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IMPROVED MANIPULATION DEVICES FOR USE IN SMALL ENCLOSURES

By

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ABSTRACT

The increasingly stringent safety and handling requirements associated with higher burn up fuels are leading to the need for many of the traditional hands-on operations to be undertaken remotely. With these requirements has come the need to make progressive improvements to existing equipment and to examine the handling requirements for the future, with a view to reducing the capital cost of plant as well as improving the reliability of the equipment, thereby reducing the dose uptake by operators.

The paper describes the recent UK development for the replacement of the gloved hand with a tong type device with more degrees of freedom, and a teleoperator development known as the Elite. The latter would permit a radically different and smaller design of cells. Finally, the role and future of industrial robots are examined as the ultimate replacements for the gloved hand.

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INTRODUCTION

1. The gloved hand has been extensively used to carry out manipulative tasks involving toxic and alpha emitting materials within sealed enclosures. Gloves are extremely cheap devices providing high dexterity with a minimal maintenance requirement. Close proximity to the active material in terms of dose rate can be offset by the rapidity of operations together with negligible maintenance to minimise exposure times.

2. Against this background the necessity to handle materials with significant levels of alpha and neutron emission, the increasing stringency of regulations regarding airborne contamination and internal doses and the apprehension of operators have led to the quest for remote handling devices to replace the use of the gloved hand in small shielded and sealed enclosures.

3. This paper describes two developments currently underway at Harwell, the direct replacement of the glove with an 'In-Line' manipulator and the use of a remotely controlled teleoperator, the 'Elite'. Another possible approach, the use of commercially available robots, is also considered.

THE IN-LINE MANIPULATOR

4. The In-Line Manipulator can be considered as one of the first steps towards remote handling in gloveboxes. The primary objective is to provide a device with sufficient dexterity to carry out some glovebox operations and which can physically replace a glove, and thereby be fitted to existing gloveboxes. A survey was made of a number of glovebox installations to determine the range of tasks performed. This resulted in the following requirement specification:

Capacity:	5kg
Reach:	Available to 900mm maximum
Vertical pivot:	$\pm$ 45°
Horizontal pivot:	$\pm$ 45°
Arm rotation:	continuous
Wrist pivot:	+80°-100°
Wrist rotation	continuous

10. In order to ensure that the In-Line Manipulator is an economically viable replacement for a glove, the aim is to achieve a final batch manufacturing cost of less that £3K per unit.

THE 'ELITE' TELEOPERATOR

11. The Elite concept is being pursued in family form. The smallest member is the Elite 1 (Figure 3) which is aimed primarily at the handling and preparation of samples for metallographic examination. The Elite 1 is a free standing device which can be inserted through a standard posting port and be remotely operated. Larger members of the family comprise the Elite 4 and the the Elite 10 which are roof mounted and should be considered together with their enclosures as cell systems for handling, for example, large batch quantities of re-cycled plutonium.

THE ELITE 1

12. The basic specification for the ELITE 1 is:

Load:	0.4kg
Reach:	300mm from the slewing axis
Vertical:	410mm
Wrist Tilt:	$\pm 100^{o}$
Forearm Rotation:	continuous
Finger Rotation:	continuous
Slewing:	400^{o}
Speed:	2 cms/second linear movement.

13. The ELITE 1 slave arm is operated remotely through controlling electronics and a master unit. The ELITE 1 slave arm can therefore be viewed directly through a shielded window or by means of CCTV in order to obtain visual feedback.

14. The ELITE 1 features six degrees of freedom together with a jaw grip, see Figure 4. All motions except the jaw grip are driven through an electro mechanical system involving gear trains, linkages and stepper motor drives. The jaw gripper is driven by compressed air and is actuated by a solenoid in the control system. The slave arm has a maximum radial reach of 300mm, and a vertical reach of 410mm. The load capacity of the slave arm is 0.4kg. The slave arm can be driven at a linear speed of 20mm/second and possesses a nominal positioning accuracy of 0.1mm.

proof AC motor connected to the individual motion drives via magnetic particle couplings see Figure 6. The slave arm is fully gaitered to protect it from contamination.

19. Remote control is effected by joystick or master arm control in the same manner as the ELITE 1 and with a microprocessor interface which permits teach and repeat operations.

THE ELITE 4

20. The Elite 4 will be very similar in construction to the Elite 10 with the exception that individual drive motors will be used for each degree of freedom. Its capacity will be 4 kg and its range of operation half of that of the Elite 10.

