

Refurbishment of Shielded Facilities in the UK

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SUMMARY

Most of the shielded facilities in the UK were constructed in the 1960's and in recent years substantial refurbishment has taken place in order to bring them up to current standards. This paper provides examples of the type of work that has been carried out at 3 establishments in the UK to meet this requirement.

INTRODUCTION

This paper deals with aspects of refurbishment of Shielded facilities in 3 UK establishments. In part 1 selected items of the work carried out to enable the cave line at Berkeley Nuclear Laboratories (BNL) to handle fuel elements from Nuclear Electric's Advanced Gas Cooled Reactors (AGR) are described. In part 2 the refurbishment of part of the cave line in building B13 at Windscale to provide a metallographic facility and waste handling facilities is presented, and in part 3 a system for the introduction of a service plug into a sealed and shielded cave at Dounreay, without man entry, is set out.

PART 1

PREPARATION OF THE CAVE LINE AT BNL FOR THE RECEIPT OF AGR FUEL ELEMENTS

1. BACKGROUND

Over the period 1987 to 1990 papers were presented to EC Hot Laboratories meetings (refs. 1 to 3) on the decontamination and refurbishment techniques used to convert a cave line set up for the examination of fuel elements from Magnox (graphite/gas) reactors to a configuration that would allow the handling of fuel elements from AGR's. These fuel elements consist of a graphite cylinder ~ 1 m long and 238 mm diameter which contains 36 stainless steel clad, UO₂ filled fuel pins. The complete assembly weighs ~ 80 kilos.

The work is now almost complete and receipt of the first fuel elements is expected by June. The philosophy behind the refurbishment and re-equipment of the cave line is described below.

2. SPACE UTILISATION AND POSTING

The cave line at BNL is located within the Shielded Area as shown in Fig. 1.1 and the proposed configuration after refurbishment is shown in Figs. 1.2 and 1.3.

Flasks are unloaded in a pond and the fuel elements transferred by an elevator to cave 1. This system required complete rebuilding to handle the heavier AGR items which have a maximum weight of ~ 150 kilos compared with typical weights for the Magnox system of ~ 20 kilos. It was also necessary to provide a subsidiary system to allow the transfer of reusable items to the decontamination facility.

Because of the number of operations to be carried out in the examination process it was necessary to make maximum use of the shielded volume and this was achieved in a number of ways.

- (i) Use of free standing equipment which could be remotely repositioned. The benching was designed to be flat and continuous as far as was possible.
- (ii) Operation with cave to cave closure doors open and the incorporation of additional infill benching that is remotely removable.
- (iii) Scrapping of the cave 4/5 separation door and its replacement with a shielded plug which enabled an x-ray machine to be included within the thickness of the rear shielding wall (ref. 4).
- (iv) Use of the cave roof area to accommodate additional shielded facilities viz
 - (a) a γ scanning facility.
 - (b) a shielded tie bar store.

Location of the γ scanning unit on the roof had the advantage that this was no longer an in-line procedure so that lengthy counting programmes could be used without affecting the pin examination rate.

A problem that is experienced with in-cave equipment is the degradation of electronic components, e.g. transducers, plugs, leads by radiation. Tie bars (which are used for AGR fuel element discharge) are particularly harmful since they are made of Nimonic alloy and contain $\sim 0.2\%$ Cobalt. Provision of a roof store allows them to be kept away from the measurement equipment.

(v) Use of Space Below the Bench.

In order to reduce the spread of contamination the benching is sealed to the walls and where bench sections are removable a vertical overlap is provided. This prevents access to a substantial part of the shielded volume and to reduce space wastage vertical storage tubes have been installed in parts of this area (see Figs. 1.2, 1.3). These cannot be sealed as avoidance of flooding is an important part of the criticality safety assessment. To control contamination and to allow recovery of dropped items the storage tubes are designed to allow remote removal.

Apart from the pond elevator access to the caves for routine posting operations can be gained via roof or rear wall posting ports. Although the roof posting facility is convenient for small items, e.g. replacement equipment modules, the newly installed rear posting facilities are preferred for the transfer of high active items. The advantage is that high (~ 7 m) flask lifts are avoided so that the posting operation is simplified.

The rear posting ports are closed by rotating γ gates and are unsealed. Operation of the open port system over a period of 30 years had revealed no problems with contamination spread or radiation levels it was decided that the additional expense of an engineered sealed posting system could not be justified.

3. PROVISION OF SERVICES

A major consideration in the refurbishment of the cave line has been to eliminate the need for man entry to the shielded facility for repair and maintenance. Previous operating experience showed that the need to service power manipulators was one of the biggest sources of man dose and these have been eliminated. Heavy lifting within the caves is achieved by hydraulically operated hoists of 300 kilos capacity that can be inserted and withdrawn through the rear walls. These are augmented by smaller hoists (~ 150 kilos capacity) and cranes which operate over the complete cave line. Provision of heavy lift equipment ensures that the master slave manipulators (MSM's) are used only within their design capability in order to minimise the number of manipulator breakages.

Wallischmiller sealed and shielded manipulators have been chosen as the main machines for remote operation although Vickers VNE 80 and GEC GT15 manipulators of this type are also available. However, the conventional system in which the manipulator gaiter is sealed to the hot side of the wall penetration by an expanding ring has not been adopted. The problem with this arrangement is that the sealing area is not easily accessible and the manipulator has to be fed through the gaiter after it has been sealed to the wall. Any problems that occur during loading result in the loss of the gaiter.

In conjunction with Walischmiller an alternative system has been designed in which the gaiter is sealed to the machine so that it can be fully assembled and checked for sealing before the manipulator is loaded. On loading, the manipulator through tube is sealed against the through wall penetration at special insert rings that have been attached to the hot side of the cave. This arrangement has the advantage that the gaiter can be disconnected from the manipulator by a positive action from the operating face. The gaiter falls back into the cave allowing the manipulator to be withdrawn. This system has worked well in handling and commissioning trials.

All services are introduced into the cave by removable stepped plugs inserted through either the rear or the front wall. The service leads pass through the plug along spiral grooves and source testing confirms that the design objective, of having service penetrations which offer the same level of shielding as the walls, has been achieved. This system also provides the flexibility to vary the type of services according to the work being carried out.

For routine shielded posting operations access ports through the rear walls and the roof up to 320 mm diameter are available. In caves 5 and 6 these are mounted in movable roof beams so that they can be located at the optimum position. For cave access, or for the insertion or removal of larger items it is possible to remove sections of the cave roof or to open the sliding doors at the ends of the cave line. The cave ends are enclosed by contained transfer bays which can be used as a base for work on contaminated equipment.

