negotiated. A full-size battle tank can climb over almost any obstacle with ease — but this is only because tanks are so large, heavy and powerful. If a tank tries to climb over an object so large that the tank's centre of gravity is moved outside the area of its tracks it will fall over. This does in fact happen occasionally when the ground is very rough. The same thing will happen to your tracked robot if it tries to climb over surfaces that are too steep.

The second disadvantage is that tracks cannot be controlled precisely. Steering is carried out by halting one track so that the other track continues running; the robot (or tank) thus moves through an arc. When this happens, the stationary track may easily slip slightly and the final position may not be what was expected. A battle tank that is driven by a person can readily correct any error of this kind but, for a robot, the necessary course corrections are considerably more complicated.

For robot control, it is obviously desirable to have a set of instructions that will always cause the robot to move to exactly the right place, facing in an exactly predictable direction. For these reasons, the most common form of robot movement uses wheels. Wheels have several obvious advantages, being simple, efficient and capable of producing a much smoother movement than legs could ever manage.

Once it has been accepted that the robot should use wheels, the only problem is exact control of the movement. Consider, for instance, a clockwork toy motor car. This runs on wheels but it is not a robot, as it has no means of 'knowing' its position at any given time. What is needed is a co-ordinate system that can be used to determine an object's position on a surface — the most common system for this purpose uses Cartesian co-ordinates. With this system it is possible to locate a robot's precise position and to specify the movements needed to move it to another defined location. All that is then needed is a device to ensure that the robot can move precisely within this frame of reference.

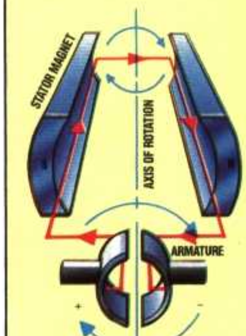
Although hydraulic or pneumatic power is occasionally used, the most common method of moving robots is via an electric motor. As we have seen in our Workshop series (pages 585 and 612), a simple electric motor can provide movement and a modest amount of control over direction. This is not suitable for precise control — a simple electric motor always turns through at least 180 degrees before coming to rest, and inertia will often cause it to rotate a little more than that.

So, for robot control, the stepper motor is normally used. This is a motor that contains a large number of coils and, although designs may vary widely, the general principle of the stepper motor allows very small, exact amounts of rotation to be specified, with little overshoot (rotating more than it should) or undershoot (rotating too little).

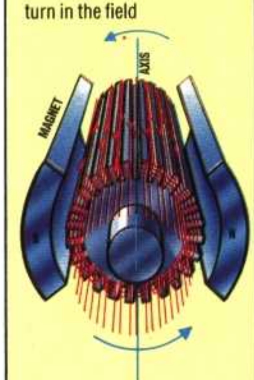
Robots that use stepper motors are widely available. Such robots often have a pen attached, allowing them to draw a line on the surface they are travelling over. These pen-wielding robots are called 'turtles', and the designs they produce are known as 'turtle graphics'. These are capable of precise movement — their accuracy may be judged by instructing them to draw a closed shape, such as a rectangle or a star, and checking to see whether or not the line drawn meets itself at the starting point.

Stepper motors and Cartesian co-ordinates can therefore give us a relatively precise method of controlling a robot's movement. However, if the robot is to do more than simply roll around in a given area, bumping into obstacles, it will need to be able to respond quickly and accurately to external conditions. We will consider this further in the next instalment.

Stepping A Measure



In the simplest electric motor, a flow of current in the rotor coil creates a magnetic flux opposed to that of the stator magnet's field; this opposition of forces causes the rotor to turn in the field



The stepper motor has many (sometimes hundreds) of coils. Switching current from one coil to another causes the whole to rotate in precisely controllable increments of arc

