ICANS-VI

INTERNATIONAL COLLABORATION ON ADVANCED NEUTRON SOURCES

June 27 - July 2, 1982

REMOTE HANDLING EQUIPMENT FOR SNS

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1. INTRODUCTION

This report gives information on the areas of the SNS facility which become highly radioactive preventing "hands-on" maintenance. Levels of activity are sufficiently high in the Target Station Area of the SNS, especially under fault conditions, to warrant reactor technology to be used in the design of the water, drainage and ventilation systems. These problems, together with the type of remote handling equipment required in the SNS are discussed.

2. DESIGN OF THE SNS FACILITY

The SNS facility is being built in the old "Nimrod" accelerator buildings, some existing "Nimrod" equipment is being utilised wherever possible in order to save costs. This fact restricts the design parameters when consideration has to be given to remote handling as neither the buildings nor the Nimrod equipment was designed with remote handling in mind.

This has not deterred the designers from considering the problems of remote handling. All equipment has been designed to cater for quick release of the water, electrical and vacuum connections. The majority of accelerator components are in modular form; a module, once disconnected, can be slid or lifted out of its position and a new modular unit fitted. The old unit is then taken to an active handling area in Hall 1 where maintenance can be undertaken. "Nimrod" magnets have also been set in modular units down the EPB line.

When designing an SNS type accelerator the ventilation, water and drainage systems have to be considered for active and remote handling. Systems have to be designed to cope with a target failure however low the probability of this type of incident occurring. If such a failure should occur, the ventilation and filters in the water circuit should be capable of being renewed by remote handling techniques. Radioactive material spilt on the floor must be able to be washed down to a recovery tank in the drainage area.

There have been very few problems in designing these basic requirements into the systems as standard Atomic Energy Codes of practice, proven over the years, have been used. The main codes of practice used, especially in the Target Station area, are listed in Table 1.

3. REMOTE HANDLING AREAS

Fig 1 shows the SNS facility with the Ion Source, pre-injector and linac in the foreground. It is envisaged that these items should be able to be maintained with normal "hands-on" maintenance. Special handling equipment has been devised to handle the steering magnets and chopper vessel installed after the linac[Ref 1]. This equipment (modified fork lift trucks) will aid in keeping time spent by the maintenance crews in a high radiation area down to a minimum.

All other areas shown in figure 1 require some form of remote handling equipment to undertake maintenance tasks around the facility. They are:-

Area 1 Synchrotron Hall.

Area 2 The Extracted Proton Beam Line running from the Synchrotron Hall to the Target Station.

Area 3 The Target Station in Building R55.

Area 4 Transfer Tunnel and Cell.

4. REMOTE HANDLING EQUIPMENT

4.1 Area 1 Synchrotron Hall

As yet no firm decision has been made as to the type of equipment to purchase for work in the area. It is thought that radiation will not reach a level that will prevent "hands-on" maintenance until two years after the start-up date.

To keep radiation levels as low as possible in this area, it is proposed to encase the accelerator in a shielding wall. All electrical and water connections to the synchrotron will be outside the wall to enable "hands-on" maintenance methods to be applied, vacuum vee band clamps are to be disconnected by long rods or by over-the-wall type manipulators.

Some special components, eg. scrapers, will be handled by some form of remote handling from very early on. The main purpose of the shield wall is to minimise activation of the building itself and to contain the activity of "hot" items so allowing freer access elsewhere. The shield will be added gradually as and when needed. We must be careful that the extra time needed for access to the enclosed units does not result in greater doses to the people involved.

Long term plans are to install a mobile remote manipulator aided by remote manipulators mounted from one of the cranes. This type of equipment has been proven at LAMPF, Fermi and CERN labs. Consideration is also being given to purchase a Marauder type vehicle[Ref 2].

Cranes will be radio-controlled in this area; special techniques are being devised to determine the position of a crane to aid remote handling. So that "hands-on" maintenance can be undertaken on the cranes, they will be parked in special shielded areas when the accelerator is operating.

Viewing will be via television cameras. TV cameras are to be mounted on cranes and specially designed track vehicles[Ref 2]. Lighting intensity will be as that proposed for the HEF mock-up at Los Alamos[Ref 3].

4.2 Area 2 The Extracted Proton Beam Line

This is the most difficult area of the accelerator to maintain, for not only are the radiation levels high but the area available for remote handling work is extremely restricted. Also the major part of the equipment is ex-Nimrod stock. Vacuum, electrical and water connections are to be disconnected by a mobile manipulator. The modular units are mounted on rails, once released from their supplies they are then motored down the tunnel to an area where they can be removed.

Viewing equipment will be the same as that used for Area 1 in the Synchrotron Hall.

