70p

Easy 6502 machine code

YOUR COMPUTER

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BBC Buggy road test – first small step for home robots

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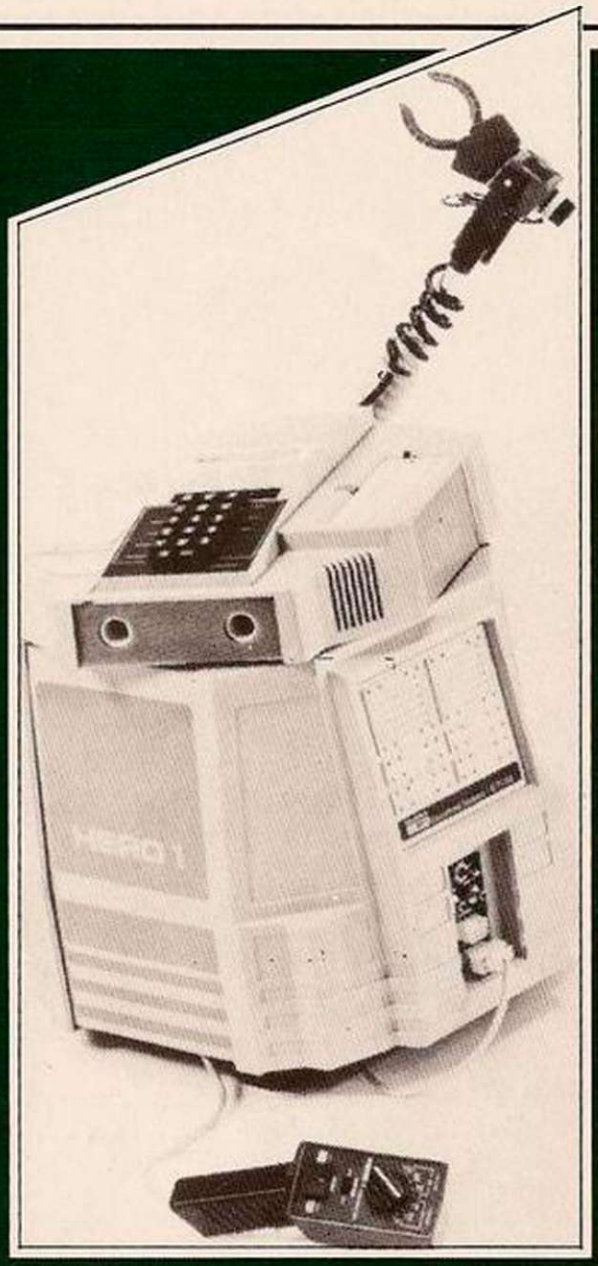


Watch out there's a robot about. The BBC Buggy is not alone. From £30 to £2,500 the robots are ready to move into your home.

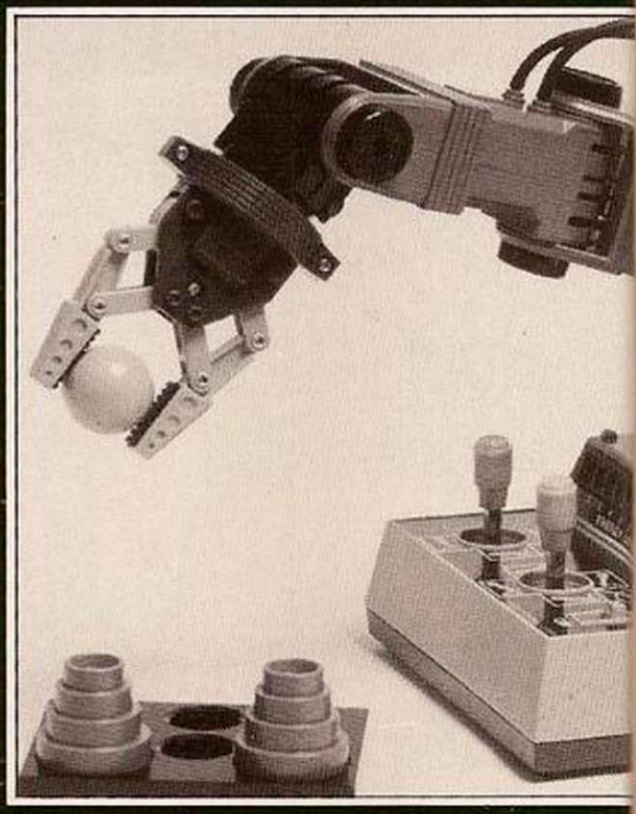
The Buggy's only competition comes from the Japanese toy industry and infant American domestic robot industry.

