ENTERGY OPERATIONS INCORPORATED
ARKANSAS NUCLEAR ONE

TITLE: MANUAL ULTRASONIC EXAMINATION FOR PLANAR FLAW SIZING	PROC/WORK PLAN NO. 1415.029	REV. 1
	EXP. DATE N/A	SAFETY-RELATED ☒YES ☐NO
CONTROLLED COPY #	PAGE 1 OF 1	IPTE ☐YES ☒NO

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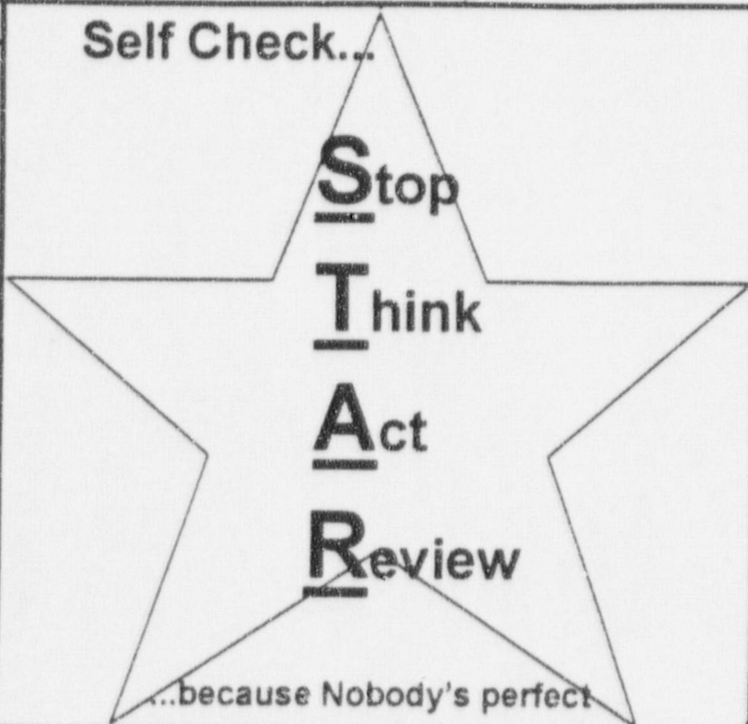

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FORM TITLE: LIST OF AFFECTED PAGES	FORM NO. 1000.006A	REV. 44

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ENTERGY OPERATIONS INCORPORATED
ARKANSAS NUCLEAR ONE

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AFFECTED UNIT	PROCEDURE	WORKPLAN ☐	SAFETY-RELATED	
☒1 ☒2	☒	EXP. DATE N/A	☒YES ☐NO	PAGE 1 OF 1

REASON FOR REVISION/NEW PROCEDURE:

Periodic review and update including editorial and format corrections.

DESCRIPTION OF REVISION:

Editorial, spelling and format corrections made during periodic review.
Added procedure 1000.020 to References section while deleting references to Ultrasonic Thickness procedures.
Deleted QC/QE Manager in Responsibility section.
Added PDI qualification for sizing to paragraph 5.3.1.C.
Added 5.6 RECORDS.

Supersedes or Replaces Another Procedure? ☐YES ☒NO
If Yes, Complete and Attach Form 1000.006H

Does this revision alter or delete an existing Regulatory Commitment? ☐YES ☒NO
If Yes, coordinate with Licensing BEFORE implementing

DOES THIS DOCUMENT:	Yes	No
Change MTCL to be Untrue?	☐	☒
Create an Intent Change?	☐	☒
Implement or Change IPTE Requirements?	☐	☒
Require a 10CFR50.59 Review per step 6.3.2 of 1000.131	☒	☐

Was MEF used as source document? ☒ YES ☐NO

OTHER SECTION LEADER(S): (Required for assignment of responsibility outside of responsible section leader's section) DATE:

	DATE:		DATE:
ORIGINATOR: Ken Panther	11/13/97	UNIT SURVEILLANCE COORDINATOR: N/A	
INDEPENDENT REVIEWER: [signature]	11-19-97	SECTION LEADER: J M Roy	12-15-97
ENGINEERING: N/A		QUALITY ASSURANCE: N/A	
QUALITY: N/A		PSC CHAIRMAN/TECHNICAL REVIEWER: J M Roy	12-15-97
FINAL APPROVAL: [signature]	1/8/98	REQUIRED EFFECTIVE DATE:	

FORM TITLE:	FORM NO.	REV.
PROCEDURE/WORK PLAN REQUEST	1000.006B	44

ARKANSAS NUCLEAR ONE		
FORM TITLE: 10CFR50.59 DETERMINATION	FORM NO. 1000.131A	REV. 3 PC-1

Document No. 1413.029 Rev./Change No. 1

Title Manual Ultrasonic Examination for Planar Flaw sizing

Brief description of proposed change: Periodic review, reference and responsibility changes, editorial

Will the proposed Activity:

1. Require a change to the Operating License including:

   Technical Specifications (excluding the bases)? Yes☐ No☑
   Operating License? Yes☐ No☑
   Confirmatory Orders? Yes☐ No☑

2. Result in information in the following SAR documents (including drawings and text) being (a) no longer true or accurate, or (b) violate a requirement stated in the document:

   SAR (multi-volume set for each unit)? Yes☐ No☑
   Core Operating Limits Report Yes☐ No☑
   Fire Hazards Analysis? Yes☐ No☑
   Bases of the Technical Specifications? Yes☐ No☑
   Technical Requirements Manual? Yes☐ No☑
   NRC Safety Evaluation Reports? Yes☐ No☑

3. Involve a test or experiment not described in the SAR? (See Attachment 2 for guidance) Yes☐ No☑

4. Result in a potential impact to the environment? (Complete the Environmental Impact Determination of this form.) Yes☐ No☑

5. Result in the need for a Radiological Safety Evaluation per section 6.1.5? Yes☐ No☑

6. Result in any potential impact to the equipment or facilities utilized for Ventilated Storage Cask activities per Section 6.1.6? Yes☐ No☑

7. Involve a change under 10CFR50.54 for the following SAR documents per Section 6.1.7:

   QAMO? Yes☐ No☑
   E-Plan? Yes☐ No☑

Basis for Determination (Questions 1, 2 & 3): This revision will not require a change to any of the LBD's or cause any of the LBD's to be untrue because the specific details of Ultrasonic Examination are beyond that specified by the LBD's. This procedure is not a test or experiment as defined in the SAR's and does not impact the equipment or facilities for the Ventilated Storage Cask activities.

☐ Proposed change does not require 10 CFR 50.59 Evaluation per Attachment 1, Item #_____, (If checked, note appropriate item #, send LDCR to Licensing).

ARKANSAS NUCLEAR ONE		
FORM TITLE: 10CFR50.59 DETERMINATION	FORM NO 1000.131A	REV 3 PC-1

Document No. 1415.029 Rev./Change No. 1

Search Scope:

List sections reviewed in the Licensing Basis Documents specified in Question 1, 2 and 3. If a keyword search was done on LRS, "all" may be entered under "Section" with the keyword(s) used in parentheses. Controlled hard copies of the documents shall be reviewed (LRS is not verified and searches only text, not figures or drawings). **Attach and distribute a completed LDCR per Section 6.1.2 if LBD changes are required.**

Document	Section
LRS:	All -Ultrasonic Examination, Planar Flaw Sizing
MANUAL SECTIONS:	QAMO
FIGURES:	None

Ken Panther — Certified Reviewer's Signature

Kenneth C. Panther — Printed Name

11/13/97 — Date

Reviewer's certification expiration date: 2/19/98

Assistance provided by: None

Printed Name Scope of Assistance Date

Search Scope Review Acceptability (NA, if performed by Technical Review per 1000.006)

[signature] — Certified Reviewer's Signature

NED FINNEY — Printed Name

11-19-97 — Date

ENVIRONMENTAL IMPACT DETERMINATION (UNIT 1 and UNIT 2)

Document No. **1415.029** Rev./Change No. 1

Complete the following Determination. If the answer to any checklist item is "Yes", an Environmental Evaluation is required. See Section 6.1.4 for additional guidance.

Will the Activity being evaluated:

Yes	No	
☐	☑	Disturb land that is beyond that initially disturbed during construction (i.e., new construction of buildings, creation or removal of ponds, or other terrestrial impact)? See Unit 2 SAR Figure 2.5-17. This applies only to areas outside the protected area.
☐	☑	Increase thermal discharges to lake or atmosphere?
☐	☑	Increase concentration of chemicals to cooling lake or atmosphere through discharge canal or tower?
☐	☑	Increase quantity of chemicals to cooling lake or atmosphere through discharge canal or tower?
☐	☑	Modify the design or operation of cooling tower which will change drift characteristics?
☐	☑	Install any new transmission lines leading offsite?
☐	☑	Change the design or operation of the intake or discharge structures?
☐	☑	Discharges any chemicals new or different from that previously discharged?
☐	☑	Potentially cause a spill or unevaluated discharge which may effect neighboring soils, surface water or ground water?
☐	☑	Involve burying or placement of any solid wastes in the site area which may effect runoff, surface water or ground water?
☐	☑	Involve incineration or disposal of any potentially hazardous materials on the ANO site?
☐	☑	Result in a change to nonradiological effluents or licensed reactor power level?
☐	☑	Potentially change the type or increase the amount of non-radiological air emissions from the ANO site.

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1.0 PURPOSE AND SCOPE

1.1 The purpose of this procedure is to define the methods and requirements which govern manual ultrasonic sizing of discontinuities and defects in austenitic and ferritic steel piping and components utilizing pulse-echo, A-scan techniques. This procedure does not address the initial detection of flaws, which is governed by the applicable process procedures.

1.2 The objective of the procedure is to determine the through-wall depth of planar-type flaws using one or more sizing techniques. The sizing techniques must be performed from the outside surface or diameter of the pipe or component being examined.

1.3 It is recognized that of the sizing methods described in this procedure, no one technique is completely accurate in sizing all flaws at all depths. However, by using complementary methods a realistic approximation of flaw depth can be obtained. The extent to which complementary sizing techniques may be useful will depend on the physical conditions of the weldment, the crack structure, form and the time constraints imposed by radiation considerations. The following sizing techniques are described:

1.3.1 30-70-70 Mode-Conversion Technique

1.3.2 High-Angle Longitudinal-Wave Technique

1.3.3 Multipulse Observation Sizing Technique (MOST)

1.3.4 Flaw Tip Defraction Technique

A. Relative Arrival-Time Technique (RATT), formerly referred to as the Satellite Pulse Observation Technique (SPOT)

B. Absolute Arrival-Time Technique (AATT), formerly referred to as the Pulse Arrival Time Technique (PATT)

2.0 REFERENCES

2.1 EPRI UT Operator Training for Sizing Intergranular Stress Corrosion Cracking (IGSCC) Competency Area 911

2.2 Quality Procedure QCO-10, "Qualification, Certification and Training of NDE Personnel"

2.3 ASME Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components", 1980 Edition with the Winter 1981 Addenda and the 1986 Edition with no Addenda

2.4 ASME Section V, "Nondestructive Examination", 1980 Edition with the Winter 1981 Addenda and the 1986 Edition with no Addenda

2.5 ANO Operating Procedure 1415.015, "Ultrasonic Instrument Linearity Calibration Verification"

2.6 ANO Operating Procedure 1415.028, "Control of M&TE used for Nondestructive Examinations"

2.7 ANO Administrative Procedure 1000.020, "Consumable Chemical Material Control"

3.0 DEFINITIONS

3.1 Flaw Indication - Denotes the evidence or signal obtained by the application of a nondestructive examination that may reveal the presence of a flaw or surface degradation. Flaws include cracks, slag inclusions or segregates, aligned or clustered rounded indications, lack of weld fusion, and laminations or combinations thereof.

3.2 Functional Verification (FV) - Certification of the individual System Component. Certification of performance capabilities to a specified tolerance prior to assembly into a functioning examination system, e.g., transducer, wedge, A-scan ultrasonic flaw detection instrument.

3.3 Heat-Affected Zone (HAZ) - That portion of the base metal which has not been melted, but whose mechanical properties or microstructure have been altered by the heat of welding or cutting.

3.4 Inservice Inspection (ISI) - Examinations completed during each of the inspection intervals for the service lifetime of the power unit or component.

3.5 Intergranular Stress Corrosion Cracking (IGSCC) - A defect which occurs in Austenitic Materials and is generally located in the heat-affected zone of pipe welds. During the welding process (particularly welding repairs) heat causes sensitization of the material grains. When contaminants such as chloride, sulfur, etc., and stress are induced into the system, intergranular stress corrosion cracking may occur.

3.6 Preservice Inspection (PSI) - Examinations completed prior to plant commercial or component operating date.

3.7 System Calibration (SC) - The adjustment of a functioning examination system to a Basic Sizing Calibration Block as appropriate for the examination.

4.0 RESPONSIBILITY

4.1 DIRECTOR, QUALITY

The Director, Quality has overall responsibility for control of NDE activities that are accomplished under the direct supervision of the NDE Supervisor.

4.2 NDE SUPERVISOR

The NDE Supervisor is responsible for ensuring that examinations are performed in accordance with this procedure and that personnel performing the examinations are qualified in accordance with reference 2.2 and the requirements of paragraph 5.3.

5.0 DETAILS

5.1 TEST EQUIPMENT AND MATERIAL

5.1.1 Ultrasonic Instrument

A. A pulse-echo A-scan or digital thickness instrument may be used for wall thickness measurements in accordance with the applicable process procedures.

B. A pulse-echo ultrasonic flaw detection instrument shall be used for flaw sizing.

1. The instrument must be capable of transmitting and receiving ultrasonic energy in a frequency range of 1.0 to 5.0 megahertz (MHz).

2. The instrument shall meet the requirements of reference 2.5.

3. When using the multipulse observation sizing technique (MOST) method, it is desirable that the instrument be capable of radio-frequency (RF) signal display.

4. When a remote master/slave system is employed, the cathode ray tube (CRT) used as an aid for the scanner (slave unit) may be of any type that will produce a video display.

a) It should not contain any independent controls that could alter the performance parameters or calibration of the master instrument being monitored by the Level II or III Examiner.

b) If the ultrasonic instrument is capable of being used in master or slave modes the instrument in the slave position must be in slave mode and the calibration shall be done on the master instrument with the slave instrument attached.

5.1.2 Search Units

A. Search Units - the search unit used for each method requires careful consideration by the examiner performing the sizing and will depend on the structure and form of the flaw under investigation.

Normally the frequency will be between 1.0 and 5.0 MHz with a refracted angle of 45° to 60°, unless specified otherwise by a Level III in ultrasonics.

B. Prior to performing system calibration the exit point of the sound beam and the actual refracted beam angle of the search units in the material being examined (e.g., carbon or stainless steel) shall be determined. The IIW block or similar blocks may be used.

1. Determination of Beam Index Point

a) Position the angle-beam search unit on the block so that the beam is directed toward the radius surface.

b) Move the transducer parallel to the sides of the block until a maximum echo is obtained from the reflecting radius. The beam index point is now above the centerline of the radius, as scribed on the block.

c) Place a mark on the side of the wedge to identify the index point.

2. Determination of Refracted Angle

a) Position the angle-beam search unit on the block and obtain the peak amplitude signal from the reflector.

b) Read the refracted beam angle from the side of the block using the angle which corresponds with the beam index point.

c) Record the measured refracted angle.

3. Alternate methods for determination of refracted angle such as mathematical calculations in combination with distance measurements may be used.

5.1.3 Search Unit Cables

A. The search unit cables shall be coaxial, type RG-178 or RG-58, in good working condition.

B. The coaxial cable used for system calibration must be used for the examination, including any in-line connectors used.

5.1.4 Calibration Blocks

A. Calibration blocks made of the same or similar material with reflectors at appropriate depths may be used for calibration.

1. Blocks with notches of various depths (e.g., from 5% to 90% of block thickness) or holes may be used.

2. The ASME basic calibration block with the addition of appropriate notches may be used.

3. The block design, layout, and notch depths, will be approved by a level III in ultrasonics.

5.1.5 Reference Blocks

Reference blocks may be used to perform linearity verifications, establish sweep (metal path or depth), and determine the search unit beam exit point and refracted angle.

5.1.6 Thermometers

Thermometers used for measuring the temperature of calibration blocks and components shall be calibrated and certified annually in accordance with reference 2.6.

5.1.7 Materials

A. A suitable liquid, semi-liquid, or paste couplant such as Ultragel II, Sonotrace 40 or plant DI water shall be used.

1. Couplant containers (except Plant DI water) shall be affixed with the designation of "controlled materials" either my use of a pre-printed sticker or by marker and shall reflect the identity and applicable batch number of the contents.

2. Plant DI water containers shall be identified by marker or label.

B. All marking materials (white pencils or other surface markers) applied to components must be purchased per plant procedures.

C. All couplants, marking materials and other materials used shall be approved for use and meet the requirements of reference 2.7.

5.2 CALIBRATION

5.2.1 System Calibration

A. Complete ultrasonic examination system calibration in each thickness range examined shall be performed each day prior to use of the system.

B. Substitution of any of the following shall be cause for recalibration:

1. Search unit, wedge or transducer

2. Couplant

3. Ultrasonic instrument

4. Examination personnel

5. Cable type or length

6. Change in type of power source, e.g., a change from alternating to direct current.

5.2.2 System Check

A. A system check, which is the verification of the system calibration, shall be performed:

1. At the start and finish of each examination

2. With any substitution of the same type and length of cable

3. With any substitution utilizing the same type of power source, e.g., a change from one direct current to another direct current source

4. At intervals not to exceed 4 hours

5. Whenever the validity of the calibration is in doubt.

B. Perform the following corrective action if any point on the sweep has moved more than 0.050 inch of depth reading:

1. Void all depth measurements referring to the calibration in question and performed after the last valid calibration

2. Conduct a new calibration

3. Re-measure the flaw depth in the areas for which the depth measurements have been voided.

5.3 LIMITS AND PRECAUTIONS

5.3.1 Personnel performing ultrasonic examination by this procedure shall be qualified and certified in accordance with QCO-10 (reference 2.2), or to a program that meets the requirements of QCO-10 as a minimum.

A. Personnel shall be certified to at least Level I in ultrasonics with no restrictions.

B. Level I personnel may perform equipment setup, calibration, examination scanning, and data recording per this procedure, under the direction of a higher level individual. The Level I shall not independently evaluate or accept the results of an ultrasonic examination.

C. Only personnel certified Level II or III, with at least one of the following additional qualifications may evaluate the results of examinations to this procedure or perform actual flaw measurements:

1. Satisfactory completion of the Ultrasonic Testing Operator Training for Planar Flaw Sizing, competency Area 911, developed by the EPRI NDE Center is required along with successful completion of the sizing practical examination within the last three years.

2. Alternatively, satisfactory completion of the applicable ultrasonic flaw sizing qualification examination administered by the PDI (Performance Demonstration Initiative) is required within the last three years.

5.3.2 When a "Master/Slave" system is used, the Level II or III monitoring the master ultrasonic instrument shall meet the requirements of 5.3.1.C.

A. Personnel performing the ultrasonic scanning may be Level I as described in 5.3.1.A and shall be trained with a Level II or III prior to weld examinations.

B. The purpose of this training is to familiarize the Level I in following scanning and dimensioning instructions directed by a Level II or III to the satisfaction of the personnel responsible for evaluating the examination results.

5.3.3 Prerequisites

A. The temperature of the basic sizing calibration block must be within ± 25°F of the examination surface temperature.

B. The temperature of the component should remain between 32°F and 120°F for effective transducer function. Lower and higher temperatures may be examined with specialized transducers.

C. The examination surface must be free of irregularities, loose material, or coatings which interfere with ultrasonic wave transmission.

5.4 INSTRUCTIONS

5.4.1 General Requirements

A. Examinations to determine flaw size begin by reviewing the recorded indication data from the detection examinations. This recorded data will give the information used for calculating the flaw depth and length based on the detection procedure (dB drop) and locate the areas requiring flaw depth evaluation.

B. A pure dB drop technique must not be used by itself, to determine the flaw depth. One or more additional techniques must be chosen to confirm the flaw depth.

C. If the detection information is not useful, it may be necessary to re-examine the area of interest using the original equipment or using other search unit beam angles.

D. If during depth sizing, a flaw length other than that reported during the detection examination is measured, the new flaw length shall be reported.

5.4.2 Flaw-Tip Diffraction Method

A. The flaw-tip diffraction method takes advantage of an additional ultrasonic signal which is generated by the interaction of the ultrasonic beam with the flaw.

1. The use of this technique has quite a unique advantage in that the diffracted wave originates at the flaw tip. By observing the arrival time of this signal, it is possible to deduce the location of the flaw tip.

2. It is convenient to divide this method into the RATT and AATT techniques. Both are applicable to 1/2-Vee and full-Vee examinations.

B. Relative Arrival-Time Technique (RATT)

1. With this technique the flaw depth is derived from observing the time difference between the flaw corner echo and the diffracted tip echo (satellite pulse).

a) When using the 1/2-Vee RATT, the satellite pulse will occur earlier in time than the corner trap due to its shorter metal path.

b) It may also be possible to obtain a tip signal after reflection from the Inside Diameter (ID) of the pipe (full-Vee RATT). The principles are the same, except the tip will appear later in time than the corner signal instead of earlier.

2. Calibration

a) Select a calibration block with at least two notches of known depths, preferably 20% and 70% of the examination thickness.

b) Obtain the notch corner and tip signals from the shallow notch at the same time. Once both signals are present, keep the search unit stationary.

c) Using the sweep and delay controls, adjust the distance between the two signals to read the notch depth, in inches.

d) Perform the same calibration for the deep notch. Alternate this procedure between the two notches until the screen represents linear sweep distance.

3. Sizing

a) Once the specific area containing the flaw is identified, position the search unit to obtain a signal from the flaw base (corner trap).

b) Manipulate the search unit until the doublet, flaw base and tip signals are observed. The doublet separation indicates the flaw depth from the ID.

C. Absolute Arrival-Time Technique (AATT)

1. The AATT technique takes advantage of uniquely locating the flaw tip. This is done by peaking the reflection from the flaw tip and noting its arrival time, which is a measure of the distance from the tip to the OD examination surface.

2. Calibration

a) Select a calibration block with at least two notches of known depths, preferably 20% and 70% of the examination thickness.

b) Alternately peak the notch tip signals from a shallow (20%) and a deep (70%) notch. Using the sweep and delay controls, adjust these responses to read linear distance, in inches.

3. Sizing

a) Once the specific area containing the flaw is identified, position the search unit to obtain a signal from the flaw base (corner trap).

b) Move the search unit forward to obtain a, signal from the diffracted wave at the flaw tip. Peak this signal and note the distance to the flaw tip. This distance indicates the amount of material above the flaw.

c) Flaw depth is then determined by subtracting this dimension from the material thickness.

D. Full-V Corner Reflection Technique

1. For very deep cracks extending near the outer surface, a corner reflection at the Full-V-Path position might be obtained similar to that at the Half-V-Path position. A part of the ultrasonic beam is reflected at the crack face and is reflected via the outside surface back to the search unit.

2. Calibration

a) Calibration must be performed using a reference calibration block to establish the horizontal sweep linearity.

b) The screen distance chosen must be the shortest applicable size to include at least 1/8 V-Path beyond Full-V for the material containing the flaw to be sized.

c) Observing echoes from the applicable reference block, adjust the range and delay controls to obtain the required linear sound path distance displayed along the screen baseline.

