will not be required, but in more than a few cases, it is.

Tests for the holding power of nails (and spikes) ranging in size from 6d to 60d are shown in Table 1-4. It is interesting to note, in view of the relatively small force required to withdraw nails, that

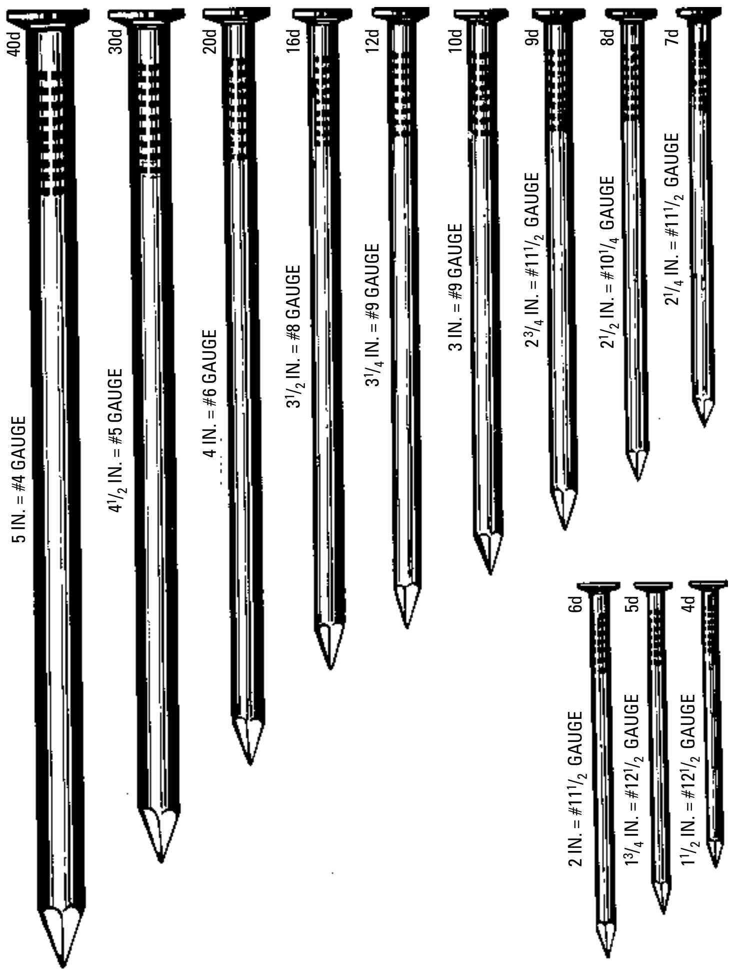


Figure 1-4 Common wire nails. The standard nail for general use is regularly made in sizes from 1 inch (2d) to 6 inches (60d).

spikes take tremendous pulling power. In one test it was found that a spike $^3/_8$ inch in diameter driven $3^1/_2$ inches into seasoned yellow pine required 2000 pounds of force for extraction. And the denser the material, the more difficult the extraction is. The same spike required 4000 pounds of force to be withdrawn from oak and 6000 pounds from well-seasoned locust.

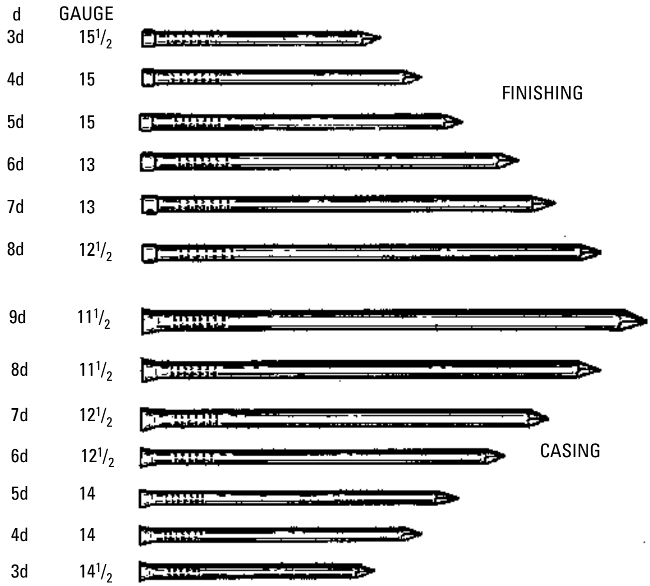


Figure 1-5 Casing and finishing nails (shown full size). Note the difference in the head shape and size. The finishing nail is larger than a casing nail of equal length, but a casing nail is stronger.

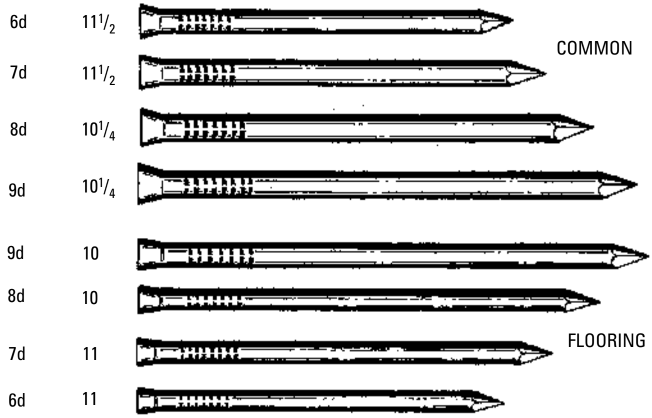


Figure 1-6 Flooring and common nails (shown full size). Note the variation in head shape and gauge number.

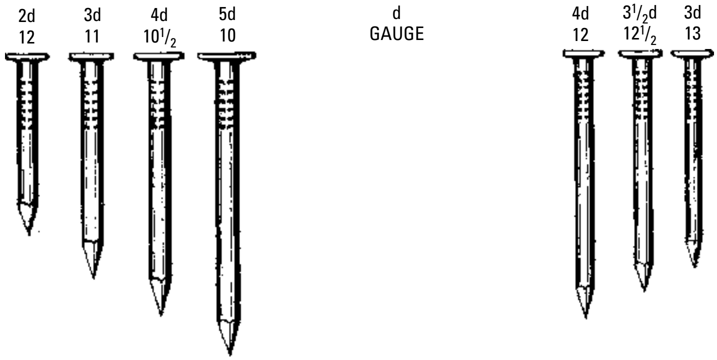


Figure 1-7 A few sizes of slating and shingle nails. Note the difference in wire gauge.

Figure 1-8 Hook-head, metal lath nail. This is a bright, smooth nail with a long, thin flat head, made for application of metal lath. It is also made blued or galvanized.

Table 1-3 Withdrawal Force of Cut vs. Wire Nails (pounds per square inch)

Wood	***Wire Nail***	***Cut Nail***
White pine	167	405
Yellow pine	318	662
White oak	940	1216
Chestnut		683
Laurel	651	1200

Roofing Nails

The *roofing nail* has a barbed shank and a large head, which makes it good for holding down shingles and roofing paper felt without damage (the material couldn't pull readily through the head).

Such nails come in a variety of sizes but usually $^3/_8$ inch to $1^1/_4$ inch long with the nail sized to the material thickness (see Figure 1-9).

Table 1-4 Holding Power of Nails and Spikes (Withdrawal)

Size of Spikes	*Length Driven In*	*Pounds resistance to Drawing, Average Lbs.*	*Max. Lbs*	*From 6 to 9 Tests Each Min. Lbs*
5 × $^1/_4$ in. sq.	$4^1/_4$ in.	857	1159	766
6 × $^1/_4$	5 in.	857	923	766
6 × $^1/_2$	5 in.	1691	2129	1120
5 × $^3/_8$	$4^1/_4$ in.	1202	1556	687

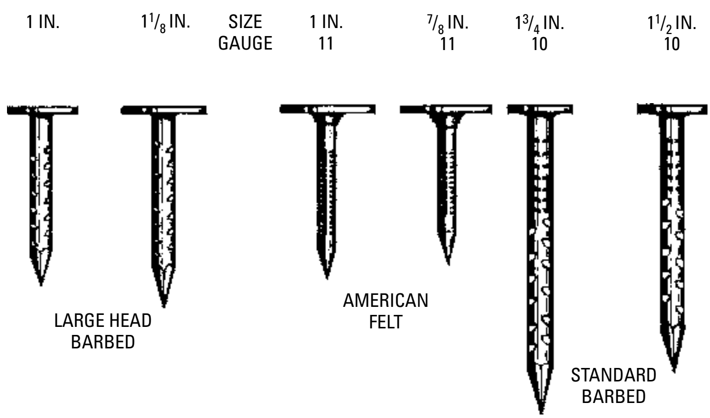


Figure 1-9 Various roofing nails (shown full size).

Drywall Nails

As the name implies, these are for fastening drywall (Sheetrock). The shank of the nail is partially barbed and the head countersunk so that if the nail bites into the stud, it takes a good bite. *Drywall nails* come in a variety of lengths for use with different thicknesses of Sheetrock (see Figure 1-10).

Masonry Nails

Masonry nails are cut (that is, stamped) out of a sheet of metal rather than drawn and cut the way wire nails are (see Figure 1-10). A masonry nail is made of very hard steel and is case hardened. It has a variety of uses but the most common is probably for securing studs or furring to block walls. Safety is important when doing any kind of nailing, but, when using masonry nails, it is particularly important to wear protective goggles to guard the eyes against flying chips.

