UNIT I SCOPE OF ROBOTS

The scope of industrial Robots - Definition of an industrial robot - Need for industrial robots –Economic and Social Issues- applications.

TEXTBOOKS

1. D J Todd, "Fundamentals of Robot Technology- An introduction to Industrial Robots, Teleoperators and Robot Vehicles", Kogan Page Ltd, 1986.
2. Mikell P.Groover, Mitchell Weiss, Roger N.Nagel Nicholas G.Odrey, —Industrial Robotics Technology, Programming and Applications —, McGraw Hill Book Company 1986.
3. Fu K.S. Gonzaleaz R.C. and Lee C.S.G., —Robotics Control Sensing, Vision and Intelligence — McGraw Hill International Editions, 1987.

TEXTBOOKS

4. Barry Leatham - Jones, ―Elements of industrial Robotics‖ PITMAN Publishing , 1987.
5. Bernard Hodges and Paul Hallam, ― Industrial Robotics‖, British Library Cataloging in Publication 1990.
6. Deb, S.R. Robotics Technology and flexible automation, Tata Mc GrawHill, 1994.

www.sathieshkumar.com/tutorials

SCOPE & DEFINITION OF ROBOTICS

- Automation and robotics are two closely related technologies.
- Automation is concerned with the use of mechanical, electronic and computer based systems in the operation and control of production.
- Robotics is a form of industrial automation.
- Three broad classes of industrial automation:

1. Fixed automation
2. Programmable automation
3. Flexible automation

SCOPE & DEFINITION OF ROBOTICS

- Fixed automation is used when the volume of production is very high and it is therefore appropriate to design specialized equipment to process the product (or a component of the product) very efficiently and at high production rates.
- Eg: Automobile Industry: Transfer lines consisting of several dozen workstations are used to perform machining operations on engine and transmission components.

SCOPE & DEFINITION OF ROBOTICS

SCOPE & DEFINITION OF ROBOTICS

Fixed automation:

- Economics: The cost of the special equipment can be divided over a large number of units and the resulting unit costs are low.

- Risks:

1. Since the initial investment is high, if the volume of production turns out to be lower than anticipated, then the unit costs becomes greater than anticipated.
2. Equipment is specially designed to produce the one product, and after that product’s life cycle is finished, the equipment is likely to become obsolete.

SCOPE & DEFINITION OF ROBOTICS

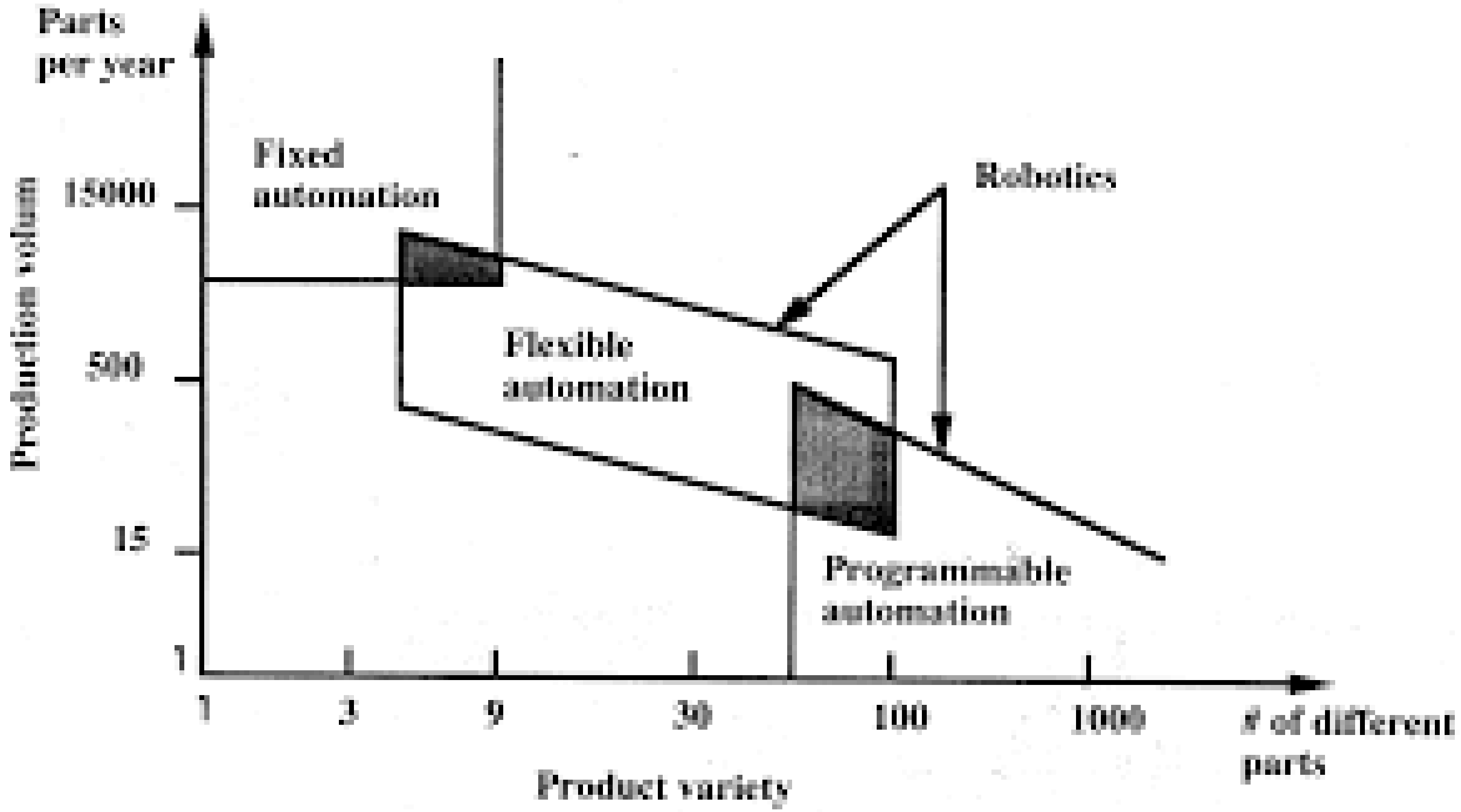
- Programmable automation is used when the volume of production is relatively low and there are a variety of products to be made.
- Production equipment is designed to be adaptable to variations in product configurations.
- Adaptability comes from programming the equipment.
- Economics: The cost of the programmable equipment can be spread over a large number of products even though the products are different.

SCOPE & DEFINITION OF ROBOTICS

- Flexible automation possess some of the features of both fixed automation and programmable automation.
- Flexible automated systems typically consists of a series of workstations that are interconnected by a materials-handling and storage system.
- A central computer is used to control the various activities that occur in the system, routing the various parts to the appropriate stations and controlling the programmed operations at the different stations.
- Also known as flexible manufacturing systems (FMS) or computer-integrated manufacturing systems.
- Most suited for mid-volume production range.

SCOPE & DEFINITION OF ROBOTICS

- Relationship of fixed automation, programmable automation and flexible automation as a function of production volume and product variety.



Dr. V. Sathiesh Kumar Department of Electronics, MIT, India

SCOPE & DEFINITION OF ROBOTICS

- Difference between the programmable automation and flexible automation:

1. Programmable automation : The products are made in batches. When one batch is completed, the equipment is reprogrammed to process the next batch.
2. Flexible automation: Different products can be made at the same time on the same manufacturing system

SCOPE & DEFINITION OF ROBOTICS

- Of the three types of automation, robotics coincides most closely with programmable automation.
- An industrial robot is a general purpose, programmable machine which possess certain anthropomorphic or human like characteristics. Eg: Robotic arm.
- Examples for robotic applications: Machine loading and unloading, spot welding and spray painting.

SCOPE & DEFINITION OF ROBOTICS

- Official definition of an industrial robotics is provided by the Robotics Industries Association (RIA), formerly the Robotics Institute of America.

"An industrial robot is a reprogrammable, multifunctional manipulator designed to move materials, parts, tools, or special devices through variable programmed motions for the performance of a variety of tasks"

SCOPE & DEFINITION OF ROBOTICS

➢ List of characteristics required for a robotic systems:

1. A robot must be produced by manufacturer rather than by biology.
2. It must be able to move physical objects or be mobile itself.
3. It must be a power or force source or amplifier.
4. It must be capable of some sustained action without intervention by an external agent.
5. It must be able to modify its behavior in response to sensed properties of its environment, and therefore must be equipped with sensors.

SCOPE & DEFINITION OF ROBOTICS

- Classification of Robots:

1. A telemanipulator is a manipulator whose actions are remotely controlled by a human operator, sometimes by mechanically replicating his hand movements and sometimes by obeying pushbuttons or joystick controls. Such a manipulator is often called a teleoperator or telechir.
2. An android is a robot of human appearance and physical abilities. There is no agreement on whether an android must be built from engineering materials or grown in some biochemical way.
3. A cyborg is a being part machine and part biological. 'Cyborg' is a hybrid of 'cybernetics' and 'organism'. Cybernetics is the science of control systems in engineering and biology; the word was invented by Norbert Wiener.

ASIMOV & ANDROID ROBOT

ASIMOV

- Three laws of Robotics by Asimov:

1. A robot may not injure a human being or, through inaction, allow a human to be harmed.
2. A robot must obey orders by humans except when that conflicts with the First Law.
3. A robot must protect its own existence unless that conflicts with the First or Second Laws.

NEED FOR INDUSTRIAL ROBOTS

- Industrial robots (programmable manipulators) can be regarded as replacements for human workers.
- Some reasons for installing robots are as follows:

1. to save money, if the cost of a robot over its lifetime is less than the cost of employing a person (or persons if it replaces more than one),
2. to increase the speed of an operation and so increase production,
3. to improve product quality through improved consistency,
4. to handle loads too heavy for a person,
5. to handle dangerous loads (radioactive, explosive, toxic),
6. to eliminate boring or unpleasant work,
7. when a person cannot gain access, e.g. in narrow tubes,

NEED FOR INDUSTRIAL ROBOTS

8. when a task needs movements too precise for a person to make.

ECONOMIC COSTS AND BENEFITS OF INSTALLING INDUSTRIAL ROBOTS

- The economic costs and savings of replacing a man or men by a robot are:

Costs:

1. purchase price,
2. special tooling,
3. installation,
4. staff training,
5. maintenance,
6. power,
7. finance,
8. depreciation.

ECONOMIC COSTS AND BENEFITS OF INSTALLING INDUSTRIAL ROBOTS

- The economic costs and savings of replacing a man or men by a robot are:

Savings:

1. labour displaced,
2. quality improvement,
3. increase in throughput (not always positive),
4. savings on quality of working conditions.

ECONOMIC COSTS AND BENEFITS OF INSTALLING INDUSTRIAL ROBOTS

- If these items can be quantified it is possible to calculate a payback period.
- If a robot is considered as a replacement for a person it is possible to calculate how long the robot must work before it shows a net saving.
- This is the payback period, and is given by:

$$P = \frac{I}{L - E}$$

where **P** is the payback period in years, I is the initial cost, **L** is the total annual labour costs replaced by the robot and **E** is the annual maintenance cost.

ECONOMIC COSTS AND BENEFITS OF INSTALLING INDUSTRIAL ROBOTS

- The payback period must obviously be less than the life of the robot, which might be five or ten years, and in fact payback times of three years or less are sought.
- The payback period is reduced if the robot replaces more than one worker, usually by working two or three shifts.

Assumption: Robot does a job which can be done by human workers.

ECONOMIC COSTS AND BENEFITS OF INSTALLING INDUSTRIAL ROBOTS

- Theoretically, almost any manufacturing process can be carried out by

(a) human workers operating individual machines

(b) robots loading individual machines

(c) a dedicated machine doing the whole process

- Mixtures of these methods often occur.
- As the volume of production rises, the most economical method progresses from (a) through (b) to (c).

