PRESENTATION OF ACCESSIBILITY EQUIPMENT FOR PRIMARY PIPINGS, IHX, PUMPS AND APPERTAINING MANIPULATOR TESTS

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Summary

Accessibility and inservice inspection procedure of SNR-300 components are described.
Due to the high radiation level in the primary system it was necessary to develop and to design special equipment to permit access to the testing components. The pertinent examination methods for surveying welding seams are acoustic (ultrasonic) and optical procedures (TV-cameras, surface crack tests). This can be done by remote-controlled manipulators and special devices, which can transport the inspection system by rails to the testing position.
Presently, relatively limited experience exists for such remote-controlled handling in nuclear power plants. Thus model experiments were carried out on a model pipe section at INTERATOM. The performed test shows that the concept planned to perform inservice inspection by using remote-controlled manipulators can be realized successfully.

1 Design work for accessibility of the primary cells, the reactor cell, the primary pumps and the intermediate heat exchangers (IHX)

1.1 Introduction

The SNR plan calls for regular inspection of the plant components. Because of the high radiation levels in the range of 1 to 3 rem/h created by deposition of corrosion products and fission products in the primary heat transfer loop, it was necessary to design special equipment to permit access to these rooms to allow maintenance, inspection, and repair.

For that reason components with an expected very high radiation level were shielded. These components included the IHXs, the primary pumps, the cold traps, and the cold trap heat exchangers.

Shielding walls are provided between the reactor cell and the three primary cells. This permits maintenance personnel to enter one of the primary cells during decay heat removal with the primary system adjoining the primary cell that is being maintained. In order to enter the reactor cell all primary systems must be drained and decay heat will be removed by means of the emergency cooling system.

The requirement for immediate access to the cells is generally avoided by limiting the components contained in these cells to those that do not require frequent maintenance or for which installation can be done by remote handling. Examples are:

- A pump impeller or an IHX tube bundle can be exchanged without requiring access to the primary cell.

- All valves and valve drive mechanisms attached to the auxiliary piping are situated in a separate valve cell and the valve drive rods are remotely exchangeable.

- Instrumentation (e.g. thermocouples, sodium level indicators) can be remotely exchanged.

- Redundant trace heating is used throughout.

A minimum distance of 1 meter is provided between primary piping runs, and also auxiliary piping runs, which permits access to the system using shielded cabins and electrically-controlled manipulators. An adequate amount of space is provided so that this type of equipment can be used throughout the primary cells.

In the reactor cell space is provided along the walls where no equipment is installed. This area is used to permit access with movable screens and shields.

1.2 Primary cells

The accessibility to a primary cell having a high radiation level will be done with a screened cabin operating on tracks at the ceiling of the cell. The screened cabin is used for inspection and control of the work being done, and for the transportation of maintenance personnel to other screened buildings in the primary cells.

Master slave manipulators and power manipulators are provided for difficult operations and for the handling of heavy tools in the primary cell. This manipulator system will be used, for example, to remove the insulation and for positioning remote-control devices to be used for maintenance and repair. The power manipulator then takes the heavy device and puts it in the proper place so that the master slave manipulator can operate it.

The schematic diagram (Fig. 1) shows how accessibility to the primary cells will be achieved. The 17.2 level is the operating floor which is fully accessible during all conditions of the reactor operation. Below this level there are other rooms which are immediately accessible under special conditions. The ceiling of the primary cell is situated between these levels.

To enter the primary cell after the radiation level of the primary sodium has been sufficiently reduced after shutdown, and after the sodium has been drained and the primary cell ventilated, maintenance personnel can pull the shielding plugs in the primary cell ceiling.

While those operations are conducted the primary cells can be inspected with TV cameras. For that purpose, in the ceiling of the primary cells and in all upper ceilings there exist many small openings so that inspection and light devices can be introduced into the primary cells.

The primary inspection device is a TV camera on the end of a long rod.

After that the shielded cabin and the manipulator will be brought into the primary cell room using the overhead crane in the component hall. The cabin or the manipulator will be hung up on overhead tracks using a special piece of equipment which makes the connection to the track ends.

Fig. 2 shows a cross section through the reactor cell and the primary cell. Tracks run between the pipe works which provide accessibility through openings in the ceilings.

Using these tracks and turnlables maintenance personnel can reach most of the areas of the primary cell. The cabin and the manipulator are hanging at the ends of telescopic masts which are coupled with their driving devices. With these rods the cabin and the manipulator can be moved and turned.

The movement of the manipulators will be controlled by a stereo TV system. The TV and the light reflector are shown in the sketch (Fig. 1). The TV monitor is on the operating deck and the main steering gears of the manipulators are situated on the operating floor deck. Two smaller steering gears for manipulators are located in the cabin.

It is necessary to perform all the work required for maintenance, inservice inspection and repair with the manipulator system. The manipulator system permits such operations as removal of the insulation, but all other work must be done with special remote-control devices which can be placed by using the manipulators. The special remote-control devices required for inspection, etc. are still under development.

1.3 Reactor cell

In order to provide accessibility to the reactor cell, movable screened shields are provided together with small stationary screened buildings. These are located on the platforms of the reactor cell. The screening shields are opened at the side of the reactor cell walls and are movable on tracks along the cell walls. It is possible to extend the height of these movable screened shields and stationary screened buildings by stacking them one on the top of the other, thus permitting the maintenance man to reach the higher arranged screening devices via ladders, after opening the floor and the ceiling hatches.