A weakness of the previous arrangement was that access to the elevator tunnel to the pond, which is about 9 m long, could only be achieved via the caves. This made the rectification of elevator faults a time consuming process. During the refurbishment a door was built into the tunnel wall which allows direct access for repair and maintenance.

4. EQUIPMENT DESIGN CONSIDERATIONS

The basic design approach was to locate free standing equipment on flat benching. The equipment was modular in design so that units, e.g. motors, could be removed for replacement or repair and it allowed simple size reduction for ultimate disposal. Wherever possible standard production items were used that were modified to allow remote use. A good example of this was the adaptation of a bench top CNC milling machine for specimen preparation.

For pin measurement standard precision measurement slides have been installed on a carriage to provide 3 axis movement over the pin length (~ 1 m). This head also carries a miniature abrasive unit and resistance probe for measurement of the thickness of surface deposits. The probe is moved forward until a conductivity measurement indicates that the deposit surface has been located. The position of the probe is recorded and then the surface deposit is removed locally by fine abrasive grit delivered by an air jet. The probe is then moved forward until contact is re-established and this determines the deposit thickness. The process can be viewed by a TV camera which sights through a prism and measurement accuracies of a few microns have been achieved. The complete process is computer controlled and the output is visually displayed.

For the measurement of gas release and internal pin volume the can wall is breached by a sharp point and the gas released into a known volume. A simple pressure measurement followed by back filling with a known quantity of gas enables the internal pin pressure to be calculated. Samples of gas can be taken by hand pumping into detachable metal cylinders and the sample can be analysed locally by mass spectrometry. This arrangement avoids the need for bulky pumping and gas collection systems on the cave face.

Extensive use has been made of TV cameras for local viewing. Apart from the measurement machine mentioned above TV cameras are used to view the operation of the elevator and the lifting grabs used in the pond. The fuel pin and element examination systems also use TV cameras. The quality of the image is high and although not as good as achievable by direct viewing it has the advantage that information can be gathered, sorted and stored electronically. A further advantage is that the operator does not need to be located at the viewer position.

5. CONCLUSIONS

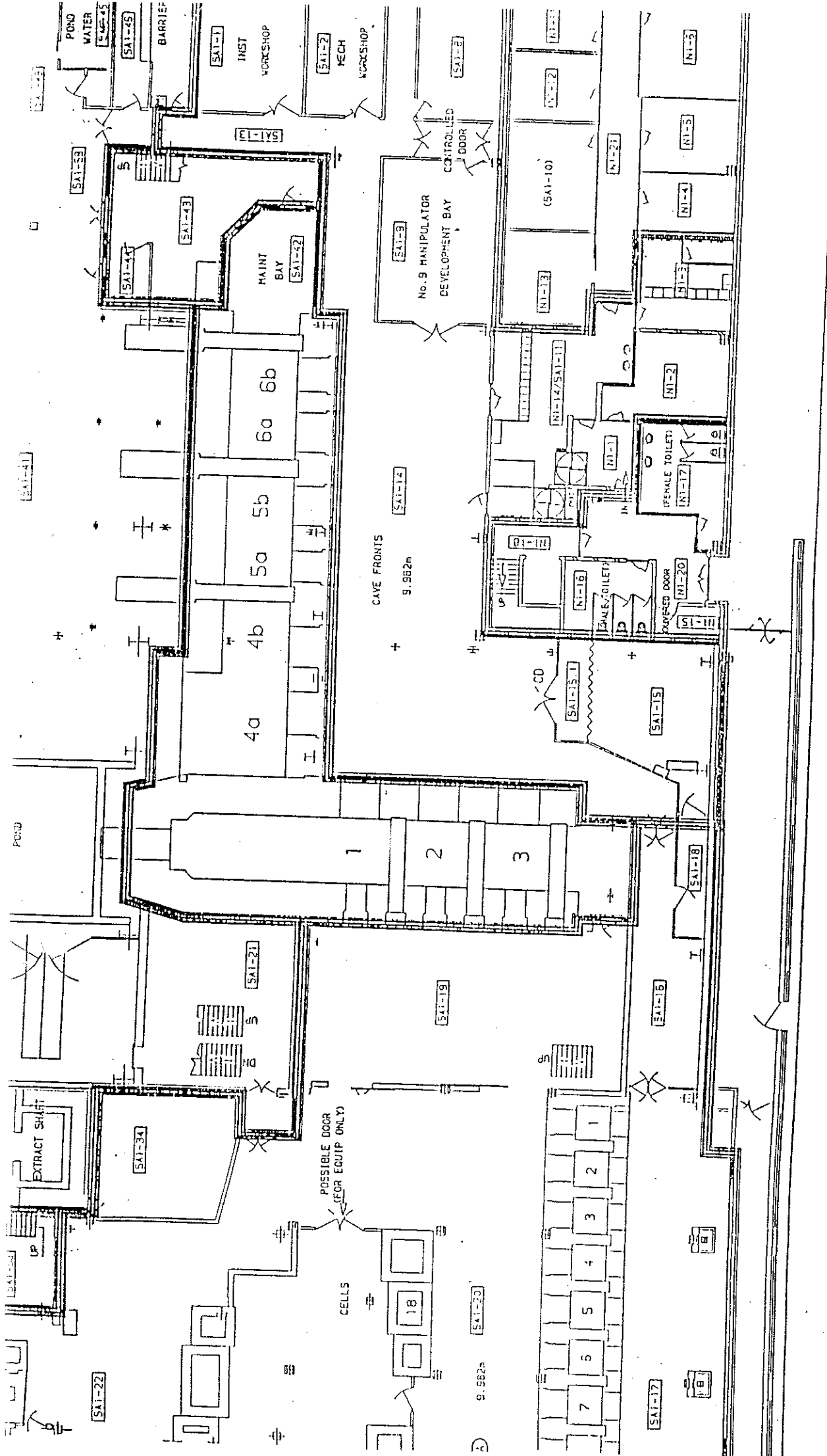
Active work began in the first part of the refurbished cave line at the beginning of 1991 and the examination of fuel elements is expected to begin in June. The refurbishment will be complete with all parts of the cave line available for active use by the end of September.

During the latter stages a major constraint on the achievement of timescales has been the requirement to provide written evidence to the regulatory authorities that refurbishment work and commissioning tests have been completed as scheduled. This justification is additional to that imposed by local and company safety panels. The volume of documentation is substantial and the review periods demanded can add many weeks to tight completion schedules.

