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Experience in Commissioning a New Active Facility

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Abstract

A new $\alpha\beta\gamma$ active facility has recently been built and commissioned at Harwell. The design is based on the remotely removable box concept which has evolved in Europe. Components available commercially from various European countries are used. The facility represents the latest in remote handling technology as applied to post irradiation examination and research and development work. Details of the design and experience in commissioning the new facility are outlined.

1. Introduction

A recent addition to the active handling capabilities, which are available at Harwell for hire, is a new active αβγ-facility built principally for undertaking chemical and allied research and development work. The design[1,2] is based on the use of remotely removable containment boxes, it achieves a high degree of flexibility in application and minimises radiation exposure consistent with the ALARA principle.

Experience has shown that significant advances in remote handling technology often tend to occur as new facilities are built. Consequently aspects do not necessarily evolve continuously and developments occur at different rates and in different parts of the world.

In designing this new facility, a deliberate attempt was made to advance the prevailing remote handling technology. The design criteria that were adopted, have been reviewed critically and, following the recent experience in completing the commissioning of this new facility, recommendations are made for possible improvements.

2. Review of the Design Concept

From a review of the nature of the work being undertaken in the existing research laboratories and of other laboratories[3-5] having a similar application, it was decided that the basic design of the new facility should be based on the use of removable containment boxes.

The use of boxes, to contain radioactive materials and located behind a biological shield to minimise radiation exposure, originated in the early days of the Nuclear Industry. However, as the concept of using boxes has evolved so they have changed from being fixed inside the shielding to becoming removable by remote means. This evolution is principally applicable to facilities used for post-irradiation examination (PIE) and research and development (R&D) work rather than in larger plant, although some aspects are applicable to both.

In simple terms the box is now regarded as a modular unit which is located in a biologically shielded cubicle and operated using conventional remote handling technology. Hence the number of modular units or the size of the facility is limited only by the space and the funding that is available.

For this particular facility the constraints imposed led to the building of five shielded cubicles or cells (Figure 1) and the purchasing of six modular units or boxes. The additional box was purchased to ensure that a fully commissioned one could be made readily available for use in the cell line once a working location was free. It is intended that boxes will be used in a cyclic manner, as will be explained later.

Once an active box has completed the intended campaign of active usage, it will not be decontaminated in situ, but will be transferred to an additional cell, attached to the cell line, specifically for decontamination and decommissioning purposes (Figure 1). The box decommissioning cell is fully equipped (Figures 2 & 3) to enable a box to be opened, emptied and decontaminated ready for reuse, without the need for man intervention in the radiation environment. Integral with this cell is a glove box area (Figure 1) which is accessible through a radiation lock and is therefore available for 'hands-on' maintenance or repair of plant and equipment, once the source of radiation has been removed.

Boxes are moved between locations, at the rear of the cell line, using a box handling machine (Figure 4). The machine[2] can be used either manually or remotely. To install a box in a cell position, the box is placed on the arms of the fork lift support, which is attached to the removable rear shield door. On closing the door the box enters the shielded working location and is then lowered onto a support plinth for operational purposes (Figure 2). The plinth carries the services to the box and is the datum to which each cell is built to ensure interchangeability of the boxes. To remove a box, the process is reversed and the box handling machine is used in its remotely operated mode within the fully shielded transfer area.

Although, of necessity, aspects of the facility are fixed dimensionally and positionally there is sufficient flexibility so that changes can be made and new components or equipment can be readily introduced as they become available. Also the shielding structure can be dismantled, either to be rearranged for alternative use or to be sent for conventional disposal, thus allowing the area to be decommissioned readily to a greenfield site.

3. Box Design

An isometric view of a typical box is shown in Figure 5. The size, which is approximately 2.4m x 1.8m x 2.5m, is dictated by the spatial location and reach of the standard master slave manipulators.

Each box contains ports for the manipulators, transfers and interconnection; there are also filters, windows, a hoist, a rear access door and service panels, to which a range of connections can be attached.

The boxes were constructed from stainless steel plate preformed sections welded together to give a smooth internal profile with rounded corners. The welds were eventually ground to a flush finish and the inside surface of the box electropolished. Experience has shown that this finish is more readily decontaminated than an untreated surface, especially in relation to cleaning up chemical spills.

For reasons of strength and stability, the box is mounted inside a support frame (Figure 5). The framework then provides the means by which a box is moved and gives the additional strength necessary for supporting such features as the in-box hoist. The base of the frame has location points for positioning the box on the arms of the fork lift and on the plinth. Support legs are also fitted so that the unit is free standing when not in use. The top of the framework connects to the box handling machine, an operation which can be done remotely and under computer control.

All of the boxes have been manufactured to ± 2mm tolerance limit specified between the centres of the various ports and they have subsequently been shown to be interchangeable in the five cell working positions. Apart from some panel deformation, they have an acceptable electropolished internal finish and, when fitted with windows and sealed ports, they have met the specification given for the pressure and leak testing.

They have been found relatively easy to handle in the manual mode for location in the commissioning and working areas. Trials on the fully automated movement under computer control are still in progress, mainly to prove and modify the computer software. Sufficient experience has already been obtained to give confidence that the fully automated and remote movement of boxes is workable.

The box handling machine basically consists of a turntable suspended from a crane gantry on a telescopic support. The crane engages with the machine and provides the means by which it can be operated in the X, Y and Z directions. Trials have shown that the machine operates successfully but a better alternative for moving the boxes could well be an adaptation of the mobile computerised system now used in modern car factories for moving car bodies about. Although this possibility has not been investigated in detail the technology would appear to be easier to implement and may have the advantage of a larger market to cover the basic development costs.

