



Wire wrapping: tools and techniques

Although popular in industry, wire-wrapping is a technique that is little used at hobby level. The recent introduction of a range of low-cost hobby tools may change that situation, however. Here we take a look at the wire wrapping technique, and explain how some of the tools are used.

by GREG SWAIN

In an earlier chapter, we dealt with the practical aspects of soldering. Soldering can make or break any electronic project, so it is important to master the technique at an early stage. It's not difficult; all it requires is a little practice.

As we've seen, soldering is used for permanently connecting the various components into circuit, and for making wiring terminations. The components are, more often than not, mounted on a printed circuit board. But there is an alternative to soldering. It's called "wire wrapping".

So what's wire wrapping? In a

nutshell, it's a process whereby a solid conductor wire is wound tightly (or wrapped) around the sharp corners of a rigid metal terminal to form an electrical connection. No soldering is needed! The accompanying photographs illustrate the basic idea.

Development

Wire wrapping is not new. It was developed in the early 1950s by Bell Telephone Laboratories in conjunction with Gardner Denver, Michigan, for making reliable connections in high contact density telephone equipment. In particular, Bell developed the

method to overcome the mechanical and thermal difficulties of making soldered connections in such equipment. The technique was seriously adopted in the mid 1950s, and is now used extensively by the telephone industry.

During the 1960s the technique was adopted by the electronics industry, and today it is a standard technique for making terminal connections in high density electronic equipment. This particularly applies to the computer and telecommunication industries, where a large number of interconnections often have to be made.

In addition to allowing high density terminal connections, wire wrapping has a few other advantages over soldering. These include the elimination of fumes, solder splash, flux residue, and lead clippings. The possibility of heat damage to sensitive components is also eliminated.

Before going further, though, let's get a couple of things straight. Wire wrapping is a technique which, thus far, has penetrated very little into the hobby market. So if you're just getting into electronics don't rush out and buy wire wrapping tools. You may possibly never use them.

The hobbyist should, however, at least be aware of the technique. It is gaining in popularity, and may be catching up with those hobbyists who design their own logic circuits and computer boards. And with the availability of low-cost wire wrapping tools the technique can also be used for circuit prototyping.



Left: a low-cost wire wrapping kit for the hobbyist. The simple hand tool can be used for both wrapping and unwrapping. View at right shows the tool in action.

With wire wrapping you don't need artwork for PC boards. You can buy commercial IC circuit boards which carry an array of wire wrapping terminal pins. The ICs are simply plugged into one side of the board, and the pin connections made by running leads between the various terminals on the reverse side. In addition, you can buy IC sockets, edge connectors, and LED displays with wire wrapping terminals, assorted wrapping posts (which can be soldered to a circuit board), and a range of accessories to make the wire wrapping process fast and efficient.



Above & below: the "Just Wrap" from OK Machine & Tool Corporation. The tool wraps insulated wire onto the terminal; terminal corners bite through insulation for electrical contact.

Wire wrapping tools

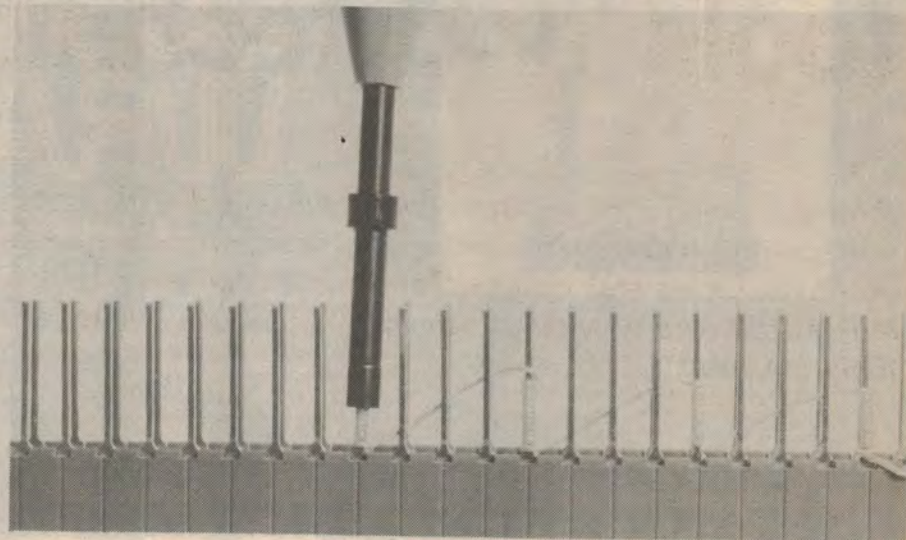
Essential to the wire wrapping process is the wire wrapping tool itself. This contains a bit which, when fed with wire, is placed over the terminal to be wrapped, and rotated to obtain the desired wrap.

