L.H.M.A.
TEC/39.3619/13/ACD/AD/JVdV/TVR
April 30th, 1981

20th PLENARY MEETING OF THE WORKING GROUP
"HOT CELLS AND REMOTE HANDLING"

at Karlsruhe

May, 1981

DECONTAMINATION AND REFURBISHMENT OF A HOT CELL TO BE USED FOR THE PRESSURE VESSEL STEEL SURVEILLANCE PROGRAMME

A.C. DEMILDT, A. DANIELS, J. VAN de VELDE, T. VAN RANSBEECK
S.C.K./C.E.N. - LHMA, 2400 MOL, BELGIUM

TABLE OF CONTENTS

Abstract

The β-γ concrete hot cell called the 1000 Ci-cell, which has been used for several years as a prototype chemical plant for the isolation and production of actinium oxide, is now completely evacuated, decontaminated, and refurbished. Equipment for mechanical measurements has now been installed.
After decontamination of the two independent stainless steel α-boxes, mounted in the cell and the evacuation of the inner equipment, the α-boxes themselves have been dismantled and discarded. The final step in the cleaning stage has been the decontamination of the hot cell itself and the refurbishment.
It consisted of sandblasting the epoxy-painted concrete walls and the steel floor and lining it again with a polyester cement, applied as a paint. The new measurement equipment could then be installed in an area considered as non active.

1. Introduction

The β-γ concrete hot cell, called the 1000 Ci-cell, is one of the larger facilities available at the LHMA laboratory of S.C.K./C.E.N. Mol. During the last years it has been operational as a prototype semi-industrial chemical plant for the isolation and production of actinium oxide [1].
By the end of this programme it was decided to have a complete refurbishment of this cell.
Work started with the decontamination of the two independent stainless steel alpha-boxes of the cell and the dismantling and evacuation of the equipment. The following step was to dismantle and discard the α-boxes themselves. Decontamination was completed by personnel who entered the cell.
For the refurbishment and in view of a post-irradiation examination programme, major infrastructure modifications and adaptations have been made.
Finally new examination equipment was installed.

2. Planning

In order to cope the rather complicated operations and to assure safe actions all the time, it has been necessary to draw up detailed procedures and to execute a series of simulation tests.
In this way, it has been possible to guarantee a continuous operation of all other post-irradiation examination installations in the same work-hall.

3. Description of the hot cell

The β-γ hot cell infrastructure has been used during five years to isolate ^{227}Ac and ^{228}Th from neutron-irradiated radium carbonate [1].
Slide 1
A ground plan how the cell was organized for that purpose is given in Fig. 1.
The two α-boxes installed inside the concrete walls were in close circuit, connected to a radon ventilation system. Outside the concrete hot cell a lead-shielded α-box has been constructed for the insertion and removal of the radium carbonate charged irradiation capsules. In the basement under the hot cells storage facilities for liquid waste effluents has been installed.
The non-shielded α-box installed in front of the hot cells and between the two work-stations has been used to introduce all chemical reagents needed for the process.

4. Decontamination and dismantling

The feared contamination one was confronted with, was caused by the following three isotopes and their daughters, representing three radioactive natural families :

^{226}Ra - α-irradiation - t 1/2 : 1,62.10^{3}Y
^{227}Ac - β-irradiation - t 1/2 : 21.8Y
^{228}Th - α-irradiation - t 1/2 : 1.91Y

The presence of the three isotopic families implied following gaseous daughter products :

^{222}Rn, t 1/2 : 3.82 d
^{219}Rn, t 1/2 : 3.92 s
^{220}Rn, t 1/2 : 52 s

Due to the complexity of the contamination and the permanent presence of radioactive α-emitting gases, the whole decontamination and dismantling operation had to be divided into three phases [2 and 3] :

1. removal of the in-cell equipment and decontamination of the α-boxes ;
2. dismantling of the α-boxes and evacuation as conditioned radioactive α-emitting waste ;
3. decontamination of the inner concrete hot cell itself.

4.1. Remote decontamination and removal of in-cell equipment

This task has been completely performed by remote control using the existing master slave manipulators (IRL type ME and M8). The dismantled equipment has been discarded in tinned waste boxes, which had been put in La Calhène 270 waste transport containers.

- The two emptied α-boxes in the concrete cell, the bottom of which was mainly contaminated, have the subject of following operations :
  - mechanical cleaning of the bottom ;
  - chemical cleaning with decontaminated reactants (Exal-Turco, diluted nitric and hydrochloric acids with addition of Ba - La - Th salts) ;
  - rinsing with highly pressurized water jets.

The degree of decontamination was controlled by gamma measuring in the α-boxes and by sampling with wet absorbing paper the remaining contaminating deposits.
After performance of the described procedures, the gamma-ray field was $15Rh^{-1}$ in the α1-box and $25Rh^{-1}$ in α2-box.

4.2. Dismantling and waste disposal of the α-boxes

The use of a plasma burner has been preferred over other techniques, as in this situation it was the fastest way to cut the stainless steel α-boxes into suitable pieces for the accepted waste containers.
The rapidity with which this could be realized reduced most drastically the radiation risks of the personnel.

The disadventages of this cutting technique were however, the real fire hazard including the vulnerability of the P.V.C. intervention air-tight suits and a supplementary diversion of formed contaminated metal oxides creating an additional waste and decontamination problem.
Dismantling of the α-boxes with the plasma burner has been mainly performed manually ; a semi-automatic system has also been used but its efficiency was rather small due to the very special form of those α-boxes.
This operation procedure has required a large number of personnel entries in the 1000 Ci hot cell.
The whole operation was made possible and authorized by the radiation control responsibles thank to an intervention lock [2] which was temporarily installed at the hot cell (Fig. 2). This lock was equipped with a shower, the necessary air ducts and the infrastructure for conditioning and removal of the waste.

Slide 2

The non-burnable waste has been removed via 400 ℓ oil drums, mixed with concrete (Fig. 3) and intensely vibrated for creating a good setting.

Slide 3

Slide 4

The burnable waste, essentially P.V.C. suits, has been transported as such to the Waste department for further treatment.
Apart from this, an 11 ton weighing port considered as slightly α-contaminated has also been discarded, creating in this way available space at the front side for a third work-post later in the refurbishment stage. This should after refurbishing the hot cells, create a third work-post.

4.3. Work area decontamination

As the hot cell during the dismantling period of the highly contaminated alpha boxes, has been used during 2 years as a work-hall, the floor received a considerable enhancement of contamination. The walls and the ceiling of the hot cell have also been considerably contaminated, partially by the gaseous daughter isotopes and partially by the volatilization of the metal oxides due to the plasma burning activity.
Sandblasting using a specially treated metal slack (VASILGRIT) has been chosen as decontamination technique for the inner walls of the concrete hot cell. This choice was based on a high efficiency and a low price of the product. An important disadvantage of this techniques was the production of a new type of solid waste (powder). Eight tons VASILGRIT have been used for decontaminating 200 m^2 of wall. The used and contaminated VASILGRIT has been discarded, mixed with vibrated concrete in oil drums of 400 ℓ. An other important disadvantage of the use of VASILGRIT was the creation of fine dust (broken grains) which blocked and congested the air filters of the ventilation circuit.
To avoid this problem the absolute filters had to be equipped with a supplementary prefilter which implied a delay in the work as they had to be regulary renewed.
A last phase in this decontamination was the thorough discarding of the fine dust, deposited everywhere in the hot cell. This was performed with vacuum cleaners and by sperging the ceiling and walls with water under high pressure (10 bar). These solutions have been collected in 50 ℓ PVC flasks and after sedimentation of the dust,the decantated fluid has been sent to the Waste department.
The remaining sludge (fine wet dust) has been treated with concrete to form solid waste.