3. Sizing

a) Position the search unit to obtain a signal from the flaw base at 1/2 - VEE Path.

b) Move the search unit back to obtain a corner reflector from the top of the flaw.

c) Manipulate the search unit back and forth, looking for a doublet. If the doublet is observed, peak the first pulse.

d) Measure the difference between the two peaks, per the calibration. The separation reveals the amount of material above the flaw tip. The flaw depth is then determined by subtracting the separation in inches from the local material thickness.

5.4.3 High-Angle Longitudinal Wave Technique (HAL)

A. The high-angle longitudinal wave tip diffraction method is a sizing technique that is useful only for deep flaws (approximately .4 inches maximum below the examination surface).

1. Ultrasonic longitudinal waves refracted at a high angle are used to detect either diffracted or reflected waves from the deepest extremities of the flaw.

a) The pulse transit time indicates the depth of the flaw measured from the examination surface.

b) This dimension is then subtracted from the local thickness of the pipe to determine the depth of the flaw.

B. Calibration

1. A calibration block similar to the illustration shown in Figure 1 may be used for calibration. Other block configurations may also be used.

2. The search unit generates a refracted longitudinal wave at about 85° in the examination medium. The operating frequency must be 2.0 to 4.0 Mhz.

3. Position the search unit on the calibration block and maximize the response from the reflector that is 20% below the scanning surface. Using the sweep and delay control, position the peak of this signal at the fourth major division on the CRT.

4. Position the search unit to maximize the response from the reflector that is 40% below the scanning surface. Position the peak of this signal at the eighth major division.

5. Alternate between the two reflectors until a linear sweep is obtained. The screen is now calibrated so that two (2) major divisions represent 10% of material beneath the examination surface.

6. For thick materials, the CRT screen may be set up for 1" instead of 1/2" as directed in steps 1 through 5 above by setting the 20% at the second major division and the 40% at the fourth major division.

C. Sizing

1. Position the search unit on an unflawed area of the weld to be examined. Scan the area in back-and-forth movements observing the noise level in the calibrated region of the CRT.

   Adjust the gain so that noise level is about 10% full screen height (FSH). This is the scanning gain level.

2. Position the search unit on the part in the region of the flaw.

   a) Manipulate the search unit to locate the flaw.

   b) When the flaw is located, maximize the response and read the depth below the examination surface at the peak of the signal.

   c) Subtract this dimension from the local wall thickness to determine the flaw depth.

5.4.4 Multipulse Observation Sizing Technique (MOST)

A. Multipulse Observation Sizing Technique is a flaw sizing method which combines both of the tip diffraction techniques (RATT & AATT) into a single system.

1. This technique is made possible with the use of uniquely designed search unit modules such as the SLIC-40 or ADEPT-60.

   a) The transducer is a dual-element search unit comprised of two transducer elements mounted in tandem in an enclosed case.

   b) The rear element transmits a high-angle longitudinal wave (70°) which inherently results in a low-angle shear wave (35°) being generated.

   c) The front element of the module is mounted to receive signals of about 50°.

   d) The premise is to process sound through the entire pipe wall and receive signals from the flaw tip as well as the flaw base.

2. The MOST method uses basically the same principles as the flaw-tip diffraction technique. The main difference being the Bimodal module utilizes a separate element to receive the returned signal(s).

3. Three associated pulses that move together on the CRT screen (i.e., a triplet) can be expected when the module is scanned over an inside surface connected flaw.

   a) The first pulse (pulse 1) originates from the flaw tip.

   b) The next pulse (pulse 2) is a longitudinal wave from the flaw base which is a result of mode conversion from the shear wave.

   c) The reflection of the mode-converted shear wave at the flaw base gives rise to the third pulse (pulse 3).

4. Pulse 1, which is a satellite pulse equivalent to the AATT described in 5.4.2.C, is designated Absolute Time.

5. The doublet separation of pulses 1 & 2, which is equivalent to the RATT described in 5.4.2.B, is designated Relative Time.

B. Calibration

1. Connect the Bimodal module to a high resolution ultrasonic instrument operating in the pitch-catch mode.

2. Using the calibration block shown in Figure 1 or another suitable block configuration,

   a) Position the search unit near the end of the calibration block and peak the edge diffracted signal.

   b) Adjust the delay control to position the signal at origin of the time base (5th major division).

3. With the Bimodal module coupled to the calibration block, call the last pulse in the initial pulse standing near the 0 major division mark "Pulse 0".

4. Peak the satellite pulse from the diffracting edge of the fourth step 80% from the top of the calibration block (Figure 1).

   Position the signal at the fourth major division on the CRT. This pulse is called the CALIBRATION SIGNAL.

5. Verify that the satellite pulses from the first, second, and third steps occur at the first, second, and third major divisions, respectively. Make fine adjustments for a linear sweep display.

6. Assign 100% of crack depth to the origin of the time base and 0% of crack depth to the fifth major division mark.

7. The instrument is now calibrated to read percent through-wall height of an inside surface flaw.

8. Adjust the dials (Range, Sweep, and Delay) such that the CALIBRATION SIGNAL peaks at 0% (5th major division) with "Pulse 0" still at 100%. The instrument is now calibrated for .8T thick part.

9. Enter the dial settings on the Calibration Data Sheet (Figure 4) across from Pipe Thickness = .8T inch.

10. Adjust the dials such that the CALIBRATION SIGNAL appears at 100% (10th division) and Pulse 0 still stands at 100%. The instrument is now calibrated for .4T thick pipe. Enter the dial settings on the Calibration Data Sheet across from Pipe Thickness = .4T"

11. Adjust the dials such that the CALIBRATION SIGNAL appears at 50% (2.5 major divisions) while Pulse 0 is still at 100%. The instrument is now calibrated for 1.6T" thick pipe. Enter the dials setting on the Calibration Data Sheet (Figure 4) across from Pipe Thickness = 1.6T in.

12. Continue with the determination of the dial settings for other pipe wall thickness' as shown in Figure 4.

13. Calibrate the instrument for the thickness to be examined using the appropriate calibration block. Plot the variation of doublet separation relative time between pulses 1 and 2 in major screen divisions against the 20% and 70% notch depths in the manner shown in Figure 5.

C. Sizing

1. Connect the Bimodal module to a High Resolution instrument operating in the pitch-catch mode.

2. Calibrate the instrument for the appropriate pipe wall thickness using the Calibration Data Sheet. Check the calibration by observing 0 at T=0 from the edge of the block and a tip diffracted signal from the stepped calibration block (Figure 1).

3. Process sound through a weld volume void of flaws from both sides of the weld and observe the irrelevant indications, both standing and moving, to the left of midscreen.

4. Adjust the instrument gain such that the average background level is about 10 percent of FSH. This gain setting is the scanning sensitivity.

5. Mark on the CRT screen, the amplitude of the peaked satellite pulse from the 20% deep notch in the most appropriate reference block. Refer to 5.4.4.B.(13). This pulse is the "small reference signal". The amplitude of the peaked satellite pulse from a small un-oriented crack (i.e., a crack grown perpendicularly to the inside surface) should be less than that of the small reference signal.

6. Mark on the CRT screen, the amplitude of the peaked satellite pulse from the 50% deep notch in the most appropriate reference block. Refer to 5.4.4.B.(13). This pulse is the "large reference signal". The amplitude of the peaked satellite pulse from a large un-oriented crack should be less than that of the large reference signal.

7. Return to the pipe and scan from the pipe side with broad back-and-forth movements over the area where the flaw has been found.

   Look for pulses 2 & 3 to the left of midscreen. If the flaw is un-oriented, only two pulses separated by about 2.2 major screen divisions and peaking between major divisions 5 and 7 (i.e., near midscreen) should be observed. The longer the pulse train, the deeper the flaw.

8. Scan the area from the weld side (when practical) with broad back-and-forth movements and again look for pulses only to the right of midscreen.

   If the pulse patterns are essentially the same, when the flaw is viewed from the two sides, then it is likely that the flaw has grown perpendicular to the inside surface (i.e., the flaw is un-oriented).

9. Next, look for pulse 1 to the left of midscreen from both sides of the weld.

   a) If the amplitude from the satellite pulses observed from the two sides are comparable and smaller than that of the appropriate reference signal, then it is still likely that the flaw is un-oriented.

   b) The separation Relative Time measured between pulses 1 and 2 anywhere along the pipe from both sides of the weld yield the first two estimates of flaw depth according to the curve in Figure 5.

   c) The more extensive the flaw, the greater the distance between the pulses.

10. Weld crown permitting, move the Bimodal module toward the weld from the pipe side far enough to maximize the satellite pulse.

    The delay time between the peaked pulse 1 and the midscreen mark yields a third estimate to depth directly on the screen in percent of local wall thickness.

11. If possible, repeat the Absolute-Time measurement from the weld side to verify that the satellite pulse peaks at the same screen distance when the flaw is viewed from different directions and the measurements are equally hard from the two sides. These are still signs of an un-oriented flaw.

12. Follow the peaked satellite pulse along the length of the flaw and note the maximum depth based on both Absolute-Time and Relative-Time measurements.

13. Compare the depth estimates based on Absolute-Time and Relative-Time measurements for consistency.

    If the two sets of estimates are comparable, report the average of the larger set.

14. Repeat the Absolute-Time and Relative-Time measurements. If the average of the two sets of depth estimates are significantly different, determine which pulses may have been incorrect.

    Pulse patterns associated with reference notches of comparable depths may help in the decision process (e.g., observing where pulse 2 peaks relative to the satellite pulse and comparing the amplitude of pulse 2 to that of pulse 3 for small, medium, and large notches).

5.4.6 30-70-70 Mode-Conversion Technique

A. Introduction

1. The 30-70-70 mode-conversion technique provides a qualitative measurement of the through-wall height of flaws. By observing the presence and echo-dynamic behavior of each of the three obtainable signals, it is possible to categorize flaws as shallow, midwall, or deep.

2. Either single-element or dual-element search units may be used provided it is designed to generate a 70° refracted-longitudinal wave (L-wave) in the part under examination.

   a) Typically, a WSY-70 search unit is used for this technique.

b) The single-element WSY-70 search unit transmits a 70° high-angle L-wave which inherently generates a 35° direct shear wave and a 31.5° indirect shear wave.

3. When the search unit approaches an inside-surface-connected reflector, three different echoes will occur in sequence.

a) If the crack extends to within approximately .375 inch of the outside surface, the direct L-wave will reflect from the upper extremes of the crack face.

b) If the crack exceeds 10% to 15% of the wall thickness, an indication from the mode-converted direct shear wave will occur. This indication will be the second indication from "0" time base and referred to as Collateral Echo 1 (CE1).

c) The third indication, referred to as CE2, results from the Inside-Surface (ID) creeping wave. The ID creeping wave results from mode conversion of the indirect shear wave at the ID surface.

B. Calibration

1. Connect a 70°-refracted L-wave search unit to the ultrasonic test instrument.

2. Adjust the delay control to display the initial pulse at the left side of the screen.

3. Place the search unit on an unflawed section of the calibration block.

4. Set instrument gain so noise level is about 10% FSH.

NOTE

Calibration for this sizing technique requires special calibration blocks. The block must have a set of planar reflectors located at various depths from the examination surface. The typical design is a flat plat or pipe section the same thickness as the component with inside-surface notches in increments of 0.1 inches in depth, ranging from 10% to 90% of block thickness.

5. Obtain the mode-converted signal and inside-surface creeping-wave signal from the end of the block.

6. Adjust delay and range controls to place the initial pulse at "0" horizontal divisions and the ID creeping wave signal and mode-converted signal on the right side of the screen.

7. Scan the search unit over various height notches and observe the echo dynamic signal patterns generated from the different notches.

C. Sizing

1. Scan the flawed area and observe the signals obtained.

2. Scan an unflawed area of the component to verify signals are flaw-related.

3. Once the reflector location has been interrogated to confirm the observed signals are flaw-related, the following process should be utilized:

a) If only the inside-surface creeping-wave (CE2) signal is observed, suspect a shallow flaw and use the flaw-tip diffraction method to size.

b) If the inside-surface creeping-wave (CE2) and the mode-converted direct shear wave (CE1) signal is observed, suspect a shallow to midwall flaw and use in the MOST method to size.

c) If the 70°-direct L-wave signal along with CE2 and CE1 are observed, suspect a deep flaw and use the high-angle L-wave method to size.

5.5 ACCEPTANCE CRITERIA

5.5.1 All observed or calculated dimensional values of component thickness and of detected indications used for comparison with acceptance standards for flaw indications shall be expressed to the nearest 0.1 inch for values 1 inch and greater. For values less than 1 inch, round off to the nearest 0.05 inch. Rounding off shall be per the following:

A. When rounding off a digit to the nearest tenth, choose that which is nearest to the tenth. If two choices are possible, as when the digits dropped are exactly a 5 or a 5 followed only by zeros, choose the one ending in an even digit.

B. When rounding off a number to the nearest twentieth, double the observed calculated value and round off as in item A above, then divide by two.

5.5.2 Evaluation of Indications

All indications shall be reported on a Crack Sizing Data Sheet (Figure 6) or a similar form and evaluated by a Level III and/or Engineering Programs-ISI.

5.6 RECORDS

5.6.1. The system calibration and examination data shall be recorded on an Ultrasonic Calibration Sheet-Sizing or a similar form (Figures 4 and 5).

5.6.2 Reports of flaw depth measurements shall be recorded on a Crack Sizing Data Sheet (Figure 6) or a similar form.

6.0 ATTACHMENTS

6.1 FIGURE 1 PLANAR FLAW SIZING CALIBRATION BLOCK

6.2 FIGURE 2 FLOW CHART FOR CLASSIFICATION AND SIZING

6.3 FIGURE 3 GUIDANCE FOR FLAW CLASSIFICATION AND SIZING

6.4 FIGURE 4 ULTRASONIC CALIBRATION DATA SHEET-SIZING

6.5 FIGURE 5 ULTRASONIC CALIBRATION DATA SHEET-SIZING

6.6 FIGURE 6 ULTRASONIC CRACK SIZING DATA SHEET

FIGURE 1
PLANAR FLAW SIZING CALIBRATION BLOCK

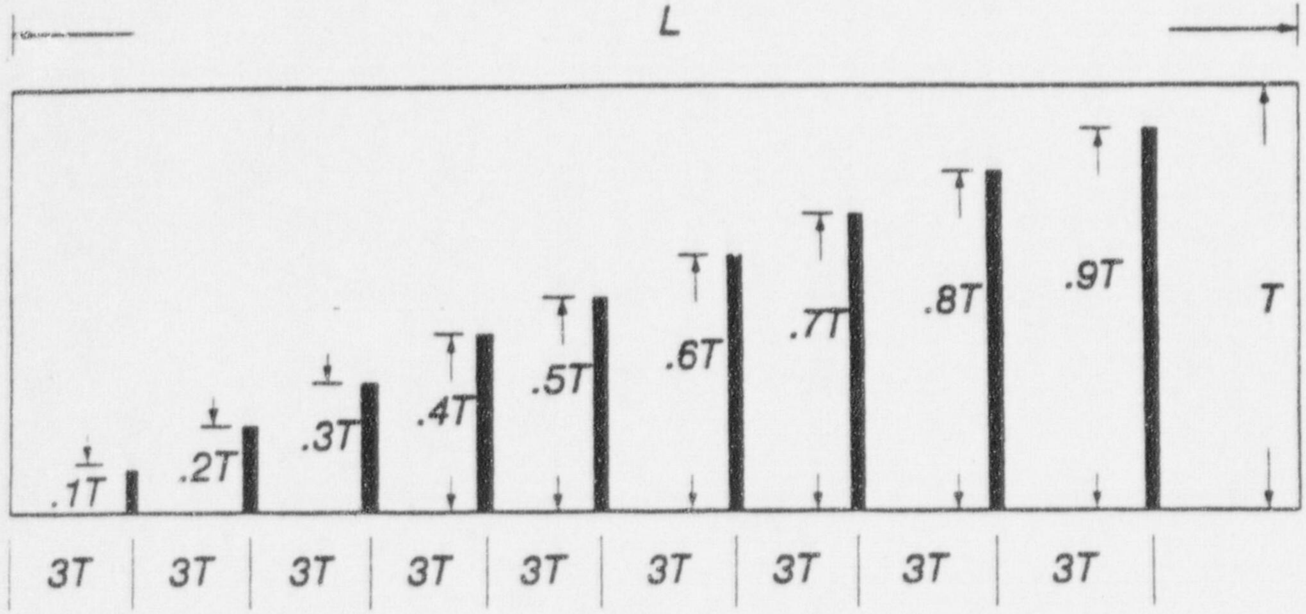


FIGURE 2
FLOW CHART FOR CLASSIFICATION AND SIZING

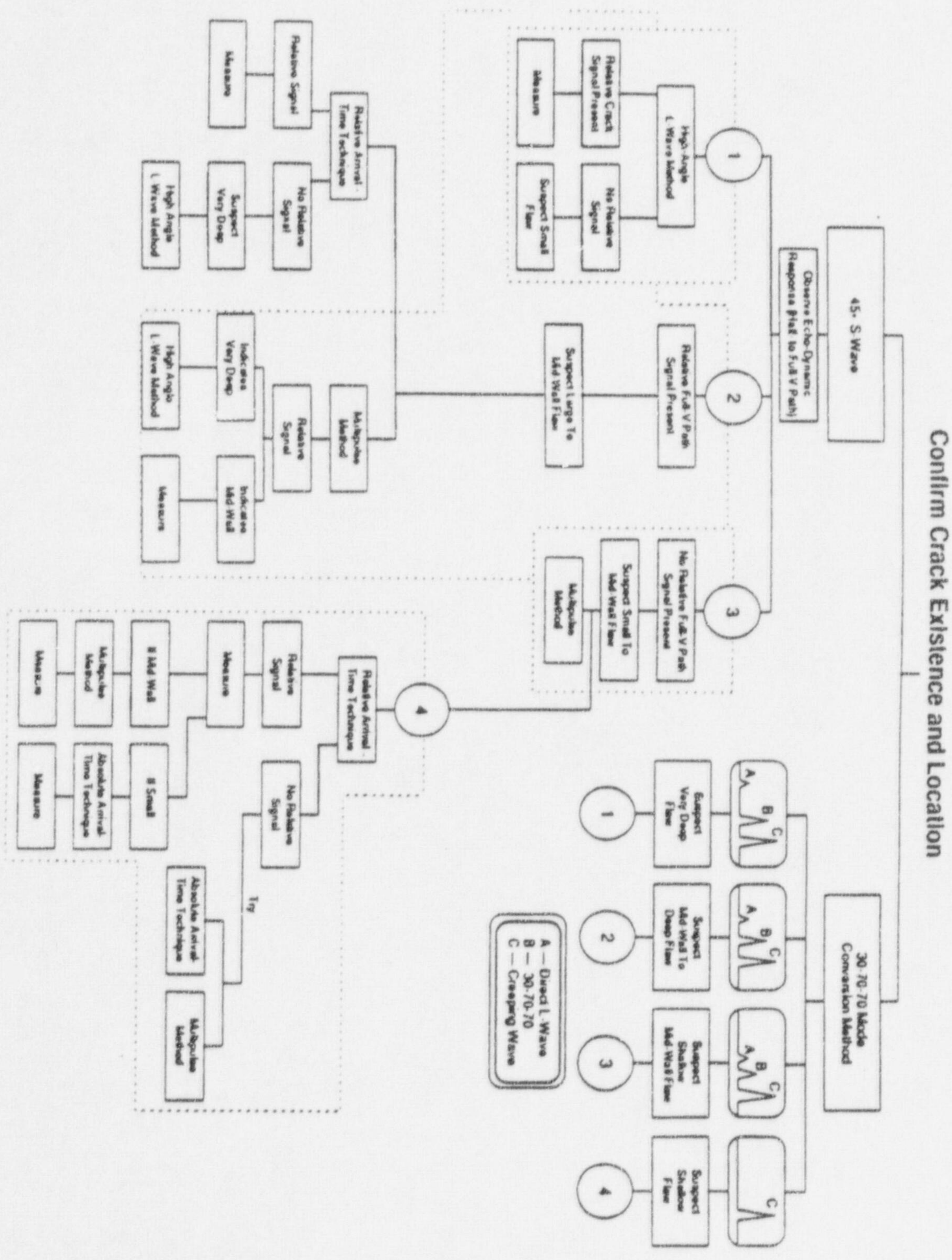


FIGURE 3
GUIDANCE FOR FLAW CLASSIFICATION AND SIZING

1. Verify location and extent of flaw.

2. Search for evidence of a very deep flaw:

   (a) High-angle longitudinal wave.

   (b) Full-V Path corner reflection.

   (c) Tip Diffraction.

3. Search for evidence of a shallow flaw:

   (a) Tip Diffraction.

   (b) Multi-wave mode methods.

4. If evidence of a shallow flaw exist:

   (a) Confirm with a complementary technique.

   (b) Prove that a deep flaw does not exist.

5. Confirmation might also be achieved by different angle of incidence or by the opposite direction of incidence.

6. If two or more techniques give differing results:

   (a) Eliminate those results with lowest confidence based on range of applicability or repeatability of results.

   (b) In case of doubt, take value with greater depth.

CAUTION:
Be aware of possible indications from weld fabrication flaws.

FIGURE 4
ULTRASONIC CALIBRATION DATA SHEET-SIZING

ARKANSAS NUCLEAR ONE

ULTRASONIC CALIBRATION DATA SHEET - SIZING

NDE REPORT NO.

DATE

[illegible]

PROCEDURE NO. / REV.

INSTRUMENT

MANUFACTURER: ____________

MODEL NO: ____________

SERIAL NO: ____________

TRANSDUCER

MANUFACTURER: ____________

SERIAL NO: ____________

SIZE: ________ FREQ: ________

MEASURED ANGLE: ________

CALIBRATION BLOCK

ID OR SN #: ____________

THICKNESS: ____________

TEMP: ____________ °F

PTC THER. NO.: ____________

CAL. DUE DATE: ____________

COUPLANT

TYPE: ☐ SONOTRACE 40 ☐ OTHER ________

BATCH NO.: ____________

CABLE

LENGTH: ☐ 6' ☐ 12' ☐ ________

TYPE: ☐ 174U ☐ 58U ☐ ________

WAVE MODE: ☐ LONGITUDINAL ☐ SHEAR

PIPE THICKNESS	PULSE 1 SETTING (%)	RANGE	SWEEP	DELAY
.40	-100			
.45	-78			
.50	-60			
.55	-45			
.60	-33			
.65	-23			
.70	-14			
.75	-7			
.80	0			
.85	6			
.90	11			
.95	16			
1.00	20			
1.05	24			
1.10	27			
1.15	30			
1.20	33			
1.25	36			
1.30	39			
1.35	41			
1.40	43			
1.45	45			
1.50	47			
1.55	48			
1.60	50			

DATA SHEETS:

EXAMINER: ____________ FINAL REVIEW: ____________

LEVEL: ________ DATE: ________ DATE: ____________

FIGURE 5
ULTRASONIC CALIBRATION DATA SHEET-SIZING

ARKANSAS NUCLEAR ONE
ULTRASONIC CALIBRATION DATA SHEET - SIZING

NDE REPORT NO.:

DATE

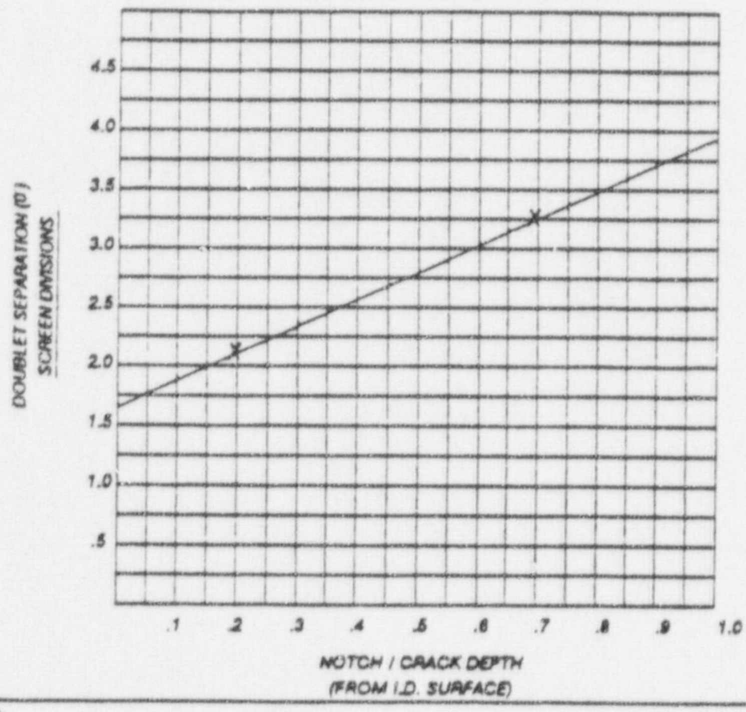
RELATED DOC. NO.

