Remote handling for an ISIS target change

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1. Introduction

During 1987 two ISIS targets were changed. This document describes the main features of the remote handling aspects of the work. Many people took part in the job, either directly or indirectly, and their considerable efforts are gratefully acknowledged.

All the work has to be carried out using remote handling techniques. The radiation level measured on the surface of the reflector when the second target had been removed was about 800 mGy/h demonstrating that 'hands on' operations on any part of the target reflector moderator assembly is not practical.

The target changes were the first large scale operations in the Target Station Remote Handling Cell and a great deal was learned about both equipment and working practices. Some general principles emerged which are applicable to other active handling tasks on facilities like ISIS and these are discussed below.

The sequence of operations for the remote handling is given in appendix A as an aid to understanding the video film of the work

2. The remote handling cell

Figure 1 shows the layout of the Target Station. In operation the target is positioned in the centre of the biological shield. For all maintenance work the target with its associated shield plug, cryogenic and ambient water services trolleys is moved back to position the target reflector and moderator assembly in the Remote Handling Cell as shown in Fig. 2.

A plan view of the RHC is shown in Fig. 3. The cell is equipped with two pairs of VNE 80 master slave manipulators, a remotely controlled crane of capacity 1 tonne and viewing is through two zinc bromide windows 1.6m thick.

For target changes video cameras are installed to improve the view for the operators. There are three fixed cameras, one on each side of the cell (positions A and B on Fig. 2) and one at high level (position C). All of these fixed cameras were equipped with remotely operated pan, tilt, zoom and focus. In addition two small cameras were used which could be held by the manipulators to give a view of areas not well covered by

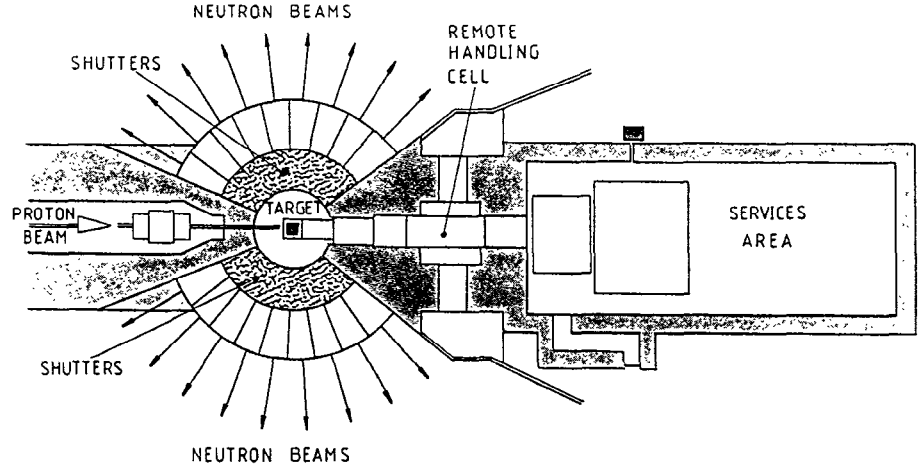

Fig. 1 Layout of target station.