RELIABILITY

- A measure of reliability is uptime: the percentage of the time for which the robot is available.
- It is equal to 100% minus the downtime, which is the percentage of the time for which the robot is out of service for repair or maintenance.
- An uptime of 97% or 98% can be achieved, which is enough for many industrial processes but not all, and so in critical cases some form of back-up must be provided.

$$\text{downtime} = \frac{\text{MTTR}}{\text{MTBF}}$$

MTTR- Mean time to repair

MTBF- Mean time between failures

SAFETY AND ENVIRONMENTAL FACTORS

Safety issues in robotics:

1) safety of human beings where robots are working,

2) safety benefits due to robots,

3) prevention of mechanical damage by robots to other equipment,

4) prevention of damage to the robot,

5) avoidance of fires and pollution produced by robots,

6) protection of robots from adverse environments.

SAFETY AND ENVIRONMENTAL FACTORS

Safety of Human Beings:

1. unpredictability in part due to malfunction
2. Robot may wait for some event to occur (no pattern of movements to observe) such as an interlock signal.
3. Many robots can move a heavy payload with great force at speeds of 1m/s or more and can easily kill or seriously injure.

- Obvious precaution is to cage a robot in, but there is always some need to go into the cage, e.g. to service the machinery within it.
- Use light beams and pressure mats to detect the presence of intruders into the danger area.

SAFETY AND ENVIRONMENTAL FACTORS

Safety of Human Beings:

- A more sophisticated approach is to fit the robot with proximity sensors on its moving parts and to couple these to the controlling program so that if the robot detects an impending collision it stops.
- Fit the work cell with a vision or range imaging system which would track a person and stop the robot if necessary.
- Emergency stop buttons can be provided in addition to active or passive guards. The effect of such buttons should be carefully considered; simply cutting power off may cause the robot's load to sag under its own weight, or trap a person with no safe way of freeing him.

SAFETY AND ENVIRONMENTAL FACTORS

Safety of Human Beings:

- Safety precautions for Automatic Guided Vehicles (AGVs) are (a) low speed, (b) clearly marked routes, (c) turn indicators, horns and flashing lights. and (d) touch and proximity sensors which can stop the vehicle quickly.
- A danger with legged robots is of their becoming unstable and falling over, endangering the crew if any and anyone nearby.

SAFETY AND ENVIRONMENTAL FACTORS

Safety benefits of using robots:

- can improve safety by saving people from dangerous tasks such as reaching into presses and injection molding machines, lifting heavy loads and working in dangerous environments.

SAFETY AND ENVIRONMENTAL FACTORS

Prevention of mechanical damage:

- Ensuring human safety is easier since most equipment is static and if it moves it does so predictably.
- Precaution: limit joint torque by friction clutches, by limited motor power or by sensing loads and cutting power off if some limit is reached.

Dr. V. Sathiesh Kumar Department of Electronics, MIT, India

SAFETY AND ENVIRONMENTAL FACTORS

Avoidance of robot-generated fires and pollution:

- Any hydraulic oil which leaks is a fire hazard, and may also be unacceptable if high cleanliness is desired, as in food processing.
- Electric joint motors can produce sparks from commutators or faulty connections and so may be unacceptable in explosive atmospheres;
- Emissions such as heat, vibration and acoustic and electrical noise may have to be controlled.

SAFETY AND ENVIRONMENTAL FACTORS

Protection of robots from adverse environments:

1) radiation (nuclear applications),

2) extremes of temperature (foundries),

3) abrasive particles (grinding),

4) sparks and molten metal splashes (welding, casting),

5) clogging particles (paint spraying),

6) corrosive chemicals (investment casting),

7) shock and vibration (forging),

8) electrical noise (any factory),

9) water and other liquids (from coolant sprays and washing),

10) steam (from steam cleaning).

SAFETY AND ENVIRONMENTAL FACTORS

Protection of robots from adverse environments:

- The precautions to be taken are the same as for any machine:

1. flexible coverings on joints,
2. circulating filtered air at positive pressure throughout the robot,
3. non-flammable and corrosion-resistant materials,
4. mains filters or uninterruptable power supplies and so on.

ACCEPTABILITY OF INDUSTRIAL ROBOTS BY THE WORKFORCE

- The likelihood of robots being welcomed is increased if the following conditions are met:

1) they do not lead directly to redundancies, but the displaced workers are transferred to other work;
2) they are built into a new installation such that there is no traditional manning level for comparison;
3) the tasks they take over are unpleasant or dangerous;
4) they result in the workers being retrained to do more skilled and interesting jobs;
5) they are perceived as enhancing the status of those who work with them;
6) they create new jobs such as programming and maintenance;

ACCEPTABILITY OF INDUSTRIAL ROBOTS BY THE WORKFORCE

- The likelihood of robots being welcomed is increased if the following conditions are met:

7) as with any new equipment, the ease of introduction depends on the state of industrial relations in the factory.

SOCIAL ISSUES

1) Should the use of industrial robots be encouraged or opposed?
2) Is an increasing use of industrial robots inevitable?
3) When they are introduced, what safeguards should be established?
4) Is there a real prospect of increased military use of robotics, and what are the consequences?
5) Do robots for police and security work pose a threat to freedom?
6) Does robotics have any real potential to enhance people's lives by, for example, relieving them of drudgery and dangerous work?
7) Are domestic robots feasible, and if so are they desirable?
8) Is robotics likely to enhance or diminish economic equality, both within and between nations?.

APPLICATIONS OF INDUSTRIAL ROBOTS

1) die casting (make (a metal object) by pouring molten metal into a mould.)

2)spot welding (one form of resistance welding, which is a method of welding two or more metal sheets together without using any filler material by applying pressure and heat to the area to be welded.)

3) arc welding (uses a welding power supply to create an electric arc between an electrode and the base material to melt the metals at the welding point)

4) investment casting (a technique for making small, accurate castings in refractory alloys (Tungsten, Molybdenum, Rhenium etc.) using a mould formed around a pattern of wax or similar material which is then removed by melting.)

5) injection molding (the shaping of rubber or plastic articles by injecting heated material into a mould.)

APPLICATIONS OF INDUSTRIAL ROBOTS

APPLICATIONS OF INDUSTRIAL ROBOTS

6) Forging (shape (a metal object) by heating it in a fire or furnace and hammering it.)

7) press work (machine tool that changes the shape of a work piece by the application of pressure)

8) spray painting

9) foundry work (Factory that produces metal castings. Metals are cast into shapes by melting them into a liquid, pouring the metal in a mold, and removing the mold material or casting after the metal has solidified as it cools.)

10) machine tool loading (machine for shaping or machining metal or other rigid materials, usually by cutting, boring, grinding, shearing, or other forms of deformation)

APPLICATIONS OF INDUSTRIAL ROBOTS

11) heat treatment (Heat treating is a group of industrial and metalworking processes used to alter the physical, and sometimes chemical, properties of a material.)

12) Deburring (smooth the rough edges or ridges of an object, typically one made of metal.)

13) Palletizing (machine which provides automatic means for stacking cases of goods or products onto a pallet)

14) brick manufacture

15) glass manufacture

16) packaging

17) electric harness manufacture

APPLICATIONS OF INDUSTRIAL ROBOTS

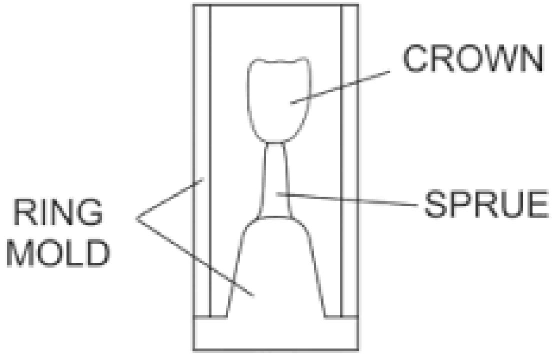
18) assembly and sheep shearing (process by which the woollen fleece of a sheep is cut off)

APPLICATIONS- MACHINE LOADING

- unloading die-casting machines
- In die casting the two halves of a mould or die are held together in a press while molten metal, typically zinc or aluminium, is injected under pressure.
- The die is cooled by water; when the metal has solidified the press opens and a robot extracts the casting and dips it in a quench tank to cool it further.
- The robot then places the casting in a trim press where the unwanted parts are cut off.

APPLICATIONS- MACHINE LOADING

- The robot often grips the casting by the sprue.
- The sprue is the part of the casting which has solidified in the channels through which molten metal is pumped to the casting proper.
- Several castings may be made at once; in this case they are connected to the sprue by runners.
- When the sprue and runners are cut off by the trim press, the press must automatically eject the casting(s) onto a conveyor.



APPLICATIONS- MACHINE LOADING

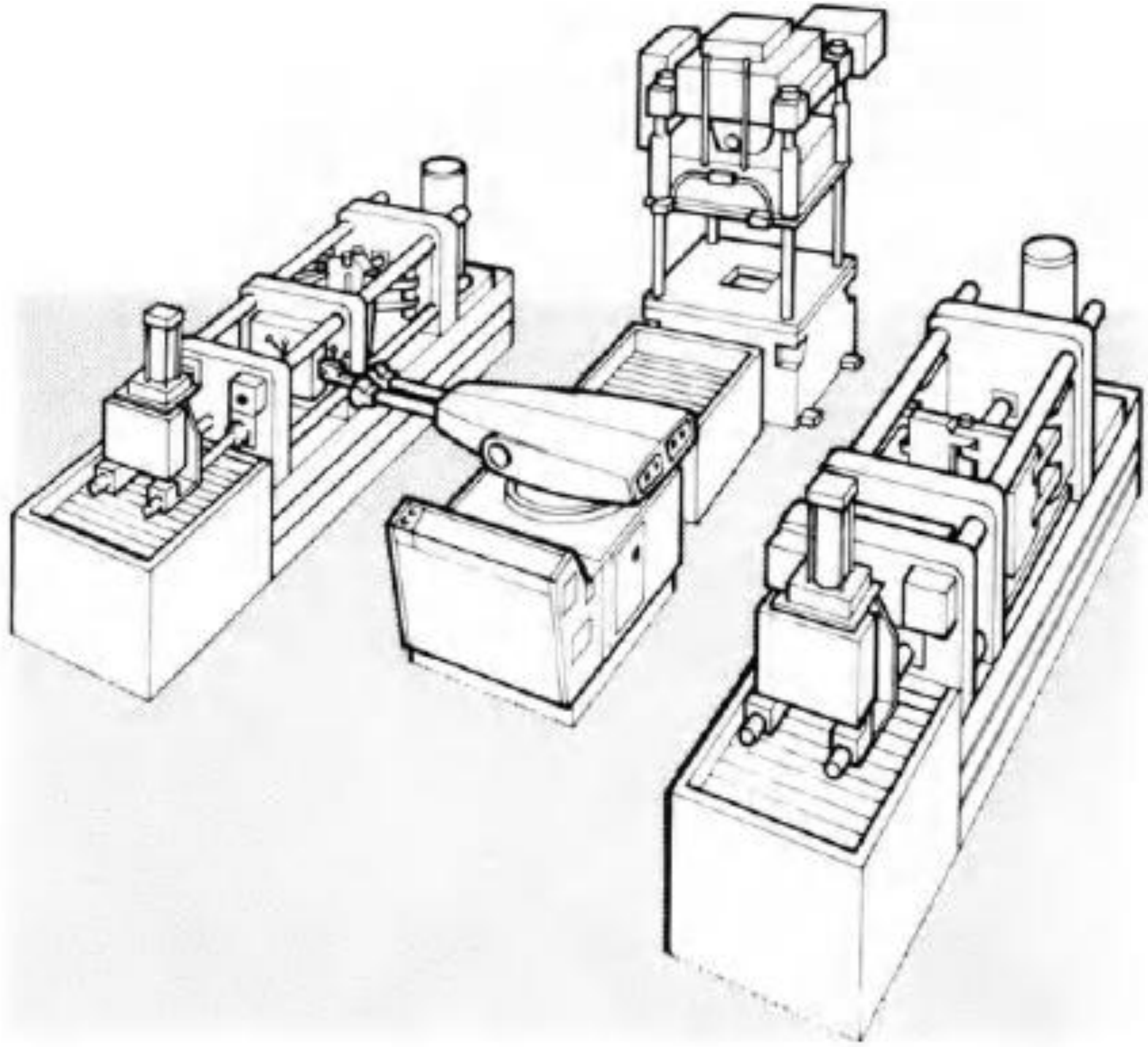


Figure 7.1 *A robot serving die-casting machines.*

APPLICATIONS- MACHINE LOADING

- Many combinations of robot, die-casting machines and presses are possible.
- In some cases the robot fits inserts into the die before casting takes place.
- It may have to spray the die with lubricant.
- A point to point robot can be used.
- Its geometry must allow it to reach into the presses.
- With proper placement of the machines a two-axis wrist may be sufficient.
- The cycle time of the die-casting process is at least several seconds, so a relatively slow robot can be used.