PROCEDURE NO.: / REV.

INSTRUMENT	TRANSDUCER	CALIBRATION BLOCK
MANUFACTURER: ____	MANUFACTURER: ____	ID OR SN #: ____
MODEL NO: ____	SERIAL NO: ____	THICKNESS: ____
SERIAL NO: ____	SIZE: ____ FREQ: ____	TEMP: ____ °F
	MEASURED ANGLE: ____	PTC THER. S/N: ____
COUPLANT	**CABLE**	CAL. DUE DATE: ____
TYPE: ☐ SONOTRACE 40 ☐ OTHER ____	LENGTH: ☐ 6' ☐ 12' ☐ ____	WAVE MODE: ☐ LONGITUDINAL
BATCH NO.: ____	TYPE: ☐ 174U ☐ 58U ☐ ____	☐ SHEAR

CALIBRATION BLOCK T = ____

NOTCH DEPTH	SCREEN DIVISIONS
20% = ____	____
70% = ____	____



DATA SHEETS:

EXAMINER: ____	FINAL REVIEW: ____
LEVEL ____ DATE: ____	DATE: ____

FIGURE 6
ULTRASONIC CRACK SIZING DATA SHEET

ARKANSAS NUCLEAR ONE
CRACK SIZING DATA SHEET

WORK AUTHORIZATION	[illegible]	NDE REPORT NO.
OTHER TRACE DOC.	WELD / ITEM NO.	DATE
CODE CAT.	PROCEDURE NO. REV.	CRACK DETECTION REPORT NO.

UT - INSTRUMENT: ______	UT - INSTRUMENT: ______	UT - INSTRUMENT: ______
MAKE: ______	MAKE: ______	MAKE: ______
MODEL: ______	MODEL: ______	MODEL: ______
SERIAL NUMBER: ______	SERIAL NUMBER: ______	SERIAL NUMBER: ______

SEARCH UNITS	A	B	C	D	E	F	G
MAKE/MODEL							
SERIAL NUMBER							
CONTACT SURFACE SIZE							
CURVATURE							
FREQUENCY							
WAVE MODE							
ELEMENT SIZE(S)							
SINGLE/DUAL							
NOMINAL ANGLE							
ROOF ANGLE							
FOCUS POINT							
FOCUS RANGE							
INSTRUMENT NUMBER							

DAC-Curves, other search unit characterization curves, special calibration curves and sketches of calibration blocks used shall be added to this report.

SIZING RESULTS USING EACH METHOD						
METHOD DESCRIPTION	SEARCH UNIT	HALF-V	FULL-V	THROUGH BASE METAL	THROUGH WELD METAL	CRACK DEPTH

ULTRASONIC WALL THICKNESS MEASUREMENT: ______ ANALYZED CRACK DEPTH: ______

COMMENTS ON FINAL RESULT: ______

SIZING PERFORMED BY: ______	RECORDED BY: ______	FINAL REVIEW: ______
LEVEL: ______ DATE: ______	LEVEL: ______ DATE: ______	DATE: ______

PAGE ____ OF ____

004(D)

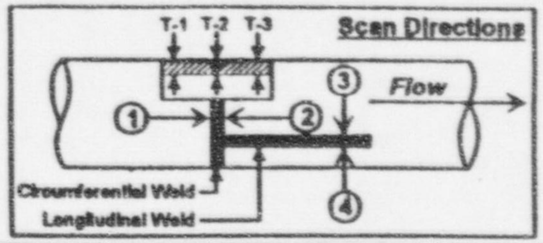
CONSUMERS ENERGY
NONDESTRUCTIVE TESTING SERVICES
Ultrasonic Examination Report

Examiner Richard Humphrey Level III Date 11-19-97 Sheet No. RAH-01
Examiner N/A Level N/A NDT Company Consumers Energy
Project No. 249715225005 Requesting Dept DES
Job Location Palisades Nuclear Plant Total Hours Worked N/A

NDT Procedure NDT-UT-26 Rev 3
For Guidance

Interpretation Requirements:
Code N/A Year N/A Section N/A Part N/A
Other Reference Examination Performed for Plant information
Material Type Carbon Steel Joint Design Single Groove
Nominal Diameter 62.5" Nominal Thickness Lid 3.0" Shell 1.0"
Weld Type Shell To Structural Lid
System Name DES Line No. MSB Mock-UP

Weld Crown: A. Height .062" B. Width 1.5"
Thickness at: T-1 Shell 1.0" T-2 Weld ℄ .75" T-3 Lid 3.0"



Scan Start Hour 11:24
Scan End Hour 12:06

Scan Directions	Scan #	Exam #	Performed	Reference Sensitivity	Scan Sensitivity
0° Base Metal	N/A	1	No	N/A	N/A
Perpendicular to Weld	2	2	yes	40	50
Perpendicular to Weld	N/A	3	No	N/A	N/A
Parallel to Weld	N/A	4	No	N/A	N/A
Parallel to Weld	N/A	5	No	N/A	N/A
0° WRV	N/A	6	No	N/A	N/A

System Calibration Sheet Number RAH-01
Percentage of Volume Scanned 50 %

Scanning Surface ✓ OD N/A ID Surface Condition Clean L_o Rule No. A WO/MO N/A

Item ID Number	Indication Number	Exam Number	% of DAC	L1	L2	Metal Path	Surface Dist.	Indication Depth	Indication Height	Indication Location	Search Unit Angle	Evaluation Acceptable
MSB Mock	1	2	127%	4.7"	12.5"	1.458"	1.5"	.960"	.151"	Shell	45°	N/A
UP	2	2	125%	69"	71"	1.509"	1.2"	.924"	.189"	Shell	45°	N/A
↓	3	2	126%	118.7"	119.3"	1.66"	1.3"	.826"	.138"	Shell	45°	N/A
	4	2	126%	141.5"	142.6"	1.622"	1.3"	.853"	.114"	Shell	45°	N/A
	5	2	127%	186"	189.8"	1.509"	1.6"	.933"	.189"	Shell	45°	N/A

Examiner Richard Humphrey Page 1 of 1 Reviewed By Richard Humphrey Level III Date 11-19-97 Rev 1/97

Channel 1 UT Settings

Channel On:	Yes		Gain:	50.0	dB
Acq. Type:	RF		Voltage:	250	Volts
A/D Rate:	10	Msps	Width:	220	nsec
A-Delay:	8.25	usec	Pulser Type:	Sq. Wave	
A-Width:	67.40	usec	Damping:	50	Ohms
LP Filter:	OFF	MHz	HP Filter:	0.5	MHz
Video Mode:	Full		Video Filter:	2	
Reject:	OFF		Reject Value:	0.0	

	Gate 1	Gate 2	Gate 3	Gate 4	
Gate On:	Yes	Yes	No	No	
C-Delay:	13.74	15.00	15.00	20.00	usec
C-Width:	60.48	10.00	5.00	5.00	usec
Threshold:	0.0	15.0	15.0	15.0	%FSH
C-Scan Type:	Peak	TOF	Peak	Peak	
Min:	13.74	15.00	15.00	20.00	usec
Max:	74.22	25.00	20.00	25.00	usec
Peak Mode:	Max	Max	Max	Max	

Channel 2 UT Settings

Channel On:	Yes		Gain:	40.0	dB
Acq. Type:	Peak		Voltage:	250	Volts
A/D Rate:	25	Msps	Width:	100	nsec
A-Delay:	0.00	usec	Pulser Type:	Sq. Wave	
A-Width:	70.00	usec	Damping:	50	Ohms
LP Filter:	OFF	MHz	HP Filter:	0.5	MHz
Video Mode:	Off		Video Filter:	2	
Reject:	OFF		Reject Value:	0.0	

	Gate 1	Gate 2	Gate 3	Gate 4	
Gate On:	Yes	Yes	No	No	
C-Delay:	12.00	14.99	10.00	10.00	usec
C-Width:	3.00	0.01	5.00	5.00	usec
Threshold:	15.0	20	6.0	20	%FSH
C-Scan Type:	Peak	Peak	Peak	Peak	
Min:	12.00	14.99	10.00	10.00	usec
Max:	15.00	15.00	15.00	15.00	usec
Peak Mode:	Max	Max	Max	Max	

***** Channel 3 OFF *****

***** Channel 4 OFF *****

General Information

Exam Date:	11/18/97
Exam Time:	11:24
Exam End Time:	12:06
Test Site:	Palisades
Organization:	Consumers Energy
Operator:	Brian Lenius
Procedure:	NDT-UT-26 Rev.3 Guidance Only
Colormap Name:	BluGrnYel

Equipment Serial Numbers

I/UX Workstation:	HP 712/60	DAS System:	TDAS
UT System:	UTS-002	Scanner:	5010 S/N 0237

Software Revisions

I/UX Version:	I/UX Version 2.9
DAS Version:	DAS 2.9 for ET and UT

Test Information

Component Desc:	MSB Mock-Up
Part Number:	N/a
Serial No.:	N/a
Zone/Location:	N/A
Material:	Steel
Material Thickness:	1.000 in
Temperature:	40

Calibration / Reference Information

Cal/Ref Desc:	
Cal/Ref Part No.:	
Cal/Ref Serial No.:	
Cal/Ref Material:	
Cal/Ref Thickness:	1.000 in
Cal/Ref Temp.:	40

Transducer Characteristics

	Channel 1	Channel 2	Channel 3	Channel 4	
Index Axis Offset:	0.00	0.00	** OFF **	** OFF **	
Mode:	Shear	Longitudinal			
Connection:	Single	Single			
Insp. Angle:	45.00	0.00			deg
Material Vel.:	126.00	5.80			mils/usec
Wedge Delay:	8.50	6.80			usec
Transducer Freq.:	2.25	5.00			MHz
Skew Angle:	0.00	0.00			deg
Scan Axis Offset:	0.00	0.00			
TX Manufacturer:	Megasonics	ABB AMDATA			
TX Model No.:	MST	0			
TX Serial No.:	C1266	0			
RX Manufacturer:	ABB AMDATA	ABB AMDATA			
RX Model No.:	0	0			
RX Serial No.:	0	0			

AMBIENT - AFTER PAINT

FLAW COMPARISON TABLE

UT Sizing

Flaw 1
Length .50"
Depth .05"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.4"				.11"				
X										
10°	↓	NOT DETECTED								
X										
45°		NOT DETECTED								
X										

Flaw 2
Length .50"
Depth .075"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.45"				.07"				
X										
10°	↓	NOT DETECTED								
X										
45°		NOT DETECTED								
X										

Flaw 3
Length .750"
Depth .100"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.8"				.2"				
X										
10°	↓	NOT DETECTED								
X										
45°		NOT DETECTED								
X										

Flaw 4
Length .500"
Depth .150"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.6"				.19"				
X										
10°	↓	NOT DETECTED								
X										
45°		NOT DETECTED								
X										

Flaw 5
Length .500"
Depth .200"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.5"				.19"				
X										
10°	↓	NOT DETECTED								
X										
45°		NOT DETECTED								
X										

6/15

FLAW COMPARISON TABLE

UT Sizing

Flaw 6
Length 1.50"
Depth .25"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		1.6"				.225"				
10°	↑	NOT DETECTED								
10°	↓	NOT DETECTED								
X										
45°										
X										

Flaw 7
Length .50"
Depth .10"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.52"				.11"				
10°	↑	NOT DETECTED								
X										
X										
45°										
X										

Flaw 8
Length .50"
Depth .05"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.65"				.19"				
10°	↑	NOT DETECTED								
10°	↓	.50"				.08"				
X										
45°		.65"				.14"				
X										

Flaw 9
Length .500"
Depth .075"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.3"				.11"				
X										
10°	↓	.6"				.15"				
X										
45°		.74"				.1"				
X										

Flaw 10
Length .750"
Depth .10"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.63"				.11"				
X										
X										
X										
45°		.6"				.13"				
X										

FLAW COMPARISON TABLE

UT Sizing

Flaw 11
Length .50"
Depth .150"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.60"				.15"				
10°	↑	.45"				.15"				
X										
X										
45°		.7"				.17"				
X										

Flaw 12
Length .50"
Depth .20"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.96"				.11"				
10°	↑	.90"				.10"				
X										
X										
45°		.7"				.20"				
X										

Flaw 13
Length 1.50"
Depth .250"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		1.5"				.27"				
X										
10°	↓	1.5"				.23"				
X										
45°		1.75"				.10"				
X										

Flaw 14
Length .50"
Depth .050"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.6"				.11"				
10°	↓	.75"				.22"				
X										
X										
45°		.5"				—				
X										

Flaw 15
Length .50"
Depth .075"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.8"				.15"				
10°	↓	.75"				.25"				
X										
X										
45°		NOT DETECTED								
X										

FLAW COMPARISON TABLE

UT Sizing

Flaw	16
Length	.750"
Depth	.10"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.6"				.19"				
10°	↑	.4"				.25"				
~~X~~										
~~X~~										
45°		NOT DETECTED								
~~X~~										

Flaw	17
Length	.50"
Depth	.150"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.5"				.1"				
10°	↑	.8"				.30"				
~~X~~										
~~X~~										
45°		NOT DETECTED								
~~X~~										

Flaw	18
Length	.50"
Depth	.20"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.9"				.15"				
10°	↑	.6"				.25"				
~~X~~										
~~X~~										
45°		NOT DETECTED								
~~X~~										

Flaw	19
Length	1.50"
Depth	.250"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		1.9"				.23"				
10°	↑	2.4"				.15"				
~~X~~										
~~X~~										
45°		NOT DETECTED								
~~X~~										

Flaw	20
Length	.50"
Depth	.05"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.7"				<.1"				
~~X~~										
10°	↓									
~~X~~										
45°		.6"				.17"				
~~X~~										

FLAW COMPARISON TABLE

UT Sizing

Flaw	21
Length	.50"
Depth	.075"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.7"				<.1"				
X										
10°	↓									
X										
45°		.7"				.17"				
X										

Flaw	22
Length	.750"
Depth	.10"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.9"				.07"				
X										
10°	↓									
X										
45°		1.0"				.25"				
X										

Flaw	23
Length	.50"
Depth	.150"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.9"				.12"				
X										
10°	↓									
X										
45°		.7"				.3"				
X										

Flaw	24
Length	.50"
Depth	.20"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.7"				.18"				
X										
10°	↓									
X										
45°		.6"				.26"				
X										

Flaw	25
Length	1.50"
Depth	.25"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		1.4"				.27"				
X										
10°	↓	1.8"				.2"				
X										
45°		2.0"				.2"				
X										

FLAW COMPARISON TABLE

UT Sizing

Flaw	26
Length	.50"
Depth	.10"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.7"				.23"				
10°	↑	.5"				.19"				
[illegible]										
[illegible]										
45°		.4"				.27"				
[illegible]										

Flaw	27
Length	.50"
Depth	.10"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.6"				.11"				
15°	↑	.45"				.2"				
[illegible]										
[illegible]										
45°		.6"				.171"				
[illegible]										

Flaw	28
Length	.50"
Depth	.30"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.6"				.34"				
10°	↑	.6"				.4"				
10°	↓	.5"				.4"				
[illegible]										
[illegible]										
[illegible]										

Flaw	29
Length	.50"
Depth	.40"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.65"				.33"				
10°	↑	.80"				.35"				
10°	↓	.7"				.41"				
[illegible]										
[illegible]		.6"				.23				
[illegible]										

Flaw	30
Length	.50"
Depth	.50"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°		.75"				.4?"				
[illegible]						.3"				
10°	↓	.7"								
[illegible]										
45°		.6"				.2"				
[illegible]										

FLAW COMPARISON TABLE

UT Sizing

Flaw: 31
Length: .375 Ax
Depth: .10

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°										
X°										
X°										
X°										
45°	→	.6"				.14"				
X°										

Flaw: 32
Length: .375 Ax
Depth: 20"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°										
X°										
X°										
X°										
45°	→	.5"				.1"				
X°										

Flaw: 33
Length: .375 Ax
Depth: .30"

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°										
X°										
X°										
X°										
45°	→	.35"				.12"				
X°										

Flaw:
Length:
Depth:

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°										
10°										
10°										
35°										
45°										
70°										

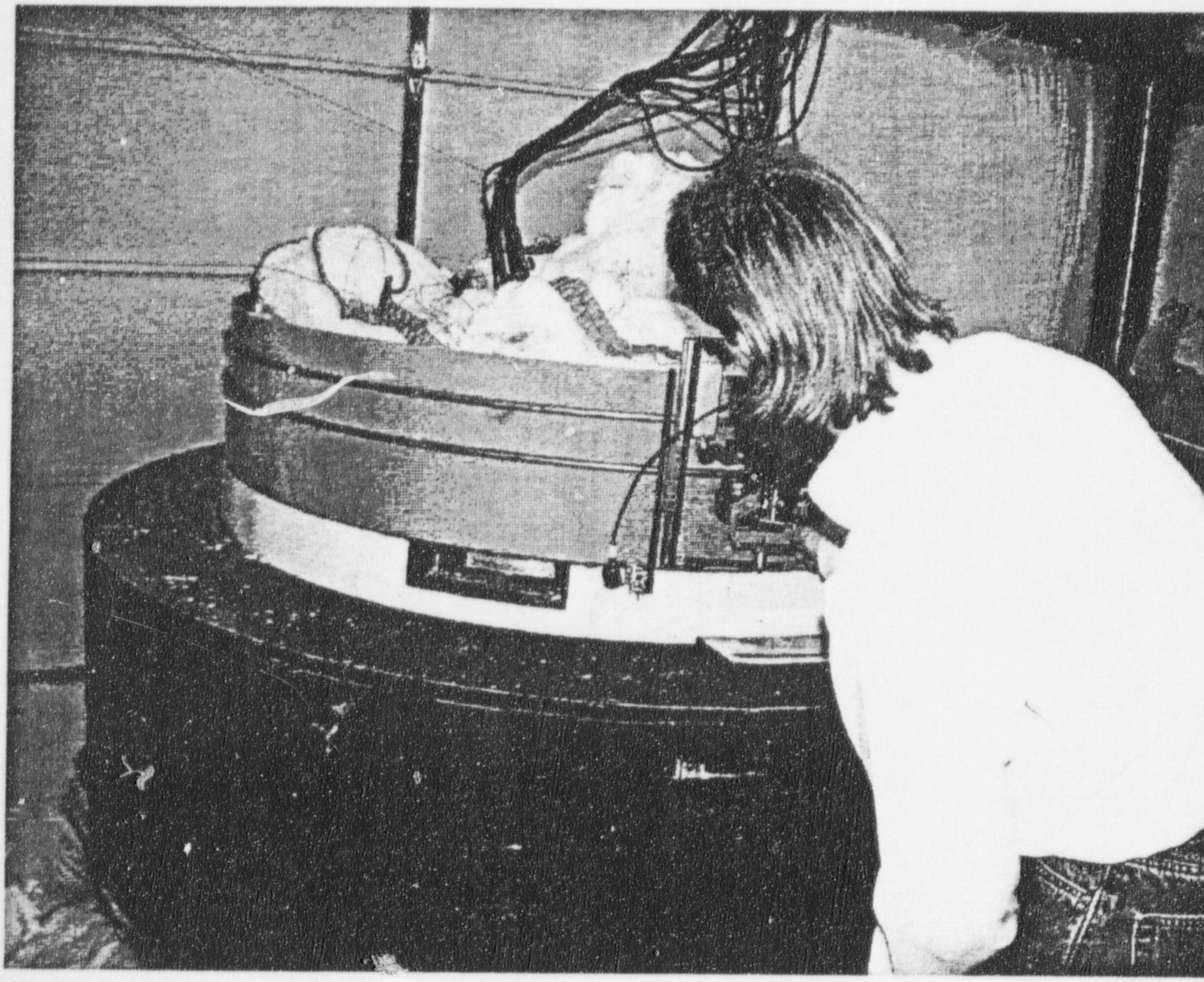
Flaw:
Length:
Depth:

Angle		Length	Over	Under	Useful	Depth	Over	Under	Useful	Zone
0°										
10°										
10°										
35°										
45°										
70°										