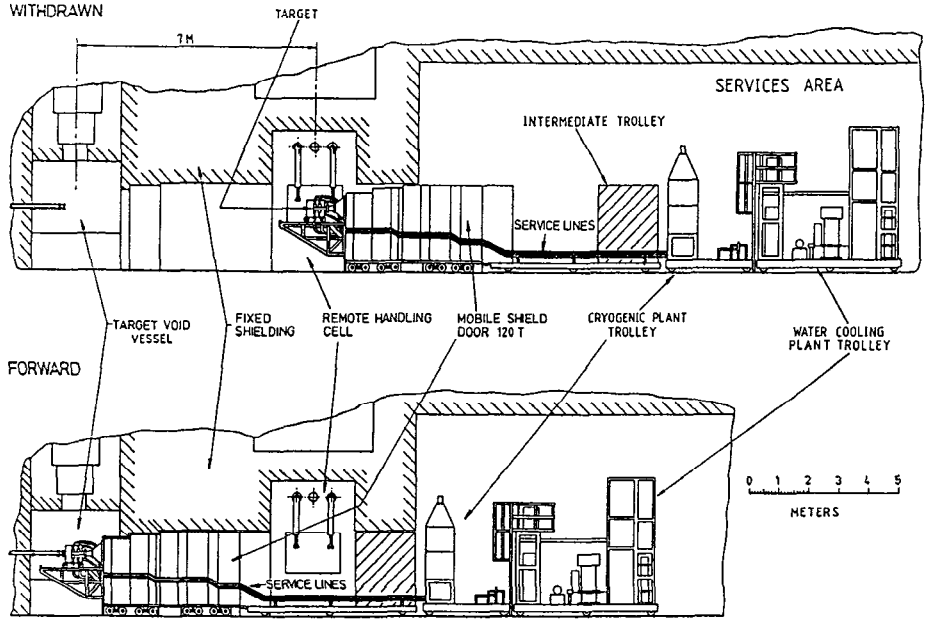

Fig. 2 Target assembly and services trolley.

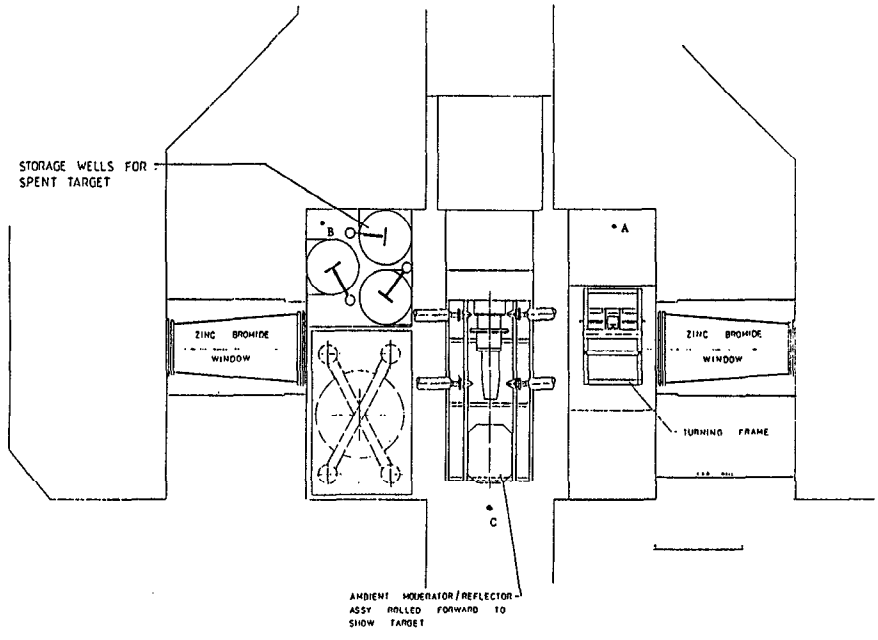

Fig. 3 Remote handling cell - plan view.

the windows or the other cameras. Pictures from the cameras were displayed on monitors in the manipulator rooms and were also recorded on video tape.

An intercom system allowed the operators in the two manipulator rooms to talk to each other and to listen to the sound inside the RHC.

3. Tools

The desirability to test the remote handling equipment in dummy runs or a mock-up before it is installed was recognised but there was only time and resources in the installation schedules to prove the overall concepts. Also the first target failed somewhat earlier than had been expected so the equipping of the cell and provision of tools was, of necessity, done in a very short time which inevitably lead to some compromises and development during the job.

Ordinary open ended and ring spanners were used for tightening and loosening nuts. They were fitted with special grips for the manipulator jaws. An air operated wrench was tested before the first change on a spare target flange bolt. However, the nut seized possibly because the rotational speed of the wrench was too high so it was decided not to use it on the real job.

The only specialist tool, the cropper for the thermocouple umbilical, worked well although some redesign of its support on the crane would make it easier to align.

4. Management of the work

Effective management of the work was essential to its efficiency and success. The responsibilities were split into two areas—safety, and control of the actual remote handling operations.

4.1 Control of safety

In general the day to day problems of radiation protection on ISIS are the responsibility of a 'Radiation Protection Supervisor' who is normally the leader of the operations crew on duty. It was felt that the demands of the task of changing a target were sufficient to require a full time Radiation Protection Supervisor who was appointed for the duration of the job.

