ROBOTIC ARMS

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ROBOTIC arms operate under the control of a pre-programmed computer or computer-like control system. Any one of various types of end-of-arm tools can be added to create a machine capable of performing almost any number of industrial tasks such as painting, welding, or in a physically smaller version, even moving chess pieces on a board. For industrial purposes the arms are usually fixed to some form of baseplate, making them static. This type of mechanism is sometimes called a "pick-and-place" device since that is about the extent of their use.

There are three types of arm actuation—hydraulic, pneumatic, and electrical. The first two require the use of large, expensive, and

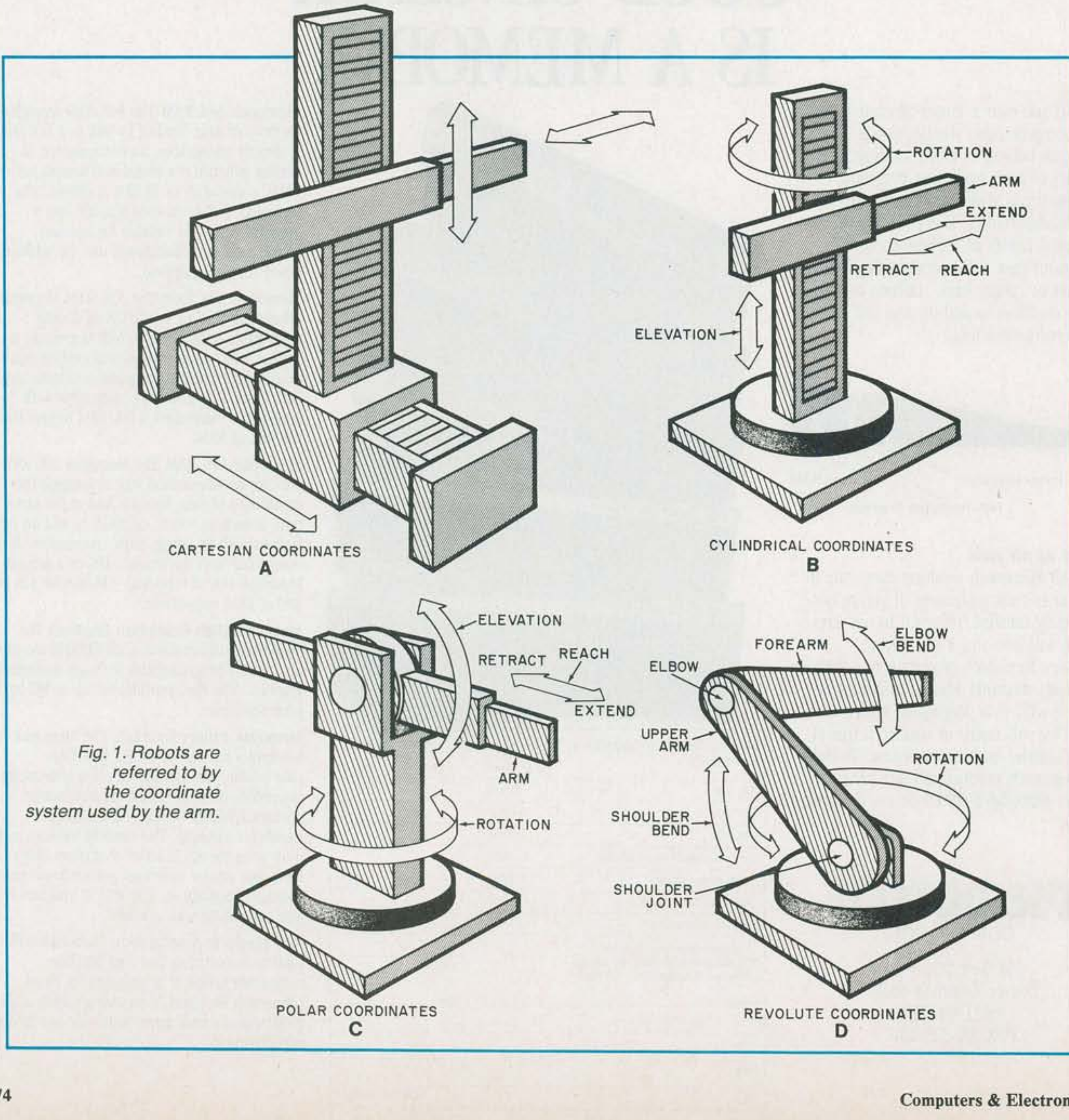

Fig. 1. Robots are referred to by the coordinate system used by the arm.

