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CSNI No. 119

Appendicies 1 to 4 to PISC II Report No. 3

X-Ray Examination of the PISC II RRT Plates Before Destructive Examination

Programme for the Inspection of Steel Components

PISC

X-Ray examination of the PISC II RRT plates

Objectives

The X-Ray examination of the four plates of the PISC II Round Robin Tests pursued two main objectives :

- Detection and sizing of the defects in these thick test sections by a general X-Ray examination.
- Preparation of references for the following iterative destruction and detailed X-Ray examination of the important parts of the plates.

As a consequence of the different geometries of the 4 plates, different approaches have been used for the X-Ray examination. The following three pieces of X-ray equipment have been used for the examination. Their specific application for each operation phase (general application and inspection after the several cutting phases) will be given together with the inspection history of each plate.

Characteristics of the X-Ray equipment and related parameters

MEL - 8 MeV - Linear accelerator (ANSALDO-BREDA)
(Fig. 1).

Source type :	X-Ray Linear accelerator MEL up to 8 MeV energy
Focal spot :	Ø 3 mm
Focal distance :	2000 mm (+ Wall thickness)
Incidence :	Radiation through single wall
Penetrameters :	DIN 54109 Fe
Film type :	KODAK AA - M
Front screen :	1 mm Ta.
Back screen :	1 mm Ta.
Film size :	30cmx40cm - 15cmx30cm
Film density :	1,8 - 3,5 D
Film development :	Automatic
Radiographic wire sensitivity :	from 1 to 0,5% (in function of the steel thickness)

VARIAN 200 A - 2 MeV Linear accelerator (JRC-Ispra)
(Fig. 2)

Source type : X-Ray linear accelerator VARIAN 200 Aof 1 and 2 MeV energy
Focal spot : Ø 2 mm
Focal distance : 2000 mm
Incidence : Radiation through single wall
Penetrameters : DIN 54109 Fe
Film type : AGFA Gevaert D4-D7
Front screen : 0,2 mm Ta.
Back screen : 1 mm Ta.
Film size : 24cmx30cm
Film density : 1,8 - 3,5 D
Film development : Automatic
Radiographic wire sensitivity : from 1 to 0,5% (in function of the steel thickness)

BALTEAU 400 KV Radiographic equipment (JRC-Ispra)
(Fig. 3)

Source type : Industrial radiographic equipment 400 KV BALTEAU
Focal spot : $4x4mm^2$ - $1,5x1,5mm^2$
Focal distance : 1000 mm
Incidence : Radiation through single wall
Penetrameters : DIN 54109 Fe
Film type : AGFA Gevaert D7 - D5 - D4 - D2 with Pb
Front screen : 0,10 mm Pb
Back screen : 0,20 mm Pb
Film size : 30cmx40cm - 18cmx24cm - 10cmx24cm
Film density : 1,8 - 3,5 D
Film development : Automatic
Radiographic wire sensitivity : 1%

APPENDIX I

X-Ray examination of RRT plate No. 9 (see Fig. 4)

The general X-ray examination of plate No. 9 consisted of three different examinations shown schematically in Fig. 5.

A. Specific X-ray examination of the welding and in the neighbourhood of the known defects with a total of 12 radiograms with the MEL equipment. All the defects could be put in evidence and localized in the right X-Y position.

B. Industrial examination of the plate No. 9 each 30^0 by a total of 12 radiograms with the MEL equipment. This inspection confirmed the results already obtained by the inspection described in point A.

C. X-ray examination of the inner radius corner at the following Y angles ($0^0/90^0/225^0$). The three radiograms at the indicated positions were done with the MEL equipment on different films (Kodak AA, T and M) in order to take into account the different wall thickness of the test specimens.
Only the existing defects at 90^0 and 225^0 Y angles could be put in evidence.

After this general X-ray examination of the plate a first cutting has been done as shown in Fig. 6, resulting in four annular pieces (1-4) only the annuli Nos. 2 and 3 were then subsequently submitted to further detailed examination.
The further inspection of annulus No. 3 with MEL is shown in Fig. 7.
The complete inspection of annulus No. 3 was done in radial (X) and perpendicular (Z) direction thus to obtain exact X/Y/Z location of the defects in annulus No. 3. With this procedure all three defects at Y angles (90^0, 225^0 and 315^0) could be put in evidence, localized and dimensioned.

The detailed X-ray inspection of annulus No. 2 of plate No. 9 required four further iterative cutting phases and related X-ray examinations. The X-ray examinations of the different pieces of annulus No. 2 of plate No. 9 required a total of more than 160 radiograms which have been done with BALTEAU 400 KV equipment varying the exposition time and film characteristics adapting them to the thickness of the different cutted pieces (see Fig. 9 of main PISC Report No. 3).
Detailed results of the different inspection phases are given in the chapter 3 of the PISC II report No. 3.

APPENDIX II

X-ray examination of plate No. 2

Plate No. 2 of the PISC II round robin test is shown in Fig. 8. The inspection of plate No. 2 has been subdivided in different phases.
The first phase (see Fig. 9) was effectuated on the reduced piece of plate No. 2 with the MEL equipment and Kodak M film with 15 radiograms in the Z direction (1 radiogram every 100 mm) and 30 radiograms in the X direction (2 radiograms every 100 mm).
The two radiograms every 100 mm in X direction were necessary for a better location of the defects with the beam centre at Z = 50 mm and at Z=200 mm position.
For the second inspection phase (sizing phase), the block has been cut into slices and the radiograms were taken with the VARIAN equipment and AGFA GEVAERT film D4 in the Y-direction for a better sizing of the defects in the X-Y directions. In the following phases 3 and 4 after additional cutting, the resulting pieces (see Fig. 27 of PISC II report No. 3) were examined with the BALTEAU 400 KV equipment and Agfa Gevaert film D5, D4 and D2.
Detailed results of the different inspection phases are given in the chapter 4 of the PISC II report No. 3.

APPENDIX III

X-ray examination of Plate No. 1

Plate No. 1 of the PISC II RRT is shown in Fig. 10.
The X-ray examination procedure of plate No. 1 was similar to that applied to plate No. 2.
Plate No. 1 was reduced as shown in Fig. 11 and inspected with the MEL equipment and Kodak M film in Z and X directions using 10 radiograms for each direction (one radiogram every 100 mm). For the inspection phase No. 1bis, the block has been furthermore reduced to a thickness of 100 mms and inspected by 10 radiograms in the X direction with the VARIAN 200 equipment and Agfa Gevaert film D4. For the inspection phase No. 2 with VARIAN 200 equipment and Agfa Gevaert film D4, the remaining block has been furthermore cut in (X/Y/Z) directions as shown in Fig. 35 of PISC II Report No. 3. A final even more detailed inspection of the pieces after final cutting is foreseen, also with VARIAN 200 equipment and Agfa Gevaert D2 film.
Detailed results of the inspection phases 1, 1bis and 2 are given in the chapter 5 of the PISC II report No. 3.

APPENDIX IV

X-ray examination of RRT plate No. 3

Plate No. 3 of the PISC II RRT, also called nozzle plate is shown in Fig. 12.
The plate theoretically contains 31 implanted defects in the welding range and 3 radius corner defects. The implanted defects were known to the Referee Laboratory that means : type and dimensions of the defects, their position and their inclination in the Z/direction (see Table 1).
A visual impression of the distribution of the defects of plate No. 3 is given in Figs. 44 and 45 of the PISC II Report No. 3.
The following three X-ray examinations have been performed on plate No. 3 all with the MEL equipment; they are schematically shown in Fig. 13.

A. X-ray examination of the welding zone in the nozzle plate by centering the X-ray on the known defects and with inclination of the X-ray source parallel to the defects inclination (max range of the angles from + 10^{0} to - 7^{0}) with the film attached to the countersurface of the plate (then not necessarily perpendicular to the X-ray beam).
The examination has then been completed by 3 radiograms for the detection of the radius corner defects, also shown in Fig. 13 (A). In total 40 radiograms were taken in the three positions shown in Fig. 13 (A) detecting 28 of the 34 implanted defects. Exposition time and film characteristics (Kodak AA and M) were adapted to the respective wall thickness.