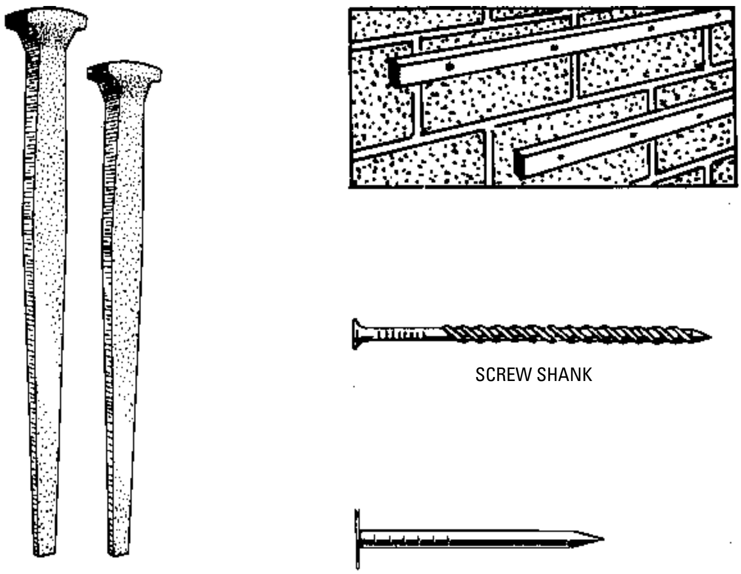


Figure 1-10 Miscellaneous nails.

Spiral Nails

The most tenacious of all nails in terms of holding power is the *spiral nail* (also known as the *drive screw*). Its shank is spiral so that as the nail is driven, it turns and grips the wood. Its main use is to secure flooring, but it is also useful on rough carpentry.

Corrugated Fasteners

This fastener is a small section of corrugated metal with one sharpened and one flat edge. *Corrugated fasteners* are often used for making boxes or joining wood sections edge to edge (see Figure 1-11). They come in a variety of sizes.

Staples

Many varieties of *staples* are available, from ones used to secure cable and fencing to posts (such staples are always galvanized) to ones used in the various staple guns. Fence staples range in size from $^{7}/_{8}$ inch to $1^{1}/_{4}$ inches, and some are designed (the so-called *slash point*) so that the legs spread when the staple is driven in place. This makes it grip better.

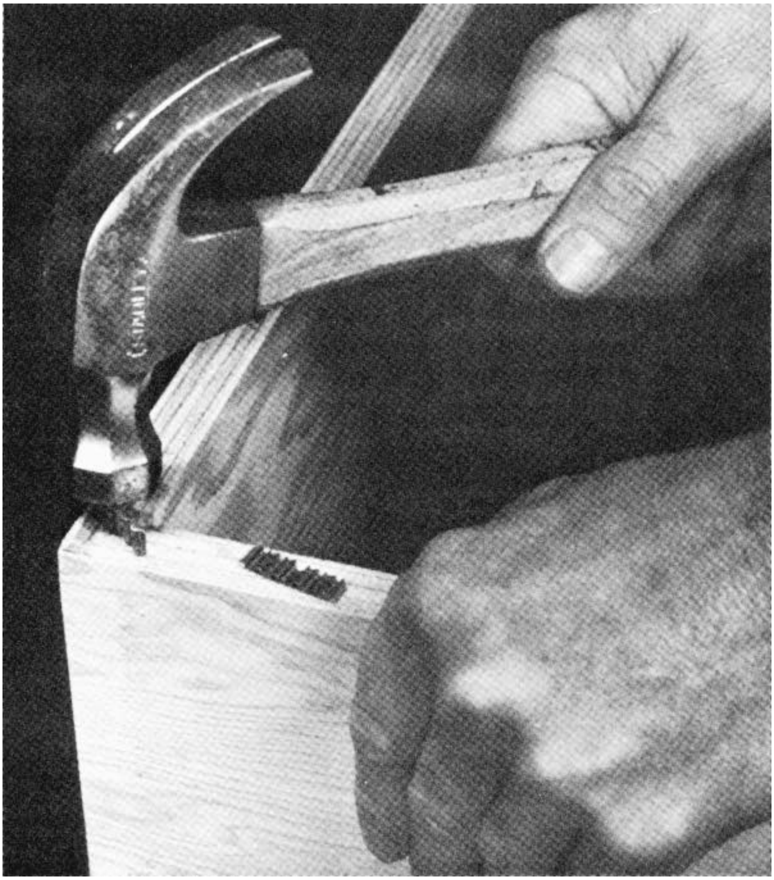


Figure 1-11 Corrugated nails do not have great holding power, but they are for noncritical or temporary work.
(Courtesy of The American Plywood Assn.)

Selecting Nail Size

In selecting nails for jobs, size is crucial. The first consideration is the diameter. Short, thick nails work loose quickly. Long, thin nails are apt to break at the joints of the lumber. The simple rule to follow is to use as long and as thin a nail as will drive easily.

Definite rules have been formulated by which to determine the size of nail to be used in proportion to the thickness of the board that is to be nailed:

1. When using box nails in lumber of medium hardness, the penny of the nail should not be greater than the thickness, in eighths of an inch, of the board into which the nail is being driven.
2. In very soft woods, the nails may be one penny larger, or in some cases, two pennies larger.
3. In hard woods, nails should be one penny smaller.
4. When nailing boards together, the nail point should penetrate within $^1/_4$ inch of the far side of the second board.

The kind of wood is, of course, a big factor in determining the size of nail to use. The dry weight of the wood is the best basis for the determination of its grain substance or strength. The greater its dry weight, the greater its power to hold nails. However, the splitting tendency of hard wood tends to offset its additional holding power. Smaller nails can be used in hard lumber than in soft lumber (see Figure 1-12). Positive rules governing the size of nails to be used as related to the density of the wood cannot be laid down. Experience is the best guide.

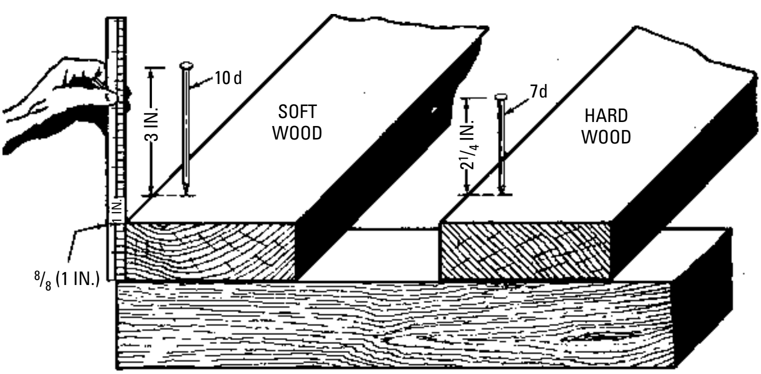


Figure 1-12 Application of rules 2 and 3 in determining the proper size of nail to use.

Table 1-5 shows the approximate number of wire nails per pound.

Driving Nails

In most cases, it is not necessary to drill pilot holes for nails to avoid splitting the wood. However, in some instances it is advisable to first drill holes nearly the size of the nail before driving, to guard

Table 1-5 Approximate Number of Wire Nails per Pound Length

American Steel & Wire Co's. Steel Wire Gauge	Length																				
	3/16	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/2	4	4 1/2	5
3/8	.....	.....	.....	.....	.....	.....	.....	29	26	23	20	17	15	15	12	11	11	8.9	7.9	7.1	6.4
5/16	.....	.....	.....	.....	.....	.....	.....	43	38	34	29	25	22	20	18	16	15	13	11	10	9.0
1	.....	.....	.....	.....	.....	.....	.....	47	44	40	34	29	26	23	21	20	18	16	14	12	11
2	.....	.....	.....	.....	.....	.....	.....	60	54	48	41	35	31	28	25	23	21	18	16	14	13
3	.....	.....	.....	.....	.....	.....	.....	67	60	55	47	41	36	32	29	27	25	21	18	16	15
4	.....	.....	.....	.....	.....	.....	.....	81	74	66	55	48	41	37	34	31	29	25	22	20	18
5	.....	.....	.....	.....	.....	.....	.....	90	81	74	61	52	45	41	38	35	32	28	24	22	21
6	.....	.....	.....	213	174	149	128	113	101	91	76	65	58	52	47	43	39	34	29	26	24
7	.....	.....	.....	250	205	174	148	132	120	110	92	78	70	61	55	51	47	40	35	31	28
8	.....	.....	.....	272	238	198	174	153	139	126	106	93	82	74	66	61	56	48	42	38	34
9	.....	.....	.....	348	286	238	213	185	170	152	128	112	99	87	79	71	67	58	50	45	41
10	.....	.....	.....	469	373	320	277	242	616	196	165	142	124	111	100	91	84	71	62	55	49
11	.....	.....	.....	510	117	366	323	285	254	233	200	171	149	136	122	111	103	87	77	69	61
12	.....	.....	.....	740	603	511	442	397	351	327	268	229	204	182	161	149	137	118	103	95	87
13	.....	.....	1356	1017	802	688	590	508	458	412	348	297	260	232	209	190	175	153	138	123	110
14	.....	2293	1664	1290	1037	863	765	667	586	536	459	398	350	312	278	256	233	201	176	157	140
15	.....	2899	2213	1619	1316	1132	971	869	787	694	578	501	437	390	351	317	290	256	220	196	177
16	.....	3932	2770	2142	1708	1414	1229	1099	973	872	739	635	553	496	452	410	370	318	277	248	226
17	.....	5316	3890	2700	2306	1904	1581	1409	1253	1139	956	831	746	666	590	532	486	418	360	322	295
18	.....	7520	5072	3824	3130	2608	2248	1976	1760	1590	1338	1150	996	890	820	740	680	585	507	448	412
19	.....	9920	6860	5075	4132	3508	2816	2556	2284	2096	1772	1590	1390	1205	1060	970	895	800	.....	.....	.....
20	18620	14050	9432	7164	5686	4795	4230	3596	3225	2893	2412	2070	1810	1620	1450	1315	1215	1035	.....	.....	.....
21	23260	17252	12000	8920	7232	6052	5272	4576	4020	3640	3040	2665	2310	2020	1830	.....	.....	.....	.....	.....	.....
22	28528	21508	14676	11776	9276	7672	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
23	35864	27039	18026	13519	10815	9013	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
24	44936	34018	22678	17008	13607	11339	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
25	57357	43243	28828	21622	17297	14414	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

