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Identification of a Breached Fuel Pin in the Interim Examination and Maintenance Cell

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IDENTIFICATION OF A BREACHED FUEL PIN IN THE IEM CELL

By

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ABSTRACT

At the Interim Examination and Maintenance (IEM) Cell, experiments are routinely disassembled and examined following irradiation in the Fast Flux Test Facility (FFTF). Recently and for the first time, a fueled experiment which had breached its cladding during irradiation was disassembled in the cell. The processing objective was to locate and identify the one pin (out of 217 pins) with breached cladding, and recover selected test pins for further examination. Identification of the breached pin proved to be challenging. After all pins were weighed the data were inconclusive, and alternate procedures had to be developed and implemented. Ultimately, four independent methods were used to pinpoint the breached pin.

INTRODUCTION

The Fast Flux Test Facility (FFTF) is a U. S. Government owned 400 MWT sodium-cooled fast reactor plant designed for irradiation testing of nuclear reactor fuels and materials, safety R&D, equipment demonstration for liquid metal fast reactors and advanced reactor concept testing. The FFTF is located on the Department of Energy's Hanford Site near Richland, Washington and is operated by Westinghouse Hanford Company, a wholly owned subsidiary of Westinghouse Electric Corporation.

The Interim Examination and Maintenance (IEM) Cell is located inside the FFTF containment building, and is used for disassembly and examination of irradiated fuel and material experiments, as well as remote maintenance activities.

All in-cell equipment is designed to operate in a dry argon atmosphere and in a high radiation environment. All cell operations are performed remotely using master slave manipulators (MSMs) at window stations, two remote controlled Electro-Mechanical Manipulators (EMMs) and two overhead cranes (1-ton and 4-ton).

BACKGROUND

An experimental fuel assembly known to contain at least one breached fuel pin was removed from the FFTF reactor in November, 1984. Later, this assembly was brought into the FFTF's IEM Cell to be disassembled and, for the first time ever at FFTF, to identify a breached fuel pin. Normally, fuel assemblies processed in the IEM Cell are water washed to remove all residual sodium prior to disassembly. However, because of the potential contamination of the sodium removal system, this assembly could not be washed and therefore received only a hot argon blowdown to remove excess sodium.

Most of the FFTF fuel assemblies have 217 fuel pins. Each fuel pin contains a tag gas, unique to that assembly, which enables the reactor operators to quickly identify an assembly with a leaking fuel pin. Calculations predicted that the release of fission gases and other volatile fission products from the breached pin into the primary coolant would result in a pin weight reduction of approximately 1900 milligrams. A pin weighing system was developed which could accurately weigh each of the assembly's fuel pins to within 100 milligrams. This weighing was intended to be the primary method used to identify the breached pin. Unfortunately, when all 217 pins had been weighed after disassembly, the weight difference data were inconclusive. Several pins were considered suspect due to weight loss or visual indication, but no single pin showed a significant enough weight change or visual flaw to be specifically identified as the breached pin. The most plausible explanation for the absence of a significant weight change was that sodium had entered the breach site, and had approximately cancelled the weight loss of the escaped fission gas and other volatile fission products.

INDIVIDUAL PIN WASHING STATION

A new strategy was quickly developed to identify the breached pin. Because the pins were still coated with sodium, and it was suspected that there was sodium in the breach, it was decided that selected pins should be individually washed and then reweighed. In two weeks, a portable wash station was designed and thirteen wash containers were fabricated. The wash station consisted of an upper tank connected to a existing single pin container with a quick disconnect fitting (see Figure 1). A candidate fuel pin was placed in the upright pin container in the cell. The tank, which had been previously filled with de-ionized water and passed into the cell, was then connected to the pin container via the quick disconnect. The vent valve at the top of the tank and the valve the at bottom of the tank were then opened, allowing the wash water to fill the pin container and react with the residual sodium on the fuel pin. The vent valve was then closed and the entire wash station was lifted and inverted with an EMM (see Figure 2). When the wash water had completely drained into the tank, the bottom valve was closed and the wash station uprighted. The tank was then separated from the pin container and transferred from the cell. The fuel pin's wire wrap was removed and the pin cladding was smeared and counted for activity. Finally, the pin was visually re-examined and reweighed. As a parallel activity, water samples were taken from each wash station tank at the FFTF decontamination facility. Each sample was subjected to radiochemical analysis for fission products, providing additional data to aid in identifying the breached fuel pin. Using this procedure would provide four important pieces of information that could be used together to identify the breached fuel pin.

- Pin weight loss(after weighing).
- Smear activity.
- Wash water activity(alpha count rate).
- Visual examination.

PIN IDENTIFICATION

Thirteen initial suspect pins were selected for examination by this method. After these thirteen pins had been washed, the pattern of count rates from the pin smears directed the search to a particular region of the assembly. Using the pin bundle map as a guide, pins from that part of the pin bundle were selected to be washed and reweighed. By following the pattern of higher smear activity and selecting the next pin to be weighed based on the previous pin's activity, the breached pin was positively identified (see Figures 3 and 4). When the 23rd pin was removed from its wash container, the breach site was immediately apparent, since residual sodium and water were still reacting. The breach (see Figure 5) had been hidden from earlier visual detection by the wire wrap. Later, both the radiochemical analysis of the wash water and the results of reweighing positively confirmed the identification (see Figure 6).

