# TESTING TIME

**In the previous instalments of Workshop, we investigated many of the ideas and techniques used in the construction of computers and their peripherals. Before proceeding to undertake more complex projects for your home computer, we now pause for a brief overview of the work covered so far.**

We started the course by suggesting that the right tools for the job are essential (see page 44). A range of equipment is desirable for the specific tasks involved in construction, alteration and repair work. You *can* use a flat head screwdriver on a cross head screw, but that is likely to lead to damage to both of them. You *can* use a pair of pliers to undo a nut, but a spanner will do the job quicker and without ruining the nut. In the long run, it pays to invest in a set of tools specifically designed for these jobs.

Attaching and joining wires is the same. A good solder joint will last longer and operate better than one that has been hastily connected. Always apply the solder to the wire, not to the iron, as the solder will slowly corrode away the tip of your iron. The less contact the two have, the better. Let the solder flow over the two wires you want to join, and only when the whole joint is covered, remove the heat and cool the joint by blowing on it gently. Keeping to these rules will ensure the joint is not dry. Desoldering allows you to remove components from circuit boards safely for repair or replacement (see page 68).

We have discussed the fundamental concepts of digital electronics, both in Workshop and in the Computer Science course. We have introduced the basic components and seen how these interact. The resistor is the simplest of all the components, but also the most frequently used. If you look inside your microcomputer, you will see more resistors than integrated circuits.

The capacitor is also very common. In computers, these are used to filter off the unwanted noise that attaches itself to a signal. Every time that a signal is changed, amplified, or otherwise used, it is degraded. So a means of restoring the signal to its uncorrupted form is essential. The capacitor is the simplest way of removing the unwanted elements of a signal.

The most important component that we've discussed, however, is the transistor. This is the essential component of all the devices that are used to change and manipulate the signals in a computer. The transistor can be used to amplify a signal, or to switch signals on and off. Most importantly for the computer, the transistor can switch a signal on and off in accordance with one or several other signals. This is what goes on inside a logic gate.

We have built the three simplest logic gates, NOT, OR and AND, from a handful of components (although individual gates within the computer's integrated circuits are often made up of other, more complex types of transistors).

Logic gates are not particularly useful in themselves, but they can be combined into logic circuits that can perform operations on data. In the last instalment, we constructed a half adder — a simple logic circuit to add two binary bits — from the logic gates on two integrated circuits.

Integrated circuits are some of the most complex components used in electronics. The simple transistor-transistor logic (TTL) chips that you have used so far are small scale integration (SSI) packages. There are only a few transistors in each chip. These were the first type of chip made, and early computers relied upon them. As techniques improved, however, so the number of transistors that could be fitted onto a single chip increased. Medium scale integration (MSI) allowed complete logic circuits to be available on a single chip. An example of these is a full adder — equivalent to two of the half adders we built (see page 165) combined.

Large scale integration (LSI) and very large scale integration (VSLI) have also been developed. A complete CPU on a single chip is an example of VLSI. As there are literally thousands of transistors inside a microprocessor, it is difficult to imagine the logic circuit of such a chip, but this complexity makes individual chips very powerful and easy to design into circuits.

Having mastered these fundamentals, we can proceed to tackle more complex ideas, and this should enable you to construct some useful additions to your micro. First, though, try your hand at the projects opposite. None of them is very complex, and none requires more than a couple of transistors or integrated circuits.

## 1) Resistors

Resistors have a series of coloured bands around them to identify their value. What are the resistances of the two resistors shown here? What would the colour bands be for a 150-ohm resistor?