APPLICATIONS- MACHINE LOADING

- Interlocking with sensors and micro switches is needed to ensure that the robot grasps and removes the casting successfully, that the trim press is emptied correctly and that the die-casting machine and trim press are open when the robot tries to insert its arm.
- Robots are now used for loading and unloading injection molding machines (some of which make plastic items as large as dust bins and boat hulls), lathes, milling machines, sheet metal presses and other machines.

APPLICATIONS- MACHINE LOADING

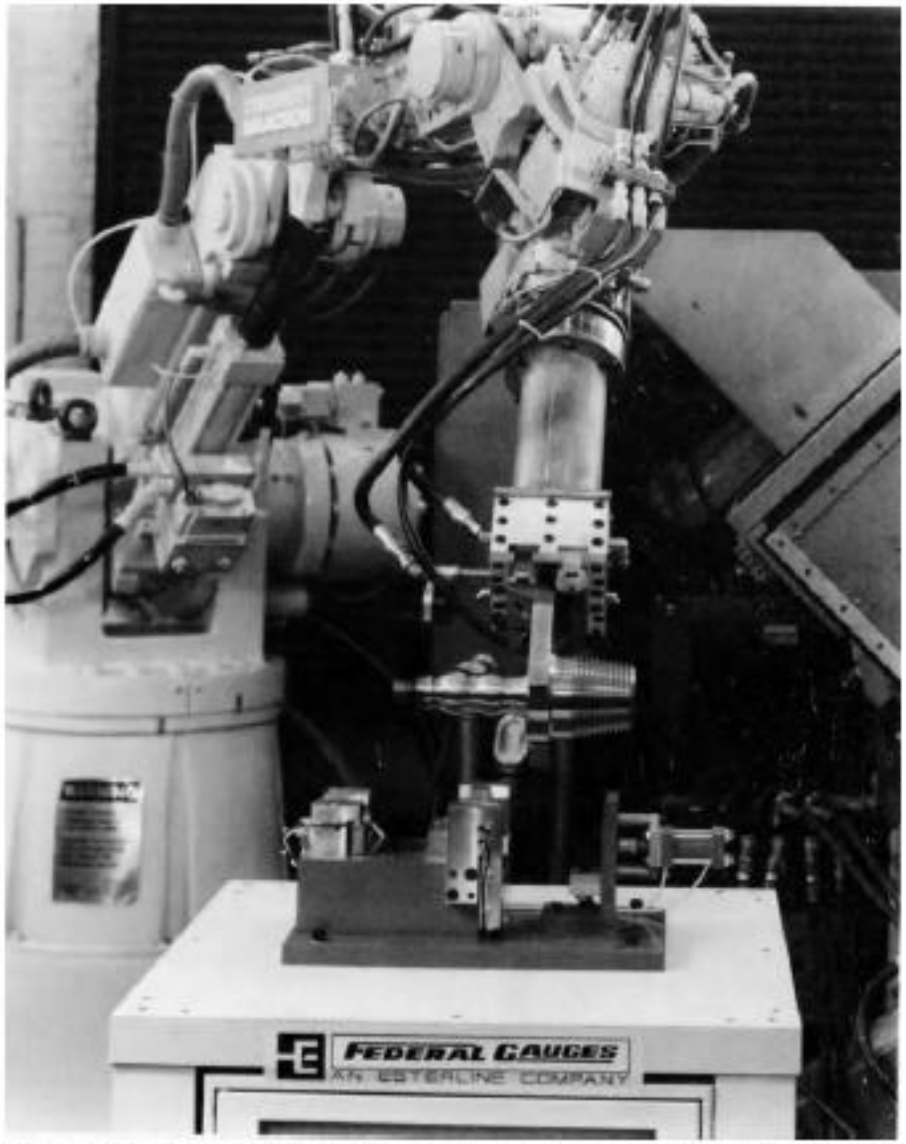


Figure 7.2 *A robot transferring parts betwen the machines of a manufacturing cell. It is shown loading a turned part into a gauging station (courtesy of Cincinnati Milacron).*

APPLICATIONS- MACHINE LOADING

Figure 7.3 *A numerically controlled lathe with a built-in loading robot (courtesy of Cincinnati Milacron).*

APPLICATIONS- PALLET LOADING AND UNLOADING

- Stacking boxes, sacks of cement or bricks on a fork-lift pallet in a stable and space-efficient way requires the robot to put each item in a different place.
- A point to point robot can be taught or programmed all these locations individually.
- A step-and-repeat facility is sometimes provided so that as long as the stack is regular it is necessary only to teach the first position, the increment and the number of steps in each direction.

APPLICATIONS- PALLET LOADING AND UNLOADING

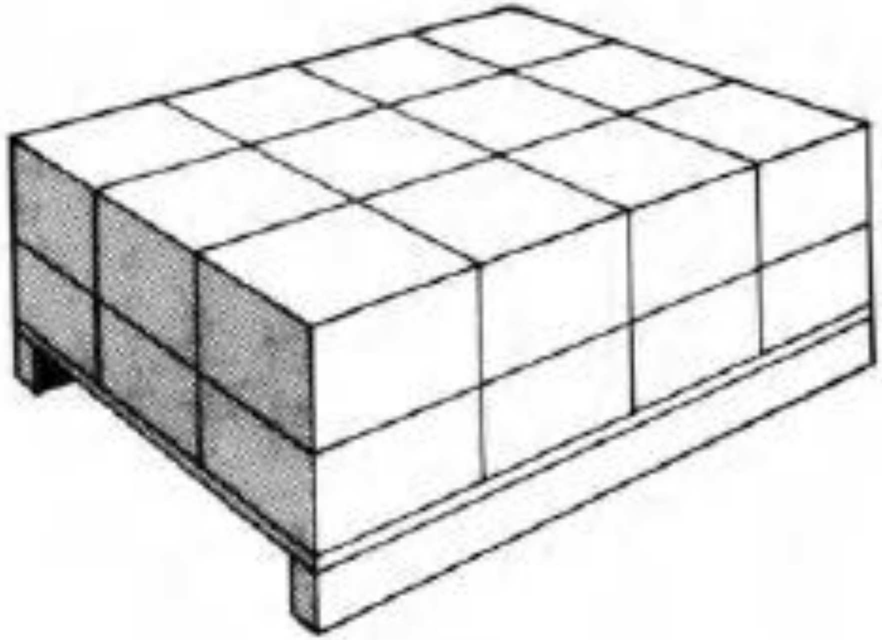


Figure 7.4 *Arrangement of boxes on a pallet: each must be placed in a different position, and often there is more than one orientation needed to pack the maximum number of boxes in.*

APPLICATIONS- PALLET LOADING AND UNLOADING

- A practical problem with palletizing is the gripping of the objects in such a way that the gripper does not collide with the items already in place .
- Special grippers with thin blade-like jaws can be designed; also, instead of dropping each object straight down it can be brought in with a slight sideways movement; another way is to grip the object by its top surface with a suction gripper.

APPLICATIONS- PALLET LOADING AND UNLOADING

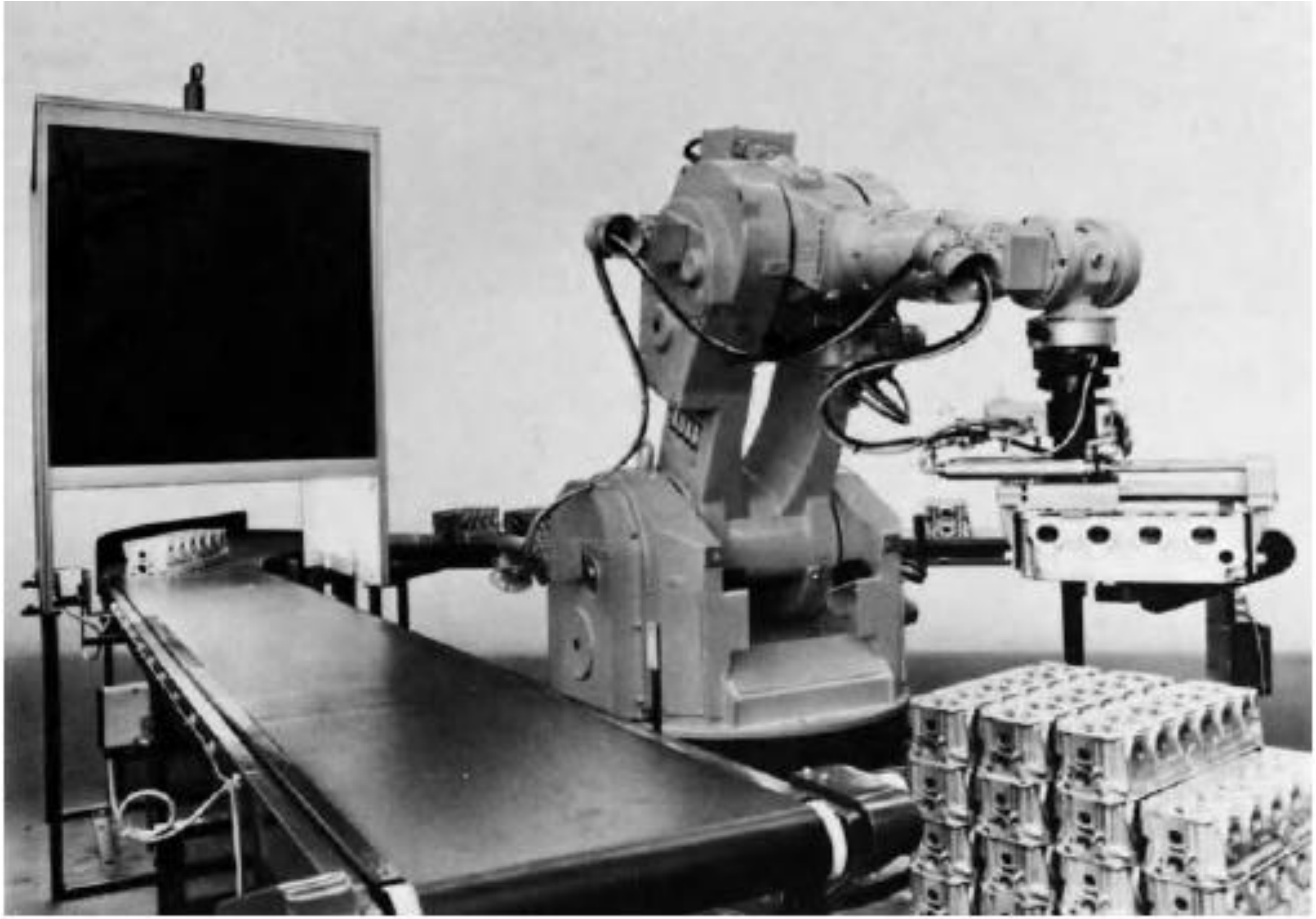


Figure 7.5 *A KUKA IR 160/60 palletizing cylinder heads (courtesy of KUKA Welding Systems & Robots Ltd).*

APPLICATIONS- INVESTMENT CASTING

- This uses the lost-wax process: a wax pattern is made on which a mould is formed by repeatedly dipping the pattern in a ceramic slurry until a thick coat is built up; the ceramic is fired in a kiln (after the wax has been melted and run out); metal is cast in the ceramic mould; and finally the mould is broken to release the casting.
- The stage of repeatedly dipping the pattern in the slurry has been done by robot.
- The only unusual feature is that the mould has to be spun to spread the slurry evenly over the surface and throw off any excess.
- This is done by a special gripper incorporating a spin motor.