In general the development of the box and the support framework has been relatively straight forward although problems have been experienced with the sealing and the handling of the access door. The sealing was eventualy overcome after testing various rubber gaskets, although the long term suitability of use has still to be ascertained. Part of the problem in handling the door is its weight, brought about by having the edges of the door sufficently thick not to deform when compressing the rubber seal. Although the door can be handled and sealed, it is about the only part of the box that would benefit from some further development and re-design.

In addition to a standard box, which simply has a flat base, two boxes have been made with wells that extend the useful volume of a box below the normal working level. This enables fairly large pieces of equipment such as furnaces, centrifuges, dissolvers etc. to be installed in a more convenient position for operation using the master slave manipulators.

Boxes are also capable of being connected horizontally and vertically to provide various combinations as appropriate for the task in hand (Figure 6). Such an arrangement permits a ready exchange of equipment simply by sealing and disconnecting a box from the array and replacing it with an alternative one. The replacement box and the new equipment, which is commissioned elsewhere, is simply connected into the array and the facility is again operational. All of these exchanges are possible without breaking containment, through the use of connections based on the double lidded principle. The used box is decontaminated and then recommissioned for further use.

4. Application of the Double Lidded Principle

The so-called double lidded principle was first conceived in the US in the 1950s as the means by which a waste container could be sealed to a port located on the side or underneath an active enclosure, to transfer the waste, whilst still maintaining the integrity of the working environment. The concept was eventually commercialised in Europe in the 1960s as a relatively simple but completely shielded transfer system and this was ultimately introduced into UK laboratories in the 1970s.

However, the principle, which basically consists of sealing together and accessing two independently contained volumes, has a wider application than just an active waste transfer system. In this new facility the principle has been used to interconnect boxes in the cell line, to connect a box to the box handling area and as a flexible port for introducing services. It is also being used in the UK as the basis for developing a pneumatic or 'rabbit' sample transfer system. A further development is being investigated which aims to minimise contamination of the seals by using a protection gas purge across the seals.

4.1 Interconnection of boxes

To interconnect the boxes, components of a commercially available double lidded system are used. The port component is fitted to the side of a box and is adjacent to an interconnecting unit fitted in the inner shielding wall. This unit comprises a tube with mechanically operated bellows fitted on each end. The bellows are moved by a gear mechanism, which is operated through the front face of the cell with a drive rod, and they are capped on each end with the lid component from a corresponding transfer container.

The bellows, when fully retracted, are sealed by their own lids. When fully extended they interface with the port in the same manner that a container would be interfaced. The double lidded arrangement can be then opened and the box is then connected to the transfer tunnel. The operation is repeated at the other end of the bellows tube thus allowing two adjacent boxes to be connected through the inner shielding wall. Since in this particular facility, the interconnected boxes are just over a metre apart, manually and automatically operated transfer systems can be fitted in the connecting unit for the ease of movement of materials between boxes.

4.2 Box door

At the time when the boxes were being designed, the largest double lidded system that was available was only of the order of 300mm diameter. As there was much to gain from using the double lidded principle for sealing a containment box to the partition in the box handling area, a new door arrangement with seals and clamping mechanism was developed. This door was designed to be as large as possible to allow easy access to the box.

The clamping mechanism eventually evolved to be a series of simple latches which can be operated manually from the rear side of the door during box commissioning. For remote operation these are coupled with drives in the partition door actuated remotely from the active side of the box handling area. Although these simple latches are easy to operate manually in the hands-on situation, it was not until a box was checked in a mock-up of the box handling area that the difficulty in reaching and operating the latches, by manipulator, at the top of the doors was fully appreciated. By making some postional changes and modifying the remote handling tools, used to operate the latches, access to those latches located at the top of the doors was made easier.

4.3 Service plug

A further development has been to modify the standard double lidded transfer container into a versatile service port. A plate is welded about 5-10cms below the lid of the waste container and in the interspece between the plate and the lid are fitted the service outlets (electrical sockets or self sealing couplings etc.) The service supplies are connected through the container, in a stepped manner to avoid radiation shine; they then terminate in the base of the container with an appropriate connector.

This unit can now be introduced through the biological shield and connected onto the box through a double lidded standard port. When the unit is connected to the box, the double door is removed into the box revealing the service sockets to which the corresponding plugs can now be fitted. Outside the biological shield the services can be connected to the appropriate supplies.

Should the services need to be changed the transfer arrangement is reversed, the double lid is put in place, the sealed container is removed from the biological shield with its sealed lid and replaced with an alternative supply as necessary.

5. Shielding Structure

The shielding specification given for the facility was the ability to handle up to 10^4 MeV γ curies of fission product activity with radiation levels of 0.25mR/hr on the external surface of the wall. Calculations based on using ordinary concrete (density 2.35 $g.cm^{-1}$) resulted in recommending that the outer shielding walls should be 1.4m thick.

To ensure the boxes were interchangeable in each working position, the penetrations through the biological shielding had to be within the same specification (± 2mm) as the associated ports in the box. The shielding was therefore constructed using accurately positioned steel frameworks, previously assembled in a workshop on a flatbed. The through tubes, which form the penetrations, were positioned using a jig representing the box.

The completed frameworks were eventually transported to the construction site where they were erected and adjusted relative to the plinth position, again using the jig. Once the framework was secured the concrete was poured and vibrated into position to ensure that it penetrated round the ports and the window frame.

