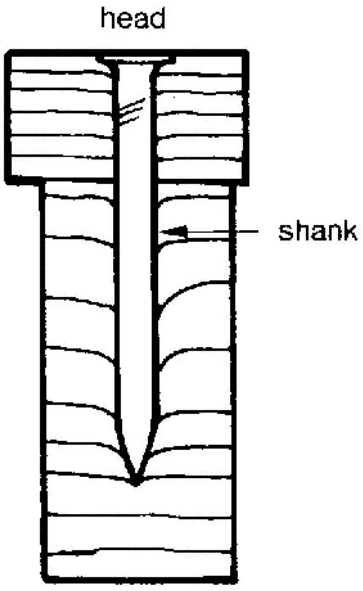
Ways of joining materials

In order to choose the best way of joining any combination of materials in any situation which is likely to arise, we must have a good general knowledge of methods of joining. Joints can be classified in several ways such as temporary and permanent, flexible and rigid, and hot and cold formed.

In the pages which follow we have given enough details of the common ways of joining for you to be able to choose the best method and use it correctly.



Nails

Nailing is the quickest way of making a permanent joint in wood. Nails cannot be removed easily or without damage, and therefore should not be used as temporary joints.

The nail punches the fibres of the wood away from the nail head. They grip the shank of the nail and resist attempts to withdraw it. The serrations round the shank, below the head, give extra grip. The treaded pattern on the head stops the hammer from slipping. Always nail through the thinner piece of wood into the thicker piece. The nail length should be about 2.5 to 3 times the thickness of the thinner piece.

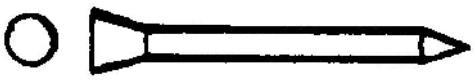
Nails are sold by length, type, material and weight (not number).

Common types

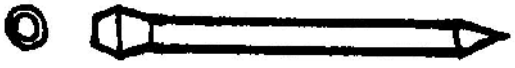
Round wire nails have a round shank and a flat head. They are made from steel wire and can be galvanized to stop rusting. The usual sizes are from 12 mm to 150 mm long and they are used for general joinery work.

Oval wire nails have an oval shank and a narrow head which is driven below the surface. Turn the long axis of the oval shape in line with the grain to prevent splitting. They are made from steel wire and can be galvanized. The usual sizes are from 12 mm to 150 mm. Because they have no heads they do not hold the wood as firmly as round wire nails, but they are neater and are therefore used for interior joinery. The nail holes can be hidden by filling.

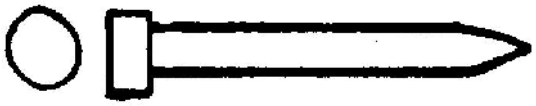
Standard panel pins have a thin round shank and a small head which is driven below the surface with a nail punch. The usual sizes are from 12 mm to 50 mm and they are used for strengthening joints and fixing thin sheets.



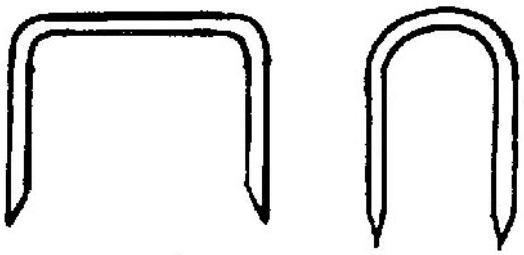
Hardboard pins have a hard square shank to penetrate hardboard without bending and a pointed head which does not need punching below the surface.



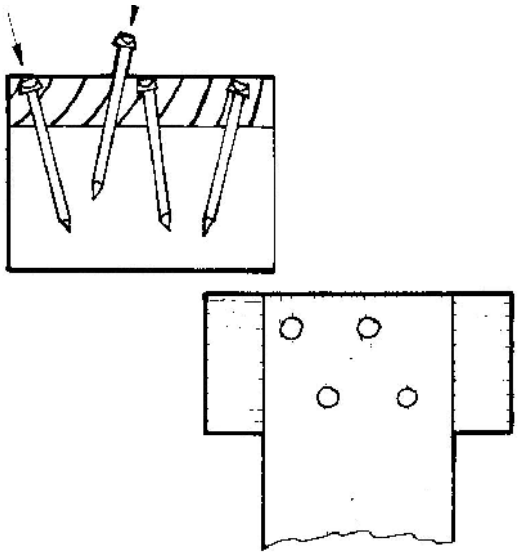
Clout nails are short nails with extra large heads for fixing roofing felt, canvas chair webbing, etc. They are usually galvanized to prevent rusting.



