WORKBENCH IS THE HEART OF THE WORKSHOP

If you are setting up your workshop, there is no better place to start than with the workbench. A quality workbench is a pleasure to use, but a rickety structure will quickly prove a hindrance every time it is used.

A strong, well-designed workbench is just as important as any other tool in the workshop.

A robust bench can support a decent bench vice and also cope with any force exerted on the vice. Benches can be free standing or fixed to a wall as many are placed against walls when setting up the workshop.

Wall-mounted benches can be built into the shed structure to improve their strength by welding supports to uprights. Free-standing benches are more versatile and can be placed in the centre of a room for access to all sides, or moved around as needs change. They can be bolted to the floor to improve rigidity and prevent movement when using the bench vice.

Build or buy?

There are now many options for those wishing to purchase a prefabricated workbench and some are more than suitable for heavy work. Others are nothing more than lightweight tables and not worth it.

If you are setting up a new workshop the purchase of some prefabricated workbenches will save a great deal of time compared to making your own. Choose a model with as heavy a construction as you can afford because it is far better to have a strong bench which is never tested to its limit than a lightweight unit which becomes rickety every time a heavy toolbox is placed on it.

The advantage of making your own workbench is that it can be tailored to suit your needs and the space available in your workshop. It can also be sturdily constructed and often a large amount of recycled materials can be used in its construction.

Second-hand steel pipe, RHS or angle iron makes an excellent building material for workbenches because it can be welded into any form desired, providing rigidity and strength without being overly heavy if designed correctly. But there are many excellent workbenches constructed entirely of timber that have provided years of service to their owners.

Top choice

Whether you buy or build the choice of workbench surface is an important decision. It is likely you will end up with several benches each with a different surface suited for a particular task such as welding, engine strip-down or wood work.

Metal is a popular choice for general use, but needs to be at least three millimetres thick for light work and a thicker gauge for heavier work.

Metal is easy to keep clean and ideal for working on engines and other items that are sensitive to dirt. Spilt oil is easily cleaned up and an angle iron draining lip is often added to the bench top edges to avoid mess.

But oily metal creates a slippery surface which can cause problems. Metal bench tops also tend to react badly to hammering creating noise and vibration.

Thick wooden bench tops absorb vibration well and are less slippery when coated with oil, but thick, wide hardwood planks are becoming increasingly hard to purchase cheaply. Any warping or bowing of the timber will create gaps between the planks which will lead to the loss of small items through cracks.

TIPS FOR BUYING TOOLS

With so many different brands and styles of hand tools on the market today the choice is sometimes daunting when buying a new spanner, hammer or socket set.

Whether stored in a toolbox under the bench, a canvas bag behind the ute seat, or in a large mobile toolbox in the workshop, hand tools are fundamental to fixing things.

We'd all like to be able to afford a Sidchrome or Snap-on 2000-piece toolkit and matching roller draw toolbox, but most of us acquire our tools in dribs and drabs as we need them. Sometimes we buy quality and sometimes the lure of a cheaper set of spanners is too great.

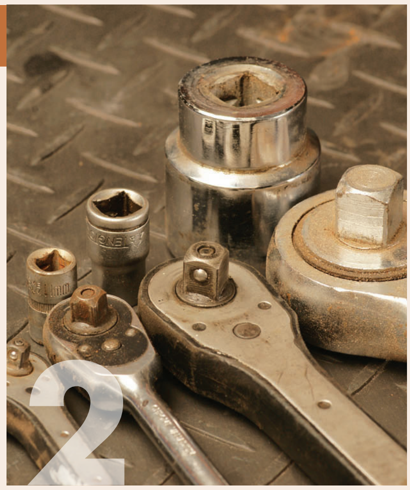
While there are no hard and fast rules to tool selection there are several tips, which may help anyone looking for that perfect socket set or screwdriver.

If you are looking to save money, but expand your tool collection, there is generally nothing wrong with buying second-hand, provided the tools are in good condition. There are many options for finding good second-hand tools at bargain prices such as online auction sites and classified advertisements as well as second-hand stores. Even auctions and dispersal sales can throw up bargains every now and again.

Other tools are so cheap these days you may as well purchase them new. If you are buying a tool to use occasionally then it also makes sense to purchase a lower cost brand rather than an expensive label.

Sockets

Sockets are a good starting point for a decent tool set. Impact sockets (left) have six points and thick, solid walls to stand up to the strain of being used with an impact wrench. They are also good for using with rounded-off nuts and bolts, which may slip when used with a standard double hexagon (12 point) socket (right). Choose a quality set of 12-point sockets, which will have thinner walls, but are easier to use in tight, confined spaces. Beware of cheap, low-strength sockets such as the 6-point socket (centre).