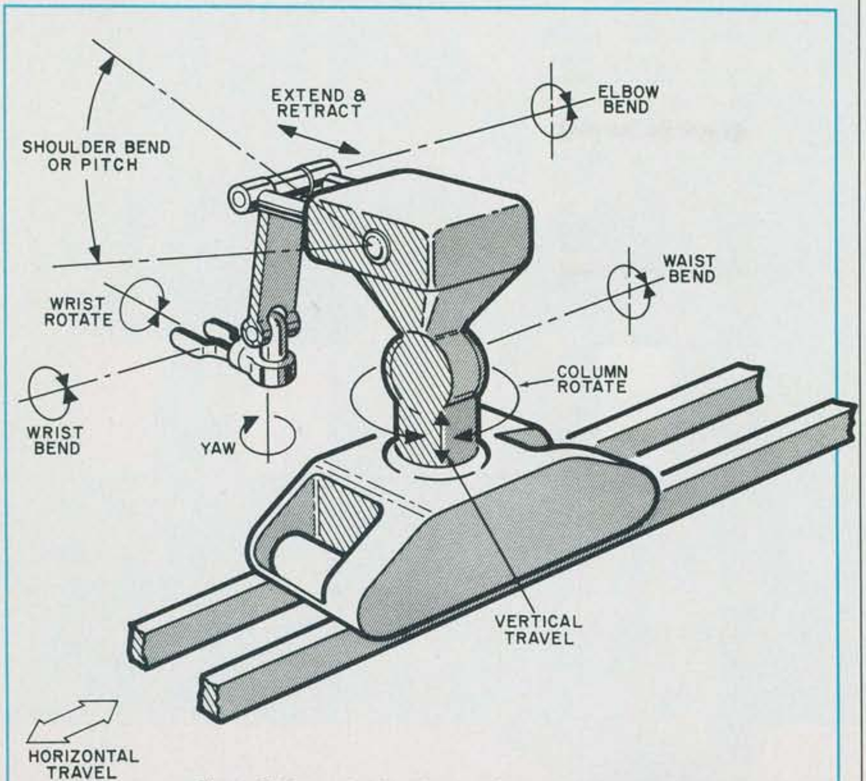

Fig. 2. This mechanism has 10 degrees of freedom, with the axes of movement resembling those of a human torso.

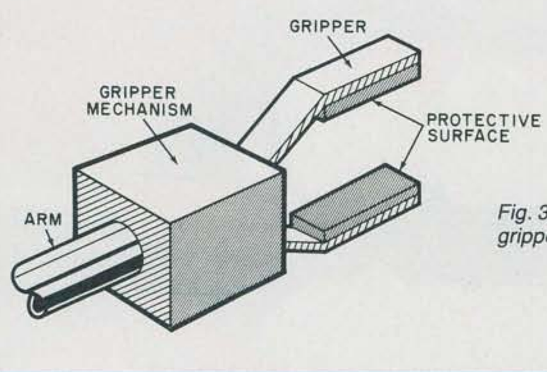

Fig. 3. Diagram of a typical gripper attachment.

noisy pumps and compressors. Therefore they are for heavy-duty, factory-type applications where physical strength is required to manipulate large heavy objects. The electrical approach can essentially be divided into two areas—heavy-duty (factory) and mobile robots. The heavy-duty area is similarly used in a factory environment, and requires large multi-horsepower motors and heavy-duty gear trains and reduction gears.

In the low-power, electrically actuated mobile robot, movement is via fractional horse-power dc motors, which limits its "work" power to light loads. However, this approach lends itself to relatively low cost and permits operation from batteries. This frees the robot from restraints of power system cabling, allowing it to be mobile.

Some of the terms used for fixed-arm industrial robots are also applicable to "personal" robots. Such configurations refer to the coordinate system used by the arm, and include Cartesian, Cylindrical, Polar, and Revolute. These are shown in Fig. 1. The particular coordinate system used dictates the shape and size of the area, called "work envelope," in which the end of the arm and its attached manipulator (gripper, etc.) can be placed. As can be determined from Fig. 1, the Cartesian system can produce a work envelope shaped like a cube; the Cylindrical coordinate system's work area will be shaped like a thick cylinder; the Polar coordinate system produces a work space shaped like half a sphere; and the Revolute approach can almost emulate the human arm.

Degrees of Freedom. The number of intricate motions that a robot's arm can perform is determined by the number of axes it has. These are often called "degrees of freedom." A device having 10 degrees of freedom is shown in Fig. 2. Note that other than the capability of extension and retraction of the arm "shoulder," all axes resemble those of the human torso. Most industrial robots have three to five degrees of freedom to perform their specified task. Obviously, the greater the number of degrees of freedom, the more complex task the robot can perform.

In the mechanical systems shown in Fig. 1, some form of gripper or manipulator as in Fig. 3 is assumed to be attached to the end of the arm. In Fig. 1B, the manipulator can be extended, retracted, moved up or down, or rotated to any desired azimuth. Thus, the work envelope forms a cylinder. In the approach shown in Fig. 1C, the manipulator can be extended, retracted, pivoted in the vertical plane, and rotated around the base to form a half-sphere work envelope. The Revolute approach shown in Fig. 1D closely resembles the human arm. It has a base plus an "upper arm" and "forearm" that move in a vertical plane with respect to base, while the "elbow" and "shoulder joint" resemble those of the human arm. The work envelope of this approach approximates a major portion of a sphere. ◊