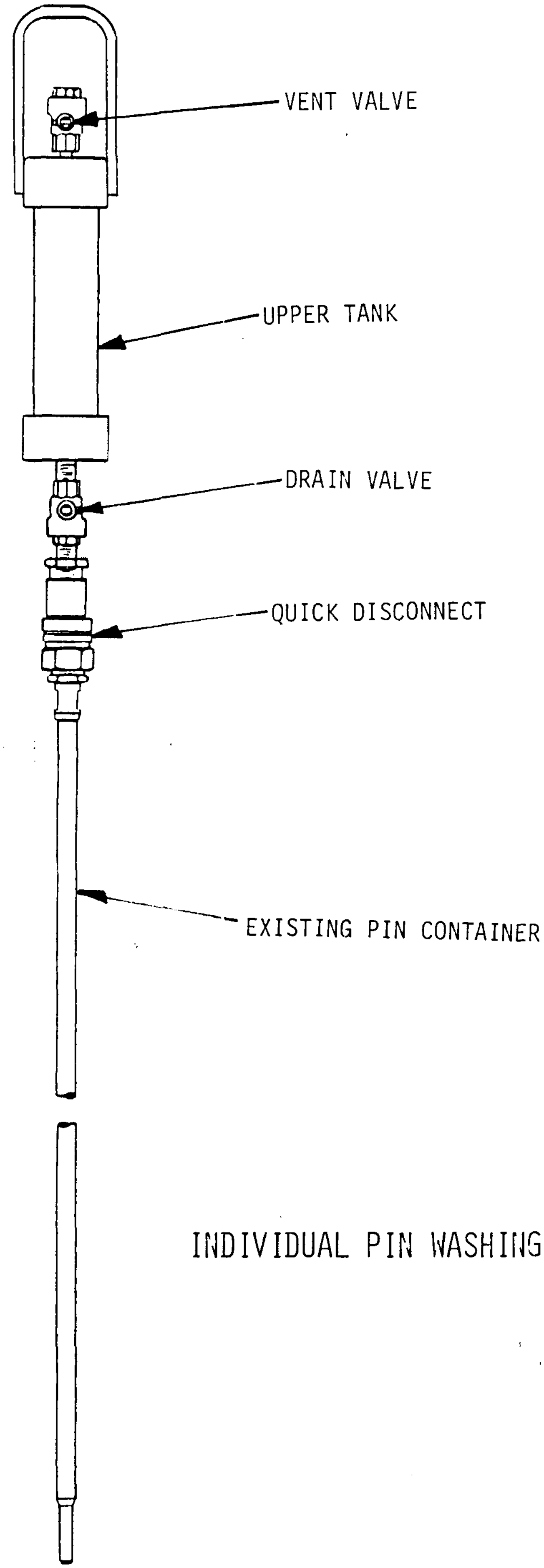
SUMMARY

Through ingenuity, the potential problem of identifying a fuel pin with breached cladding became a success story. The synergistic evaluation of the four different verification techniques, (visual examination, pin cladding smear activity, wash water radiochemistry, and pin weight) provided for a rapid and positive identification of the breached fuel pin. The capability to perform future "detective" work of this kind has been conclusively demonstrated.

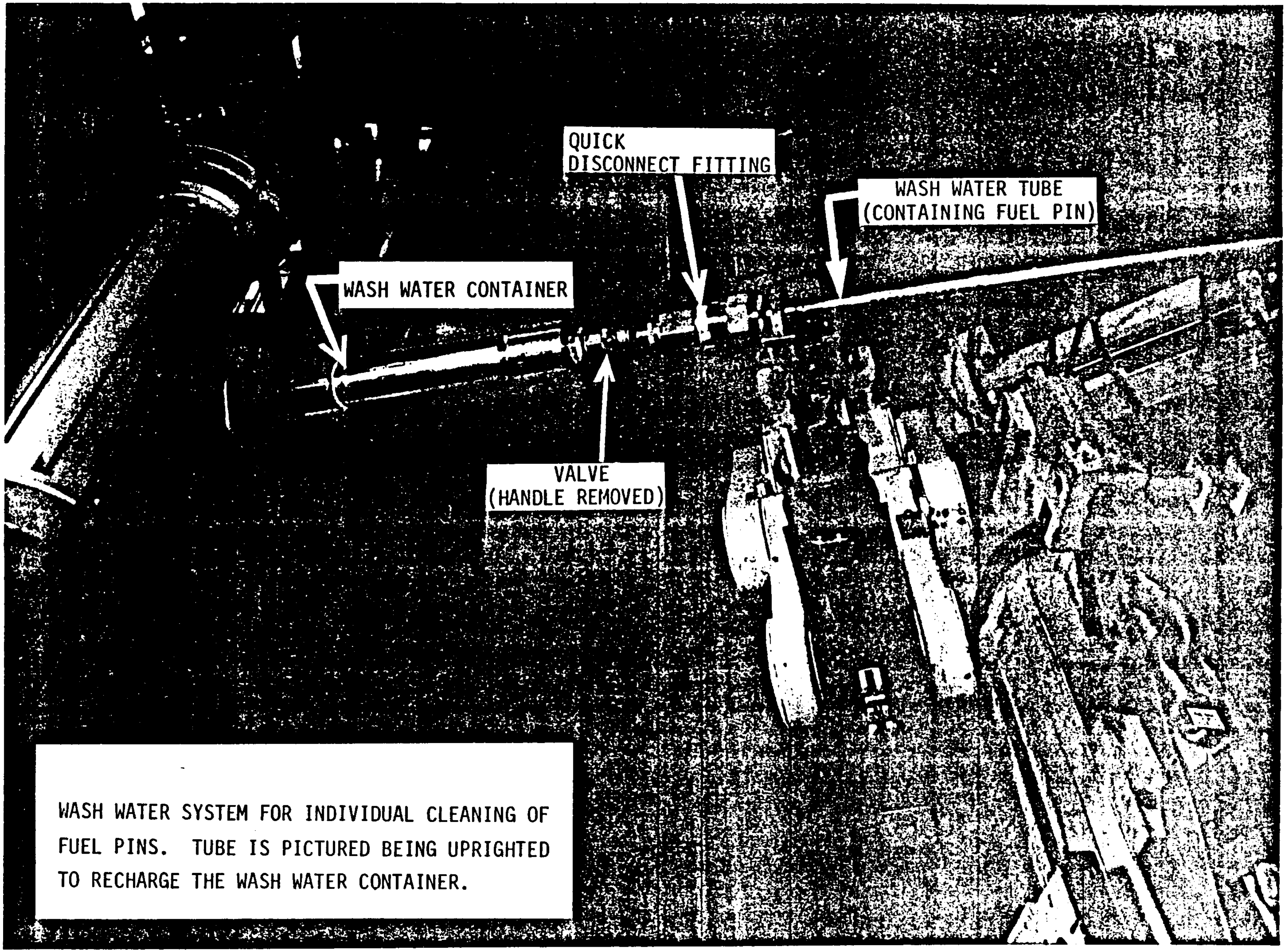
REFERENCES

1. P. W. Gibbons, "FFTF/IEM Cell Fuel Pin Weighing System," ANS Proceedings 35th Conference on Remote Systems Technology, 1987.