There are different drive sizes used with sockets: ¼ inch, ⅜, ½, and ¾ inch are common (left to right), but other larger sizes such as inch and 1½ are used for heavy machinery. The ¼ inch is fine for fiddly work, but a 3/8 drive is more handy and can stand up to more forceful use. Sockets often come in combination ¼ and 3/8 drive sets, or ¼ and ½ inch sets. A good starting point set for everyday work is the ½ inch drive, which can handle a large amount of force and usually covers sizes from about 12-32mm. For heavy duty work, ¾ or one inch drive will handle large force without failure.

Quality work requires accurate measurement and marking out. While there is a range of tools to help you with this, you also need a thorough understanding of some of the pitfalls and areas where inaccuracy can creep into you work.

MASTER THE ART OF MARKING OUT

The secret to completing a successful task is knowing how to mark out and measure a job accurately.

While there are some very expensive precision measuring and marking tools available, there are also cheaper alternatives that can provide good results if used correctly.

Most jobs require some form of marking or layout before any work commences. This is where many mistakes occur, leading to wastage of materials and time.

The old adage 'measure twice, cut once' holds true because it only takes a second to double-check your measurements and marks before any cutting commences.

Metric is the standard

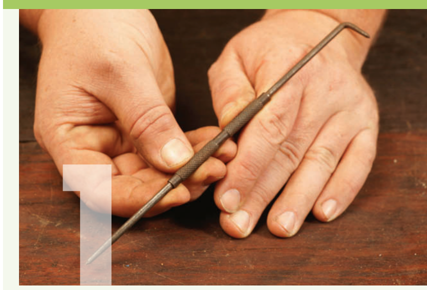
Today, the standard system of measurement is the metric system, with the metre being the base or standard unit according to the international system of units (SI).

In engineering, the millimetre is king, and all units are usually expressed in millimetres. The standard unit of precision is a hundredth of a millimetre, or 0.01mm.

The imperial system was used for many years in Australia before the metric system was introduced and is still the favoured measurement system in the USA. The standard imperial engineering unit is the inch (25.4mm), and precise measurements are usually expressed in thousandths of an inch (0.001" or 1/1000 inch).

Measurements less than an inch are often expressed in fractions, for example, 3/8 of an inch is equivalent to 0.375" (3x1000/8). Even if you have never needed to use the imperial system you should learn how to make precise imperial measurements. Many components and fasteners are still based on imperial units.

Scribing a line



A scriber is the first place to start because it is used to make accurate marks or scratches on metal. While there is nothing wrong with using a pencil or marker pen for basic marking out, if you want accuracy better than plus or minus a millimetre a scriber is the tool to use. This scriber has a straight end for general marking and a bent end for access in restricted spaces. Scribers are sharpened to a fine, sharp point on a bench grinder.

KNOW YOUR THREADS

Discovering the identity of a mystery thread need not be a guessing game, but a methodical approach, coupled with a little know-how, will usually solve the puzzle.

Countless hours are wasted each year in workshops around the country trying to match-up a mystery nut or bolt. For example, UNC, BSW, UNF, NPT, ANF or metric – it can really do your head in trying to determine what that thread is. If we lived in a perfect world all thread sizes would be standardised, but that is not the case. Today, many machines and vehicles use mainly metric threads, or Unified National Coarse (UNC) and Unified National Fine (UNF).

Other less common threads include British Standard Whitworth (BSW), British Standard Fine (BSF), American National Fine (ANF) and American National Coarse (ANC). Pipes and fittings generally have their own specified thread types, including British Standard Pipe Thread (BSP) and National Pipe Thread (NPT). BSPT (the T means the thread is tapered) is commonly used in all water pipe fittings today.

Often a machine's country of origin can provide a clue as to the fastener thread types. For example, machinery made in Europe will use metric threaded fasteners, while North American machinery will feature fasteners with UNF or UNC threads. Older British machinery will invariably use BSW or BSF threads, which are a real pain as taps and dies can be difficult to source.

TABLE 1: Common thread acronyms

UNC	Unified National Coarse
UNF	Unified National Fine
ANC	American National Coarse
ANF	American National Fine
BSP	British Standard Pipe
NPT	National Pipe Thread
BSW	British Standard Whitworth
BSF	British Standard Fine

DRILLING FOR PERFECT HOLES

There is more to drilling a hole in metal that just whacking a drill bit in a drill and going for it. There are several variables such as speed, feed rate, coolant and drill bit that need to be taken into account.