4.4. Personnel interventions and quantities of waste

The whole dismantling and decontamination operation has been performed by personnel wearing intervention suits. A one-piece PVC suit has been chosen for these duties. The PVC material was mostly self-extinguishing. In view of the plasma burning, an aluminium-lined asbestos coat was worn over the PVC suit. For mechanical interventions, a leather apron has been used.

As safety measure, each PVC suit has been equipped by LHMA with a double-vent connection system for medical air supply. In this way at the transition from the shower room to the work-lock and vice-versa, a continuous air supply could be assured, so that temporary air shortage could be prevented such as to avoid psychological disastrous reactions due to panic.
A wireless electronic communication system provided the contact between the personnel in the active zone and the supervising personnel at the outside of the hot cell.
The personnel itself has been medically screened for major lung and trachea affections as well as for claustrophobia.
Sl. e 5 Slide 6
Fig. 4 gives a synoptic view of the procedure of access to the intervention zone.
Table 1A provides a survey of the different work periods, mentioning the number of interventions and the quantities of discarded conditioned and non conditioned waste.
Table 1B gives the number of man-rem which has been received by the personnel [7].

TABLE IA

Review of interventions in the 1000 Ci-cell

Date	Description of the intervention in the 1000 Ci-cell	Number of interventions of 2 men during 2 hours	Evacuated waste
10.05.76 24.05.76	dismantling α1	60	19 vessels (400 ℓ)
06.12.76 21.12.76	dismantling α2	51	19 vessels (400 ℓ)
21.03.77 31.03.77	dismantling α4-α7 and glove-box	20	10 vessels (400 ℓ)
23.05.77 27.05.77	delay-tank (200 m long - Ø 32 cm)	16	50 pieces with a 4 m length
06.06.77 24.06.77	dismantling α3	10	1 α-box
05.09.77 21.09.77	decontamination and evacution of γ-door	28	two parts total 11 tons
14.11.77 13.12.77	dismantling of waste boxes and ventilation circuit in the cellar	55	25 vessels
13.02.78 07.04.78	decontamination of the 1000 Ci-cell by sand-blasting	100	23 vessels
09.04.78 08.05.78	vacuum cleaning	37	solid waste
11.05.78 23.05.78	wet cleaning	11	liquid waste
05.09.78 15.09.78	decontamination of the cellar	12	7 vessels (200 ℓ)
22.01.79 31.01.79	test decontamination of lead bricks	8	
16.03.79 03.04.79	evacuation of contaminated lead bricks	17	16 wooden boxes total : 17 tons

TABLE 1B

Dose equivalent man-rem received by the personnel during the dismantling

Period	Collective dose equivalent man-rem	Number of persons	Individual measured max. dose (man-m-rem)
1. Dismantling α1 May 1976	61	56	2100
2. Dismantling α2 December 1976	45	42	1960
3. Dismantling α4-α7 March 1976	3.7	14	600
4. Dismantling γ-door September 1977	25	10	411
5. Dismantling cellar September 1978	6.1	26	956
6. Decontamination 1000 Ci-cell February-March 1979	5.1	83	within the normal limits
7. Total 1+2+3+4+5+6 + dismantling α3 and delay tank May 1977	130	-	2100

5. Refurbishment of the cell

5.1. Cell interior refurbishment

Complete refurbishment of the cell inner surfaces was necessary. After the cracks in the concrete of the inner walls had been sealed by an epoxy resin, several (epoxy-finish) coatings were applied to create approximately a 180 µm film.

Epoxy finish has been selected to provide good radiation resistance and a highly impervious surface (easy decontamination) and the light colour finish improves in-cell visibility.

5.2. Supplementary work-station

Slide 7

In order to cover the entire available volume of the hot cell and in view of future equipment to be installed for the planned post-irradiation programme, a supplementary work-station at the front side of the cell was found necessary (Fig. 1). Therefore, the big concrete plug in the front side between the two windows has been replaced by a steel box, filled with baryte concrete, equipped with a lead glass window and one master slave manipulator (Fig. 5).

5.3. In-cell overhead crane

The 10 kN in-cell bridge crane was inspected and modified. This crane has not been removed from its rails, it was serviced during cell entry. In view of the high contamination level, the steel cable, electrical wires and control rack have been replaced. The mechanical parts of the bridge were in good condition and no replacements have been required.

5.4. Cell lighting modifications

The existing light fixtures have been replaced by six 250 W mercury vapour lamps located above the cell work-stations. Additional lighting has been supplied as well by three halogen 500 W lamps. The new lighting levels have been determined to be about 1000 lux.

5.5. In-cell intervention possibility

Cell access has been made possible by installing an alpha tight door behind the heavy concrete door at the left side of the cell (Fig. 1).
In this panel a transfer system, i.e. La Calhène α-door, has been installed allowing introduction of material or evacuation of waste with low activity.

5.6. Transfer system (Fig. 6)

Slide 8

In the lateral wall at the right side of the cell, the existing rotating heavily contaminated introduction system (Fig. 1) has been completely removed from the concrete shielding and replaced by a "La Calhène α-tight" transfer system.
At both sides of the lining a 15 cm thick lead-shielded door has been installed.
Both systems,i.e. the "La Calhène α-tight doors and the lead shielding doors are operated pneumatically.

6. Installation of new equipment

The post-irradiation examination of an irradiated pressure vessel steel is important in Belgium, as seven power plants will become operational from 1984 on, then producing about 58% of all electric power.
For these PWR power stations, systematic surveillance of the pressure vessel steel must be made during the whole time of the nuclear reactor. Table 2 projects the number of tests per year from 1985 on [4].
In order to satisfy this future demand for pressure vessel surveillance tests, new devices have been installed in this 1000 Ci-cell, and within the near future, this new test equipment will be operational [5, 6].

6.1. Tension test apparatus installation

A 10 ton capacity Instron tension apparatus, adapted to remote handling has been mounted in the cell. In order to satisfy the tension tests on the tension specimens as well as on the fracture mechanics W.O.L. specimens, at high and low temperatures, a furnace and cold chamber, mounted on an electro-mechanical frame designed in the laboratory, have been installed.
Slide 9
Fig. 7 gives an in-cell view of this frame with furnace and cold chamber.