Overall it appears that whilst the concepts underpinning the refurbishment were good the work required on the provision of safety cases and documentation to support operation was underestimated and this, in turn, exacerbated problems arising from lack of manpower to carry out commissioning. Despite this it is anticipated that the fuel element examination programme requirements will be met.

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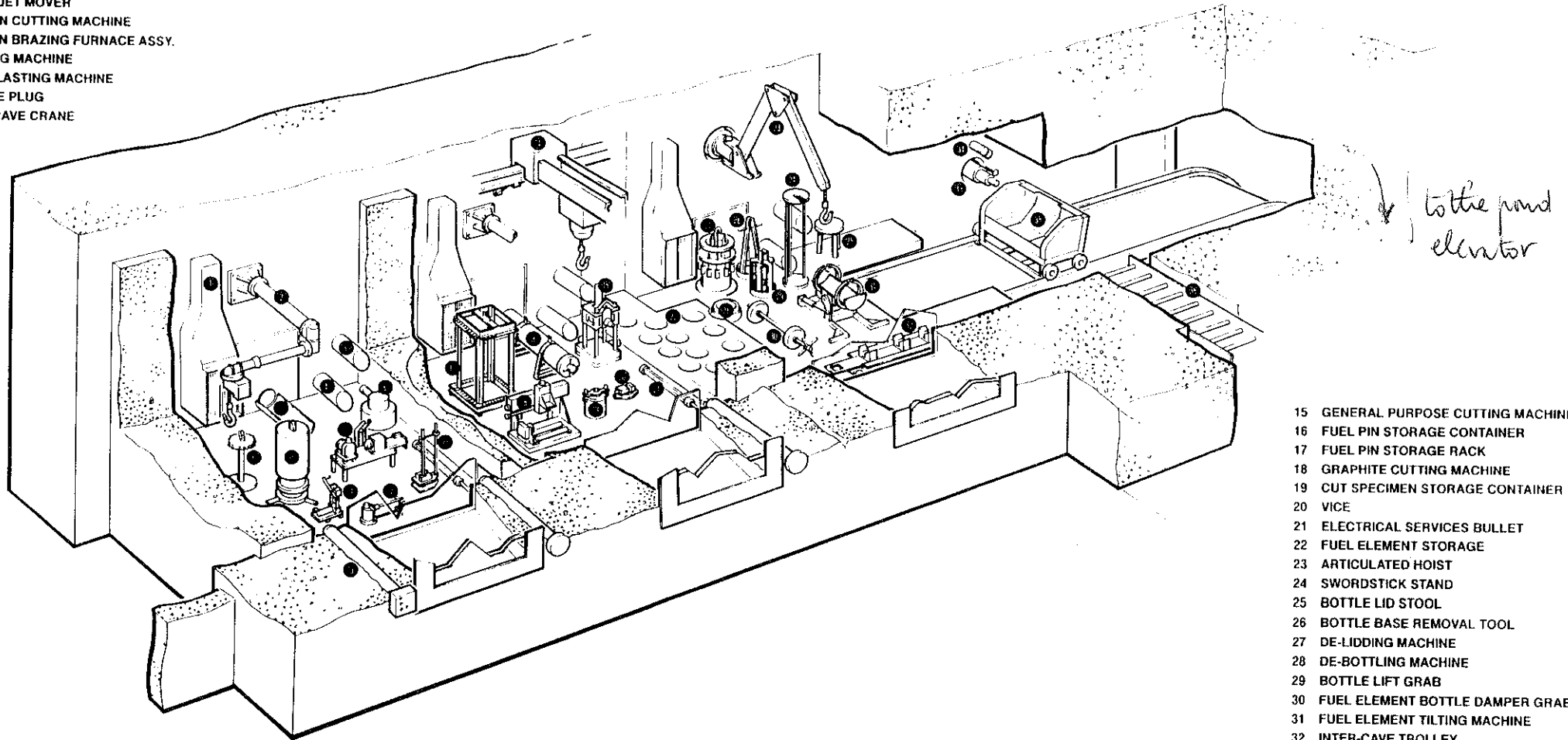


PLAN OF THE BNL CAVE LINE

FIG. 1.4

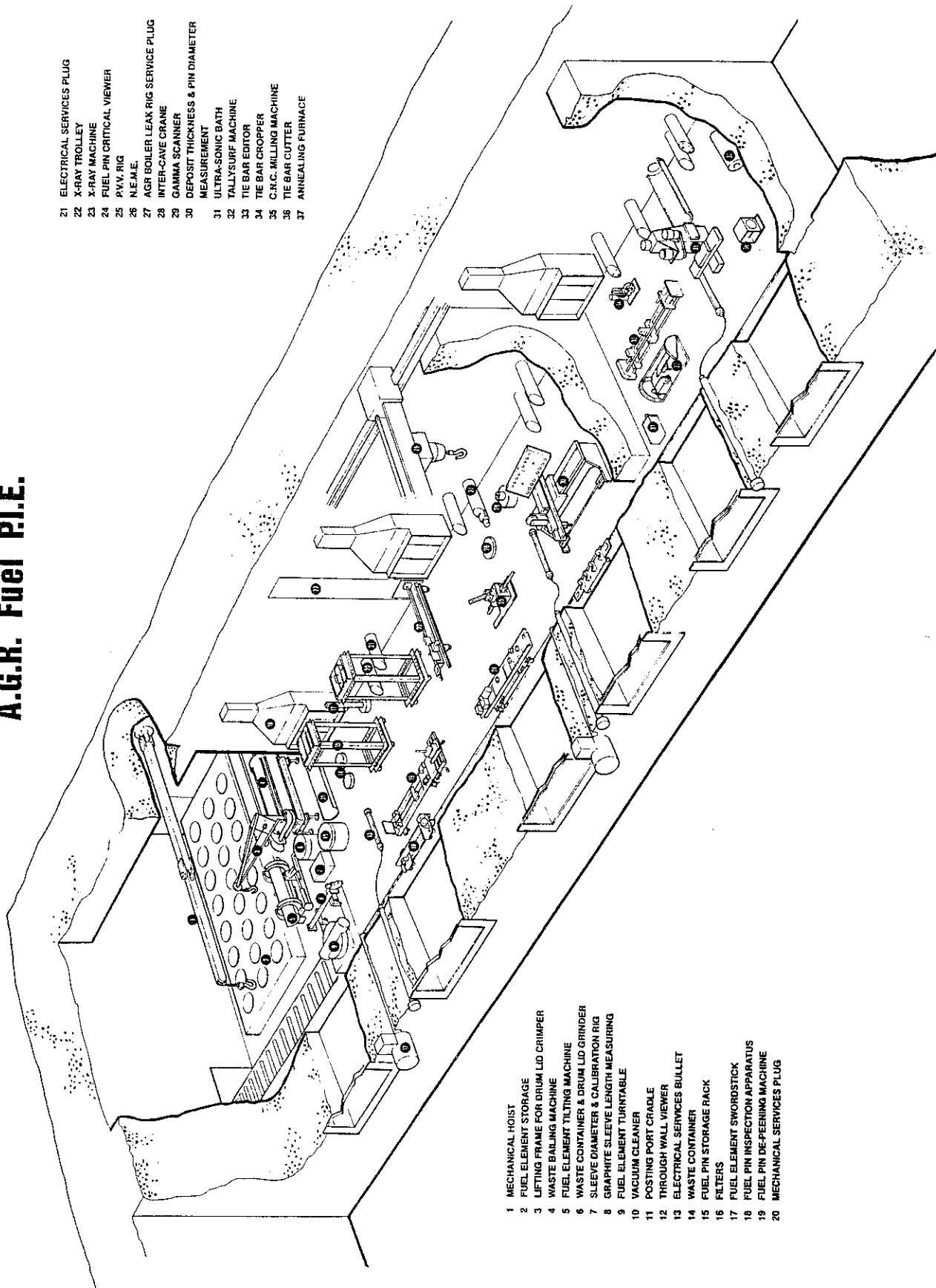
FIG. 1.2 Berkeley Nuclear Laboratories Shielded Area Caves 1, 2 & 3. A.G.R. Fuel P.I.E.