These approximate numbers are an average only, and the figures given may be varied either way by changes in the dimensions of the heads or points. Brads and on-head nails will run more to the pound than table shows, and large or thick-headed nails will run less.

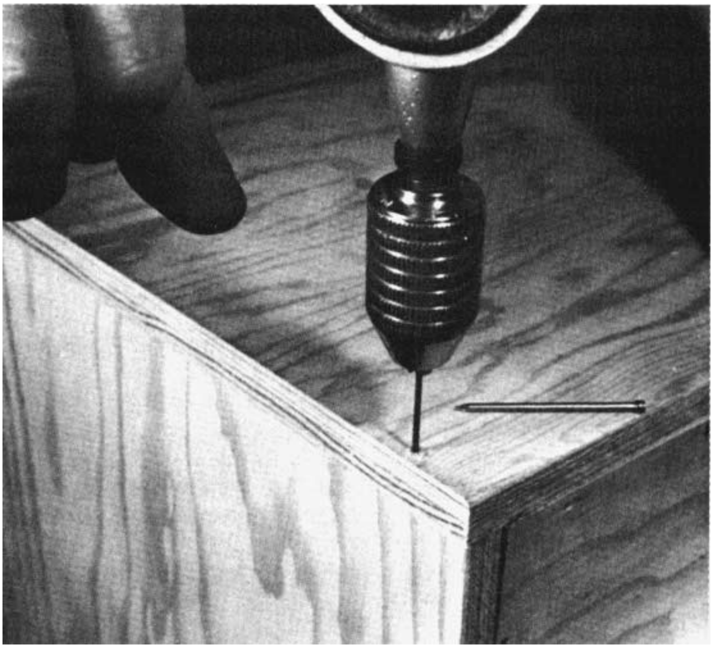


Figure 1-13 To prevent a nail from splitting wood, a pilot hole is sometimes drilled. Pilot-hole drilling is common when using screws. *(Courtesy of The American Plywood Assn.)*

against it (see Figure 1-13). In addition, in fine work, where a large number of nails must be driven, such as applying cedar clapboards, holes should be drilled. This step prevents crushing the wood and possible splitting because of the large number of nails driven through each board. The size of drill for a given size nail should be slightly smaller than the shank diameter.

The right way to drive nails is shown in Figure 1-14. Figure 1-15 illustrates the necessity of using a good hammer to drive a nail. The force that drives the nail is caused by the inertia of the hammer. This inertia depends on the suddenness with which its motion is brought to rest on striking the nail. With hardened steel, there is practically no give, and all the energy possessed by the hammer is transferred to the nail. On a hammer made with soft and/or inferior metal, all the energy is not transferred to the nail. Therefore, the power per blow is less than with hardened steel.

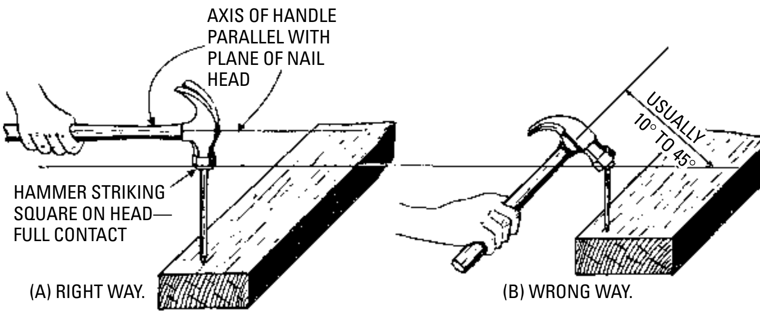


Figure 1-14 (A) Right way to drive a nail. Hit the nail squarely on the head. The handle should be horizontal when the hammer head hits a vertical nail. (B) Wrong way to drive a nail.

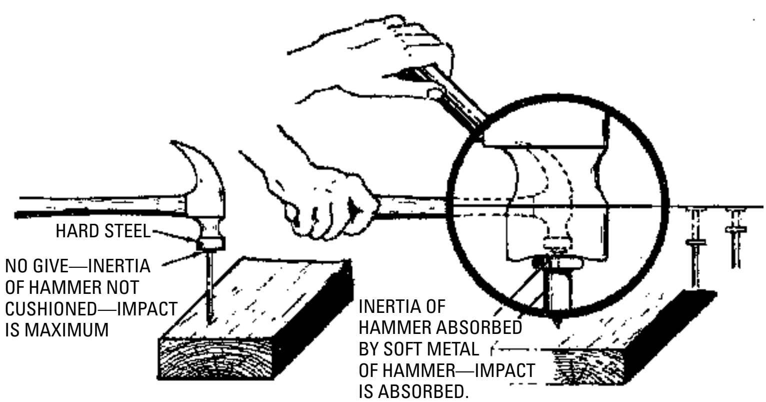


Figure 1-15 Why a cheap hammer should not be used.

Screws

Wood screws have several advantages over nails. First, screws are harder to pull out. Pull on a screw and pull on a nail—the screw will give greater resistance. Second, should you tire of an item at some time in the future; screws usually let you disassemble it without great travail. It is possible to damage the work if it is nailed together and you want to take it apart. These advantages cost more in the effort and time it takes to install screws.

Screws are normally used to fasten things such as hinges, knobs, and so on, to structures, and in the assembly of various wood parts.

They are not used in heavy building simply because, in this type of work, things are built so that there is a minimum of stress on the fasteners and the withdrawal resistance is not required. Indeed, if stress were created, even the most tenacious screw could not stand up much better than a nail (which is to say very little).

The wood screw consists of a gimlet point, a threaded portion, and a shank and head, which may be straight slot or Phillips.

Screws of many types are made for specialized purposes, but stock wood screws are usually obtainable in either steel or brass, and, more rarely, are made of high-strength bronze. Three types of heads are standard:

- The *flat countersunk head*, with the included angle of the sloping sides standardized at 82°
- The *round head*, whose height is also standardized, but whose contour seems to vary slightly among the products of different manufacturers
- The *oval head*, which combines the contours of the flat head and the round head

All of these screws are available with the Phillips slot, or crossed slots, as well as the usual single straight slot.

The Phillips slot allows a much greater driving force to be exerted without damaging the head than the usual straight-slotted head. The greater part of all wood screws used (probably 75 percent or more) used to be the flat-head type. However, this has changed to the Phillips head screw in recent years because of the advent of the inexpensive power screwdriver attachments available on electric drills. The reversible electric drill combined with the variable speed trigger makes it possible to quickly drive a screw and to extract if necessary.

Material

For ordinary purposes, *steel screws* (with or without protective coatings) are commonly used. In boat building or other such work where corrosion will probably be a problem if screws are used, the screws should be of the same metal or at least the same *type* of metal as the parts they contact. While it is possible (and indeed probable) that a single brass screw driven through an aluminum plate, if it is kept dry, will show no signs of corrosion, many brass screws driven through the aluminum plate in the presence of water or dampness will almost certainly show signs (perhaps serious signs) of galvanic corrosion.

Dimensions of Screws

When ordering screws, you must know that length varies with head type. The overall length of a 2-inch flat-head screw is not the same as a 2-inch round-head screw (see Figure 1-16 and Figure 1-17).

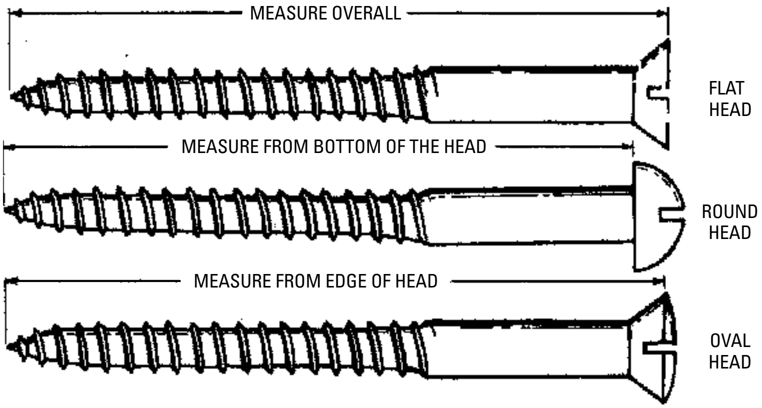


Figure 1-16 Various wood screws and how their length is measured.