Subsequent radiation checks on the structure showed, that despite leaving adequate pathways to release entrained air and permit the concrete to flow, holes were present in the shielding. Some of these occurred in similar positions in each cell and are therefore attributed to design weaknesses which prevented good concrete penetration. The appearance of other holes were more of a random nature and are attributed to insufficient care in pouring the cement. Most of the holes have since been drilled out and refilled, some by tamping lead wool into position.

The framework for the rear removable doors were also constructed in the workshop and then reassembled in position before being filled with concrete. All of the drive mechanisms and the wheels are built within the framework of the doors so when they are closed they exhibit a flush external finish. After the initial construction the wheels had to be removed and repinned but subsequently the 80 ton mass of each door has been found quite easy to move.

The shielding thickness of the ordinary concrete on the front operating face is comparible to that required for the lead glass windows and therefore there is little to be gained by using a denser shielding material for the concrete. However, the corresponding thickness of the rear doors plus the thickness of the gamma gate means that transfer operations have to be performed over relatively long distances. This has created some difficulties in using the double lidded transfer system, particularly if some relatively heavy loads are being transfered. Therefore from the aspect of undertaking transfers, a more dense shielding resulting in a shorter posting distance is likely to be beneficial.

On completion of the shielding structure, a final survey was undertaken and the position of all the ports were found to be well within the dimensional specification.

6. Development of associated equipment

Where possible all of the equipment associated with the facility has been made in modular form to enable change or to allow new components to be introduced more readily.

One of the new features developed specifically for this facility has been the introduction of circular filters[6]. Conventional rectangular filters used in the existing facilities have proved difficult to handle and position remotely. They also required a high degree of flatness for the sealing face and frequently give problems in disposal, particularly with respect to volume reduction.

Having stipulated the need for the containment boxes to have minimal internal protrusions, for ease of ultimate decontamination, a proposal for using a circular filter located in the extract trunking with the filter inlet flush with the inside of the box was pursued. A radial flow filter was designed with seals in the end flanges, which could be installed in the circular stainless steel ductwork (Figure 7).

To effect a filter change, a clean filter, placed behind the used filter, is pushed into the filter housing by a distance of one filter length. In so doing it replaces the used filter which is ejected into the box. These filters are easier to seal and have a simple structure which can be readily crushed for disposal. The initial experience with using and changing these filters has shown them to be very satisfactory.

An important aspect in being able to use the containment boxes in a cyclic manner is the ability to readily empty and decontaminate to low levels. The preferred method is initially to use standard techniques such as swabbing or vacuum cleaning, once the box is empty an electropolishing technique will be used.

A variety of small probes have been developed which range from using a solvent dampened swab to a solvent recirculating system. Although these probes can currently be used manually, the next stage in the development is to automate their application and integrate this with a radiation monitor to survey the activity removal. Ultimately the total system will be computer controlled and set to decontaminate the boxes routinely.

7. Potential improvements

Much of the commercially available equipment that was purchased for the facility, which includes the windows, manipulators, lighting, transfer system, and service connectors is working satisfactorily. However, problems have been experienced with obtaining suitable manipulator gaiters that are capable of being sealed on the inside of the box. Although some commercially available gaiters are being used it is an area requiring further development.

Apart from the equipment designed specifically for use in the facility such as the box handling machine, the large double door system, etc., for which some further development is contemplated, most of the proposed improvements relate to the building. More support equipment has been acquired than was originally thought necessary and consequently insufficient storage space has been allocated. Although cranes have been installed in each area, not all of the gantries are wide enough to ensure complete floor coverage and consequently not all of the hooks can be used close to walls.

The method of using a support framework to house the containment boxes means that provided certain parameters, such as port positions, are maintained a variety of box designs are possible. It may also be possible to use different structural material for the boxes, which could result in cheaper manufacturing costs.

8. Conclusions

Substantial advances have been made in the UK in the design and construction of active handling facilities through the building of this facility.

Some of the problems experienced during the commissioning of the facility may well have been avoided had a longer period been allowed for component development. However the modular approach to the design and construction permits a flexible approach and allows change or further development to be undertaken as and when necessary.

Most of the components necessary for building an active facility are now commercially available as modular units, but further development of the modular concrete shielding would give greater opportunity to rearrange the structure as necessary.

The use of mock-up areas for checking design layouts and developing equipment has proved to be a major asset, they need to be established as early in the project as possible.

The double lidded principle has wider application for interconnecting independently contained volumes, in addition to transfer containers.

The introduction of circular filters has greatly enhanced the handling, sealing and ultimate disposal capabilities.

Future developments are likely to be in the peripheral equipment such as that for moving boxes and for decontamination. For such applications, the use of robotics could be important and developments in this area are to be encouraged.

The continued development of the remotely removable box concept together with other modular components has the potential to further advance the technology and safety in active handling.

References

1. P.E. Brown et al. A new chemical alpha beta gamme active handling facility - conceptual aspects. 27th ANS annual meeting Miami June 1981.

2. D. Campbell et al. A new chemical alpha beta gamme active handling facility - engineering aspects. 27th ANS annual meeting Miami June 1981.

3. J.M. Davis et al. Central Laboratory for Hot Chemistry at Julich. Proc of 13th ANS Conference on Remote Systems Technology 1965.

4. G. Samsel. Five years operational experience of the $\alpha\beta\gamma$ laboratory at the European Institute for Transuranic Elements - Karlsruhe. 13th meeting of the European Hot Laboratories Committee, Julich 1971.

5. C. Ceaarano et al. Design and Safety criteria of the alpha gamma hot laboratory of CNEN - Italy. 17th Meeting of the European Hot Laboratories Working Group., May 1976.