Hardened fixing pins are hard, round shanked nails designed to withstand persistent hammering and to penetrate bricks, etc. They should be long enough to go through the job being fixed, any plaster on the wall, and then 15 mm to 20 mm into the wall.



Staples are square for crate-making and upholstery, and round for holding wire. Square staples are usually fired in by a staple gun. Round staples are heavier and are hammered in.

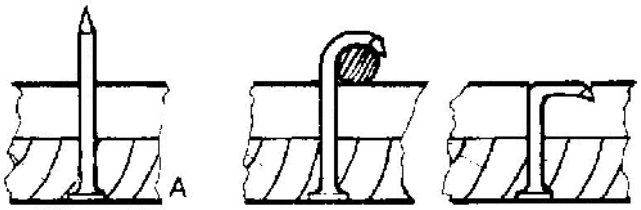


Dovetail nailing. To give extra strength to a joint, drive in pairs of nails towards each other dovetail fashion.

Staggered nailing. When nailing a frame together stagger the nails across the width of the wood to avoid splitting the grain.

If the wood is brittle or tough, bore a small hole and blunt the nail point. These precautions help to prevent splitting, especially when nailing close to the end of a plank.

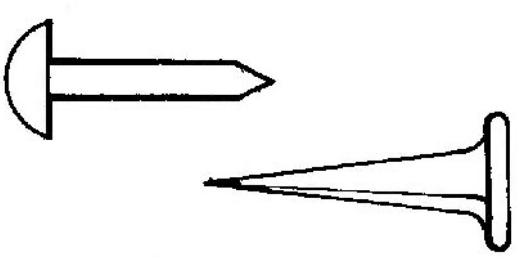
Clinched nailing. This is used to prevent nails being easily pulled out when nailing into thin wood. The process is shown right. Note that the usual rule is still used to calculate the length of the nail (3 x thickness of piece A). A convenient round bar, such as one handle of a pair of pincers, is used to help in turning the nail point back into the wood to give a strong, safe joint. Simply bending the nail over leaves a dangerous point exposed.



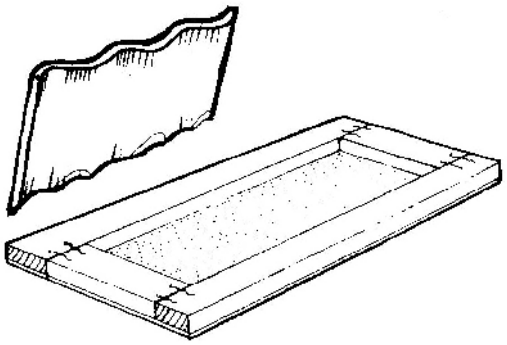
Nails for upholstery

Gimp pins are small wire nails, often of brass, with a large head used in upholstery where the nail heads will show.

Cut tacks are short, sharp-pointed, flat-headed nails, usually with a blued or black mild steel finish. They are used in upholstery where the nails will be hidden.



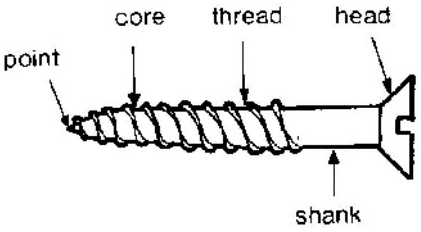
Corrugated fasteners are short strips of corrugated steel with one sharp corrugated edge, used to make crude joints in cheap work. They are hammered in across the joint lines at each corner to hold the frame together.