TABLE 2

Pressure vessel surveillance programme peak demand

Year	Nuclear power supply (GW)	PIE demand		
		Charpy-V	Tension	WOL
1977	1.4	80	14	10
1985	5.2	220	40	30

6.2. *Impact test apparatus installation*

For the Charpy-V impact testing and according to ASTM specifications, a Tinius Olsen impact tester with a 36.5 kgm (359 J) capacity fitted for remote handling is installed.
This apparatus has been fitted with dynamic load recording equipment.
Impact specimen conditioning is made by a furnace and cold chamber assembly, while for the positioning on the anvil of the impact tester, an automatic electro-pneumatic robot was purchased and adapted to the specific needs.
Slide 10 Fig. 8 represents the impact tester and the specimen positioning stage.
Slide 11 The additional information obtained from the instrumented impact test i.e. general yield load, maximum load and energy differentiation between
(Slide 12) initiation and propagation, can be useful for the relation with fracture mechanic tests [6].

6.3. *Profile projector installation*

A profile projector is installed between the tension apparatus and the impact tester, in front of the supplementary work-station which has been planned.
This apparatus, allowing specimen contour projection on a screen, equipped with a precision measuring X-Y table (250 x 125 mm displacement), driven
Slide 13 by stepping motors, has a digital measuring system outside the hot cell (Fig.9).
The main purpose of this device is dimensional measurements on the specimens such as :

- dimensional controls on the tension specimen before and after fracture :
- lateral expansion measurement on the broken halves of the Charpy-V specimen.

As in the same hot cell post-irradiation examination programmes will be made on LWR fuel assembly spacer grids, the contour projector will be indispensable for dimensional controls of these grids.

6.4. Cutting apparatus

As the handling of the surveillance capsule itself in fuel material contaminated hot cells must be avoided at any time, it was decided to install a cutting device for dismantling of the capsule in the 1000 Ci-cell as well.

Slide 14

Dismantling is carried out by cutting longitudinally the weldings of the capsule shelves over a length of about one metre.

Slide 15 general view of 1000 Ci-cell.

Conclusions

Presently the refurbishment and installation of new equipment into the 1000 Ci-cell has been completed and acceptance tests are going on. The first irradiated capsule will probably be handled after the summer holidays. The programme of operations which has been presented here proved that it is possible to safely decontaminate and refurbish a big hot cell facility after many years of remote operation even in rather severe chemical circumstances.

Planning of work was performed in such a manner that no radiation risks developed.

The personnel was never exposed to radiation in excess of our current limits and no contamination was released beyond normal controls.

The following observations can be useful for future hot cell design considerations :

- removal of contaminated equipment or parts of equipment must be foreseen wherever possible ;
- the surface finish of the cell walls is of high importance in view of decontamination easiness ;
- the technique of plasma-torch cutting for the α-box evacuation and spray-cleaning of cell walls has been proved useful in this kind of work.

REFERENCES

[1] L.H. BAETSLE, P. DEJONGHE, A.C. DEMILDT
M.J. BRABERS
A. DE TROYER, A. DROISSART, M. POSKIN
"Large-scale production of ^{227}Ac and development of an isotopic heat source fuelled with Ac_2O_3"
A/CONF/49/P/287, 1973.

[2] R. HEREMANS, C. LAMBIET, G. HOYAUX, L.H. BAETSLE
"Intervention humaine en zone chaude contaminée par gaz radioactifs"
XVIième Comité des Laboratoires Chauds organisé par l'Euratom (CCE)
Winfrith (GB), 18-19 sept. 1974.

[3] A. DANIELS, A.C. DEMILDT
Hot laboratories committee meeting '79
Decontamination problems created by hot cells used for the separation of actinium-227 from neutron-irradiated radium oxide
LHMA/TEC/39.3619/10/ACD/AD - June '79.

[4] Ph. VAN ASBROECK, H. TOURWE, J. VAN de VELDE, P. GUBEL, P. DE REGGE
Pressure vessel surveillance experience in Belgian power plants
17/04/79.

[5] J. VAN de VELDE
Pressure vessel steel surveillance programmes
Hot laboratory examinations
LHMA/TEC/39.936/298.a/02/JVdV - 30/05/79.

[6] J. VAN de VELDE
Pressure vessel surveillance specimens evaluation techniques
LHMA/TEC/39.235/04 - 15/04/80.

[7] J.P. DEWORM, G. FIEUW, J. MARLEIN
Stralingskontrole gedurende de ontmanteling van de actinium installaties
Annalen van de Belgische vereniging voor stralingsbescherming - Vol.4 - nr.2.

FIGURE CAPTIONS

Fig. 1. The 1000 Ci-cell before dismantling

Fig. 2. Intervention chamber with tent for dismantling of the infrastructure of the 1000 Ci-cell