There are basically four different types of wire wrapping tools available. They are the pneumatic or air type, the mains operated type, the battery operated type, and the manually operated type. Within these broad groupings are many styles and classifications. For example, the manual tools are operated either by squeezing a trigger, or by manually twisting the entire tool with the hand.

If you look closely at the bit, you will notice three major features:

- First, a large central hole. This hole allows the bit to be slipped over the terminal, and marks the point around which the bit rotates;
- Second is a slot in the top of the bit, beginning at the front (or face) and extending rearward. This slot accepts the wire to be wrapped around the terminal;
- Third is the special contour (cutout) on the face of the bit. This contour applies tension to the wire during the wrap, to ensure that the wire is wrapped tightly around the terminal.

In tools designed for professional use, the bit is housed in a metal tube called a sleeve. This serves to retain the bit in the collet (socket) of the wrapping



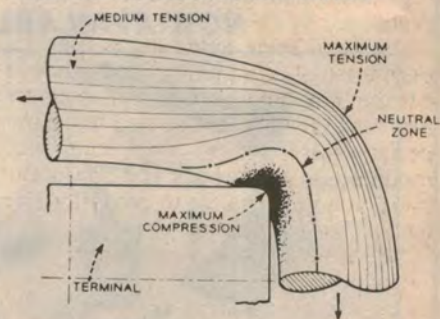
tool, and prevents the wire from falling out of the slot or spinning loosely during the wrapping process. Since the sleeve does not rotate, it also protects the user from the spinning bit.

Both the bit and its mating sleeve are precision items, and for this reason are quite expensive. A typical bit and sleeve are shown in one of the accompanying photographs.

Hobby tools

To overcome the problem of expense, a range of low-cost tools has been developed specially for the hobbyist and for prototyping. In these, the bit and the sleeve are combined to form one piece. They don't do quite as good

METAL-TO-METAL CONTACT



By bending the wire around the sharp corner of the terminal, the oxide layer is crushed or sheared, and a clean metal-to-metal contact is obtained.

Wire wrapping step-by-step:



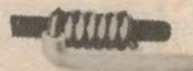
Step 1
WIRE INSERTION AND ANCHORING



Step 2
TERMINAL INSERTION



Step 3
WRAPPING



Step 4
FINISHED CONNECTION



REGULAR WRAP



MODIFIED WRAP

The two types of wrap used. Regular wrap (left) wraps bare wire only; modified wrap (right) coils 1½ turns of insulated wire around the terminal to add mechanical stability. (Courtesy OK Machine & Tool Corp.)

IPRACTICAL ELECTRONICS

a job as the professional tools, but are still quite adequate for hobby work.

Costs are further reduced by making hobby tools either battery or hand operated. The more expensive pneumatic and electric tools are generally fitted with precision bits and sleeves, and are reserved for production work.

