for recharging when its batteries run down. (Note that this will require the robot to possess an internal sensor for monitoring the state of its batteries so that it 'knows' when they are low.)

This simple photoelectric cell can allow a robot to perform a number of tasks. A robot working on an assembly line would be able to check if a component was present by detecting the change in brightness that results from the object's absence; this task can be made easier by ensuring that the lighting is arranged so that such a difference is accentuated. The robot could detect colour changes if three photoelectric cells were incorporated, each responding to light of different colours — red, green and blue would cover the visible spectrum. Such a robot could be programmed to pick out red bricks from a pile containing bricks of many different colours. This gives the impression of 'intelligent' behaviour from a very simple sensor.

Providing the robot with a microphone will allow it to 'hear' acoustic signals. It will not 'understand' what it is hearing, but this need not matter — by repeating a set of commands several times, the robot can build up a 'template' of sound for each command that will enable it to match new commands against those it has already heard. The number of commands to which it can respond will be limited, but we could tell it to 'go forward', 'stop', 'turn left', and so on, and it would be able to follow these instructions.

A robot can also have a simple sense of touch. Microswitches can be incorporated into the robot's design so that they make an electrical connection whenever pressure is applied to them. These lack the sophistication of the human sense of touch, but they can still be very useful. For example, touch sensors mounted around the edge of a mobile robot can allow it to respond intelligently to any obstacles: it will be able to back away from the obstruction and try a different route. Touch sensors incorporated into a robot hand will let it 'know' when it has something within its grasp so that it can respond accordingly.

Smoke or gas detectors can be used to give a robot something of a sense of smell. Gas detectors normally use a sensory element (such as a platinum wire) that responds to the presence of certain gases, thus altering the electrical current flowing through the element. Smoke detectors have two chambers — one enclosed, acting as a reference or 'control', and the other open. Both chambers contain ionised helium and the number of charged particles in the open chamber varies when smoke is present. A detector that counts the number of charged particles in each chamber will register a difference between the two if smoke is present.

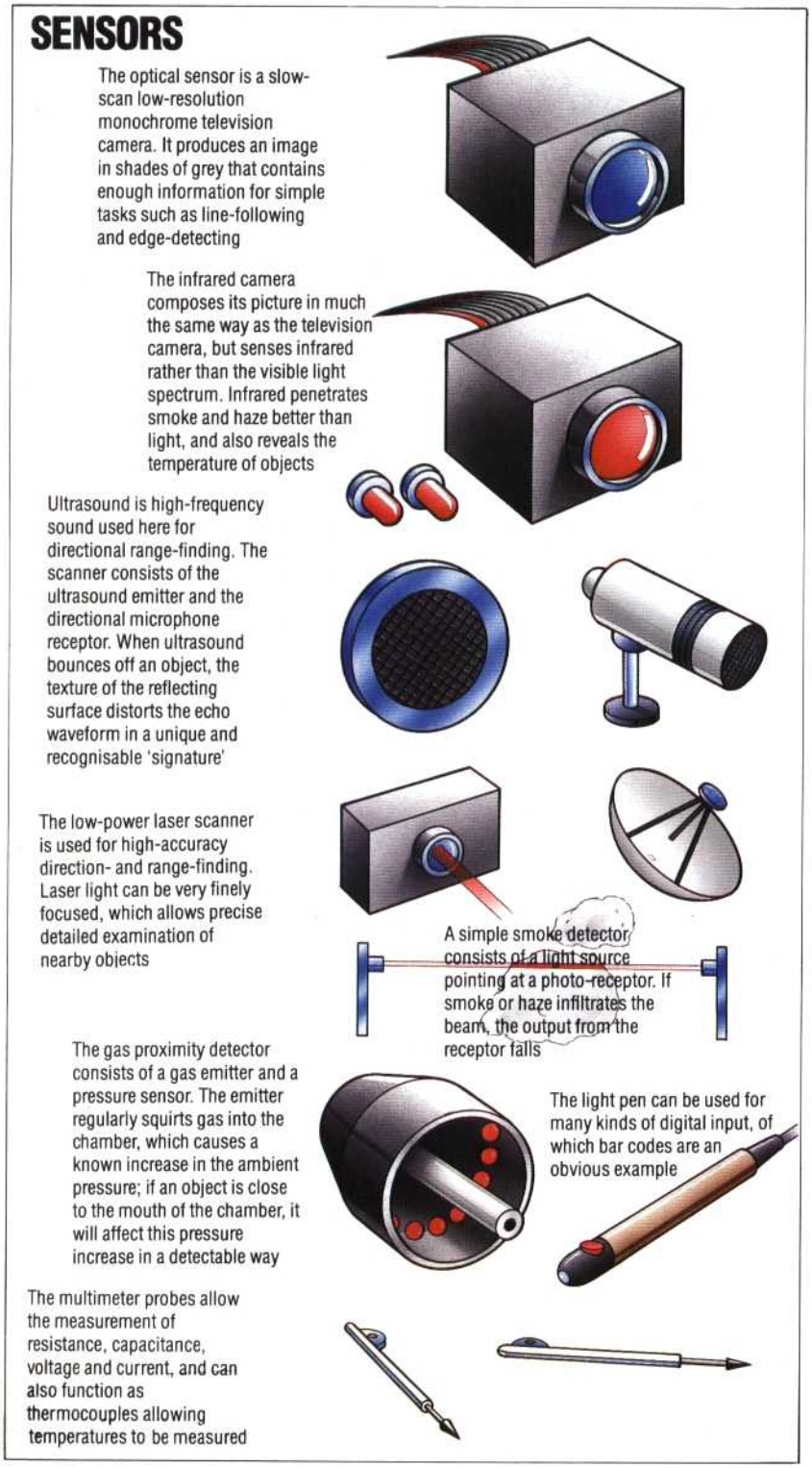
As yet, there appears to be no way in which a robot can be given a sense of taste. However, using the methods suggested above, we at least have a robot that can see, hear, feel and smell well enough to detect a fire in a building, rush towards the flames, avoid obstacles in its way and, if it happens to have a fire extinguisher in its end effector, spray the fire with foam.

POTENTIAL GAIN

But in limiting a robot to the type of senses possessed by humans, we lose much of its potential. There is no reason for the robot to be restricted to detecting things in the ways that we detect them. A better approach might be to consider what senses can be given to a robot and to decide if there is any practical use for them.

A good example of this concerns robot arms.

SENSORS



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