APPLICATIONS- SPOT WELDING

- The spot welding of car bodies is the most well-known use of industrial robots.
- Twelve Cincinnati Milacron HT 3 robots on each line together make 300 spot welds on each body shell; this line can handle 43 bodies an hour.

APPLICATIONS- SPOT WELDING

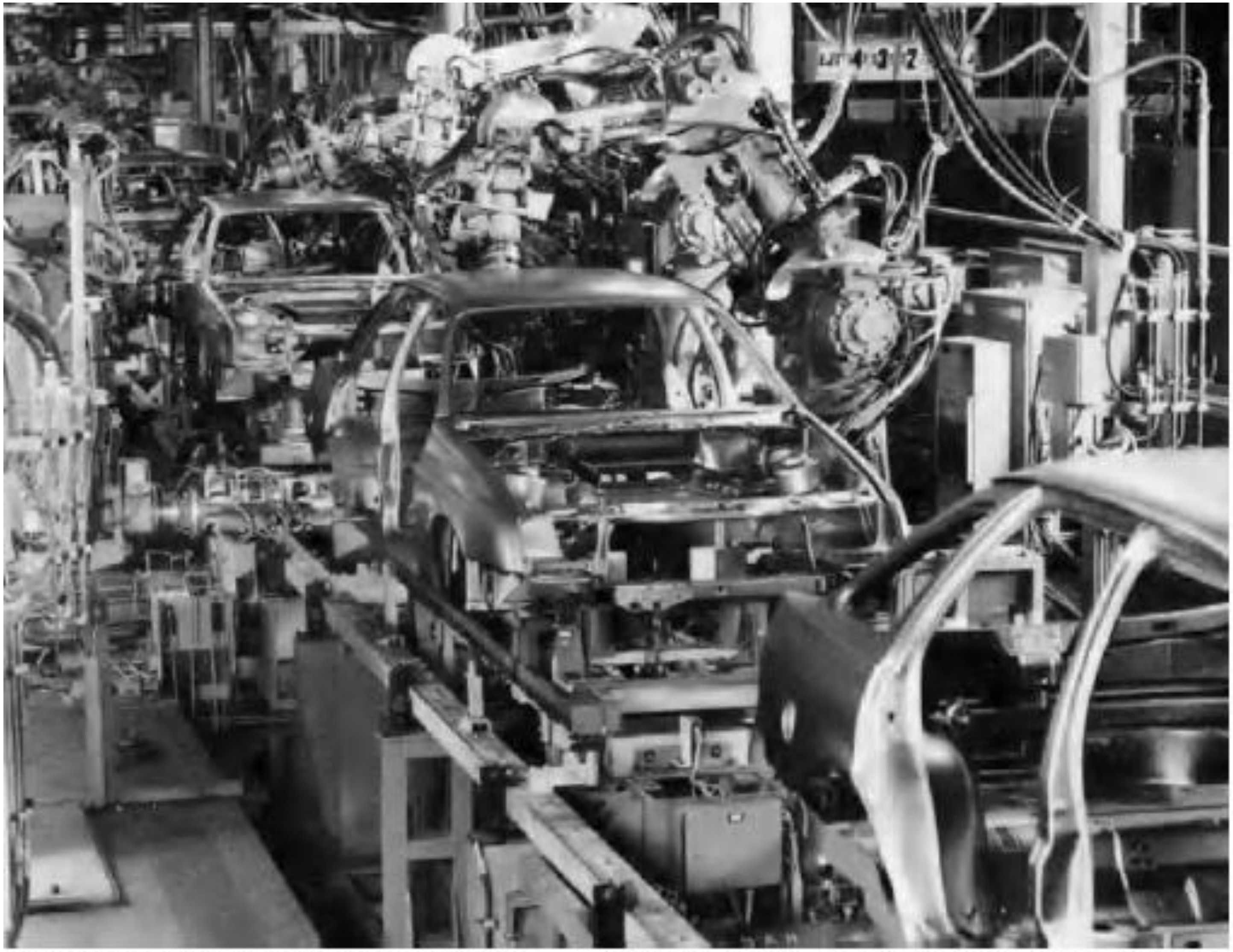


Figure 7.6 *A car body spot welding line — Ford Sierras being welded by Cincinnati Milacron HT^3 robots (courtesy Cincinnati Milacron).*

APPLICATIONS- SPOT WELDING

- Spot welding is useful for moderately resistive metals such as mild steel, in thin sheets, two pieces to be joined are clamped between copper electrodes and enough current is passed through the point of contact to heat the steel to melting point by resistance heating.
- AC power can be used, and is applied for typically 1/5 s.
- The welding head needs thick cables and cooling hoses and can weigh as much as 100 kg, so a powerful robot is needed .
- Most of the time is spent moving between welds, so it needs to be fairly fast.
- Accuracy need not be extreme: a few millimeters may be good enough.

APPLICATIONS- SPOT WELDING

- Spot welding is done both on static assemblies on indexed conveyors or AGVs and on assemblies on continuously moving lines;
- in this case the robot must be capable of being taught on a static assembly and then tracking a moving one.
- It will be able to make only a limited number of welds before the assembly moves out of the tracking window.

APPLICATIONS- ARC WELDING

- Arc welding uses metal-inert gas (MIG) technique.
- An arc is struck between the work piece and a wire of filler metal which is slowly extended as it is consumed.
- It is surrounded by a tube through which argon or helium is blown to protect the weld area from the oxygen and nitrogen of the atmosphere, both of which can combine with the weld metal at the temperature of an arc.
- Arc welding can be used with a wide variety of metals including aluminium alloy and stainless steel.
- Typical arc conditions are 100 A at 20 V and a gap of several millimetres.

APPLICATIONS- ARC WELDING

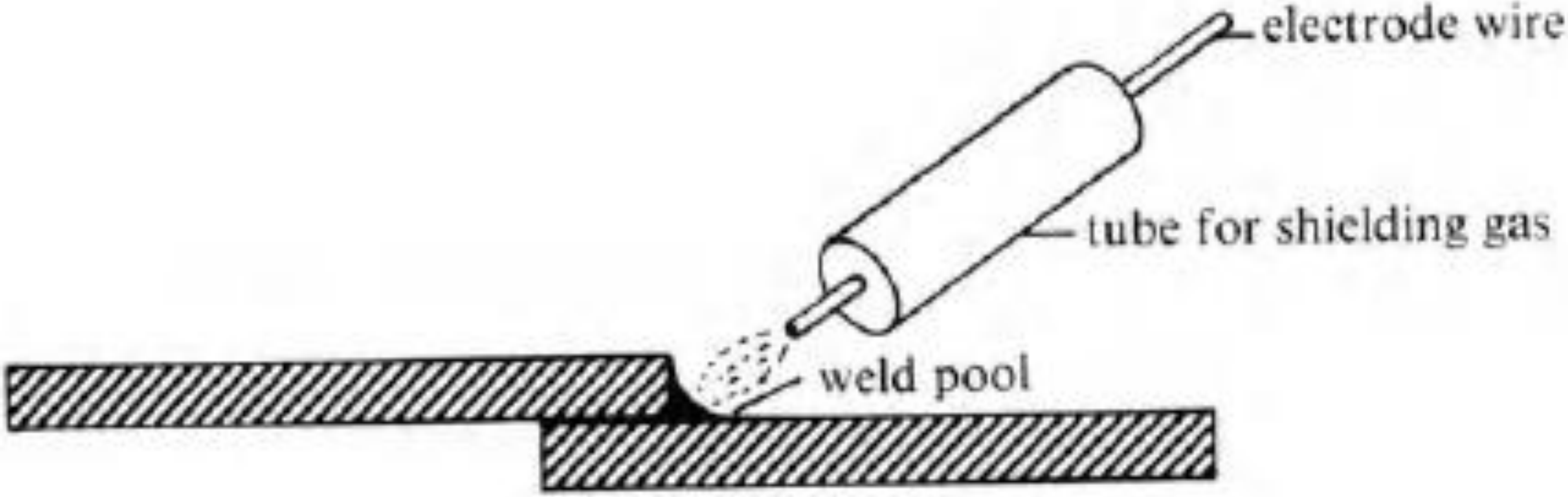


Figure 7.7 *The basic arrangement for arc welding.*

APPLICATIONS- ARC WELDING

- In arc welding the electrode is often oscillated at right angles to the seam or moved in small circles; this is called weaving and is needed to make the weld of adequate width.
- Also, several passes may be made along the seam to build up the thickness of the weld.
- Therefore welding robots have facilities for weaving and multiple passes.
- Circular joints must often be welded, so software for this is also provided.
- An alternative is to mount the work piece on a rotary positioning table and to rotate it while welding.
- Arc welding obviously needs a robot with continuous path control.