B. Industrial peripheral inspection has been effectuated in (Z) direction by means of radiograms, also with varying exposition time and film characteristics as shown in Fig. 13 (B) which confirmed in the main lines the results obtained by the procedure described in (A).

C. A third additional control inspection as shown in Fig. 13 (C) has then been undertaken at the same conditions as inspections (A) and (B) with the only difference that the film was perpendicular to the X-ray beam, which has been maintained parallel to the Z direction (axis of the nozzle). This permitted to correct and increase the precision of the location and sizing of the detected defects.

The evaluation of these three inspection procedures put in evidence 29 of the 34 defects and the existance of about 10 supplementary natural defects. All the defects (natural and artificial) are listed in Tables 6 at 7 of the PISC II Report No. 3.

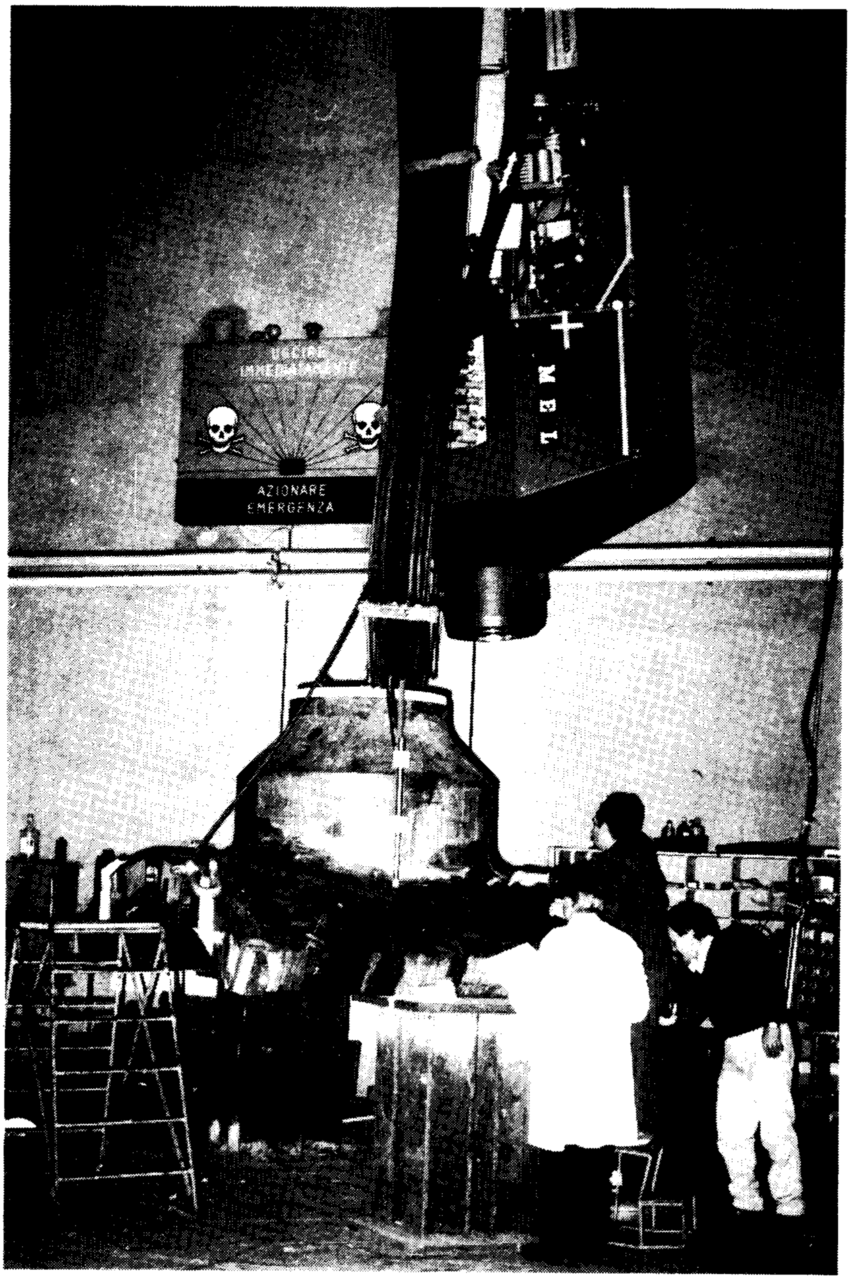

Fig. 1 MEL 8MeV Linear Accelerator

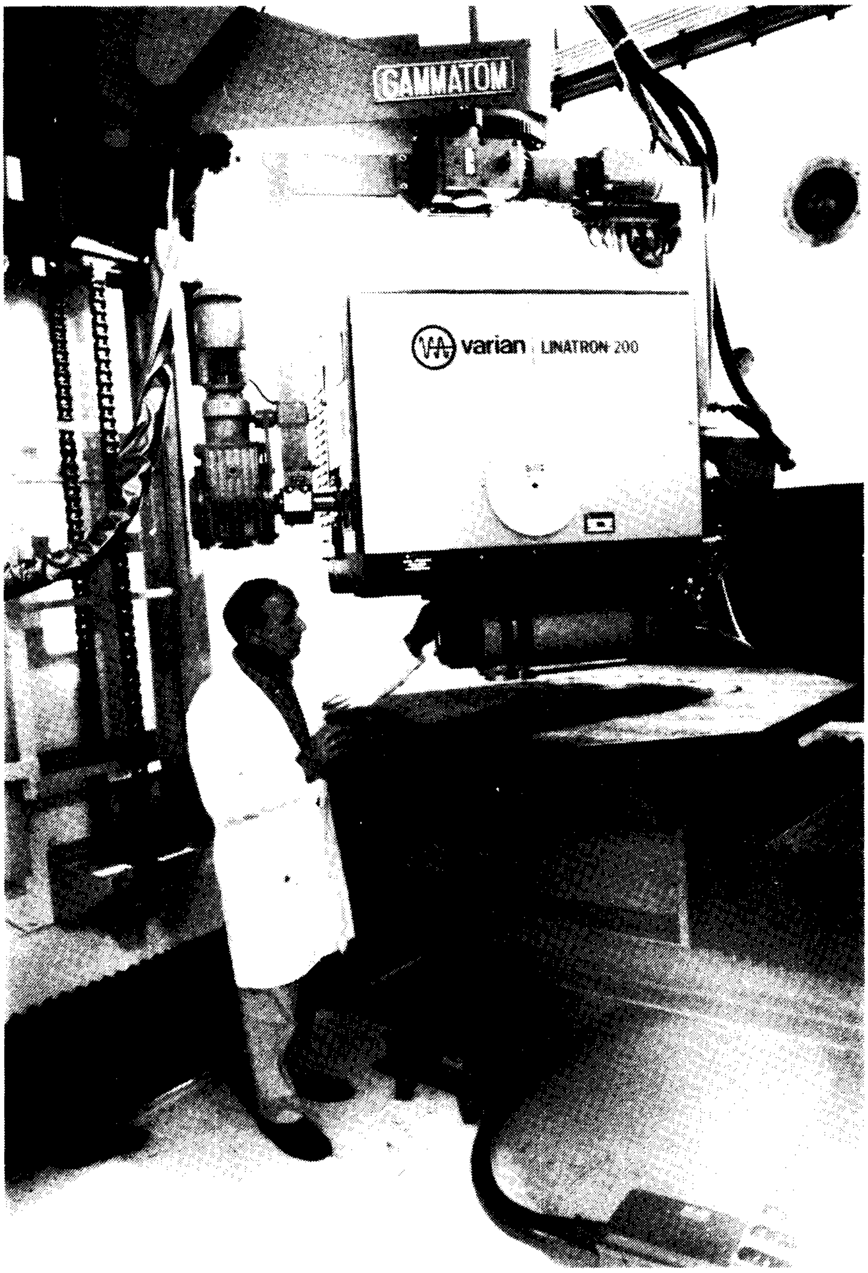

Fig. 2 VARIAN 200 A 2 MeV Linear Accelerator