In particular his duties involved:

(i) Controlling access to the various areas of the Target Station namely:
Services Area
Remote Handling Cell
South Tunnel
Manipulator Rooms

(ii) Issuing of 'Permits to Work' which are required for personnel to work in areas where the dose rate is greater than 250 uSv/h

(iii) Issuing 'Permits' to allow people to work in the Remote Handling Cell which is defined as a 'confined space 'i. e., an enclosed volume with only one access

(iv) Keeping a detailed log of the work

The RPS was based at the Target Station throughout the target change and he was in very close liaison with the person controlling the work, although these two people have independent and distinct roles. For the second target change the RPS had a television screen showing the work in progress in the Remote Handling Cell. In addition there were detailed video tapes from the first change available for reference.

It is also necessary to keep the operations staff informed of the progress of the work and the state of the Target Station when it is left unoccupied. It was convenient for the Radiation Protection Supervisor to do this. Also he was the natural person to keep the Laboratory Safety Officer fully informed and to consult him when necessary.

4.2 Control of the work

This task was performed by a person independent of the Radiation Protection Supervisor. The manipulator rooms are small and it was found important to limit the number of people in them to the minimum required to perform the task in hand. For most of the time only four people were permitted to be in each room—two to operate the manipulators, one to operate the cameras and a fourth person to operate the crane. For this reason the progress of the job was monitored and controlled in

conjunction with the RPS, much use being made of the remote television pictures in the target change control office.

The work was planned to be carried out in set elements following the written procedures. Generally this worked well but on occasions, particularly during the first target change there was a tendency to press on. It is important to remember that remote handling is physically and mentally taxing and the person in charge must be aware of fatigue setting in. If individual tasks are not going according to the procedures laid down the work should be stopped and the problem considered away from the working area and the master video tape referred to. This was done several times during the second target change and proved to be a successful method of working. The target change control office was found to be the most convenient place to discuss problems.

5. General comments on the target changes

The target changes carried out were generally very satisfactory. However, neither change went entirely to plan and it can be anticipated that future target changes will have their own special problems.

Very little testing of the principles and equipment needed to change a target remotely had been possible before the original installation so the two target changes represented the first chance to develop the system. Before starting to change target number one as much mock-up work as practical was carried out. The target storage was checked completely with a spare target and the positions of the cameras in the cell checked, as far as possible, to ensure that they would provide the required views for the various operations.

One main general problem was the unreliability of the VNE 80 manipulators. There is one pair on each side of the cell and all four became unserviceable at some time during the work. In fact, both target changes had to be stopped for the manufacturer to repair the manipulators. The manipulators are absolutely crucial to the work and steps have been taken in conjunction with the manufacturer to improve their reliability.

Before the first target change there was very little experience with manipulators at RAL. A specialist from Harwell Laboratories assisted with both target changes and his comments were very useful and appreciated. By the end of the second change several of the RAL team had become very proficient in the use of manipulators and it is not expected that external specialist operators will be necessary in the future.

The design of the tools, particularly their handling fixtures, was improved a great deal between the two target changes. Experience is showing what type of attachments are best for each tool to make them convenient for use with the manipulators. Getting the spanners properly located on the nuts was frequently quite difficult. They all fitted the nuts slightly too well and they will be machined, with a lead in, before the next target change. Also some of the spanners were quite heavy and tiring to use. Aluminium alloy spanners will be tested as an alternative to the current steel ones. All the tools were fitted with chains. This was to aid retrieval when they were dropped.

Detailed check lists of equipment for use in the cell were produced which proved to be most important. In addition to the tools expected, a range of others was put in to cater for the unforeseen. In both target changes all the tools were used and more had to be put in as well so the provision of tools will need careful review before the next change.

The positions of the video cameras in the cell, and their mounting arrangements can be improved. In the second change the overhead camera (position C in Fig. 3) was fitted with remote pan, tilt, zoom, and focus which it did not have in the first change and this made the work considerably easier and resulted in the the small cameras with flying leads being used somewhat less in the second change than in the first. A colour camera was used in the second change and it was generally felt that it gave a better view than black and white.

Video recordings were taken continuously during both target changes which is a practice which will be continued in the future. When a problem occurs the relevant film from previous changes can be viewed which may well present a solution. The master film will need to be updated after each target change to make sure it includes not only the work which went according to plan but also the techniques and methods found useful for dealing with any unexpected difficulties.