APPLICATIONS- ARC WELDING

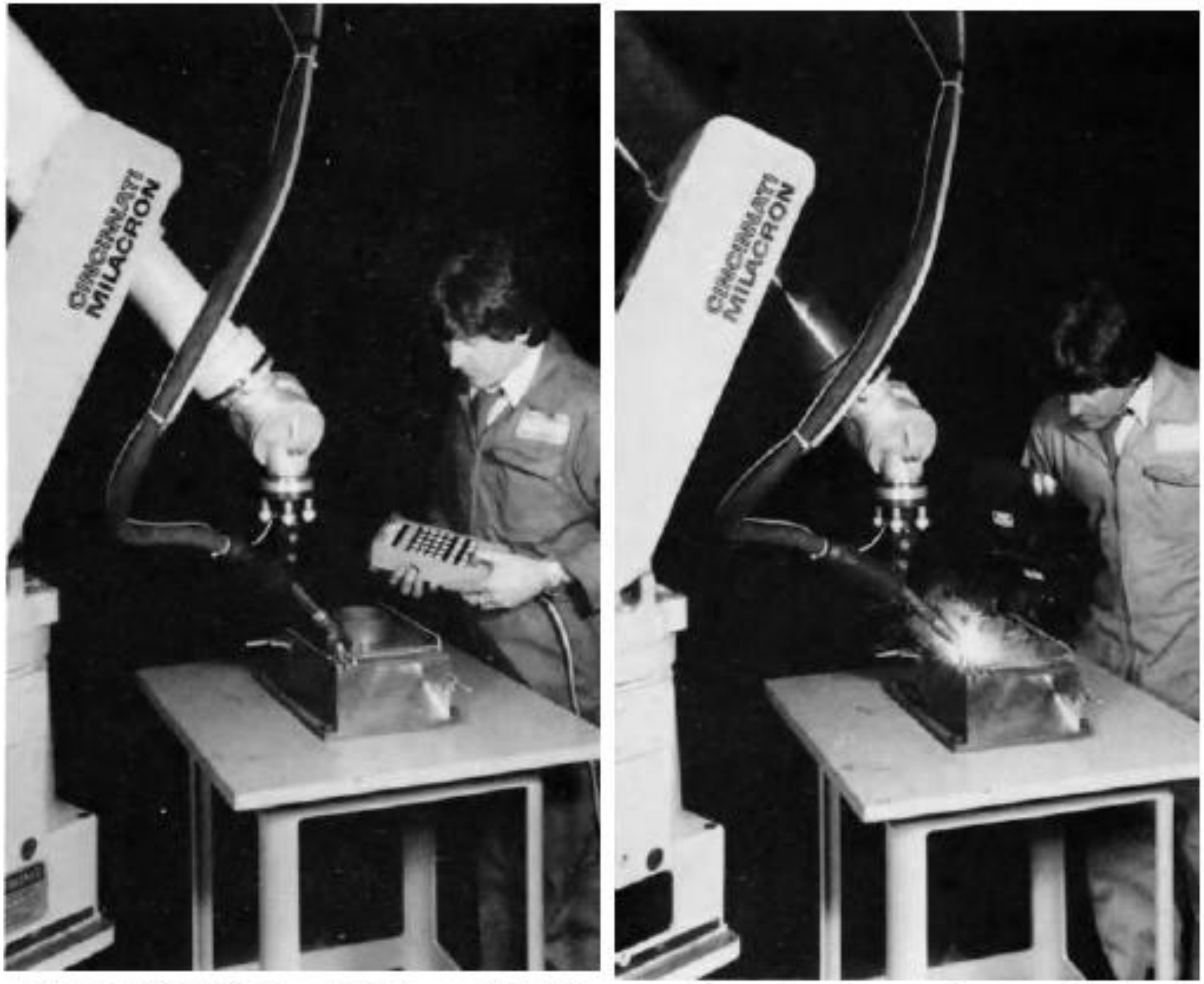


Figure 7.8 *A Cincinnati Milacron* T^3*–726 arc welding a circular seam (courtesy Cincinnati Milacron).*

APPLICATIONS-SPRAYING(PAINT, ENAMEL, EPOXY RESIN AND OTHER)

- Because many pigments and solvents are poisonous, the automation of paint and other types of spraying is desirable for health reasons as well as for reasons of economy and consistency.
- Continuous path robots are needed, but need not be very precise.
- Since the solvent-laden atmosphere is potentially explosive, precautions have to be taken to avoid sparks.
- The work pieces often move on a continuous conveyor, so the ability to program or teach on a stationary work piece and then to reproduce the action while tracking a moving one is commonly needed.

APPLICATIONS-SPRAYING(PAINT, ENAMEL, EPOXY RESIN AND OTHER)

- The number of degrees of freedom needed depends on the work piece: for spraying flat panels on one side a rather simple robot can be used, whereas to reach into the interior of a car body shell requires a more dexterous one, such as the Spine robot (Figure 7.10), whose unusual geometry allows it to reach like a snake or elephant's trunk through small openings.

APPLICATIONS-SPRAYING(PAINT, ENAMEL, EPOXY RESIN AND OTHER)

(a)

APPLICATIONS-SPRAYING(PAINT, ENAMEL, EPOXY RESIN AND OTHER)

(b)

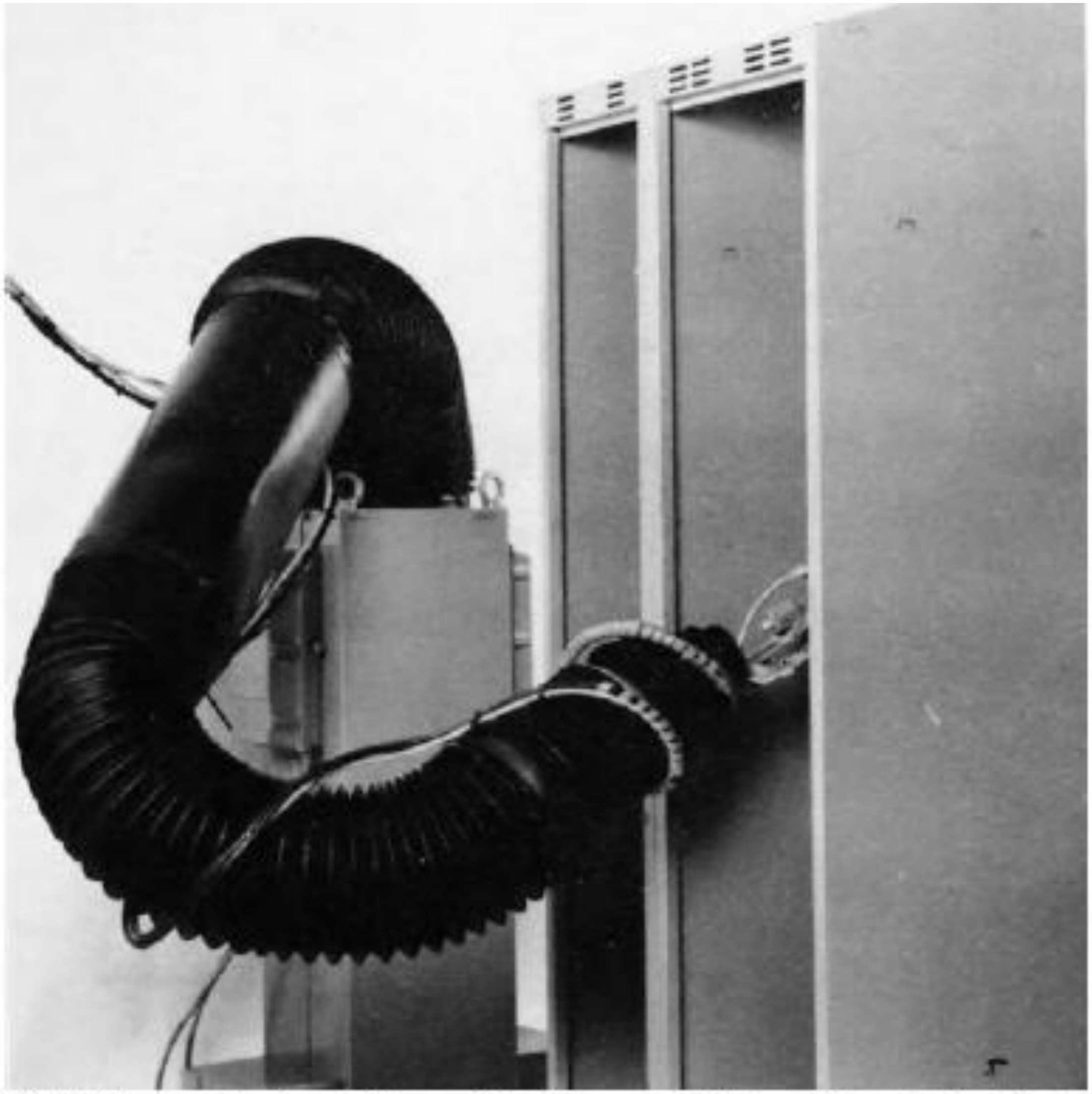


Figure 7.10 *Paint spraying by a Spine robot: (a) a van interior; (b) a steel cabinet (courtesy Spine Robotics).*

APPLICATIONS-SPRAYING(PAINT, ENAMEL, EPOXY RESIN AND OTHER)

- The successful use of robots for spraying depends very much on care of the spraying equipment to avoid clogging, mixing of colors and so on.
- Spraying robots are generally taught by lead-through or walk-through, sometimes using a teaching arm.
- When the stored program is replayed the actual movements can be modified by feedback from a conveyor so as to track a moving work piece.

APPLICATIONS-FETTLING (GRINDING, CHISELLING); POLISHING

- In fettling (trim or clean the rough edges of (a metal casting or a piece of pottery) before firing) and polishing the robot either applies a power tool to a fixed work piece or holds the work piece and presses it against the tool; which of these is done is dictated by the size and weight of the tool and work piece.
- A grinder may be powered by a motor of 20 kW or more, which is too heavy for most robots.
- If an object is to be polished all over by holding it against a wheel or belt, it will have to be put down in a jig and re-grasped so that the part by which it was originally held can be polished; this might be termed the Achilles' heel problem.

APPLICATIONS-FETTLING (GRINDING, CHISELLING); POLISHING

- In grinding it is often necessary to follow the edge of, say, a casting.
- The amount of metal to be removed can vary along the edge; one way of coping with this is to mount the robot-held tool in a resilient suspension which exerts a constant grinding force, with the tool free to move until it comes up against a stop.
- The robot is programmed with a path which follows the edge of the casting, and must move slowly enough for the tool to grind its way to the stop at every point along the path.
- Fettling by robot is important because it is an unpleasant and unhealthy job: dirty, noisy and dangerous.

APPLICATIONS-FETTLING (GRINDING, CHISELLING); POLISHING

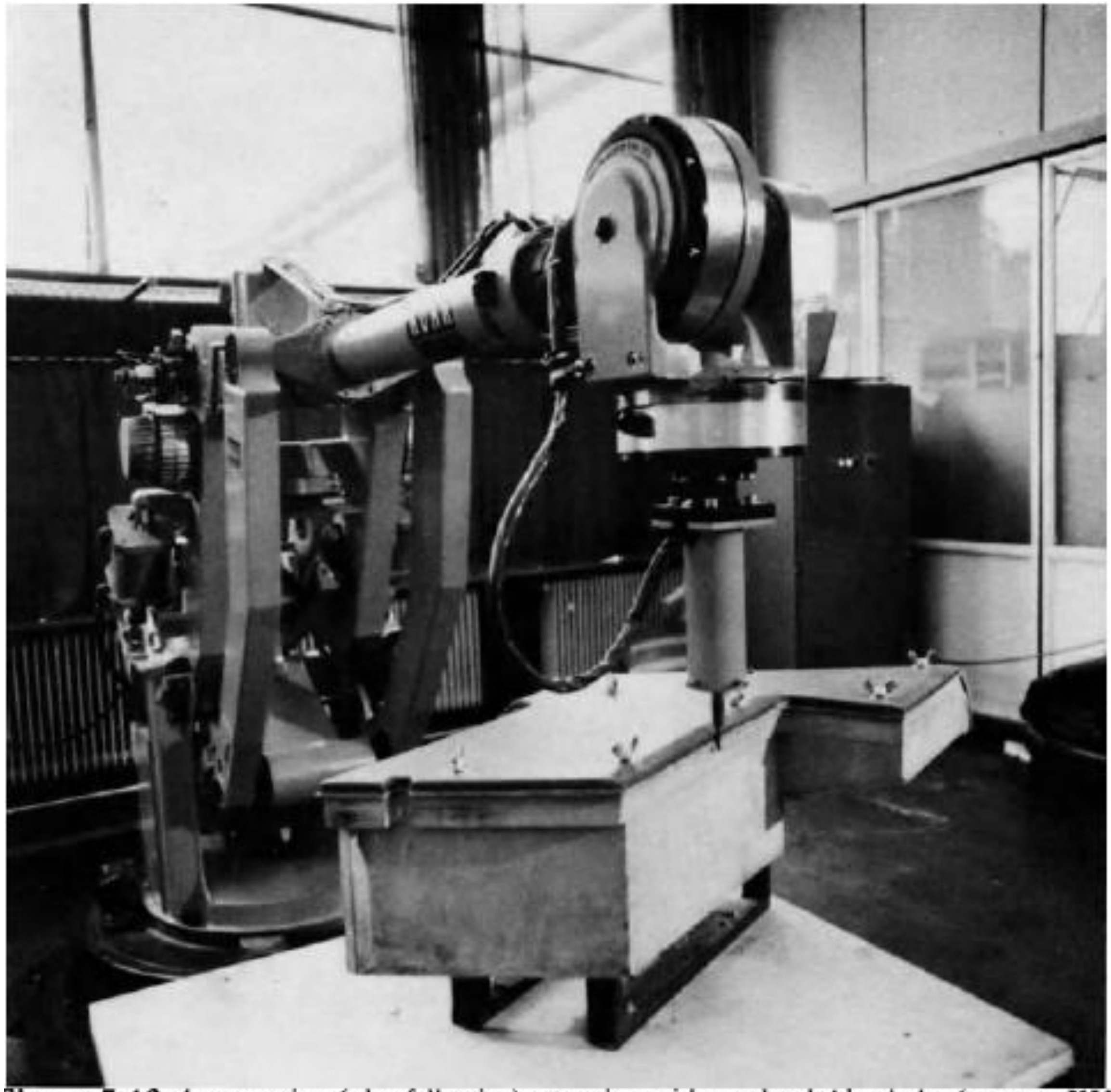


Figure 7.12 *A contouring (edge-following) operation with a robot held grinder (courtesy KUKA Welding Systems & Robots Ltd).*

APPLICATIONS- CUTTING

- Robots are used for flame, laser, plasma torch and water jet cutting.