2. M. O. Anglesey and D. M. Romrell, "Remote Weighing of Irradiated Fuel Pins at FFTF," ANS Proceedings, 34th Conference on Remote Systems Technology, 1986.



INDIVIDUAL PIN WASHING STATION

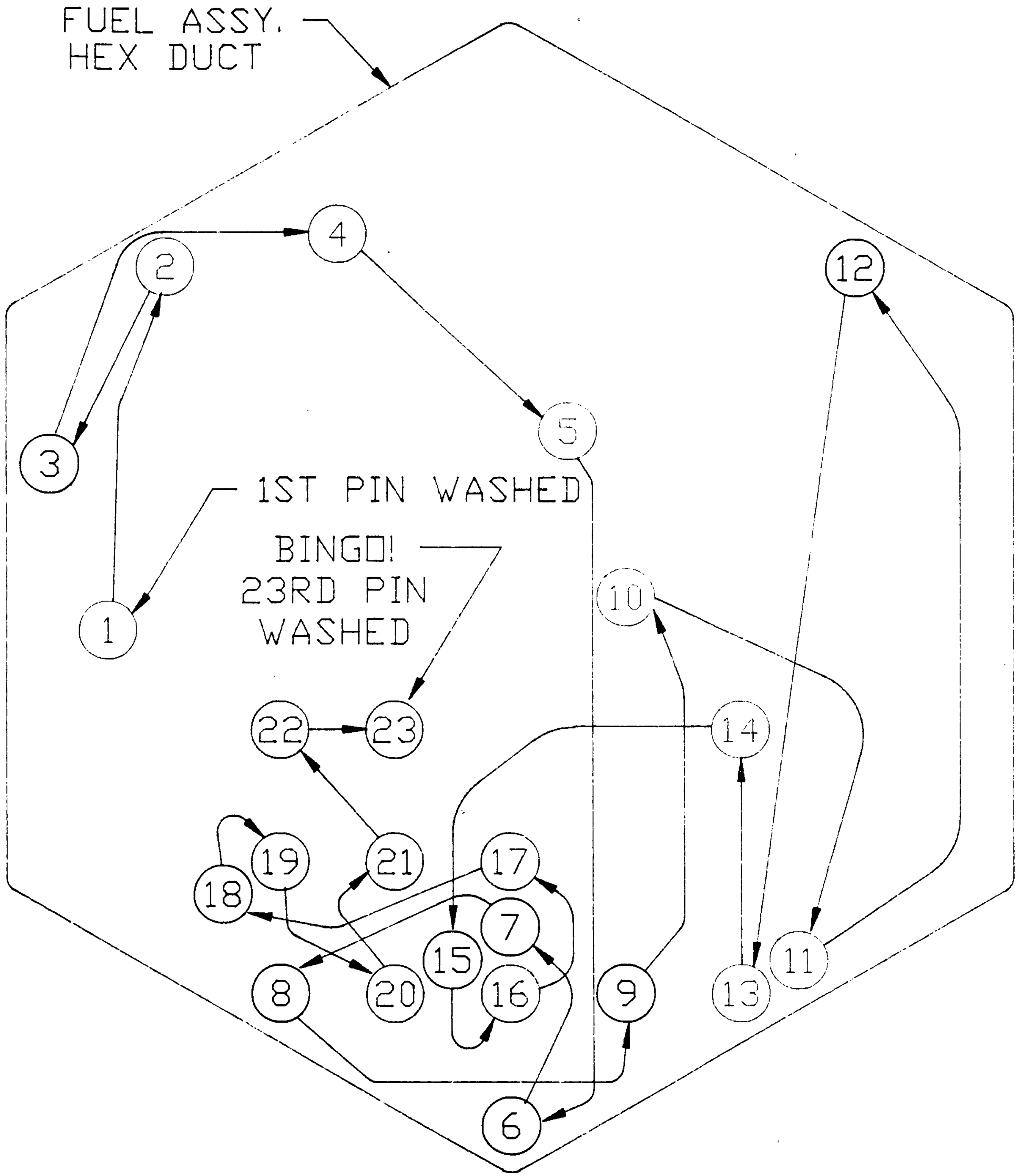


WASH WATER SYSTEM FOR INDIVIDUAL CLEANING OF FUEL PINS. TUBE IS PICTURED BEING UPRIGHTED TO RECHARGE THE WASH WATER CONTAINER.

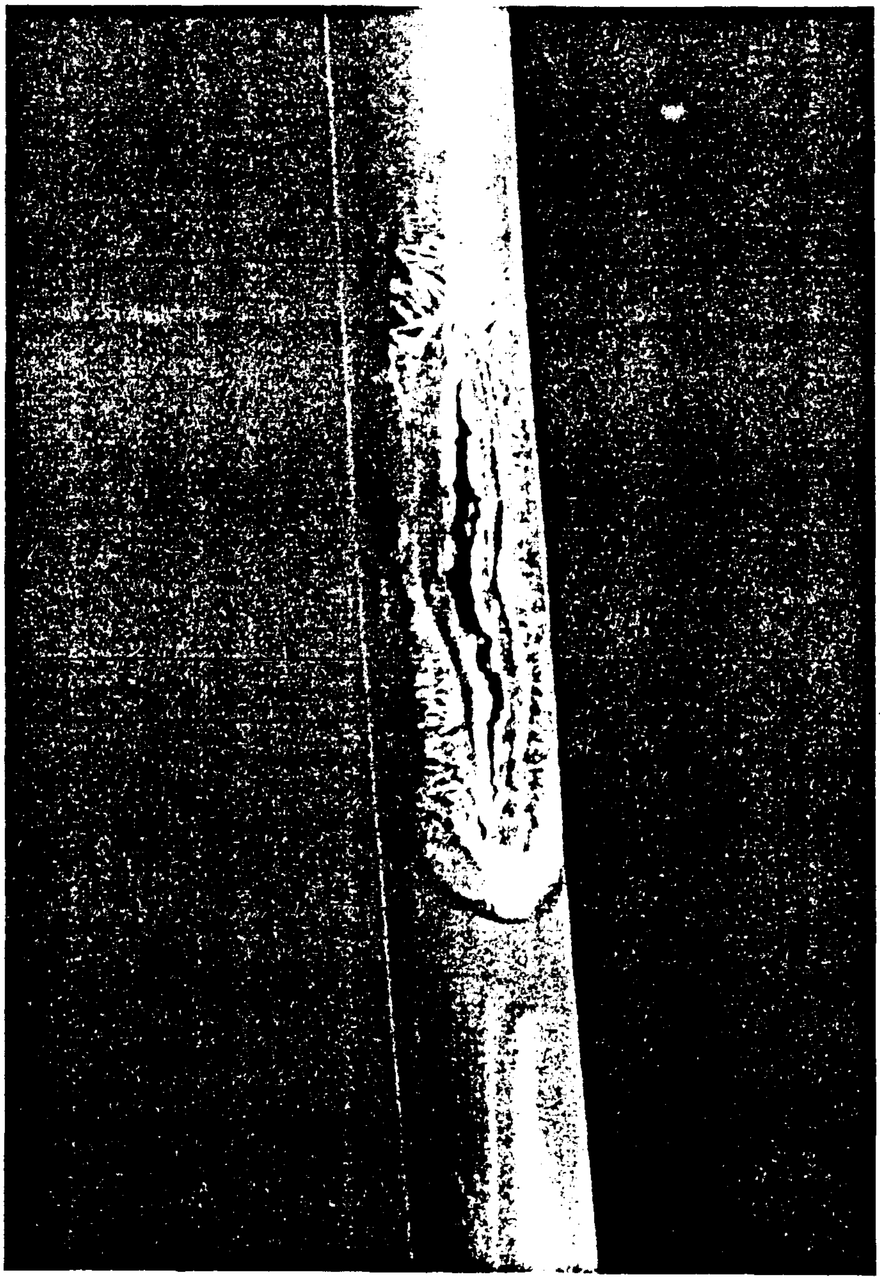
INDIVIDUAL PIN WASHING (IN SEQUENCE)