With this system of screened accessibility it is possible to reach the working places that are immediately at, or very close to the place desired without the maintenance personnel receiving a high radiation dose on the way to the work place. Minor operations can be then performed by the maintenance personnel leaving the screened devices for short periods of time.

Furthermore the electrical remote-controlled manipulators for the primary cells can also be used in the reactor cell, Master-slave manipulator for difficult work and power manipulator for heavy work. These manipulators will also be controlled from areas without radiation with the help of stereo and TV cameras and direct sighting by maintenance personnel in the screened devices, with continuous radio contact to the operator on the operating deck.

A sectional view through the reactor cell is shown in Fig. 3. After the access door is opened the movable screening shield on the operating platform, which is standing in front of the opening, will be loaded with electrical motors, glass windows, and all other tools which cannot remain in the reactor cells during normal operation. Then the inspection cabin moves on the tracks along the walls of the reactor cell to the desired place on the platform. If it is necessary to go up on the higher platform, the inspection cabin will be driven under the 2.6 meter cabin and the inspector can go up on a ladder. In the same way persons can reach the 5.5 meter cabin. Heavy tools or manipulators will be lifted by means of special openings using the small ceiling hoist. A dolly will then be driven under the equipment, which will then be set down on the dolly and fixed to it. Supply cables will be let down through the opening in the ceiling to the manipulators or tools.

1.4 Primary pumps

The inspection of the pump cavities and of the pumps themselves will be made through an opening in the cover of the cavity. In this case the inspector and the inspection equipment will be brought with the cabin and the manipulator to a stationary shielded small building over the cover opening of the cavity. After pulling the plug, the maintenance man inserts the visual inspection device into a small guide rail at the upper part of the cavity. The visual inspection device is a small electrically-driven vehicle with a TV camera on the end of a telescopic mast. By moving along the circumference of the cavity and by movement of the hight, the surface and the welds of the pump housing and cavity can be inspected. All movement will be controlled from the operating deck.

In a similar way it is possible to bring the inspection device for ultrasonic testing into the pump cavities. Therefore the welds at the pumps which must be tested are surrounded with other small guide rails on which the inspection device will be coupled and driven round the weld for carrying out the inspection (Fig. 4).

1.5 IHX

Inspection of the IHX cavities and of the IHX shells will be made from the IHX headrooms. These rooms are fully accessible after reactor shutdown because they contain only secondary piping. The plugs over the IHX heads will first be pulled and the inspection openings will be opened one after the other. Using the component overhead crane a rectangular mast will be brought in through one of the openings in the IHX cavity and centered at the bottom and the head of the cavity. Then the inspection device will be coupled to the mast. The inspection device is a small electrically-driven vehicle for vertical movement and a telescopic swivel-arm with a TV camera at the end of the arm. From each position one-quarter of one of the IHX shells can be inspected. By using all 8 positions the entire interior can be inspected, with overlap (Fig. 5).

And in the same way as mentioned above for the primary pumps, ultrasonic testing at the IHX shells will be done with small guide rails round the welds of the IHX.

2 Manipulator tests

2.1 Introduction

A single arm Electric-Master-Slave-Manipulator (load capacity 250 N) and a Power-Manipulator (load capacity 3000 N) are used for the experimental inservice inspection work. These trials are being carried out on a model pipe section of a pilot plant, at Bensberg.

The purpose of these trial runs was to demonstrate the adaptability of remote manipulators for the inservice inspection concept at pipes and butterfly valves. The emphasis of these trials was placed on the accessibility of the welds and the demounting and mounting of the butterfly valves bearing. Fig. 6 gives a general view of the experimental arrangement.

2.2 Brief description of the Electric-Master-Slave-Manipulator (EMSM)

The remotely-operated apparatus essentially consists of three components connected by a multicore cable, a slave arm, a master arm and a combined switch-control cabinet (central unit) on the control side. Movements carried out by hand and forces and torques which are applied are transferred from the master arm to the slave arm. The operator has a genuine feeling of the applied forces and torques being carried out in the slave arm when operating the master arm. For trial purposes the manipulator was mounted on a vehicle with adjustable height and outfitted with a series of tools (hammer, snips, screw driver, saw etc.). A TV-camera system is provided for carrying out works without direct visibility.

2.3 Brief description of the Power-Manipulator (PM)

This manipulator system is designed for handling heavy components. It essentially consists of a working arm, a control desk and a control cabinet. In contrast to EMSM this apparatus is switch-controlled whereby all movements can be executed at three different speeds (the fast, medium and creeping speed). The interchangeable gripping tongs are constructed for continuous rotation in either directions. The apparatus was also mounted on a lift truck and equipped with various holding devices for machine tools such as drilling, grinding, cutting-off and drive-screw machines.

Both manipulator types were placed at our disposal by courtesy of Kernforschungszentrum Karlsruhe (KfK).

2.4 Trials carried out

Up to the present date the following experiments have been carried out by the above-mentioned manipulators:

I Insertion of a flexible endoscope into a guide tube for visual tests on circumferential pipe weldings.

II Mounting and demounting of the lower butterfly valve bearing by a detaching device.

III Severing of the standard insulation, exposing of a pipe-T-section and testing of the welding seams by the MET-L-Check method.

IV Demounting and mounting of removable insulations.