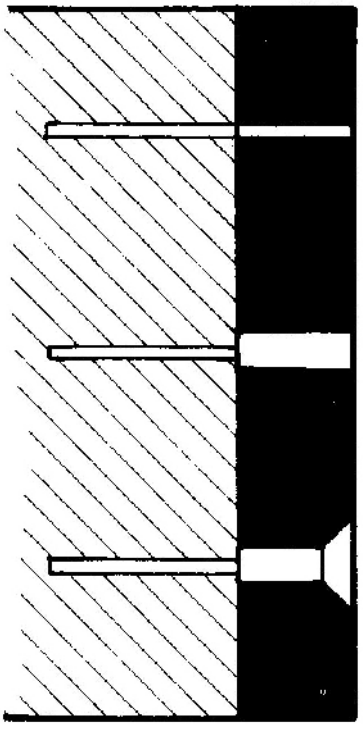
Screws for wood

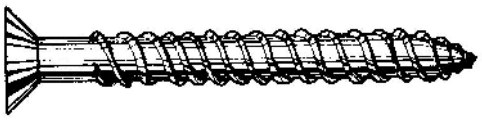
Screws are an effective way of making a permanent or temporary joint in wood. The thread of the screw becomes enmeshed with the grain fibres to make a strong joint. Screws are stronger, neater and more accurate than nails, and can be taken out without causing damage.

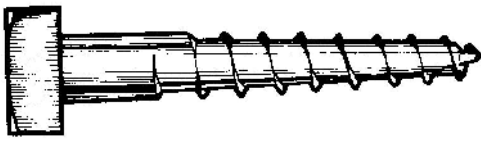
Using screws



- Select the correct length of screw. This is 2.5 to 3 time of wood. Always screw through the thinner piece of wood i
- Drill the pilot hole to slightly less than the screw length. A bradawl hole may be enough in softwood, but in hardwood and for large diameter screws, use a drill equal to the core diameter. Failure to drill properly causes chewed up screw heads and split wood.
- Drill a clearance hole for the shank.
- Countersink for the screw head if needed.
- When using brass screws which easily break, screw in a stronger steel screw first to cut a thread, and in hard-wood, lubricate the screw with soap or wax.







Common types of screws

Countersunk head screws are used to join wood to wood where the head has to be flush with the surface, and for fitting hinges. They are the most commonly used type.

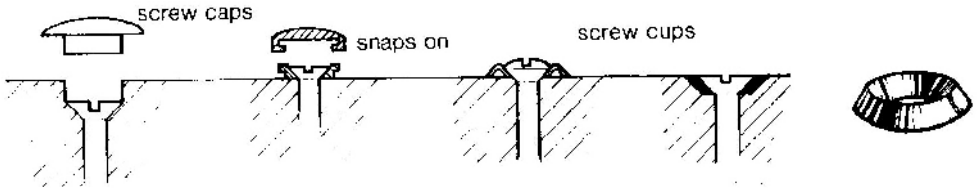
Round head screws are used to screw thin metal fittings to wood (e.g. tee hinges and shelf brackets), and for joinery work where the head need not be flush. They are often of black japanned steel to resist rusting.

Raised countersunk head screws are less common and are used to screw fittings to wood. They are often of chrome plated brass to look attractive or plated to match fittings such as door furniture.

Twinfast screws have two threads instead of one, so that fewer turns are needed to screw them in. They have more holding power than ordinary screws, and this is especially useful for joining difficult materials such as chipboard and blockboard.

Coach screws are large heavy duty screws with a square head onto which a spanner is fitted to turn them. They are used to join large pieces of wood such as bench tops, and to screw heavy metal fittings such as vices, to wood.

Screw caps and screw cups are used where appearance is important or where the screw must be removed frequently.

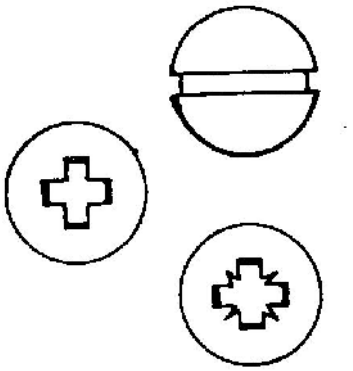


Types of screwdriver slots

Straight slot. A screwdriver can slip out of a straight slot and damage both screw head and wood.