Fig. 3. Evacuation of conditioned steel vessels

Fig. 4. Synoptic of the procedure for entrance to the intervention area

Fig. 5. Supplementary work-station

Fig. 6. Transfer system

Fig. 7. Frame with furnace and cold chamber of the tension apparatus

Fig. 8. Impact tester installation with automatic specimen positioning stage

Fig. 9. Profile projector installation

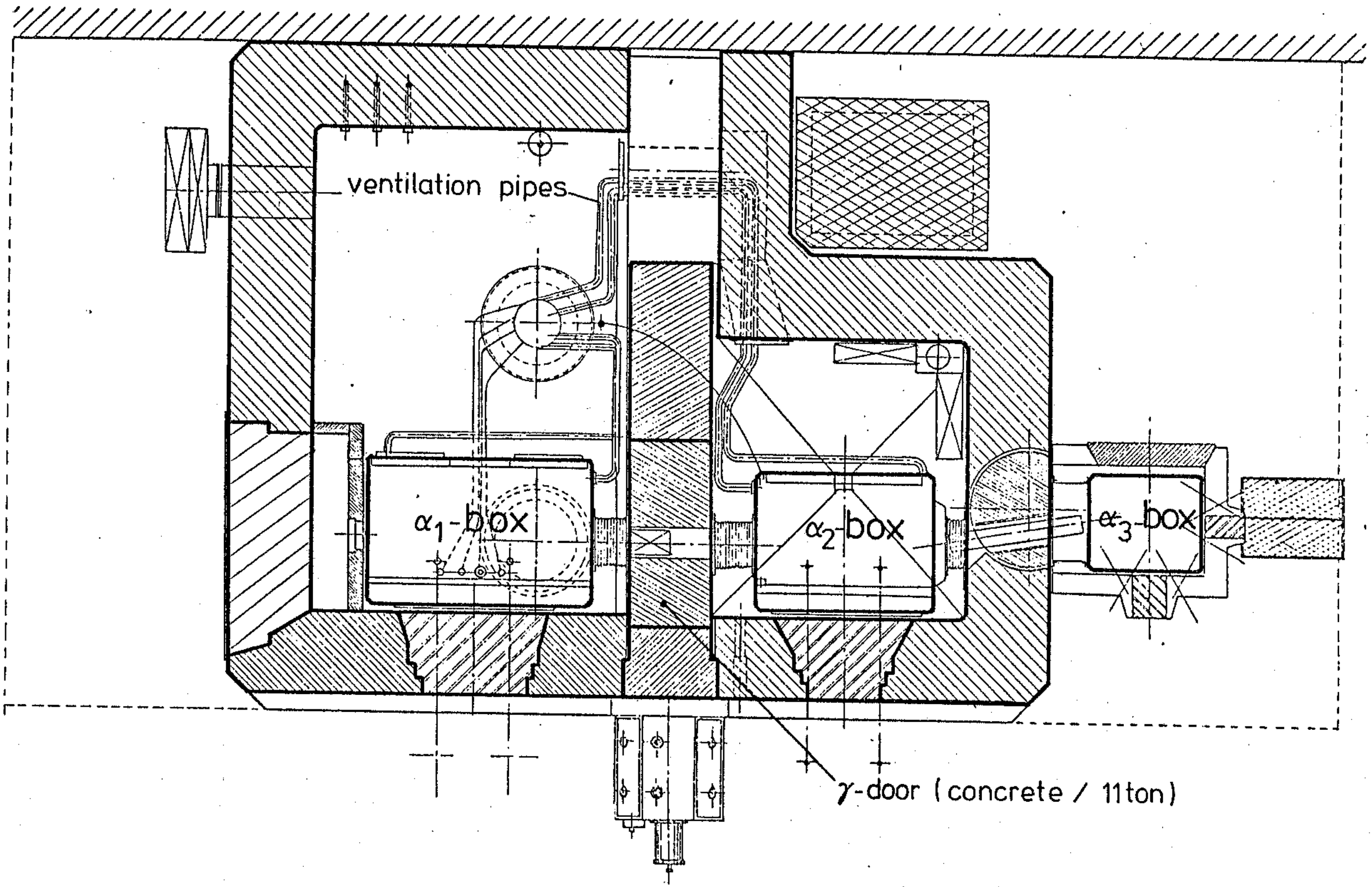


Fig. 1. The 1000 Ci-cell before dismantling.

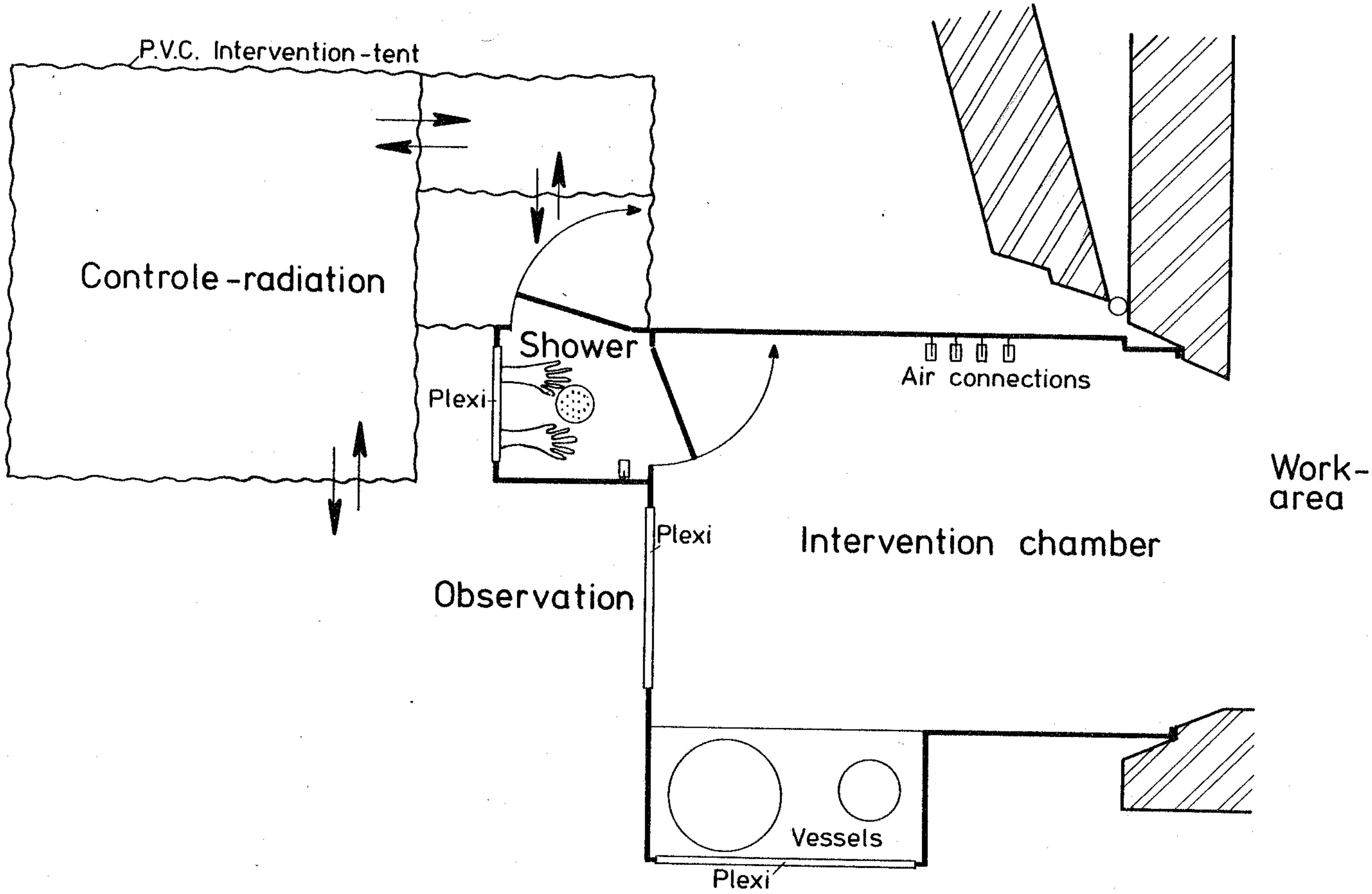


Fig. 2. Intervention-chamber with tent for dismantling of the infrastructure of the 1000 Ci-cell.