4.3 Area 3 Target Station

The target which contains 33 kg of Uranium 238 becomes highly radioactive under irradiation by the 800 MeV 200 μA proton beam. Because of this high level of radioactivity, a specially designed remote handling cell is being installed where the target can be removed safely (see figs 2, 3 and 4). The cell has been designed using four commercial through the wall type manipulators, two either side of the target, and two standard zinc bromide windows for viewing purposes. A one tonne remotely operated crane is used for lifting purposes, entry into the cell is via the transfer tunnel and then through the floor of the cell. See fig 5.

To ensure accurate fitting of the target to the water cooling flanges and to prevent the mating flanges from being damaged, a special lifting frame for the target has been produced. The target in the lifting frame is first swung into position on the rail system with the mating flanges 150 mm apart, the target is then pushed forward on a small trolley. Alignment, if required, is achieved by using the alignment screws on the lifting frame.

The target is supplied to the cell in a vertical mode and is stored after irradiation in storage wells in the same position.

In order to turn the target into the horizontal position (and back to vertical) a special turning frame has been designed.

The flanges are tightened by a pneumatic nut runner which is supported by a balancer mounted on a swinging jib.

There are three storage wells in the cell, each target is stored in a well for approximately one year before its removal. The storage wells are fitted with a separate cooling circuit to remove the decay heating in the targets. Before a target is removed from its working position, the storage well cooling circuit is coupled to a secondary cooling circuit of the target. Whilst the target is being moved and stored, the target is cooled at all times.

The reflector and cold moderators have yet to be finalised in design[Ref 4] but it is envisaged that special handling equipment will be made to help maintain the moderators in service. To give adequate viewing of these components, TV cameras are being placed in the cell.

4.4 Area 4 Transfer Tunnel and Transport Cell

The Transport Cell is similar to the Remote Handling Cell but contains only two sets of through-the-wall manipulators. Facilities for installing zinc bromide windows will be made but they will only be installed if it is proven that TV viewing is not adequate. The main function of the Transport Cell is to handle the target into its Transport Flask but it will also be used as a general remote handling workshop.

Radioactive material is received from the remote handling cell via the transfer tunnel and through the cell floor. The material is then placed in suitable radioactive containers and dispatched through a large shielded door at floor level.

To transport the radioactive material between the remote handling cell and the transport cell, a remotely operated transport trolley has been designed. The transport trolley has a cask with 100 mm lead walls to carry the active material. This thickness of lead gives sufficient protection for a person to work hands on for a few minutes on the transport trolley in the event of a breakdown. Viewing of the transport trolley in the tunnel will be undertaken with TV cameras.

5. TARGET FLANGE DESIGN

Several flange designs have been tried in the mock-up remote handling cell. See figs 6, 7, 8 and 9. The Vee Clamp performed well but it cannot be incorporated into the design as it fouled the cold moderator system. At least 10 clamps would be required to obtain the correct closing force on the seal. The lever clamp assembly and the standard nut and bolt were not as easily fitted with remote manipulators as the other two systems.

The swing or eyebolt gave some problems in the cell but worked well once the spring loaded ball was fitted. This enabled the bolt to be placed in the required position whilst the runner was fitted. A firm decision has been taken to use this bolting arrangement.

6. DRAINAGE AND VENTILATION SYSTEMS

If a target failure occurs all the activity is contained within the target station area. To ensure complete encapsulation, the drainage and ventilation systems are being designed to the latest AECP standards.

The drainage system, see fig 10 has been designed to be double sealed throughout the complex. Where pipework goes outside the complex, the pipework is double contained. All inner pipework is stainless steel but to reduce costs the outer pipes may be painted or zinc coated mild steel if they are in a rust free area.

The Synchrotron Room had a drainage and ventilation system installed for Nimrod. The low level active drainage network has been modified and checked. Extra filters are being added to the ventilation plant to ensure that the system is suitable for the SNS.

For the Target Station area a complete new ventilation system is being designed, see fig 11. Several important factors have had to be taken into consideration. They are:

a. The activated air in the target shutter vessels.
b. The helium in the target void vessel.
c. The air in the remote handling cell, the services area, the transfer tunnel and transport cell.
d. The hydrogen and methane plants in the services area.

The major activity in the shutter void vessel is ^{41}Ar (half life 1.8 hr), ^{11}C (half life 20.5 min) and ^{13}N (half life 10 min), see Ref 5. Air from the shutter void vessel is routed via the EPB line and then the Synchrotron Room, the air takes two hours to pass this route thus ensuring at least one half life decay period has occurred. The air from the shutter void vessel is also used for removing 13 kW of heat from the shielding and target void vessel, this heat is removed before it is sent down the EPB line.

To keep a safe atmosphere in the Target Void Vessel, because of the presence of hydrogen and methane, the target void vessel is run at a higher pressure than the surrounding ventilation systems, ie. the target shutter vessels and the remote handling cell. However, to ensure no activity ever escapes from the target void vessel to the surrounding atmosphere, the target void vessel is run at a negative atmospheric pressure. In operation, the target shutter vessel and the remote handling cell will be at -55 mm WG and the target void vessel at -45 mm WG.