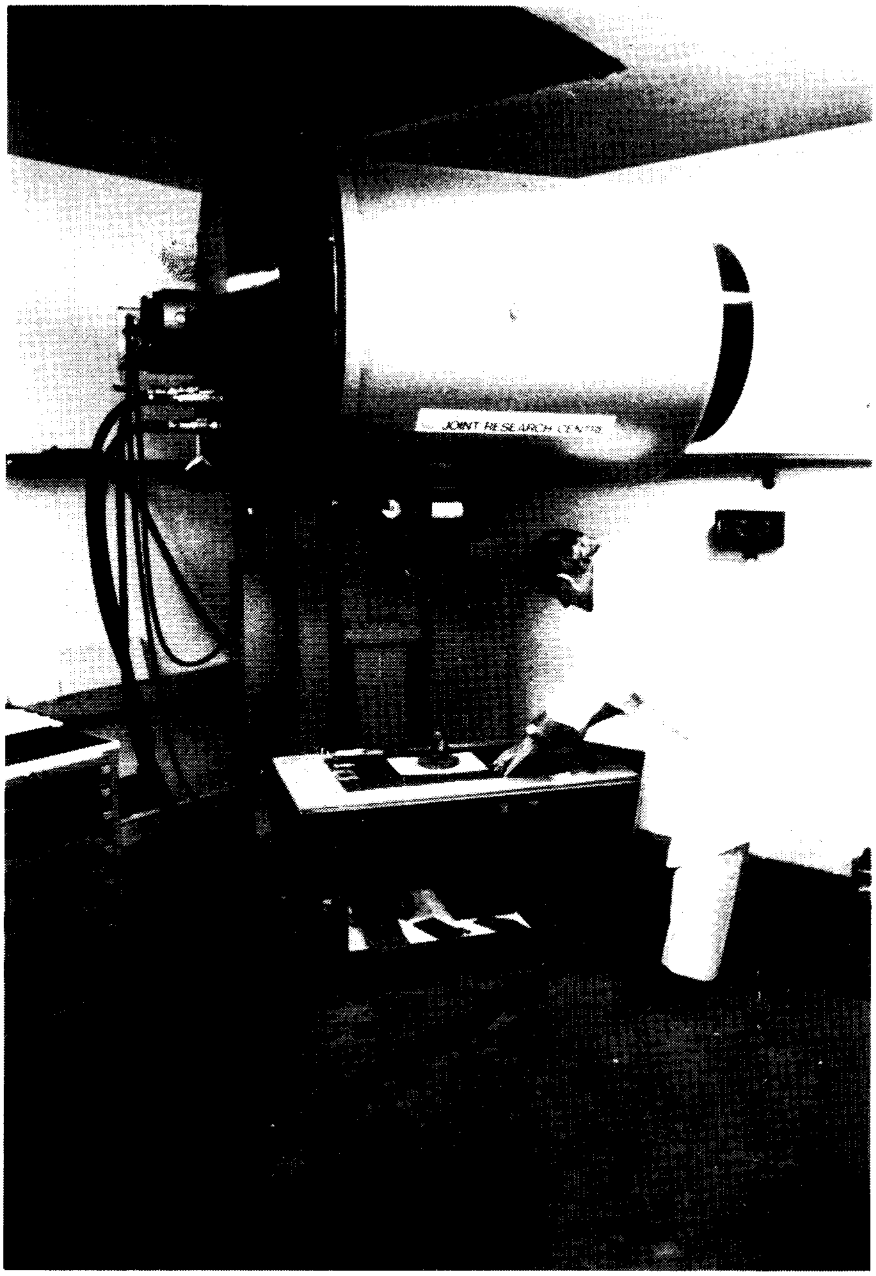

Fig. 3 BALTEAU 400 KV radiographic equipment

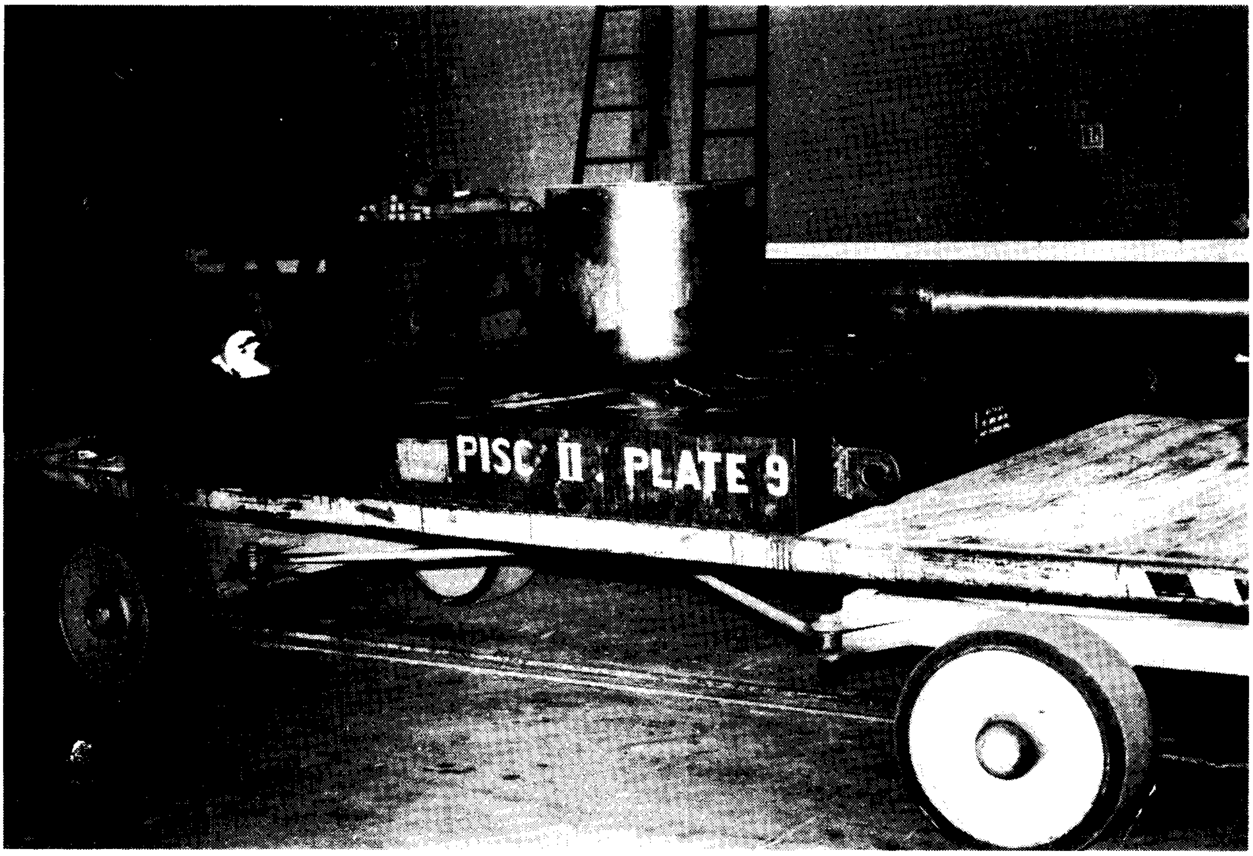

Fig. 4 Plate No. 9

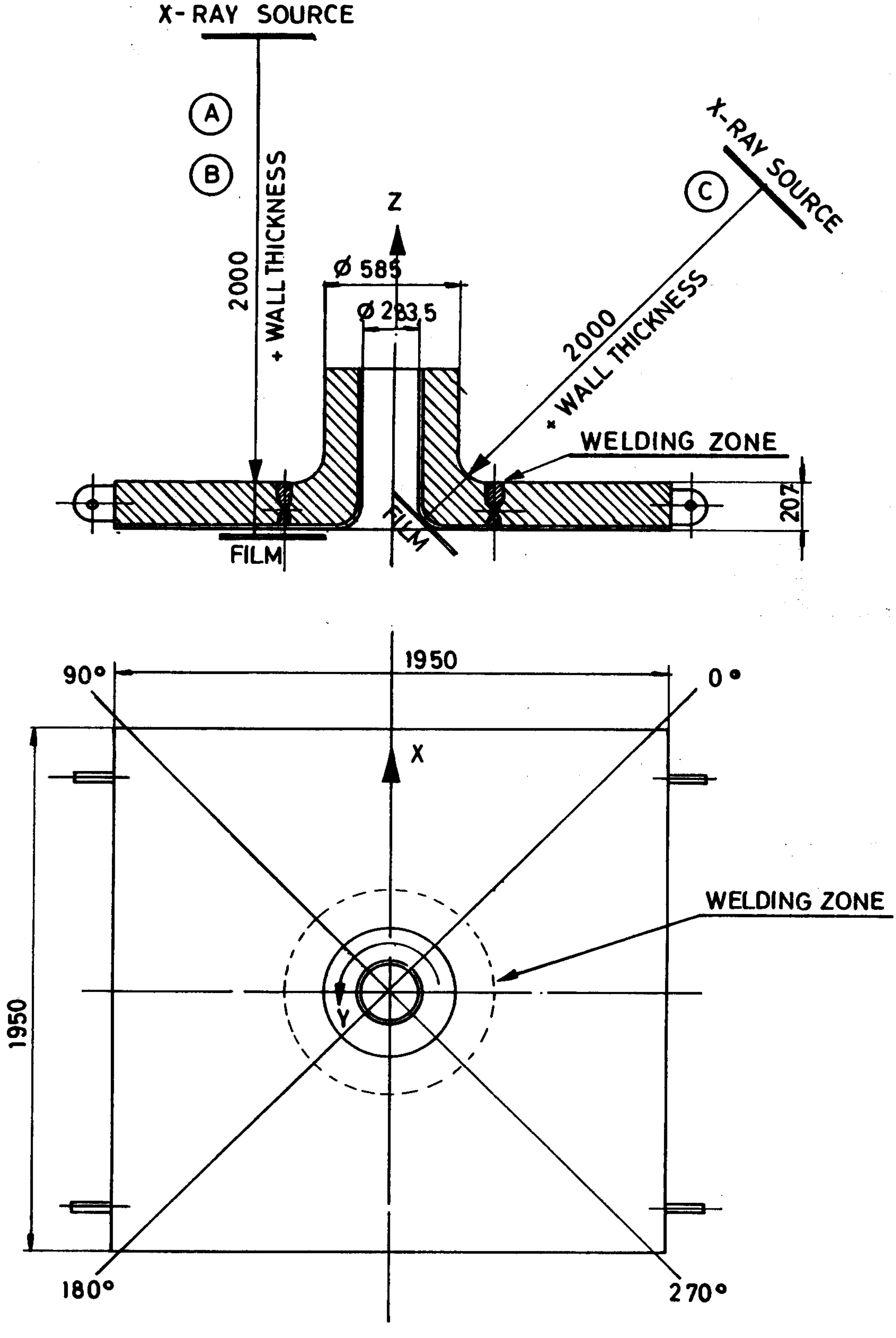

Fig. 5 X-ray examination scheme of plate No. 9

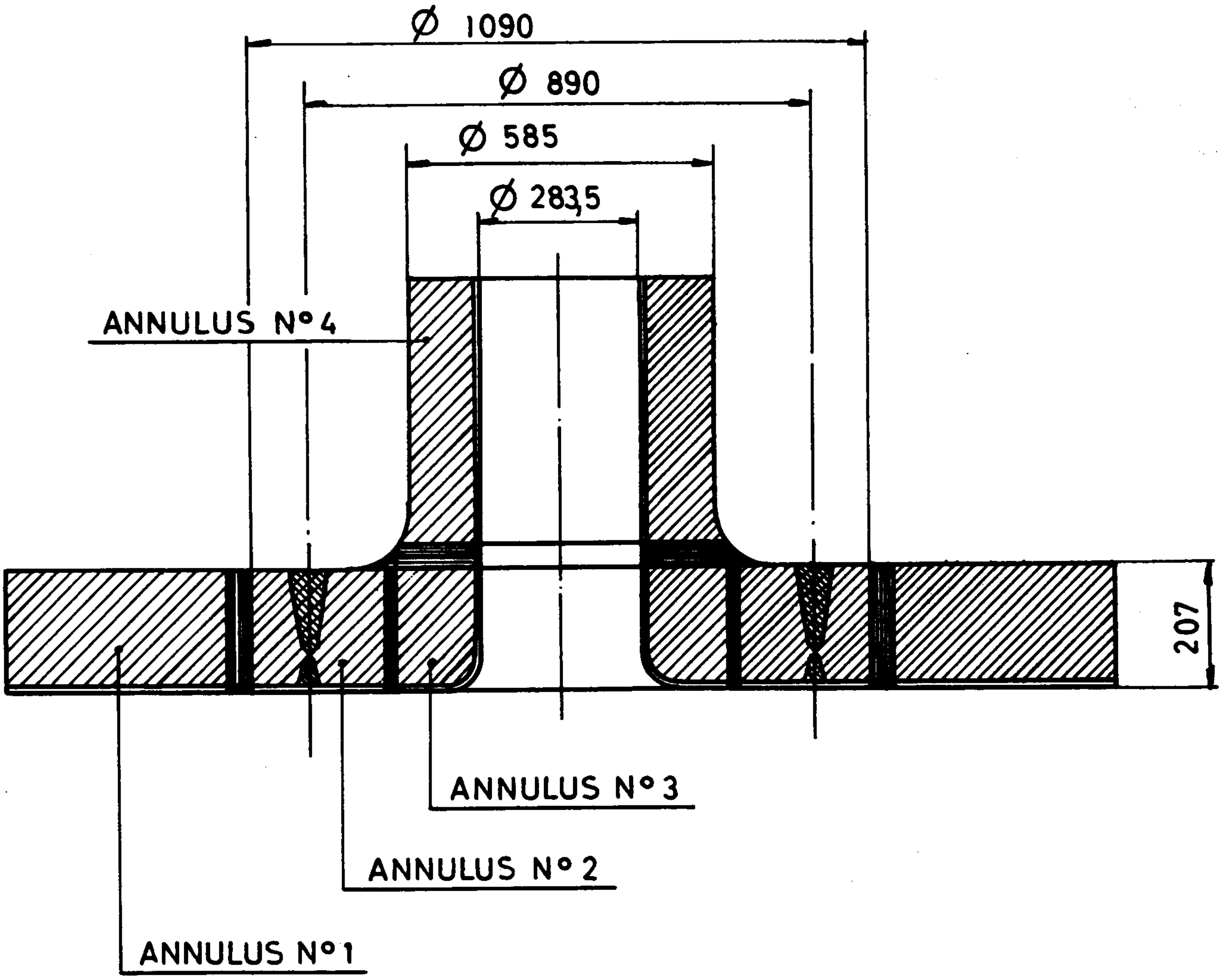

Fig. 6 First cutting scheme of plate No. 9

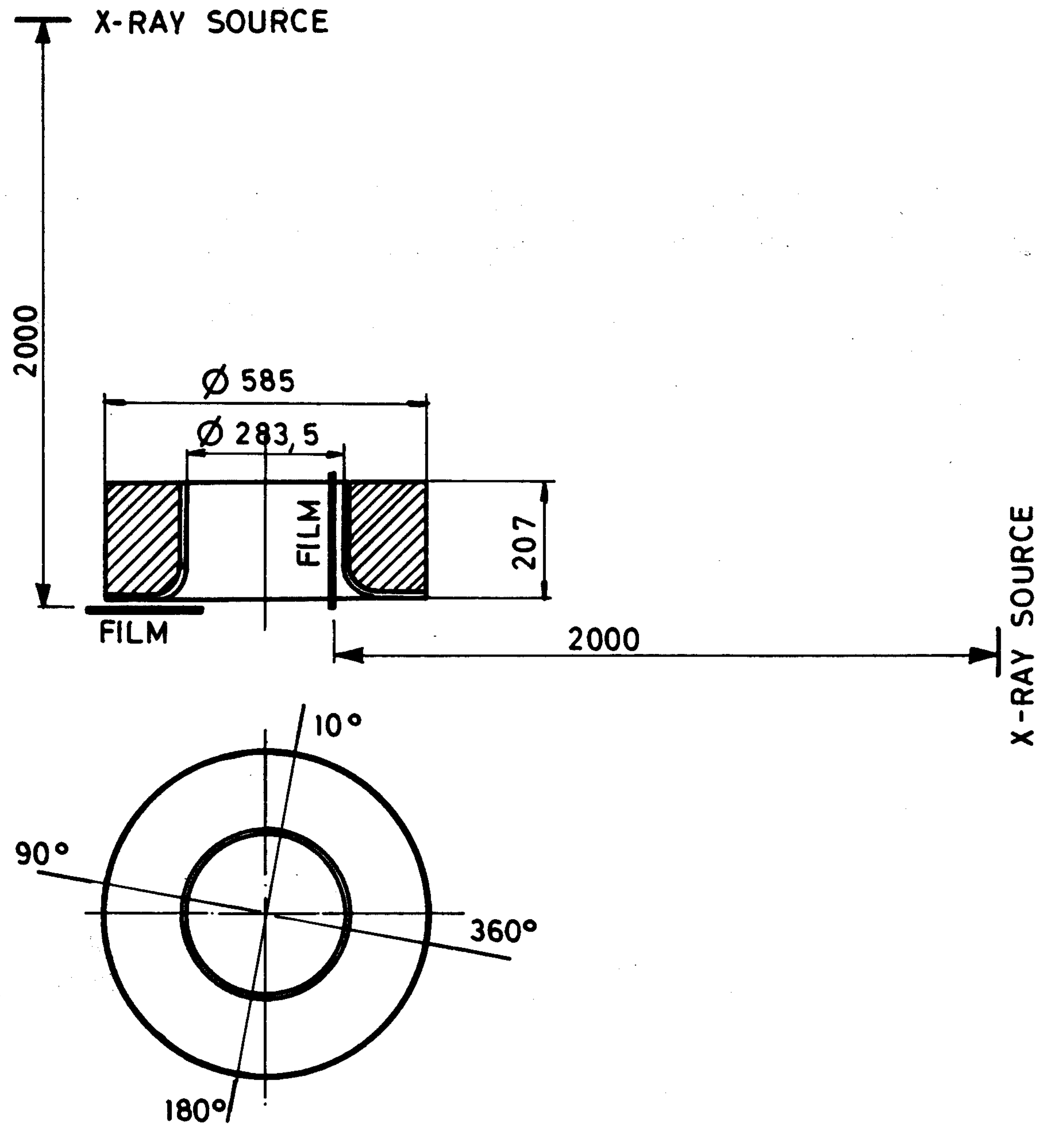