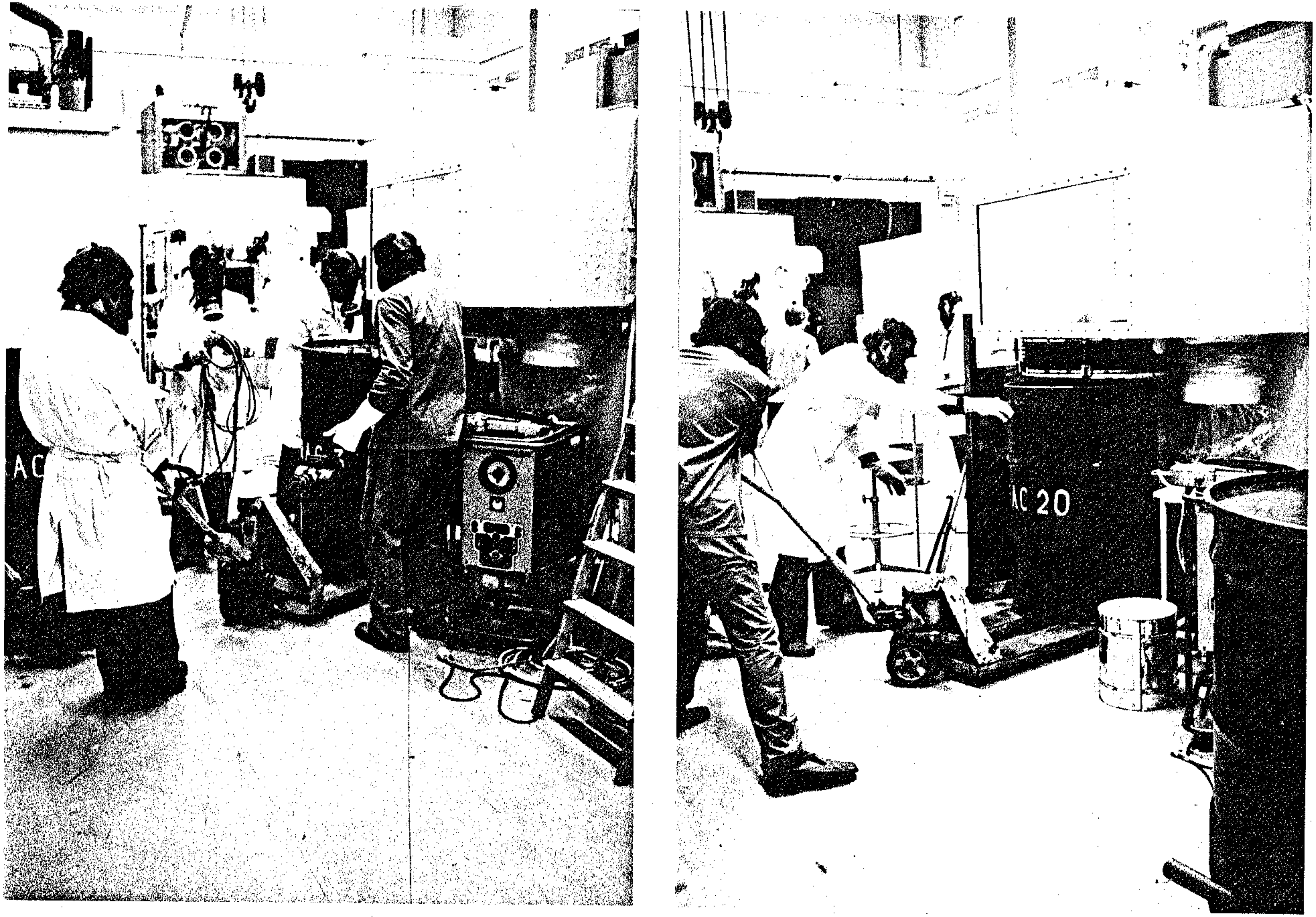


Fig. 3 Evacuation of conditioned steel vessels.

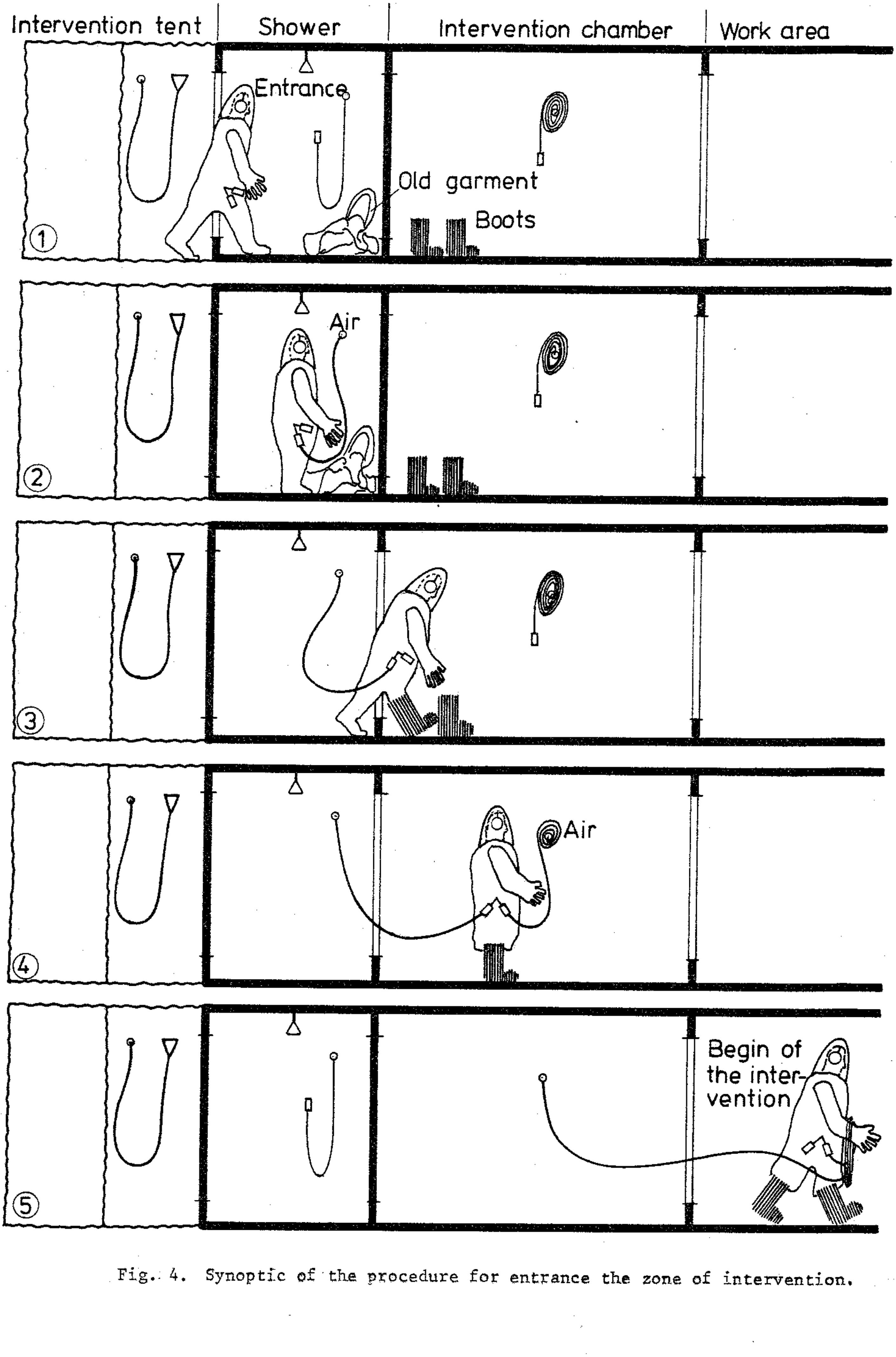


Fig. 4. Synoptic of the procedure for entrance the zone of intervention.