The drill press or pedestal drill is a fundamental machine in any metal working shop.

Whether drilling large holes through steel at slow speed, or precisely drilling accurately spaced holes for tapping threads the drill press is hard to do without.

Even a small, low-cost drill press is capable of accurate work provided it is set up and operated with care. Larger floor-standing machines can tackle a surprising range of work and are available at various prices from three pulley models (as used in this article) to geared head, radial arm units that cost many thousands of dollars.

Anyone who has tried to drill a large hole in steel with a hand drill will know how difficult and time consuming it can be. The drill press has the advantage of a moveable spindle that can be advanced down into the work under even, downward pressure.

Spindle speeds are also adjustable via changing belts on stepped pulleys or gears on more expensive machines. Low spindle speeds are used for large holes, higher speeds for smaller holes. See page 132 for recommended drilling feeds and speeds.

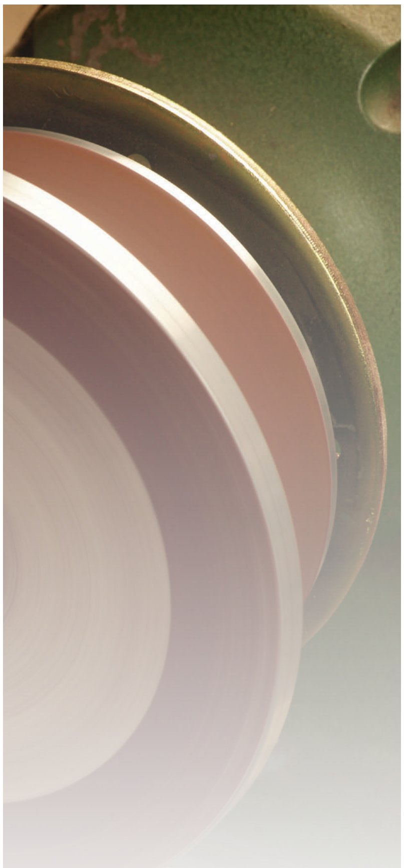
The key to drilling accurate holes is effective and firm clamping of the work. A heavy drill press vice is an essential accessory for any machine and most work can be clamped using this attachment.

Clamping odd shaped work or items at various angles other than 90 degrees can be a bit of an art, but there are a range of accessories available to help. There are also several ways of 'making do' without resorting to expensive clamping kits or vices.

A drill press has other applications than just drilling and makes a perfect centring tool for starting thread taps. Equipped with a thread tapping attachment it can power-tap threads using the quill feed to advance the tap into the work.

With a notching attachment and metal cutting hole saws, the drill press can cut notches in a range of sizes and angles for neat, strong joins in round tubing.

BENCH GRINDERS A BASIC NECESSITY



The bench grinder is capable of more work than simply grinding and can be fitted with a range of accessories for polishing and cleaning metal.

The humble bench grinder is one of the handiest machines you can have in your workshop and many workshops feature more than just one.

While bench grinders are typically used for sharpening drill bits or taking the burr off a cut piece of steel, they are capable of a wide range of tasks when fitted with the correct attachments. But like most tools in your workshop bench grinders need care to produce their best work. A poorly maintained grinder is a safety hazard as well as being difficult to use.

On even the most basic grinding tasks the bench grinder needs to be kept in tip-top shape to produce good results. Accurate sharpening of a drill bit is impossible on out-of-round, irregular grinding wheels, which cause vibrations and can lead to wheel failure at high speed. Clogged wheels also reduce work rates and lead to excessive heat.

A thorough risk assessment needs to be taken before the use of any accessories because these might not be suitable for all bench grinders. Some accessories such as wire brush wheels and polishing mops require the removal of safety guards.

The choice of bench grinder is also important in terms of both safety and useability. A 150mm (six inch) bench grinder might be ideal for sharpening drill bits, but overstressed for general grinding duties. A 200mm (eight inch) bench grinder of at least 500 watts is a suitable starting point for most workshops, with larger workshops easily justifying a more powerful unit with 250mm capacity.

One option is to use both a smaller bench grinder for delicate jobs such as sharpening drill bits and polishing and a larger grinder for general grinding duties.

WORKING WITH SOLID STEEL SECTIONS

Solid steel sections are great to work with, as they bend well, are easy to weld, and can be made into decorative shapes. Once, all metalwork was done by a blacksmith using solid wrought iron, but today mild steel is often worked by cold forming as well as hot working.