Fig. 7 X-ray examination of annulus No. 3 of plate No. 3

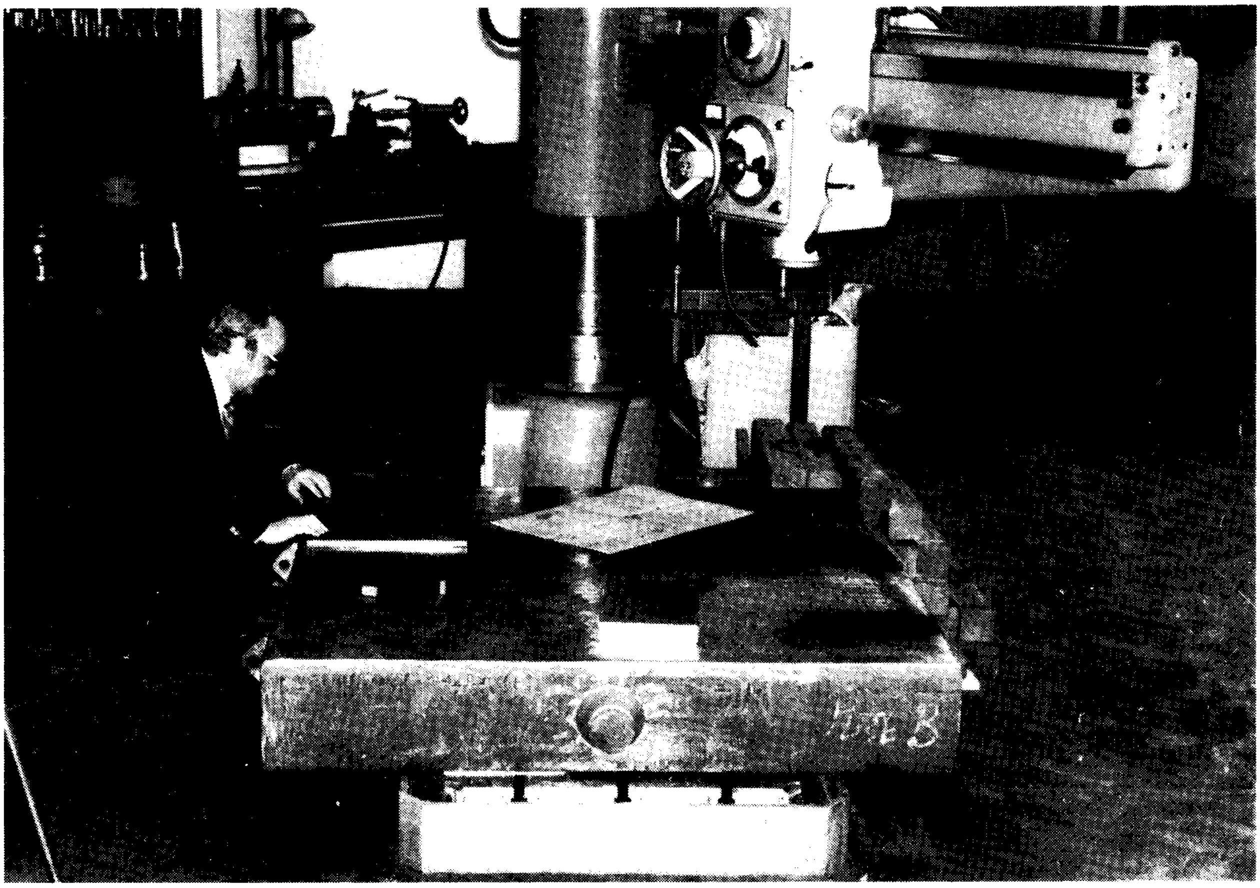

Fig. 8 Plate No. 2

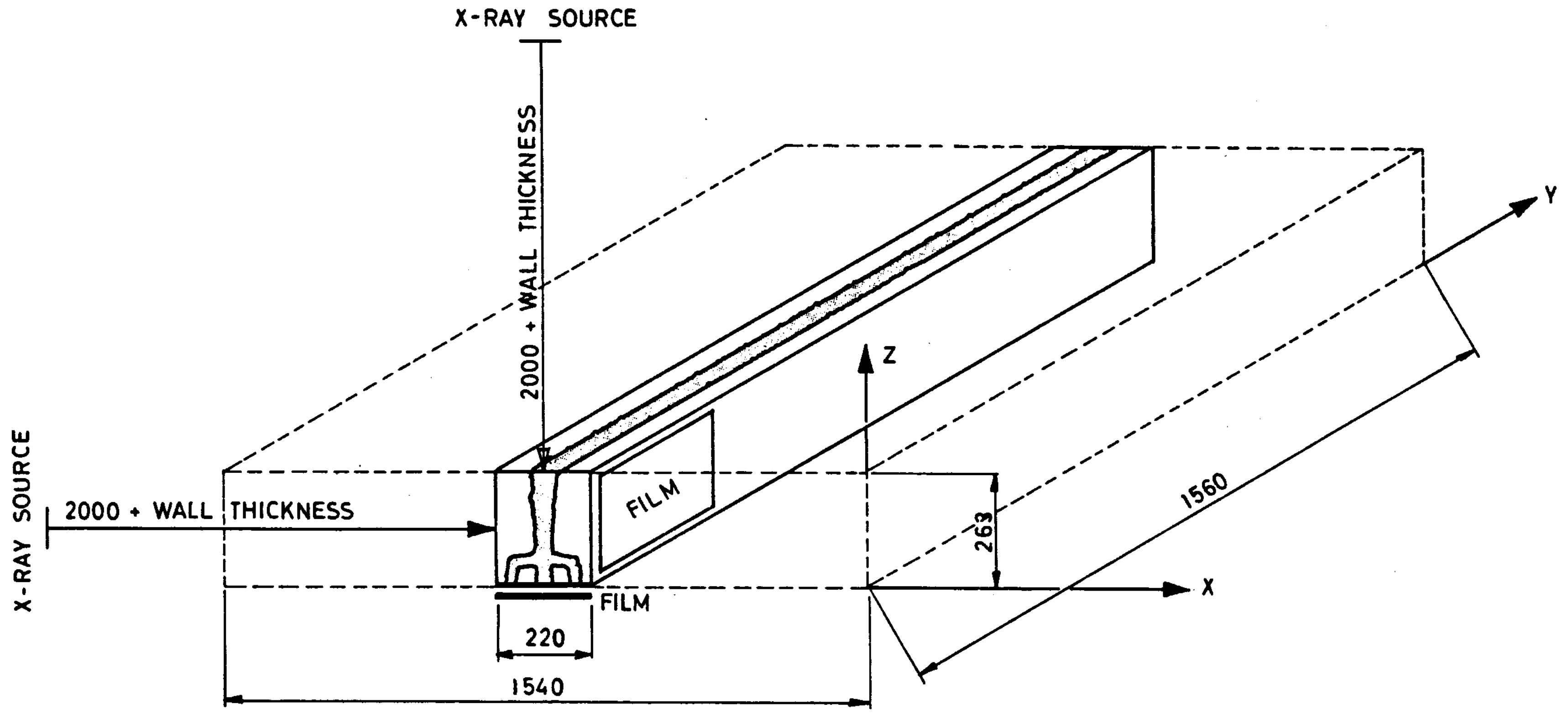

Fig. 9 X-ray examination scheme of plate No. 2 (phase 1)

Fig. 10   Plate No. 1

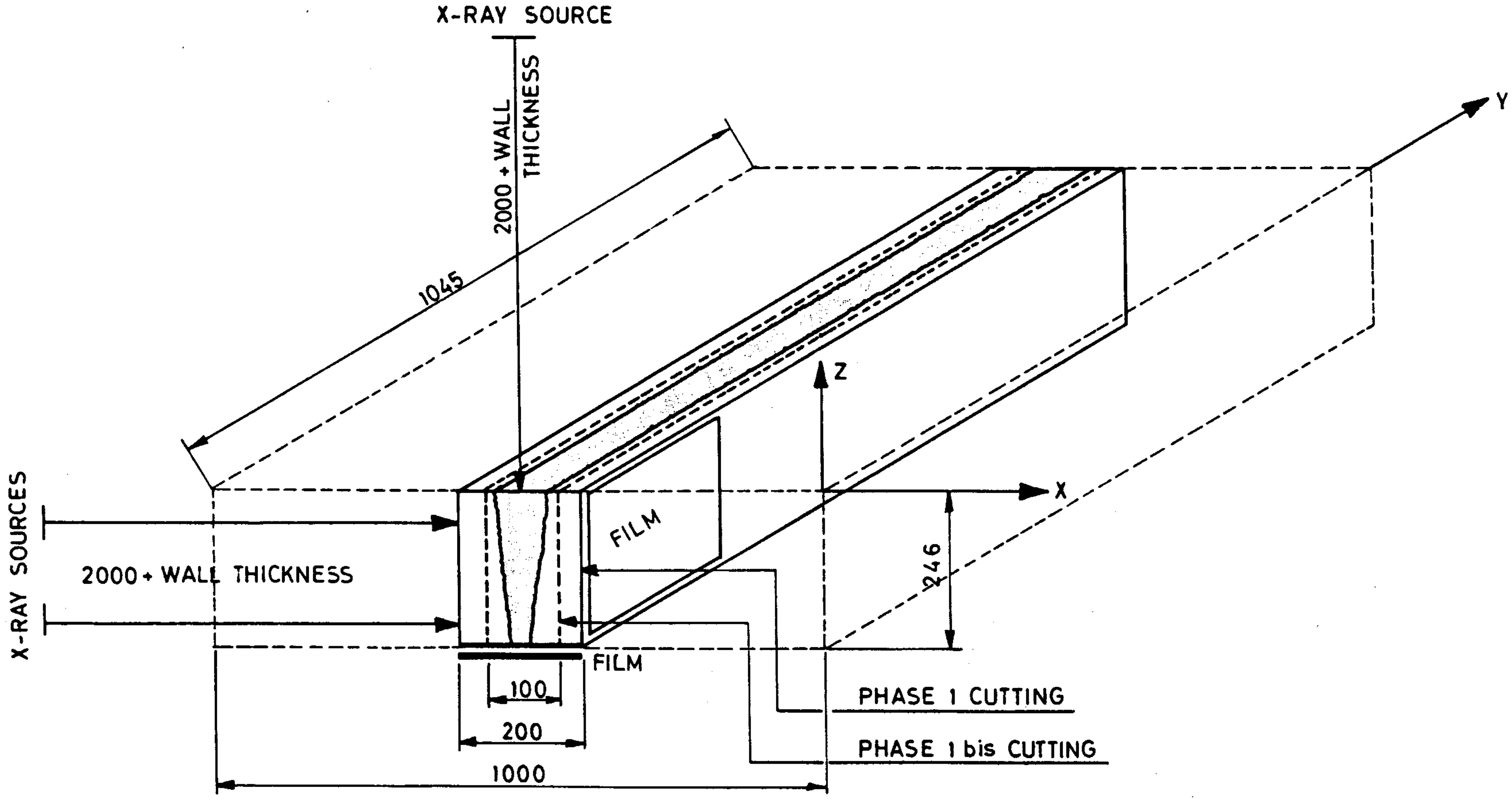

Fig. 11 X-ray examination scheme of plate No. 1 (phase I and Ibis)