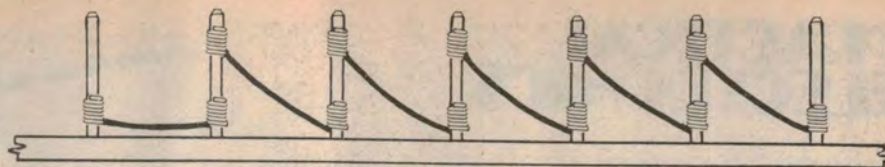
The best-known companies in the wire wrapping business are Gardner Denver (Michigan), Vector Electronic Company (California), and Cambridge Thermionic Corporation (Massachusetts). These are all American companies, and mainly manufacture up-market equipment for industry.

Another company involved in wire wrapping in a big way is OK Machine & Tool Corporation, New York, which not only makes professional equipment but low cost hobby tools as well. Professional tools are generally sold under the "Speed Wrap" label, while typical hobby tools retail under such names as "Hobby-Wrap" and "Just Wrap".

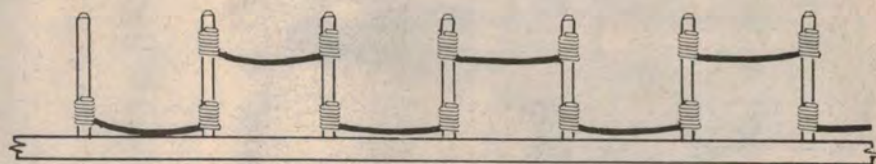
Also available is a "Wire-Wrapping Kit", which includes a simple hand wrapping tool, various lengths of pre-stripped solid conductor wire, and a spare reel of wire. The wrapping tool, by the way, also includes an unwraping bit.

Making the connection

The wire wrapping process is actually quite simple, although it may take a



DAISY CHAIN



LEVEL ORDERED

(WRAPPING LEFT TO RIGHT)

Wire wrapping styles: daisy chain (top) and level ordered (bottom). (OK Machine & Tool Corp.)

little practice to get it quite right. First, the end of the wire (single conductor wire only, not stranded) is stripped of insulation to allow several turns of bare wire (generally at least 6) around the terminal. The bared wire is then inserted into the smaller hole (or slot) in the tool bit, and anchored either in a notch in the sleeve or by simply holding with the hand — it all depends on the tool you're using.

This last step is to prevent the wire from spinning when the bit starts to turn.

Next, the wrapping tool is placed over the terminal to be wrapped, with the terminal going into the large central bit hole. The final step, the wrap, is then accomplished either by squeezing the tool's trigger or by twisting manually.

The end result will be a uniform,

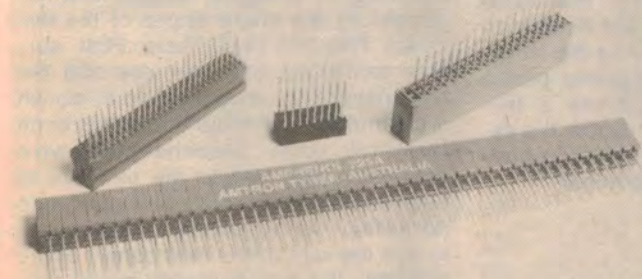
closed, non-overlapping helix of wire wrapped tightly around the terminal.

Types of wrap

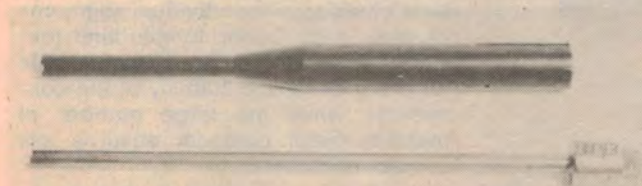
A wire wrapped connection can be either "regular" or "modified", depending on the user's needs and the wrapping bit used. The regular wire-wrapped connection is the one we have been discussing so far; it consists of wrapping uninsulated wire only around the terminal. A modified wrap, on the other hand, coils approximately 1½ turns of insulated wire around the terminal in addition to the bare wire.

The idea behind the modified wrap is that the insulation serves as a shock absorber. This increases the ability of the connection to withstand vibration and flexing stresses on the wire.

To produce a modified wrap, you



IC sockets, edge connectors and a range of other accessories are available with wire wrapping terminals.