PIN S/N	WASH CONTAINER EXTERNAL COUNTRATE β-γ (mR/hr)	*WEIGHT LOSS ΔW(g)	PIN SWIPES α (dpm)	PIN SWIPES β-γ (mR/hr)
1	50-55	30.68	<500	2
2	13	30.68	1050	1
3	10	30.59	1400	3
4	---	30.59	700	2.5
5	---	30.68	500	3.5
6	7	30.55	<500	0.5
7	100	30.52	8750	50
8	25	30.53	9100	12
9	20	30.50	980	10
10	70	30.56	1120	25
11	8	30.47	2100	4.3
12	11	30.60	2100	6
13	10	30.61	1120	2.5
14	35	30.67	2100	25
15	47	30.52	12,600	11
16	25	30.72	7,000	13
17	220	30.63	21,000	70
18	150	30.64	21,000	30
19	350	30.71	49,000	45
20	40	30.59	12,600	17
21	500	30.63	28,000	35
22	380	30.59	168,000	100
23	2000	30.78	4,900,000	>5000

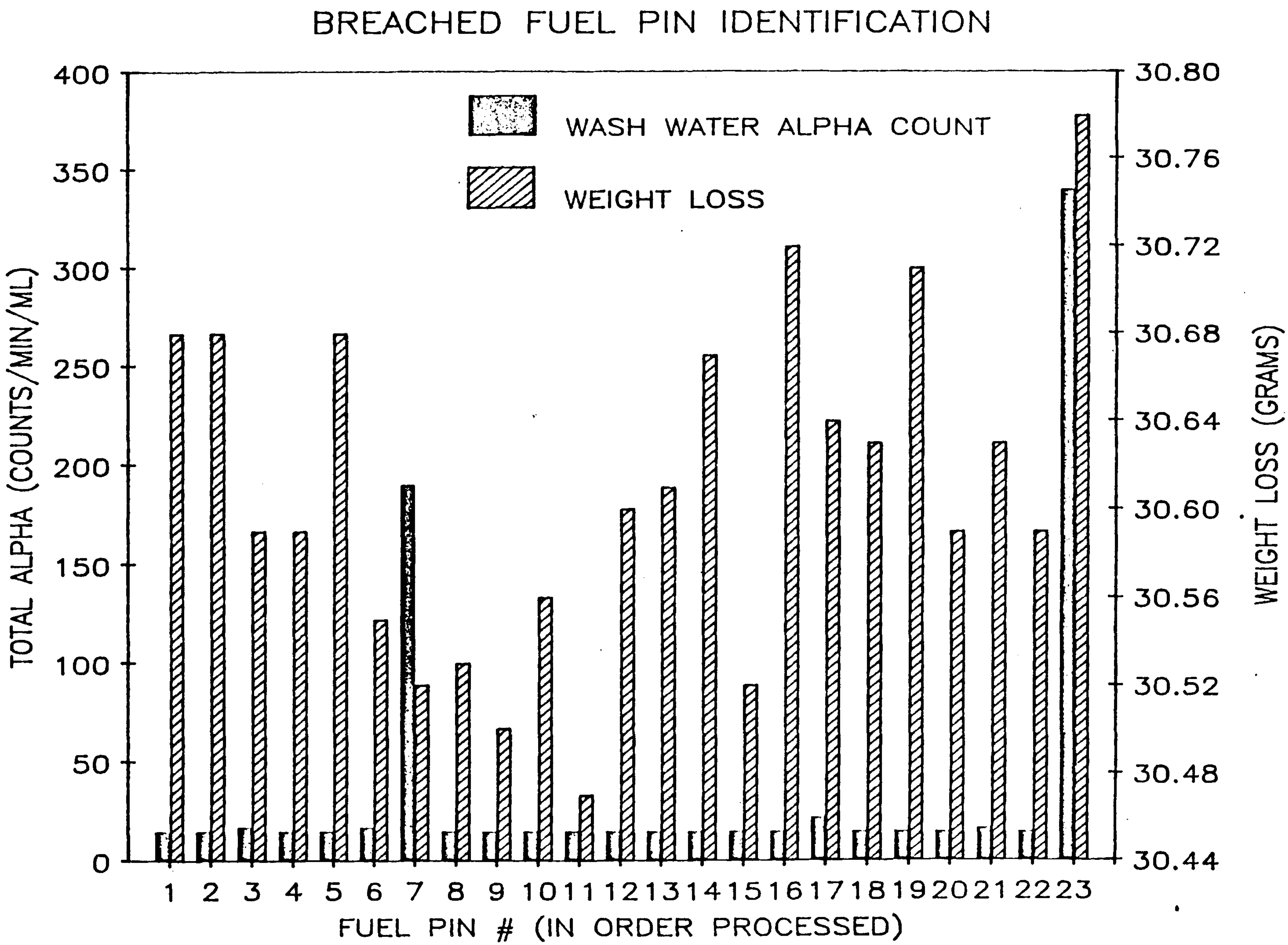
*Weight loss between pre-irradiated and post-processed conditions   Pin washed and wire wrap removed during processing.