The intercom system which allowed the operators on the two sides talk to each other was essential for many operations particularly when using the crane to move equipment when a good view could only be obtained from one side or the other. It was found that the use of the intercom required some discipline to avoid a general babble with at least four and sometimes more people being able to talk at the same time.

6. Essential improvements

The margin between success and failure for both target changes was at times small. For example, on the first target change there were difficulties in removing the old target and on the second change it was necessary to replace the pipe and flanges feeding the casing circuit. It is quite likely that future target changes will present new problems. While it is difficult to anticipate exactly what these will be several improvements were identified, regarded as essential, which should make the job easier and give greater scope for dealing with any difficulties.

The main single improvement needed is the provision of a posting port for introducing small items of equipment into the remote handling cell. The design of the cell included posting ports but they have yet to be installed.

The tools while mainly adequate can certainly be improved. It is felt to be important to have some power operated spanners and to find more convenient methods of applying known torques when tightening nuts.

Some design changes are necessary. The attachment of the thermocouple connector to the main shield door was extremely difficult in both changes and this has already been redesigned. Also the bayonet connectors on the water pipes will be strengthened

to avoid the problems encountered in the second change when one of them was damaged and had to be replaced.

7. Remote handling general

During the two target changes several principles became evident which it was felt would be applicable to general remote handling tasks.

a. A comprehensive list of all items required , no matter how trivial, is vital
b. Spares of all components which could need to be replaced should be available before the job starts
c. Only one operation or function at a time should be attempted
d. Good location should be achieved first before any locking or tightening is attempted. i. e., the task should involve a change to one dimension only at a time.
e. When dowel location is used the dowels should be of unequal lengths to enable the component to be fitted in one plane at a time.
f. Hexagon shapes appear to be easier to handle than round shapes with two flats
g. A video film of detailed operations is a very useful tool, this is different from a publicity film
h. It is not always possible to 'feel' things with manipulators particularly at extended reach

APPENDIX 1. Outline of the Remote Handling Procedure

As an aid to understanding the operations shown in the video film the components of the target reflector and moderator assembly referred to in the procedure below are illustrated in Figs. 4 to 8. Figures 4 and 5 show the target reflector moderator assembly during initial installation. Also visible in the bottom left hand corner of the photograph of the top of one of the wells for storing used targets. Figures 6, 7 and 8 show various features of the assembly mentioned in the procedure below.

A video film showing the stages in replacing a target has been produced by editing film recorded during the two target changes. It should be noted that the object of these recordings was to aid the work in progress and to help with future changes. Thus the camera pictures chosen during the operation were those which best supplemented the direct view of the job via the windows rather than the one which itself gave the best view of the task. Much of the remote handling was, in fact, done without the need for camera pictures at all.

The process of changing a target can be split into eight basic parts.

1. Exposing the target by rolling back the upper section of the reflector
2. Draining the remaining water from the target
3. Unbolting the target and thermocouple connector
4. Preparing the target for storage
5. Storing the target
6. Bolting on a new target and thermocouple connector
7. Reconnecting the cooling systems
8. Replacing the upper section of reflector