A precision bit (bottom) together with its matching sleeve. Different wire gauges require different bits and sleeves.



A manual wire-wrapping tool for professional use. This is the G200/R3278 "Speed Wrap" tool from OK Machine & Tool Corp.



Model 14G2 mains-powered "Wire Wrap" tool from Gardner Denver.



The "Hobby-Wrap" from OK Machine & Tool Corp. is battery powered and produces a modified wrap.

simply need to use a modified bit. In this, the wire slot is enlarged at the front to permit insulated wire to enter. The length of this enlargement is such that just enough insulated wire is admitted to wrap approximately 1½ turns.

A regular bit, on the other hand, is just large enough to accept the bare wire. In both cases, you just push the wire into the end of the tool as far as it will go, and then proceed with the actual wrap.

Another type of modified wrap is produced by the "Just Wrap" tool. This differs from other types of wire wrapping tools in that insulated wire is fed directly to the bit from a spool mounted at one end of the tool. In use, the "Just Wrap" wraps the insulated wire directly onto the terminal, the idea being that the sharp edges of the terminal cut through the insulation and into the wire.

The advantage of this arrangement is

that it permits a wiring technique whereby the wire can be wrapped on successive terminals without having to break the wire. What's more, "Just Wrap" completely eliminates the need for wire stripping and wire insertion into the bit for each wrap.

It's an idea that works extremely well in practice. The "Just Wrap" tool is fast, easy to use, and would be an ideal tool for the hobbyist who's just starting in wire wrapping.

Yet another variation is used by the "Slit-N-Wrap" wire wrapping tools from Vector Electronic Company Inc., California, USA. As with the "Just Wrap," insulated wire is fed directly to the bit from a spool. During the wrapping process, the wire is pulled past a sharp cutter which produces a thin longitudinal slit in the insulation, the exposed wire subsequently making contact with the wrapping terminal.

Reliability

Connection reliability is extremely important if an electronic circuit is to continue functioning correctly. So how reliable is wire wrapping?

The answer to this question is that properly formed wire wrapped connections are extremely reliable, and compare very favourably with soldered connections both in terms of mechanical strength and electrical resistance. To understand why this is so, we need to look more closely at what actually takes place during the wrapping process.

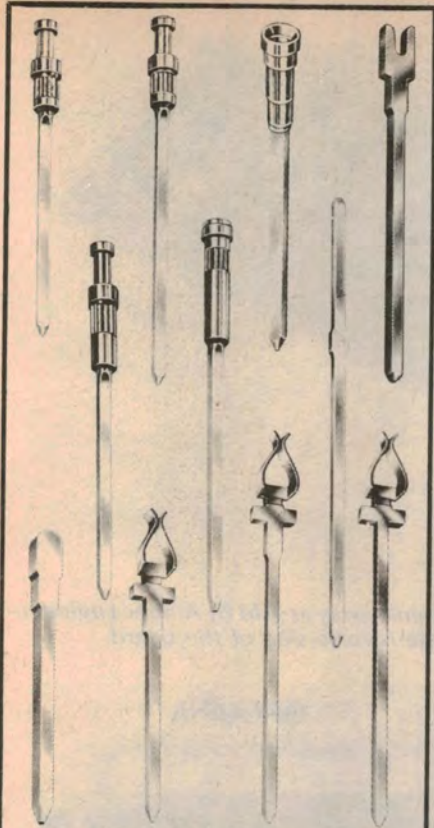
As the bit of the wrapping tool turns, the wire is dragged across and indented by the sharp edges of the terminal. This has two effects. First, surface oxides on both the wire and the terminal are sheared away to establish a clean metal-to-metal contact at each terminal edge. Second, the wire becomes anchored to the terminal at each indentation point, and can slide no further. As a result, as the bit turns to pull the wire to the next corner of the terminal, the wire is placed under tension.