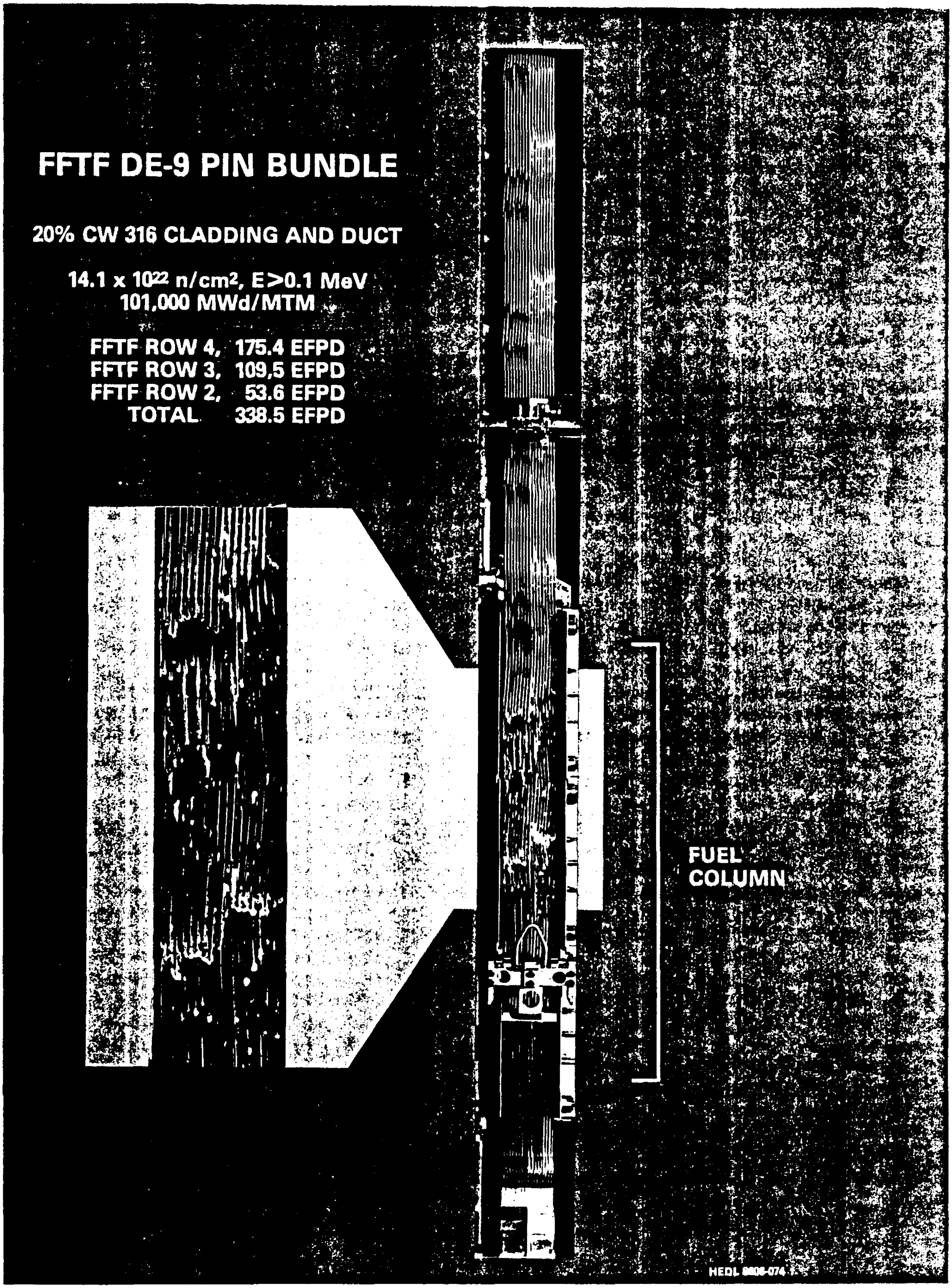


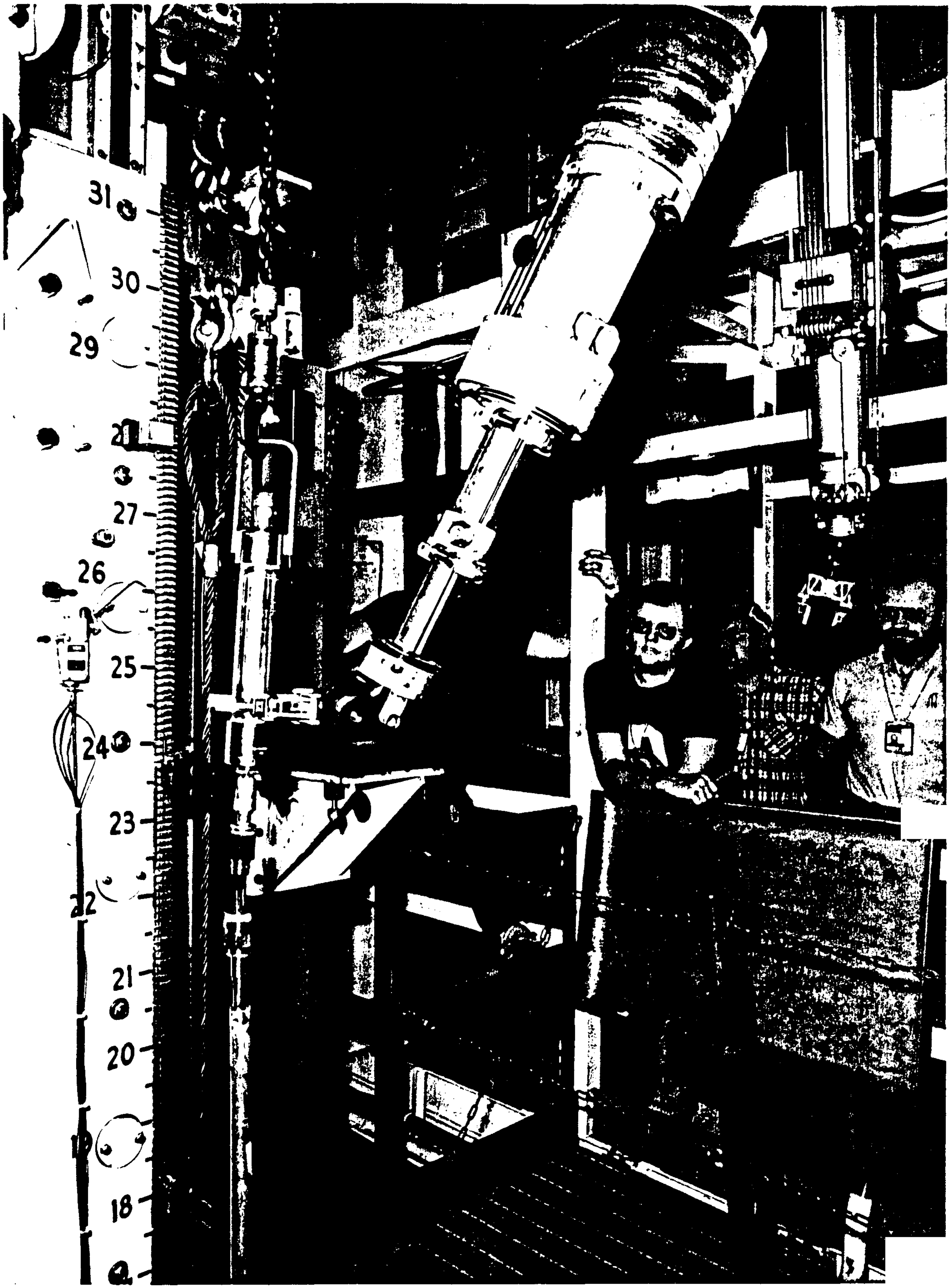
INDIVIDUAL PIN WASHING SEQUENCE
(PINS SHOWN IN BUNDLE LOCATIONS)



BREACHED FUEL PIN CLADDING
(AFTER WATER WASH)


BREACHED FUEL PIN IDENTIFICATION
WASH WATER ALPHA COUNT
WEIGHT LOSS
TOTAL ALPHA (COUNTS/MIN/ML)
WEIGHT LOSS (GRAMS)
0
50
100
150
200
250
300
350
400
30.44
30.48
30.52
30.56
30.60
30.64
30.68
30.72
30.76
30.80
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
FUEL PIN # (IN ORDER PROCESSED)