Shape of the Head

You can find a variety of head shapes on screws, but the three standard shapes are flat, round, and oval (see Figure 1-18). These usually will more than suffice.

All of these heads are available in the straight-slotted or Phillips type.

The other forms may be regarded as special or semispecial (that is, carried by large dealers only or obtainable only on special order).

Flat heads are necessary in some cases (such as on door hinges, where any projection would interfere with the proper working of the hinge). Flat-head screws are also employed on finish work where flush surfaces are desirable. The round and oval heads are normally ornamental, left exposed. Table 1-6 shows common head diameters of screws.

How to Drive a Wood Screw

Driving wood screws is made easier by drilling shank and pilot holes in the wood. Indeed, this may be the only way to do it. A shank-clearance hole (see Figure 1-19) should be the same size as the shank diameter of the screw.

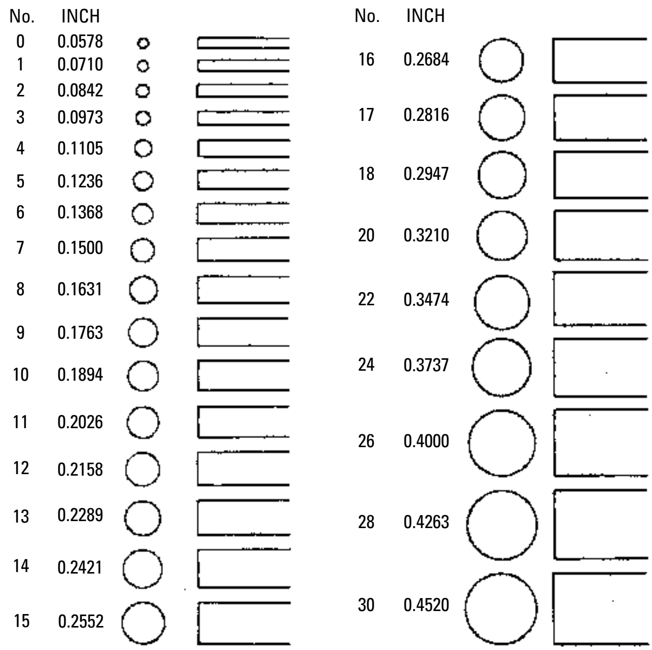


Figure 1-17 Wood screw gauge numbers.

A pilot hole should be equal in diameter to the root diameter of the screw thread and about three-quarters of the thread length for soft and medium-hard woods. For extremely hard woods, the pilot-hole depth should equal the thread length.

If the screw being inserted is the flat-head type, the hole should be countersunk (see Figure 1-20).

The foregoing process involves three separate steps. All of these can be performed at once by using a device of the type shown in Figure 1-21. This tool will drill the pilot hole, the shank-clearance hole, and the countersink all in one operation. Stanley calls its device the Screw-Mate. The Stanley company also makes a Screw-Sink, which counterbores. You can set the head of the screw beneath the surface, then plug the hole with a wood plug cut with a plug cutter from matching wood.

These tools are made in many sizes, one for each screw size, and they are available in complete sets or separately. The screw size is marked on the tool.

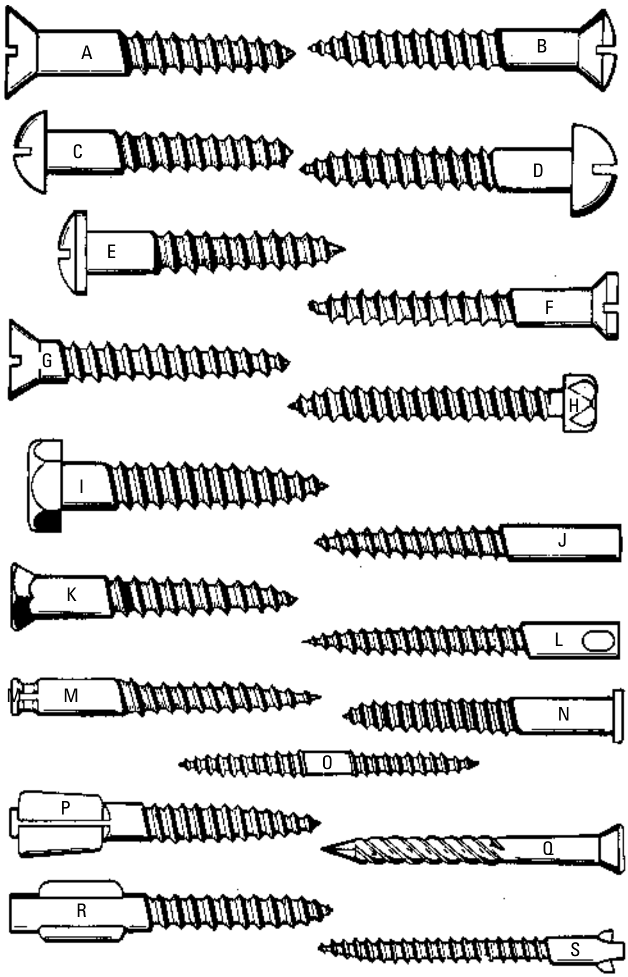


Figure 1-18 Various wood screws showing the variety of head shapes available: (A) Flat head, (B) oval head, (C) round head, (D) piano head, (E) oval fillister head, (F) countersunk fillister head, (G) felloe, (H) close head, (I) hexagon head, (J) headless, (K) square bung head, (L) grooved, (M) pinched head, (N) round bung head, (O) dowel, (P) winged, (Q) drive, (R) winged, and (S) winged head. Heads A through G may be obtained with Phillips-type head. Most will never be needed.

Table 1-6 Head Diameters

		Head Diameter		
Screw Gauge	***Screw Diameter***	***Flat***	***Round***	***Oval***
0	0.060	0.112	0.106	0.112
1	0.073	0.138	0.130	0.138
2	0.086	0.164	0.154	0.164
3	0.099	0.190	0.178	0.190
4	0.112	0.216	0.202	0.216
5	0.125	0.242	0.228	0.242
6	0.138	0.268	0.250	0.268
7	0.151	0.294	0.274	0.294
8	0.164	0.320	0.298	0.320
9	0.177	0.346	0.322	0.346
10	0.190	0.371	0.346	0.371
11	0.203	0.398	0.370	0.398
12	0.216	0.424	0.395	0.424
13	0.229	0.450	0.414	0.450
14	0.242	0.476	0.443	0.476
15	0.255	0.502	0.467	0.502
16	0.268	0.528	0.491	0.528
17	0.282	0.554	0.515	0.554
18	0.394	0.580	0.524	0.580
20	0.321	0.636	0.569	0.636
22	0.347	0.689	0.611	0.689
24	0.374	0.742	0.652	0.742
26	0.400	0.795	0.694	0.795
28	0.426	0.847	0.735	0.847
30	0.453	0.900	0.777	0.900

Strength of Wood Screws

Table 1-7 gives the safe resistance, or safe load (against pulling out), in pounds per linear inch of wood screws when inserted across the grain. For screws inserted with the grain, use 60 percent of these values.

The lateral load at right angles to the screw is much greater than that of nails. For conservative designing, assume a safe resistance of a No. 20 gauge screw at double that given for nails of the same length,

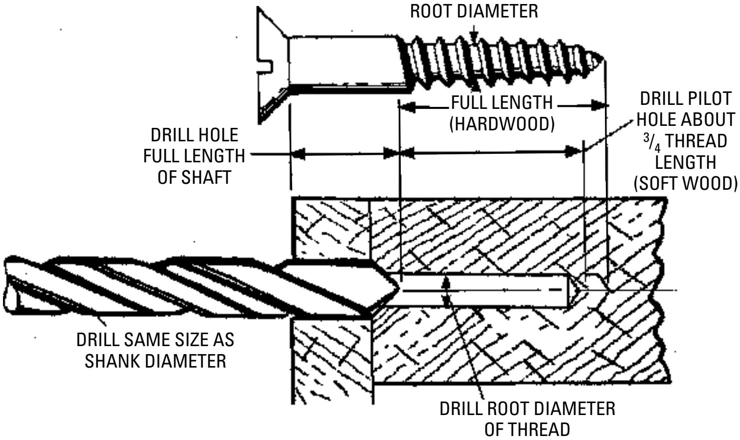


Figure 1-19 Drilling shank-clearance and pilot holes.

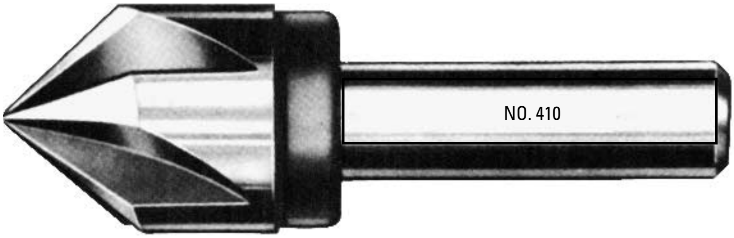


Figure 1-20 A typical countersink.

