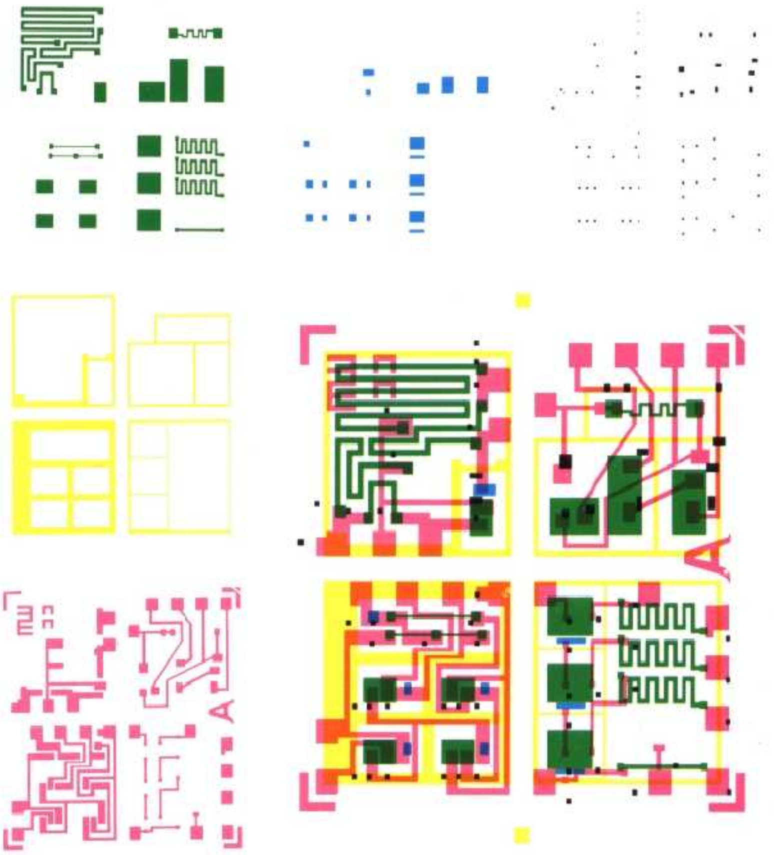
The Sum Of The Parts

The integrated circuit fabrication process calls for each layer of the circuit to be deposited separately onto the surface of the silicon wafer. This technique is necessarily very similar to the way we print HOME COMPUTER COURSE's colour illustrations. Each photograph is first separated into three colours and black. These four are then printed, one on top of the other, in very precise registration to achieve the effect you see on these pages.

The chip-making process uses deposited layers of doped silicon and other materials instead of ink, but the printing process is much simpler than the masking/depositing/etching process. As you can see from the photograph the individual masks are combined in sequence in order to build up the microcircuit in this case, a very simple transistorised device



Crystals seven to ten centimetres (three to four inches) in diameter, and 60 centimetres (two feet) or more long can be produced in this way. These are then ground to a standard diameter, usually either 76 millimetres (three inches) or 100 millimetres (four inches). The crystal is mounted, cut into slices and ground flat on both sides, before being polished on one side only. The finished 'wafer' is typically half a millimetre (a fiftieth of an inch) thick.

If the process is reasonably simple, and the raw material is so abundant, why is the silicon used in chips so expensive — at £10 per slice?

The answer lies in the absolute necessity for maintaining its purity. Extraordinary care must be taken to ensure that foreign bodies are excluded. Purity levels in the air of wafer fabrication plants are truly remarkable — fewer than 3,000 particles per cubic metre (100 particles per cubic foot). This is more than 100 times as pure as the air in modern hospitals.

The manufacture of an integrated circuit requires a method of microengraving the surface of the chips. In mass production, this is achieved by a process known as photo-lithography, similar in many ways to the methods used to produce this publication.

Each 'layer' of the circuit is treated as a separate entity right through the process. The original artwork is produced by computer-aided methods, and is converted to a line and block photograph, which is then reduced to actual size. The mask itself is formed by reproducing this photograph many times in a grid pattern to cover the whole surface of the wafer.

The wafer is first heated to 1050°C (1920°F) in an atmosphere of pure oxygen. This causes a layer of silicon dioxide to form on the surface, to act as an insulator. This layer is then selectively removed to form 'windows' on the pure silicon beneath. This process is repeated for each successive stage in the building up of the integrated circuit on the face of the silicon substrate.

The oxidised surface of the wafer is first coated with 'photoresist', a light-sensitive material whose solubility is greatly decreased by exposure to ultra-violet light. A mask in the shape of the first layer of the microcircuit is introduced between the coated surface and the light source. The surface is exposed to ultra-violet light, and then 'developed' in a solvent that removes unexposed photoresist.

A similar method is used in making copper etchings. The surface of a copper sheet is coated with wax, a design is then scratched through the wax coat, and the whole immersed in acid. When the wax is removed, the design remains etched into the surface of the copper. Where the sealing coat of wax is unbroken, no reaction takes place.

The first stage completed, the whole process is repeated with different masks and reactive chemicals until the desired circuit has finally been built up. The entire wafer is then coated non-selectively with a further layer of silicon dioxide.

This process may require ten or more repetitions of the coating/masking/etching