There are two ways of working with solid sections; hot and cold forming. Cold forming, where steel is just bent without any application of heat, is often preferable as it is quick and easy. But it often requires a great deal of force for heavier sections, and can lead to cracking and weakness around the bend.

Hot forming relies on some method of heating, whether it be a furnace, a blacksmith's forge or an oxyacetylene torch. It has the advantage of easier working, and the steel can be deformed further, allowing tighter bends, and less chance of cracking.

Many of the cold forming processes outlined here can also be performed hot. In fact, many cold forming machines are limited in the size of steel they can handle cold, but can accommodate larger sections if used hot.

Structural sections, which are often hollow like pipe and RHS, often require more involved processes to bend to stop the section collapsing or buckling. This is not generally the case with solid sections.

Solids are also easy to join by welding, unless they are very thin, as there is ample metal to form a good weld. Hollow sections need more work to provide adequate join area for welding (see page 181 for more information).

Flat bar can often be bent in the bench vice by clamping firmly, and then striking the bend with a hammer as the steel is pulled over with the other hand.

The finished bend should have a nice sharp corner, without any cracks along the outside. If you attempt to bend too thick a section, it will require considerable force, and cracks will form along the outside of the corner.

KNOW THE BASICS FOR GOOD WELDS

In order to form strong, neat welds it is important to understand the processes at play when you strike an arc.

Welding is the process of joining metals with heat, and it is as common as the use of metal in our everyday lives.

The heat, commonly generated with an electric arc or gas flame, needs to be hot enough to melt the metals being welded. The melting process is usually accompanied by a filling process where additional metal is added to make a strong joint.

Welding metal opens up a range of fabrication possibilities because welded joints are strong, neat and cheap to produce. Without welding the joining of metal parts would be limited to the use of fasteners such as bolts and rivets.

As most welding methods use an electrical arc to generate heat it is useful to have a basic understanding of how electricity works during welding.

Electric welding basics

With any electrical circuit power will only flow when the circuit is connected to the power source in a loop (see Figure 1). This is called a closed circuit — electricity flows from the power source through a switch to the load, in this case a light globe and back to the power source.

The circuit has a negative and a positive terminal, with the current flowing from the negative terminal to the positive terminal. The flow of electricity is actually a flow of electrons, which are sub-atomic particles carrying a negative charge.

The voltage of an electrical flow is a measure of the potential difference between two points, or between the positive and negative terminals.

Current is a measure of the flow rate of voltage, measured in amperes (amps). The size of the current flow depends on the electrical pressure (voltage) and the diameter and length of the wire.

More current can flow through a thick short wire than a long, skinny one. This restriction to current flow is called resistance and is measured in ohms (Ω).

Resistance depends not only on the diameter and length of a wire but also on the material it is made of. Metals in general have a low resistance to the flow of electricity (for example, copper is commonly used in electrical wiring because it has a low resistance to current flow).

Heat is generated when current flows through an area of high resistance. The tungsten filament in the light globe in Figure 1 has a much higher resistance to current flow than the wires in the circuit, so heat and light are generated.

The same process is used to generate heat for welding, except the area of high resistance is the electrical arc between the electrode and the work. The higher the current the more heat is generated.

Putting theory into practice

A welder operates on the same principle as the closed circuit in Figure 1. The switch is closed when the electrode tip touches the work (see Figure 2). The current flows through the arc between the electrode tip and the work, creating heat, and then flows back to the welder through the earth cable which is attached to the work.

The welder also reduces the mains electricity from 240 or 415 volts to a much safer level. The welder is basically an adjustable transformer, which boosts current by lowering voltage. This high current will create enormous heat when it flows through an area with a high resistance.

The welding and earth cables both have a large diameter and can carry a high amount of current with little resistance. But when the current has to flow through the welding arc and into the work it meets

MASTERING THE METAL LATHE

The metal lathe is a hugely versatile machine tool capable of a wide range of precision operations from turning, facing, boring and drilling, to more complex tasks such as thread cutting, turning tapers and milling steel.

The range of tasks a lathe can perform is vast and fitted with a range of accessories — it seems there is almost nothing it can't do.

In its most basic form a metal lathe is a machine able to turn cylindrical parts to a high degree of accuracy. Work such as a shaft can be held between centres or in a chuck and a tool applied along the rotating work piece to reduce its diameter. This is known as turning and is the most common work performed in the lathe.

Often, parts require an accurate flat surface and the lathe is also capable of producing this. Instead of feeding the tool along the work it is moved at right angles into the work. This is called facing and can be performed on cylindrical or irregular shaped objects.