- 1 FILTERS
- 2 HOIST (CAVES 2 & 3)
- 3 ELECTRICAL SERVICES
- 4 MECHANICAL SERVICES
- 5 POSTING PORT CRADLE
- 6 STRESS RUPTURE PIN STORAGE
- 7 FUEL PIN STRESS RUPTURE RIG
- 8 FILTER JET MOVER
- 9 FUEL PIN CUTTING MACHINE
- 10 FUEL PIN BRAZING FURNACE ASSY.
- 11 DRILLING MACHINE
- 12 SANDBLASTING MACHINE
- 13 SERVICE PLUG
- 14 INTER-CAVE CRANE



- 15 GENERAL PURPOSE CUTTING MACHINE
- 16 FUEL PIN STORAGE CONTAINER
- 17 FUEL PIN STORAGE RACK
- 18 GRAPHITE CUTTING MACHINE
- 19 CUT SPECIMEN STORAGE CONTAINER
- 20 VICE
- 21 ELECTRICAL SERVICES BULLET
- 22 FUEL ELEMENT STORAGE
- 23 ARTICULATED HOIST
- 24 SWORDSTICK STAND
- 25 BOTTLE LID STOOL
- 26 BOTTLE BASE REMOVAL TOOL
- 27 DE-LIDDING MACHINE
- 28 DE-BOTTLING MACHINE
- 29 BOTTLE LIFT GRAB
- 30 FUEL ELEMENT BOTTLE DAMPER GRAB
- 31 FUEL ELEMENT TILTING MACHINE
- 32 INTER-CAVE TROLLEY
- 33 BUCKET RAM
- 34 TV CAMERA
- 35 POND ELEVATOR BUCKET & CARRIAGE
- 36 BUCKET CONVEYOR

**FIG. 1.3 Berkeley Nuclear Laboratories Shielded Area Caves 4, 5 & 6.
A.G.R. Fuel P.I.E.**



0.22 Co
Tie bars

- 1 MECHANICAL HOIST
- 2 FUEL ELEMENT STORAGE
- 3 LIFTING FRAME FOR DRUM LID CRIMPER
- 4 WASTE BAILING MACHINE
- 5 FUEL ELEMENT TILTING MACHINE
- 6 WASTE CONTAINER & DRUM LID GRINDER
- 7 SLEEVE DIAMETER & CALIBRATION RIG
- 8 GRAPHITE SLEEVE LENGTH MEASURING
- 9 FUEL ELEMENT TURNABLE
- 10 VACUUM CLEANER
- 11 POSTING PORT CRADLE
- 12 THROUGH WALL VIEWER
- 13 ELECTRICAL SERVICES BULLET
- 14 WASTE CONTAINER
- 15 FUEL PIN STORAGE RACK
- 16 FILTERS
- 17 FUEL ELEMENT SWORDSTICK
- 18 FUEL PIN INSPECTION APPARATUS
- 19 FUEL PIN DE-PEENING MACHINE
- 20 MECHANICAL SERVICES PLUG

- 21 ELECTRICAL SERVICES PLUG
- 22 X-RAY TROLLEY
- 23 X-RAY MACHINE
- 24 FUEL PIN CRITICAL VIEWER
- 25 P.V.V. RIG
- 26 N.E.M.E.
- 27 AGR BOILER LEAK RIG SERVICE PLUG
- 28 INTER-CAVE CRANE
- 29 GAMMA SCANNER
- 30 DEPOSIT THICKNESS & PIN DIAMETER MEASUREMENT
- 31 ULTRA-SONIC BATH
- 32 TALLYSURF MACHINE
- 33 TIE BAR EDITOR
- 34 TIE BAR CROPPER
- 35 C.N.C. MILLING MACHINE
- 36 TIE BAR CUTTER
- 37 ANNEALING FURNACE

PART 2

REFURBISHMENT OF PIE FACILITIES AT WINDSCALE

1. BACKGROUND

An extensive programme of refurbishment of the AEA Reactor Services Post Irradiation Examination (PIE) Facilities at Windscale was started in 1991 and is due for completion at the end of 1992. The main part of the work is the refurbishment of 4 concrete caves, each measuring about 11 m long by 2.6 m wide by 3.6 m high, with 1.4 m thick walls. Each cave has 5 operating stations, with viewing through zinc bromide windows and a pair of Master Slave Manipulators (MSMs). The caves being refurbished have been in use for over 20 years and were employed on the examination of natural uranium fuel, Magnox clad, mainly from UK reactors. The refurbished caves are to be used to support the Post Irradiation Examination (PIE) work at Windscale (on UK fuel from U-Magnox and advanced gas cooled reactors and LWR fuel from overseas) by providing an integrated metallographic specimen preparation and examination facility and a facility for the treatment, handling, storage and transfer of intermediate level wastes generated within the PIE caves.

A "clean" cell is being constructed within the existing, but unused (i.e. non-active), cave adjacent to the new metallographic specimen preparation facility to house optical microscopes for the examination of specimens. This cell and its adjacent specimen preparation cave are illustrated in Figure 2.1. Extensive modifications to the ventilation extract system to all the caves (13 in total) in the facilities are also being carried out.