The filters in the Target Void Vessel will be the new Harwell circular type, see Ref 6.

The air systems in the remote handling cell and the services area all have HEPA filters (99.95% Eff) to remove particles. Charcoal filters are fitted to remove ^{131}I.

The hydrogen and methane plant ventilation systems have sufficient capacity to remove the total air volume in the plant area in one minute.

7. CONCLUSION

When designing a complex such as the SNS, certain areas of the plant are closer to reactor technology than accelerator technology and have to be designed accordingly. Although this increases the design load, no new technology is required as drainage, ventilation and remote handling techniques for highly radioactive components are well known in the nuclear industry.

8. ACKNOWLEDGEMENTS

The author gratefully acknowledges John Hogston who has carried out design work both on the remote handling cell and the drainage system, Graham Toplis for producing the illustrations and Claire Cheesmore for typing the report.

REFERENCES

Ref 1 70 MeV Injector Component Handling in the HEDS Tunnel. P Gregory. Internal SNS Report No. SNS/AMM/P8/81.

Ref 2 Manufactured by Morfax Ltd, Mitcham, England.

Ref 3 HEF Mock-up at Los Alamos. Paper No. LA-UK-82-1393.

Ref 4 Cryogenic Moderator Design. B R Diplock. This conference.

Ref 5 Activation of Air in Shutter Vessels. T Broome. Internal SNS Report No. SNS/ENV/M6/80 Amend 1.

Ref 6 Development of Filters and Housing for Active Plant. S Hackney and R Platt. AERE UKAEA. 17 DOE Nuclear Air Cleaning Conference.

Table 1. Summary of the UKAEA Atomic Energy Codes of Practice & Standards used in the Design, Construction and Testing of Components of the Remote Handling and Transport Cells

COMPONENT	SUBJECT OF CONTROL	CODE OF PRACTICE OR STANDARD
Ventilation Systems	Design, construction and testing	AECP 1054
Drainage	" " "	AECP 1058
Interior lighting	" " "	AECP 1019
Interior painting	" " "	AECP 1002
Lifting equipment	" " "	AECP 17
Electrical equipment	" " "	AECP 1039
Compressed air systems	" " "	AECP 1033
Zinc Bromide windows (optical grade)	" " "	AESS 10886
Fire prevention	" " "	AECP(W) 152
Coatings for decontamination	" " "	AECP 1057