Tomy's Robo 1 was the star of the British Toy Fair at Earl's Court. A toy version of an industrial robot arm, it is battery run and controlled by two joysticks at the base. The arm itself can be swung up and down through 180 degrees and turn 360 degrees horizontally. Further dexterity is provided by the wrist which can swivel in almost any direction. By controlling the Robo 1's claw hand the operator can grip, pick up, rotate, move and release objects with remarkable precision. This is a well constructed and absorbing toy which sells for just £30.

Like the Buggy the Hero-1 is a programmable three-wheeled vehicle driven by two stepper motors and sold in kit form. Looking like a cross between Dr Who's K9 and Star Wars R2D2 it more closely conforms to the popular idea of a robot. Unlike the Buggy the Hero-1 is self-contained with an on-board microprocessor and its own battery power supply. It uses a 6808 processor with 4K RAM and 8K ROM. Instructions are entered via a hexadecimal keypad.

The Hero-1's range of sensors is far more extensive than the Buggy's. As well as a light detector it has detectors which can sense sound, motion and distance. It uses a sonar system to work out the distance of objects within a range of eight feet. There is also a built-in clock and options for a speech synthesiser and gripper arm.

This is obviously a more sophisticated package than the Buggy and a much more expensive one. In the U.S.A. the Hero-1 robot kit sells for $1,000 without the arm and speech synthesiser. Heath Electronics U.K. will be launching a fully-assembled version including the arm and synthesiser for £2,455