Figure 7.13 *Cutting to shape of glass reinforced plastic crash helmets with a high pressure (3000 bar, 50,000 psi) water jet. The process produces a clean surface without creating injurious dust (courtesy of Cincinnati Milacron).*

APPLICATIONS- CUTTING

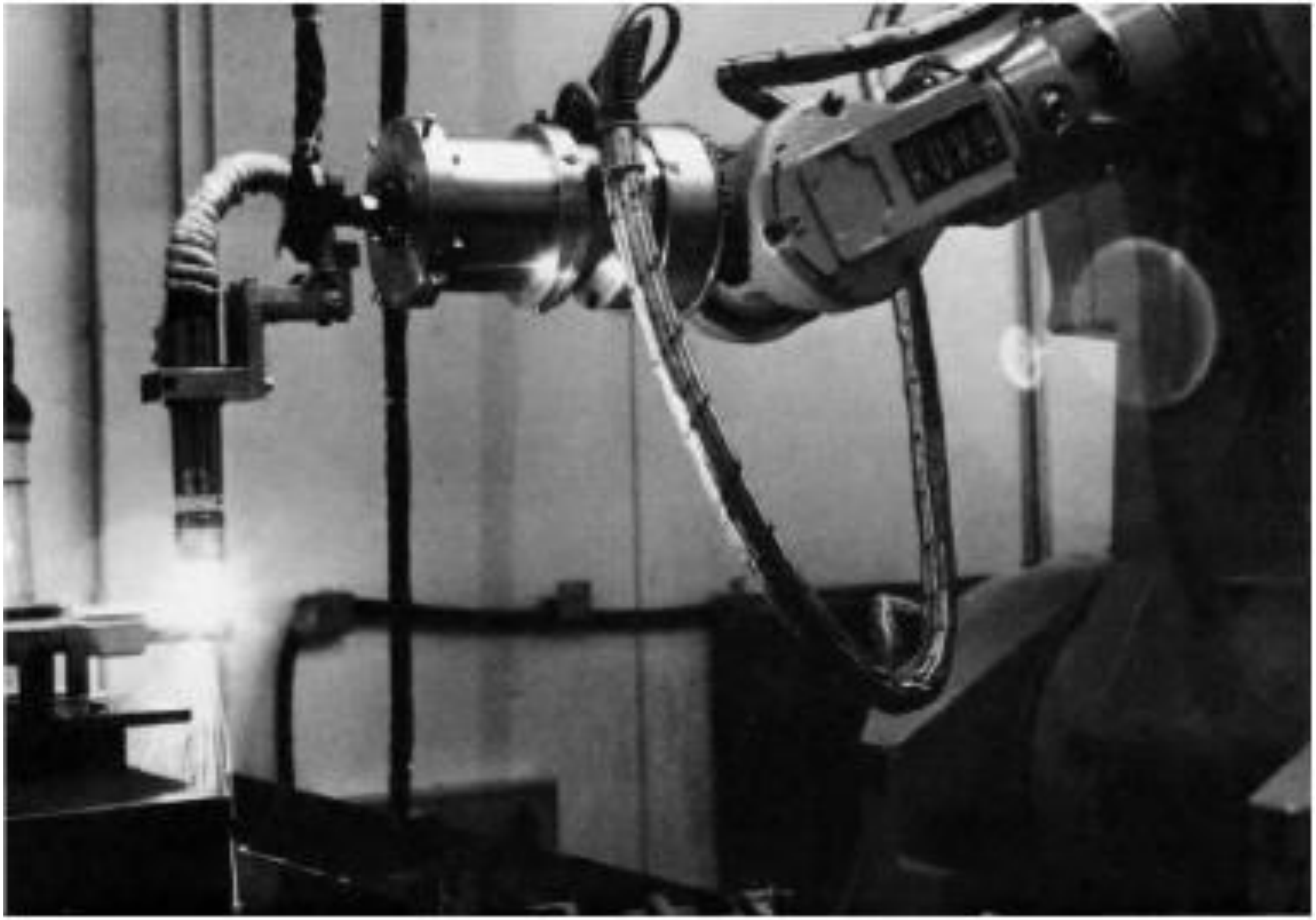


Figure 7.14 *A KUKA IR 160/60 robot being used for plasma cutting (courtesy of KUKA Welding Systems & Robots Ltd).*

APPLICATIONS- INSPECTION

1. Establish the dimensions of an object by probing with a touch probe.
2. A camera for visual inspection.
3. A robot scans the surface of a laminated panel with an ultrasonic probe under water.

APPLICATIONS- INSPECTION

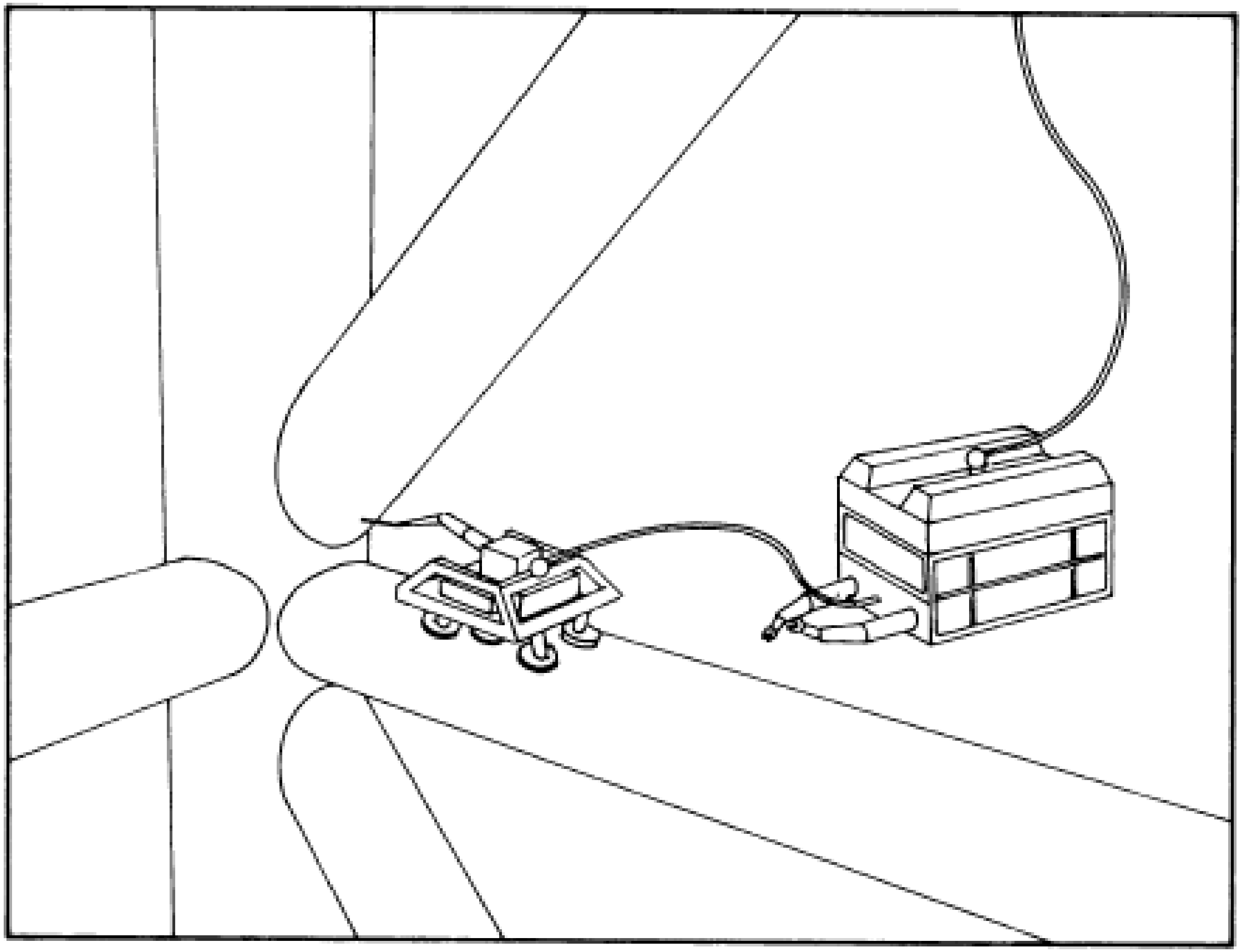


Figure 7.25 *Robotic inspection of welds in an underwater structure. The probe arm is carried to a welded junction by a crawling vehicle, which has been brought to one of the structural members by a remotely operated submersible, seen at right.*

APPLICATIONS-TRAINING AND EDUCATION; HOBBY ROBOTS

Need for robots in education and training:

1) training the workers who will use the robots in a specific factory;
2) teaching robotics as part of a certificate, diploma or degree course in engineering;
3) using a robot as a versatile and interesting peripheral when teaching computing in schools and adult education.

- Educational and/or hobby robots sacrifice performance for cheapness.
- They are generally powered by small stepper motors, which makes them fairly slow and of limited load capacity (a few hundred grams) but allows simple interfacing and software for the personal computers used to control them.