To I

For several seams, only visual tests are planned. At these inspection points guide systems are being considered for introducing flexible endoscopes, which have been installed in the insulation as shown in Fig. 7.
The pictorial transmission is achieved by adapting a television camera to a monitor or a video recorder. The handling procedure of the hereby employed endoscope dummy was performed by the EMSM at indirect visibility by using a 3-D camera. The trials showed that it is possible to insert a flexible endoscope into a slitted guide tube without any difficulties. The guiding of this endoscope on its way around the circular weld could also be performed easily.

To II

In these trial runs the lower original butterfly valve bearing was demounted by a detaching device and mounted again by a different device. This detaching device with bearing is shown in Fig. 8. The mounting of these device parts has to be done in the steps 1 - 4 as shown in Fig. 8. Both manipulators were employed for these tasks, whereby the EMSM was used for loosening the bearing screws and fitting the locking pin (part 3). The main advantage of handling this detaching device is, that the PM-tongs can be rotated infinitely to carry out screwing procedures.

Thus, the detaching of the bearing proceeded very well. The mounting of the bearing was carried out by a sub-device. Fig. 9 shows the device gripped and bearing during insertion into the bearing casing. By carefully adjusting the rate of traverse it was possible to insert the unlubricated bearing into its fit without difficulties.

To III

The aim of these experiments was to expose a pipe-T-section for a surface crack test on the welding seams. To do this the standard insulation was cut by a remotely-operated cutting-off machine. The approximate size of the cut out is shown in Fig. 10.
After removing the insulation sheet and the insulating material the exposed welding seam was firstly cleaned by a rotating wire brush, and secondly surveyed by the MET-L-Check procedure, as shown in Fig. 11. These tasks were performed by the EMSM. The manipulator tools developed such as bottle and machine clip, endured the test well. The procedure to reassemble such opened insulations is presently under development.

To IV

The accessibility of inservice-inspection-positions can be achieved on insulated pipes by partially dis-mountable insulations. Various insulation concepts were developed and tested. In the course of the experiments the cassette-insulation-concept showed the best results. This insulation consists of 4 cassettes whereby the upper one can be removed after opening a locking clamp. The remaining cassettes are conveyed by rails and so it is possible to slide them upwards and to remove one after another. The mounting has to be done in the correspondingly manner. The operational handling of such a cassette (weight: 500 N) is shown in Fig. 12.

In addition to the easy handling procedure another advantage of such cassettes is the fact, that a relatively short time of 30 min. is necessary for performing the complete handling cycle.

During the tests which were carried out up to now both types of manipulators displayed satisfactory performance. In spite of the one-armed EMSM design difficult and complicated handling operations can be performed. Thus it can be expected that the planned design of the SNR-EMSM with two working arms is capable of managing even unforeseen tasks.