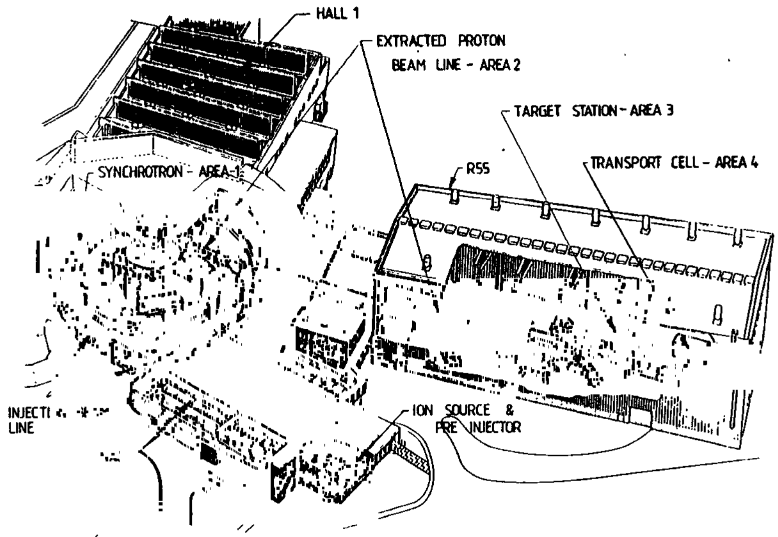


Fig. 1. The overall SNS facility

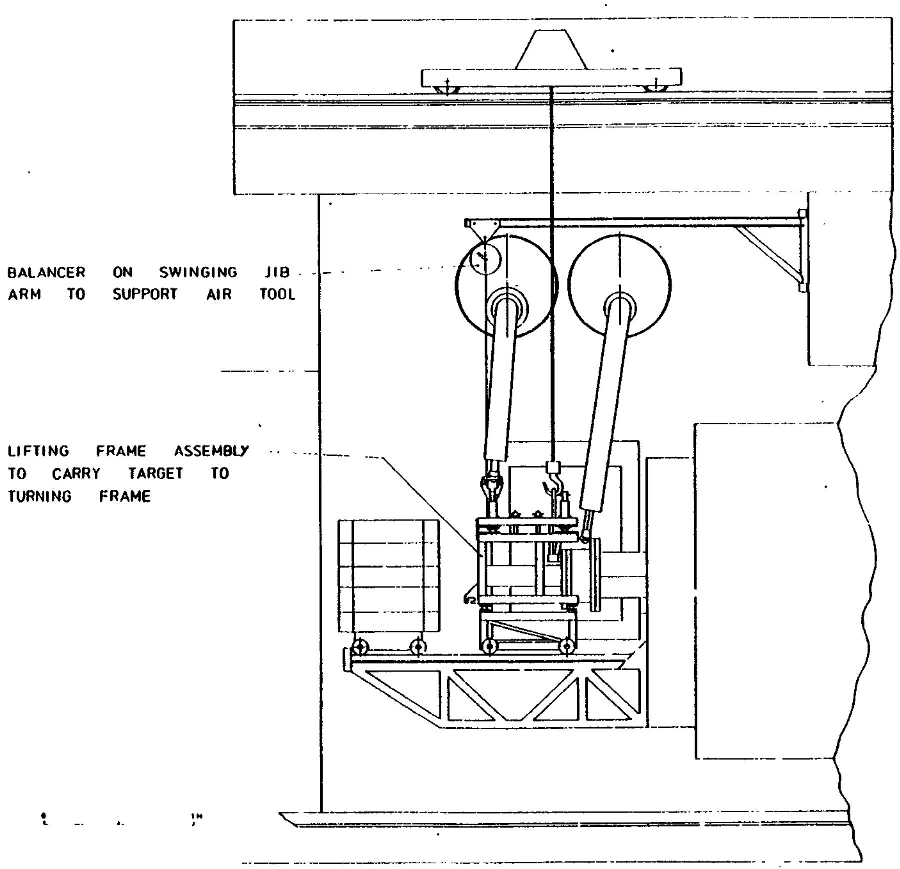
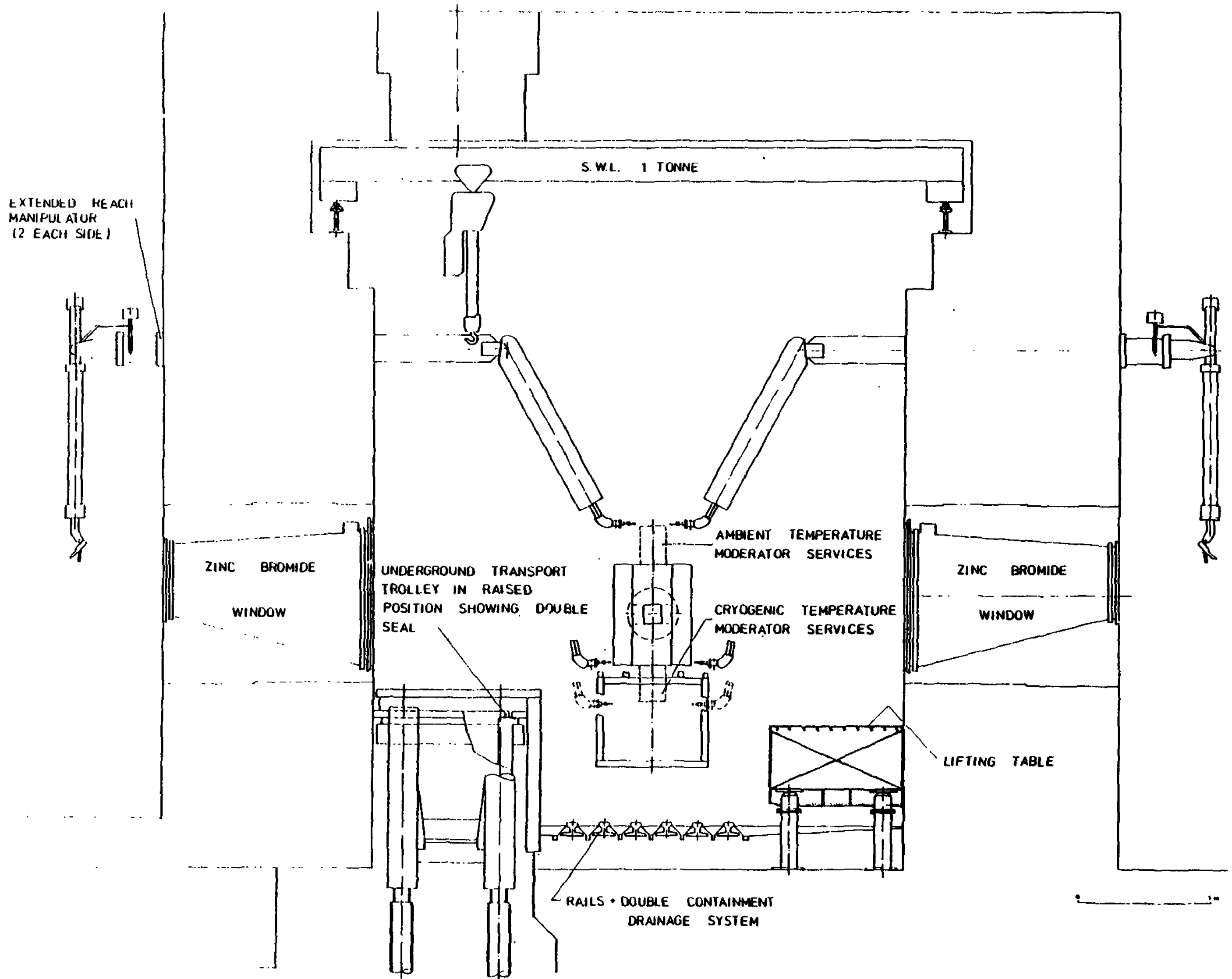