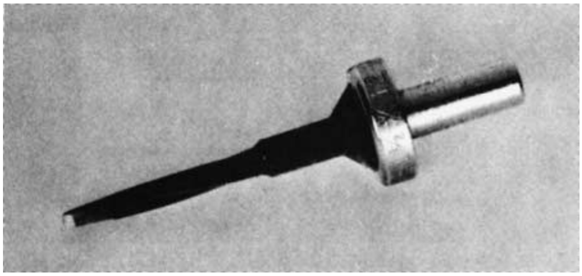


Figure 1-21 A tool for drilling pilot hole, shank-clearance hole, and countersink in one operation.

Table 1-7 Safe Loads for Wood Screws

	Gauge Number							
Kind of Wood	*4*	*8*	*12*	*16*	*20*	*24*	*28*	*30*
White oak	80	100	130	150	170	180	190	200
Yellow pine	70	90	120	140	150	160	180	190
White pine	50	70	90	100	120	140	150	160

when the full length of the screw thread penetrates the supporting piece of the two connected pieces.

Table 1-8 shows standard wood screw proportions.

Lag Screws

By definition, a *lag screw* (see Figure 1-22) is a heavy-duty wood screw provided with a square or hexagonal head so that it may be turned by a wrench. Lag screws are large, heavy screws used where great strength is required (such as for heavy timber work). Table 1-9 gives the dimensions of ordinary lag screws.

How to Put in Lag Screws

First, bore a hole slightly larger than the diameter of the shank to a depth that is equal to the length that the shank will penetrate (see Figure 1-23). Then bore a second hole at the bottom of the first hole, equal to the root diameter of the threaded shank and to a depth of approximately one-half the length of the threaded portion. The exact size of this hole and its depth will, of course, depend on the kind of wood (the harder the wood, the larger the hole).

The resistance of a lag screw to turning is enormous when the hole is a little small, but this can be considerably decreased by smearing the threaded portion of the screw with beeswax.

Strength of Lag Screws

Table 1-10 gives the safe resistance, to pull out load, in pounds per linear inch of thread for lag screws when inserted across the grain.

Bolts

Bolts are used to bind parts tightly together where high strength is needed.

Manufacture of Bolts

The bolt-and-nut industry in America was started on a small scale in Marion, Connecticut, in 1818. In that year, Micah Rugg, a country

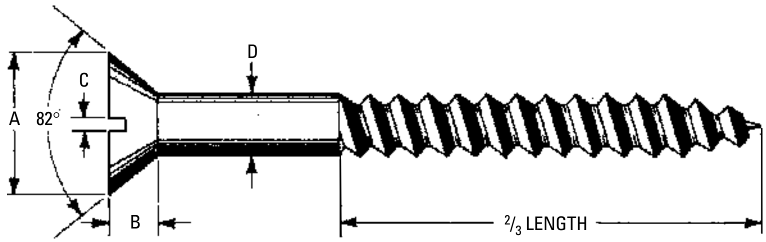


Table 1-8 Standard Wood Screw Proportions

Screw Numbers	*A*	*B*	*C*	*D*	*Number of Threads Per Inch*
0	......	......	......	0.0578	30
1	......	......	......	0.0710	28
2	0.1631	0.0454	0.030	0.0841	26
3	0.1894	0.0530	0.032	0.0973	24
4	0.2158	0.0605	0.034	0.1105	22
5	0.2421	0.0681	0.036	0.1236	20
6	0.2684	0.0757	0.039	0.1368	18
7	0.2947	0.0832	0.041	0.1500	17
8	0.3210	0.0809	0.043	0.1631	15
9	0.3474	0.0984	0.045	0.1763	14
10	0.3737	0.1059	0.048	0.1894	13
11	0.4000	0.1134	0.050	0.2026	12.5
12	0.4263	0.1210	0.052	0.2158	12
13	0.4427	0.1286	0.055	0.2289	11
14	0.4790	0.1362	0.057	0.2421	10
15	0.5053	0.1437	0.059	0.2552	9.5
16	0.5316	0.1513	0.061	0.2684	0
17	0.5579	0.1589	0.064	0.2815	8.5
18	0.5842	0.1665	0.066	0.2947	8
20	0.6368	0.1816	0.070	0.3210	7.5
22	0.6895	0.1967	0.075	0.3474	7.5
24	0.7421	0.2118	0.079	0.3737	7
26	0.7421	0.1967	0.084	0.4000	6.5
28	0.7948	0.2118	0.088	0.4263	6.5
30	0.8474	0.2270	0.093	0.4546	6

Figure 1-22 Ordinary lag screw.

Table 1-9 Lag Screws (inches)

Length	*Diameter*
3	$^5/_{16}$ to $^7/_8$
$3^1/_2$	$^5/_{16}$ to 1
4	$^5/_{16}$ to 1
$4^1/_2$	$^5/_{16}$ to 1
5	$^5/_{16}$ to 1
$5^1/_2$	$^5/_{16}$ to 1
6	$^5/_{16}$ to 1
$6^1/_2$	$^7/_{16}$ to 1
7	$^7/_{16}$ to 1
$7^1/_2$	$^7/_{16}$ to 1
8	$^7/_{16}$ to 1
9	$^7/_{16}$ to 1
10	$^1/_2$ to 1
11	$^1/_2$ to 1
12	$^1/_2$ to 1

blacksmith, made bolts by the forging process. The first machine used for this purpose was a device known as a *heading block*, which was operated by a foot treadle and a connecting lever. The connecting lever held the blank while it was being driven down into the impression in the heading block by a hammer. The square iron from which the bolt was made was first rounded so that it could get into the block.

At first, Rugg only made bolts to order, and charged at the rate of 16 cents apiece. This industry developed quite slowly until 1839 when Rugg went into partnership with Martin Barnes. Together they built the first exclusive bolt-and-nut factory in the United States.

Bolts were first manufactured in England in 1838 by Thomas Oliver of Darlston, Staffordshire. His machine was built on a

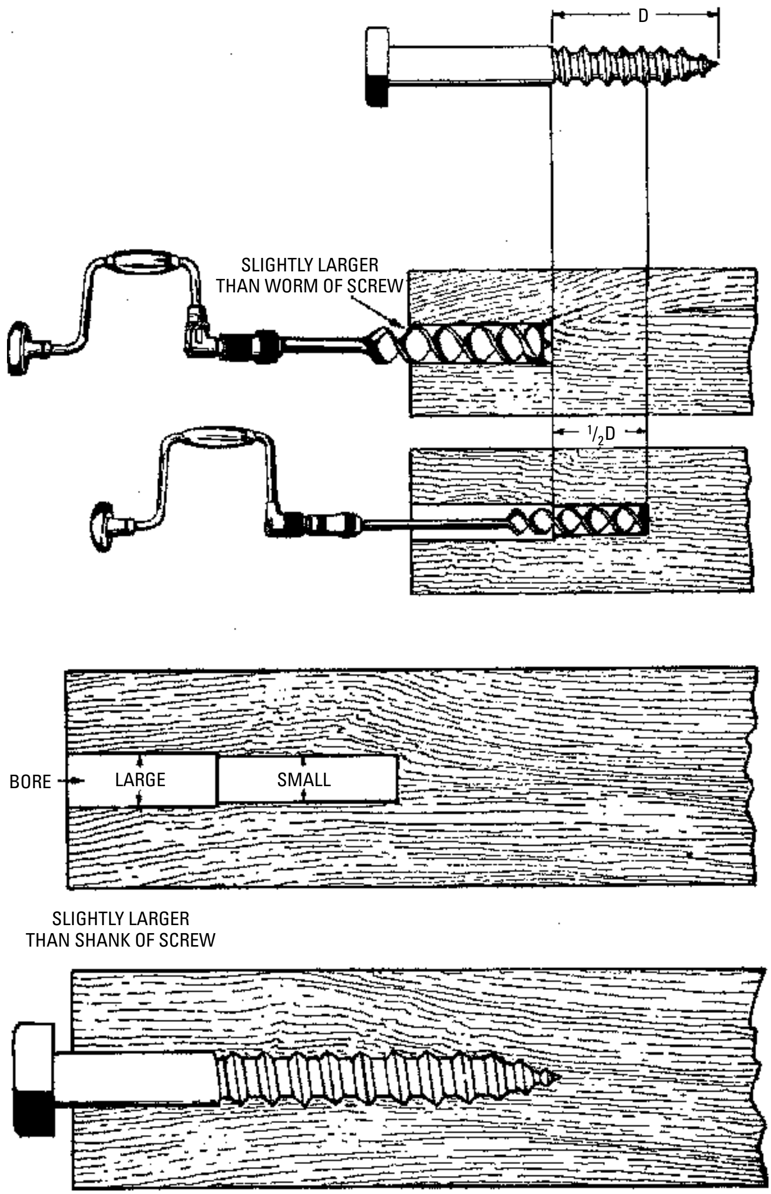


Figure 1-23 Drilling holes for lag screws.

Table 1-10 Safe Loads for Lag Screws (Inserted across the grain)

	Diameter of Screw in Inches				
Kind of Wood	**1/2**	**5/8**	**3/4**	**7/8**	**1**
White pine	590	620	730	790	900
Douglas fir	310	330	390	450	570
Yellow pine	310	330	390	450	570

somewhat different plan from that of Rugg's, but no doubt was a further development of the first machine. Oliver's machine was known as the English Oliver.