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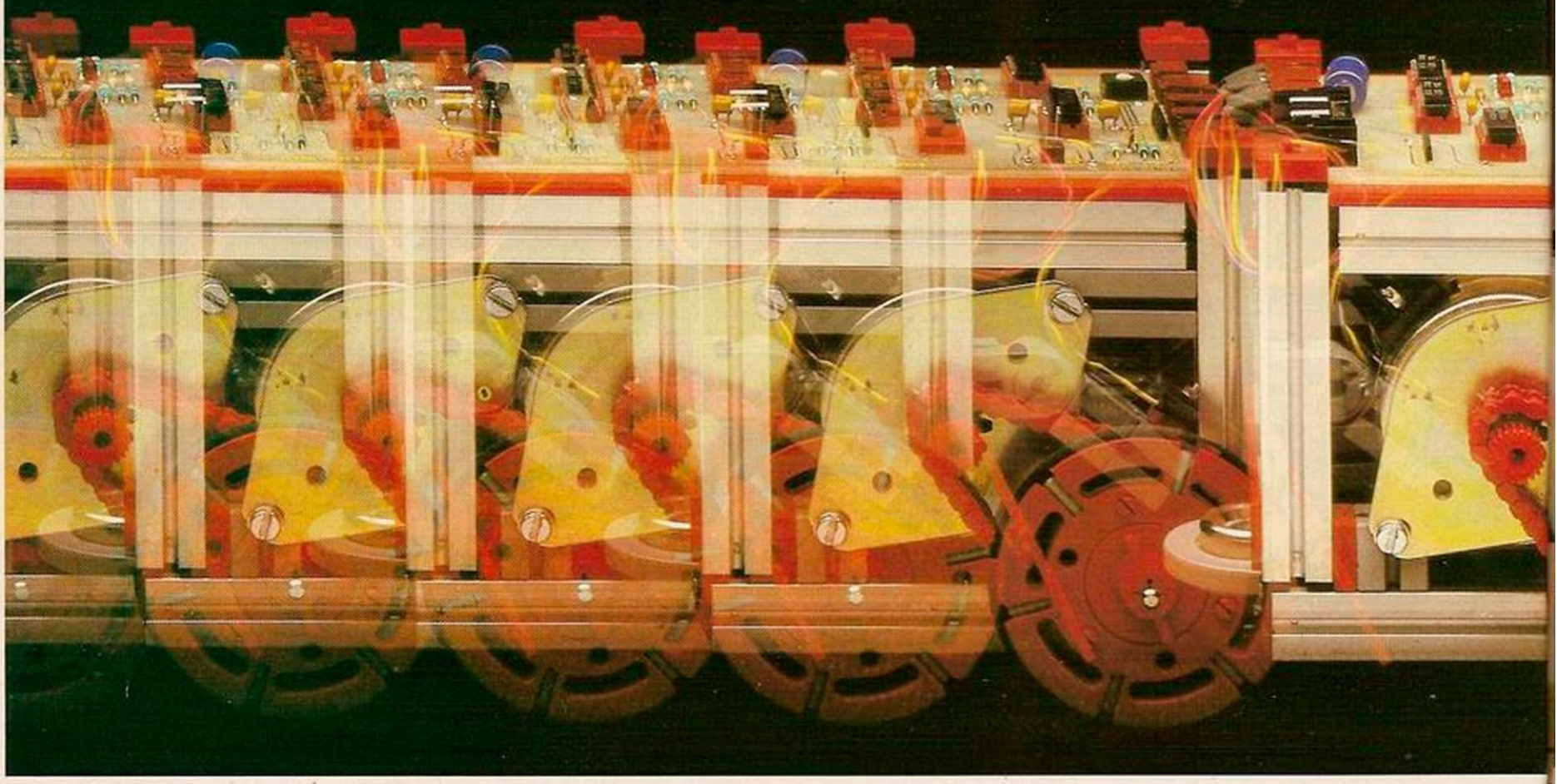
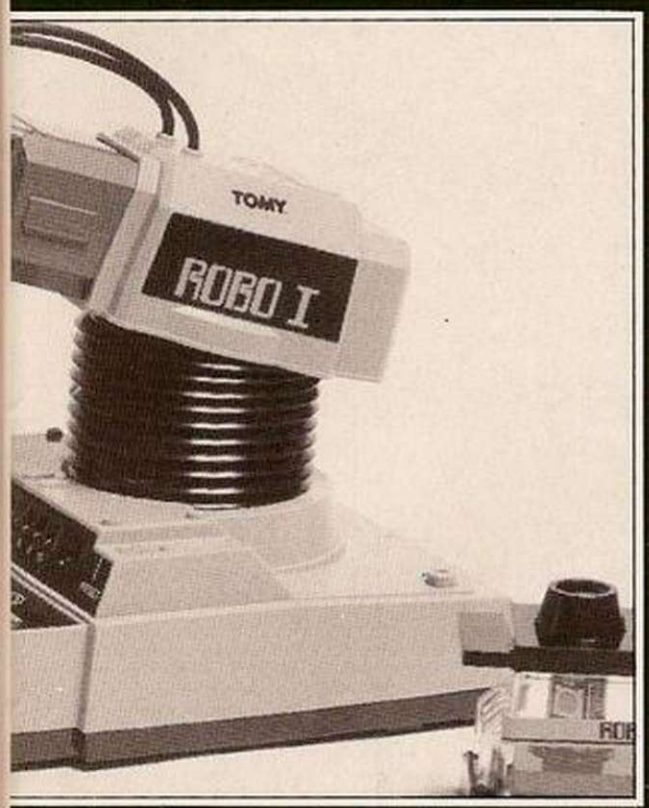