FFTF DE-9 PIN BUNDLE
20% CW 316 CLADDING AND DUCT
14.1 x 10^{22} n/cm^{2}, E>0.1 MeV
101,000 MWd/MTM
FFTF ROW 4, 175.4 EFPD
FFTF ROW 3, 109.5 EFPD
FFTF ROW 2, 53.6 EFPD
TOTAL 338.5 EFPD
FUEL COLUMN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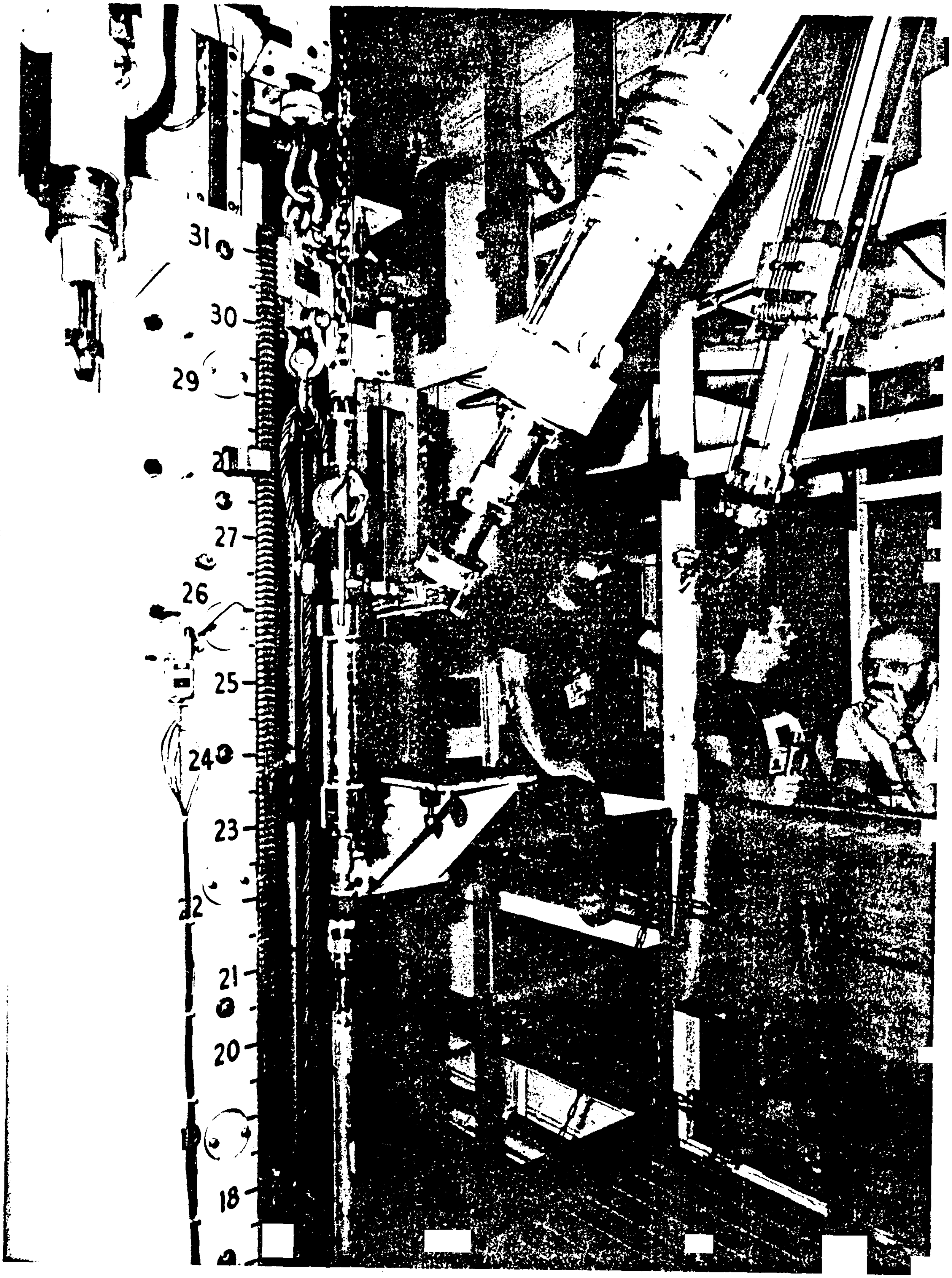
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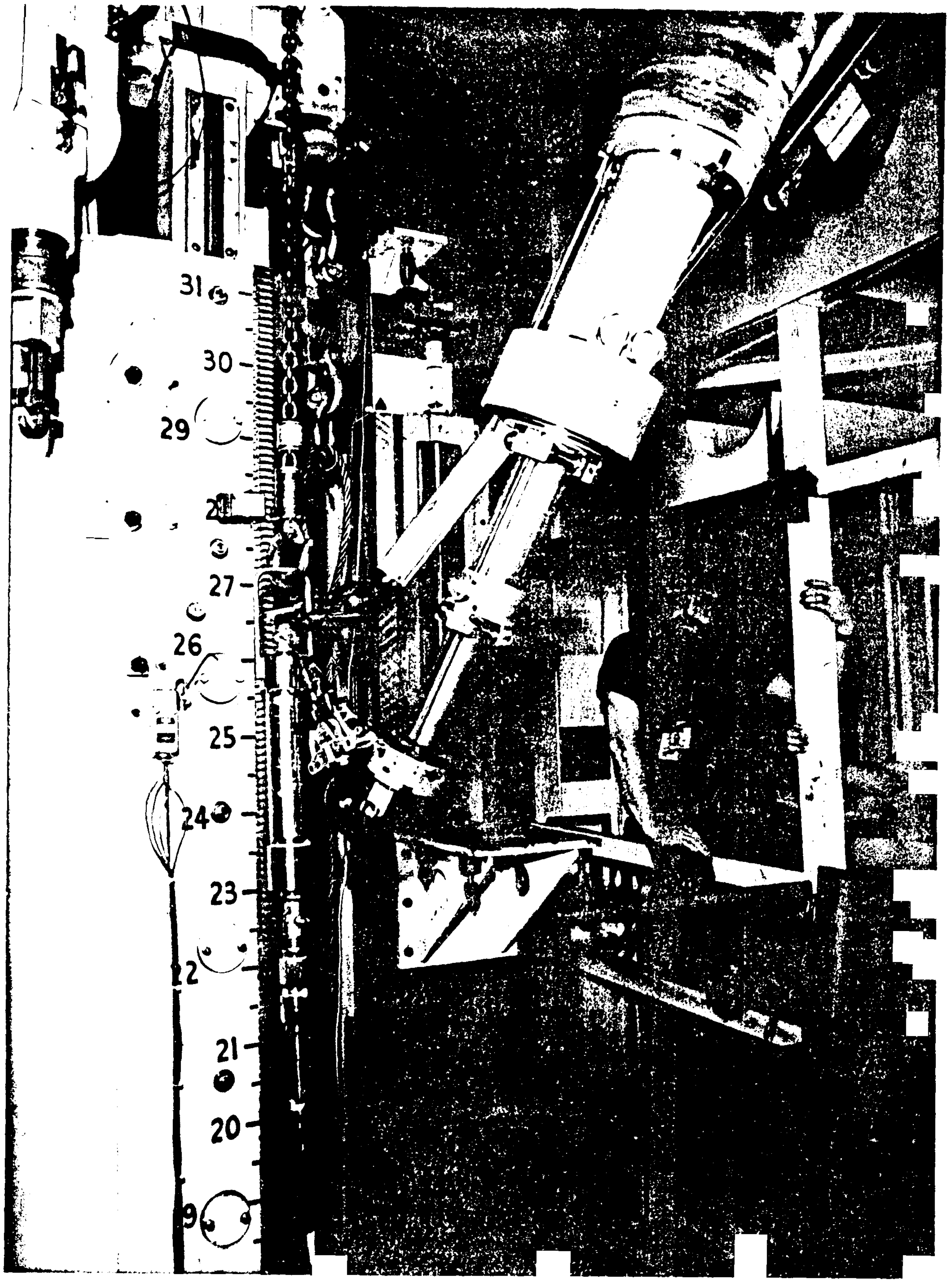