Phillips slot.

Pozidriv slot. The main advantage of Phillips and Pozidriv slots is that the screwdriver blades do not slip out of the slots so easily.



The common materials are steel and brass, and screws are often plated with chrome, zinc, nickel, or black japanning.

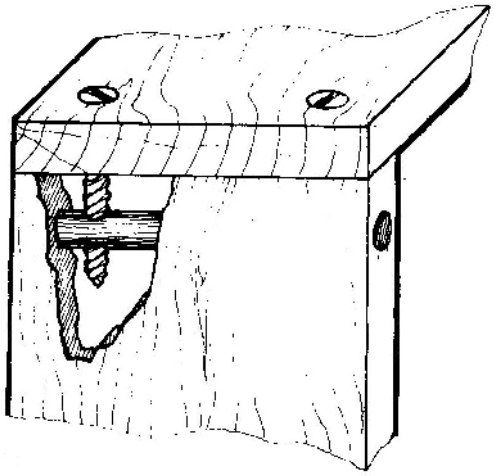
Steel screws are the strongest and cheapest. Brass screws look better and do not rust, but are not very strong.

The common sizes of steel countersunk screw are 6 mm to 150 mm long and 0 to 22 gauge number sizes. The gauge number indicates the diameter of the shank and the size of the head. The higher the number, the thicker the screw.

Screws are sold by:

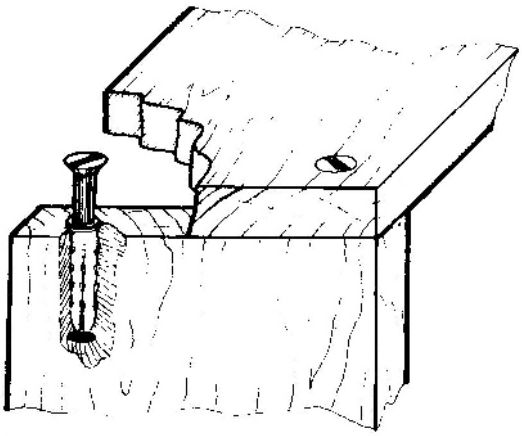
Quantity (How many?)
Length (How long?)
Gauge (How thick?)
Material (What is it made from?)
Type of head (What shape? What sort of slot?)

e.g. 100, 25 mm x No. 6 steel countersunk.



Screwing into end grain. Screws will not hold in end grain without special methods being used, and nails are often better because the screw thread cuts through the grain fibres and they crumble away.

Two ways of solving this problem are shown here.



Method 1. Let a dowel into a hole across the width of the wood to provide a nut for the screw.

Method 2. Insert a rawlplug into a hole bored down the end grain. The rawlplug holds firmly in the wood and the screw holds firmly in the plug.

Hints on glueing

Surfaces to be joined must be clean, dry and grease free. Do not apply any finishes to the parts to be joined and remove any old paint, varnish, glue etc.

Whenever possible, slightly roughen the surfaces to be joined, to help the glue to wet the surface more thoroughly.

Plastics should be washed in warm water containing a small amount of liquid detergent, rinsed in clean warm water, and left to dry. Always ***dry-cramp*** the job before glueing to make sure that the parts fit, and to work-out the best method of cramping.

Follow the manufacturers instructions carefully. Most glues have a setting time during which pressure must be applied to hold the parts together, and a longer curing time during which the job must not be roughly handled or used.

Always check for squareness and correct assembly before the glue sets and wipe off surplus glue.

Some common glues and their uses

Scotch glue is an animal glue made from bones and hide which is used *hot* to stick wood. It is available in slab or pearl (bead) forms. To use it, break a slab wrapped in cloth into small pieces and soak these in water overnight to form a jelly. Put the jelly and more water into the inner pot of a glue kettle, half fill the outer pot with water, and heat slowly until the glue melts into a liquid. The water in the outer pot prevents overheating. Pearl glue is ready for heating after a short soaking.

The glue is ready for use when it just runs from the brush and a thin skin forms on top. Remove the skin.