2. PROJECT MANAGEMENT

The refurbishment programme is required to be completed by the end of 1992 whilst the full PIE programme is being carried out in the other caves in the building. Since all caves are interconnected and share common services, ventilation and other safety systems, strong project management and control of in-house craft teams and contractors was considered essential to both maintain the PIE programmes to schedule and ensure safety of operations and refurbishment work at all times; safety being the prime consideration.

The refurbishment project is managed by the in-house engineering team who work closely with the operations and craft teams who are required to support the refurbishment work and maintain the normal operations of the facilities. These close working relationships have allowed the criteria specified above to be maintained throughout the project.

The safety significance of the modifications to the caves have been assessed and safety cases have been prepared to cover the refurbishment work, commissioning and operations in the completed facilities. The Safety Cases include fully structured hazard assessments based upon a series of Hazard and Operability Studies (HAZOPS) which involve the detailed assessment of the design, construction, commissioning and operations of the facilities. These HAZOP meetings identify all possible hazards and operability problems at all stages of the modification. Radiological hazards have been eliminated by changes to the design of the facility or the operations, or justified As Low As Reasonably Practicable (ALARP) by quantification of the hazard and its consequences where changes are not practicable. Operability problems which affect the efficient operation of the refurbished facility can be eliminated at an early stage and prevent costly design changes later in the project. Whilst HAZOP studies are acknowledged to be expensive and time consuming they have proven to be an invaluable aid to the Project Manager; they have reduced programme timescales and cost whilst providing a fully auditable and comprehensive assessment of the safety of the refurbishment work, the operation and maintenance of the modified facilities.

3. REFURBISHMENT WORK

In this short paper it is not possible to present details of all the refurbishment work on the caves; the following represents a few examples of the work being carried out:

- a) Zinc bromide windows: All the zinc bromide windows in the caves being refurbished were in need of some refurbishment, many were leaking slightly and some showed deterioration of the glass-fibre window tank liners. All windows have been repaired in-situ by a specialist contractor (the window manufacturer). This work has included the replacement of inner and outer crash and outer containment glasses, repair of the glass-fibre tank liners and resealing of the inner containment glasses to the tank liner. These repairs have been carried out at a fraction of the cost of window replacement and in a shorter timescale.
- b) La Calhene flask port: A new flask transfer port has been fitted to the metallographic specimen preparation cave. This port incorporates a La Calhene sealed posting port and Padirac shutter system. The entire inner La Calhene door assembly is attached on to the end of a large transfer tube passing through the cave wall. This transfer tube can be withdrawn from the cave wall to provide access to the door assembly for maintenance. Full containment is provided by a secondary hinged and sealed door on the inner wall of the cave which covers the La Calhene door assembly and transfer tube.
- c) Specimen transfer system: Metallographic specimens are to be transferred between the preparation cave and the microscope cell (in back to back caves as shown in Fig. 1) in an air operated transfer system. This comprises a tube through the interconnecting wall along which a specimen carrier is pushed from one side to the other by compressed air. The compressed air is exhausted into the preparation cave to reduce the possibility of contamination in the microscope cell, where easy access for microscope maintenance is required. The transfer system is fully shielded and its operation is interlocked to the man access door to the microscope cell, this allows completely safe access and prevents inadvertent posting of samples into the cell.

d) Ventilation extract system: The existing ventilation extract system for the PIE caves is being replaced. The new system will replace existing "out-of-cave" secondary HEPA filter units with modern "safe-change" secondary and tertiary HEPA filters. Each pair of caves is extracted through the existing in-cave primary filters (retained to prevent excessive contamination of the secondary filters), and the secondary and tertiary filters by a variable speed fan into the main building extract duct. The new system incorporates full instrumentation, relayed to the control room, monitoring pressure drops across filters, duct flow rate and β activity in each duct. In addition tappings are provided to allow the measurement of the efficiency (decontamination factor) of all 3 sets of filter banks.

The planning of the installation of the ventilation plant whilst retaining the full operational capacity of the facilities has been difficult. Minimum disruption to the work programmes has been achieved and each cave only needs to be shutdown for about a week whilst the old systems are disconnected and removed and the new plant connected. Installation time has been minimised by pre-installing and commissioning all electrical and instrument services and systems and pre-assembly and testing of the mechanical installations.