6. D.H. Wheeler et al. Some aspects of ventilation and filtration. EEC Working Group - Plenary meeting 1985 Cadarache, France.

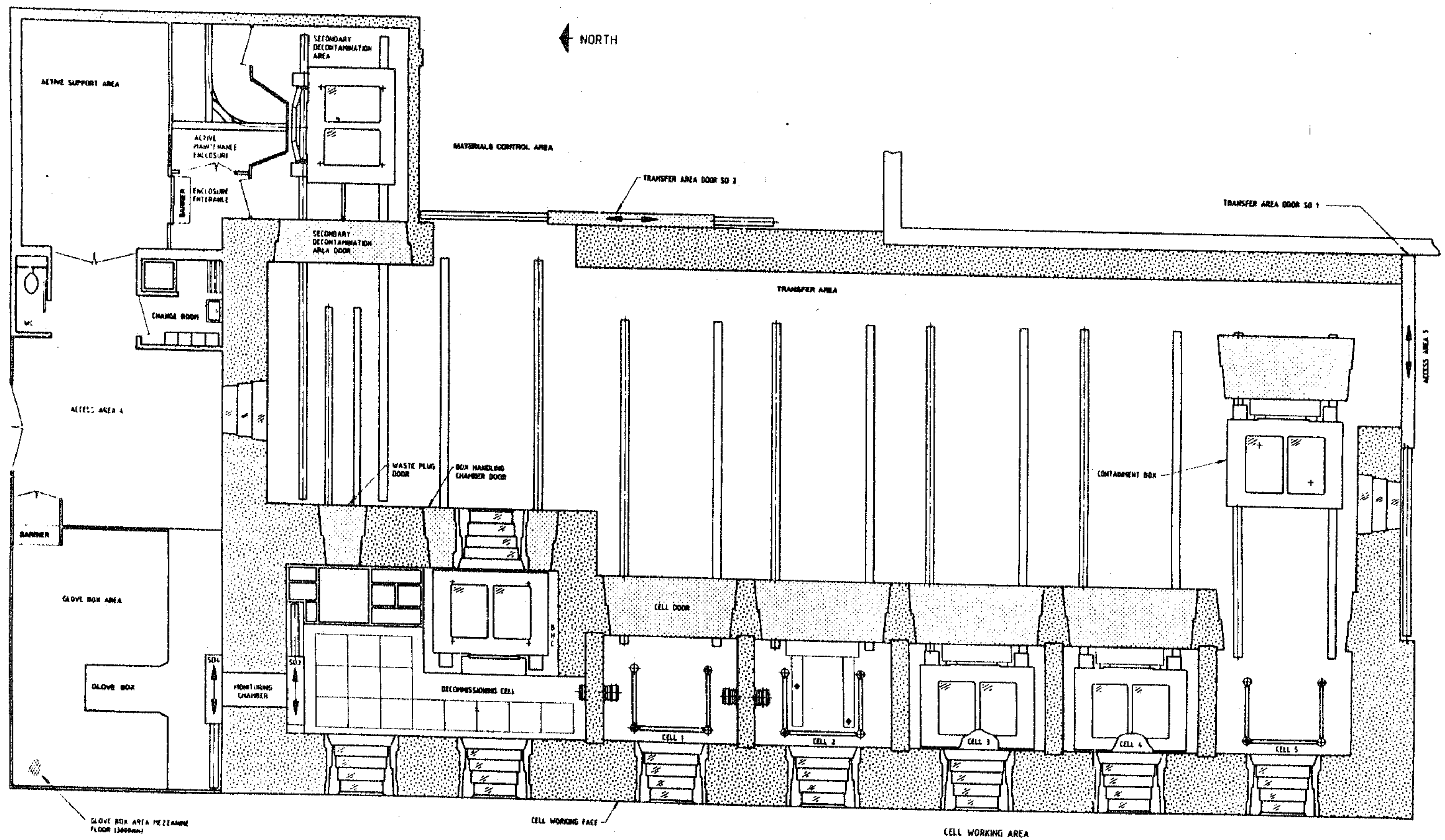