The construction of the early machines was carefully kept secret. It is related that in 1842, a Mr. Clark had his bolt-forging machine located in a room separated from the furnaces by a thick wall. The machine received the heated bars through a small hole, cut in the wall. The forge man was not even permitted to enter the room.

Kinds of Bolts

One commonly used bolt is the *carriage bolt*, which got its name from its prime early use: assembling horsedrawn carriages.

To install a carriage bolt, a hole (equal to the diameter of the shank) is bored. The bolt is then slipped into the hole, and a hammer is used to pound it down so that the neck seats well in the hole. A nut on the other end completes the job. It can be screwed on without having to hold the other end of the bolt.

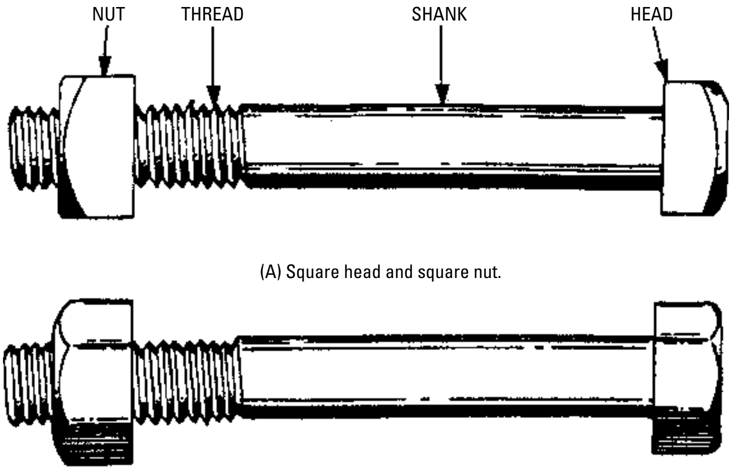
Another type of bolt is the *machine bolt*, used on metal and wood parts (see Figure 1-24). The machine bolt is slipped into the hole and a wrench is used to hold its large square head on one end while another wrench is used to tighten a nut.

Figure 1-25 shows various types of bolts and Figure 1-26 shows a lock washer used on some types of bolts.

Proportions and Strength of Bolts

Ordinary bolts are manufactured in certain stock sizes. Table 1-11 gives these sizes for bolts from 1/4 inch up to 1 1/4 inches, with the length of thread.

For many years, the *coarse-thread bolt* was the only type available. Now, bolts with a much finer thread (called the *National Fine thread*) have become easily available (see Table 1-12). These have hex heads and hex nuts. They are finished much better than the stock



(A) Square head and square nut.

(B) Hexagon head and hexagon nut.

Figure 1-24 Machine bolts.

coarse-thread bolts and consequently are more expensive. Cheap *rolled-thread bolts* (with the threaded portions slightly upset) should not be used by the carpenter. When they are driven into a hole, either the hole is too large for the body of the bolt or the threaded portion reams it out too large for a snug fit. Good bolts have cut threads that have a maximum diameter no larger than the body of the bolt.

When a bolt is to be selected for a specific application, Table 1-13 should be consulted.

Example How much of a load may be applied to a 1-inch bolt for a tensile strength of 10,000 pounds per square inch?

Referring to Table 1-13, we find on the line beside 1-inch bolt a value of 5510 pounds corresponding to a stress on the bolt of 10,000 pounds per square inch.

Example What size bolt is required to support a load of 4000 pounds for a stress of 10,000 pounds per square inch?

$$\text{area (at root of thread)} = \text{given load} \div 10,000$$
$$= 4000 \div 10,000 = 0.400 \text{ square inch}$$

Referring to Table 1-13, in the column headed *Area at Bottom of Thread*, we find 0.419 square inch to be the nearest area. This corresponds to a $^{7}/_{8}$-inch bolt.

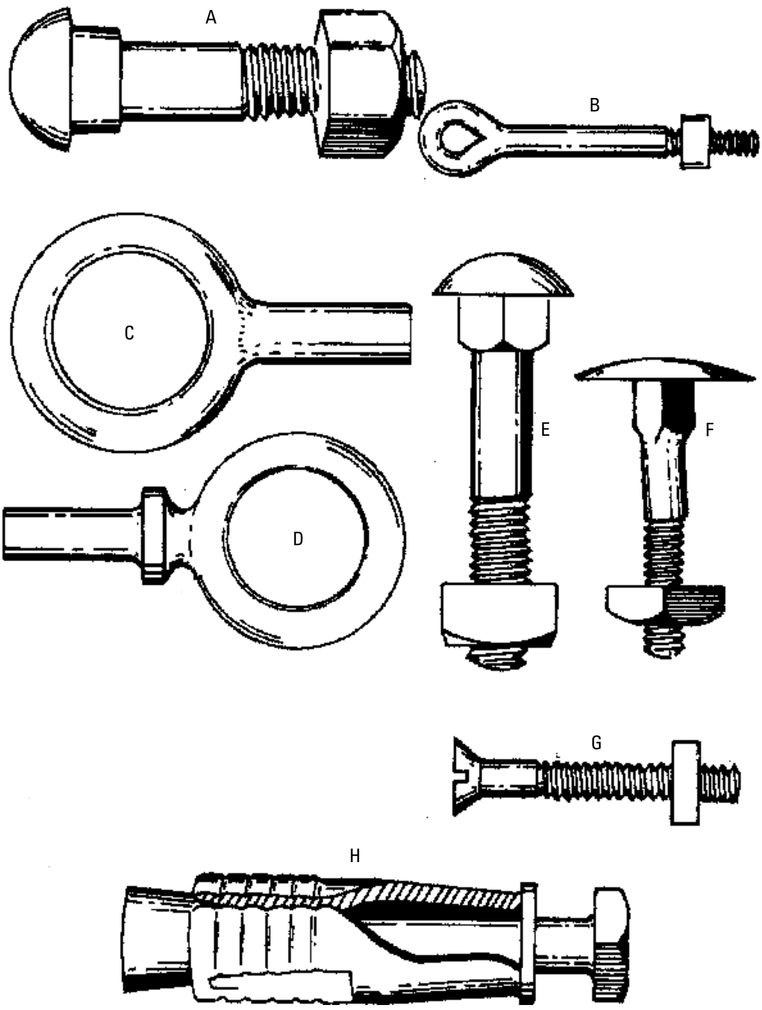


Figure 1-25 Various bolts. In the figure, (A) is a railroad track bolt, (B) a welded eye bolt, (C) a plain forged eye bolt, (D) a shouldered eye bolt, (E) a carriage bolt, (F) a step bolt, (G) a stove bolt, and (H) an expansion bolt.

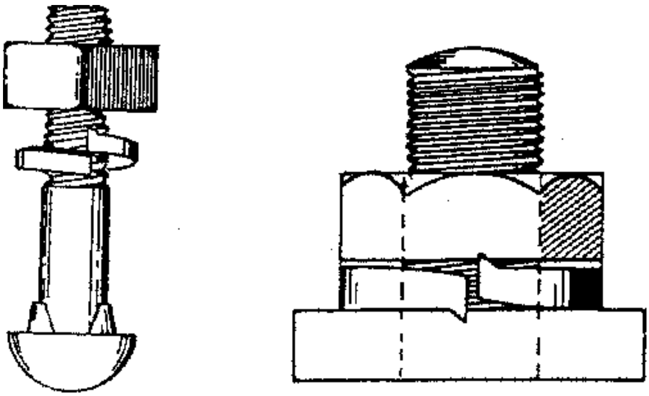


Figure 1-26 A lock washer. When the nut is screwed onto the bolt, it strikes the rib on the washer, which is much harder than the nut. The rib on the washer is forced into the nut, thus preventing the nut from loosening.

Of course, for the several given values of pounds stress per square inch, the result could be found directly from the table, but the previous calculation illustrates the method that would be employed for other stresses per square inch not given in the table.

Example A butt joint in wood timber with metal fishplates is fastened by six bolts through each member. What size bolts should be used, allowing a shearing stress of 5000 pounds per square inch in the bolts, when the joint is subjected to a tensile load of 20,000 pounds (see Figure 1-27)?

$$\text{load (carried per bolt)} = 20,000 \div \text{ number of bolts}$$
$$= 20{,}000 \div 6 = 3333 \text{ pounds}$$

Each bolt is in double shear, hence:

$$\text{equivalent single shear load} = {}^{1}/_{2} \text{ of } 3333 = 1667 \text{ pounds}$$

and,

$$\text{area per bolt} = {}^{1667}/_{5000} = 0.333 \text{ square inch}$$

Referring to Table 1-13, the nearest area is 0.302, which corresponds to a $^{3}/_{4}$-inch bolt. In the case of a dead (or quiescent) load, $^{3}/_{4}$-inch bolts would be ample. However, for a live load, take the next larger size, or $^{7}/_{8}$-inch bolts.