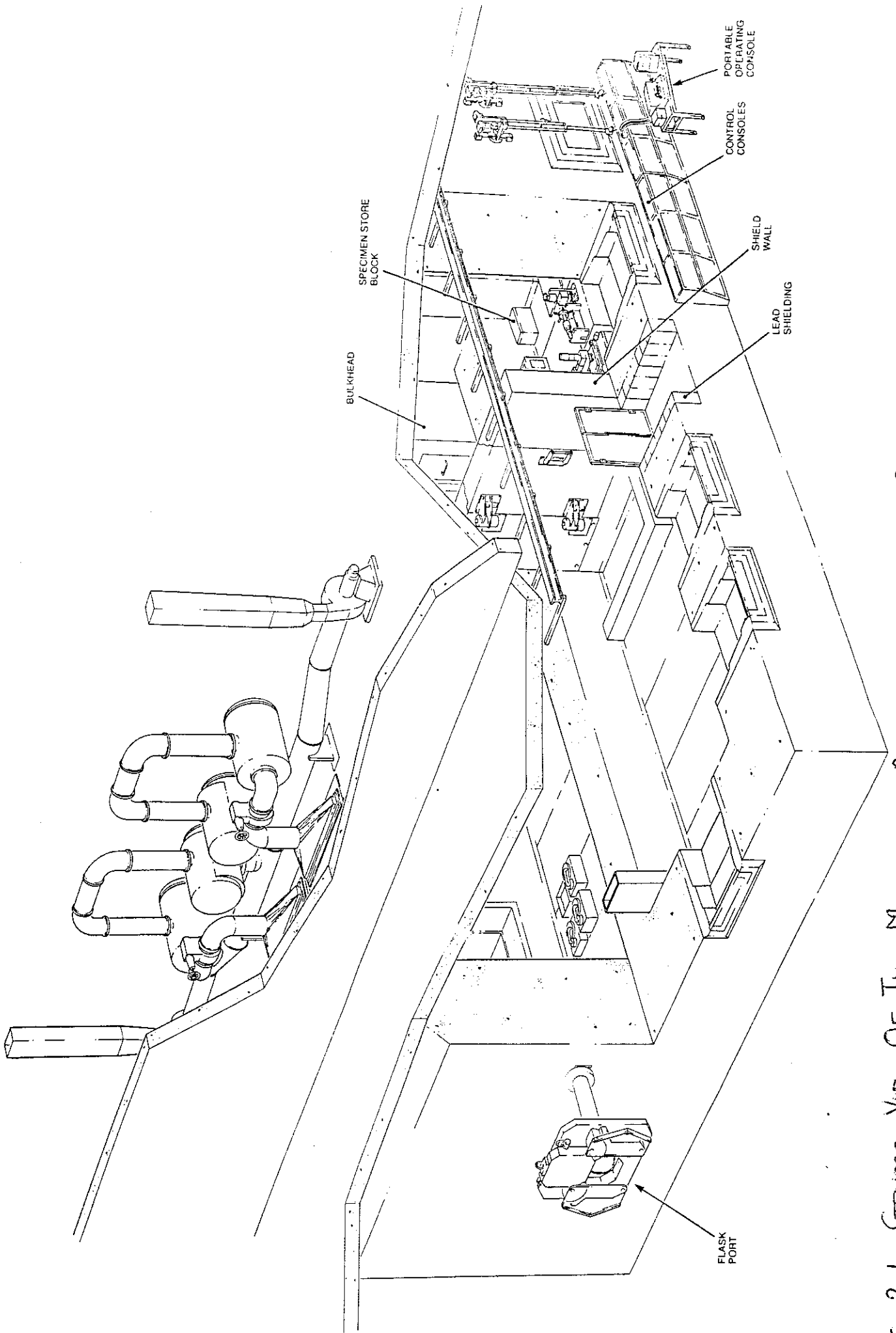


FIG. 2.1 GENERAL VIEW OF THE MICROSCOPE AND METALLOGRAPHIC PREPARATION CAVES

Part 3

THE REPLACEMENT OF HOT-CELL SERVICES WITHOUT MAN ENTRY

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The metallographic suite within the α, β, γ shielded "Hot-Cell" Facility at Dounreay comprises three cells, two of which have been more or less in continuous operation for 25 years. During this period the number of available in-cell electrical services had progressively reduced to the extent that only one in each facility remained operable. Furthermore, the installed electrical sockets and associated connecting plugs were obsolete types and replacements were unobtainable. Complete refurbishing of the in-cell services including improvements to the interior lighting arrangement was therefore essential to restore the facilities to a fully operational state.

One cell in particular had been used for irradiated fuel pin sectioning and as a result was heavily contaminated with plutonium bearing cutting debris and other finely divided hazardous material. The cell, with its associated equipment, was the only facility available at Dounreay within which fuel pin sections could be removed for post-irradiation examination. Its availability in a functional state was therefore important not only to support the continuing operation of the Dounreay Prototype Fast Breeder Reactor (PFR) but also for work in connection with the European Fast Breeder Reactor Project (EFR). As a result the time periods within which refurbishing operations could be carried out had to be strictly controlled. An extensive in-cell refurbishing scheme of the magnitude proposed would in most instances require man entry but in this case decontamination to permissible levels was considered impossible within an acceptable timescale. A further complication arose from the lack of an in-cell active drain which prevented effective wash down techniques being employed. The use of a robot was considered and rejected as being too expensive and too time consuming.

Following detailed discussions it was decided that the best course of action would be to attempt refurbishing without man entry by using a suitably engineered services carrier inserted through the working face of the facility. This had the advantage that all the required services could be built into the carrier and bench tested before installation, resulting in a considerable saving in time. Dounreay also had some previous experience in retro-fitting in-cell services using plug-in carriers, albeit into a facility having a less severe contamination problem and where man entry was possible.

The main difficulty in adopting this approach for the Dounreay facility stemmed from the lack of a removable wall plug which could give access to the cell interior. The non-availability of an installed wall penetration meant that the concrete bio-shield and the stainless steel inner lining plate would have to be drilled and a through-the-wall liner tube fitted. This tube would be a permanent fitting and would have to be sealed to the inner lining to alpha tight standards. The replacement services carrier would be located in the liner tube.

The fixing method originally suggested required the liner tube to be remotely welded to the cell inner lining. Although welding seemed to be an ideal method suitable commercial equipment was not readily available and considerable work would be needed to adapt what was available to carry out a remotely controlled

These were provided to minimise radiation shine paths. The tube carrying the various electrical cables and other pipe work within the carrier followed a helical path through the internal shielding for a similar reason. Figure 2 shows the general arrangement.

In-situ leak testing of the entire assembly, liner tube plus carrier, over a 60 hour period, showed no significant leakage past the sealing arrangements. Tests to measure the effectiveness of the gamma shielding using a cobalt 60 point source located in the worst conceivable position did reveal a small shine path and this was blocked off with some additional local shielding on the outside face of the carrier.

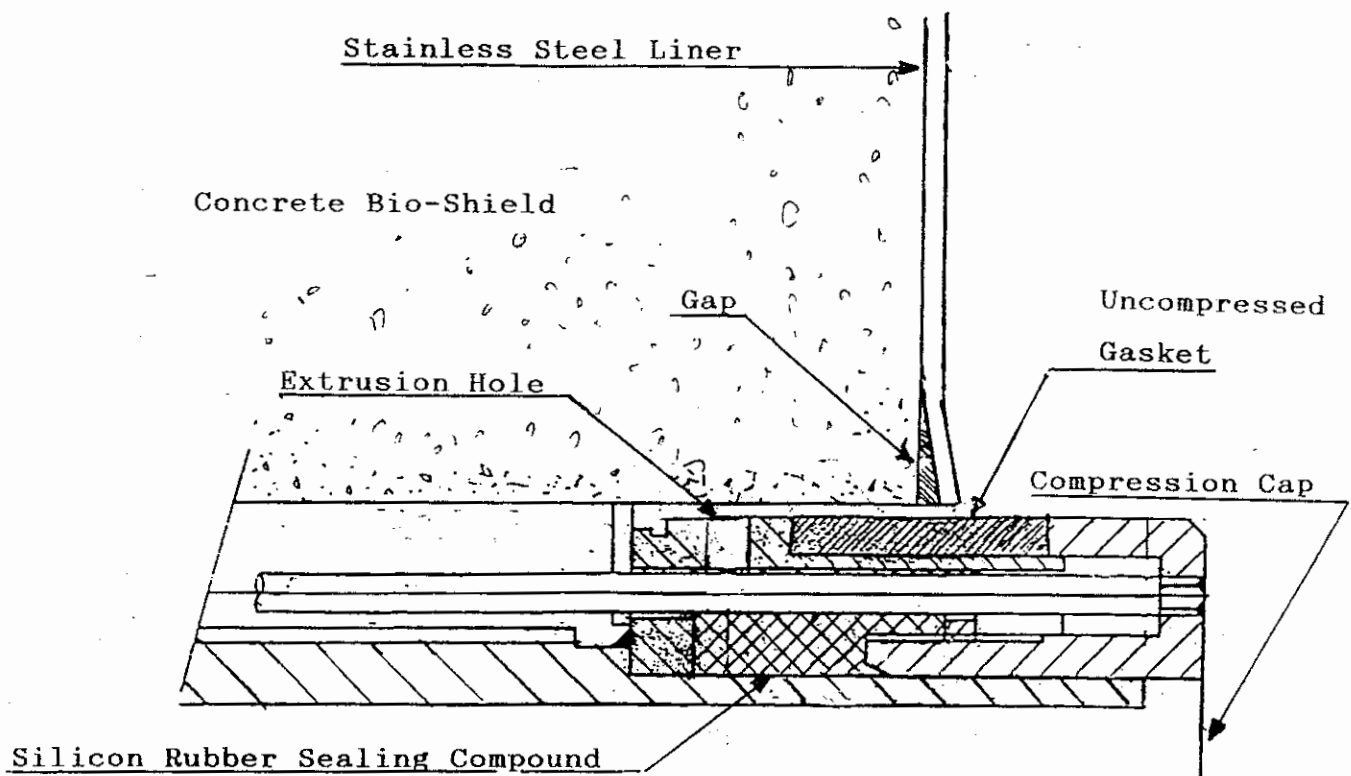
A similar penetration with an identical liner tube was provided to carry the replacement in-cell lighting arrangement. In this case the replacement carrier was fitted with a small external winch to enable the lamp holders and reflectors to be lowered to the cell floor for maintenance purposes.