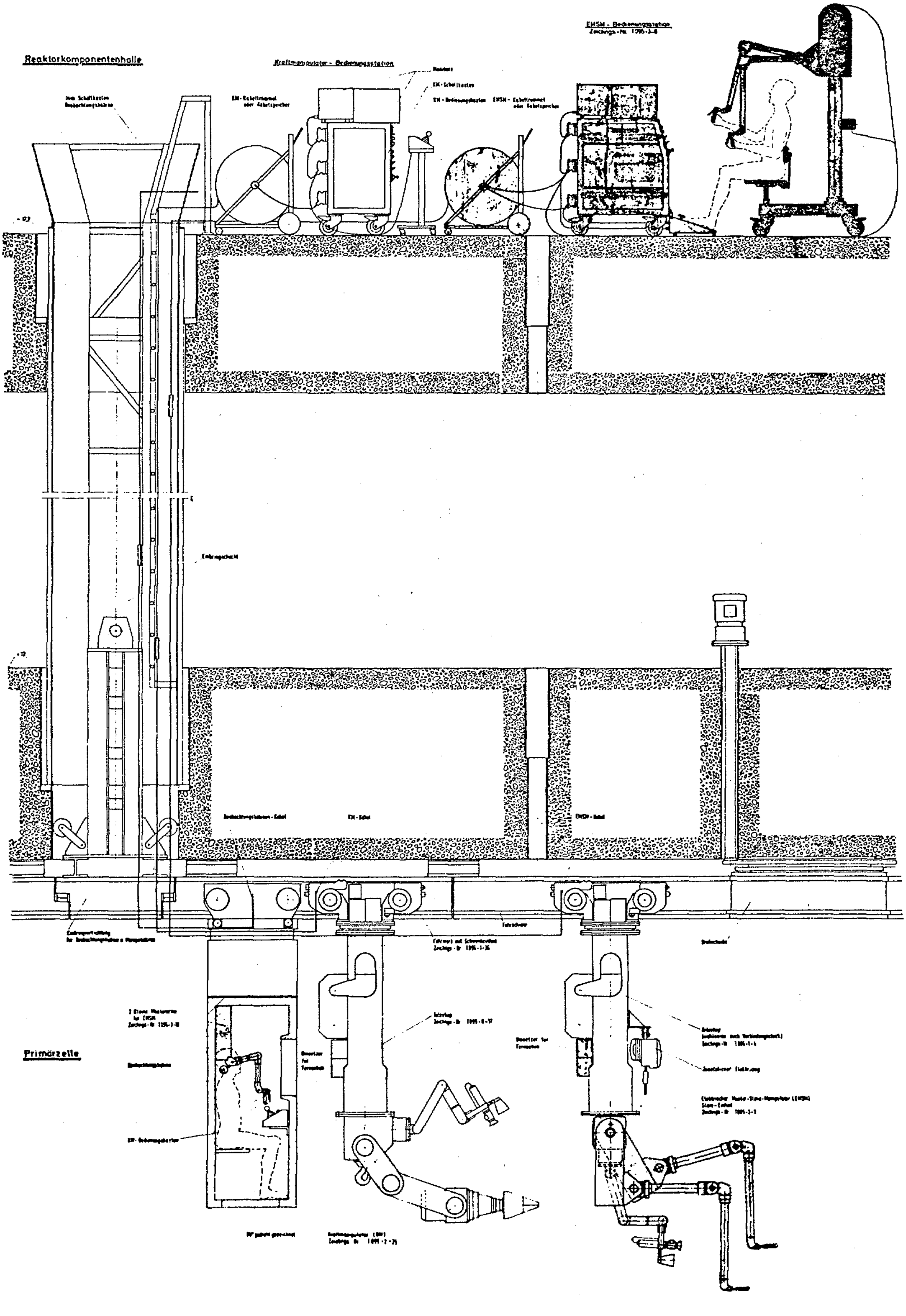

FIG. 1.

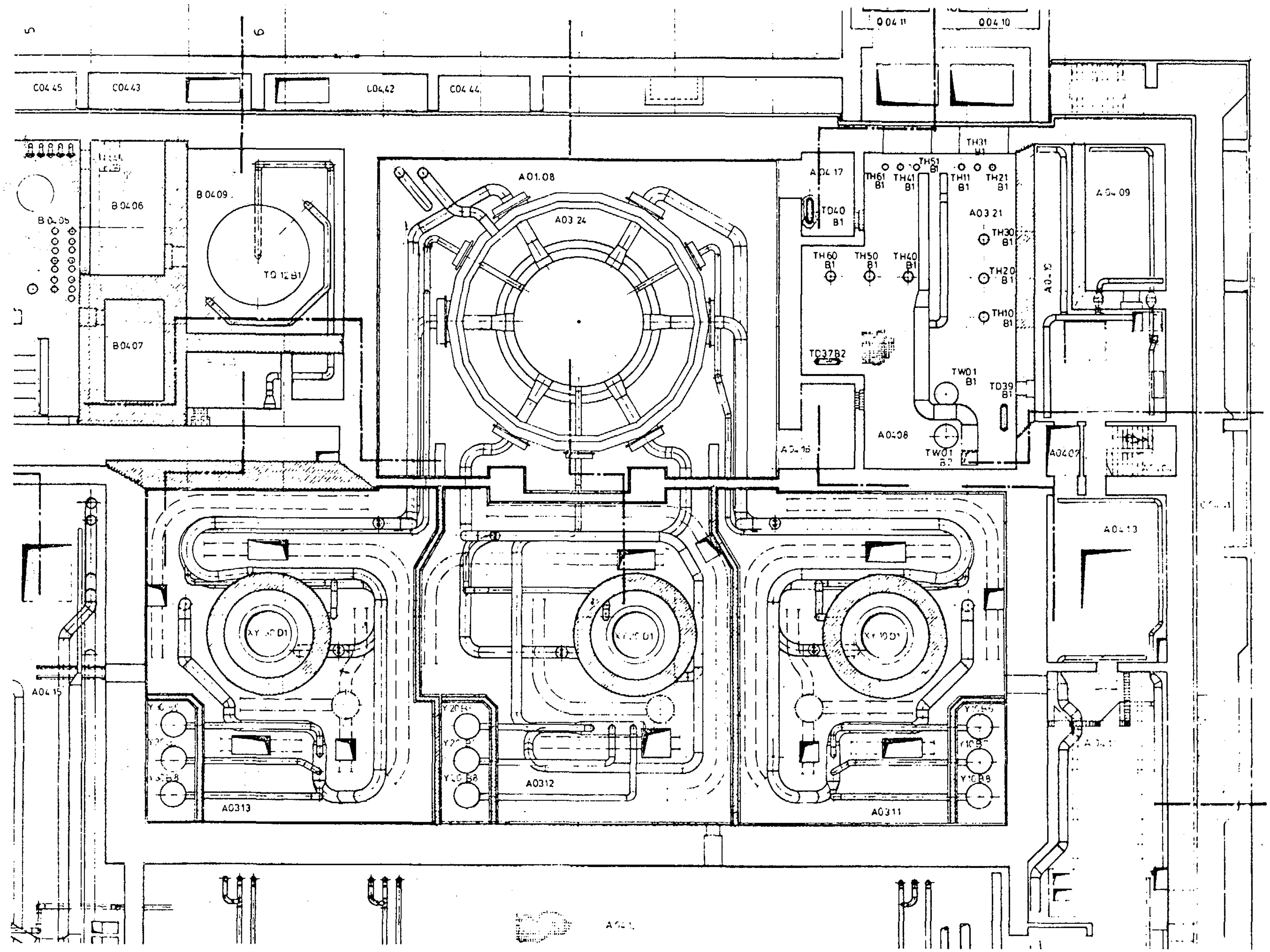

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FIG. 2.