ANO

B116

1 1



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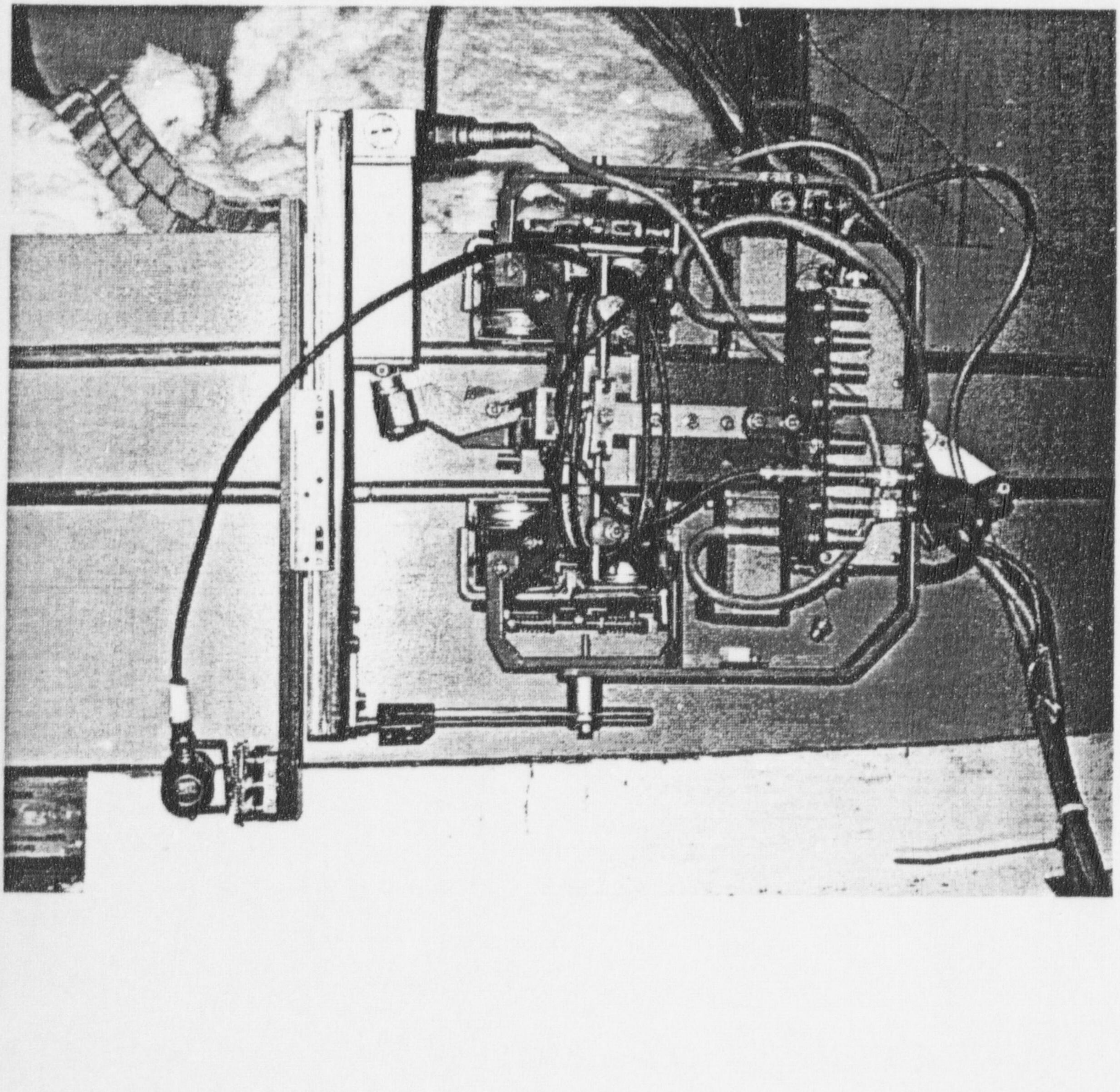
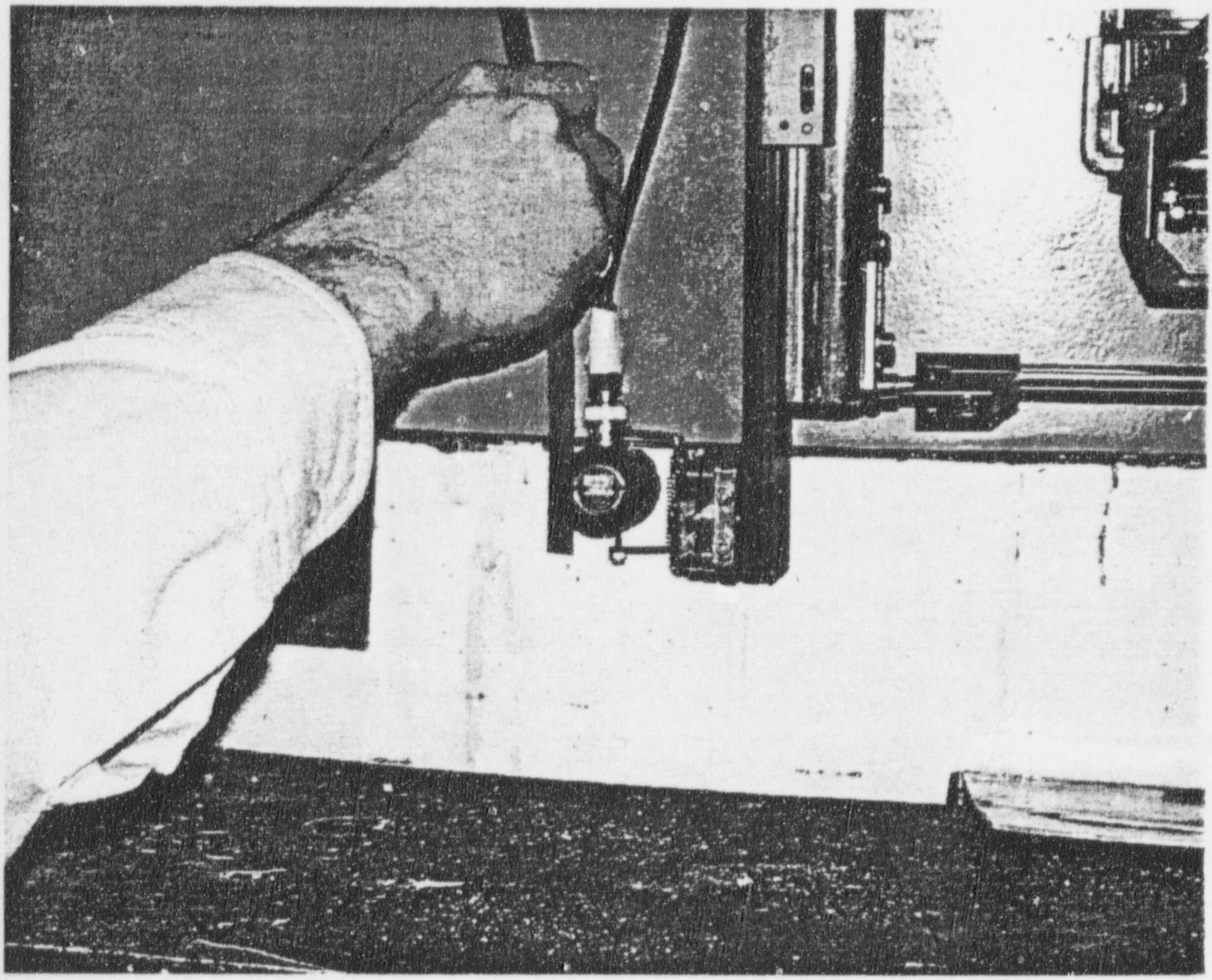
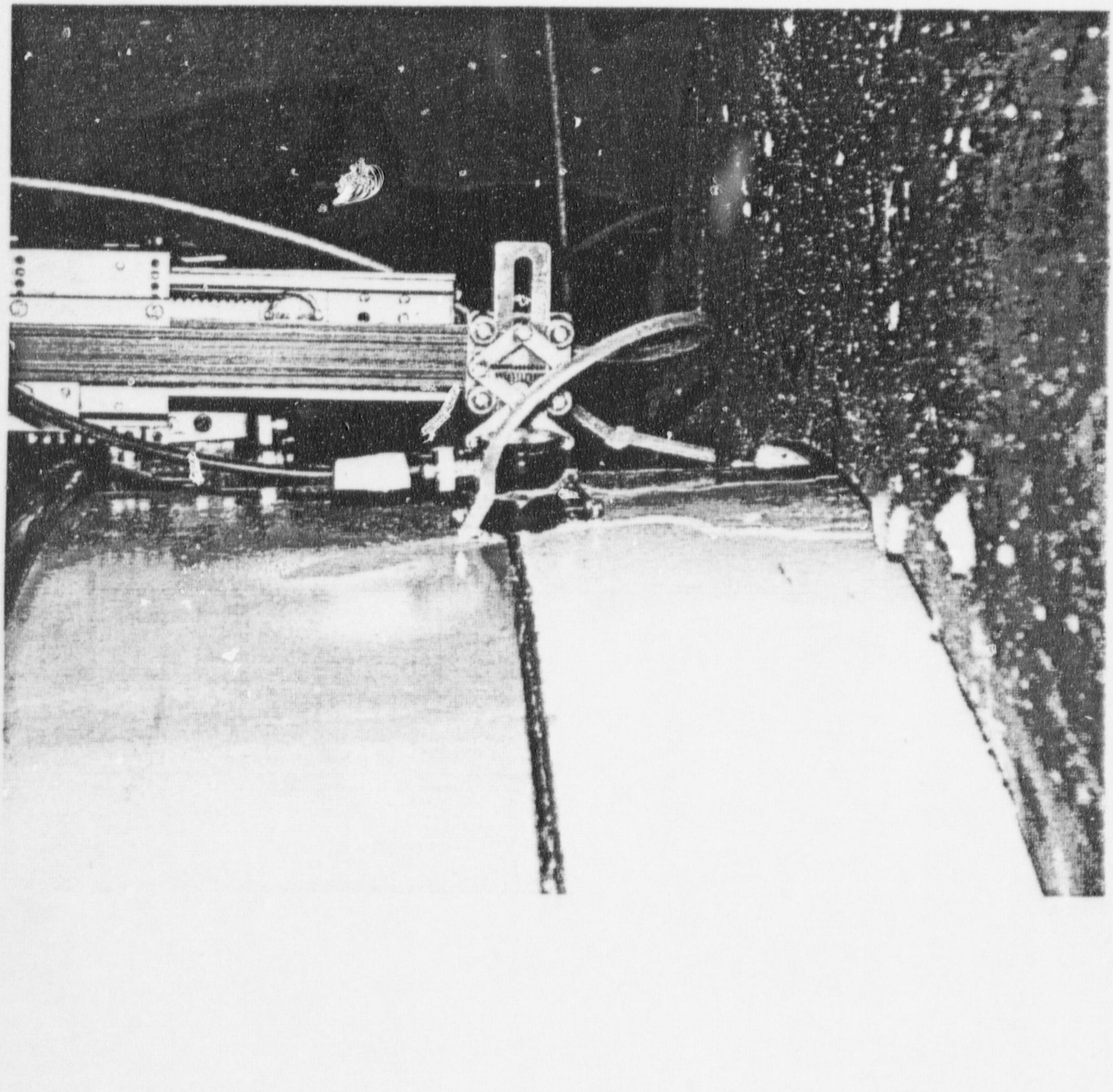
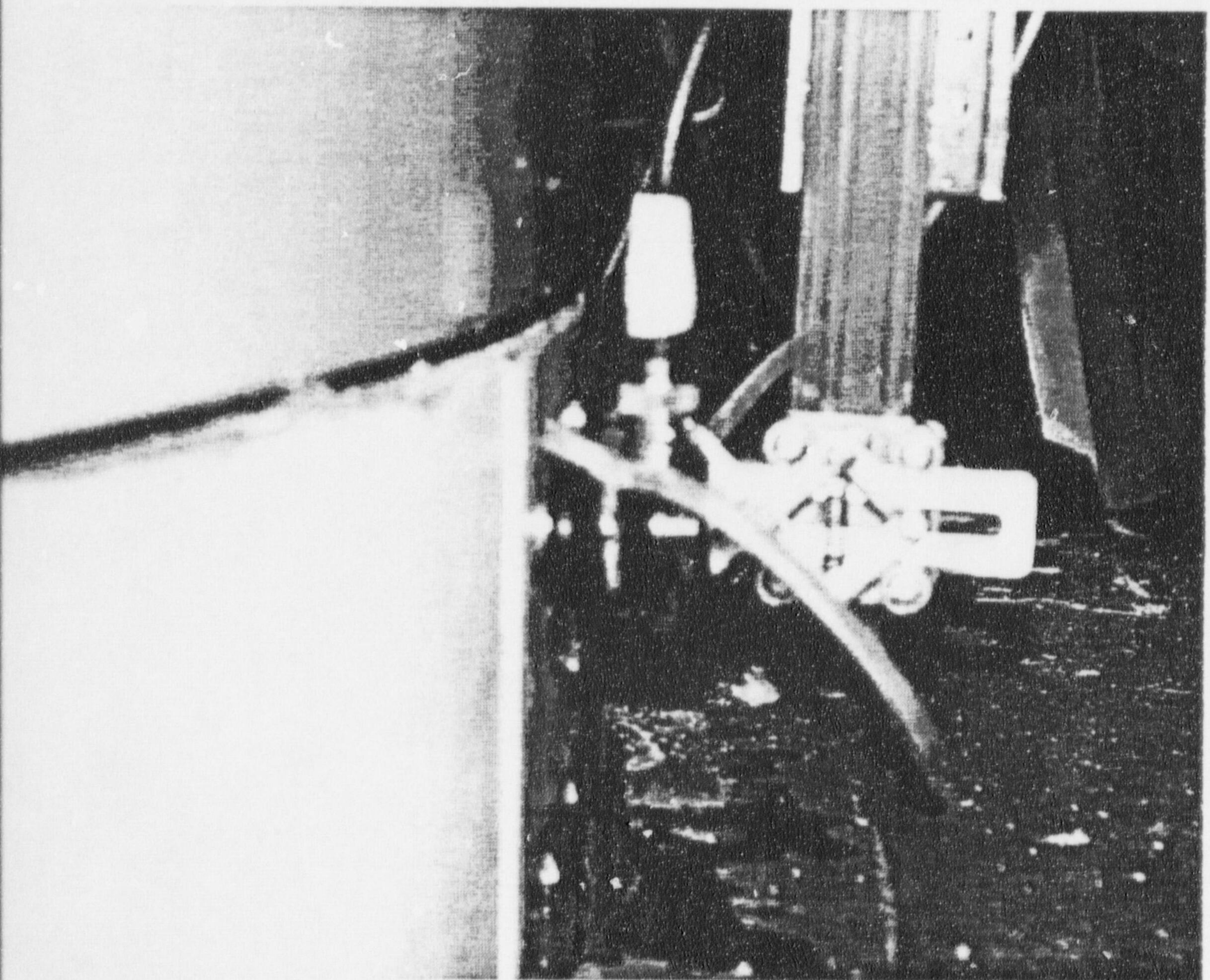
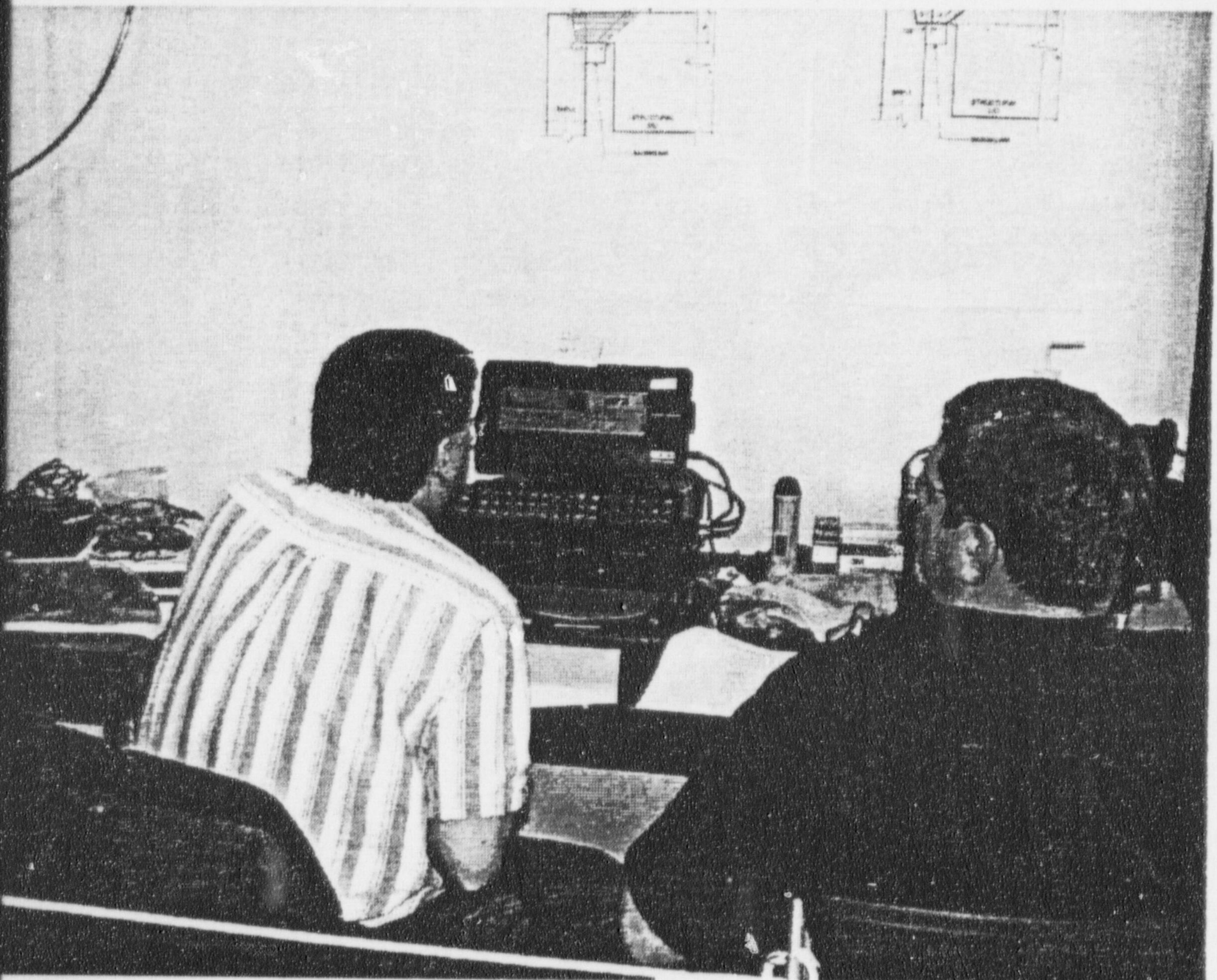
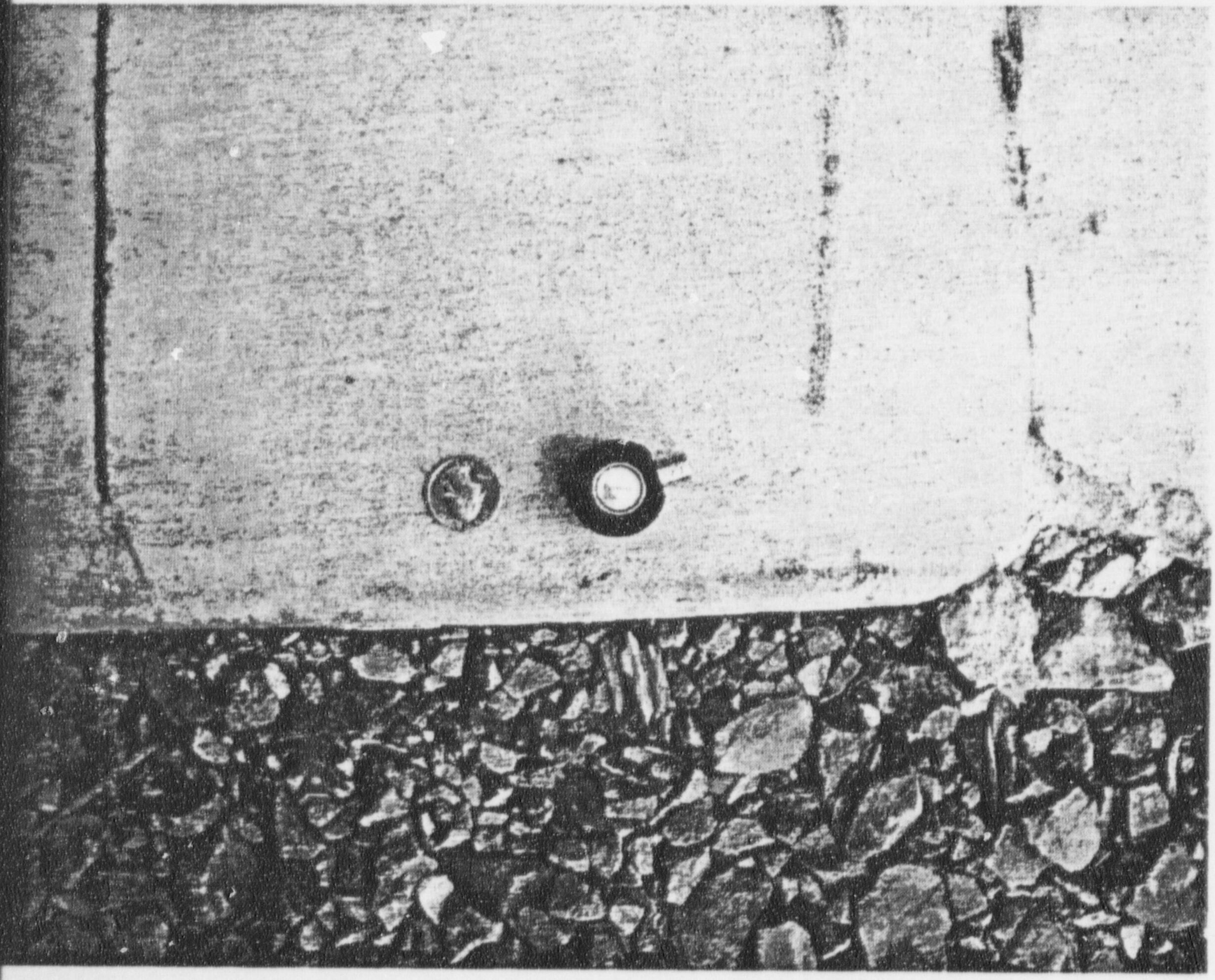