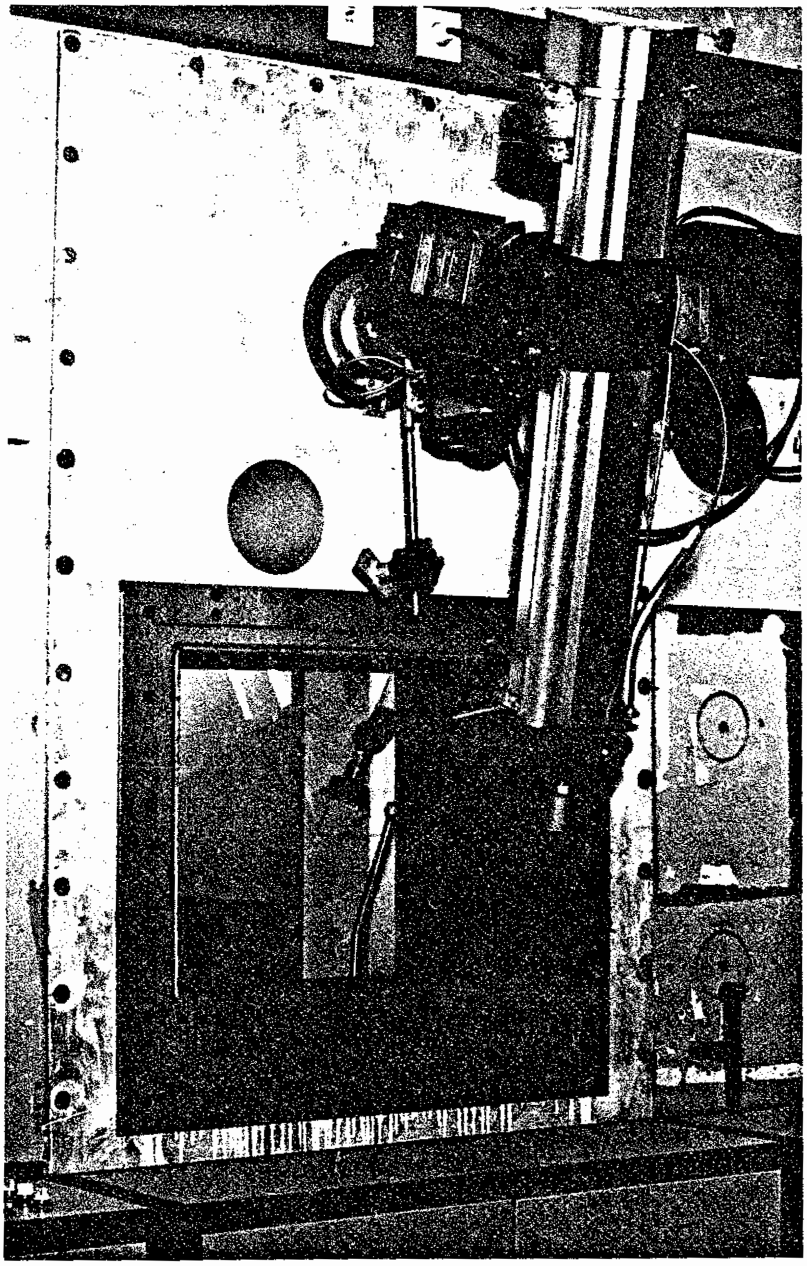
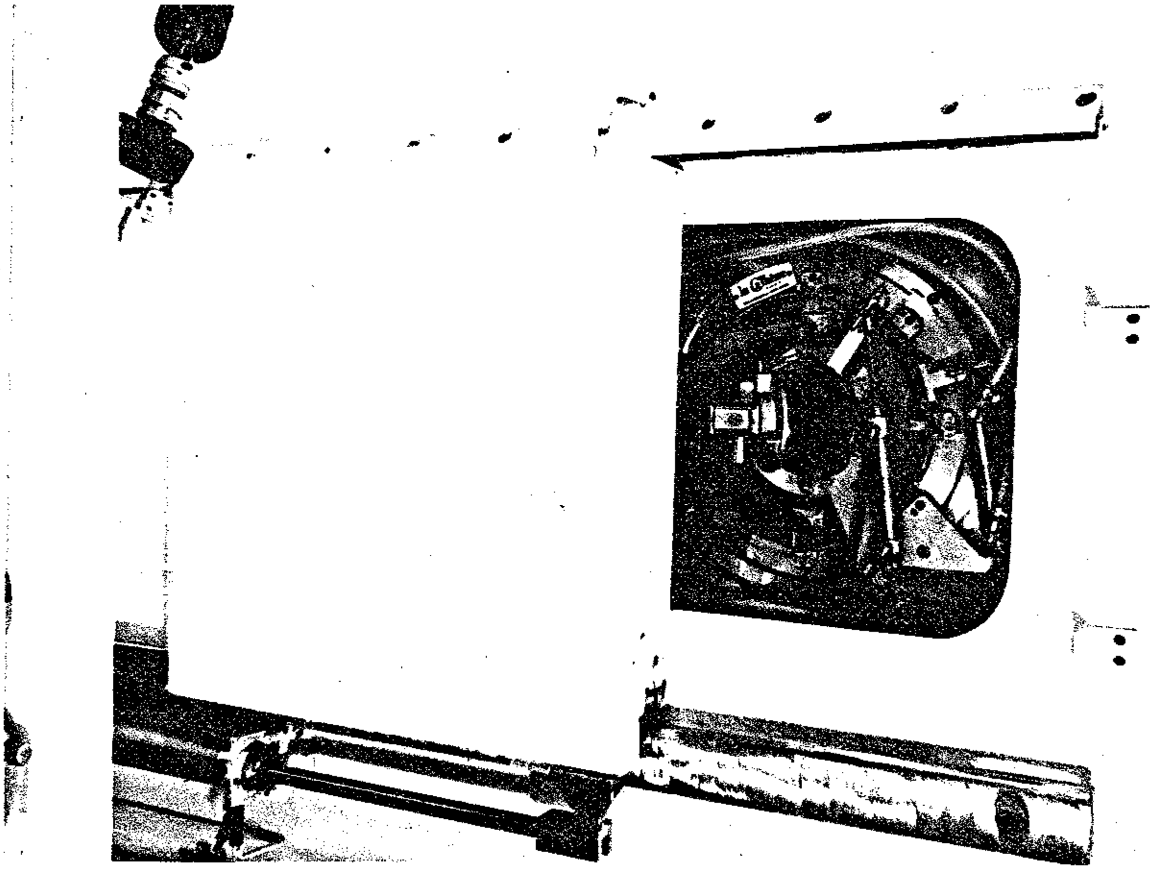


Fig. 5. Supplementary work-station.