Fig. 1 Plan View of Cell Line

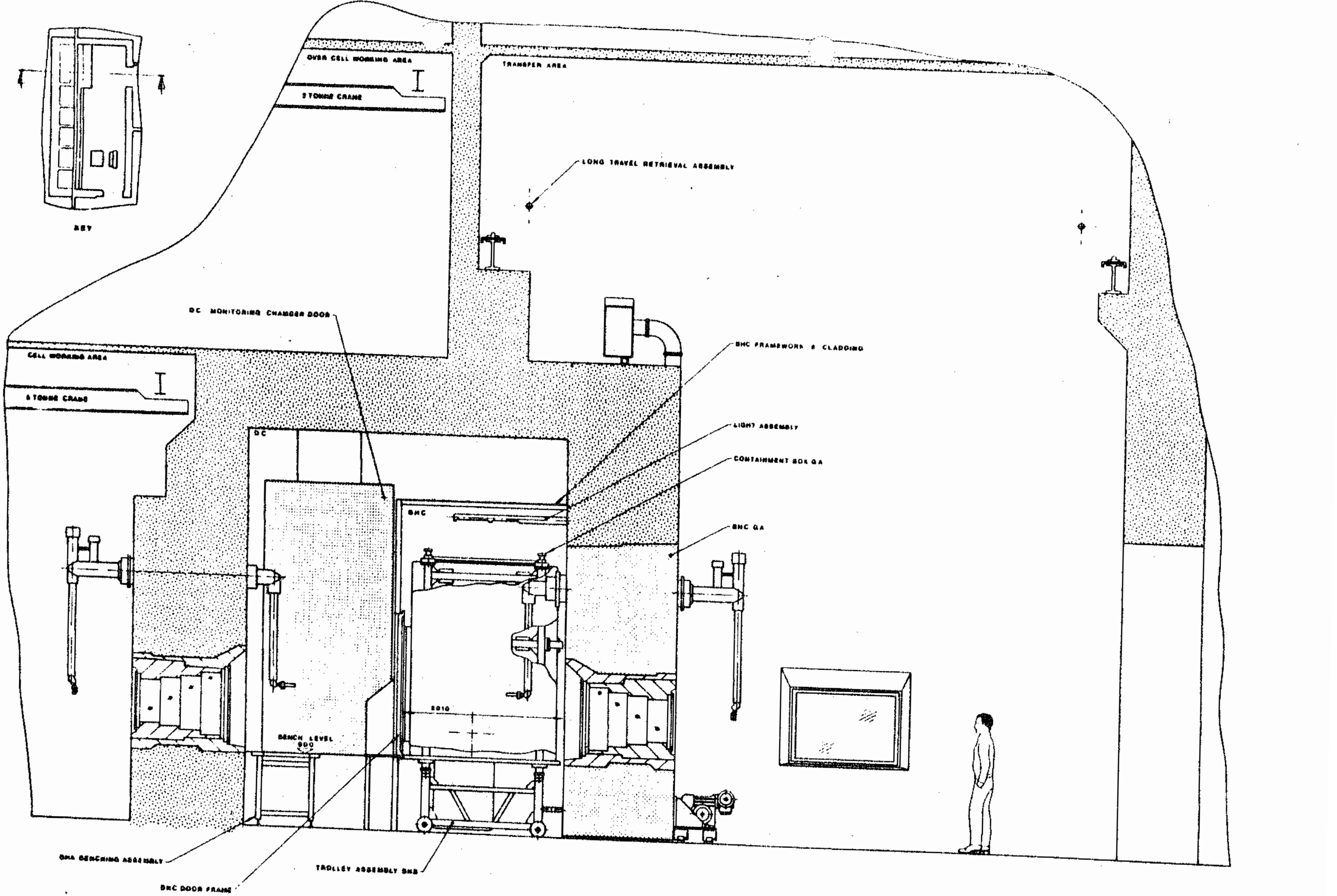


Fig. 2 Section through Decommissioning Cell and Transfer Area

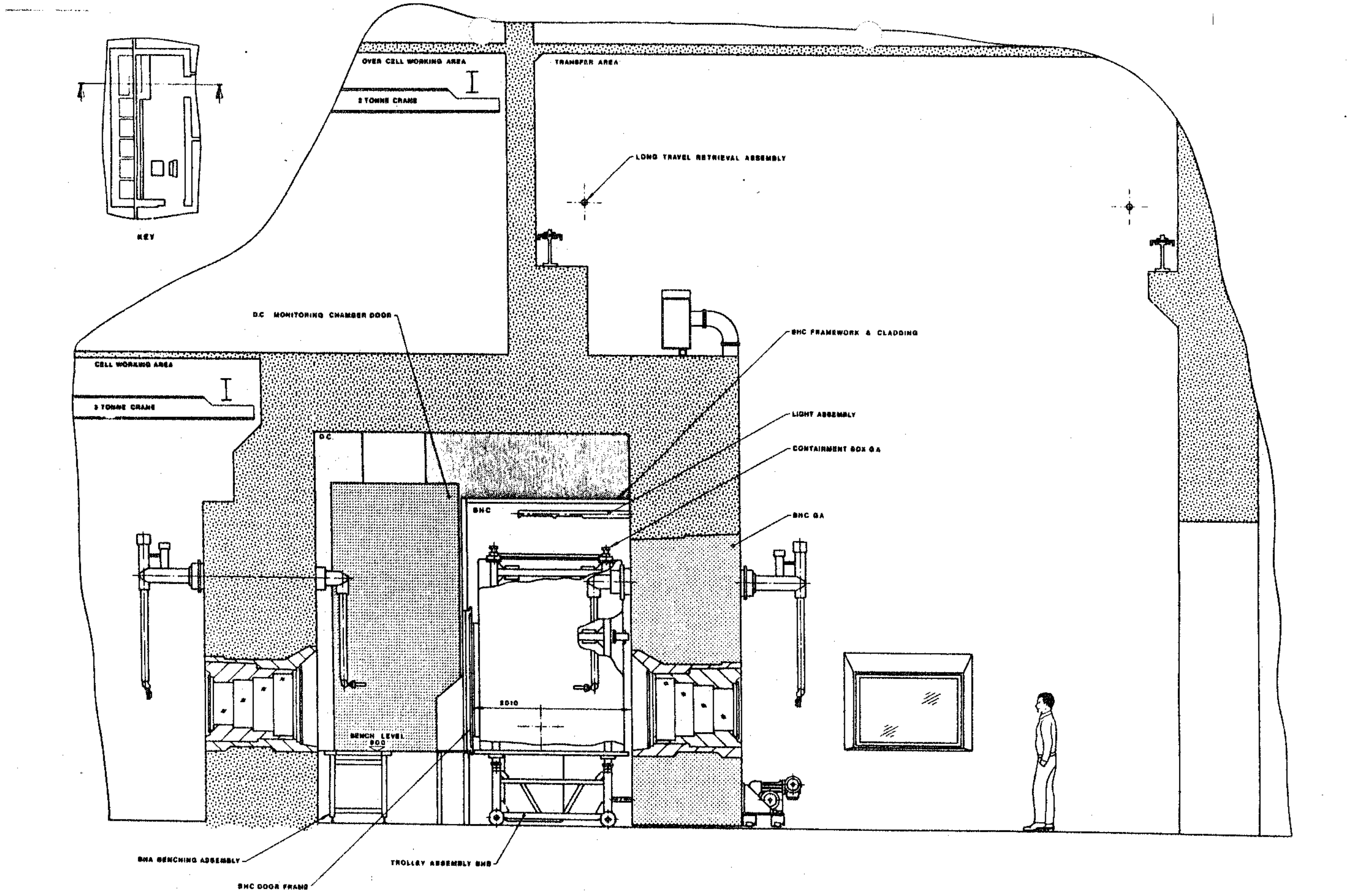