Fig. 2. Remote handling cell (side view)


S.W.L. 1 TONNE
EXTENDED REACH MANIPULATOR (2 EACH SIDE)
ZINC BROMIDE WINDOW
ZINC BROMIDE WINDOW
AMBIENT TEMPERATURE MODERATOR SERVICES
UNDERGROUND TRANSPORT TROLLEY IN RAISED POSITION SHOWING DOUBLE SEAL
CRYOGENIC TEMPERATURE MODERATOR SERVICES
LIFTING TABLE
RAILS + DOUBLE CONTAINMENT DRAINAGE SYSTEM
TRANSFER TUNNEL

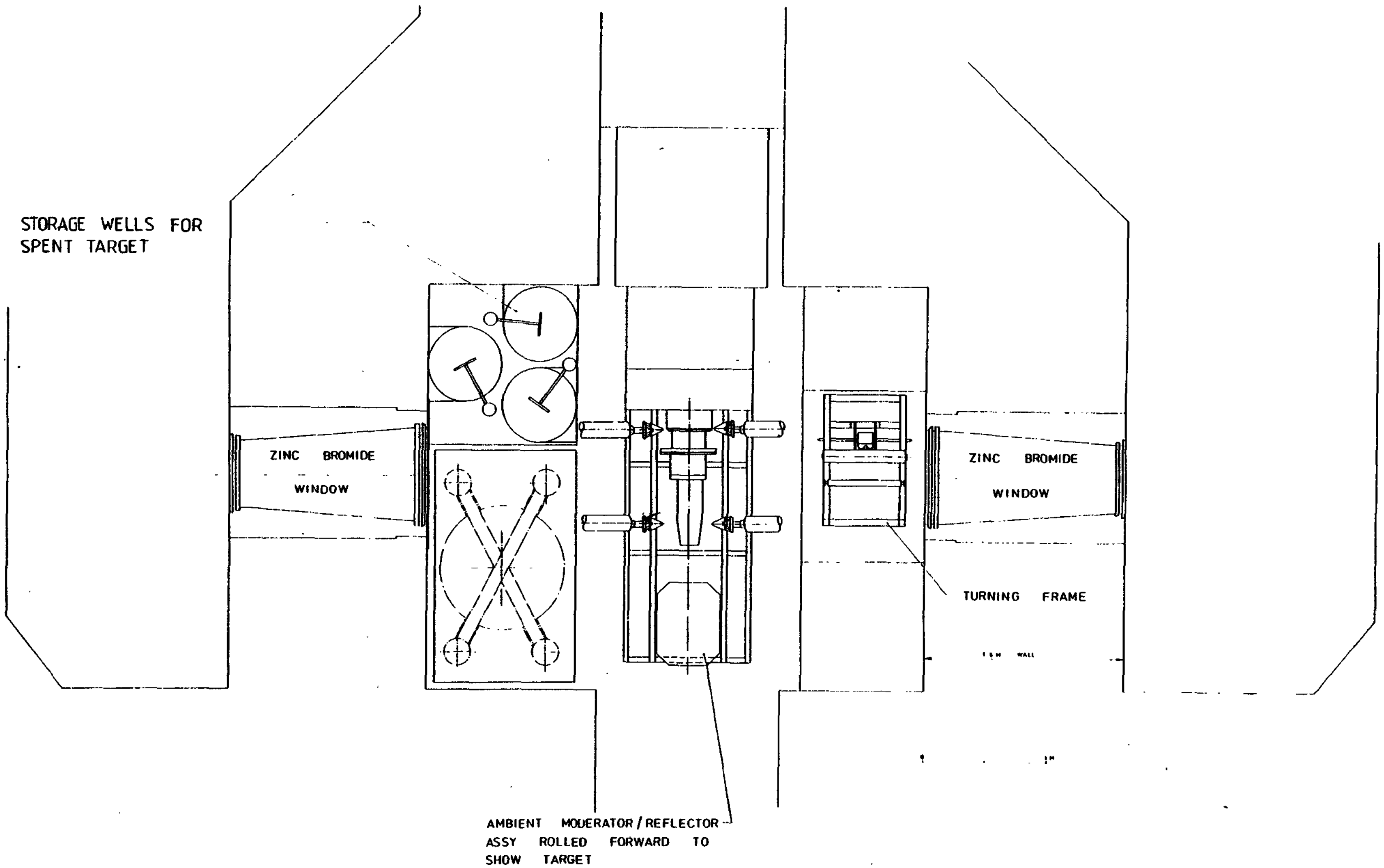


Fig. 4. SNS remote handling cell (plan view)