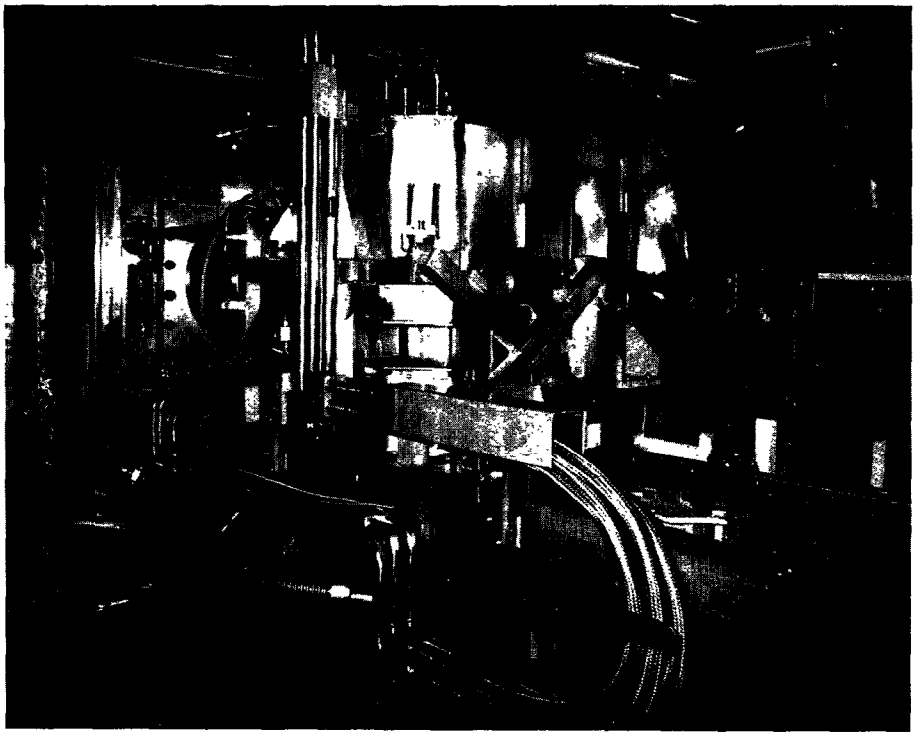

Fig. 4 Target reflector moderator assembly during construction.