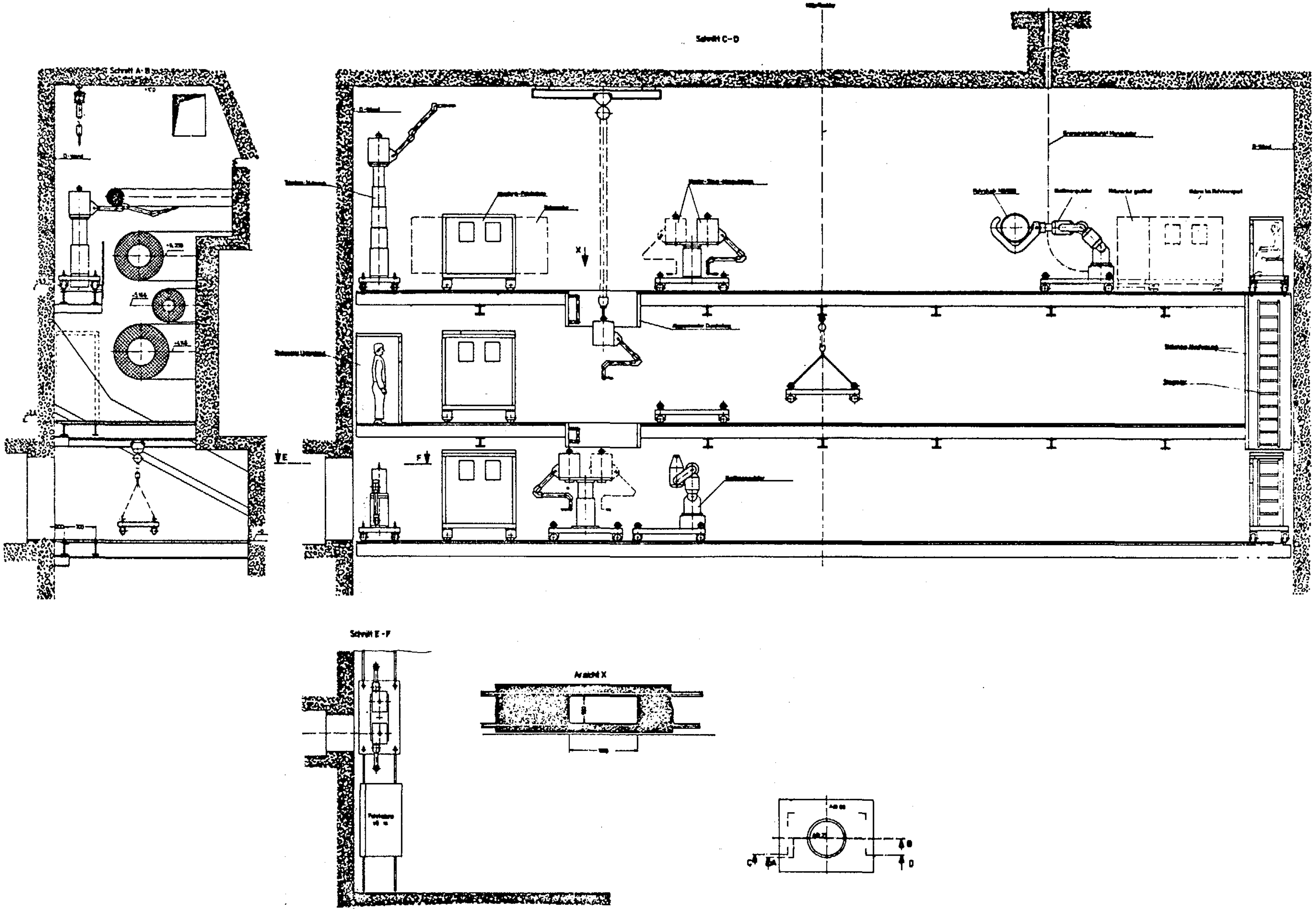

FIG. 3.