THE ACTIVE APPLICATION OF INDUSTRIAL ROBOTS

21. The ability to use commercially available and industrially proven devices in active areas has potentially offered a cost effective solution to active handling problems. However when considered against custom built equipment the industrial robot has severe limitations in the following areas:

Control
Reliability
Maintainability
Radiation Hardness
Contamination Protection
Decontamination

22. Industrial robots are supplied with what their vendors would consider a sophisticated control system but on investigation proves to be rather limited. A teach and repeat operating mode is the norm for robotic applications and the manual control facility is used during the teach process and is essentially of a push button nature. The nuclear requirement is primarily as a teleoperator with little application in the repetitive mode; the control system has therefore to be interfaced with a master arm or joystick to provide a satisfactory teleoperator image. The safety features of the control system are also very limited, the prime consideration of the robot manufacturer being to protect the operative rather than any equipment. Additional control functions have therefore to be provided to protect against spurious movements caused by component failures and to enable 'no-go' zones to be programmed.

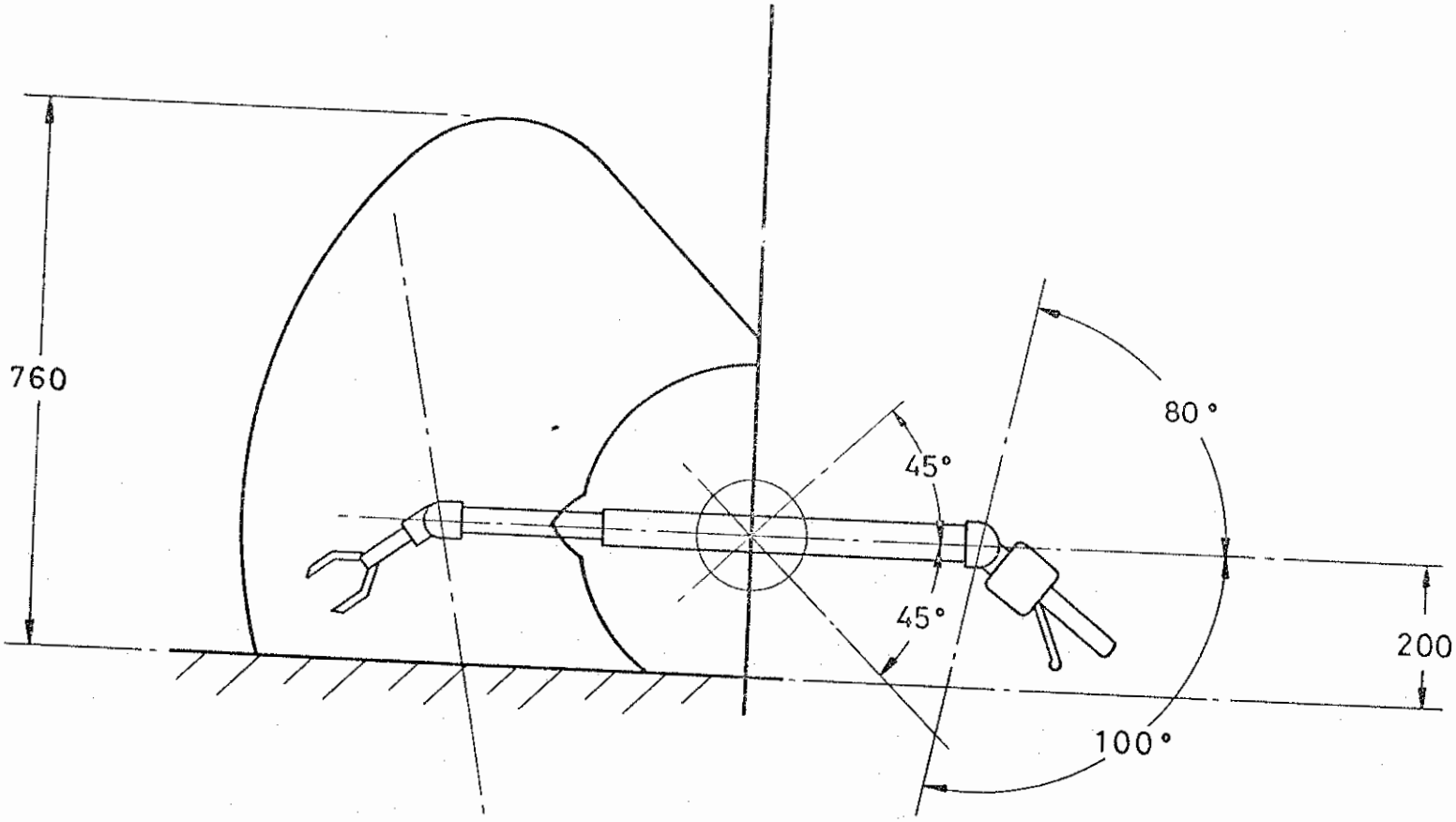
CONCLUSIONS

26. The In-Line manipulator will provide a relatively cheap solution to the requirement to provide remote handling in gloveboxes as it can directly replace a glove in existing facilities. The development programme is well advanced and delivery of preproduction models is expected by mid-summer 1984 and will then be available for demonstration. Licencing for manufacturing and marketing should be arranged by the end of the year.