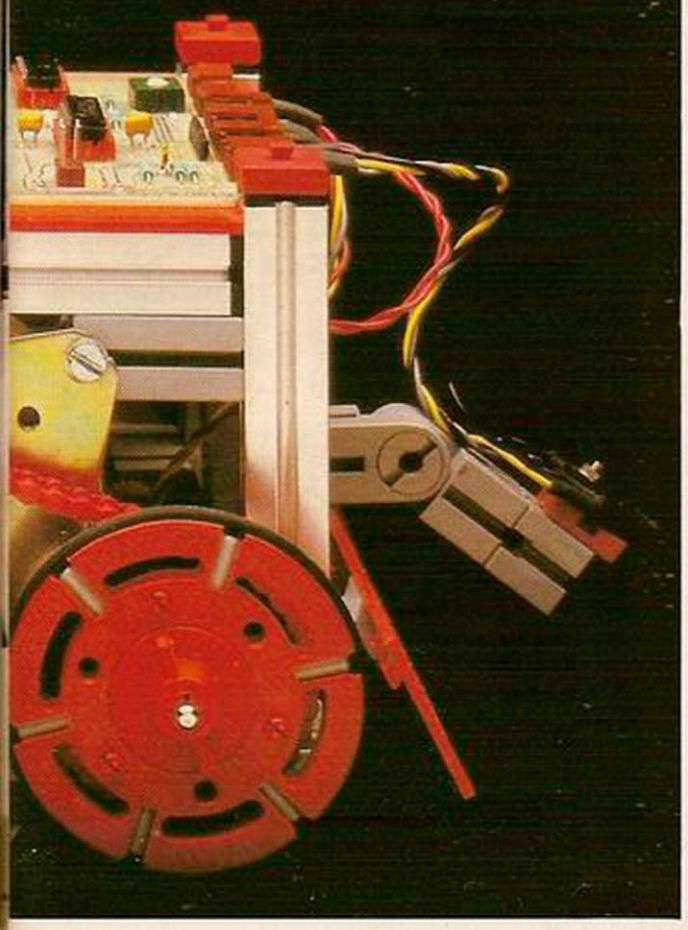
REVIEW

which will be available later this month.

But in some ways the Buggy offers the user greater scope for exploring robotics. It is easier to program and the BBC Microcomputer allows for more versatile software applications than the Hero-1's on-board computer.



OBOTS



Designed for the home.
Built by screwdriver.
Tested by Simon Beesley.
Buggy — the world's first affordable robot.

BBC BUGGY

IF YOU HAVE grown tired of all those video games and have exhausted your machine's programming potential you can now revive your interest in computing with the BBC Buggy. This is a three-wheeled vehicle which can be controlled by a BBC Micro and programmed to move in any direction, detect collisions, detect light, read a bar-code, and operate a pen-up/pen-down mechanism. In short it is a robot — and at around £120 it is the first to come within the range of the home computer user rather than the electronics hobbyist.

The Buggy is the fruit of a collaboration between the BBC Computer Literacy Project and the Microelectronics Education Programme. After discussing ideas for the BBC's *Making the Most of the Micro* series with producer David Allen, Mike Bostock, Technology Manager for the MEP, built a prototype Buggy using Lego bricks. "Everyone wants to build a robot", he says, "and at the age of 33 I finally built one".

When the Buggy goes on sale this month it will come as a construction kit containing a chassis, two stepper motors, three types of sensor, control cables and electronic circuit boards. To go with it there is a tape with 13 programs, documentation, a Buggy handbook and assembly instructions.

Fortunately the review robot arrived ready-built so we did not need to test the claims of Buggy-maker Economatics that the kit can be easily assembled in about two and a half hours using only a screwdriver.

The main body of the vehicle is a five-inch cube driven by two stepper motors which turn the front wheels. At the back there is a ball-bearing which acts as a balance wheel for the vehicle.

