HALF MEASURE

Simple integrated circuits replace numerous transistors in the computer by providing ready-made logic elements in a convenient package. We now progress from the transistor circuits that we used to build AND, OR and NOT gates (see page 144), and use two integrated circuits to build a half adder circuit.

The individual logic gates that we made in the last Workshop project are the basis of more complex digital circuits. One such group of logic gates is the half adder, which we looked at in the Computer Science course (see page 33). This circuit is used to add two single bits. The half adder uses two inputs, the single bits to be added and provides two outputs, the sum and a carry bit. The truth table that represents this is as follows:

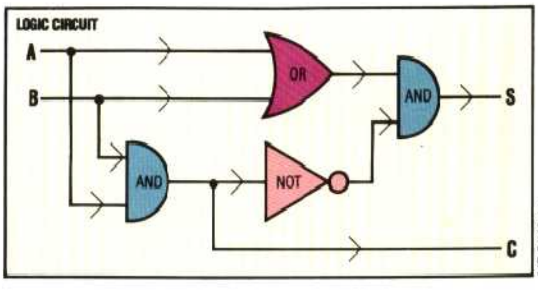
A	B	S	C
0	0	0	0
1	0	1	0
0	1	1	0
1	1	0	1

The sum output is the sum of the two input bits. When these two bits are both one, the sum is 10 in binary. This result cannot be represented with the single bit output, so the output overflows into the second bit. This overflow is the carry bit.

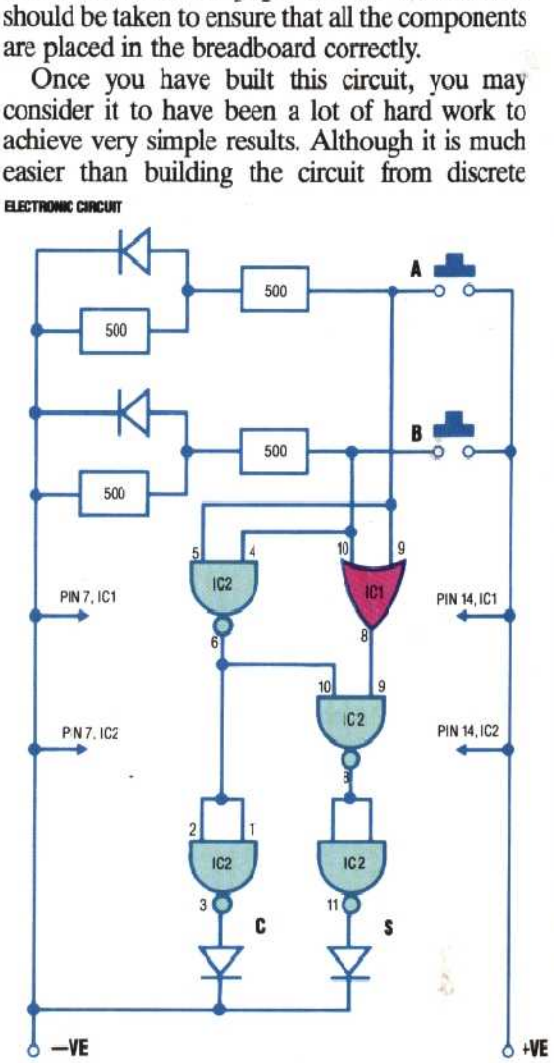
A half adder is not very useful in eight-bit computers: what is really needed is a circuit to add two eight-bit words together. This circuit can be constructed from 16 half adders. The first two bits are added using the first half adder and its sum bit forms the first bit of the result. Its carry bit is added to the result of the second sum, and the carry from that addition to the third, and so on, thus linking them together.

Even a simple half adder would require about 10 transistors in the gates we have already constructed. However, AND, NAND, OR, NOR and other logic gates are available very cheaply in groups of four in single integrated circuits. A half adder can be built more simply from such integrated circuits.

The logic circuit of the half adder is shown opposite. This is the simplest form of the circuit. It uses three kinds of logic gates: OR, AND, and NOT. As the integrated circuits we will be using each contain only a single type of gate, this logic circuit has been simplified to use fewer different gates. The circuit we will build uses four NAND gates and a single OR gate. The number of integrated circuits has been reduced to two. This circuit is more complicated than the single gate circuit we built on page 144, so special care should be taken to ensure that all the components are placed in the breadboard correctly.



Once you have built this circuit, you may consider it to have been a lot of hard work to achieve very simple results. Although it is much easier than building the circuit from discrete components such as transistors, it is hard to conceive of an entire computer built in this way.



In practice, chips are rarely ever used in this way and only occasionally crop up doing a menial task in the corner of a circuit board. Larger chips have more signals going into and out of them so that the whole chip is a complete device that will, for instance, add together two four-bit numbers.

The level of complexity grows until particular chips are capable of performing whole tasks by themselves.