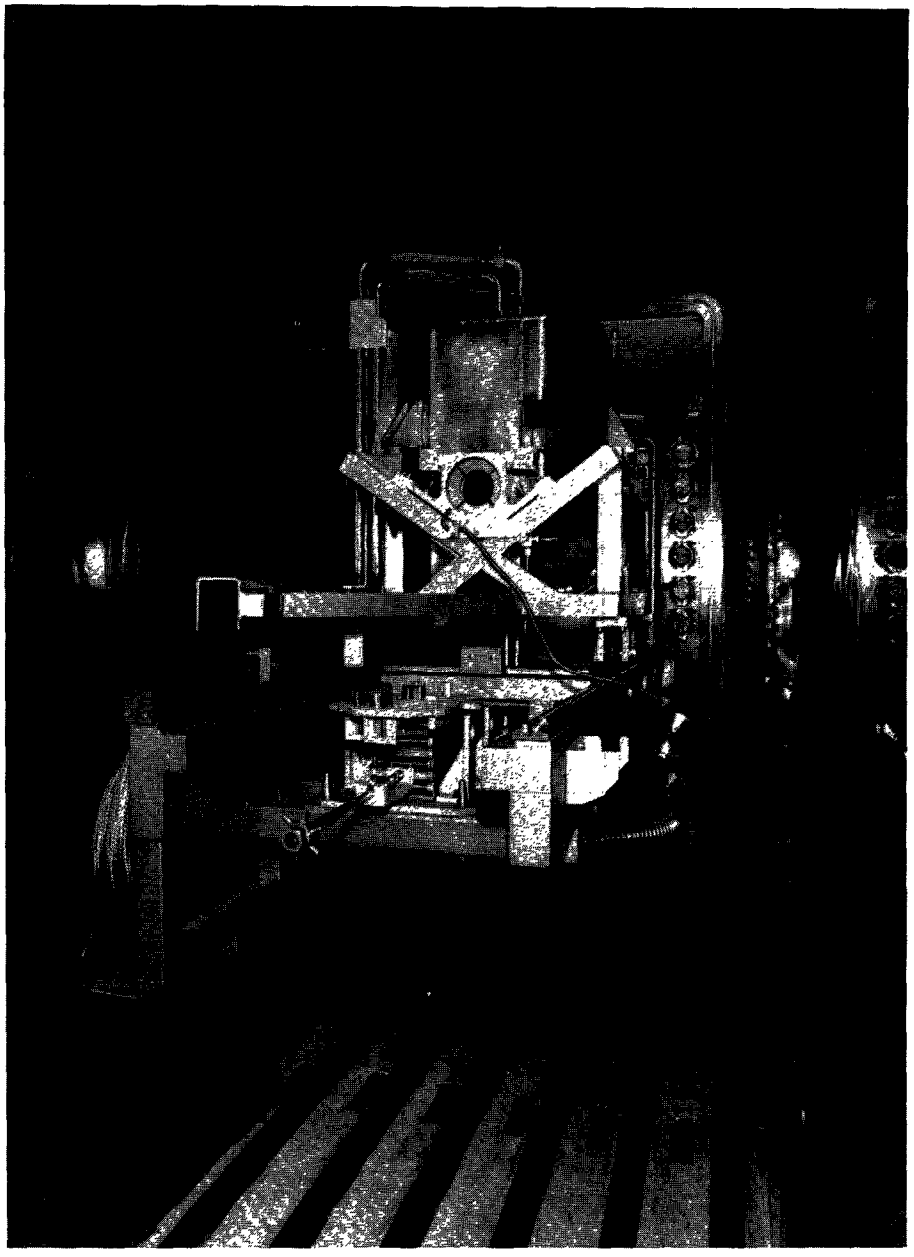

Fig. 5 Target reflector moderator assembly during construction.

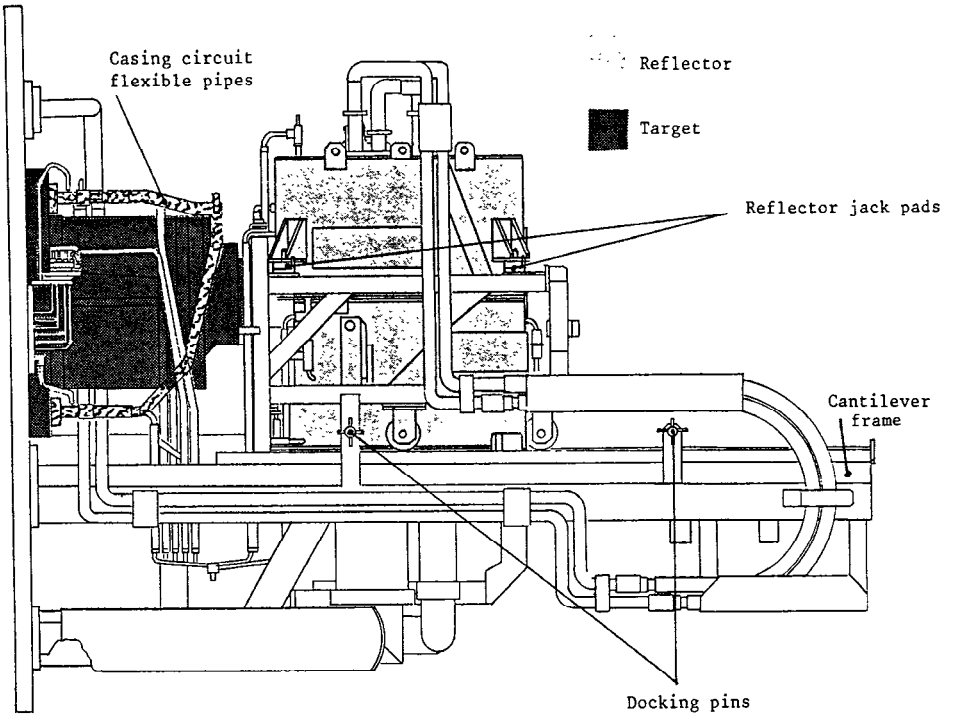

Fig. 6 Target reflector moderator assembly in operational configuration.