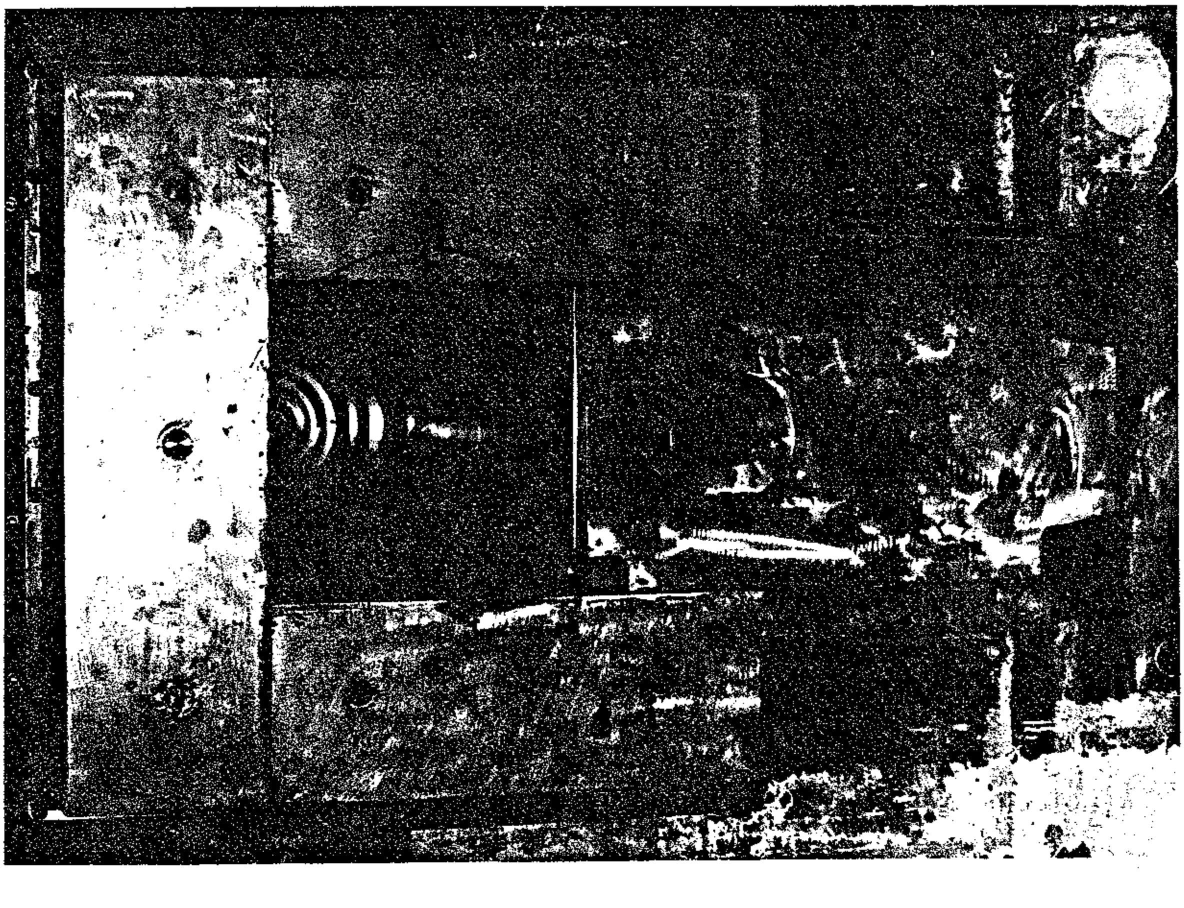


Fig. 6. Transfer system.

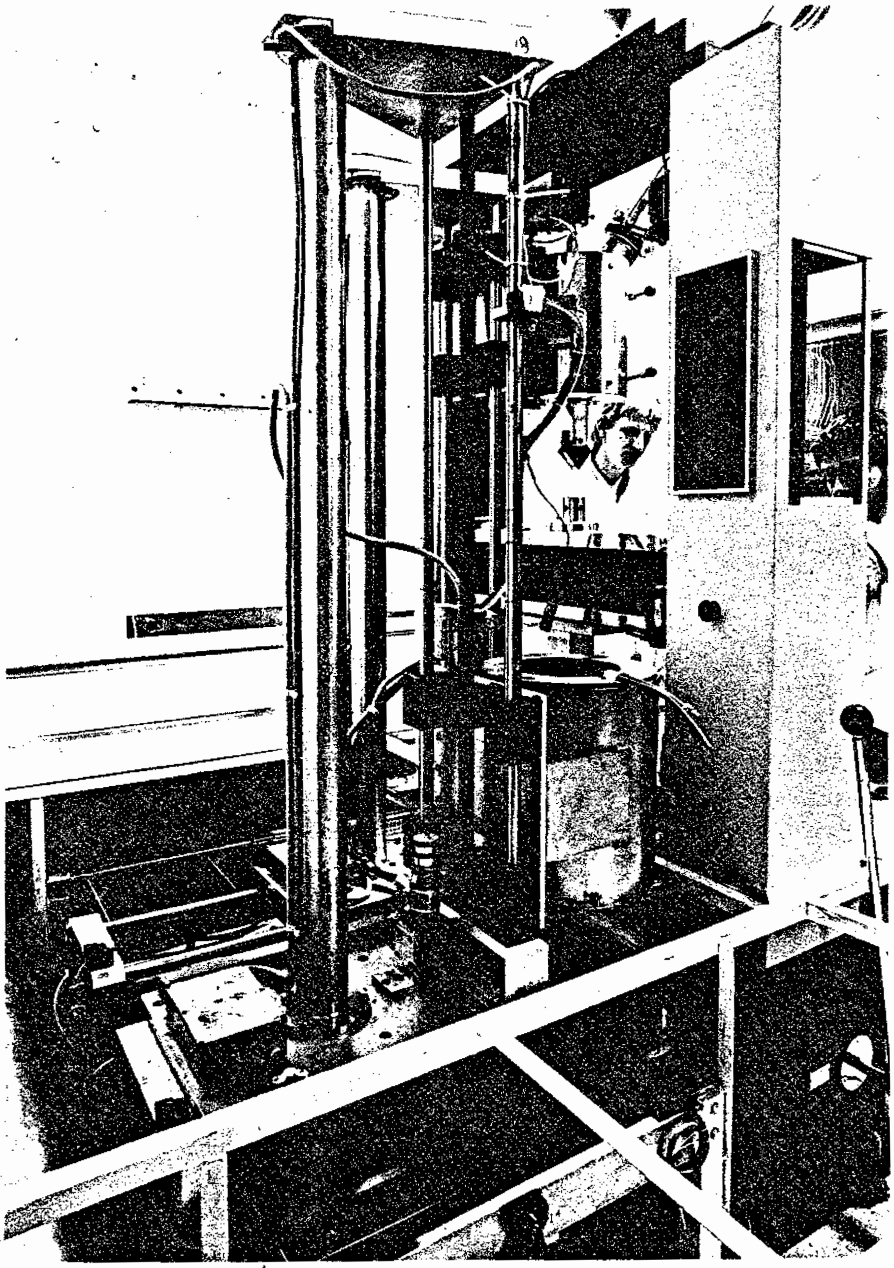


Fig. 7. Frame with furnace and cold chamber of the tension apparatus.