Using stepper motors greatly simplifies steering the Buggy since the motor can only be advanced by a fixed step at a time. This allows precise control of the vehicle's movement. Each motor has independent control over its respective wheel and the gearing is such that a single pulse to the motors rotates the Buggy by one degree.

It is comparatively easy to send the Buggy a specified distance forwards or backwards, or rotate it through any given angle. The two motors drive the vehicle at a rather stately pace with sufficient power for it to authoritatively brush aside obstacles such as books, in bulldozer fashion.

Top speed was measured at one and half miles per hour — hardly enough to trouble the man with the red flag. At the front is a split bumper with left and right microswitch collision detectors and above it a light detector — LDR. There is also a bar-code reader — BCR — mounted on a hinged arm which extends between the bumper and the LDR.

This consists of an infra-red light-emitting diode — LED — and photo-diode which respectively send out and receive infra-red light. The BCR detects a black line by measuring the amount of light it reflects. My only criticism of the vehicle's design is that the BCR arm is inconveniently positioned. Although it can fold back it tends to prevent the bumpers below from registering a head-on collision.

Logo-style turtle

In the Buggy's centre of rotation there is a pen-up, pen-down mechanism which is mounted on the centre axle and controlled by an electro-magnet. This will permit the Buggy to be used as a Logo-style turtle. It is not quite as accurate as a dedicated Logo turtle but is £180 cheaper.

On the BBC Micro the Buggy is controlled through the user and analogue-in ports. Both the LDR and BCR return an anologue input proportional to the intensity of light measured. The collision detectors send a digital on/off signal to the user port.

Each of the user port's eight bits provides a control line. Four of the lines from the user

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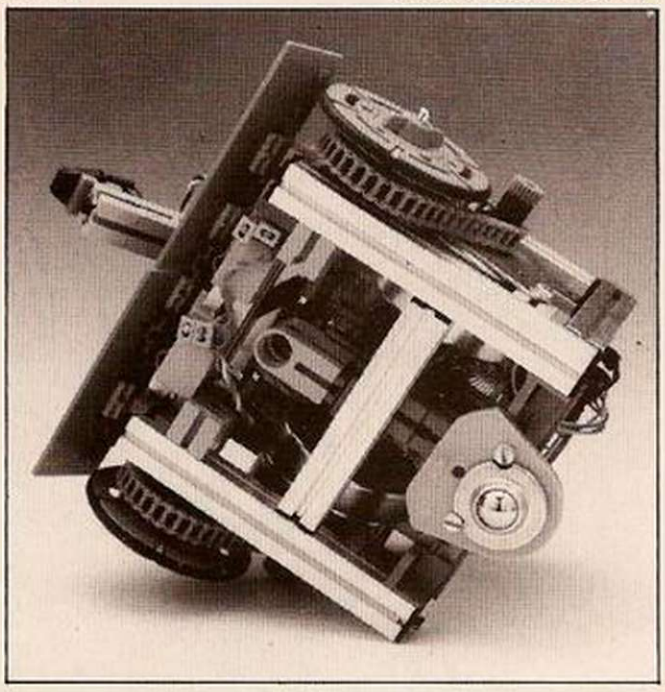