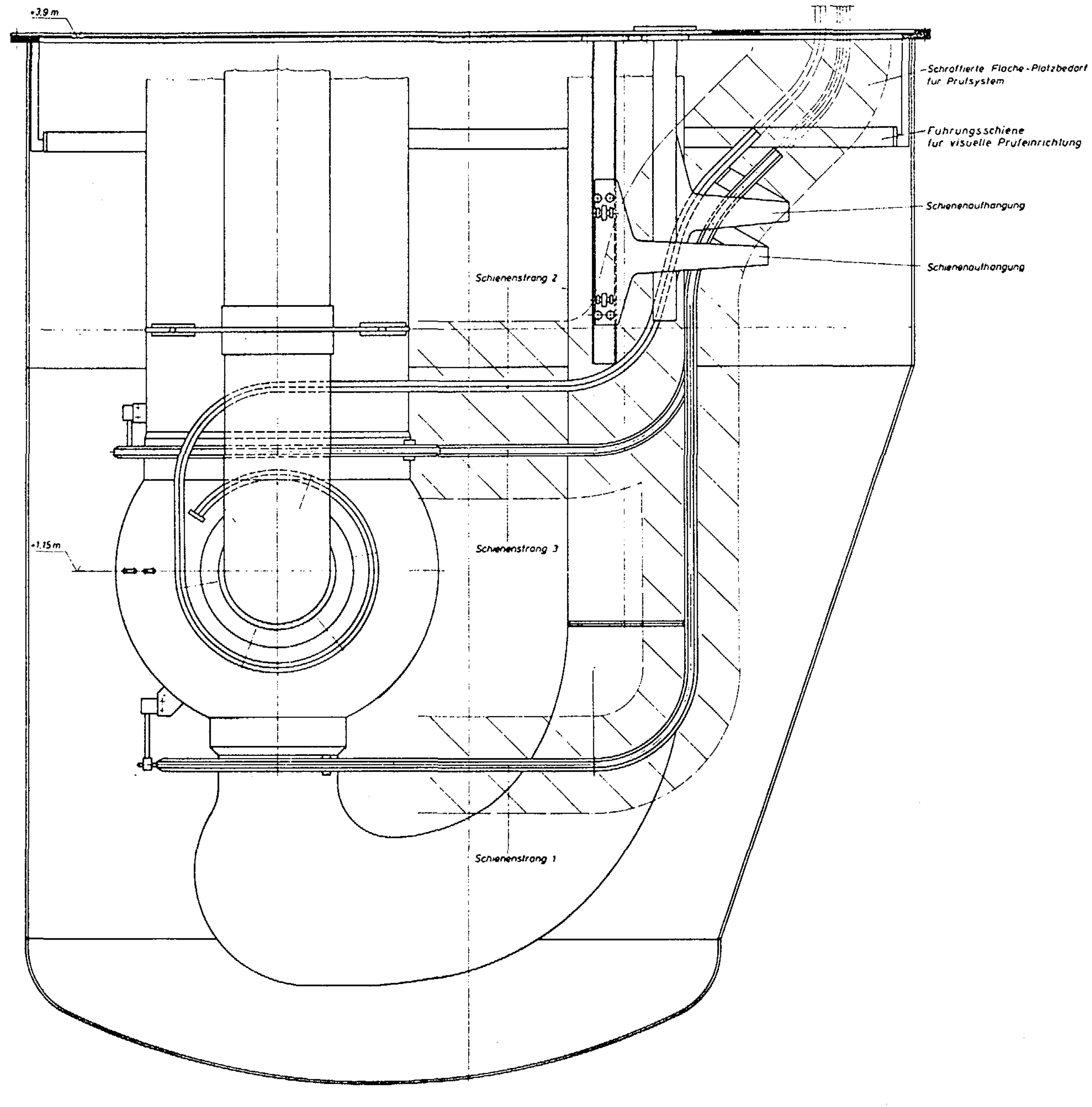
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FIG. 4.

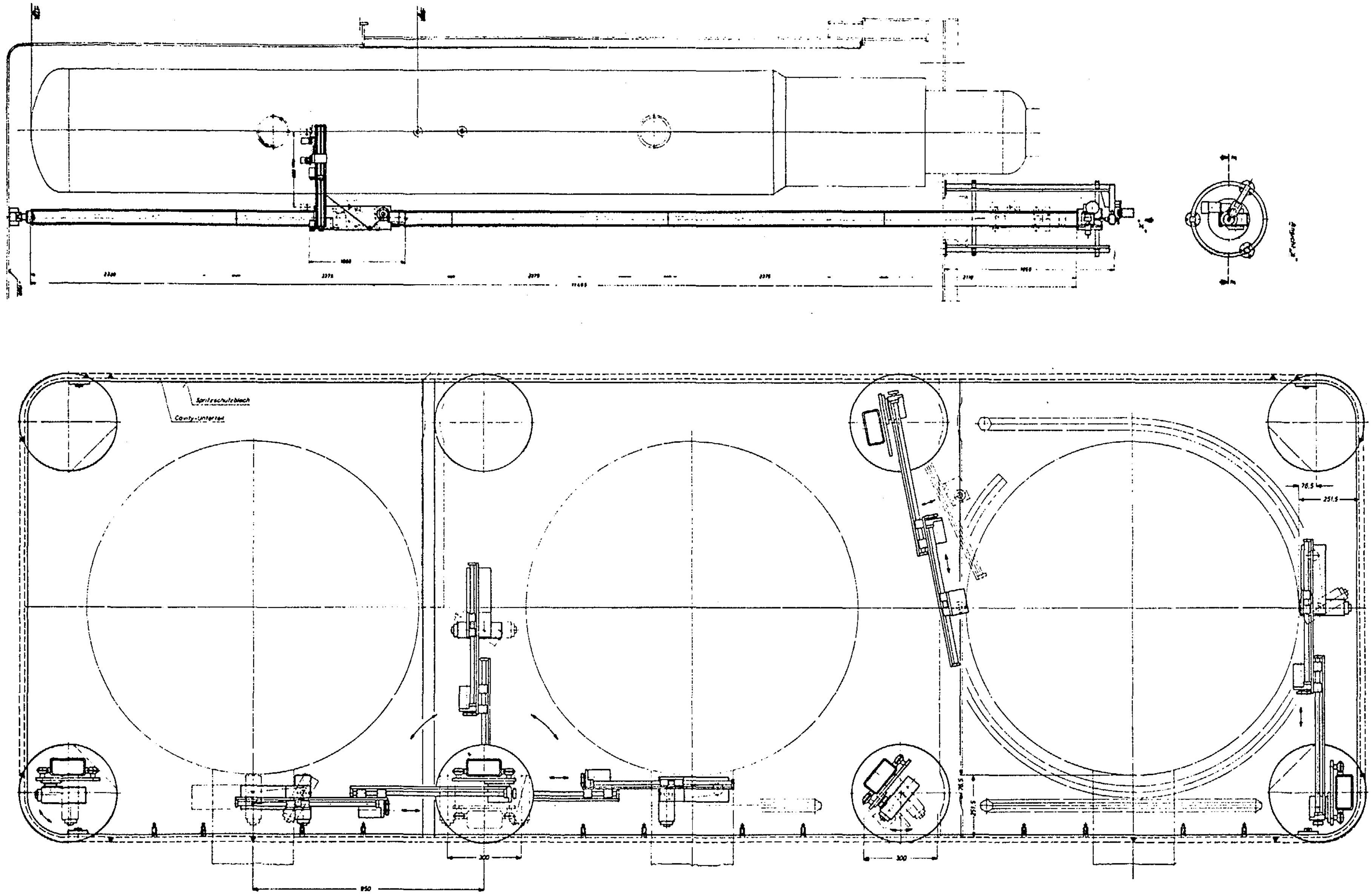

FIG. 5.