Figure 3 shows the front face of the cell with the services carrier located at the lower left hand side of the cell window and the winch assembly located above the window between the master slave manipulators. Also shown is the in-cell end of the replacement services carrier after installation.

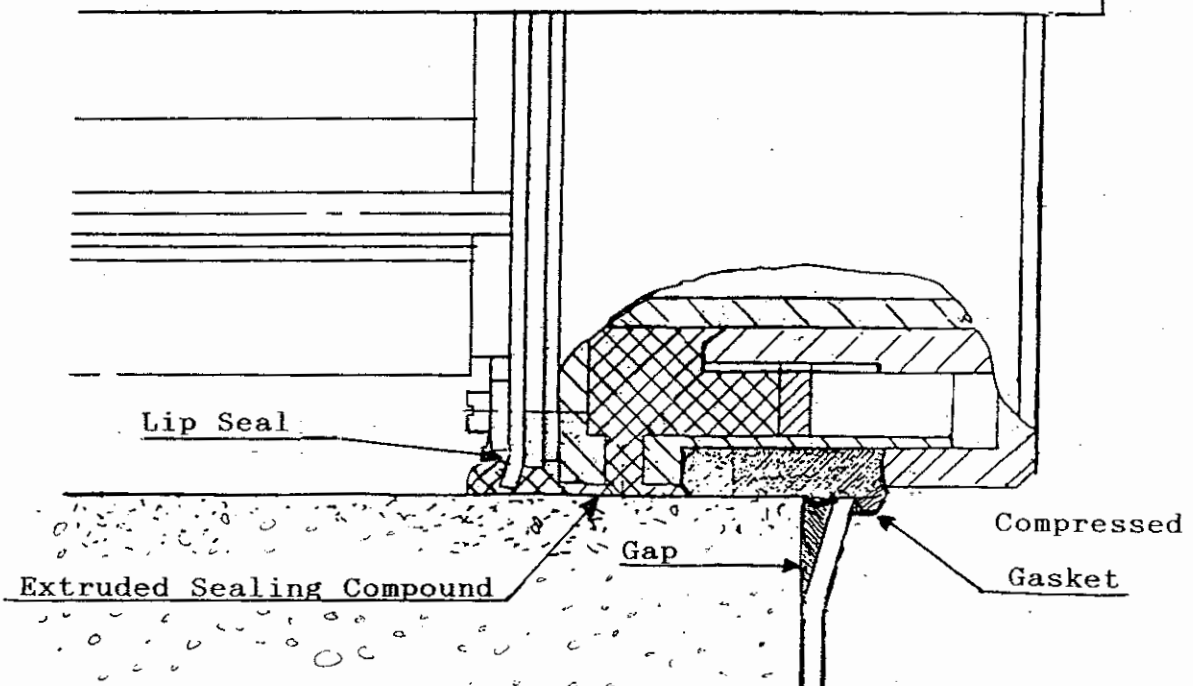
The procedures adopted to refurbish these Dounreay facilities have proved to be very effective in terms of manufacturing and installation costs. They also minimised the fiscal penalties associated with the long term non-availability of a vitally important facility. Preparation and subsequent installation were simply accomplished without resorting to complicated construction and assembly techniques and, importantly, did not require man entry.

Although the liner tube is intended to be a permanent fitting, the carriers can be replaced if required, leading to improved flexibility in considering future operations.

Provided suitable access is available there are no reasons why the techniques outlined in this paper cannot be employed to inexpensively and quickly replace obsolete or defective services in similar facilities handling radio-active material.



(a) Liner Tube installed, cap not compressed.



(b) Liner Tube installed, cap compressed.

FIGURE 1. Schematic representation of the Liner Tube In-Cell sealing arrangement.