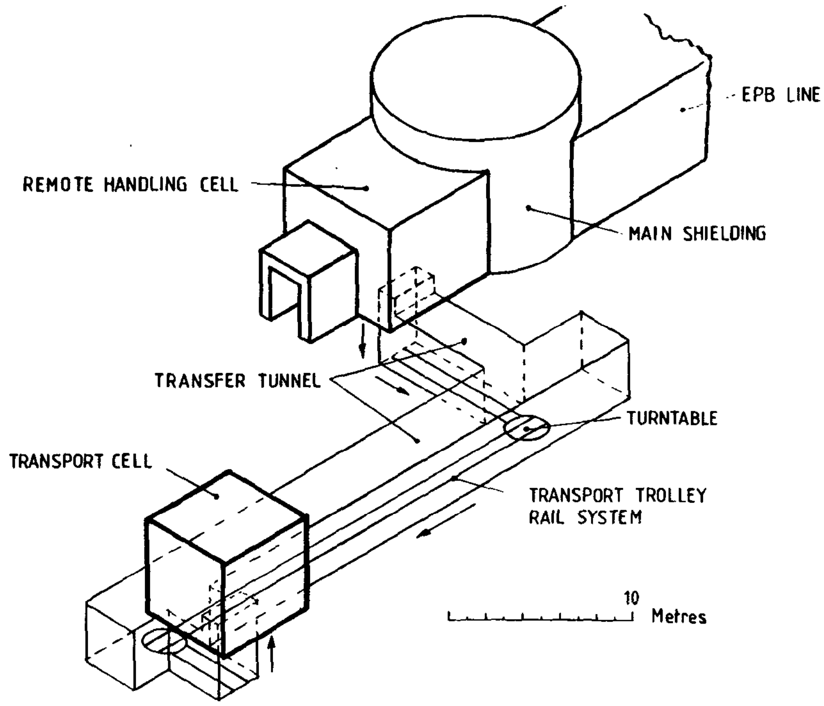


Fig. 5. Remote handling cell, transfer tunnel, and transport cell.