The process is repeated at each corner, so that the completed wrap consists of successive individual segments of wire, each under longitudinal tension. This tension is initially responsible for the mechanical stability of the connection, while the large number of metal-to-metal contacts ensures low contact resistance.

As time passes, the tension in the wire coil does decrease to some extent. However, this effect is countered by another, less obvious phenomenon.



"Slit-N-Wrap" from Vector Electronic Company is spool fed and automatically slits wire insulation during wrapping process.



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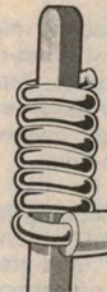
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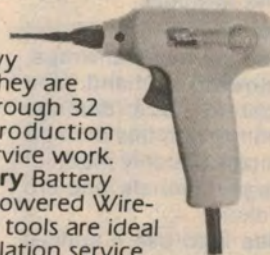
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In fact, after 70 billion wire-wrapped connections, there has never been one reported field failure. As the pioneer of the solderless wrapping process, Gardner Denver has developed and manufactured a full line of portable, semi-automatic and completely automatic wire-wrapping products.



Air Portable air powered Wire-Wrap tools, for 18 through 32 gauge wire, feature low maintenance and dependability for high production service. Pistol grip and straightline models are available. The tools have precision, bearing mounted, rotary vane motors and require only air line lubrication.

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Because the wire and the terminal edges are in such intimate contact, and because they are pressed tightly together, diffusion actually takes place between the two metals. In other words, the terminal and conductor metals actually bond together to form a cold weld.

This bonding process more than offsets the progress of stress relaxation in the wire coil. Indeed, experiments have shown that the force required to undo a wire-wrapped connection actually increases with time.

Another reason for the electrical reliability of wire wrapping is the fact that the high compression contact areas are "gas tight", and are not subject to corrosion or contamination.

Unwrapping

One of the main advantages of wire wrapping is the ease with which a wire may be removed from a terminal to make a wiring modification. This process is called "unwrapping" and consists of exactly that: uncoiling the wire helix from the terminal.

If you're working at hobby level and don't need to make too many unwraps, you can simply unwrap by hand. You have to be very careful not to damage the wrapping terminal with this method though. The terminals are only made of relatively light gauge materials, and are easily bent or broken.

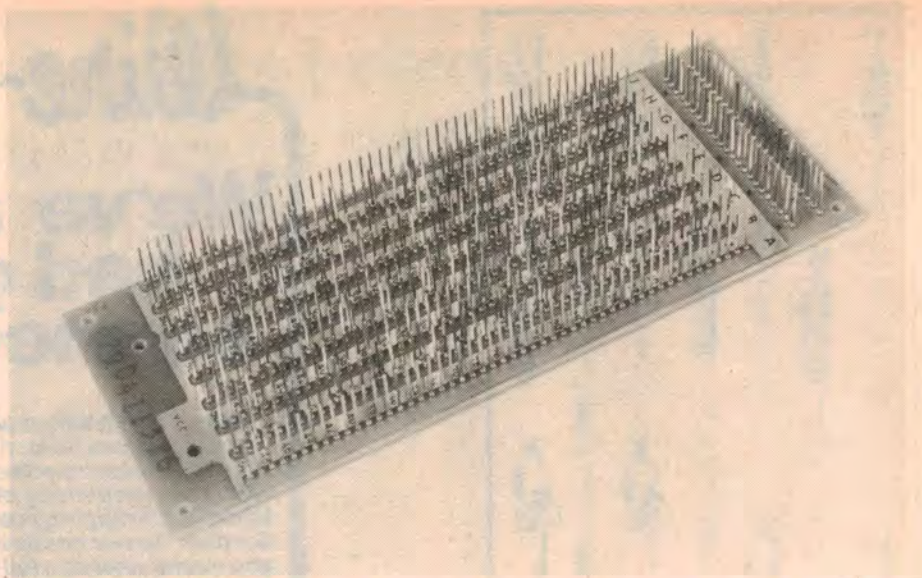
A far better idea is to use a special unwrapping tool. This tool is similar to a corkscrew and is simply placed over the terminal and rotated in the opposite direction to the wrap.