Advantages. It is cheap, does not stain wood, is very strong if the joints fit well, and there is no waste because it can be reheated several times.
Disadvantages*.* It must be used quickly before it cools, leaving little time to fit the job together and the job must be left in cramps overnight to set. It is not heat or water resistant.

Casein glue is an animal glue made from the curds of sour skimmed milk which is used *cold* to stick wood. It is sold as a white powder which must be mixed with water to make a thick cream and left for 20 minutes before use.

Advantages. It is heat and water resistant, but only semi-waterproof. It is very strong and can be used for several hours after mixing.

Disadvantages. It is liable to stain hardwoods and must be left in cramps overnight to set.

Synthetic resin glues are made from plastics resins and make joints in woods which are stronger than the wood itself. There are two main types.

*T**he one shot type*** (e.g. Cascamite) consists of a resin and a hardener ready-mixed in a powder which must be mixed with water to make a thick cream.

The two shot type (e.g. Aerolite 306) consists of a resin powder which is mixed with water and spread on one half of the joint, and a separate hardener which is spread on the other half. The two are then pressed together and cramped. Take care not to mix up the brushes.

Advantages. They make very strong, almost colourless and waterproof joints which set in only three hours. They will fill small gaps in the joints and have a long shelf life.

Disadvantages*.* They stain some woods and you must mix only as much as is needed straight away to avoid waste.

P.V.A. (Polyvinyl acetate) glue (e.g. Evostik Resin W) is sold as a white ready-mixed liquid in a plastic container. It is the most widely used wood glue and is also useful for some other materials.

Advantages. It is easy to use, non-staining, strong if the joints fit well and water resistant. It has an unlimited shelf life and joints set in two hours.

Disadvantage*.* It is not waterproof.

Contact (impact) adhesives (e.g. *Evostik impact, Bostik, Dunlop Thixafix)* are synthetic rubbers and resins in a solvent. They are used to hold sheets of light and usually dissimilar materials together, such as Formica to a chipboard worktop and P.V.C. leathercloth upholstery to a plastics chair shell. They work because two dry films of synthetic rubber will stick under light pressure. The glue is spread evenly over both surfaces with a comb and allowed to become touch-dry, usually after about 15 minutes. One part is, located over the other without allowing them to touch, and then they are pressed together. Once touched together the parts cannot be separated or moved into position.

Advantages. No cramps are needed, and this allows large difficult items to be joined.

Disadvantages. The joints are not very strong and they are not suitable for such jobs as furniture making. Once opened, the glue has a short shelf life.

Epoxy resin glues (e.g. *Araldite)* will stick wood, metal, glass, china, stone, concrete, rubber and plastics. Equal amounts of resin and hardener are mixed together, spread on very clean surfaces, and cramped together.

Advantages. They will stick almost anything.

Disadvantages. They are very expensive, and should only be used when there is no cheaper alternative. The joints are not strong enough to handle for 24 hours and do not reach their full strength for two or three days.

Resorcinol and phenol glues are considered the ultimate for high stress joints in wood. They are used mainly for such purposes as making laminated beams and boat building.

Advantages. The joints are very strong and completely waterproof.

Disadvantages. They are very expensive and leave dark brown glue lines.

Plastics cements

Joints can be made in many thermoplastics by using suitable cements containing a powerful solvent for the material being joined. Some thermoplastics (e.g. polypropylene, polythene and P.T.F.E.) cannot be cemented together because suitable solvents are not available.

Other adhesives can also be used to join plastics and to join plastics to other materials, but the joints are usually less strong than cemented joints.

Acrylic (e.g. perspex, oroglass) can be joined to itself using ***Tensol*** cement. Tensol No. 6 is a ready-mixed acrylic solvent which is easy to use for most purposes, but does not give a clear joint. Tensol No. 7 is a two part pack which must be mixed with care but has the advantages of making a completely clear and waterproof joint suitable for use outdoors.

Perspex is not usually stuck to other materials. Try to use screws, etc. if possible.

P.V.C. can be joined using Tensol No. 53 cement or a number of readily available P.V.C. adhesives, some of which will also stick P.V.C. to other materials. Acetone (nail varnish remover) can be used to clean joints and remove excess glue.