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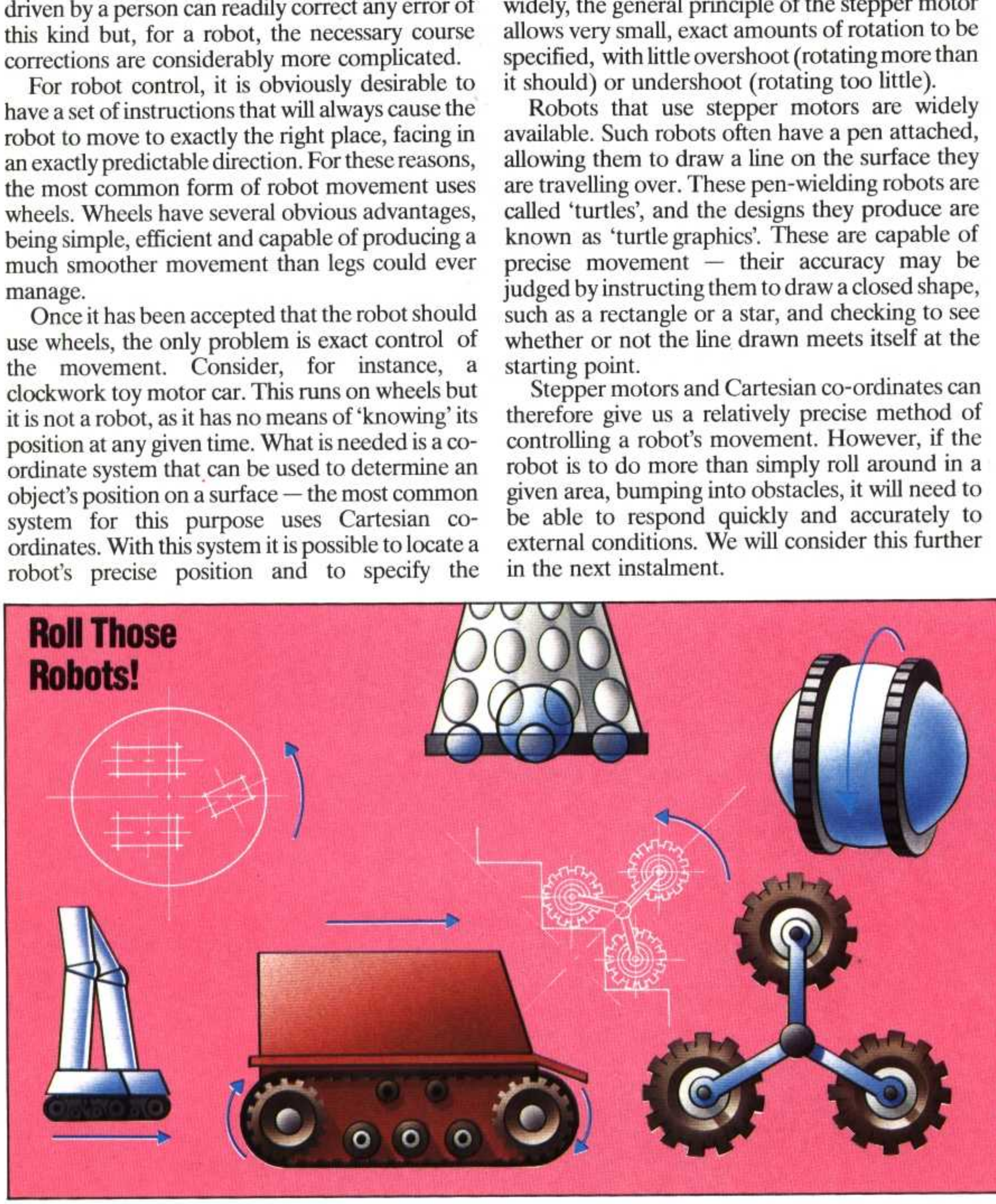
Roll Those Robots!



Robots must move, and not just on smooth laboratory floors. We show a few of the possible mechanisms.

Tracked feet give grip at the cost of steerability, but allow a shuffling gait without leg-lift, thus lessening balance problems. Tracked robot vehicles are commonplace – with bomb squads and planetary exploration teams, for example.

The tri-axle format is the only wheel adaptation that allows the robot to climb steps.

A large roller-ball surrounded by ball-bearing stabilisers is very easily steered, but is sensitive to irregular surfaces. The trolley arrangement of two fixed wheels and a steered castor is the minimum necessary for stability.

Slinging the load inside large driving wheels is an attractive idea, but it raises the centre of gravity and lessens stability

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