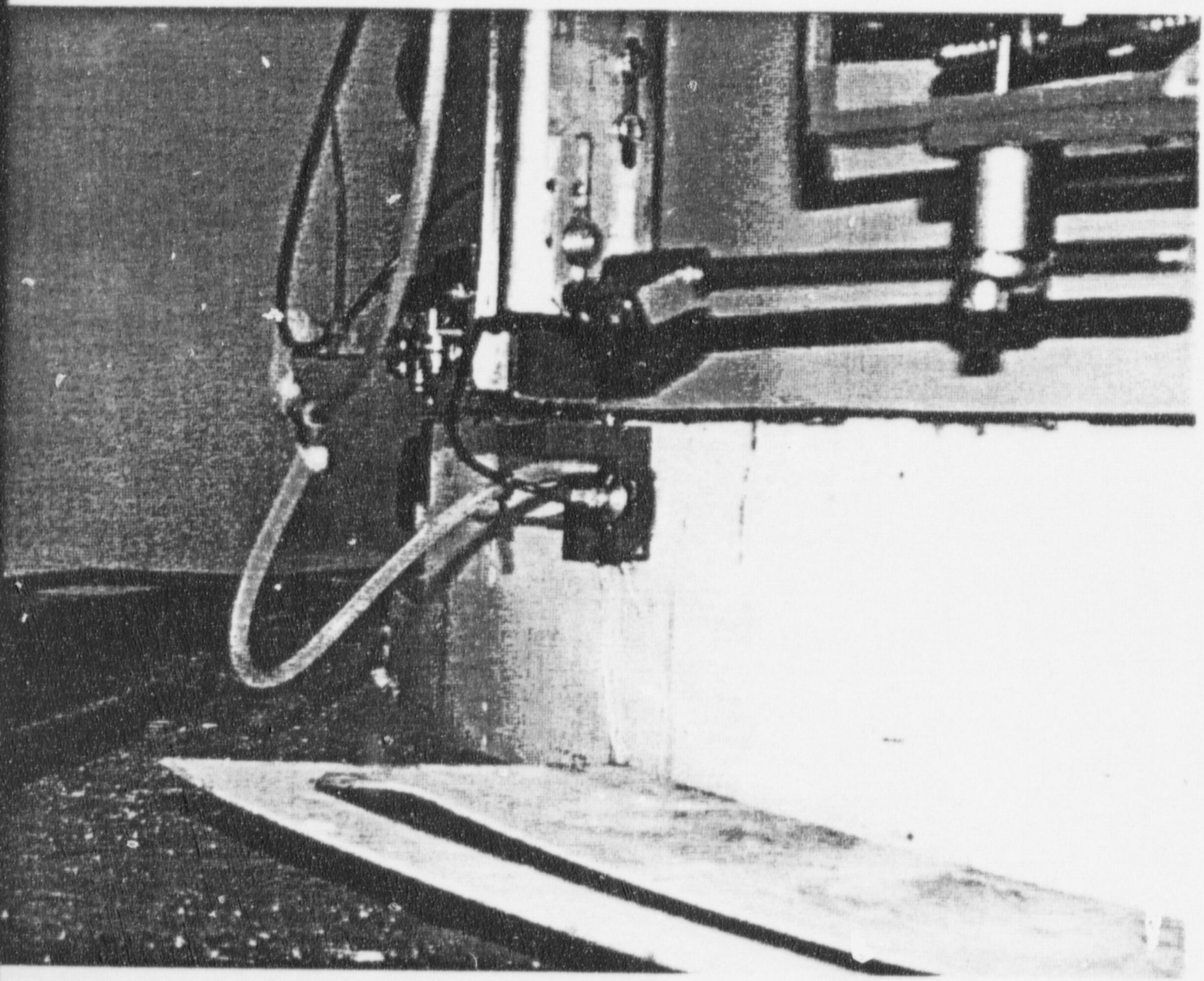


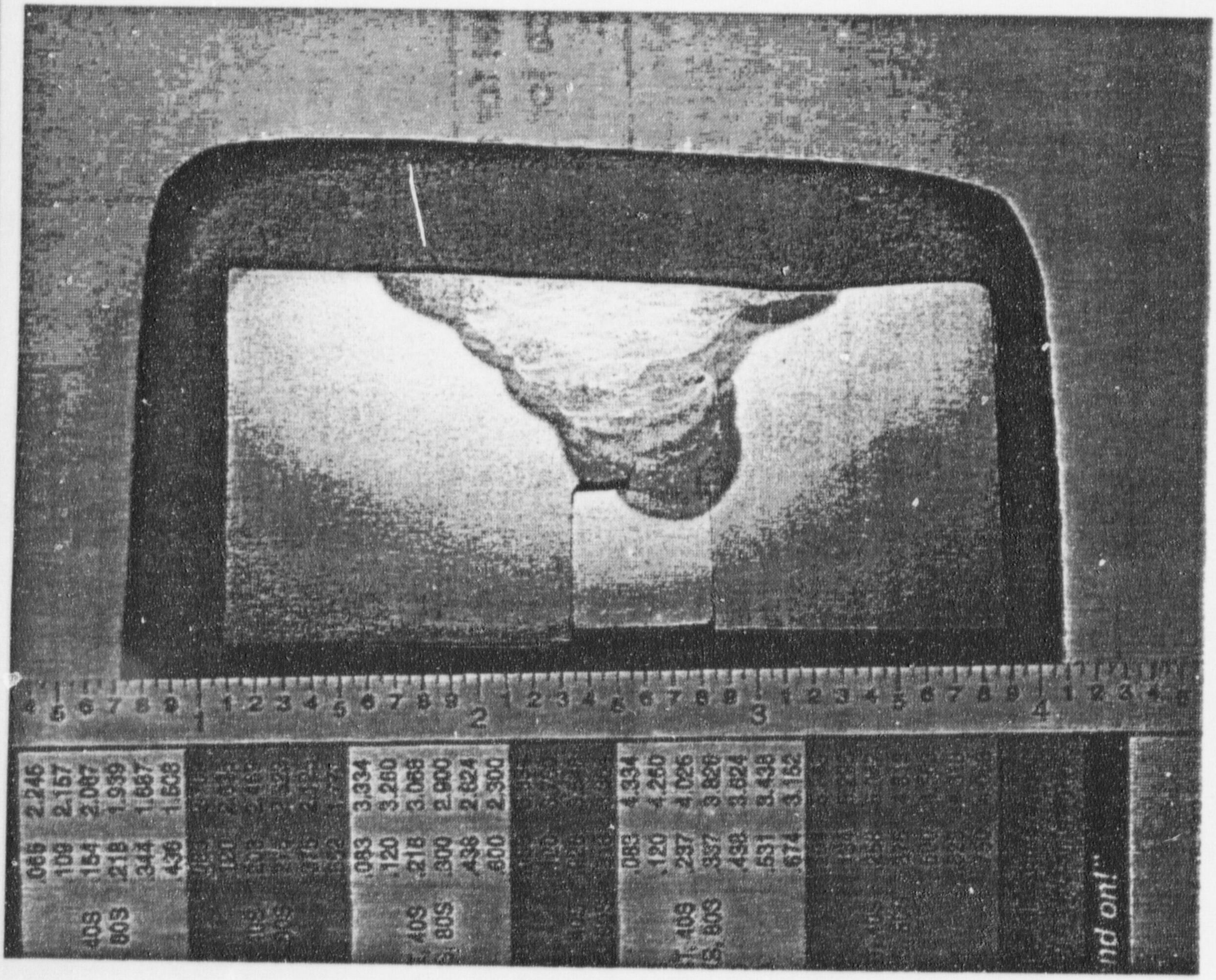


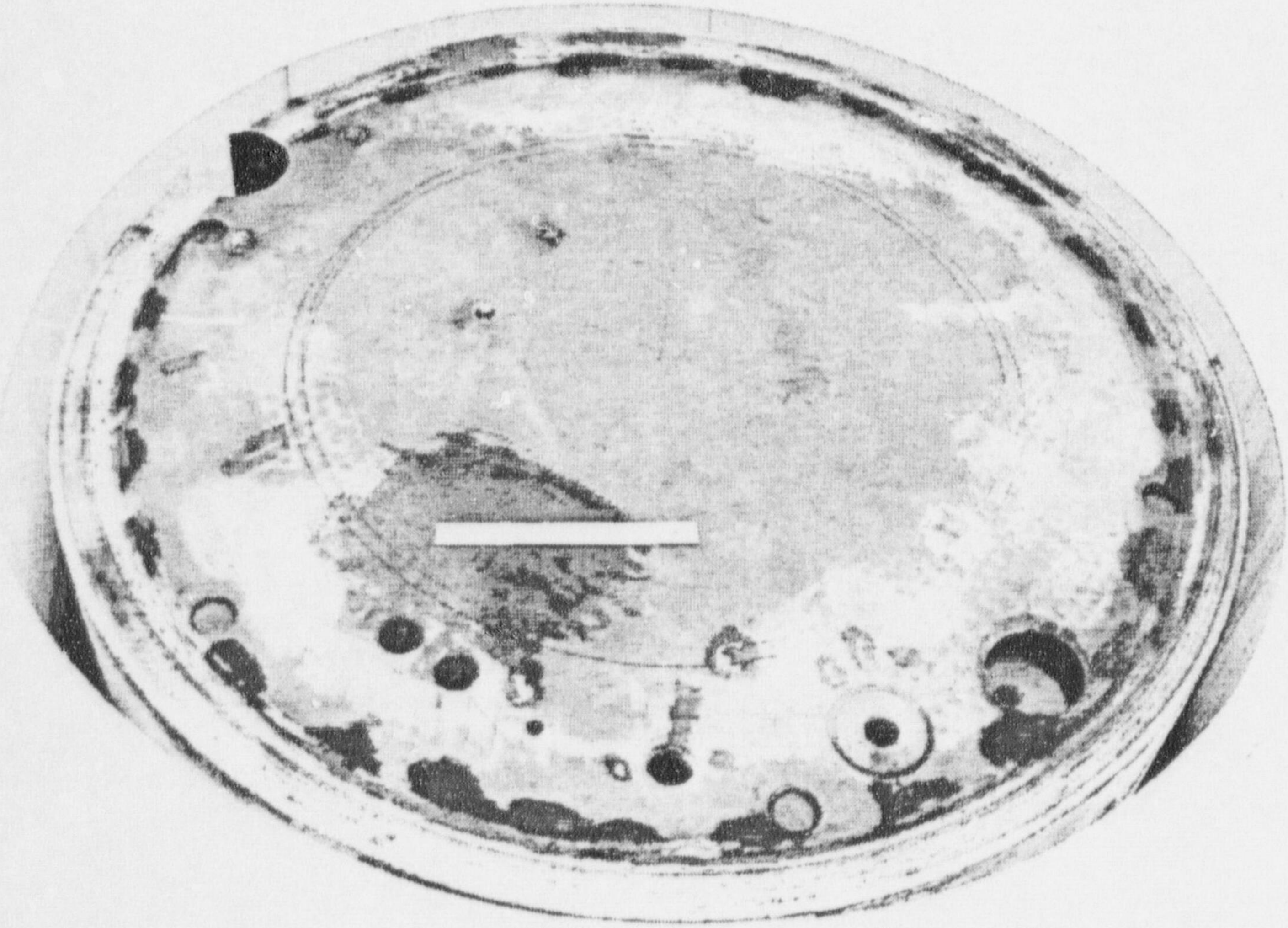


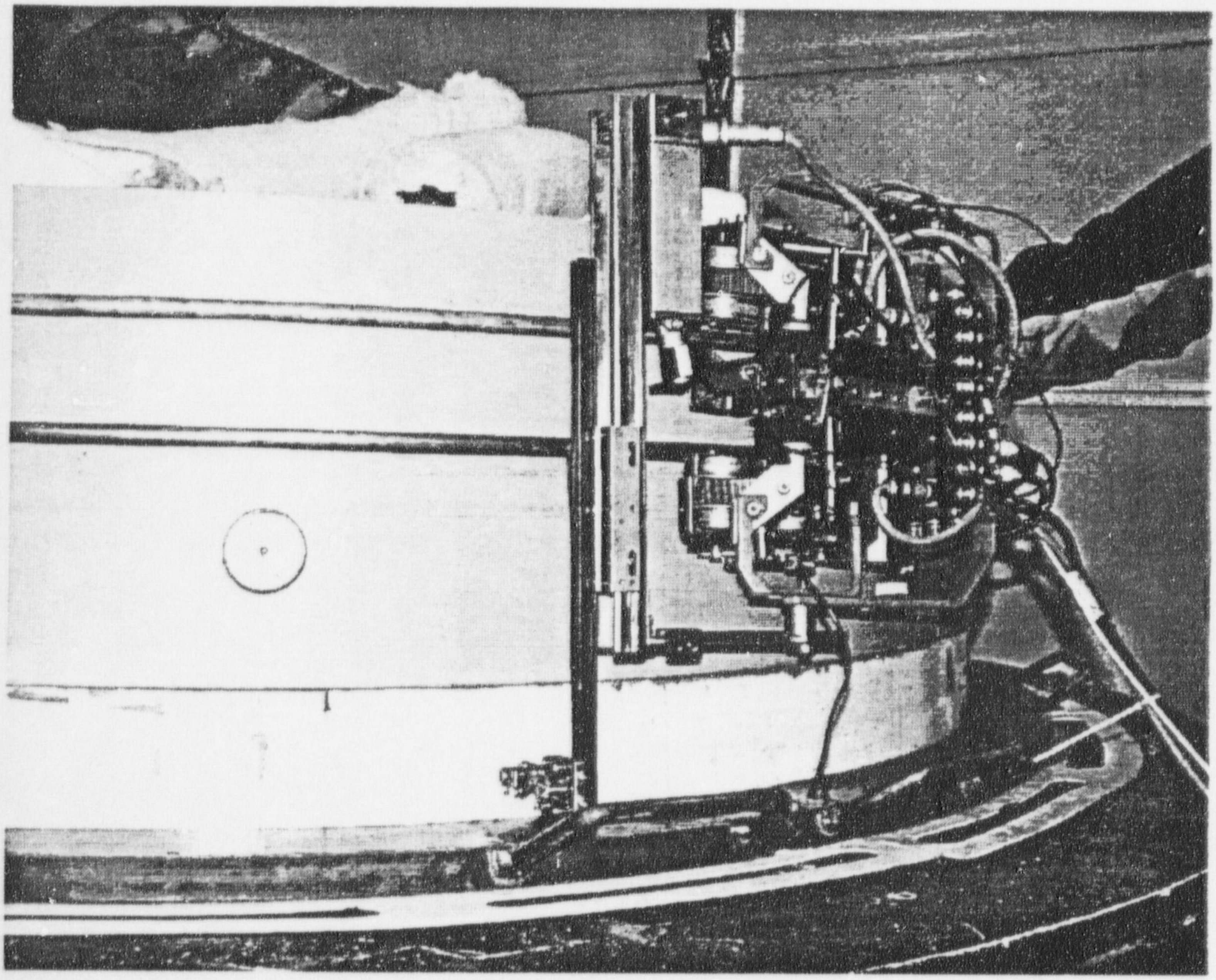


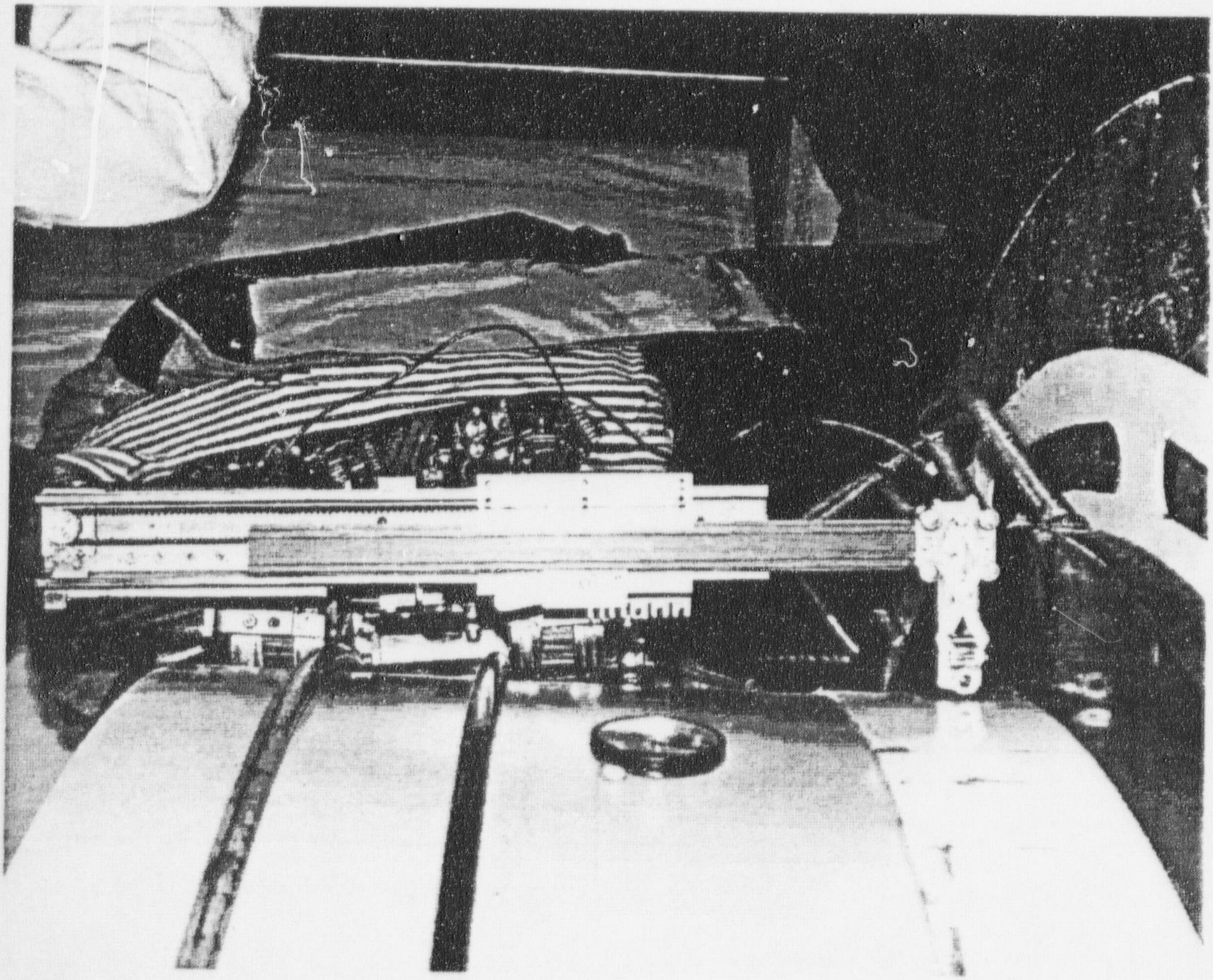


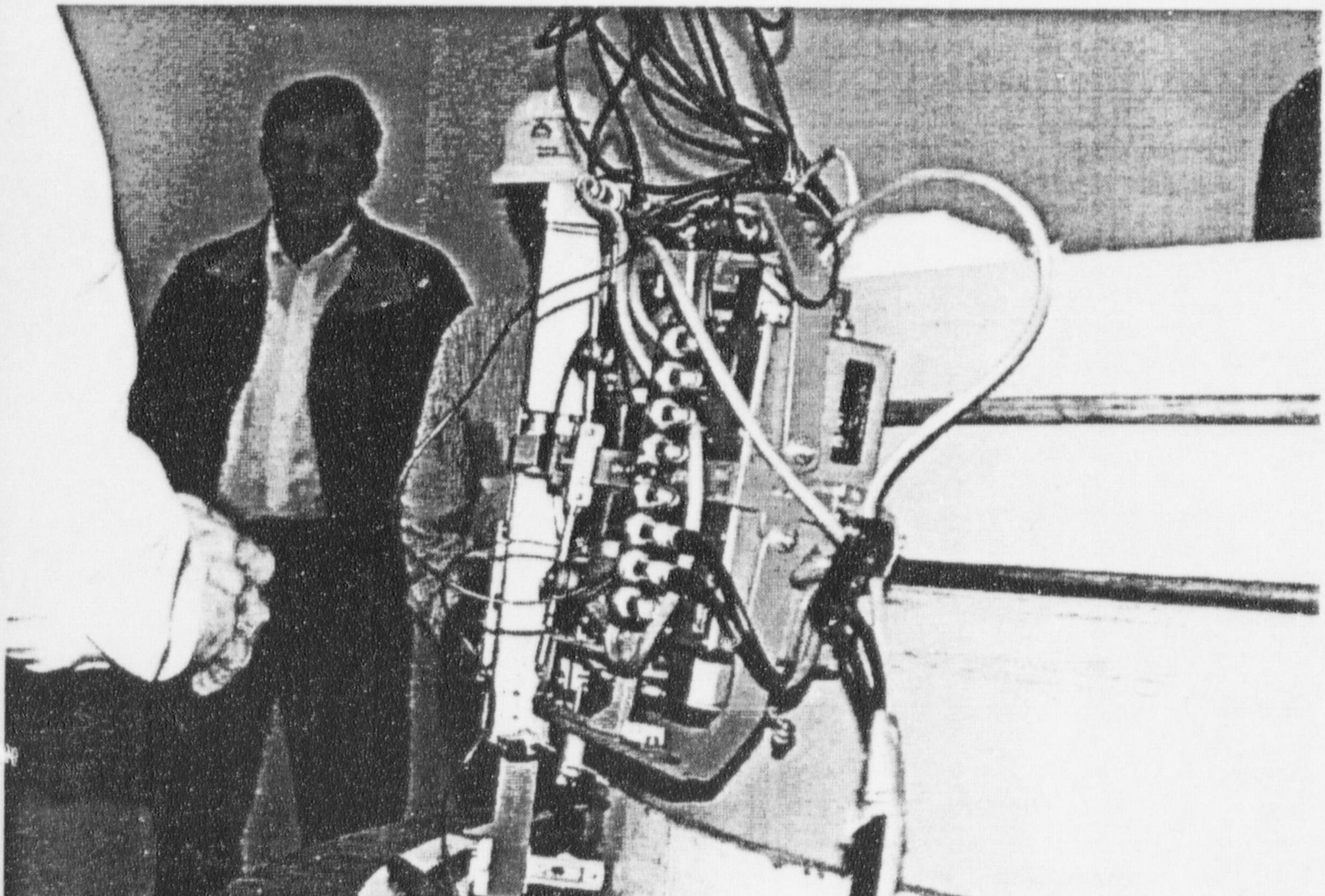


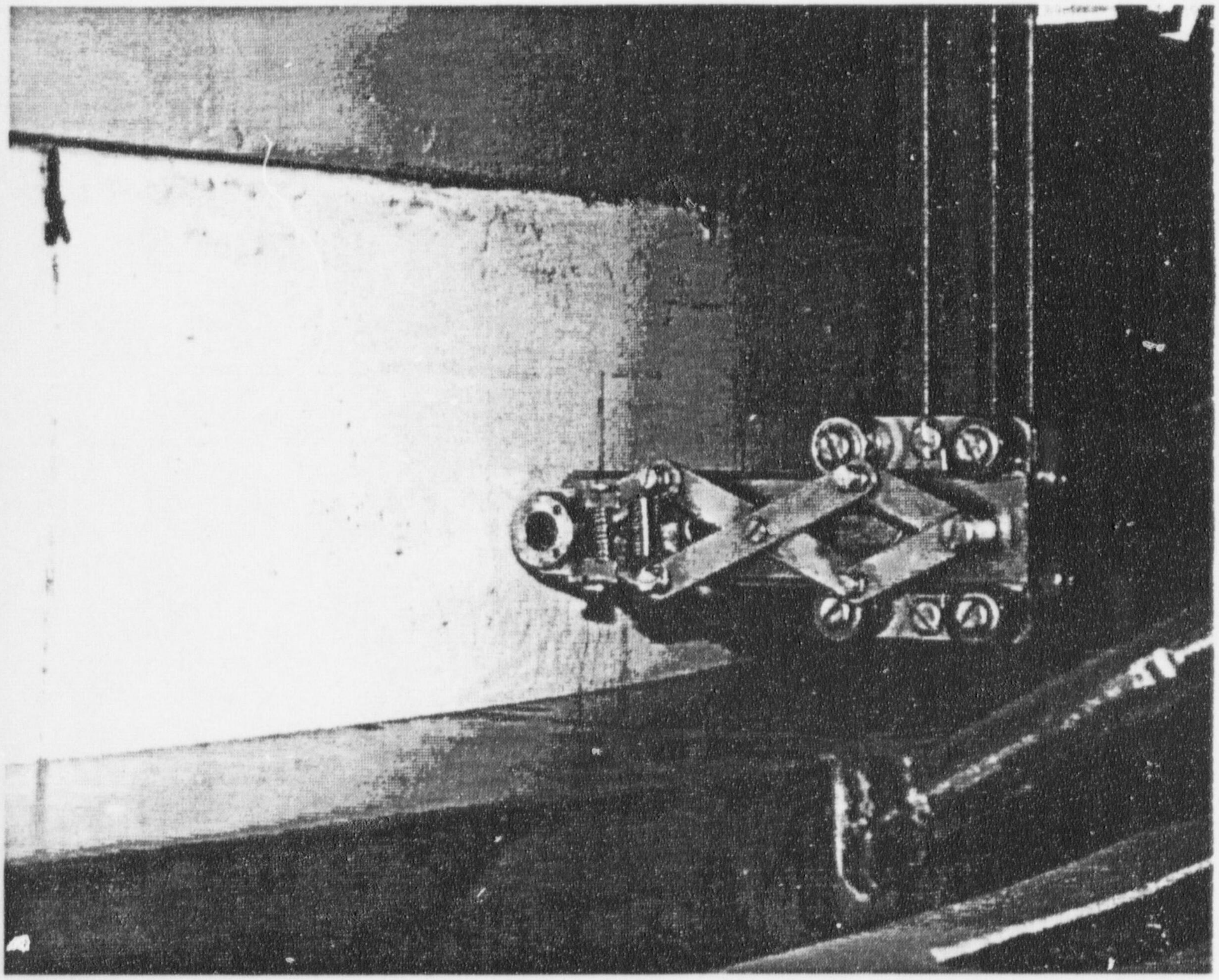


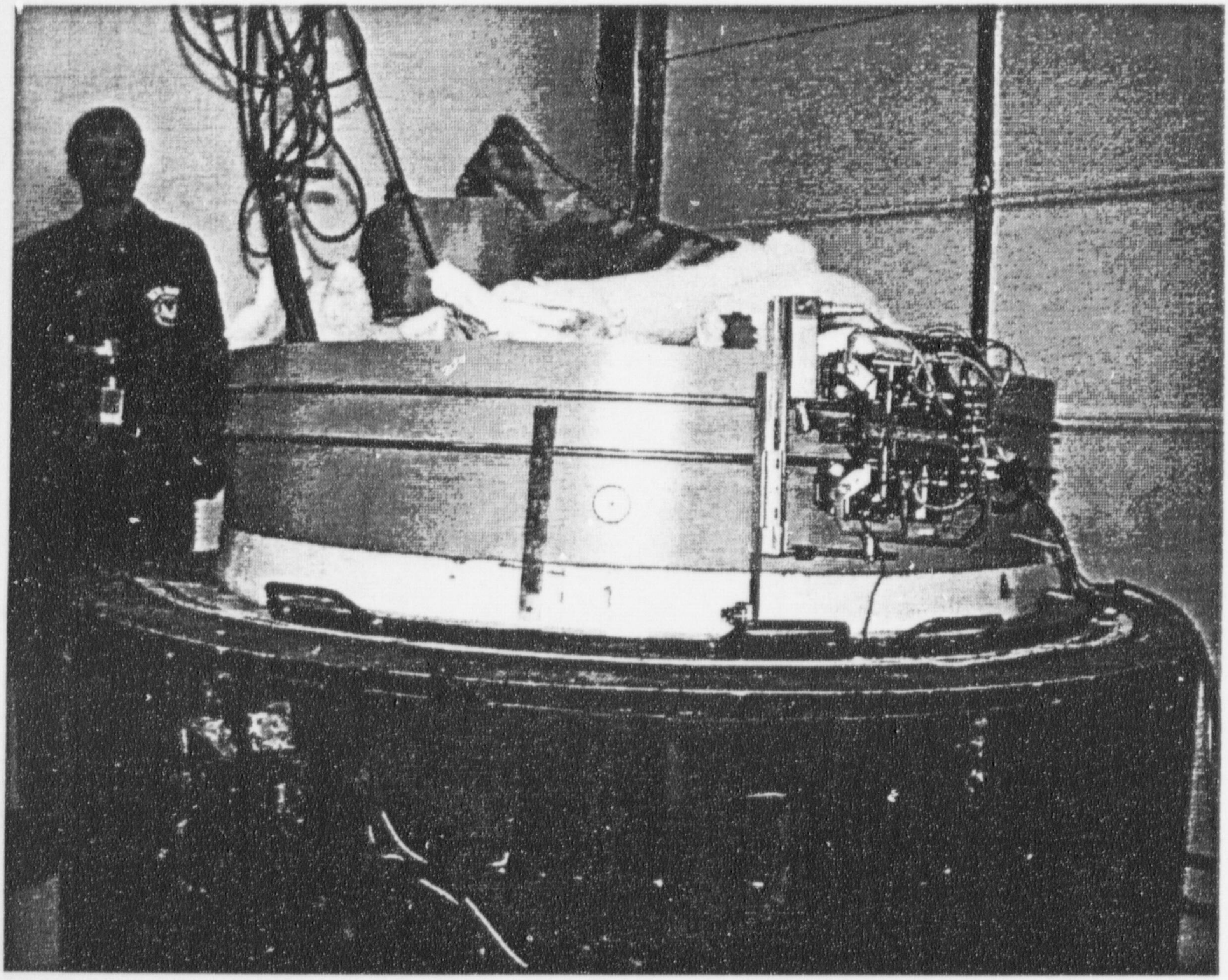