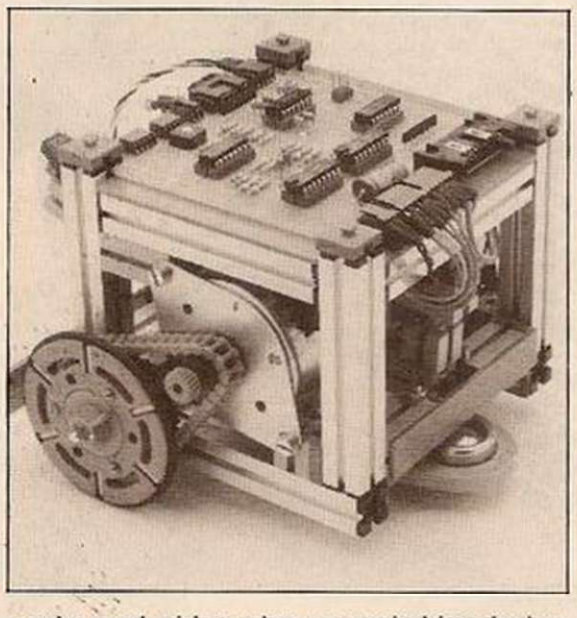
(continued from page 51)
port are used to control the stepper motors; one bit is used to turn on and off the electromagnet for the pen-up, pen-down mechanism, and two further bits are allocated to register the left and right collision switches.

I was pleasantly surprised at how easy it was to write controlling software for the Buggy. Once I found out how to write to and read from the user port it did not take long to write a short program to steer the Buggy from the keyboard, detect collisions and operate the pen.

Although the Buggy only runs on a BBC Micro at present, it should be possible to drive it from any micro with an eight-bit parallel port. Machines without analogue ports would be at a disadvantage and would require additional hardware to give the light sensors an on/off reading. Economatics is contemplating adapting the Buggy for the two machines on the DoI's list of recommended micros for schools — the Spectrum and Research Machines 380Z.

A robot can be described as an artificial intelligence in an artificial body. While the vehicle itself provides the body the BBC Micro or rather the programs it can run supply the intelligence. Along with the electronics and ironmongery almost 100K of software is supplied with the kit. The programs are graded and designed to take the user step by step up the artificial intelligence ladder.

In the process they show how a computer



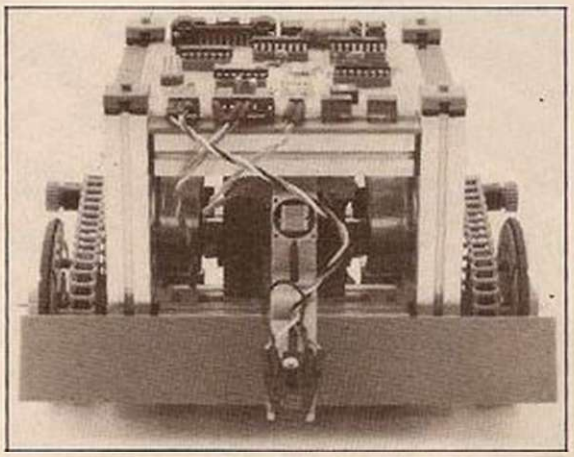
can be used with a robot as a switching device, a memory, a graphics terminal, a programmable device, an information processor and a problem solving unit. Since they demonstrate what the Buggy is capable of they are worth describing in some detail.

Test, the first program, checks that the Buggy is correctly set up and enables the user to test the sensors, displaying their input on the screen. This is followed by Switch, a short program, which lets you drive the Buggy in any direction by pressing the cursor keys. The vehicle is quick to respond and can be readily steered hither and thither.

As an advance on this facility Memory Switch records the key presses and can replay them in their sequence or in reverse order. This demonstrates how precisely the Buggy's movement can be controlled sending the Buggy along quite a complicated route several metres long and then commanding it to return, bringing it back to within a few centimetres of its starting position.

Recorder draws a map on the screen of the Buggy's progress while giving readouts of its position in an instrument panel below the map. Collisions are registered with a convincing crashing sound. Snail likewise plots the Buggy's path but also allows you to give it a coded sequence of instructions first, such as R30 or F50 meaning Turn Right 30 degrees or Go Forward 50 centimetres.

There are two programs which show how the Buggy can read in quite complex information from bar-codes. In Tin Pan Alley it reads musical information from a line of bar-codes, plays the tune and displays an animated score on the screen. Bar-Code Route Planner



instructs the Buggy to follow route instructions given on bar-code cards.