Rigid polystyrene can be joined using the polystyrene cements widely sold for use with polystyrene model kits such as *Airfix.* They dry quickly and give a clear joint. Glue can be removed with acetone or carbon tetrachloride.

Soldering, brazing and welding metals

Soldering makes a permanent joint between 2 pieces of metal, by using an alloy which has a lower melting point than the metals being joined, as a 'glue'. This alloy makes the bond by forming an alloy with the base metals which are not melted during the process.

Soft soldering, hard soldering and brazing are all examples of this process, while welding works by melting the edges to be joined so that they fuse together. A filler rod of similar metal is added to fill the weld.

When welding thick metal the joint is prepared by bevelling the edges to form a vee. In industry there is a much wider range of welding processes, including automatic and continuous methods.

Welding plastics

The process is basically the same as when welding metals. Two pieces of the same material, and if needed a filler rod of this material, are heated until they soften, and pressure is applied to fuse them together.

There are two methods commonly used in school. These are heated tool welding, to fuse thin sheets up to 1 mm thick and films, and hot air welding for thicker sheets. In industry a wider range of methods is available.

In heated tool welding a tool similar to an electric soldering iron is drawn across two thicknesses of thin sheet to soften them, followed by a roller to press the joint together. Heated tool and roller can be combined into one heated roller which is wheeled across the joint.

To prevent the sheet melting and sticking to the hot roller, a sheet of polyester film such as ***Melinex*** is placed between the roller and the sheet being welded.

In hot air or hot gas welding a stream of hot air or gas is used to heat the surfaces being joined and the filler rod, exactly as when oxy-acetylene welding. The simplest hot air welding tools are similar to hair dryers with interchangeable nozzles and temperature control. The joint is prepared by bevelling the edges to form a vee and by cleaning them. When the material has been heated to the correct temperature, the softened filler rod is pressed into the vee to fuse the parts together. This is often done by feeding the filler rod through a tube attached to the nozzle so that it can be heated and pressed with the same tool.

Suitable plastics for welding. Only thermoplastics which do not burn or decompose when heated to their softening temperature can be welded.

Polythene, polystyrene, polypropylene, P.V.C., nylon and some acrylics are examples of thermoplastics which can be welded by both the above methods.

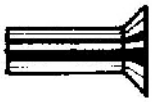
Rivets

Rivets are used to make permanent joints in metal, to join metal to soft materials and for joining soft materials to each other.

Solid rivets

Snap or round head rivets are used for general purposes where a flush finish is not important and countersinking would weaken the job.

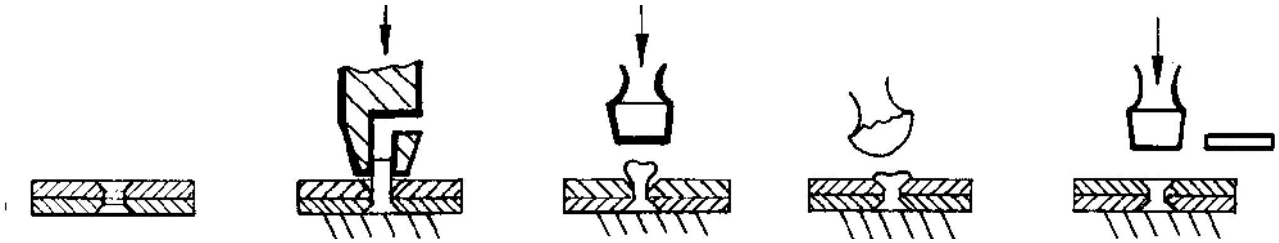
Countersunk head rivets are used for general purposes where a flush surface is needed. They are the most commonly used type.



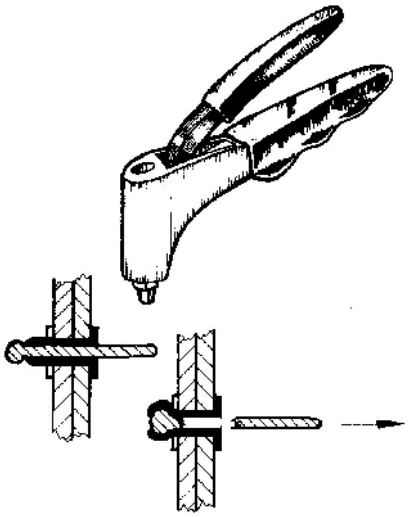
Flat head rivets are used for joining thin plates which cannot be counter-sunk.