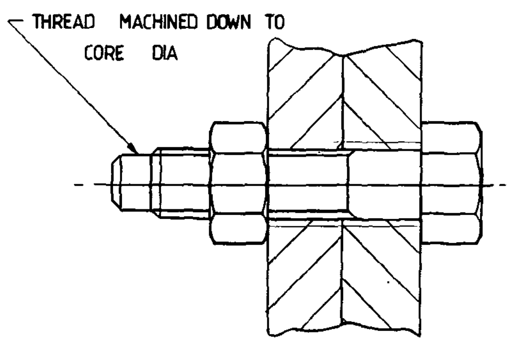


Fig. 6
Standard nut and bolt

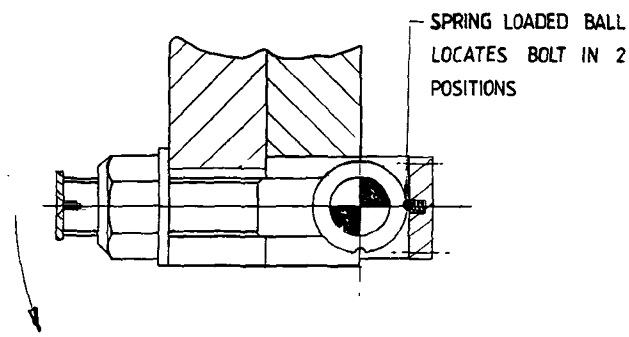


Fig. 7
Swing or eyebolt

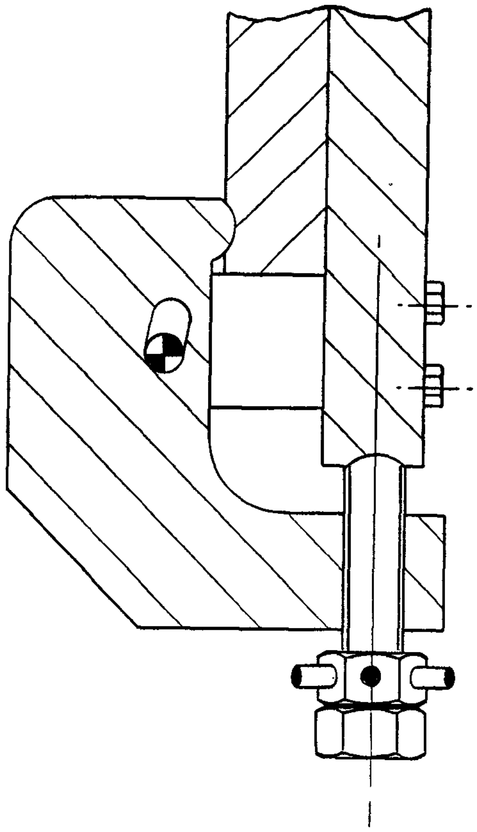


Fig. 8
Lever clamp assembly