27. The ELITE 1 can provide a light duty dextrous function in existing shielded cells. A development programme to finalise the design and evaluate the performance should be complete by October 1984 and the delivery of the first machine is scheduled for June 1985.

28. The Larger ELITE concept is being actively pursued in the form of the ELITE 4. Outline Designs are expected to be completed by the end of the year. This project is aimed at the design of future shielded facilities.

29. Industrial robot applications are being investigated at Harwell and knowledge and experience is being gained on the conversion of robots and their control systems to active system standards.



Dimensions in mm

FIG. 2 IN LINE MANIPULATOR COVERAGE – SIDE ELEVATION IN PLANE OF SPHERE

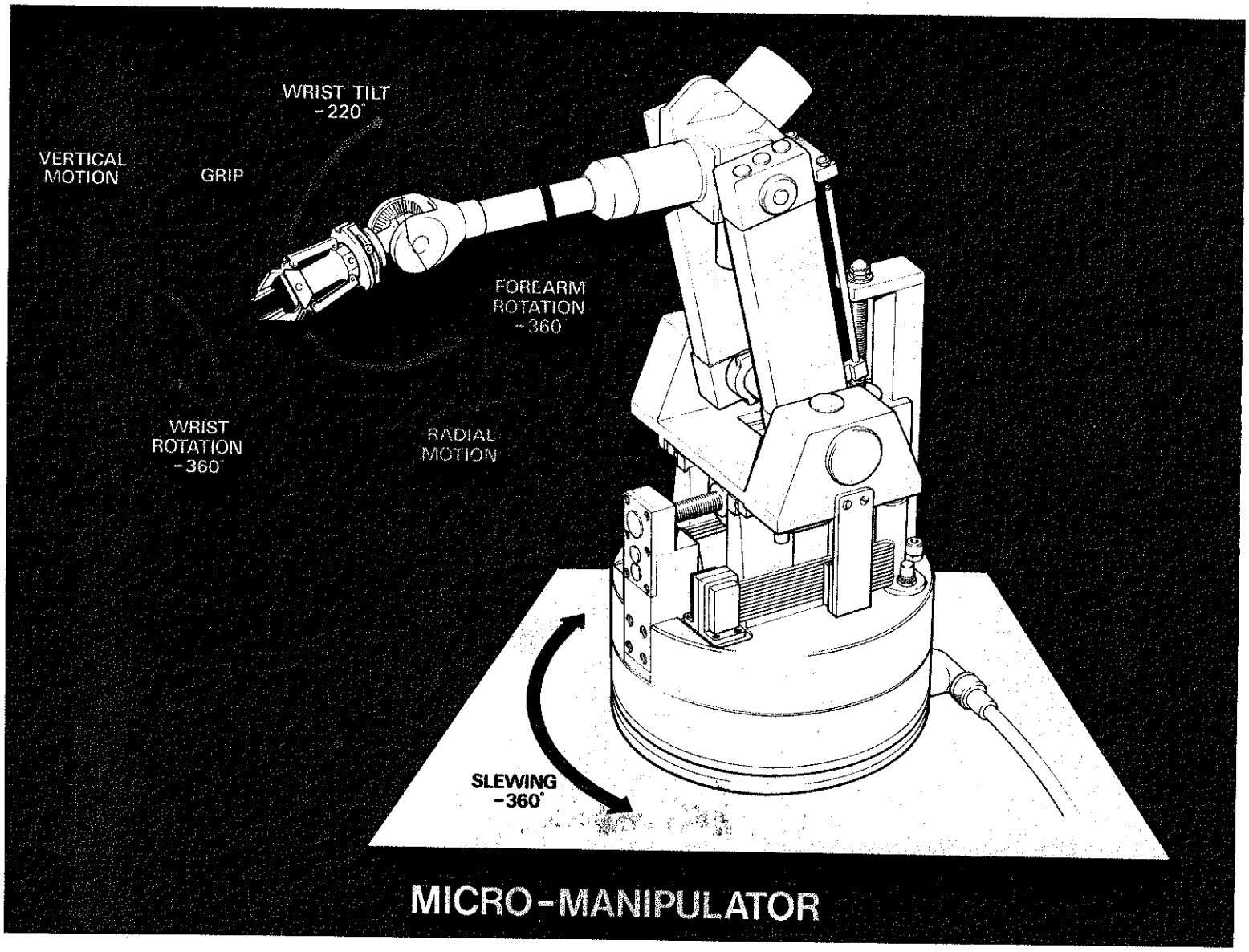


FIGURE 4 - ELITE 1 DEGREES OF FREEDOM

ELITE 10
10 Kg TELEOPERATOR

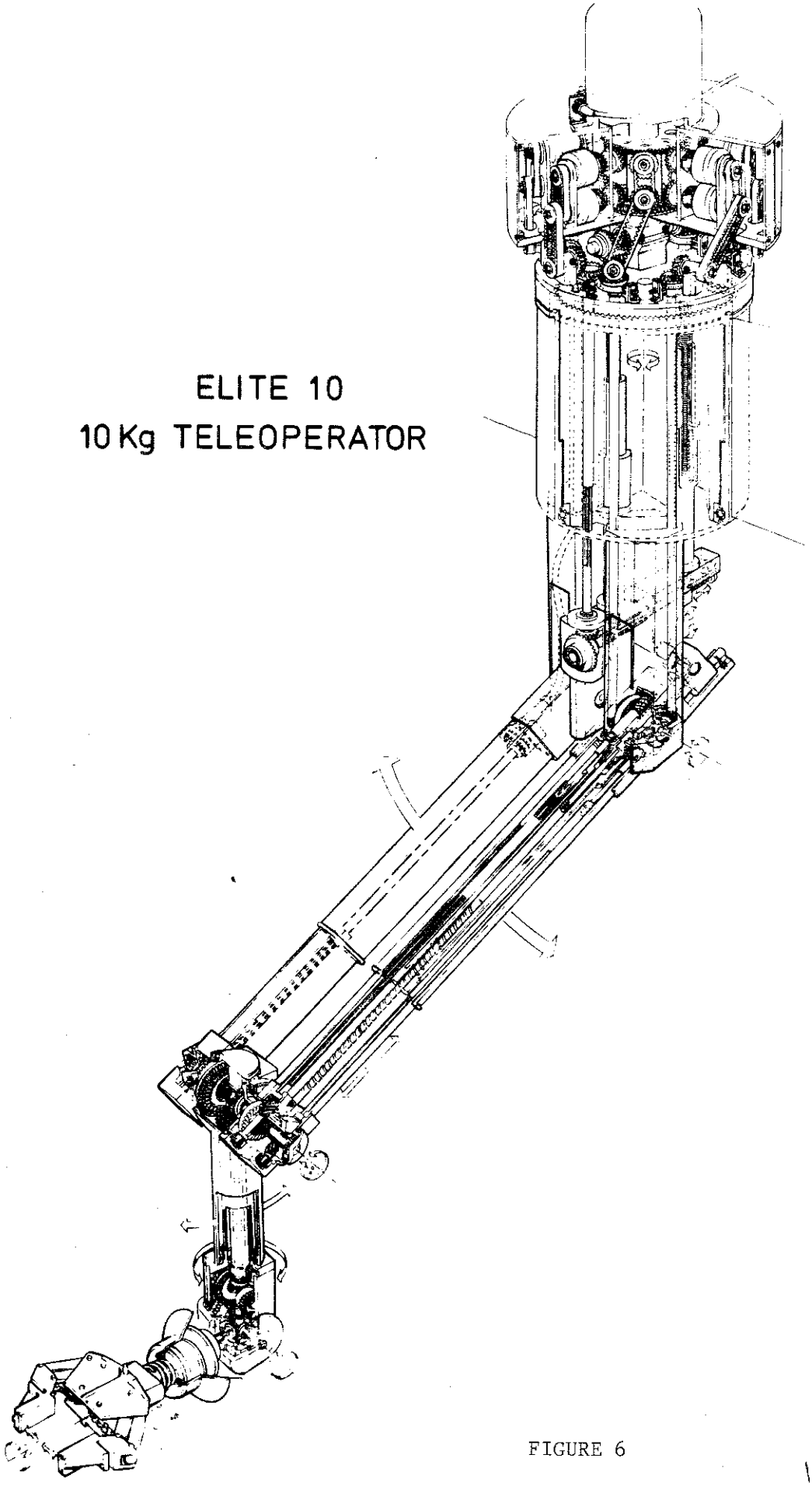


FIGURE 6