Fig. 3 Section through Decommissioning Cell and Transfer Area

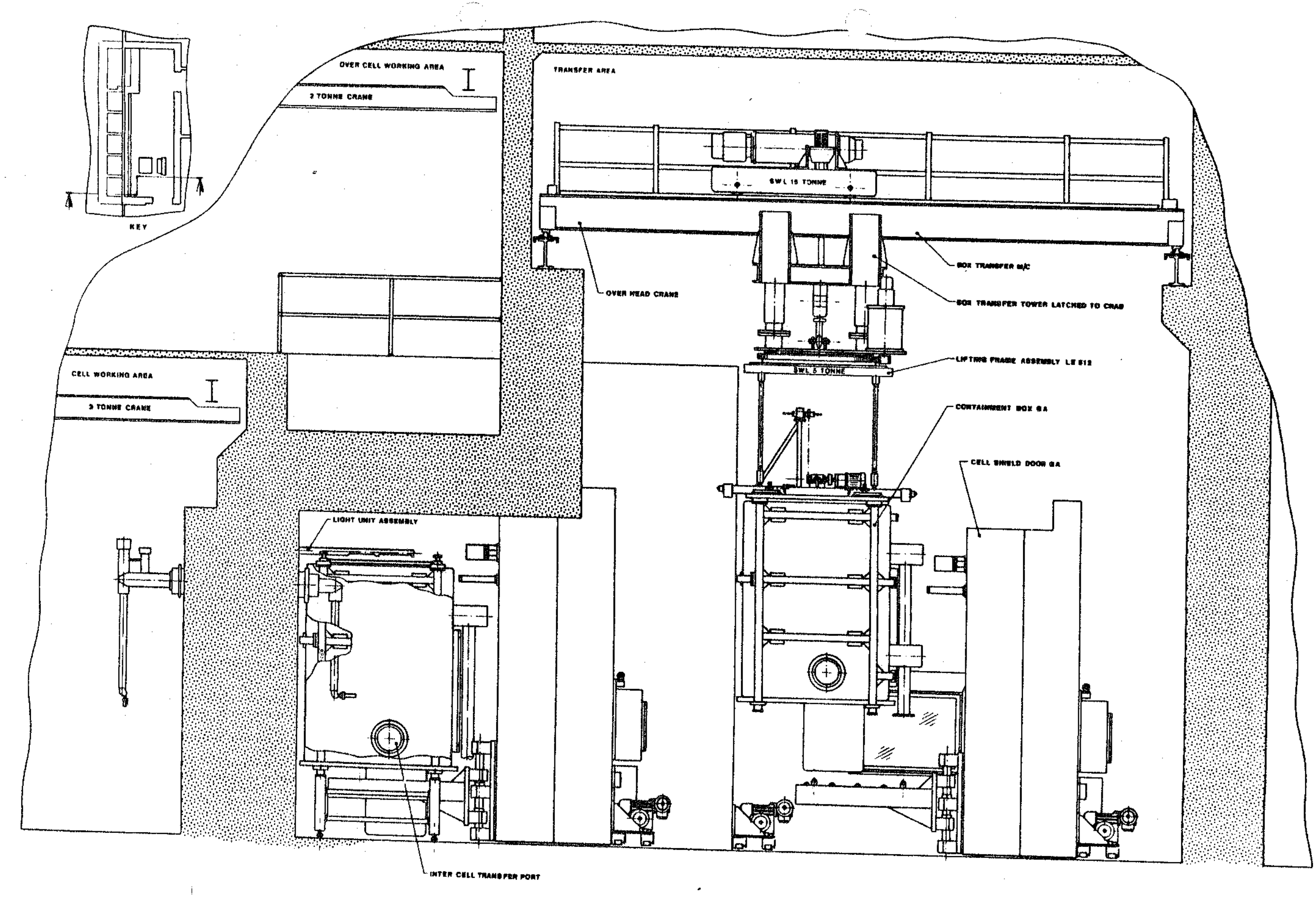


Fig. 4 Section through a Cell and Transfer Area