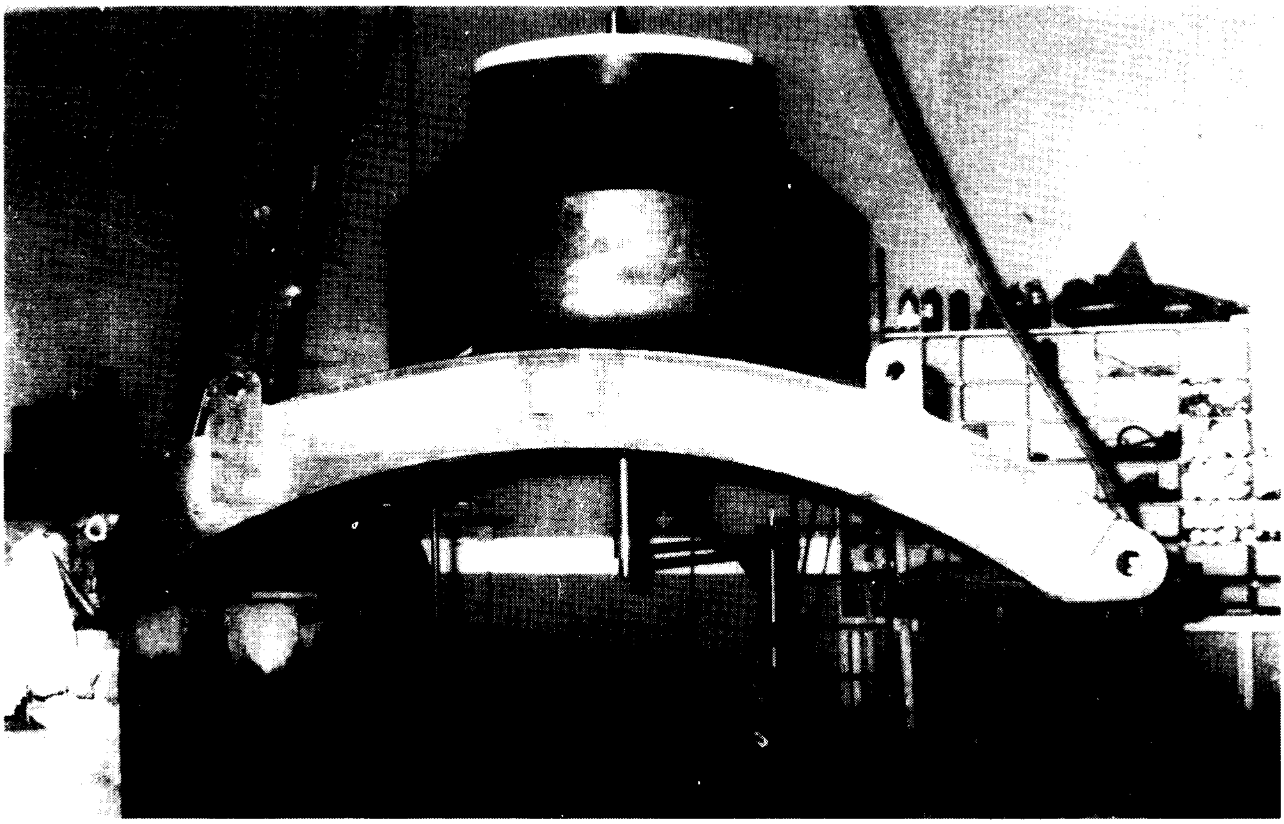

Fig. 12   Plate No. 3

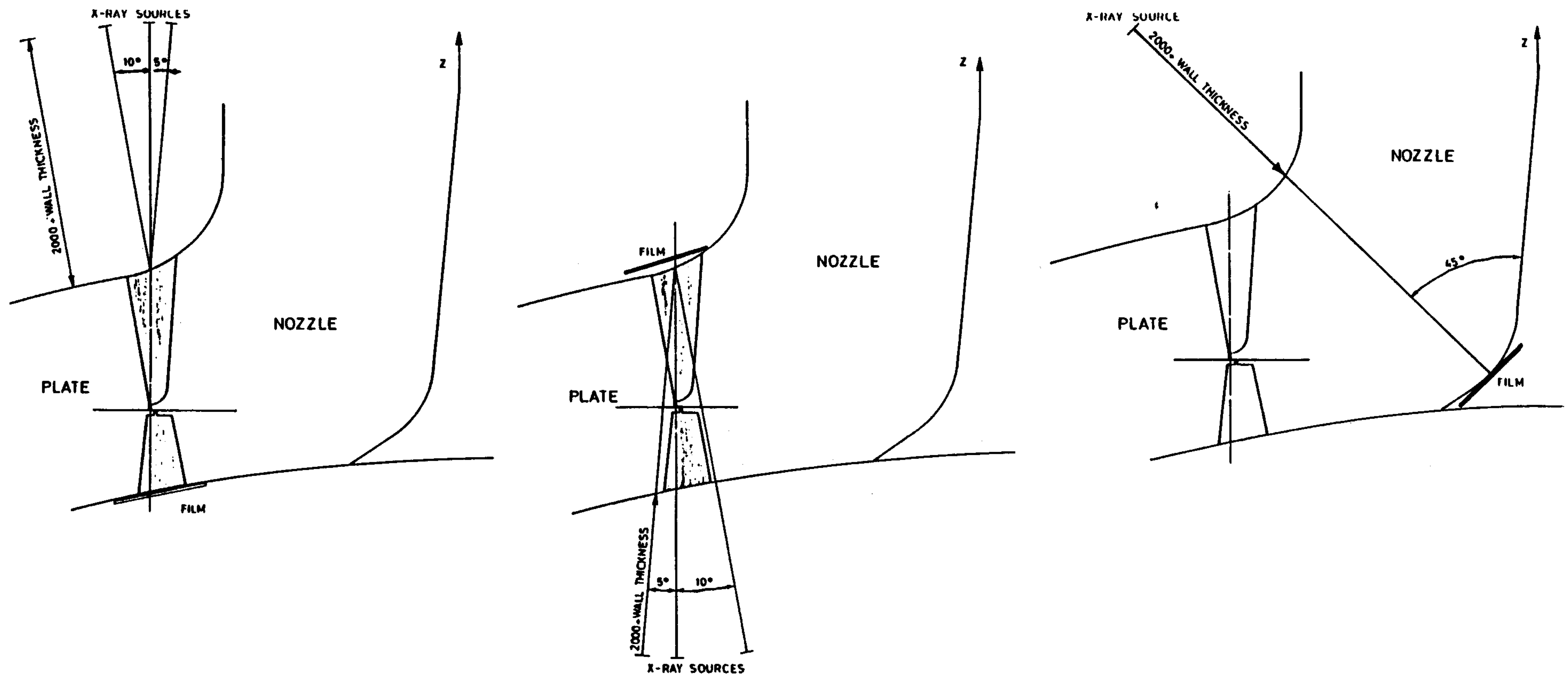

FIG. 13-(A) FIRST X-RAY EXAMINATION SCHEME OF PLATE N°3

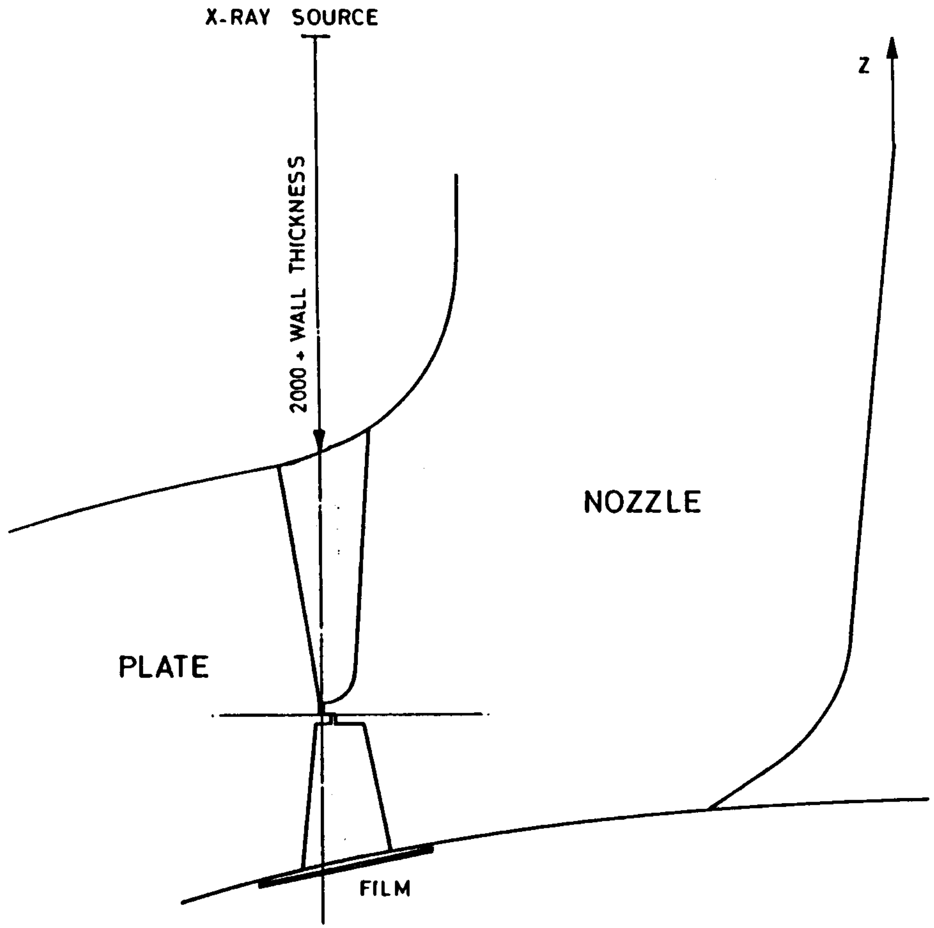

FIG. 13 - (B) INDUSTRIAL X-RAY EXAMINATION OF PLATE N° 3

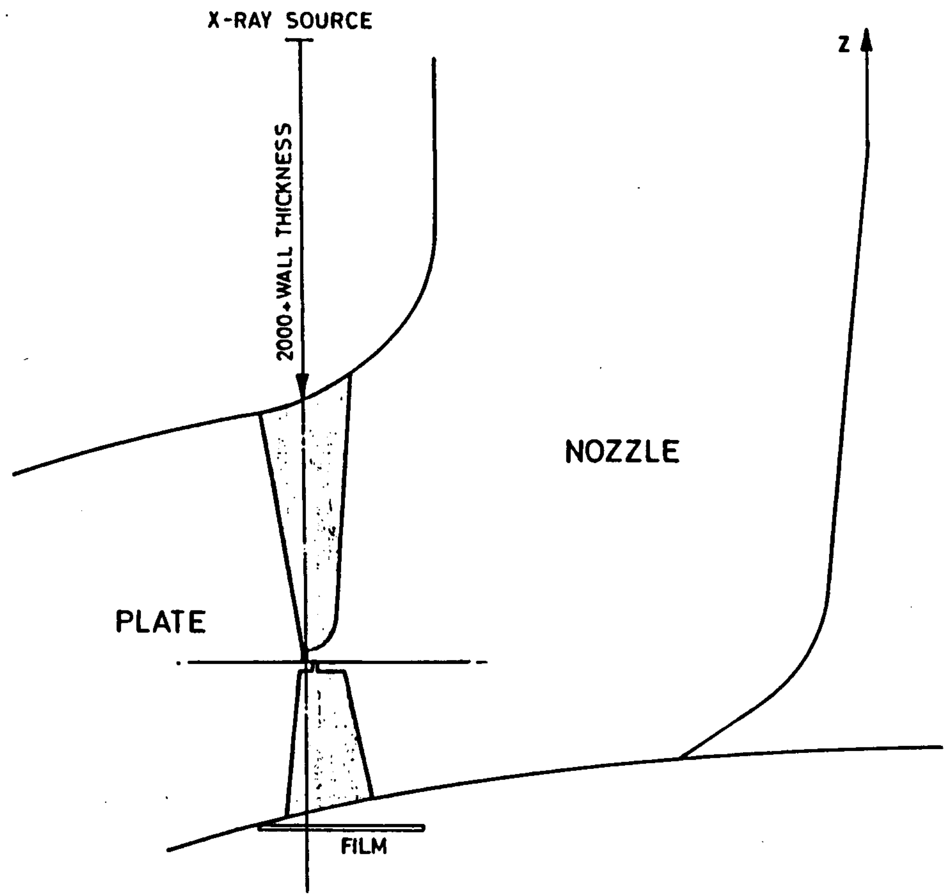

FIG. 13 - (C) CONTROL X-RAY EXAMINATION OF PLATE N° 3

TABLE 1 - DEFECT CHARACTERISTICS IN PLATE N° 3

DEFECT N°	TYPE OF DEFECT	THEORETICAL DIMENSION mm	THEORETICAL DIMENSION THICKNESS mm	ANGLE OF IRRADIATION Z	ANGLE OF POSITION Y	ANGLE OF IMPLANTATION Z	PUT IN EVIDENC YES	PUT IN EVIDENC NO
1	BREDA - INCLUSION			-10^0 cladding side	136^0 30'	$+10^0$	X	
2	IKE	Ø 10mm	-0,25 mm	-5^0 Nozzle side	146^0 30'	-5^0	X	
3	IKE	60x60mm	0,25mm	10^0 Nozzle side	319^0 30'	$+10^0$	X	
4	IKE	17x85mm + 3 mm start	0,27mm	-3^0 Nozzle side	176^0 30'	-3^0	X	
5	IKE	17x83	0,90mm	$+10^0$ Nozzle side	276^0 30'	$+10^0$	X	
6	IKE Ø 60, 3	3xØ=9-12-18 3xØ=3-6-7	0,04	$+10^0$ Nozzle side	241^0 30'			
7	IKE Ø 60, 3	3xØ=6-9-18 Ø = 40	0,25	$+10^0$ Nozzle side	211^0 30'	$+10^0$	X	
8	IKE 10	3xØ=10-10-10 Ø = 40	0,25	$+10^0$ Nozzle side	31^0 30'	$+10^0$	X	
9	IKE 10	Ø = 40 3xØ=10-10-10	0,25	$+10^0$ Nozzle side	61^0 30'	$+10^0$	X	
10	BREDA INCLUSION			-3^0 Nozzle side	106^0 30'	-3^0	X	
11	IKE	10x50 start 3mm	0,20	$+10^0$ Nozzle side	14^0	-3^0	X	
12	IKE	10x50	0,70	$+10^0$ Nozzle side	79^0	-3^0	X	
13	CETIM	3x12	$\pm$ 1,5	$+10^0$ Nozzle side	194^0	$+10^0$	X	
14	CETIM	3x12	$\pm$ 1,5	$+10^0$ Nozzle side	259^0	$+10^0$	X	