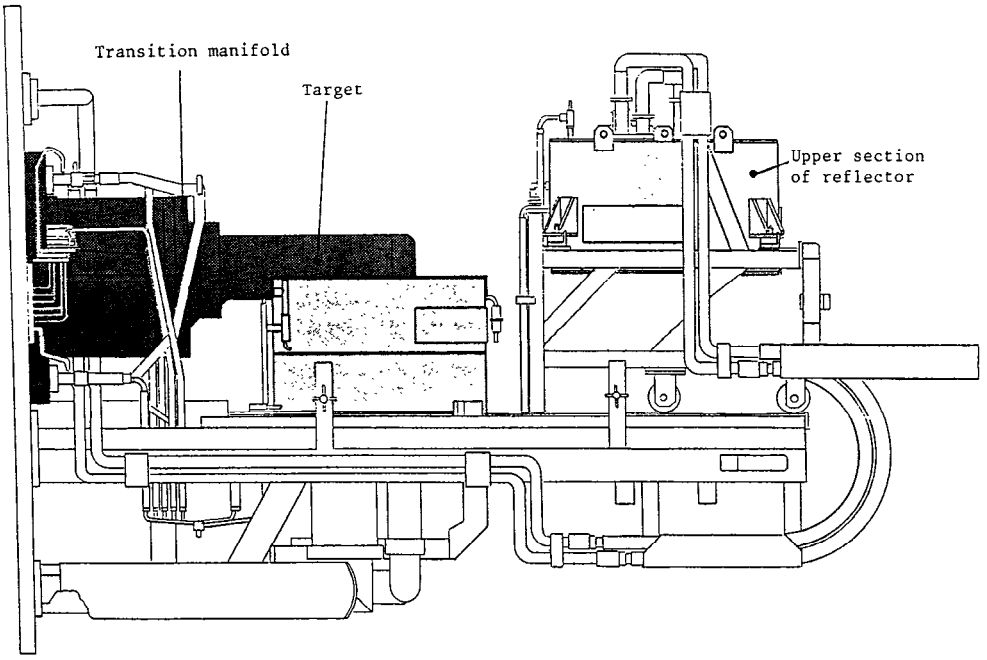

Fig. 7 Target reflector moderator assembly with upper section of reflector in maintenance position.

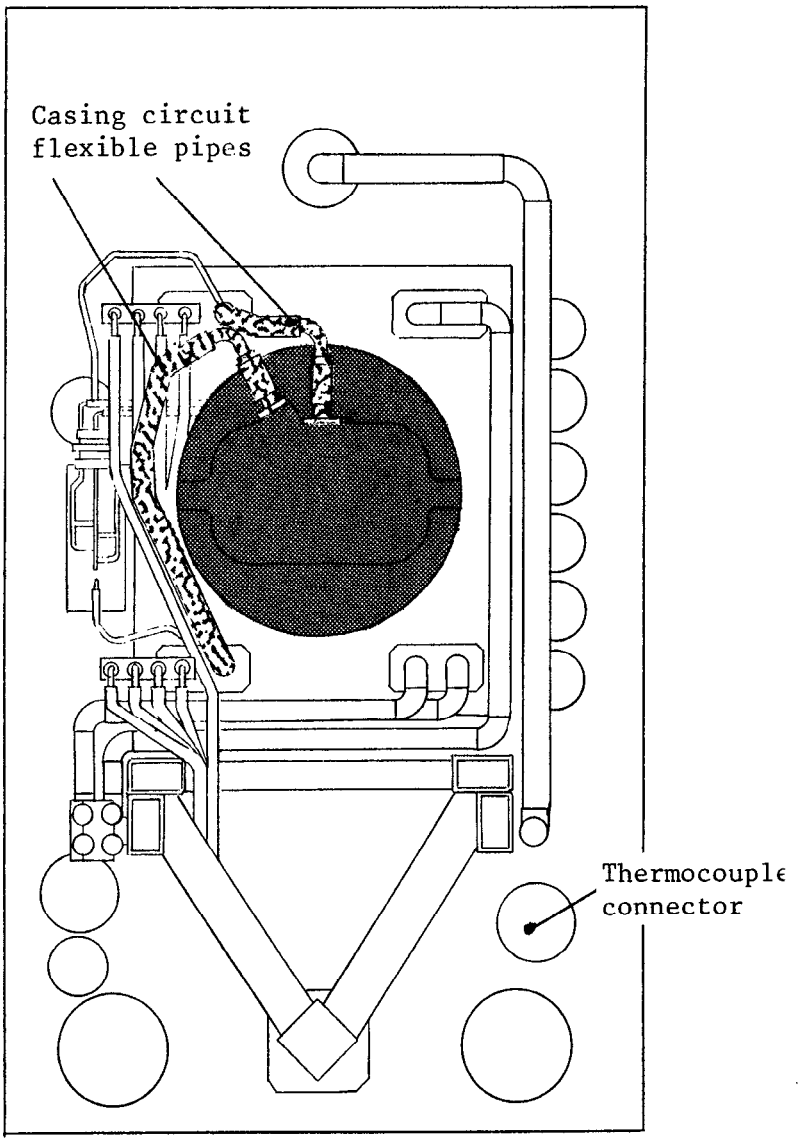

Fig. 8 Section through target reflector assembly showing connections for casing circuit.