As the bit is rotated, it "screws" down the inside of the wire helix, separating it out from the terminal. Removing the tool will now lift the expanded wire clear of the terminal.

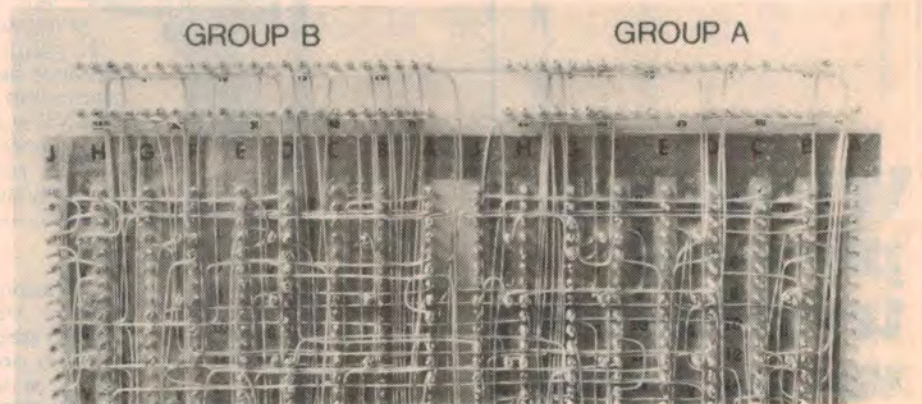
Within practical limits, unwrapping does not damage the terminal, and it may be used to make other connections. Of course, repeated wrapping and unwrapping will eventually blunt the sharp edges of the terminal and it won't bite into the wire properly.

In practice, it's best not to make more than four re-wraps of a terminal if long-term reliability is important. But for prototyping, there's no reason why a terminal cannot be re-used many times over.

Just one more point on wire unwrapping. Because the wire is indented and bent severely during wrapping, unwrapped wire cannot be straightened out and re-wrapped. It must be discarded.



An IC circuit board with wire-wrapping terminal array as sold by Ampec Engineering Company. The ICs plug directly into the reverse side of the board.



This demonstration board was produced by an automatic wrapping machine.

Wire & wire size

As mentioned earlier, solid (or single conductor) wire must be used for wire wrapping. Tin-plated copper wire is preferred for most applications, although bare copper wire and silver-plated copper wire is also available.

It is important to always use the correct size of wire. Different sizes of wire generally require different bits, sleeves and wrapping terminals if the correct results are to be obtained.

The most popular size of wire for electronic work is 30AWG (0.25mm) wire, although 28AWG (0.32mm) and 26AWG (0.40mm) are also commonly used. All of the hobby tools featured here use 30AWG wire and mate with 0.63mm square terminals.

So that's wire wrapping. As you can see, it's got quite a few advantages over soldering for certain applications. You may not have come across it as yet in general hobby work — unless you happen to be a computer freak — but if you ever do, you'll at least be prepared.

FOOTNOTE: Wire wrapping equipment is manufactured by a number of companies in the USA. Some of these companies and their Australian distributors are:

- Gardner-Denver, Michigan, USA; distributed by Sulco Pty Ltd, 469 Pacific Highway, Artarmon, NSW 2064.
- Vector Electronic Company, California, USA; distributed by Assembled Products, Box Road, Cross Roads, NSW 2170.
- OK Machine & Tool Corporation, New York, USA; distributed by Ampec Engineering Co. Pty Ltd, 1 Wellington St, Rozelle, NSW 2039.
- Cambridge Thermionic Corporation, Massachusetts, USA; distributed by Electronic Development Sales Pty Ltd, 92 Chandos St, St Leonards, NSW 2069.

Equipment featured in this chapter courtesy Ampec Engineering Co. Pty Ltd, Sulco Pty Ltd, and Radio Despatch Service, 869 George St, Sydney, NSW 2000.