Stages in countersunk riveting.

- Drill and countersink both plates. Clean off any burrs.
- Put in the rivet and press the rivet and the plates together with a set. Support the countersunk head on a flatblock.
- Swell the rivet with the flat face of a hammer until it is tight in its hole.
- Use the ball-pein to fill up the countersink.
- Finish with the flat face and file the head smooth. A good countersunk rivet should be almost invisible.



Drilling. It is impossible to drill several holes in two different pieces of metal and get them to match up exactly. To avoid this problem, drill all the holes in one piece, but only one in the other. Clean off the burrs, join the pieces with one rivet, and then drill and rivet one hole at a time.



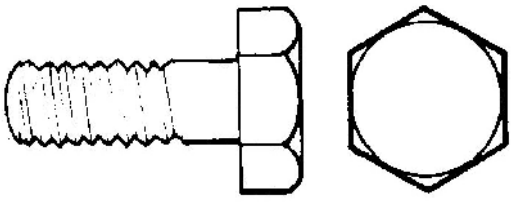
Pop rivets. These have the advantage that they can be set quickly from one side only. They are weaker than solid rivets because they are made from soft metal and are hollow. They are used mainly for joining thin sheet metal, but they can also be used for other thin materials. Washers can be put onto the rivets to enable soft materials such as leather and rubber to be riveted.

As the mandrel is pulled through by the pop riveting pliers, it expands the rivet head. When the correct pressure is reached, the head breaks off and stays in the rivet.

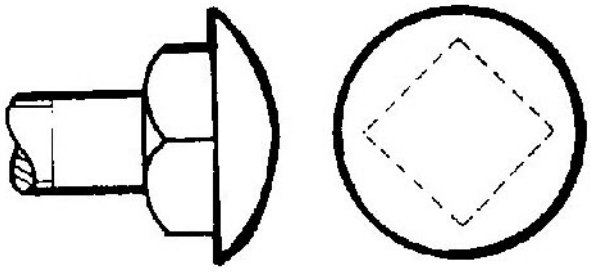
Nuts, bolts and machine screws

All these fixings are usually made of steel or brass and can be coated either to rustproof the steel or to improve their appearance.

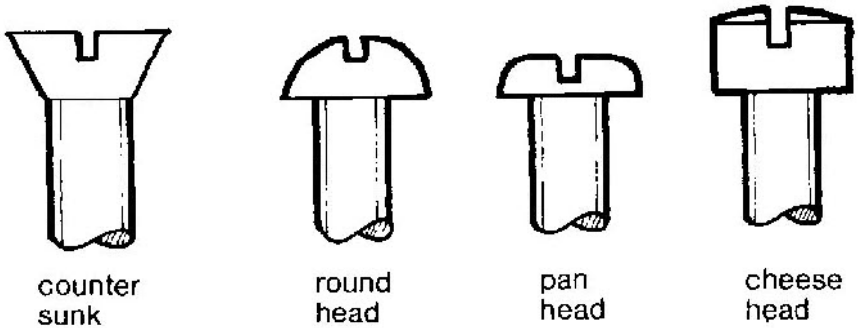
Bolts usually have either a square or a hexagonal head. or-
dered by the diameter of the thread and the length t r-
side of the head. Bolts may be threaded for all or part of :h.