Table 1-11 Properties of U.S. Standard Bolts (U.S. Standard or National Coarse Threads)

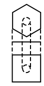
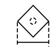
Diameter	*Number of Threads Per Inch (National Coarse Thread)*	*Head* 	*Head* 	*Head* 
1/4	20	3/8	13/32	1/2
5/16	18	1/2	35/64	43/64
3/8	16	9/16	5/8	3/4
7/16	14	5/8	11/16	53/64
1/2	13	3/4	53/64	1
9/16	12	7/8	31/32	1 15/32
5/8	11	15/16	1 1/32	1 1/4
3/4	10	1 1/8	1 15/64	1 1/2
7/8	9	1 5/16	1 29/64	1 47/64
1	8	1 1/2	1 21/32	1 63/64
1 1/8	7	1 11/16	1 55/64	2 15/64
1 1/4	7	1 7/8	2 1/16	2 31/64
1 3/8	6	2 1/16	2 17/64	2 47/64
1 1/2	6	2 1/4	2 31/64	2 63/64
1 5/8	5 1/2	2 7/16	2 11/16	3 15/64
1 3/4	5	2 5/8	2 57/64	3 31/64
1 7/8	5	2 13/16	3 3/32	3 47/64
2	4 1/2	3	3 5/16	6 63/64

Table 1-12 National Fine Threads

Diameter	*Threads Per Inch*
1/4	28
5/16	24
3/8	24
7/16	20
1/2	20
9/16	18
5/8	18
3/4	16
7/8	14
1	14

Table 1-13 Proportions and Strength of U.S. Standard Bolts

		Tensile Strength		
Bolt Diameter	***Area at Bottom of Threads***	***10,000 lbs/in²***	***12,500 lbs/in²***	***17,500 lbs/in²***
1/4	0.027	270	340	470
5/16	0.045	450	570	790
3/8	0.068	680	850	1190
7/16	0.093	930	1170	1630
1/2	0.126	1260	1570	2200
9/16	0.162	1620	2030	2840
5/8	0.202	2020	2520	3530
3/4	0.302	3020	3770	5290
7/8	0.419	4190	5240	7340
1	0.551	5510	6890	9640
1 1/8	0.693	6930	8660	12,130
1 1/4	0.890	8890	11,120	15,570
1 3/8	1.054	10,540	13,180	18,450
1 1/2	1.294	12,940	16,170	22,640
1 5/8	1.515	15,150	18,940	26,510
1 3/4	1.745	17,450	21,800	30,520
1 7/8	2.049	20,490	25,610	35,860
2	2.300	23,000	28,750	40,250

The example does not give the size of the members, but the assumption is they are large enough to carry the load safely. In practice, all parts should be calculated as described in Chapter 4, "Strength of Timbers." The ideal joint is one so proportioned that the total shearing stress of the bolts equals the tensile strength of the timbers (see Figure 1-27).

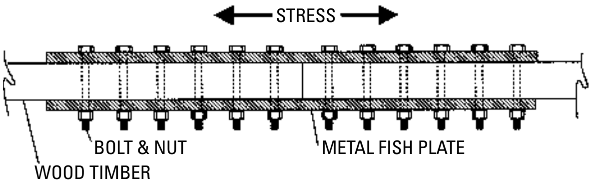


Figure 1-27 Shearing stress and tensile strength.

Fasteners for Plaster or Drywall

Because of the relatively fragile nature of plaster and drywall in comparison to brick, stone, and concrete, fasteners used with the former must necessarily be different from those used with the latter. Whenever weight of any consequence is involved, or a direct outward pull is to be exerted, a fastening is best accomplished with standard wood screws or lag screws inserted through the object to be fastened and driven through the plaster or drywall directly into the studs, rafters, or other framing material beneath. When this is impossible, anchor directly to the plaster or drywall with one or more of the fastening devices discussed in the following sections.

Expansion Anchors

Metal *expansion anchors* are unsuitable for use with plaster or gypsum board because they tend to crush the walls of the hole into which they are inserted, and then fall or pull out easily (assuming they can be tightened in place to begin with). Plastic expansion anchors (see Figure 1-28) are better in this regard, perform their best with radial loads, and are the poorest of any anchor on axial loads.

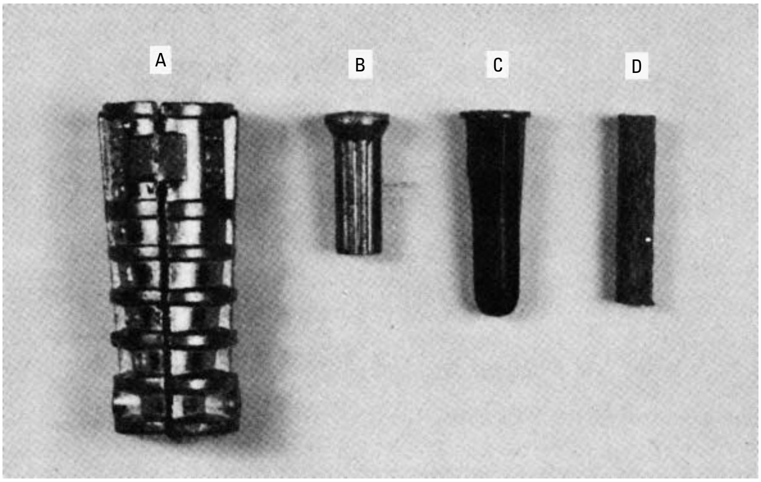


Figure 1-28 Expansion anchors: (A) made from lead alloy for use with lag screws, (B) made from a softer lead alloy for use with wood screws, (C) made from plastic and best used with sheet-metal screws, and (D) made from fiber-jacketed lead—a plug-type anchor sized here for small wood screws.

This poor axial-load performance can be countered (to a degree) by using more than one anchor to support the load (as in a ceiling-mounted traverse rod, for example).

Holes for plastic expansion anchors are best bored with a twist or push drill in both plaster and gypsum board to get an accurate fit. Holes jabbed with an ice pick, screwdriver, or similar tool are seldom sized correctly for the best friction fit and may have considerable material knocked away from the edge of the hole, inside the wall, making the site useless for an anchor. Bore the hole the diameter specified on the anchor package and use the screw size specified there, also. The length of the screw should be equal to the length of the anchor, plus the thickness of the object to be fastened, as a minimum. As a rule, sheet-metal screws work better in plastic anchors than do wood screws, possibly because their comparative lack of body taper causes a more effective expansion of the anchor.

Hollow Wall Screw Anchors

These devices are manufactured by a number of different companies. They consist of a metal tube having a large flange at one end and an internally threaded collar at the other. A machine screw is inserted through a hole in the flange, extended the length of the tube, and screwed into the threaded collar (see Figure 1-29).

In use, a hole of specified diameter is bored through the gypsum board or plaster. An anchor (see Table 1-14) of the proper grip range (depending on the thickness of the drywall or plaster) and screw size

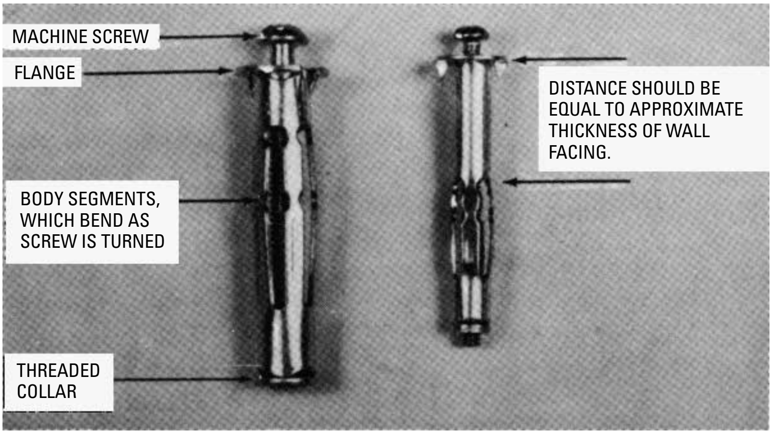
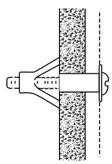
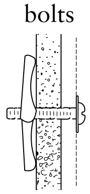


Figure 1-29 Two sizes of hollow wall screw anchors.

Table 1-14 Allowable Carrying Loads for Anchor Bolts

		Allowable Load	
Type Fastener	***Size***	***$^1/_2$-inch Wallboard***	***$^5/_8$-inch Wallboard***
Hollow wall screw anchors	$^1/_8$-inch dia. short	50 lbs	—
	$^3/_{16}$ -inch dia. short	65 lbs	—
	$^1/_4$ -inch, $^5/_{16}$ -inch, $^3/_8$ -inch	65 lbs	—
	dia. short	—	90 lbs
	$^3/_{16}$ -inch dia. long	—	95 lbs
	$^1/_4$ -inch, $^5/_{16}$ -inch, $^3/_8$ -inch		
	dia. long		
Common toggle bolts	$^1/_8$ -inch dia.	50 lbs	90 lbs
	$^3/_{16}$ -inch dia.	60 lbs	120 lbs
	$^1/_4$ -inch, $^5/_{16}$ -inch,	80 lbs	120 lbs
	$^3/_8$ -inch dia.		

(Courtesy National Gypsum Co.)

(depending on the weight of the object to be anchored) is inserted. This is so that its length is inside the wall and its flange rests against the wall's surface. The anchor is then lightly tapped with the butt of a screwdriver to seat it and prevent it from turning in the hole. The screw is then turned clockwise with a screwdriver.