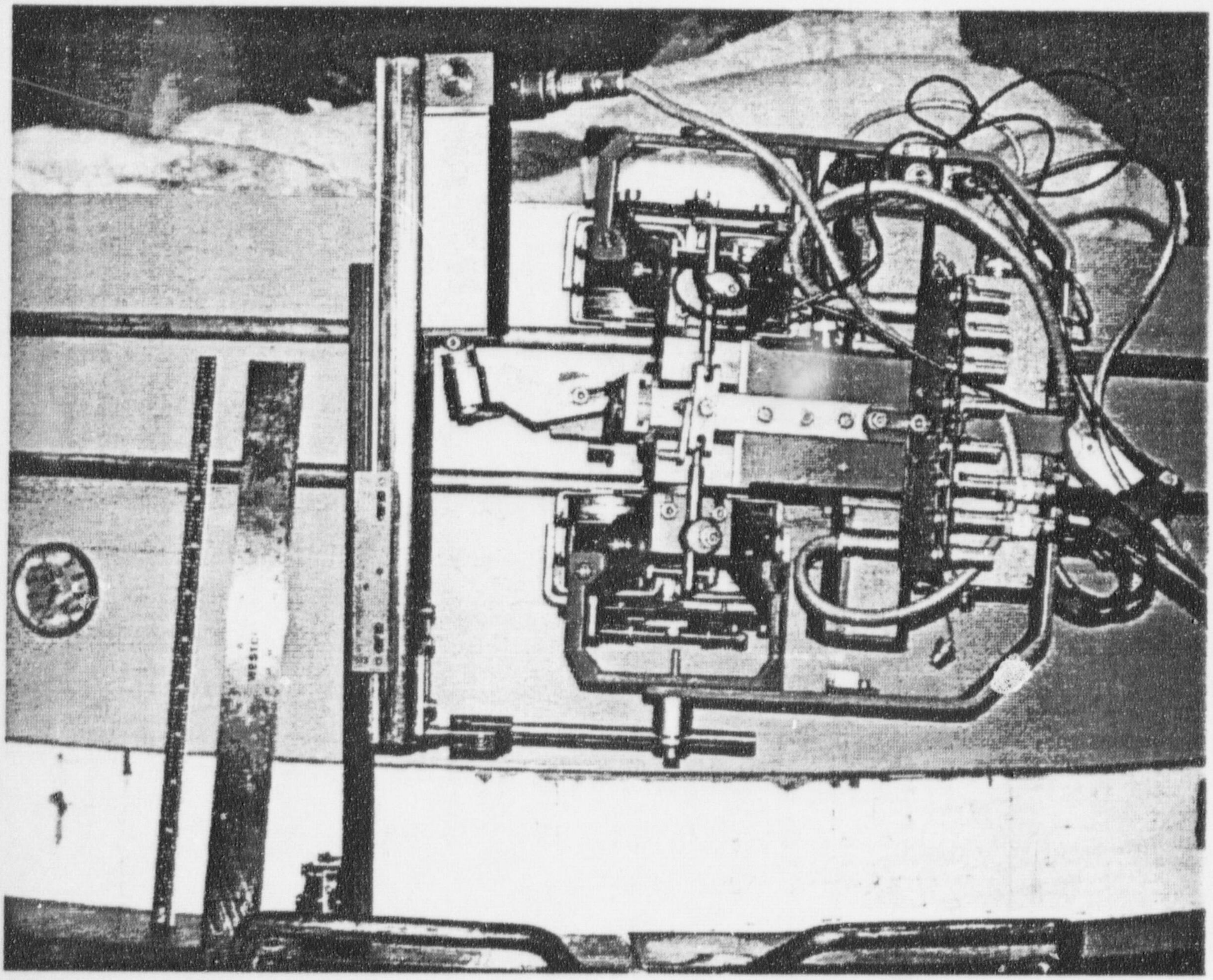


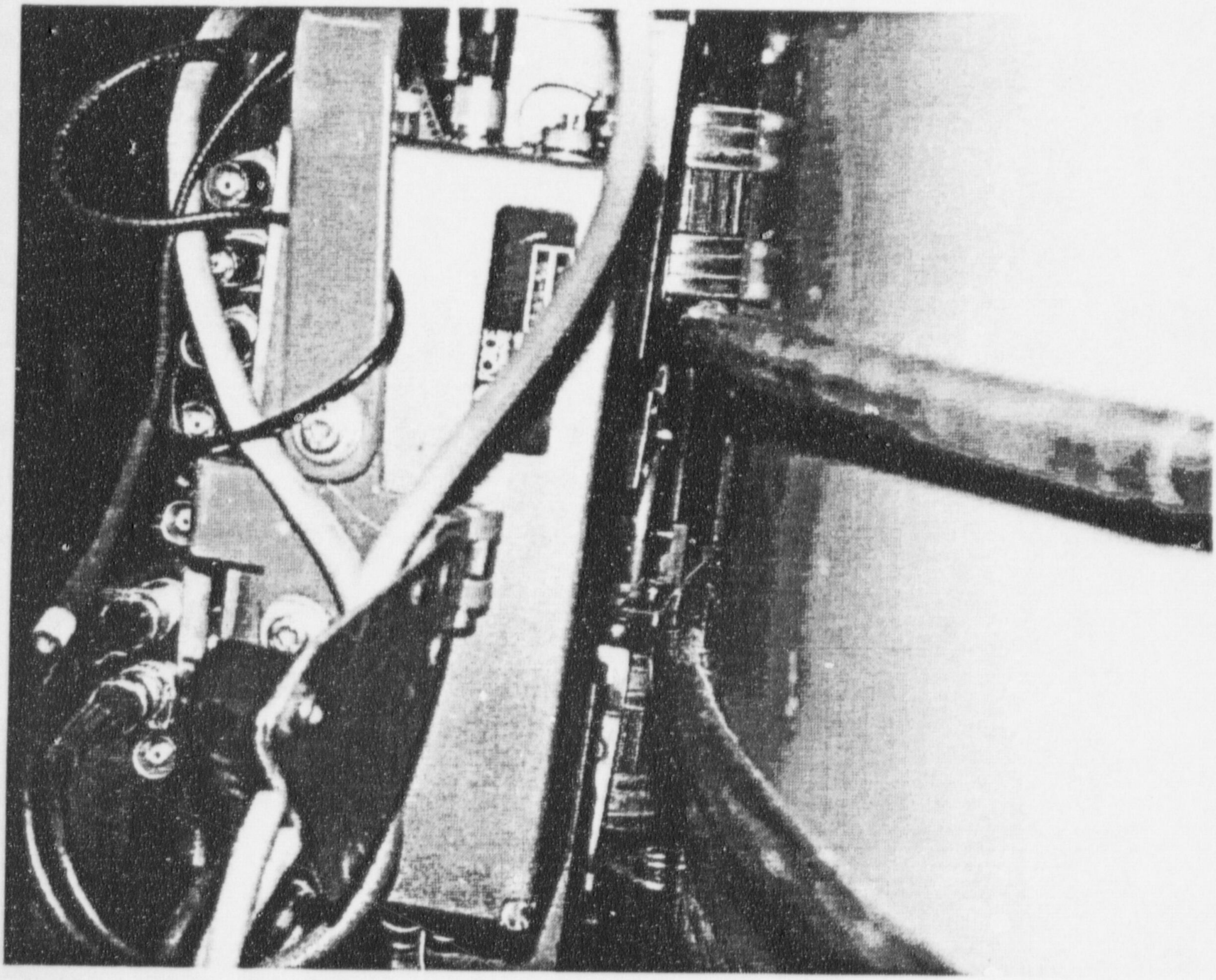


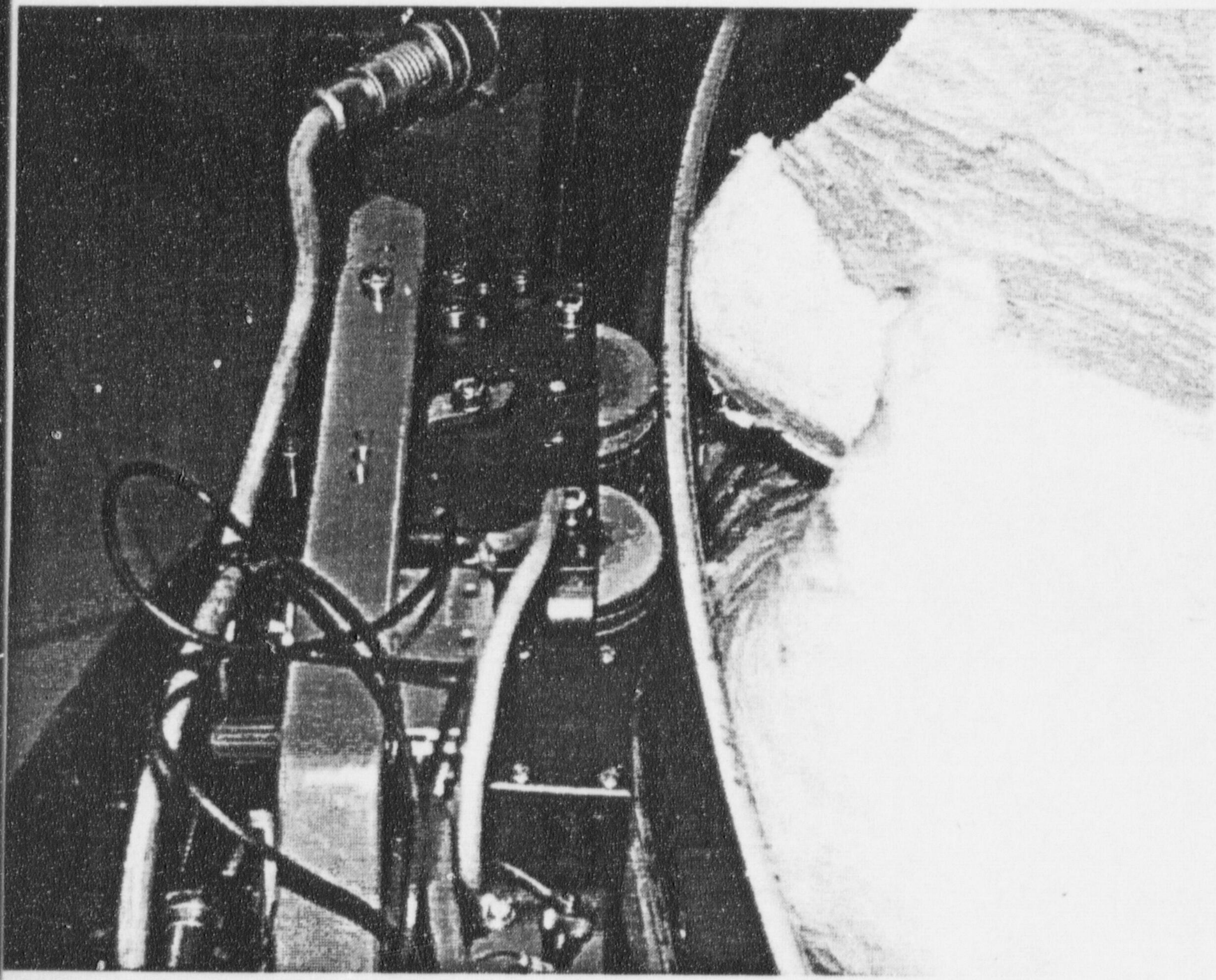


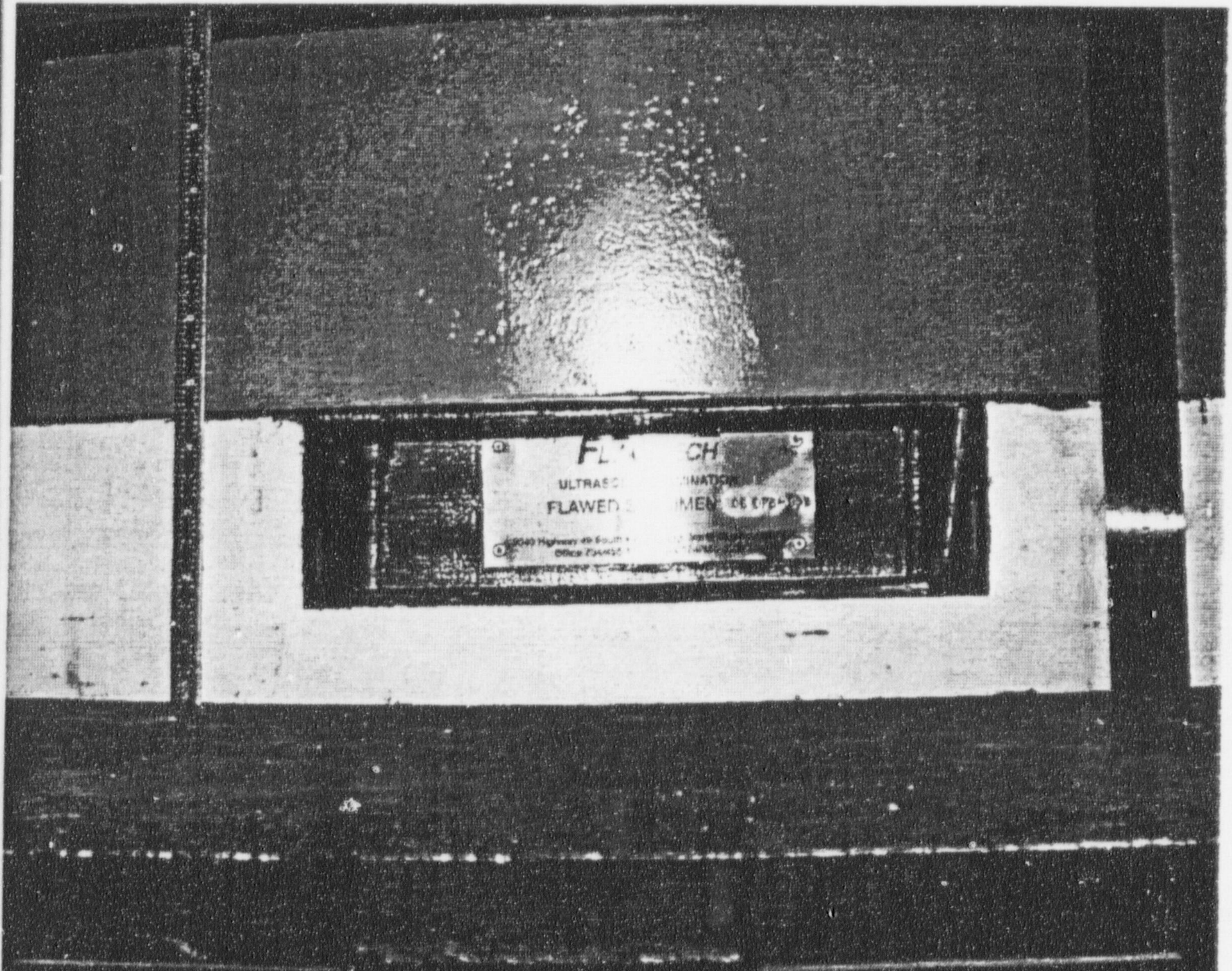


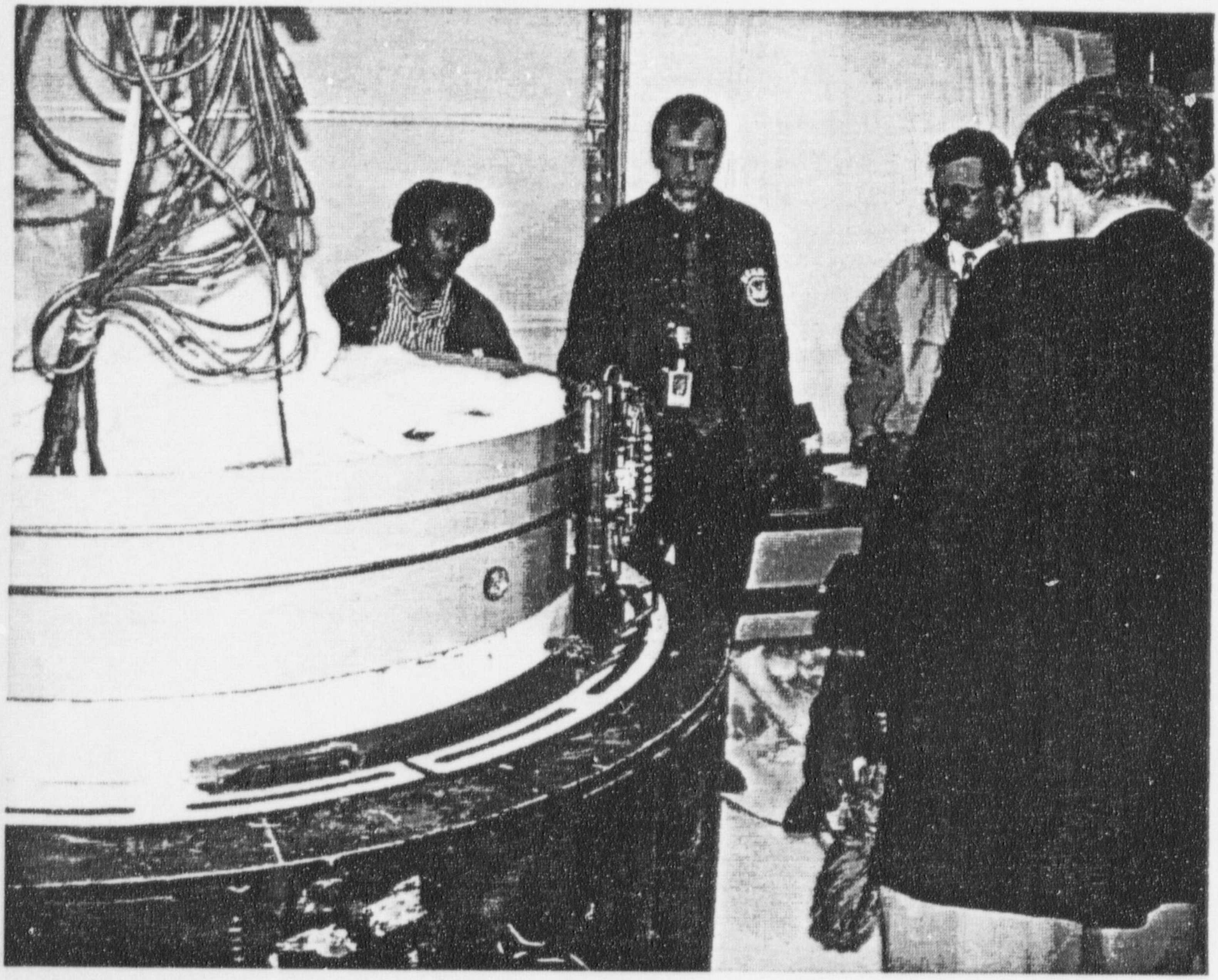


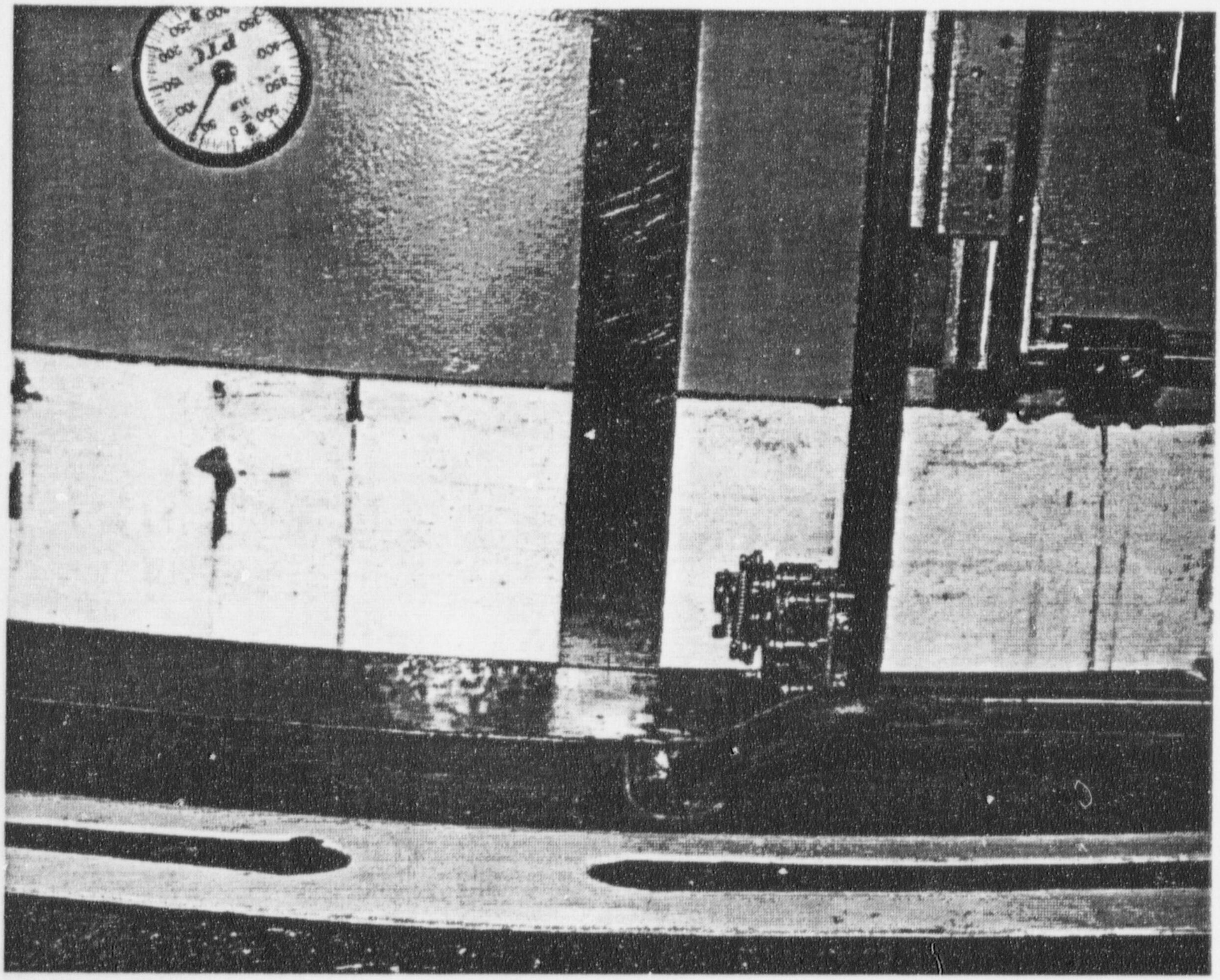


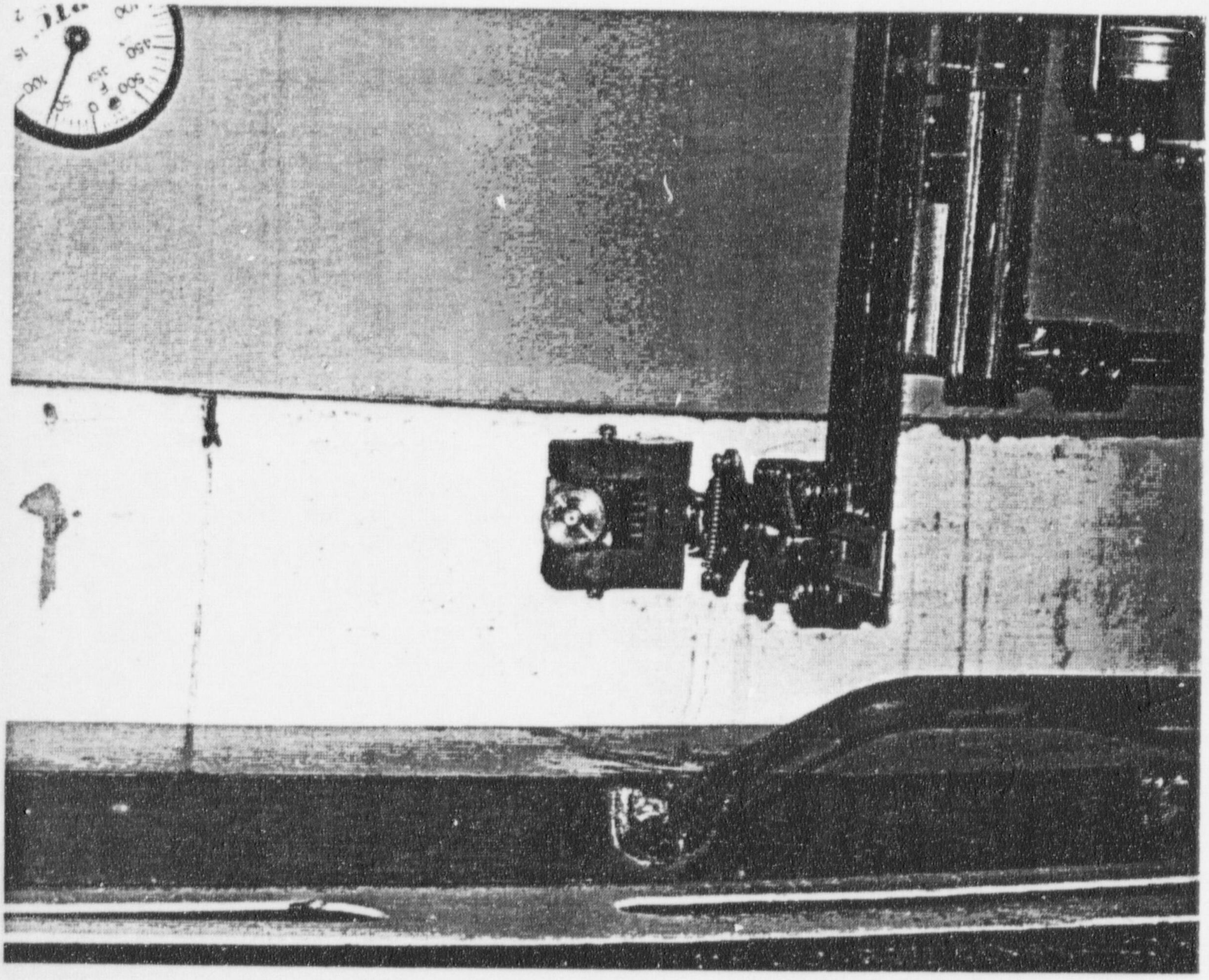


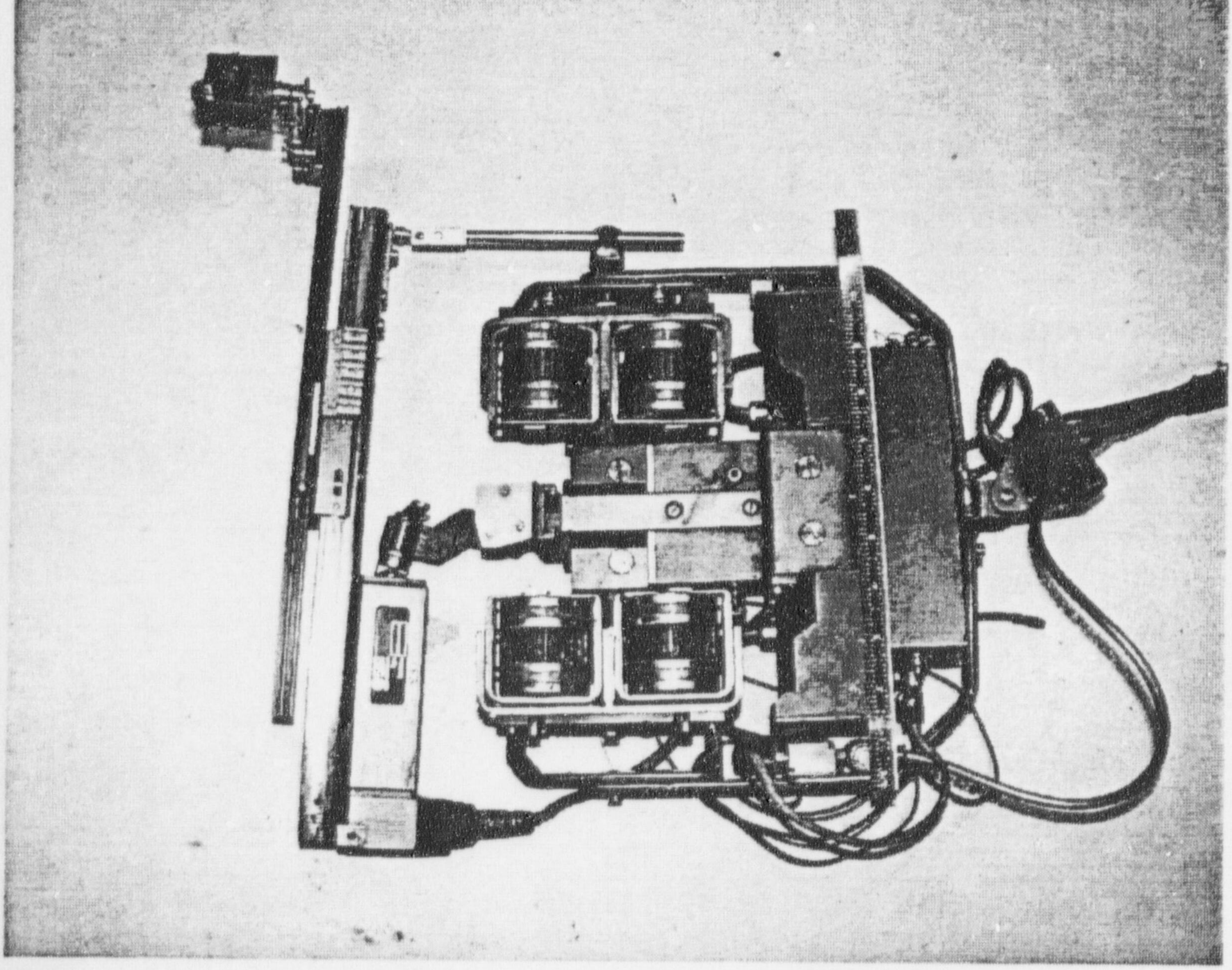