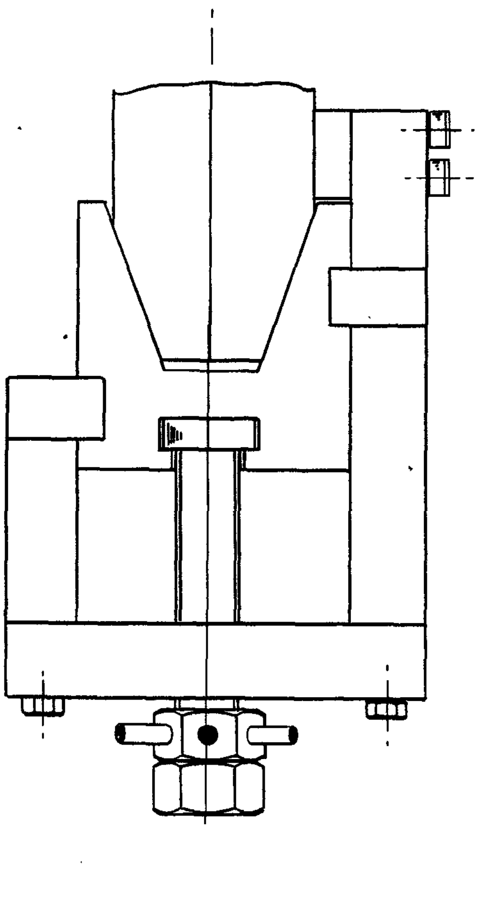


Fig. 9
Vee clamp

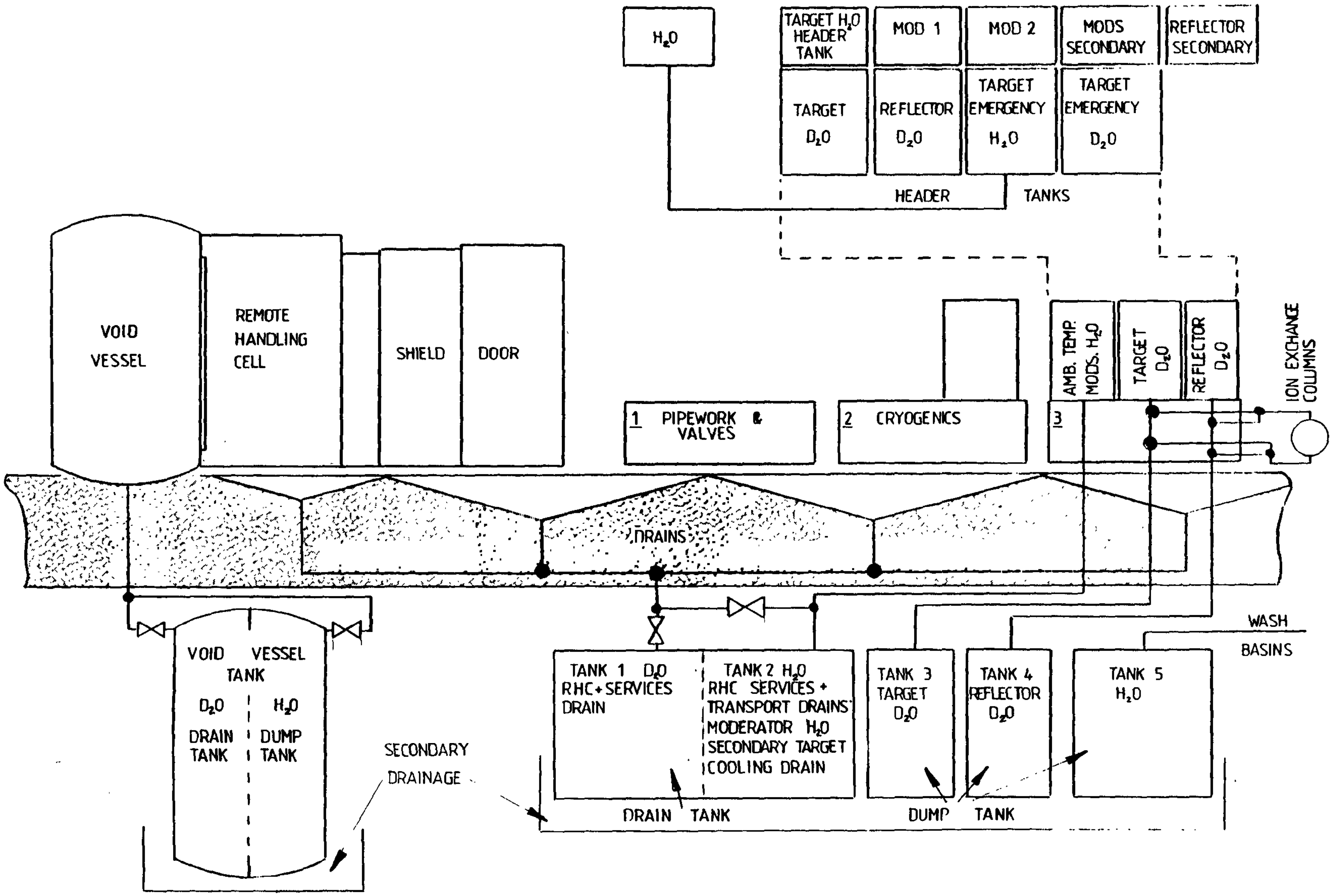


Fig. 10. Drainage system for SNS target station

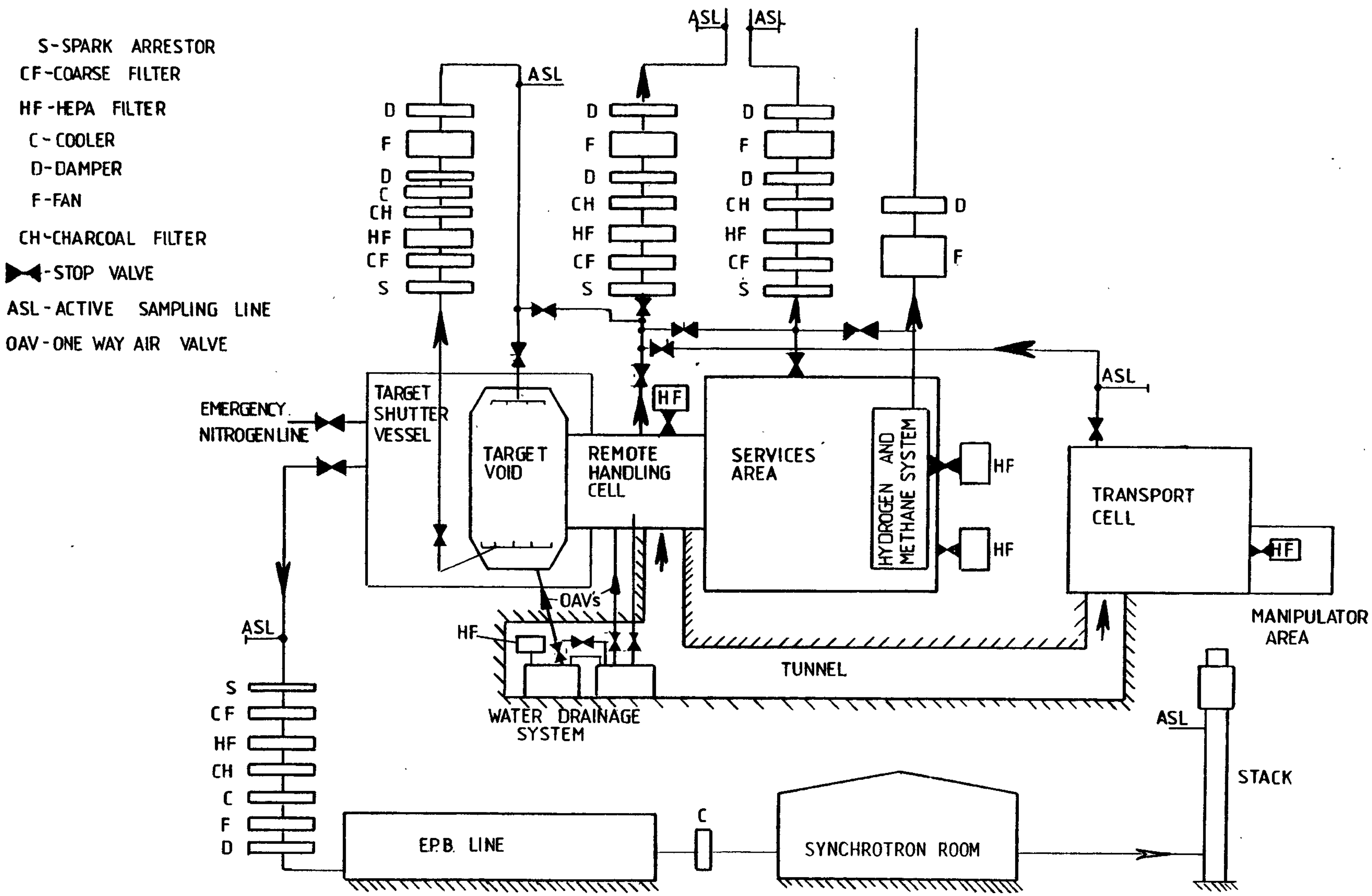


Fig. 11. Ventilation system for target station