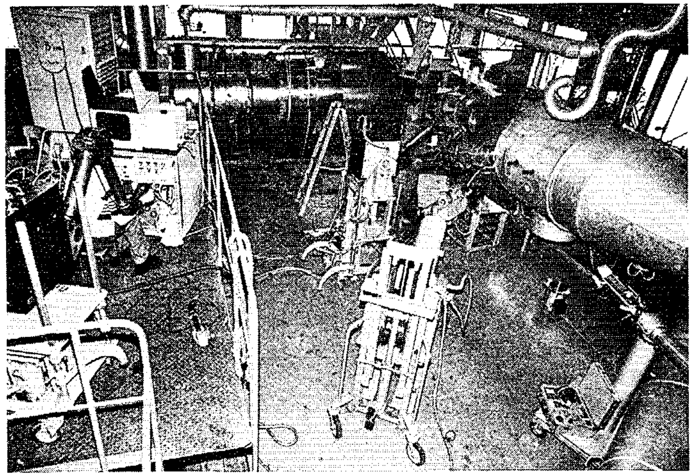

FIG. 6.

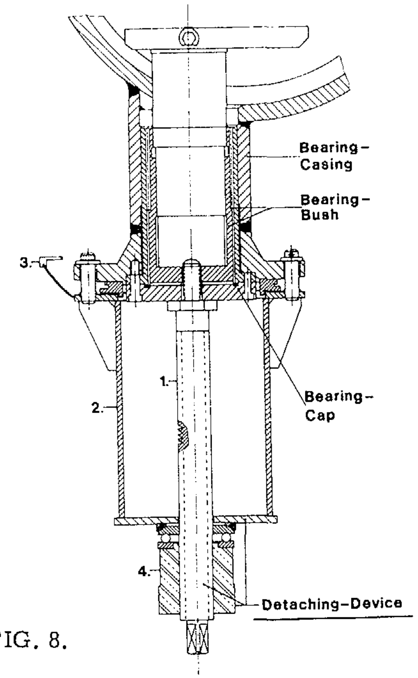

FIG. 8.

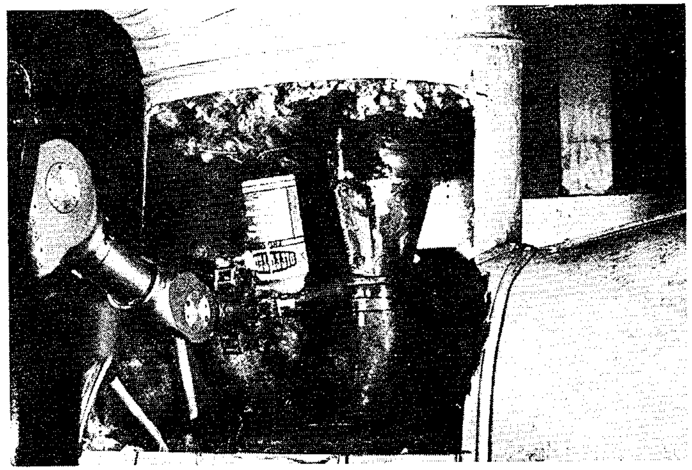

FIG. 10.

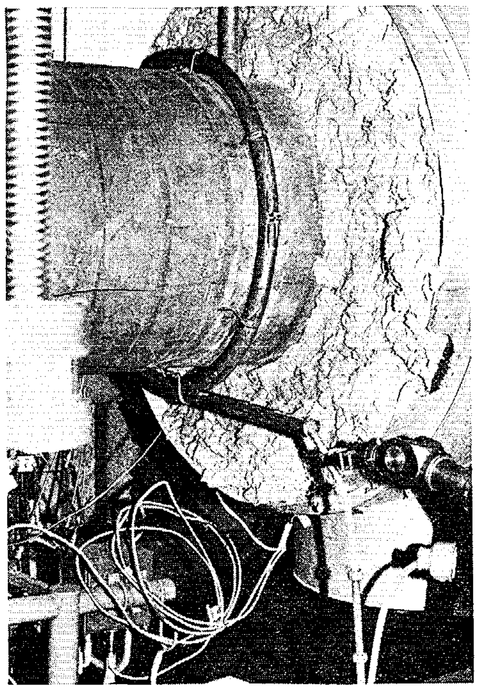

FIG. 7.

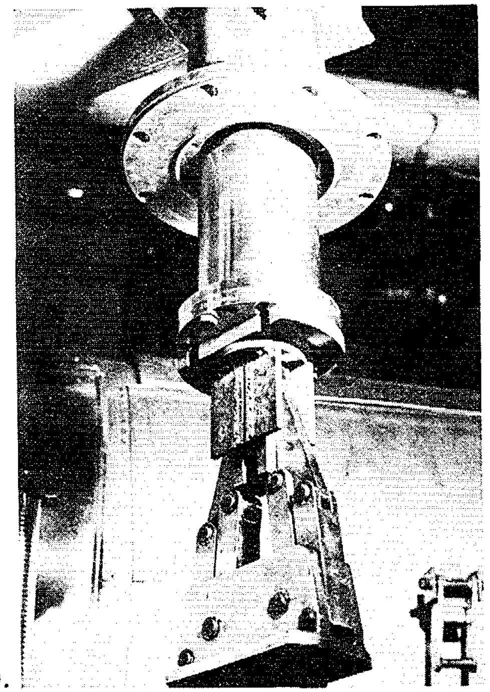

FIG. 9.