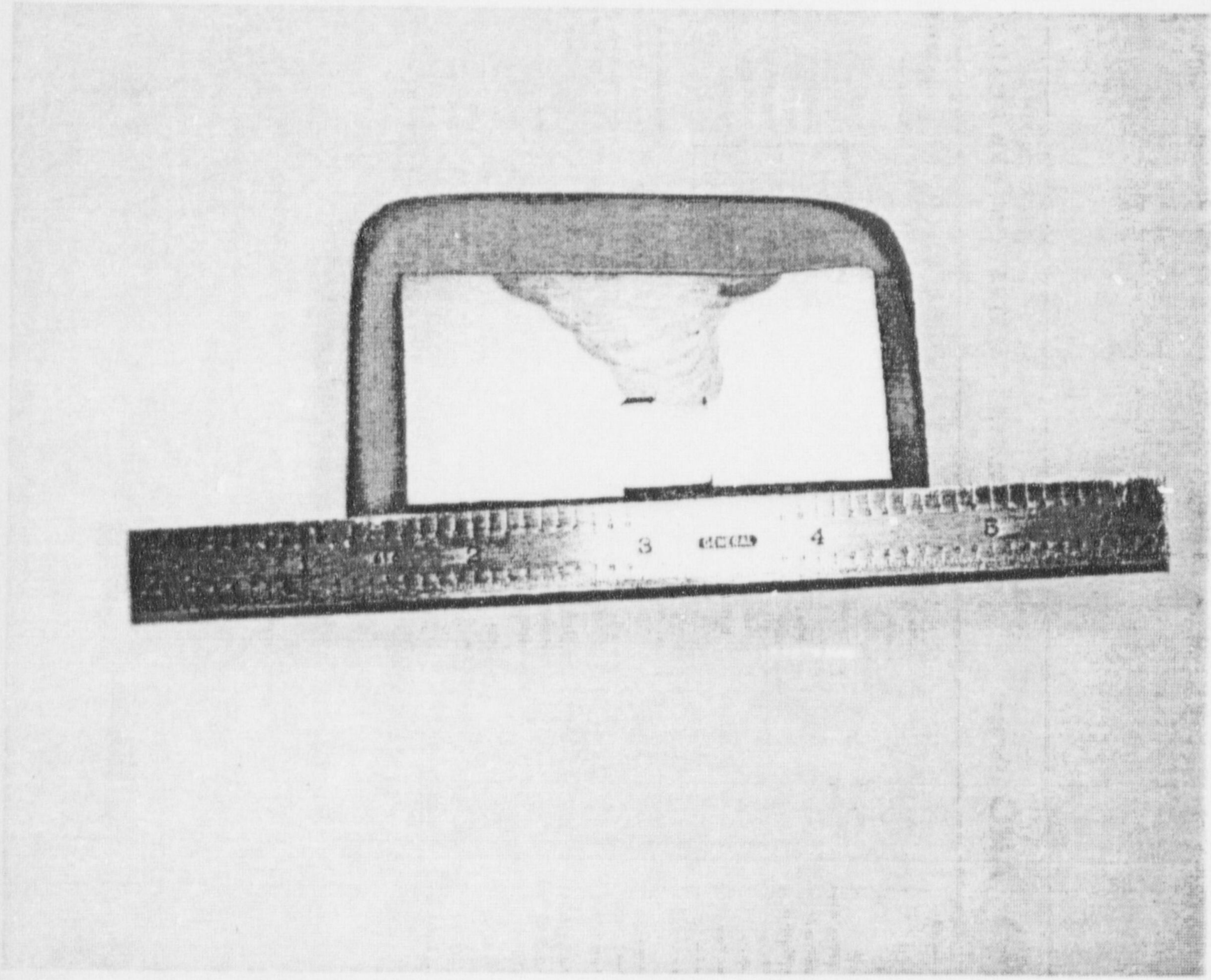

FLAWED

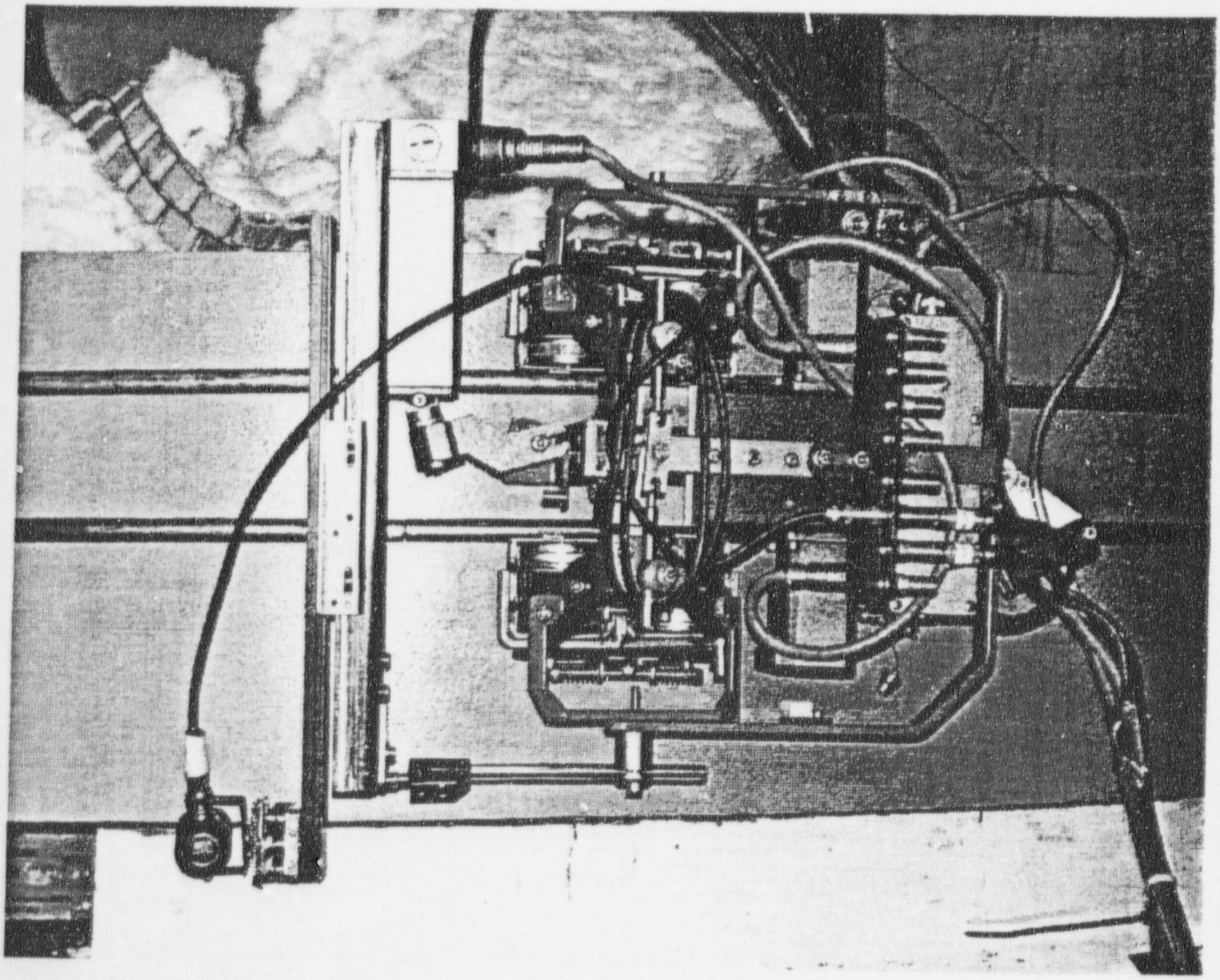


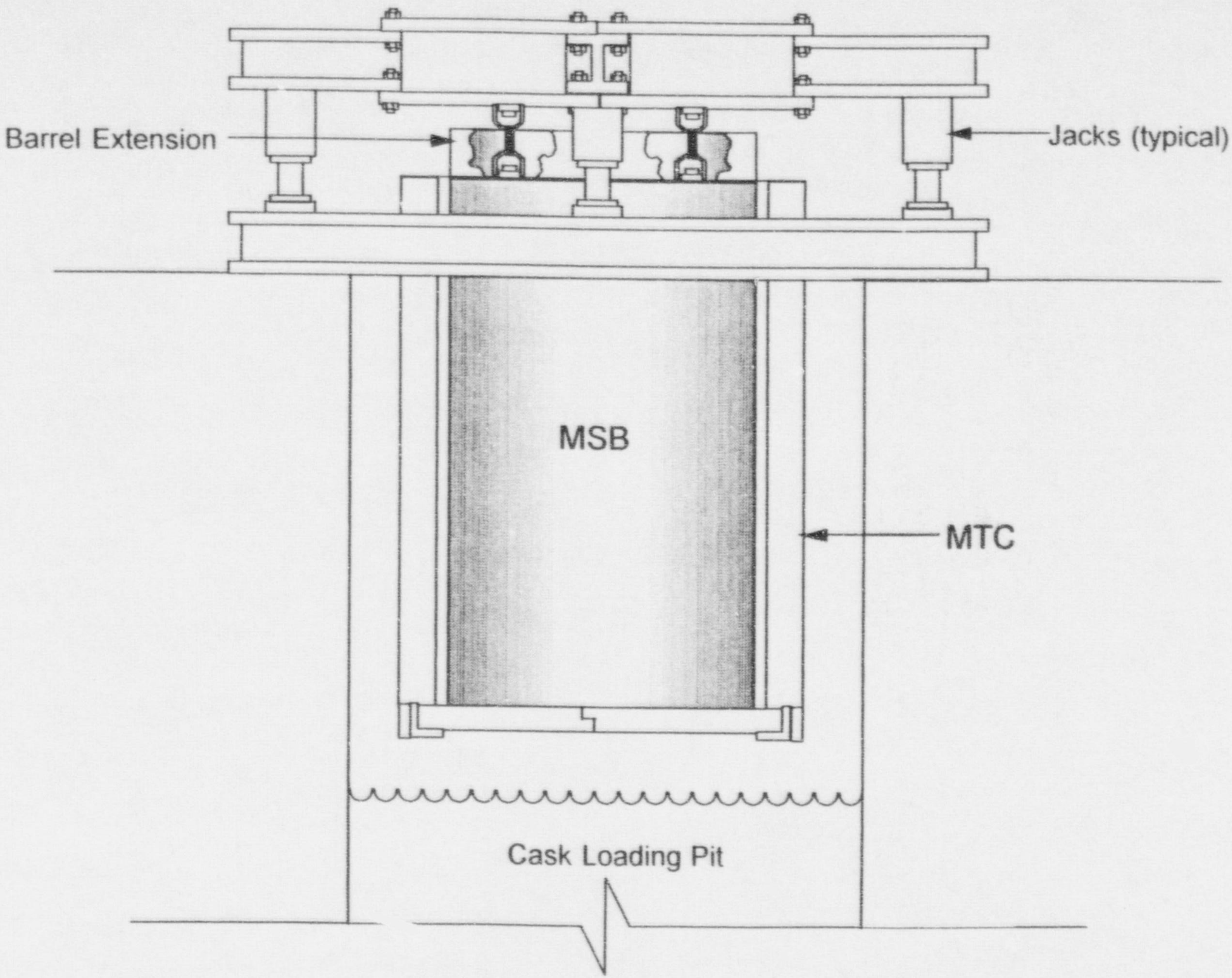


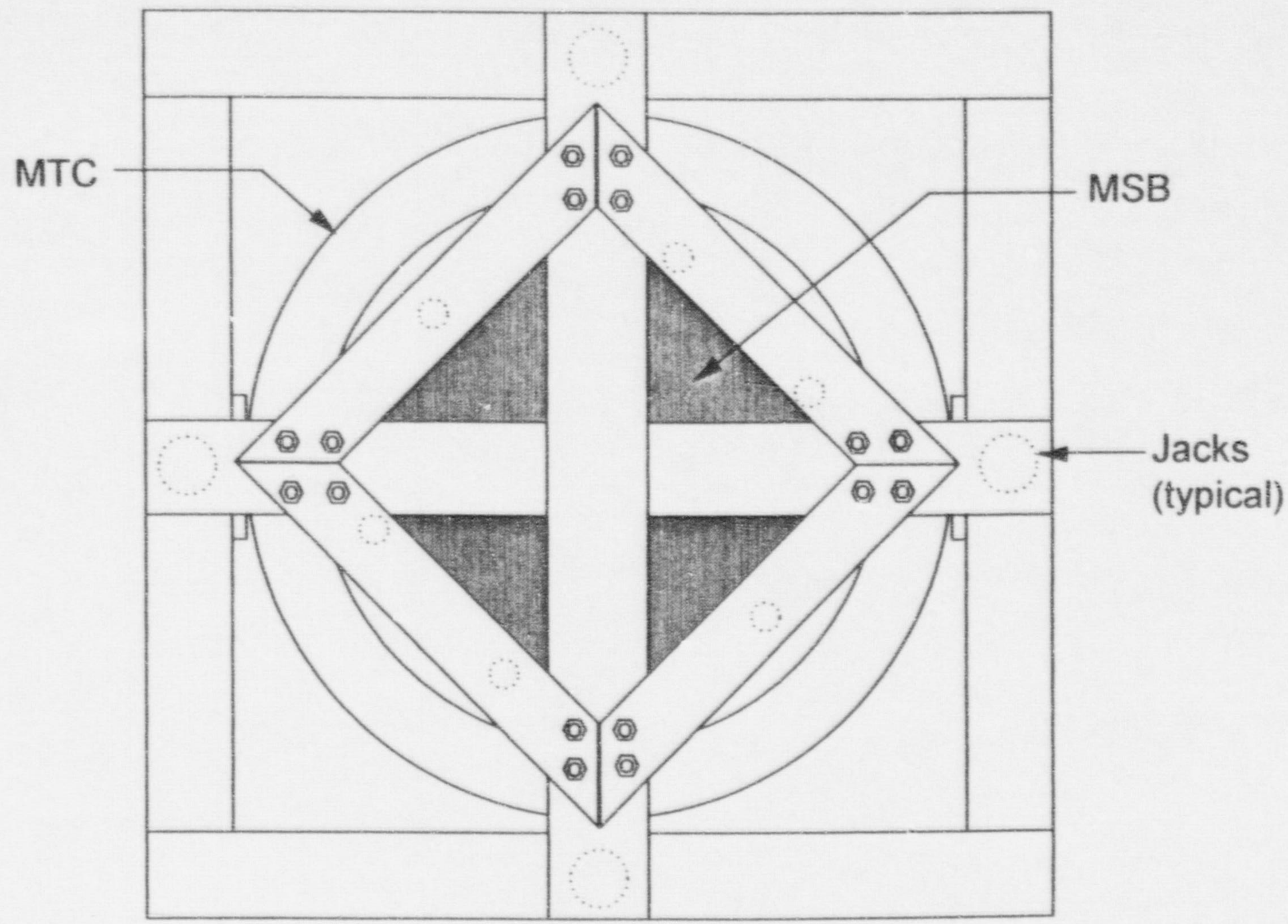





3
4
5




Barrel Extension
Jacks (typical)
MSB
MTC
Cask Loading Pit



TOP VIEW

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IMAGE, Probes and Gates Setup.1