The following list describes the operation in more detail.

A.1 Move the shielding door and associated trolley assemblies to position the reflector between the manipulators directly in front of the windows.

A.2 Pick up the halo monitor assembly from the front of the reflector trolley using the manipulators and place it in the cradle on the cantilever frame

A.3 Pick up the reflector lifting frame on the crane and locate the three hooks of the frame into the lifting eyes of the top piece of the reflector. Raise the reflector above the fixed jack pads by 20 mm, which is sufficient to allow the four pads to be rotated through 90 degrees using the manipulators.

A.4 Lower the reflector onto the rotated jack pads and remove the lifting frame from the reflector and replace it on the vertical motion table.

A.5 Remove the operating position docking pin on the cantilever frame and move the reflector trolley towards the end of the frame.

A.6 When the trolley reaches the end of the cantilever frame engage the servicing position docking pin into the hole in the reflector trolley.

A.7 Remove the drain blank from the target assembly and connect the drain hose and bottle to the outlet pipe. Open the drain valve and blow out the heavy water that remains in the target casing with nitrogen.

A.8 Remove the Drain Hose and replace the Drain Blank.

A.9 Disconnect the two flexible coolant pipes that feed the target case cooling circuit from the intermediate manifold and position the free ends out of the way.

A.10 Pick up the target handling frame from the the vertical motion table and position it on the rails of the cantilever frame over the target and lower half of the reflector assembly.

A.11 Remove the lifting dowel locking pins and push the dowels and beam window plug of the lifting frame into the target assembly locations and insert the locking pins.

A.12 Release the vee clamp bolt retaining the thermocouple connector, retract the assembly from the door flange and place the thermocouple connector in a convenient position.

A.13 Release the main target flange tee bolts fully and rotate the heads to align with the slots in the transition manifold.

A.14 Roll the handling frame and target away from the mounting manifold to clear the location dowels.

A.15 Lift the handling frame and target and position on the target turning frame the Target Flange facing away from the Void Vessel.

A.16 Rotate the target to a convenient angle and crop off the thermocouple umbilical as close to the outlet from the target vessel as possible.

A.17 Rotate the target until it is vertical and fix the target sealing flange to the target

A.18 Lift off the lid from the storage well and place it on the Access Door

A.19 Pick up the target assembly lifting beam on the crane and locate the lifting bars in the slots of the intermediate manifold, rotating them into the 'lifting' position.

A.20 Lift the target from the handling frame and lower it into the opened storage well locating it on the pins. Rotate the lifting bars to remove them from the slots and lift the Target Lifting Beam clear.

A.21 Replace the Storage Well Lid.

A.22 Bring the replacement target into the cell in its handling frame on the transfer platform.

A.23 Pick up the target and frame from the transfer platform and place it on the target turning frame on the lifting table.

A.24 Move the shielding plug trolley to position the lower part of the reflector between the manipulators and in front of the windows.

A.25 Pick up the target and frame from the turning frame and lower it over the lower half of the reflector until the wheels rest on the rails of the cantilever frame.

A.26 Remove the seal protection plate and roll the target and frame towards the mounting manifold so that it is located on the dowels and against the seal face.

A.27 Turn the tee bolts to the 'fastening' position and tighten them to the required setting.

A.28 Use the manipulators to pick up the thermocouple connector housing from the cradle on the handling frame and position it on the connector flange, reassembling and tightening the vee clamp bolt to the required setting.

A.29 Remove the lifting dowel locking pins and roll the frame away to release the target.

A.30 Lift the Frame away relocating it on the target turning frame on the lifting table.

A.31 Reconnect the two flexible coolant pipes to the case cooling connector flanges and tighten them to the required setting.

A.32 Roll the reflector trolley back to the operating position , and insert the operating position docking pin into the hole in the reflector trolley.

A.33 Raise the reflector above the fixed jack pads by 20 mm and rotate them through 90 degrees using the manipulators.

A.34 Lower the reflector down into the operating position and remove the lifting frame.

A.35 Pick up the halo monitor from its cradle on the cantilever frame using the manipulators and reposition it in its operational position on the front of the reflector Trolley.