APPLICATIONS-TRAINING AND EDUCATION; HOBBY ROBOTS

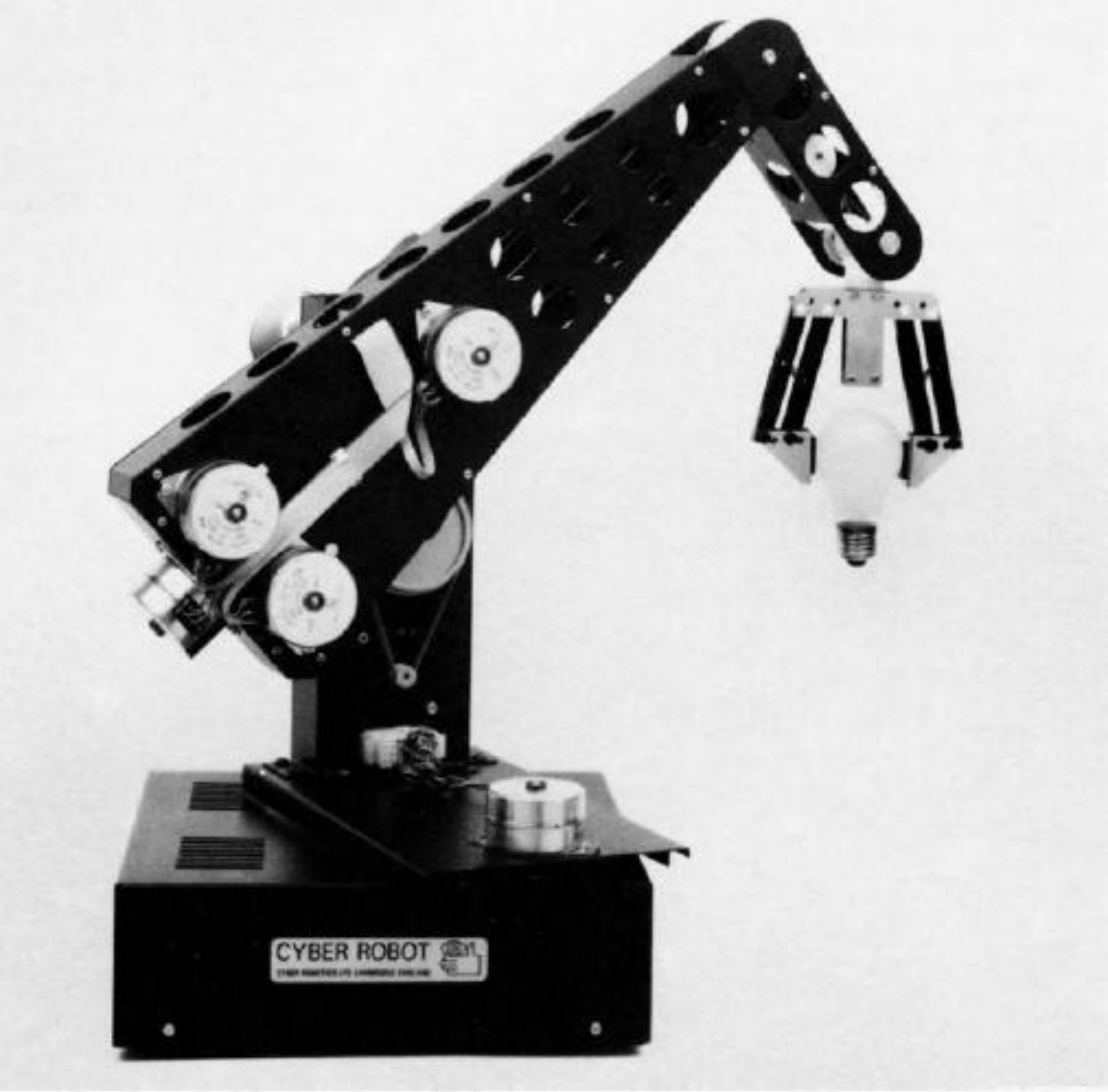


Figure 7.15 *An educational robot, the Cyber 310, it has a two axis wrist (courtesy of Cyber Robotics Ltd).*

APPLICATIONS-ROBOTS IN ASSEMBLY

- Hard Automation: using machines dedicated to the assembly of a single product.
- Disadvantage: production runs are short.
- Production runs of some products are shortening because the products become obsolete more quickly than formerly, and because they are made in many varieties.
- Pick and place arms, usually of cylindrical polar geometry, are often used as they are fast, relatively cheap and of high precision; a repeatability of ±0.02 mm (about ±0.001 in) is typical.
- Among servo-controlled robots, the Cartesian and SCARA configurations dominate.

APPLICATIONS-ROBOT TYPES IN ASSEMBLY

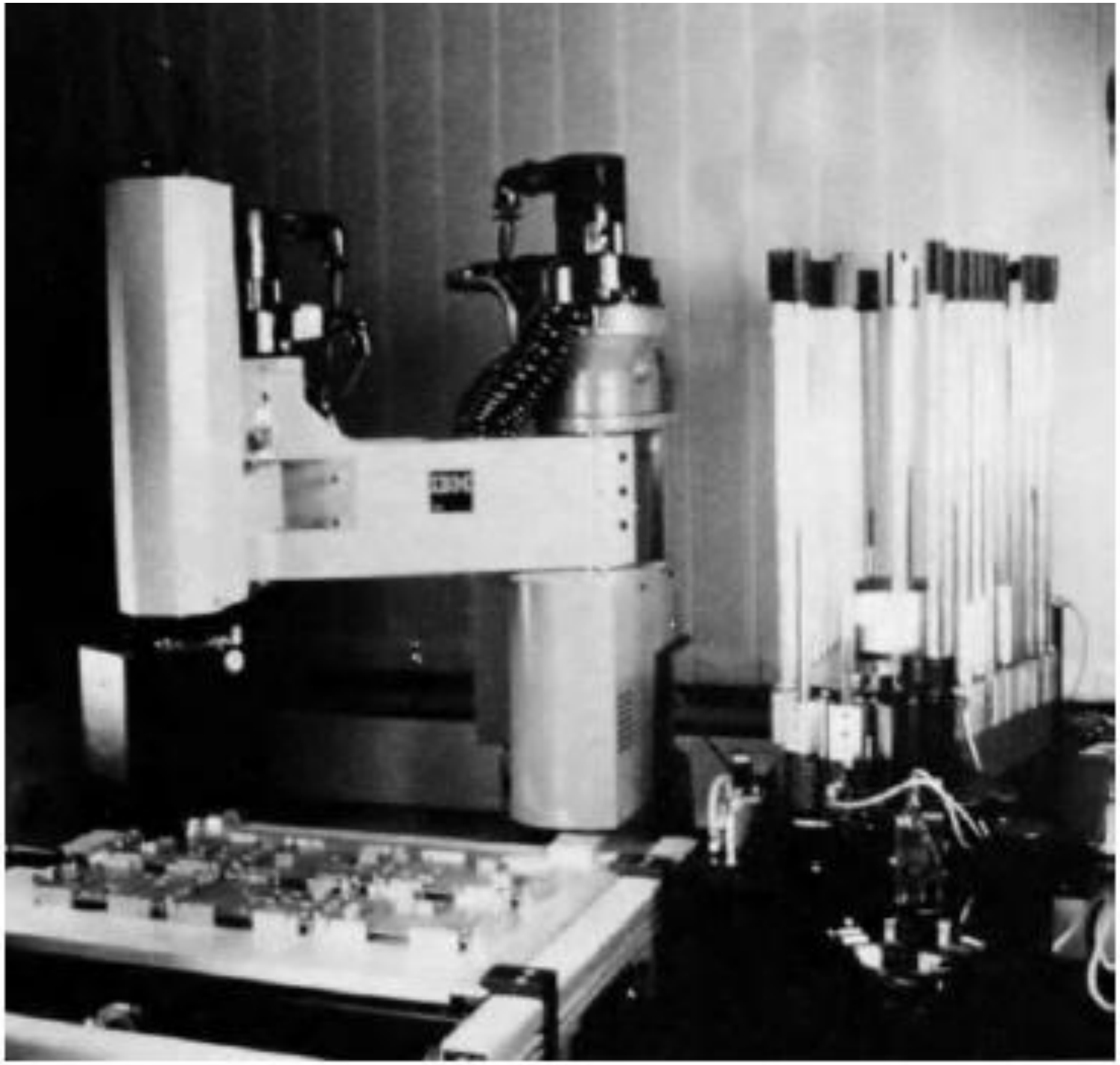


Figure 7.16 *The IBM 7545 robot (courtesy IBM United Kingdom Ltd).*

APPLICATIONS-ROBOTS IN ASSEMBLY-GRIPPERS

- The high precision with which the work piece must often be located relative to the partially completed assembly, and partly because components of several different shapes have to be handled.
- Sometimes there may be a robot for every component type; otherwise the robot must have several grippers on a turret, or be able to change grippers , or have a gripper which can adapt to different components.
- Circuit board filling (stuffing) demands very high accuracy: there may be a tolerance of only ±0.1 mm when inserting a wire in a hole.
- The gripper jaws have grooves on their inner faces into which the component leads fit.
- These must be aligned with the holes in the board before the component is pushed down by an axial piston (Figure 7.21).

APPLICATIONS-ROBOTS IN ASSEMBLY-GRIPPERS

- The leads are bent to the correct angle and cropped by fixed tooling before being picked up by the robot.

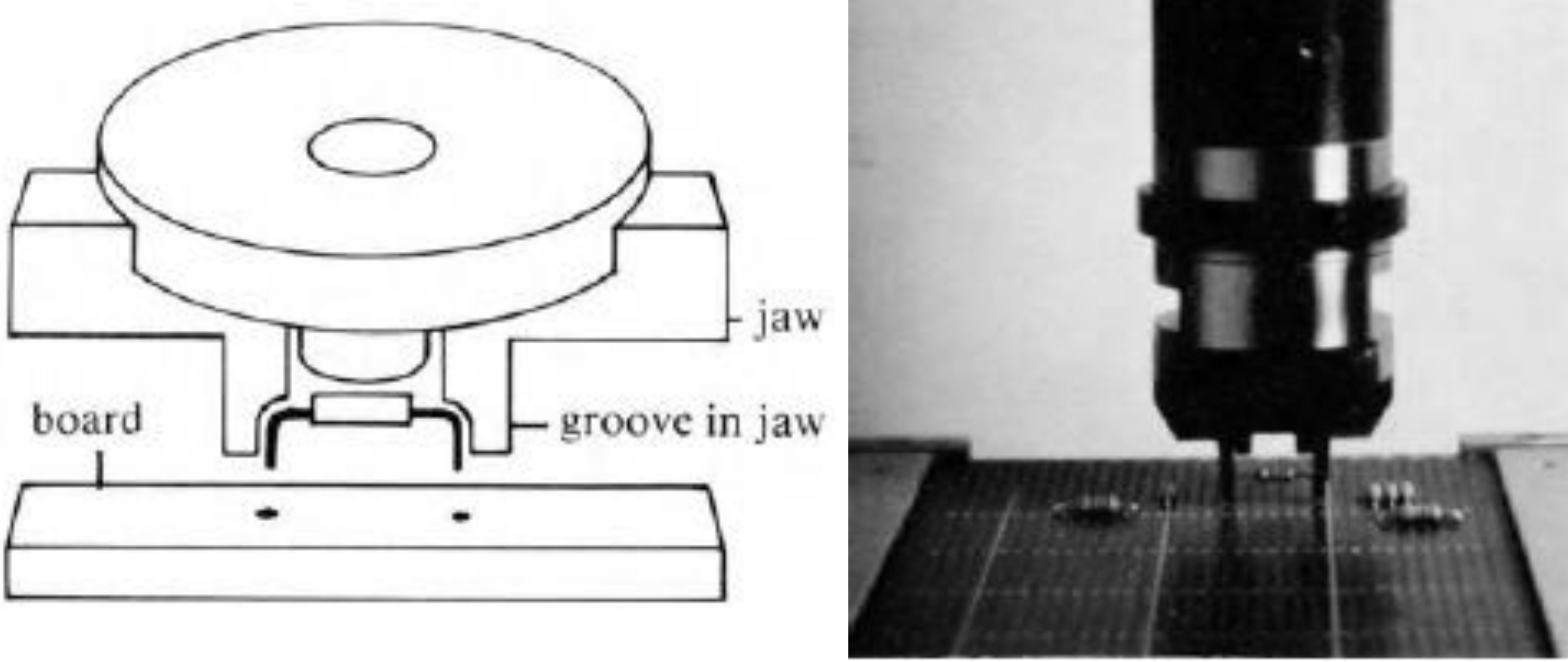


Figure 7.21 *A gripper design for insertion of resistors and diodes (courtesy IBM United Kingdom Ltd).*

APPLICATIONS-ROBOTS IN ASSEMBLY-GRIPPERS

Mechanical assembly, as opposed to circuit board stuffing, usually needs tools such as screwdrivers.

