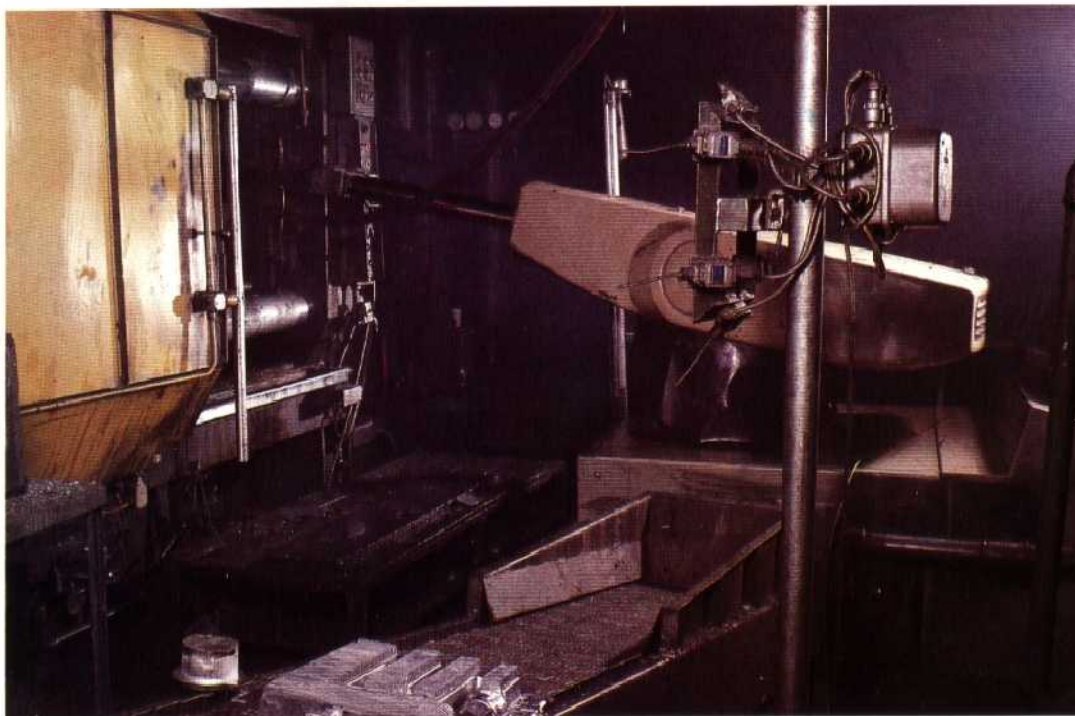




programming language resident in the robot's control computer works out what they should be. It also performs any necessary optimisation, ensuring that the tool moves from one place to another by the shortest possible route. The orientation of the tool holder is controlled automatically, maintaining both horizontal and vertical relative positions unless instructed otherwise. The speed of point-to-point movement is also automatic: the tool holder is disengaged slowly, moves rapidly to within a short distance of

workpiece was in position, and then allowed to continue. Of course, this isn't foolproof either, and for situations where complete reliability is required, it is possible to install an image recognition system based on charge-coupled device (CCD) television cameras. These cameras focus the image directly onto an array processing microchip (a chip split up into a hundred or more individual photosensors, each capable of registering not just black or white but also a range of intermediate tones). Each individual sensor



#### Factory Act

Robot arms, like the one seen here at work in a die casting shop, are taking over more and more of the dirty, dangerous and repetitive jobs to be found in industry. The cleaning of castings preparatory to their being machined is a good example. The casting, fresh from the mould, is much too hot for human hands, and would normally be put to one side to cool. The robot, however, is not susceptible to heat so can deal with it immediately and despatch it on to the next operation.

the destination point, and then slows down to re-engage the workpiece at the new site.

The robots we have discussed so far are capable only of 'blind obedience', repeating the same task at exactly the same location, irrespective of external influences. Their main use is in the engineering industry, especially in the production of motor vehicles. This has long been organised into production lines, in which the component or partially completed vehicle is always precisely located in space and time. This is vitally important to the successful operation of a robot production process, for if the component is wrongly positioned, the robot will not adapt its activity accordingly. In an attempt to overcome this, a variety of sensors can be fitted to the tool holder. The simplest of these can be an ordinary on/off microswitch. Contingency plans can be built into the control program (a WAIT command, for instance), to be executed if the switch is not brought into contact with the workpiece, but more sophisticated plans will require human intervention.

An alternative to pressure sensing might involve the use of a light sensor. If a light source were positioned so as to be obscured from the sensor on the tool holder by the workpiece, the tool holder could be stopped before it reached collision point, put into WAIT mode until the

requires perhaps one byte of memory to define the contrast in the grey scale. Initially each object is 'photographed' a number of times, and a learning program averages out the values. At run time, the CCD camera makes an image of the object, which is then compared with the reference image in memory. If the two match, then the operation can go ahead. By this method it is possible to check that the correct workpiece is present, and that its position and attitude are correct.

A further use of this image processing system is in the selection of components from a 'mixed bag'. This 'picking and placing', as it is known, is an increasingly common application for small robots as an adjunct to a regular production line. In addition to the production process itself, industrial robots are commonly used in the testing and quality control stages, often in pairs to allow a greater degree of flexibility in the positioning of the product.

We started by considering the robot in fiction — and with good reason. There are few better examples of truth following fantasy than in the development of the industrial robot, and there is no reason why robots should not eventually become the self-contained and 'self-motivated' entities of science fiction. This will not happen, however, until Artificial Intelligence is more than just a concept.