Item: 45PSL10.9

Probe no.	1
Transmitter	1
Receiver	1
Beam angle	46.0 deg
Gates	4
Rotation	90 deg

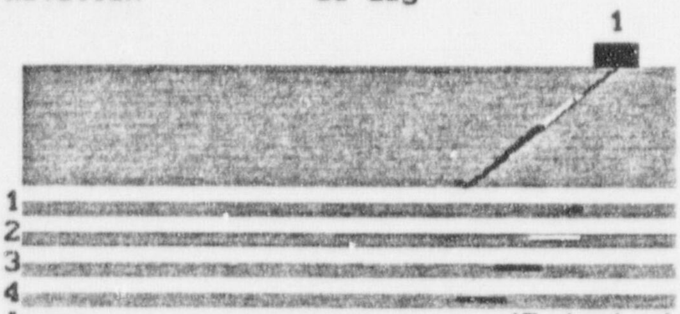

Image (End view)

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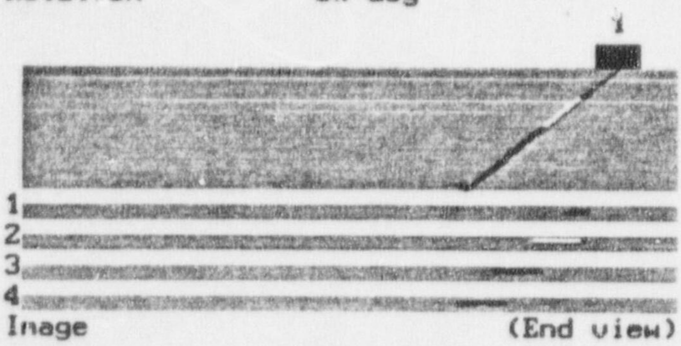
2'

IMAGE, Probes and Gates Setup.1

Item: 0P-SH-10.3

Probe no.	1
Transmitter	1
Receiver	1
Beam angle	0.0 deg
Gates	4
Rotation	S0 deg



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Projected Dose Rate During NDE on MSB

Projected dose rate during NDE on MSB structural lid weld is based on Cask 6 dose rates on contact with MSB gap and structural lid. Cask 6 values represent the most conservative estimate of projected values based on casks loaded to date. The work requires the MSB to be lifted several inches above the upper surface of the MTC to expose the test surface. Raising the MSB effectively removes a portion of the shielding provided by the structural lid and the upper steel section of the shield lid. For the purposes of this dose estimate several work scenarios were evaluated. The scenarios included:

1. Raising the MSB 3.5 inches above the MTC and shielding (Cask 6 loading)
2. Raising the MSB 4.5 inches above the MTC and shielding w/Fe or Pb (Cask 6 loading)

Actual dose rate measurements for casks 1, 3, 5, and 6 are located below in Table 1. This data was used in projecting dose rates and personnel doses on loadings similar to fuel already loaded. Projected maximum dose rates are based on design fuel load. The projected dose rate with gap shims installed on contact with the gap for design basis fuel is approximately 1,200 mrem/hr.

Table 1

	Cask 1 mrem/hr	Cask 3 mrem/hr	Cask 5 mrem/hr	Cask 6 mrem/hr
Contact Gap (γ) Shims not installed	100	320	180	480
Contact Gap (γ) Shims installed	10	90	35	200
Contact Gap (N) Shims not installed	1	5	1.6	3
Contact Gap (N) Shims installed	.6	4	.7	2.4
Structural Lid Contact (γ)	3	15	5	18
Structural Lid Contact (N)	1	4.2	.6	1.5

Projected dose rates and accumulated dose for the job is considered for each of these scenarios using the same basic assumptions. The dose rate at the top of the MSB/MTC gap due to raising the MSB a specified number of inches was calculated by taking the most conservative observed dose rate (480 mrem/hr, Cask 6) and projecting an increase due to the loss of shielding from the MSB lids and the shortened gap distance.

Most of the dose rate on contact with the MSB/MTC gap is assumed to come from scatter dose from the gap. 95% of the measured dose rate (480 mrem/hr) at the MSB/MTC gap is assumed to be due to streaming from the active fuel region of the MSB/MTC gap. The remaining 5% of the dose is assumed to be due to dose from the top of the fuel which is partly attenuated by the shield lid and the gap shims, if installed.

- Assumed Shielding Thicknesses:
  - Structural lid: 3 inches of steel. (3.81 HVL)
  - Shield lid: 7.5 inches of steel (9.53 HVL)
    2 inches of RX-277 (.85 HVL)

  For the basis of this calculation the RX -277 is approximated be the HVL of concrete
- HVL of gap shims is approximately 1.27 HVL.
- HVL of proposed 1" steel shielding ring is approximately 1.27 HVL
- HVL of proposed 1" lead shielding ring is approximately 2.31 HVL
- HVL of water level in gap is approximately 3.81 HVL (ANO)
- Raising the water level in the MSB will reduce the gap contact dose rate due to reduction of dose rates above the fuel and dose rates in the gap.

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The removal of shielding due to lifting the MSB from the MTC results in an increased dose rate due to two factors.

1. Contribution due to dose from the upper nozzle area increases due to the removal of shielding.
2. Contribution due to scattered streaming from the gap area increases due to the gap being shortened.

The contribution from the removal of approximately 4.5 inches of shielding is calculated to be an additional 950 mrem/hr (γ) with gap shims not installed. This number is derived from taking the projected dose rate in the upper nozzle area and taking into account the reduced shielding as the MSB is removed. The increase due to the shortened gap area is projected to be approximately 905 mrem/hr (γ) with gap shims not installed.

The contribution from the removal of approximately 3.5 inches of shielding is calculated to be an additional 394 mrem/hr (γ) with gap shims not installed. The increase due to the shortened gap area is projected to be approximately 760 mrem/hr (γ) with gap shims not installed.

Conclusions (Summarized in Table 2)

The overall unshielded gamma dose rate (Cask 6) at the top of the gap after lifting the MSB 3.5 inches is projected to be:

Existing dose rate at gap	*480 mrem/hr*
Increase due to loss of shielding	*394 mrem/hr*
Increase due to decreasing gap distance	*760 mrem/hr*
Total	***1634 mrem/hr***

Projected dose rate is a contact dose rate at the top of the MSB/MTC gap. **The addition of gap shims could reduce this contact dose rate to about 678 mrem/hr.** There would be an increase in the general area dose rates above the MTC and the MSB structural lid due to these increases; however, the GA dose rates will be at least a factor of 10 less.

The overall unshielded gamma dose rate (Cask 6) at the top of the gap after lifting the MSB 4.5 inches is projected to be:

Existing dose rate at gap	*480 mrem/hr*
Increase due to loss of shielding	*950 mrem/hr*
Increase due to decreasing gap distance	*905 mrem/hr*
Total	***2,335 mrem/hr***

It should be pointed out that this projected dose rate is a contact dose rate at the top of the MSB/MTC gap. **The addition of gap shims could reduce the contact dose rate to about 968 mrem/hr. The addition of steel shielding (1 inch thick by 2 inches wide) above the gap shims could further reduce the contact dose rate to approximately 400 mrem/hr.** As in the assumption above, the general area dose rates above the MTC and the MSB structural lid due to these increases are expected to be a factor of 10 less than contact dose rates.

The overall unshielded neutron dose rate at the top of the cask for a four inch lift is projected to be:

Existing dose rate at gap	3 mrem/hr
Increase due to loss of shielding	2 mrem/hr
Increase due to decreasing gap distance	23 mrem/hr
Total	**28 mrem/hr**

The overall increase in neutron dose rate is projected to be much smaller. Measurements of neutron dose rates during the four initial cask loads indicate that the installation of gap shims reduce the neutron dose rate by about 1/4. Based on this information, the projected neutron dose rate with gap shims installed would be about 21 mrem/hr. The addition of another 1 inch of steel is not expected to have a significant impact on neutron dose levels.

The overall unshielded gamma dose rate (Design Fuel) at the top of the gap after lifting the MSB 3.5 and (4.5 inches) was projected using MicroShield software. The expected dose rate at the gap after lifting the MSB was approximately 2100 mrem/hr and(5500 mrem/hr) respectively.

The addition of gap shims should reduce this contact dose rate to about 870 mrem/hr (2280 mrem/hr for 4.5 inch lift). The addition of steel shielding (1 inch thick by 2 inches wide) above the gap shims should further reduce the contact dose rate to approximately 360 mrem/hr *(945 mrem/hr). The general area dose rates above the MTC and the MSB structural lid due to these increases are expected to be a factor of 10 less than contact dose rates.

The overall unshielded neutron dose rate at the top of the cask is projected to be:

Existing dose rate at gap	12 mrem/hr
Increase due to loss of shielding	10 mrem/hr
Increase due to decreasing gap distance	60 mrem/hr
Total	**82 mrem/hr**

The projected neutron dose rate with gap shims installed would be about 64 mrem/hr. The addition of another 1 inch of steel should help to reduce streaming resulting in about 50 mrem/hr.

* The one inch of additional shielding could not be used to perform the UT exam, but would be effective in reducing exposure for all tasks other than UT exam.

Table 2

	Gap shims not installed mrem/hr	Gap shims installed mrem/hr	Gap shims & Steel ring mrem/hr	Gap shims & Lead ring mrem/hr	Raise water level in CLP mrem/hr*	Raise Water level in MSB mrem/hr
Cask 6 3.5" lift	1.634	678	281**	116**	48	40
Cask 6 4.5" lift	2.335	968	400	166	29	24
Design Fuel 3.5" lift	2.100	870	360**	149**	62	51
Design Fuel 4.5" lift	5.500	2280	945	392	67	55

* Numbers reflect additional reduction after considering steel shield ring.

** Shielding can not be used while performing UT

Total Dose Projections

Based on information supplied by NDE personnel the amount of time required to be spent in the immediate area of the MSB/MTC gap by personnel directly involved in NDE is:

Initial set-up of equipment	.6 man-hours*
Manipulations during scan	1.3 man-hours*
Removal of equipment	.1 man-hours*
Total time for NDE personnel	2.0 man-hours*

* Assumes 2 NDE personnel involved in evolution

Maintenance time at the top of the cask is based on the following assumptions:

Set-up of lifting equipment (shims installed)	3.0 man-hours
Removal of gap shims	.4 man-hours
Replacement of gap shims (after lift)	.3 man-hours
Installation of shield ring	.6 man-hours (.8 man-hours for Pb)
Total time for Maintenance personnel	4.6 man-hours

Projections for total dose for the jobs are listed below:

3.5" lift (Cask 6) (with CLP water level up)

Maintenance (with gap shims)	**.144 man-rem**
Maintenance (w/o gap shims)	**.082 man-rem**
NDE (with gap shims installed)	**.096 man-rem**
Maintenance (with gap shims)	**.144 man-rem**
RP	**.060 man-rem**
Total	**.526 man-rem**

4.5" lift (Cask 6) (with CLP water level up)	
Maintenance (with gap shims)	**.087 man-rem**
Maintenance (w/o gap shims)	**.116 man-rem**
Maintenance (install shield ring)	**.084 man rem**
NDE (w/ gap shims & shield ring)	**.058 man-rem**
Maintenance(with gap shims)	**.087 man-rem**
RP	**.080 man-rem**
Total	**.512 man-rem**

Recommendations

Due to the increased fuel length the dose rates at the top of the gap while loading Unit 2 fuel area assumed to be the higher (bounding case). It is recommended that this work be performed with gap shims and a lead shield ring mounted to the top of the MTC to provide additional shielding. Additional considerations are listed below.

1. Mock-up should be performed prior to actual performance of MSB lift and NDE.
2. Gap should be shielded with gap shims and steel or lead shield ring after raising MSB.
3. Water level should be maintained as high as possible in the gap to minimize shine.
4. Tele-dosimetry will be a requirement for entry into the weld tent.
5. Neutron dosimetry will be a requirement for entry into the welding tent.
6. Personnel involved in work around unshielded gap may require extra-issue whole body and/or extremity dosimetry .
7. Work platform area may need to be controlled as a "Locked High Radiation Area". This may require modification to tent door to provide the capability of locking.

Cask 6 Calculations

Assumptions:

1.	Highest MSB gap dose rate with shield lid and structural lid in place	480 mrem/hr
2.	Dose rate on top of structural lid (Cask 6)	18 mrem/hr
3.	Contribution to gap dose rate through MSB lids	≈ 24 mrem/hr
4.	Remainder of dose rate due to shine from gap	456 mrem/hr
5.	Design basis dose rate in upper nozzle area (under shield lid)	336, 424 mrem/hr

Dose Rate Increase Due to Loss of Shielding from Lids

3.5 inch lift

$DR_{Shielded} = DR_{Unshielded} X (1/2)^{HLV}$

$DR_{Shielded} = 336, 424 X (1/2)^{6.35}$ (5 inches steel)

$DR_{Shielded} = 4124$ mrem/hr

$DR_{Shielded} = 4124 (1/2)^{.8467}$ (2 inches RX-277)

$DR_{Shielded} = 2293$ mrem/hr

$DR_{Shielded} = 2293 (1/2)^{2.54}$

$DR_{Shielded} = 394$ mrem/hr

4.5 inch lift

$DR_{Shielded} = DR_{Unshielded} X (1/2)^{HLV}$

$DR_{Shielded} = 4124 (1/2)^{.8467}$ (2 inches RX-277)

$DR_{Shielded} = 2293$ mrem/hr

$DR_{Shielded} = 2293 (1/2)^{1.72}$

$DR_{Shielded} = 950$ mrem/hr

Dose rate increase due to loss of shielding thickness (3.5 inch lift) 394 mrem/hr
Dose rate increase due to loss of shielding thickness (4.5 inch lift) 950 mrem/hr

Dose Rate Increase Due to Loss of Gap Distance

3.5 inch lift

$D_1(R_1)^2=D_2(R_2)^2$

$D_1 = (480-24)(15.5)^2$

$D_1 = 109{,}554$ mrem/hr in the gap

$D_2 = 109{,}554 / 144$

D2 = 760 mrem/hr

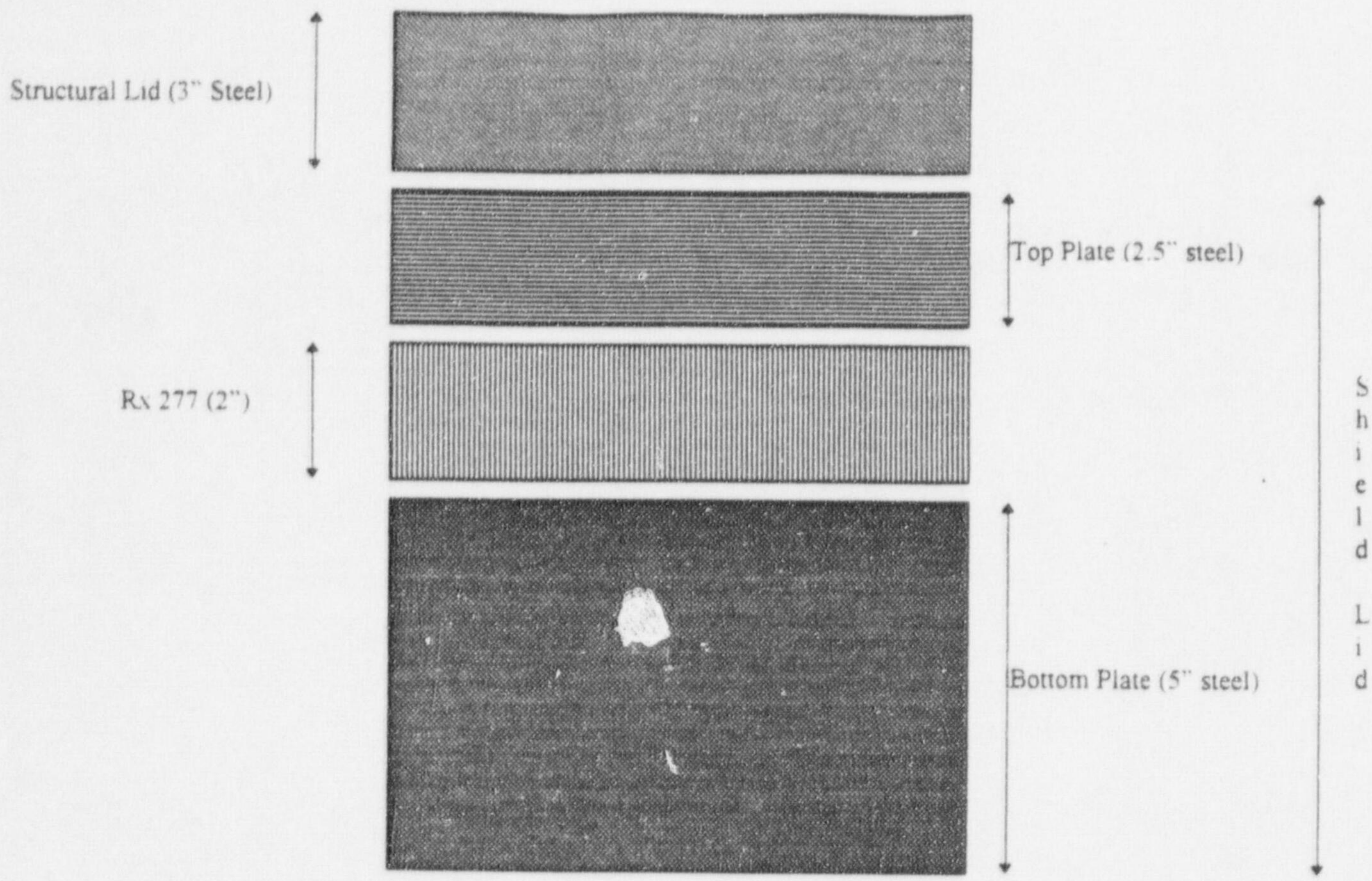
4.5 inch lift

$D_1(R_1)^2=D_2(R_2)^2$

$D_2 = 109{,}554 / 121$

D2 = 905 mrem/hr

Dose rate increase due to loss of gap distance (3.5 inch lift) 760 mrem/hr
Dose rate increase due to loss of gap distance (4.5 inch lift) 905 mrem/hr


Structural Lid (3" Steel)
Top Plate (2.5" steel)
Rx 277 (2")
Shield Lid
Bottom Plate (5" steel)

P-SCAN Indication Summary
Report Form

Search Unit 0° 10 MHz 1/2"

	Ind #	X Start	X End	Indication Length	Zone Location	TWD	Comments
D FLAW 2	1	73.2"	73.5"	.3"	1/2	.19"	
13	2	82.8"	84.4"	1.6"	1	.26"	
2	3	88.9"	89.6"	.7"	2	.11"	
3	4	91.9"	92.6"	.7"	2	.15"	
4	5	94.7"	95.5"	.8"	2	.15"	
5	6	97.5"	98.2"	.7"	2	.15"	
6	7	100.1"	101.7"	1.6"	2	.30"	
8	8	103.6"	—	—	1	—	REVIEW 45° DATA
9	9	106.2"	—	—	1	—	" " "
10	10	108.9"	109.6"	.7"	1	.19"	
11	11	111.7"	112.4"	.7"	1	.34"	
12	12	114.6"	115.4"	.8"	1	.26"	
ID FLAW 3	13	118.3"	118.6"	.3"	1	.05"	
7	14	121.9"	122.7"	.8"	2	.3"	
26	15	126.1"	126.8"	.7"	4	.19"	
27	16	128.9"	129.5"	.6"	1/3	.3"	
14	17	131.8"	132.6"	.8"	4	.19"	
15	18	134.6"	135.3"	.7"	4	.19"	
16	19	137.5"	138.3"	.8"	4	.20"	
D FLAW 4	20	143.0"	143.5"	.5"	4	.25"	INDICATION APPEARS IN NOISE
17	21	144.7"	145.5"	.8"	4	.15"	
18	22	147.7"	148.4"	.7"	4	.22"	
19	23	150.1"	151.8"	1.7"	4	.25"	

P-SCAN Indication Summary
Report Form

Search Unit 0° 10 MHz 1/2"

	Ind #	X Start	X End	Indication Length	Zone Location	TWD	Comments
28	24	153.3"	154.0"	.7"	3/4	.19"	
29	25	156.2"	156.8"	.6"	3/4	.19"	
30	26	159.0"	159.7"	.7"	3/4	.4"	
22	27	176.2"	176.8"	.6"	3	—	
23	28	179.2"	179.8"	.6"	3	—	
24	29	181.9"	182.5"	.6"	3	—	
FLAW 5	30	185.8"	188.3"	2.5"	3	.27"	
25	31	190.9"	192.6"	1.7"	3	.228"	

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P-SCAN Indication Summary
Report Form

Search Unit 45° Ax

	Ind #	X Start	X End	Indication Length	Zone Location	TWD	Comments
13	1	83.0"	84.7"	1.7"	1	.27"	
8	2	103.1"	103.7"	.6"	1	.1"	
9	3	105.8"	106.6"	.8"	1	.1"	
10	4	108.5"	109.5"	1.0"	1	.17"	
11	5	111.5"	112.3"	.8"	1	.12"	
12	6	114.3	115.1"	.8"	1	.17"	
28	7	153.2"	153.8"	.6"	3/4	.24"	
29	8	155.9"	156.5"	.6"	3/4	.21"	
30	9	158.8"	159.4"	.6"	3/4	.35"	
20	10	170.2"	171.1"	.9"	3	.20"	
21	11	173.1"	174.0"	.9"	3	.23"	
22	12	175.9"	177.0"	1.1"	3	.20"	
23	13	178.8"	179.8"	1.0"	3	.20"	
24	14	181.8"	182.7"	.9"	3	.27"	
Flaw 5	15	185.2"	188.1"	2.9"	1/3	.20"	
25	16	190.7	192.8"	2.1"	3	.30"	

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P-SCAN Indication Summary
Report Form

Search Unit 45° CIRC

	Ind #	X Start	X End	Indication Length	Zone Location	TWD	Comments
			45° CW				
31	1	162.8"	—	.470"	3/4	.167"	AXIAL FLAW
32	2	165.5"	—	.340"	3/4	.20"	AXIAL FLAW
33	3	168.0"	—	.44"	3/4	.20"	AXIAL FLAW
			45° CCW				
31	1	163.5"	—	.37"	3/4	.170"	AXIAL FLAW
32	2	165.0"	—	.30"	3/4	.10"	AXIAL FLAW

[illegible]