15	CETIM	6x24	$\pm$ 1,5	$+10^0$ Nozzle side	14^0	$+10^0$	X	
16	CETIM	6x24	$\pm$ 1,5	$+10^0$ Nozzle side	79^0	$+10^0$	X	

DEFECT N°	TYPE OF DEFECT	THEORETICAL DIMENSION mm	THEORETICAL DIMENSION THICKNESS mm	ANGLE OF IRRADIATION Z	ANGLE OF POSITION Y	ANGLE OF IMPLANTATION Z	PUT IN EVIDENCE YES	PUT IN EVIDENCE NO
17	BREDA - SLAG			$0^0 + 10^0 - 50^0$ nozzle side	356^0 30'	$+ 10^0$		X
18	IKE ○	Ø,25	0,70	$- 5^0$ nozzle side	266^0 30'	- 50	X	
19	IKE ○	Ø 25	0,20	$- 5^0$ Nozzle side	186^0 30'	$- 5^0$	X	
20	IKE ○	Ø 17	0,90	$- 5^0$ Nozzle side	286^0 30'	$- 5^0$	X	
21	IKE ○	Ø 17	0,18	$- 5^0$ Nozzle side	166^0 30'	$- 5^0$	X	
22	BREDA - INCLUSION			$+ 10^0$ Nozzle side	346^0 30'	$+ 10^0$	X	
23	BREDA } LACK OF FUSION	3x20	0,1	+ 9, +10, + 11 Nozzle side	159^0	$+ 10^0$		X
24	BREDA } LACK OF FUSION	3x20	0,1	+ 9, + 10, + 11 Nozzle side	159^0	$+ 10^0$		X
25	BREDA } LACK OF FUSION	10x40	0,1	0^0 Nozzle side	296^0 30'	$- 3^0$	X	
26	BREDA } LACK OF FUSION	20x60	0,1	$- 7^0$ Nozzle side	296^0 30'	$- 5^0$	X	
27	IKE ○	Ø 10	0,25	$+ 10^0$ Nozzle side	306^0 30'	$+ 10^0$	X	
28	IKE ○	Ø 10	0,70	$+ 10^0$ Nozzle side	146^0 30'	$+ 10^0$	X	
29	BREDA - INCLUSION			$- 5^0$ Nozzle side	96^0 30'	$- 5^0$	X	
30	IKE ○	Ø 3	0,23	$4^0, 5^0, 6^0$ nozzle side	301^0 30'	$- 5^0$		X
31	BREDA - LACK OF BONDING	—	—	—	251^0 30'	—	—	(X)
1	J R C - INRADIUS CRACK	19x32,5	1,5	45^0 Nozzle side	220^0	0^0	X	
2	J R C - " "	16x28,5	1,5	45^0 Nozzle side	230^0	0^0	X	
3	J R C - " "	19x32,5	1,5	45^0 Nozzle side	35^0	0^0	X	