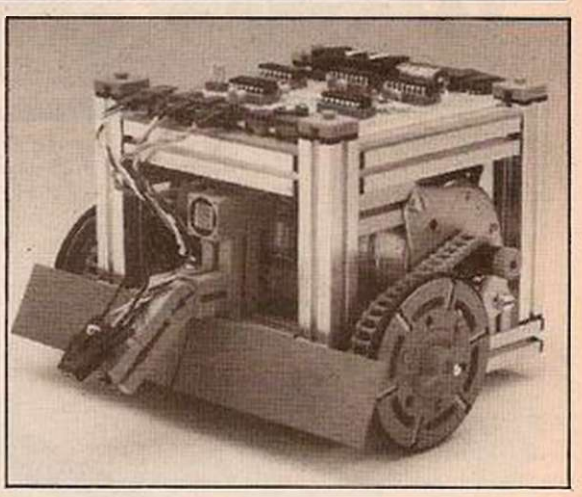
The remaining programs, in which the robot appears to act under its own control, demonstrate some of the principles of artificial intelligence. The Buggy is instructed to perform such tasks as seeking out an object and working out its size, following a black or white line, and measuring an enclosed area. Sunseeker programs the robot to track down a light source.

Once it has located its goal it homes in negotiating any objects in its way. Man versus Buggy requires the user to perform the same task — to drive the Buggy from the keyboard using the same information as is available to the computer which it presents on an instrument panel.

As soon as the vehicle starts to move in a purposeful manner it is difficult not to ascribe intelligence to its behaviour. One of the Buggy's predecessors, Dr Grey Walter's tortoise was a three-wheeled vehicle which could travel around a room avoiding obstacles. It was programmed to look for a power point to plug itself into and recharge its batteries when they ran low. Onlookers tended to feel empathy with it in its quest. The Buggy can provoke a similar response. It is bound to be a success in schools.

The 13 programs in the software kit are written in Basic and the procedures they contain can be incorporated in the user's own programs. There is clearly scope for more advanced artificial intelligence applications.

People who saw the Buggy on the BBC's *Making the Most of the Micro* series will have seen it finding its way around a maze until it reached a light source at the end and then returned to the start. If the robot were fitted with a grab-arm it could for example be programmed to demonstrate the principles of



the computerised warehouse. It would use the BCR to follow a line to a set of pigeon holes, then locate a pigeon hole which had been lit up, remove an item with a grab-arm, read its bar codes and use the information given to docket it elsewhere.

A grab-arm is one of the hardware expansions Economatics is considering. Other possibilities could be in the form of extra sensors such as a proximity detector or a heat detector.

The MEP stresses that the robot should not be seen just as a toy. But the term toy need not be applied dismissively. After all for most owners' home computers have no practical application and could be described as adult toys. Whether or not everyone wants to build a robot, the idea of controlling a robot exerts a fascination for most people. The Buggy's inventor Mike Bostock frankly describes it as "modern day Meccano."

People are not so much interested in the practical role of robots as uncomplaining drudges capable of performing menial tasks, as in their ability to carry out more complex and intricate routines. Linking the Buggy to the BBC Micro gives it considerable potential for such exercises in artificial intelligence.

The MEP which developed the Buggy sees it as finding a place in both the home and school. Andrew Hopkins who has written the manual describes it as one solution to the problem of introducing more technology into the curriculum. Whatever its application the Buggy is certainly enjoyable to play with as well being a useful introduction to control technology and artificial intelligence.

CONCLUSIONS

- The Buggy may not be able to do the washing-up or the housework for you but it can provide an excellent introduction to robotics and control technology.
- As an educational device which has its place in many different parts of the curriculum the Buggy should be very popular. It is fun to use and easy to operate. Its low cost also puts it within the reach of home computer users who are interested in robots.
- The Buggy's capabilities are well demonstrated by the 13 programs which accompany it. These do not exhaust its possibilities and there is plenty of scope for a variety of more complicated applications. ■