1. Tool changing from a magazine is relatively slow and presents interface problems;
2. a multi-tool end effector with a turret is bulky and heavy;
3. using one robot for each tool implies a large and expensive installation.

APPLICATIONS-ROBOTS IN ASSEMBLY-COMPLIANCE

- Assembly is where compliance (reciprocal of stiffness) is needed, particularly for inserting shafts into holes and fitting gears, bearings and so on onto shafts.
- The RCC device is one solution to this kind of problem but does not work for the sort of misalignment.

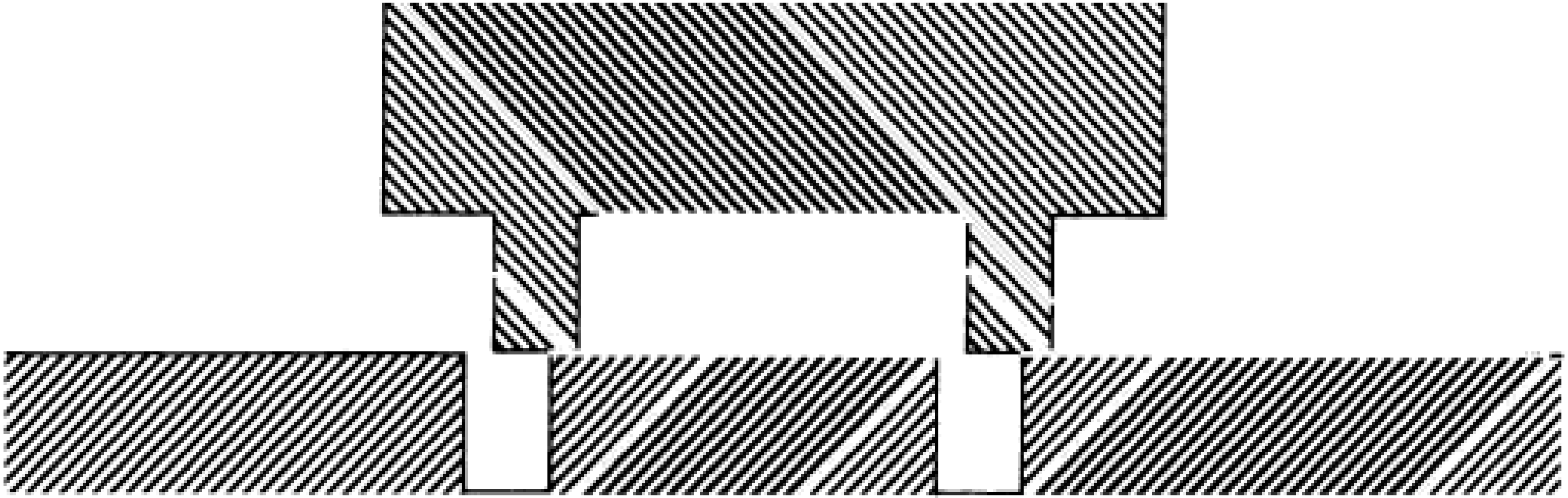


Figure 7.22 *Misalignment problem needing active compliance.*

APPLICATIONS-ROBOTS IN ASSEMBLY-COMPLIANCE

- The only solutions are to search blindly for the hole by moving the component in some pattern until it slides in, or to use visual sensing.

APPLICATIONS-ROBOTS IN ASSEMBLY- DESIGN FOR ASSEMBLY

- Always necessary to redesign a product if it is to be assembled by robots, since existing assemblies make use of human dexterity, visual sensing and intelligence to cope with objects that a robot would find hard to handle.
- Part numbers and types: To reduce the time taken to assemble the product, the total part count should be minimized.
- Similarly, within a single product there may be variations among components (e.g. several kinds of screw) which can be eliminated.
- Replacing these with a single type allows a reduction in the number of kinds of feeder and tooling, and eases stock control.
- It may be possible to reduce the part count by replacing several parts by one which combines their functions, such as a screw with a captive washer.

APPLICATIONS-ROBOTS IN ASSEMBLY- DESIGN FOR ASSEMBLY

- Component design for mechanical handling: Many conventional parts tangle easily or jam inside each other; this can be reduced by redesign

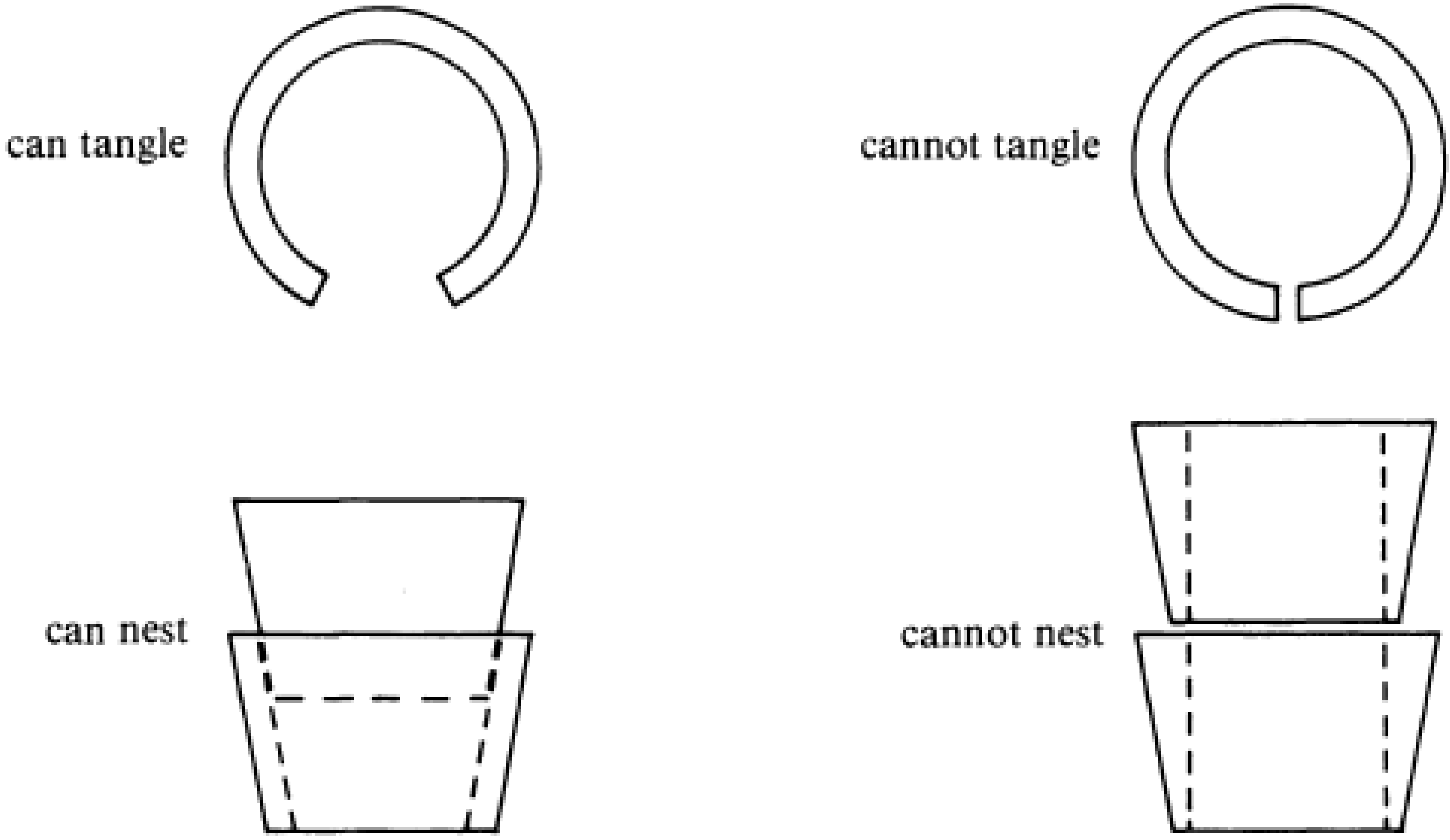


Figure 7.23 *Redesign of components to avoid tangling.*

APPLICATIONS-ROBOTS IN ASSEMBLY- DESIGN FOR ASSEMBLY

- Problems can arise with the automatic feeding of parts if there is no easy way of telling which way round a nearly symmetrical part should be.
- There are two cases.
- In the first only one end or face of the part is functional.
- In the second case if the other faces are made identical with the functional one it does not matter which way round the part is fitted.

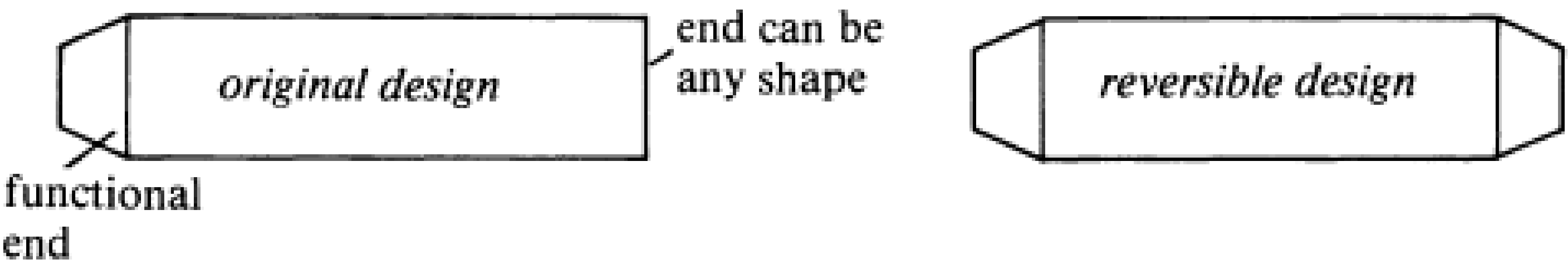


Figure 7.24 *Redesign of a part to allow it to be fitted either way round.*

APPLICATIONS-ROBOTS IN ASSEMBLY- DESIGN FOR ASSEMBLY

- Design of the assembly process: The human way of assembling a product should not necessarily be reproduced by a robot, since it is optimized differently.
- For example, the product should not have to be turned over while it is being assembled, as this needs an active jig.
- Parts should be added from a single direction if possible.
- The sequence of assembly should avoid wasted movements such as frequent tool changes.
- After assembly the product should be kept in a known orientation for further automatic handling, protected from damage and tracked as it progresses through the factory.

NEW APPLICATIONS FOR INDUSTRIAL ROBOTS

Several trends are apparent in the use of industrial robots, such as

1) the extension of existing methods to new applications,

2) the incorporation of more sensing, especially vision,

3) the increasing use of the methods of AI,

4) attempts to handle more difficult work pieces, which are flexible (Eg. Sponge, Cloth, Wires, Ropes, Threads or Tubes, compressible or elastic materials, meat, live animals, fruit picking in plants) or of irregular or varying shape.

NEW APPLICATIONS FOR INDUSTRIAL ROBOTS

Some tasks involving such objects and materials are as follows:

1) cloth cutting, joining and other handling,

2) handling flexible electrical wires (stripping, soldering, crimping, welding, labeling and tying into looms),

3) laying glass fiber reinforcement,

4) sheep shearing,

5) crop harvesting,

6) loading textile machinery.

SUMMARY

1. Definition for Automation and Robotics
2. Classification of Automation (Fixed, Flexible and Programmable)
3. Classification of Robots
4. Need for Industrial Robots
5. Economic costs and benefits of installing Industrial Robots
6. Safety and Environmental factors
7. Social Issues
8. Applications of Industrial Robots