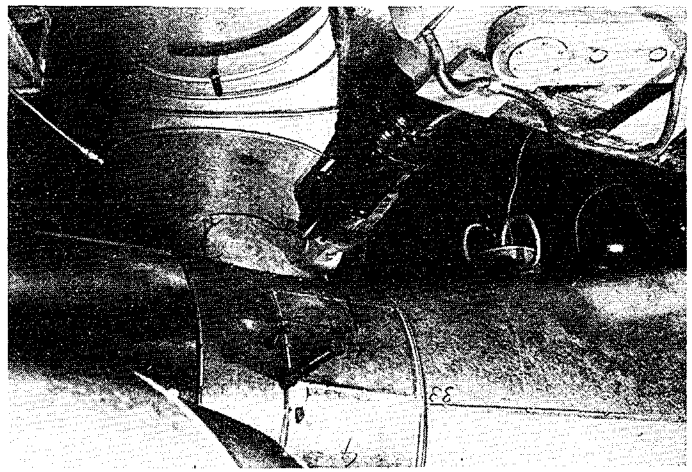

FIG. 11.

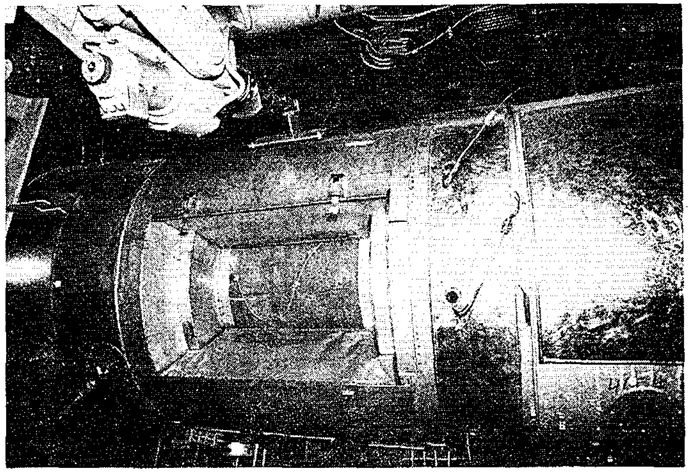

FIG. 12.

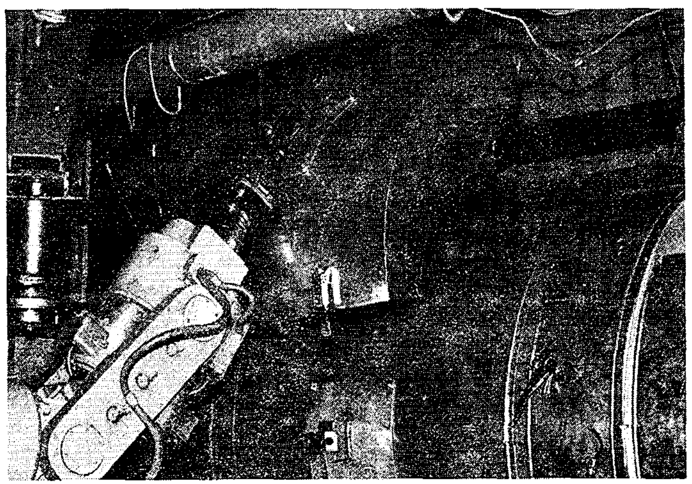

FIG. 13.

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LONGITUDINAL WAVE ULTRASONIC INSPECTION OF AUSTENITIC WELDMENTS

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ABSTRACT

Successful volumetric inspection of LMFBR primary circuits, and also much of the secondary circuit, is dependent on the availability of satisfactory examination procedures for austenitic welds. Application of conventional ultrasonic techniques is hampered by the anisotropic, textured structure of the weld metal and this paper describes development work on the use of longitudinal wave techniques. In addition to confirming the dominant effects of the weld structure on ultrasound propagation some results are given of studies utilising deliberately induced defects in Manual Metal Arc Welds in 50mm plate together with preliminary work on the inspection of narrow austenitic welds fabricated by automatic processes.

1. INTRODUCTION

Successful volumetric inspection of LMFBR primary circuits, and also much of the secondary circuits, is dependent on the availability of satisfactory examination procedures for welds made between plates of austenitic steels such as Type 316 and 304. In order to supplement radiography in the demonstration of the structural integrity of the reactor during construction and to meet possible requirements for in-service inspection there is a need to provide appropriate ultrasonic procedures.

Application of conventional ultrasonic techniques is hampered by the anisotropic, textured, structure of the weld metal and this paper describes development work on the use of longitudinal wave techniques which are generally regarded as preferable for the examination of thick sections. In addition to confirming the dominant effects of weld structure, and hence fabrication procedure, on ultrasound propagation some results are given of studies utilising deliberately induced defects in Manual Metal Arc (MMA) welds together with preliminary work on the inspection of narrow gap welds fabricated by automatic processes.