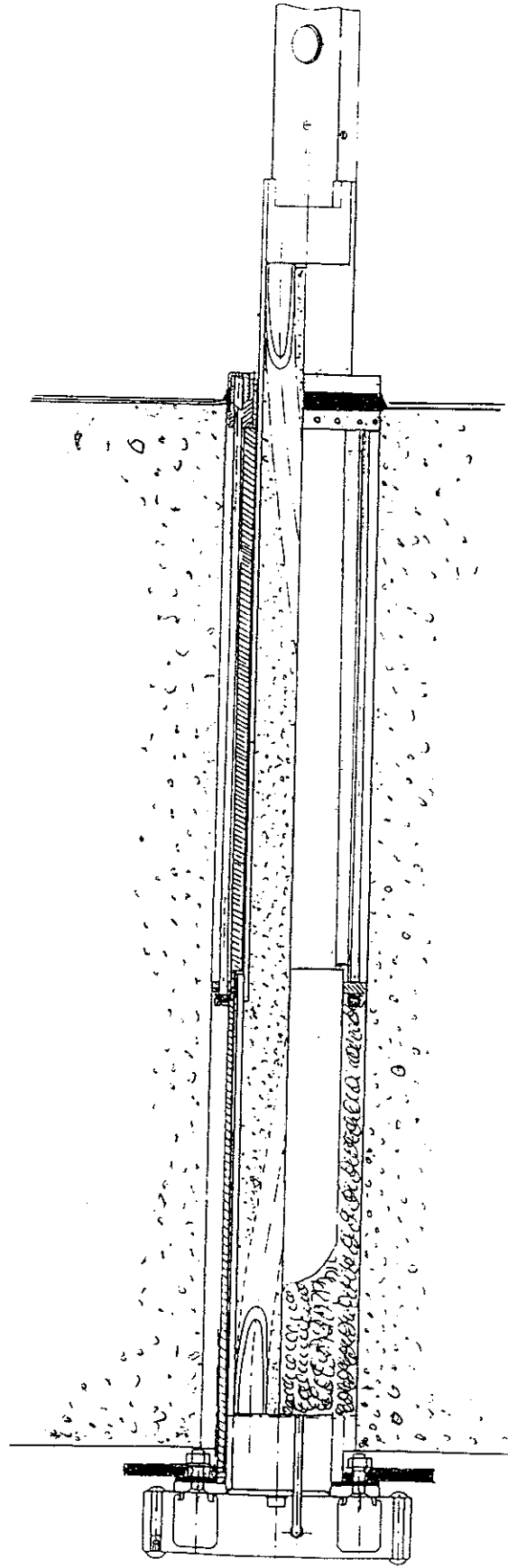
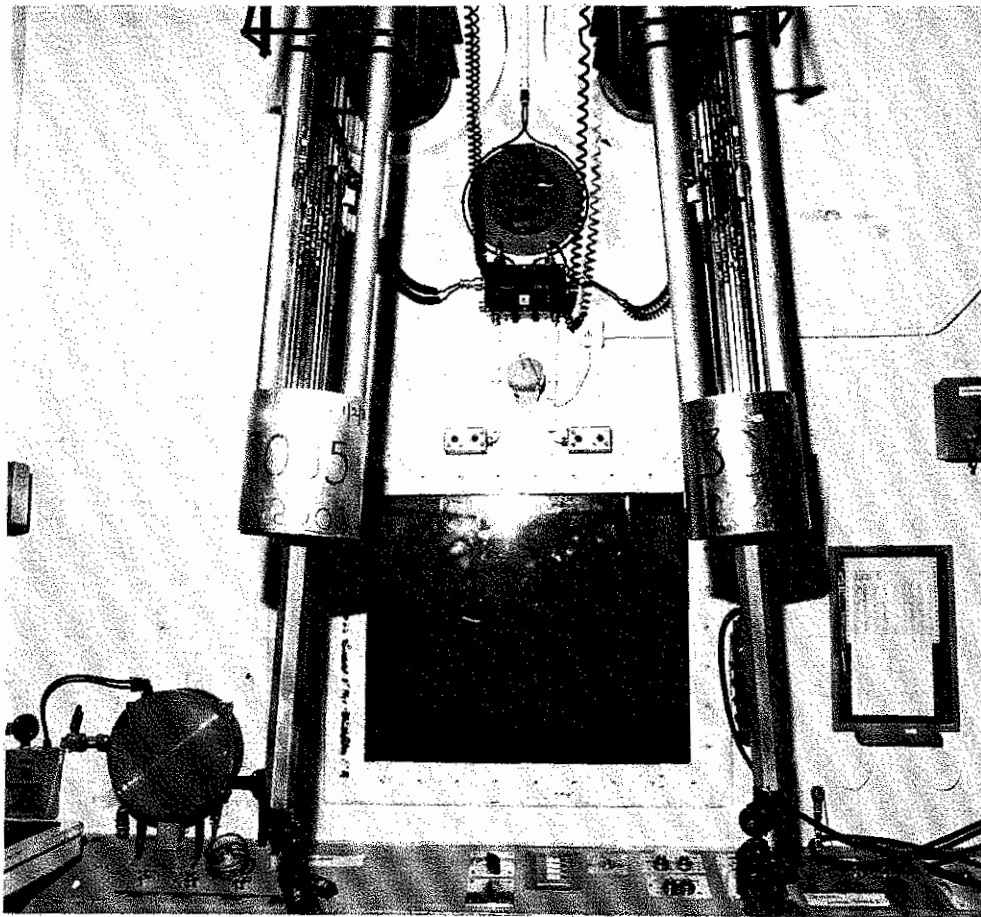
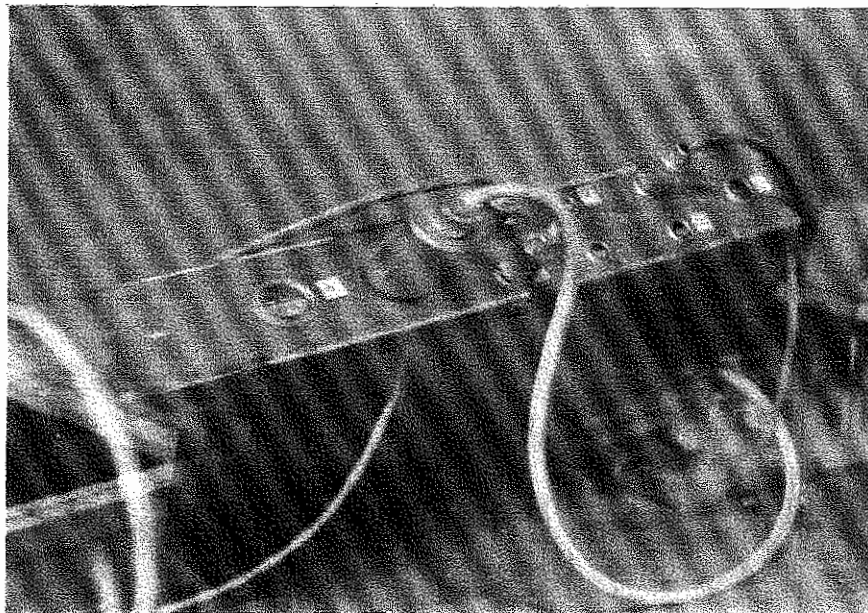


FIGURE 2. General arrangement of the installed Liner Tube with the Services Carrier inserted.



(a)



(b)

FIGURE 3. (a) The front face of the Cell showing the location of the Services Carrier at the lower LHS of the window with the Winch Assembly between the MSM's.
(b) The In-Cell Part of The Installed Services Carrier.

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