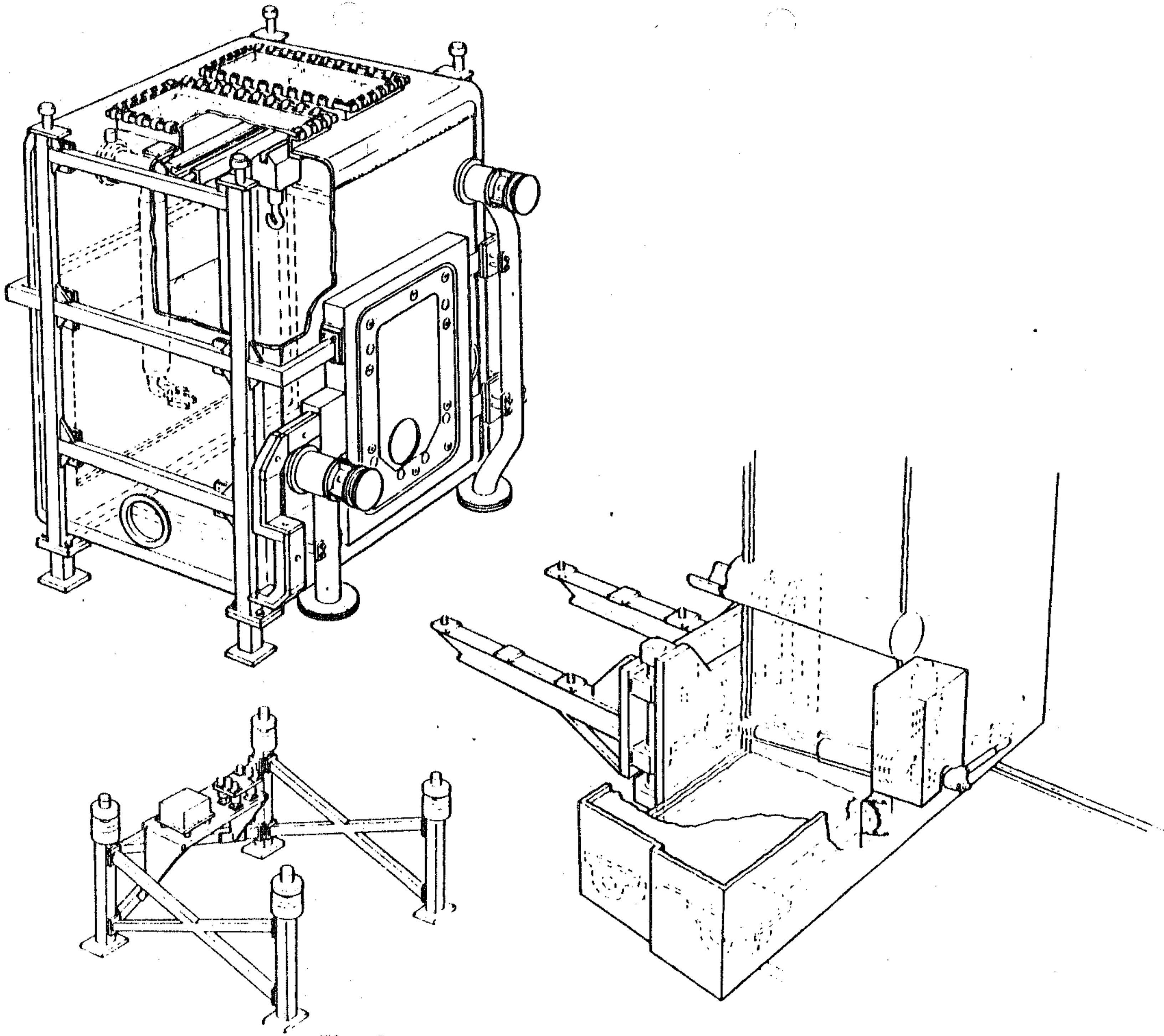


Fig. 5 Containment box, plinth and fork lift

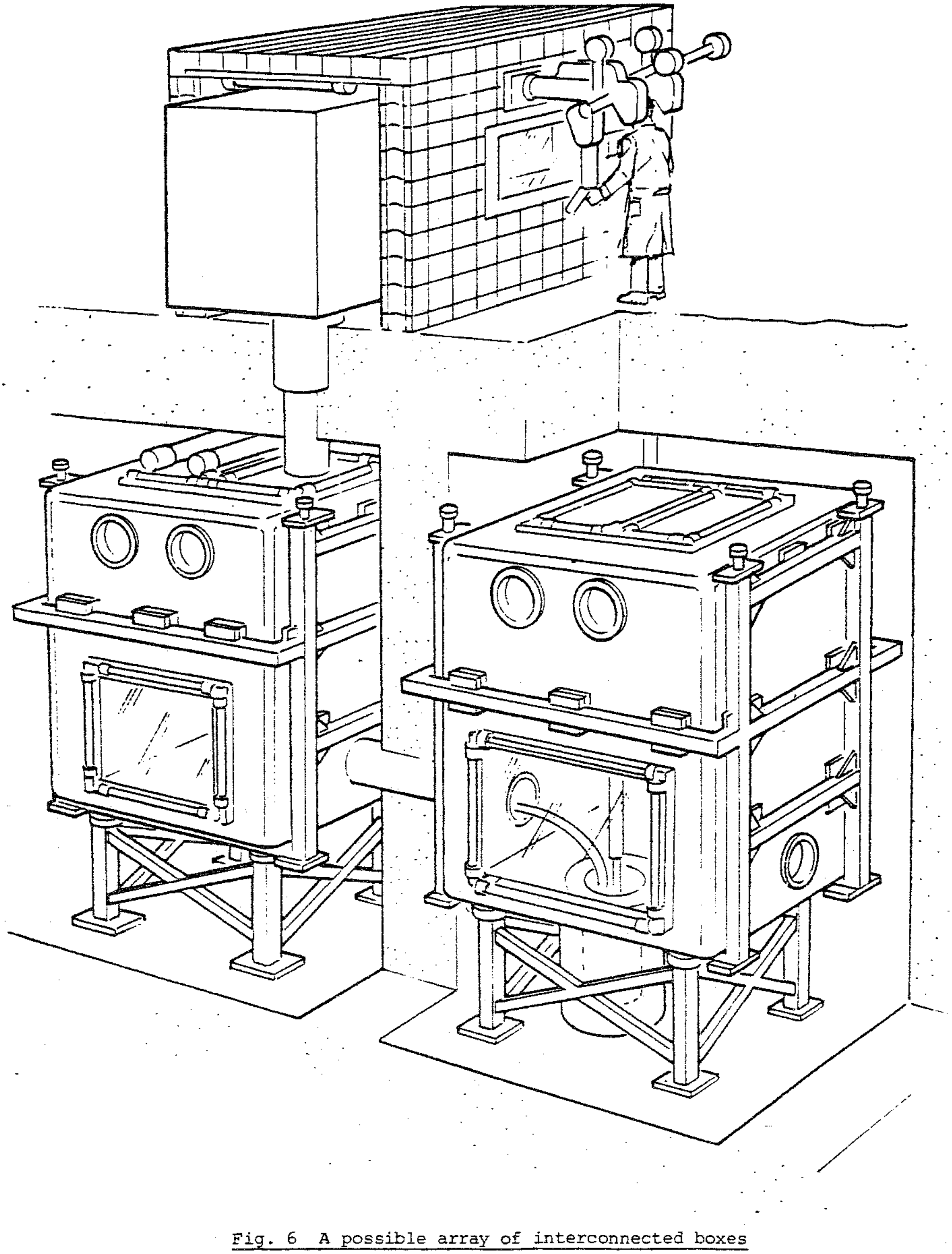
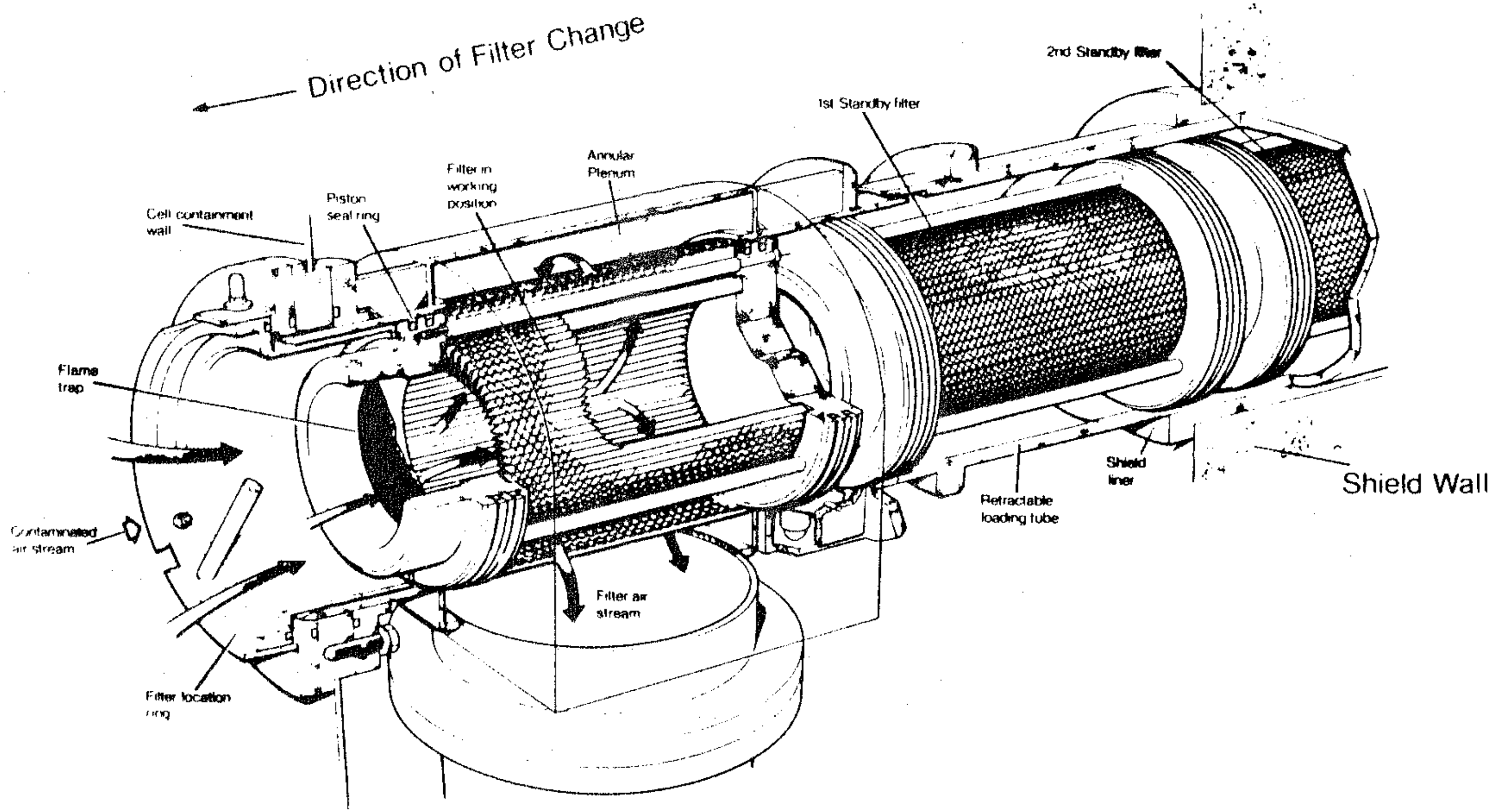


Fig. 6 A possible array of interconnected boxes



Flow rate – 150 cfm
clean air pressure drop 25 mm wg

Fig. 7 Circular filter shielded 'push-through' system