As the screw is turned, it draws the collar end of the anchor toward the flange end. Four slots cut lengthwise into the tube allow the sections of the tube between the slots to bend outward in response to pressure from the collar until they lie flat against the inside surface of the wall, drawing the flange tightly against the outside surface and locking the anchor securely in place. The screw is then removed, inserted through whatever object is to be fastened, and replaced in the anchor body, an action that can be performed repeatedly without loosening the anchor body.

Hollow wall screw anchors are also manufactured with pointed screws and tapered threaded collars. These can be driven into the wall without drilling a hole first. Very short anchors are also available for use in thin wood paneling and hollow-core flush doors.

Once they are in place, the anchors are removable only with some ingenuity if a large hole in the wall is to be avoided. One method that works (but must be done gently) is to replace the screw in the anchor with another one of the same size and thread, but longer. This replacement screw must be threaded into the anchor only one turn (if at all). Once it is in place, smack the head of the screw with a hammer. This action may straighten out the bent legs of the anchor so that it can be withdrawn from the wall intact. More frequently, it will either break off the legs or break off the flange.

Remove the screw, and in the former case, pull the flanged section of the anchor out of the wall with the fingers (if it won't come out all the way, pull it out as far as possible, cut it in two with diagonal cutters, and let the stubborn half drop down inside the wall cavity). If the flange breaks off, push the remainder of the anchor back inside the wall. The only hole to be patched will be the one originally bored for the anchor, although a too-vigorous hammer blow can produce an additional dimple in the wall surface. The method is a little risky with very soft or very thin wall facings because their relative lack of substance may allow the flange to be driven backward through the facing. Let good judgment be the guide. It may be better to leave the anchor alone.

Toggle Bolts

These differ from hollow wall anchors in that they must be attached to the object to be fastened before they are inserted into the wall. In their larger sizes, they will carry a heavier load (see Table 1-14). In all sizes, they are good for axial as well as radial loads, need a larger hole for mounting, and once mounted, cannot be reused if the screw is removed from the toggle. A longer screw is necessary in order to allow the wings of the toggle to unfold in the wall cavity.

Toggle bolts (see Figure 1-30) are simple devices consisting of a center-hinged crosspiece pierced in the middle by a long machine screw. The crosspiece (called the *toggle*) is composed of two halves (called the *wings*) hinged around a threaded center through which the screw runs. The wings are normally held at almost a right angle to the screw by spring pressure but can be folded flat along the screw to allow insertion into the wall. Once inside the wall cavity, they automatically snap upright again (they fold only one way—toward the head of the screw) and prevent removal of the unit. Tightening the screw squeezes the toggle firmly against the inner wall surface and the object to be fastened against the outer wall

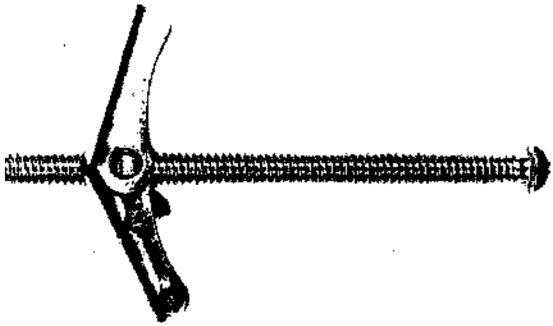


Figure 1-30 Common toggle bolt.

surface. Removing the screw allows the toggle to drop into the wall cavity; hence, the unit is easily removed but, in most cases, is not reusable because the toggle cannot be recovered.

Toggle bolts are commonly available with screw diameters from $^{1}/_{8}$ inch to $^{3}/_{8}$ inch and screw lengths to 6 inches, although they can be fitted with screws of any maximum practical length by using threaded rod. Minimum screw length should equal the thickness of the object to be fastened, plus the thickness of the wall facing, plus the length of the wings when folded, plus $^{1}/_{4}$ inch. The maximum length should not exceed the minimum by much, if at all, or the screw can bottom against the opposite wall facing and be impossible to tighten.

Figure 1-31 Hanger bolt with wood screw threads at top and machine-screw threads at bottom.

Hanger Bolts, Dowel Screws, and Toggle Studs

Whenever a hook is to be installed in a plaster or gypsum board ceiling, it should be driven through the ceiling material and into a joist if at all possible. Since most common ornamental hooks are supplied with female machine threads, a device called a *hanger bolt* (see Figure 1-31) is necessary to accomplish this.

Hanger bolts are relatively short lengths of steel rod having a machine-screw thread on one end and a wood-screw thread on the other. The machine-screw thread is turned into the ornamental hook until it bottoms, and then the whole unit is turned to sink the wood-screw threads into the ceiling and ceiling joist. A pilot hole should be bored into the joist to make turning easier and to prevent possible breakage of the hook if too much twisting force is applied.

Although ornamental hooks are mentioned here as an example, almost any device can be mounted to the ceiling or wall by using a hanger bolt in a similar manner or by using a standard nut on the machine-screw threads protruding from the wall or ceiling.

Dowel screws (which are identical to hanger bolts except that they have wood-screw thread on both ends) can be used to fasten something of wood to a ceiling or wall in the same way.

If an object having female machine threads cannot be fastened to a ceiling joist or wall stud by a hanger bolt, a *toggle stud* is used

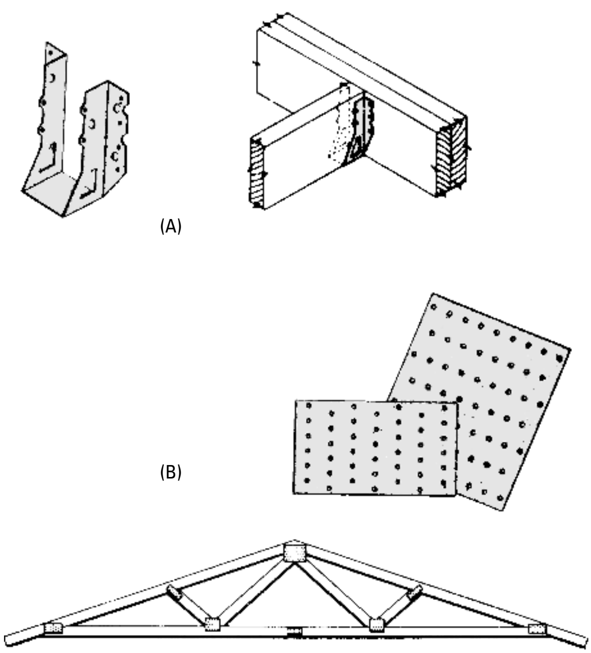


Figure 1-32 (A) One useful kind of framing fastener is the joist hanger. (B) Perforated plates such as shown can be used to make trusses. *(Courtesy of Teco.)*

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instead. All this amounts to is a toggle bolt without a head on the screw. This is so that the screw can be turned into the female machine threads in the device to be mounted. A toggle stud will not bear as much weight as a hanger bolt, but it should be adequate for a small to medium-size flowerpot and hanger. It is used the same as a toggle bolt.

Framing Fasteners

Framing fasteners are stamped metal pieces (16 or 18 gauge) with predrilled nail (or screw) holes. You set the fastener between the pieces and drive the nails through the holes to lock the members together. The result is a very strong connection. It should be noted that not all building codes accept them, so their use should be checked out beforehand (see Figure 1-32).

Summary

Nails are the carpenter's most useful fastener. Many nail types and sizes are available to meet the demands of the industry. On any kind of construction work, an important consideration is the type and size of nails to use.

An important factor in selecting nails is size. Long, thin nails will break at the joints of the lumber. Short, thick nails will work loose quickly. The kind of wood is a big factor in determining the size of nail to use.

Wood screws are often used in carpentry because of their advantage over nails in strength. They are used in installing various types of building hardware because of their great resistance to pulling out and because they are more or less readily removed in case of repairs or alterations.

There are generally three standard types of screw heads: the flat countersunk head, the round head, and the oval head. All of these can be obtained in crossed slot, single straight slot, or Phillips slot.

Lag screws or lag bolts are heavy-duty wood screws that are provided with a square or hexagonal head so that they are installed with a wrench. These are large, heavy screws that are used where great strength is needed, such as when working with heavy timber and beam installations. Holes are generally bored into the wood because the diameter of lag screws is large.

A bolt is generally regarded as a rod having a head at one end and a threaded portion on the other to receive a nut. The nut is usually considered as forming a part of the bolt. Bolts are used to connect two or more pieces of material when a very strong connection is required.

Various forms of bolts are manufactured to meet the demands and requirements of the building trade. The common machine bolt has a square or hexagonal head. The carriage bolt has a round head; the stove bolt has a round or countersunk head with a single slot. Lock washers are used to prevent nuts from loosening. Other fasteners are the toggle, Molly, and expansion bolt.

Review Questions

1. What is nail holding power?
2. Explain the penny nail system.
3. What should be considered when selecting a nail for a particular job?
4. Name and describe five kinds of useful nails.
5. Name the three basic head shapes of wood screws.
6. What type of wood screw is used where great strength is required?
7. What type of head is used on lag screws? Why?
8. What is meant by the root diameter of a screw?
9. What type of head is generally found on a machine bolt?
10. What is meant by threads per inch?
11. Explain the purpose of lock washers.
12. What is an expansion bolt?