The output shaft of the lathe is called the spindle, which protrudes form the headstock. The headstock is attached to the lathe bed on the left hand side. Long work can be supported between the headstock spindle and the tailstock on the right hand side, which is able to slide along the bed to cater for work of different length.

Cutting tools are attached to the compound slide, which allows fine adjustment of tool position, and an adjustable angle of travel for taper turning and chamfering the ends of shafts.

The compound slide is attached to the cross slide, which travels across the saddle to alter the depth of cut when turning and to advance the tool across the work when facing.

Both slides are attached to the carriage, which travels along the bed and provides sideways movement of the cutting tool for turning operations. It can be quickly moved into position using the carriage hand wheel, which acts on a geared rack running the length of the bed.

Most metal lathes are fitted with an auto-feed system inside the carriage, which takes some of the hard labour out of turning and facing operations. Apart from making these tasks easier, auto-feeds allow very fine, measured rates of feed, which improve the accuracy and surface finish on machined parts.

Metal lathes use either a gearbox or belt drive and step pulleys to vary the speed of the spindle, allowing the turning of small diameter parts at high speed, or large diameter parts at a low speed. Some small hobby lathes feature an electric variable speed drive.

Slow spindle speeds are also useful for thread cutting, another capability of the

TABLE SAW TECHNIQUES

The table saw is a simple but versatile machine and forms the cornerstone of most woodworking shops.

Capable of a wide range of accurate work the table saw is a simple machine, but must be used correctly to avoid serious injury.

In its basic form the table saw features a saw blade mounted on a shaft under the table surface (see Figure 1). The blade can be raised or lowered as desired to alter the depth of cut and tilted sideways to cut at an angle other than 90 degrees. A moveable fence is attached to rails and is used to guide work during cutting operations. The table is fitted with mitre slots, which run parallel to the blade allowing the use of mitre gauges and other accessories.

Play it safe

Any spinning blade is a potential source of serious injury, but the table saw can maim an operator who does not consider the dangers of kickback when cutting wood to size.

The table saw is fitted with two main safety features: the blade guard and the splitter. If you are buying a second-hand machine make sure they are both included.

The purpose of the blade guard is obvious and even momentary contact between the blade and the hands will result in loss of fingers and severe cuts. But the guard will need to be removed occasionally for certain operations because it will impede the work, or the use of accessories such as a mitre sled. Take extreme care when the guard is removed and always replace it when you are done.

The splitter is the second safety device fitted to the table saw and it is used to prevent kickback where the work is picked up by the blade and flung back violently towards the operator. It is fitted behind the blade and holds the cut apart preventing it from closing on the back half of the blade. Some splitters feature pawls, which hold the work down as it is slid past the splitter.

As with the blade guard there are certain instances where the splitter must be removed such as cutting a groove where the blade doesn't extend through the work. Make sure the splitter is refitted because it will save you from injury at some point.

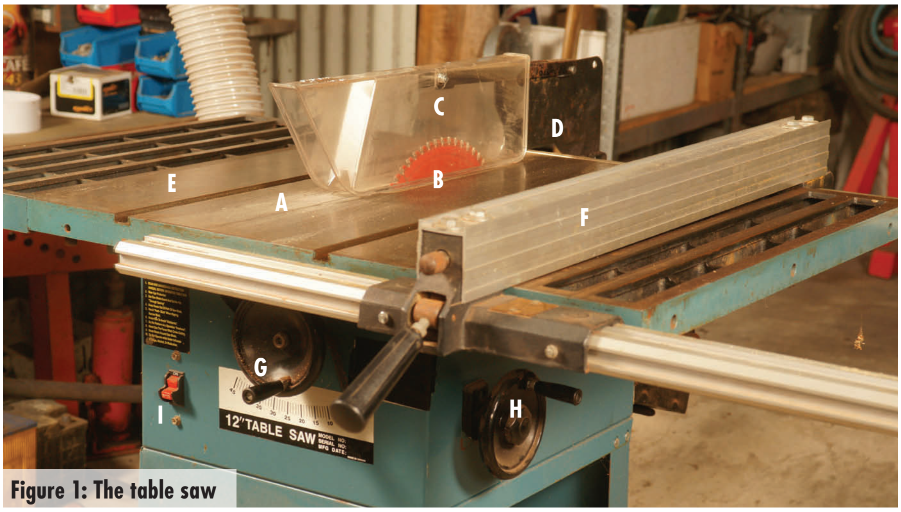


Figure 1: The table saw

A: Table. B: Blade. C: Blade guard. D: Splitter. E: Mitre slot. F: Fence. G: Blade depth hand wheel. H: Blade tilt hand wheel. I: On/off switch.