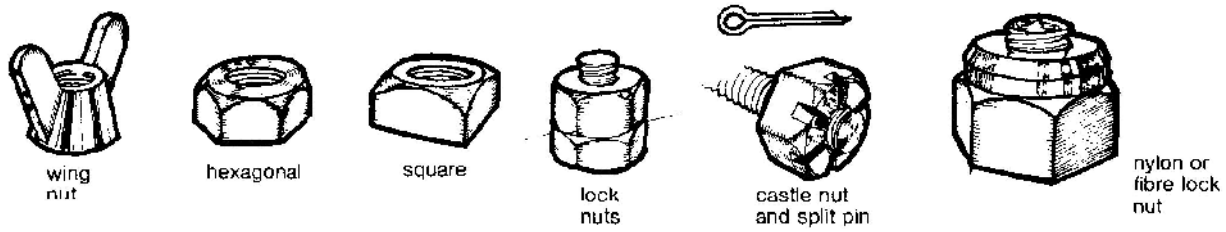
Coach bolts are used to join wood to wood or wood to other materials. They have a domed head with a square collar underneath which is pressed into the wood to prevent the bolt turning. They are usually used for strong structural woodwork.



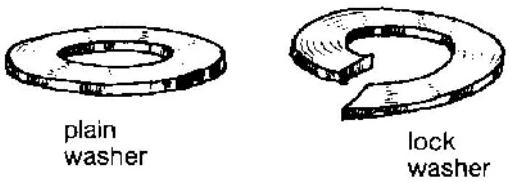
Machine screws are available in a wide range of thread diameters, lengths and head shapes.



Nuts are either plain square, plain hexagonal, wing nuts for easy removal, or special locking nuts to prevent vibration loosening them.

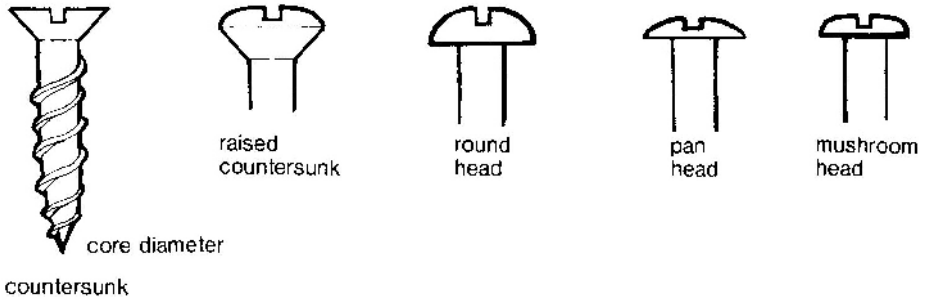


Washers are used to protect the surface when the nut is tightened, to spread the load or to prevent vibration loosening the joint.



Self-tapping screws are used to join thin sheets of metal and plastics, and as chipboard screws where ordinary woodscrews would cause the chipboard to crumble. They are made of hardened steel so that they can cut their own thread as they are screwed in.

Common sizes are 6 mm to 50 mm with Phillips, Pozidriv and straight slots.
Drill a tapping size hole equal to the core diameter of the screw.



Furniture fittings

Hinges

The sketches show a few of the common types of hinge. There are many others.

Butt hinges are used for room and cupboard doors, small boxes and windows. They are usually made of steel, nylon or brass, and may be plated. They fit onto the edge of the wood and are usually recessed so that when the door is closed they are neat and almost hidden. The main disadvantage is that because the screws are close together and in a straight line there is a danger of splitting the wood.

Back flap hinges are used for drop-down leaves and flaps, and strong tool box lids. They are usually made of steel, nylon or brass, and may be plated. They fit onto the surface of the wood and the screw holes are spaced out for greater strength.

Piano hinges are long lengths of butt hinge. They are used on box and furniture lids. They are neat and allow the screw holes to be spread out over the whole door length. They conceal the edges of man-made slabs.

Laid on hinges are used where doors fit onto the outside edge of a cupboard and must open within the width of the cabinet, for example, when a row of kitchen unit doors fit closely together in a row. The doors can usually be opened through 180°. The hinges are usually made of plated steel.

Flush hinges are light weight hinges where one flap fits into the other when closed. The hinge is thin and does not need recessing. They are usually made of plated steel.

Tee hinges are used on shed doors, gates, and workshop cupboards. The long arm spreads the load across several planks of a tongue and grooved door, while the short arm fits onto a narrow frame or post.

Stays are used to control the opening of fall flaps and to keep lift-up doors open. They are usually fitted so that the fully open stay is at 45° to the cabinet when the lid or flap is opened to 90°.