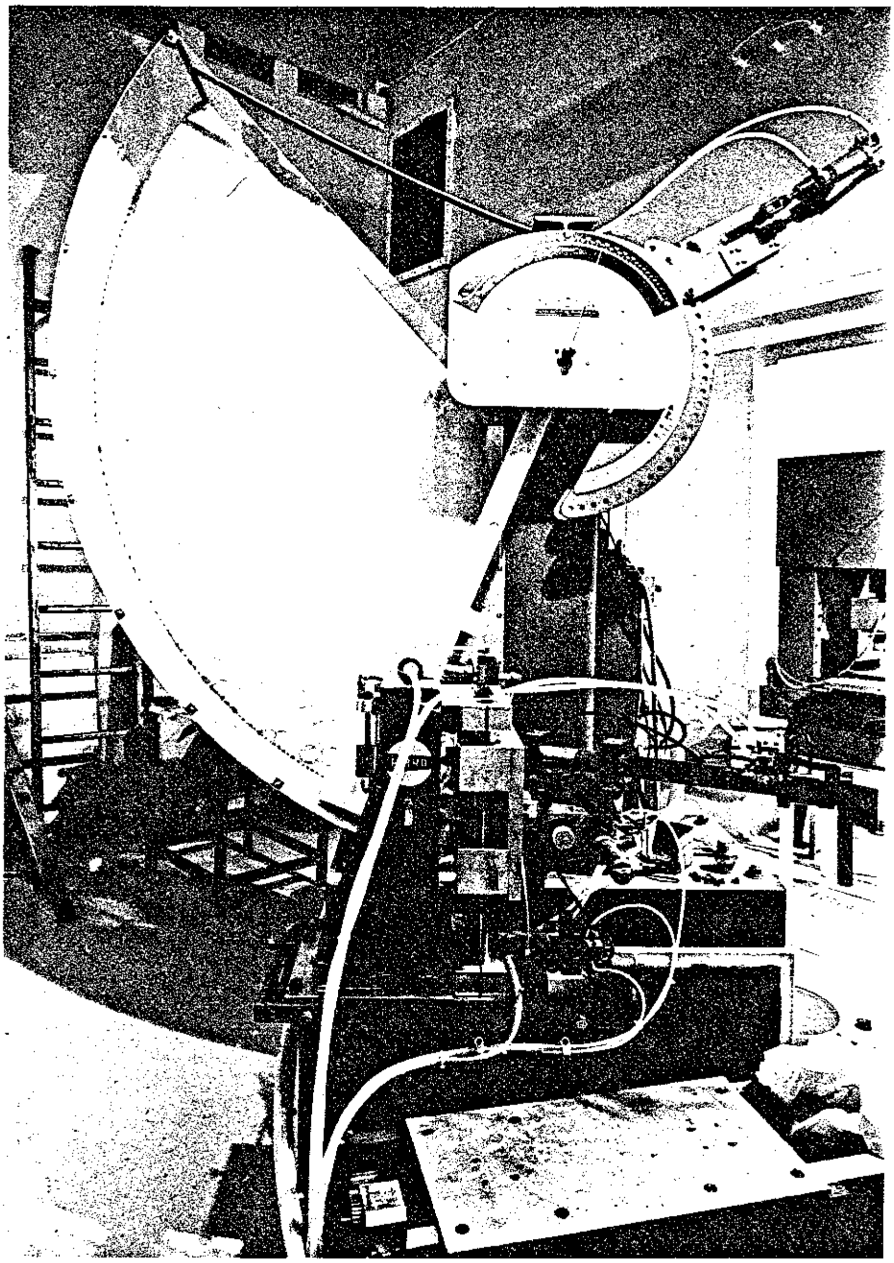


Fig. 8. Impact tester installation with automatic specimen positioning stage.

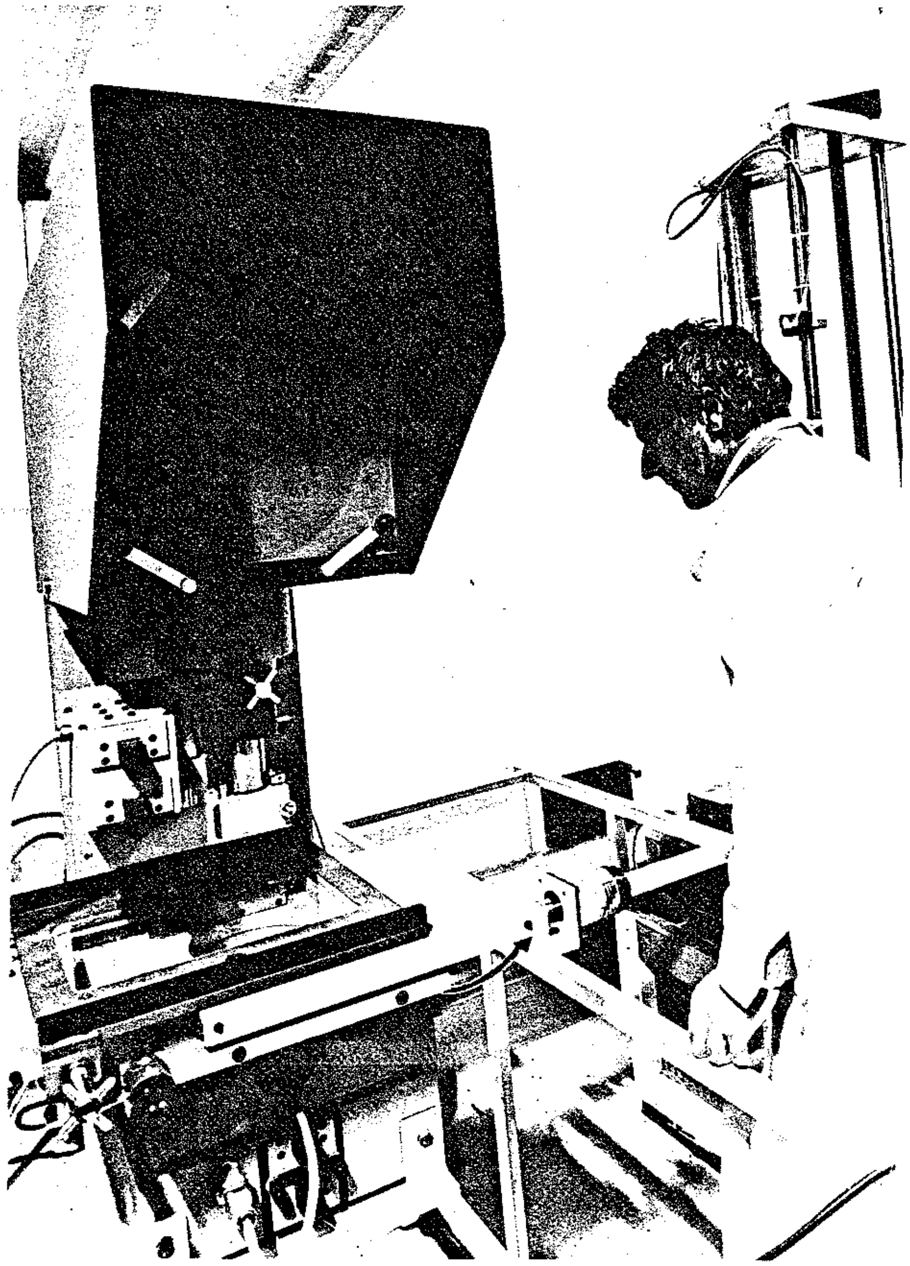


Fig. 9. Profile projector installation.