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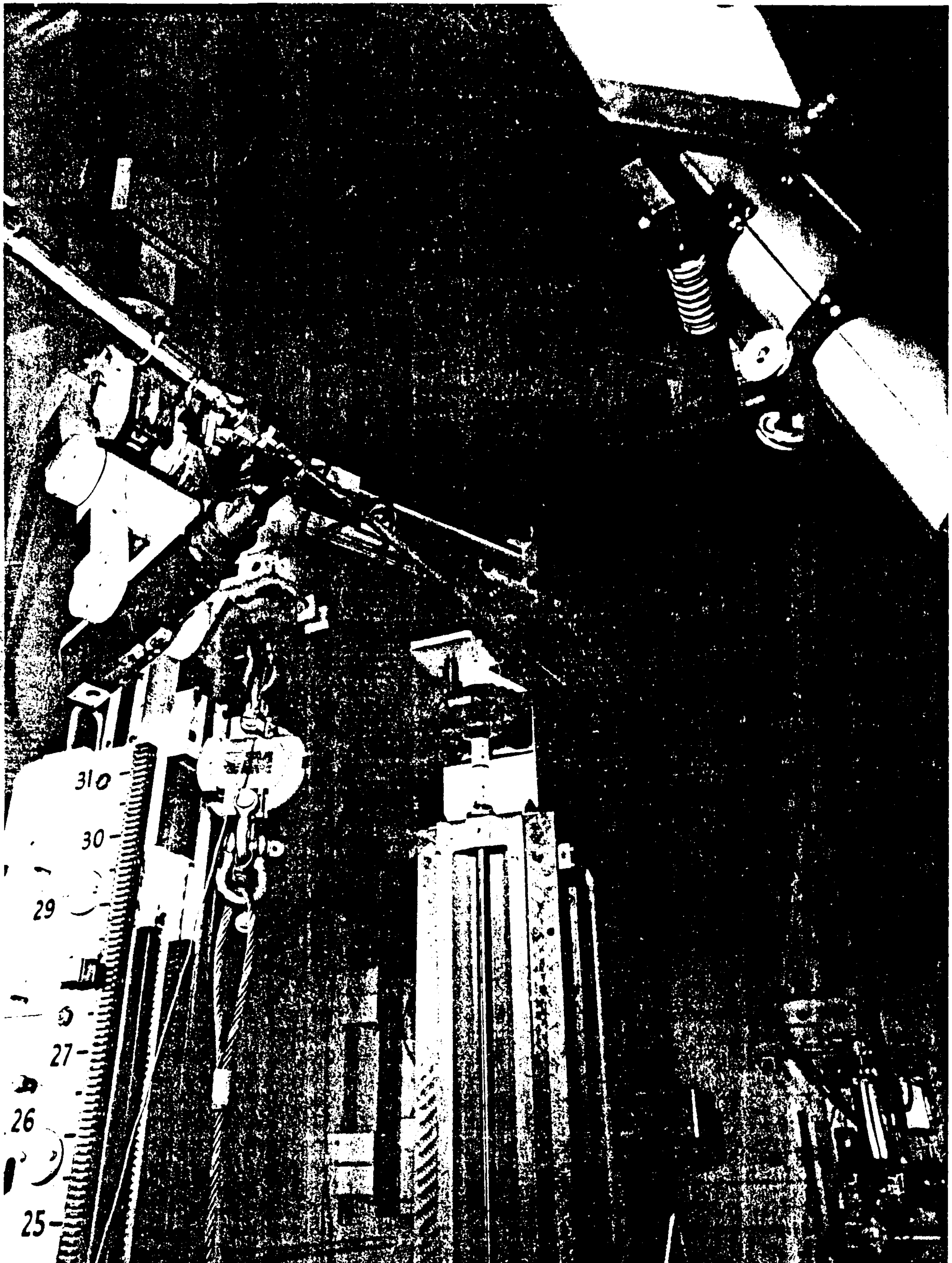
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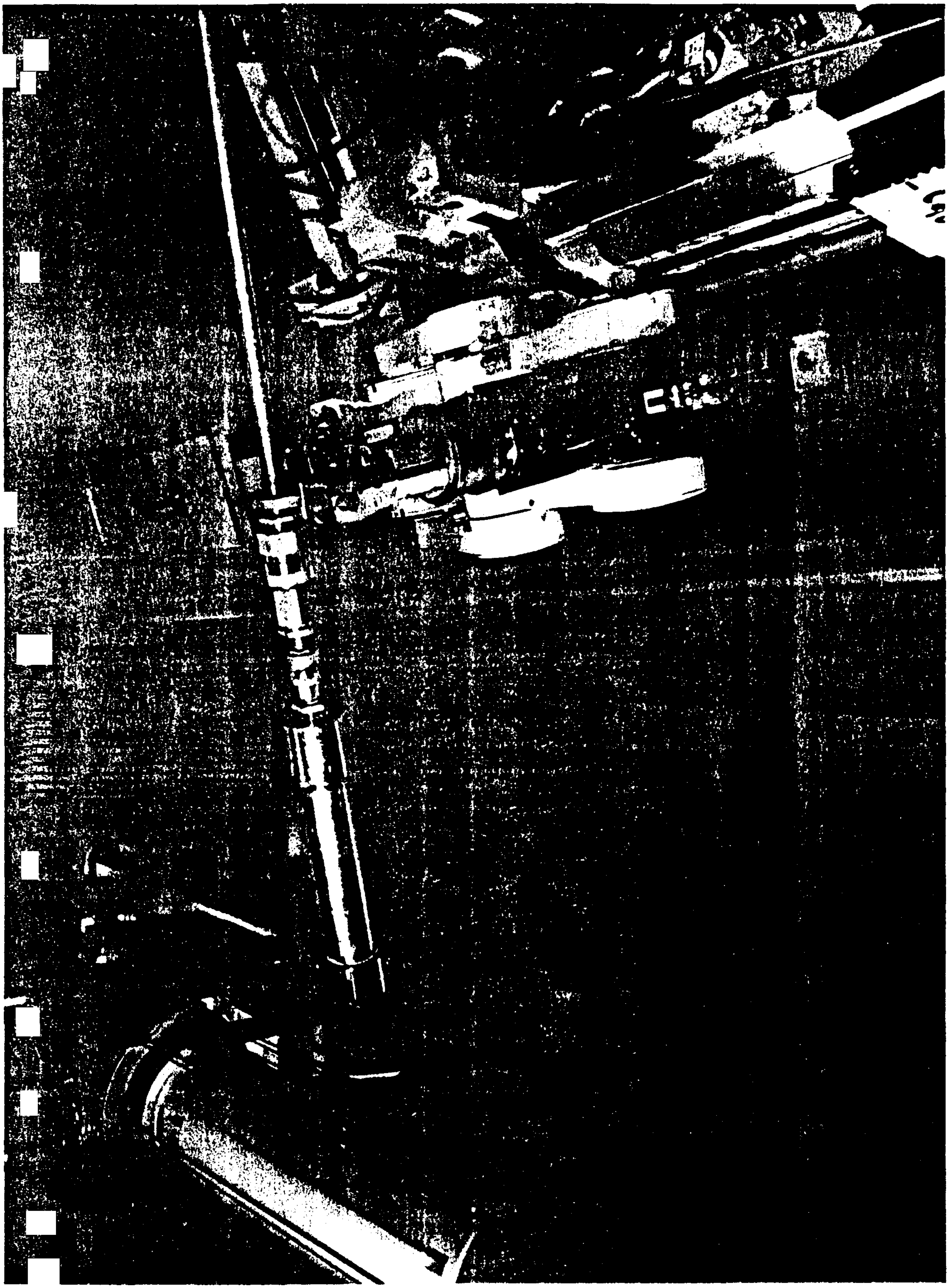

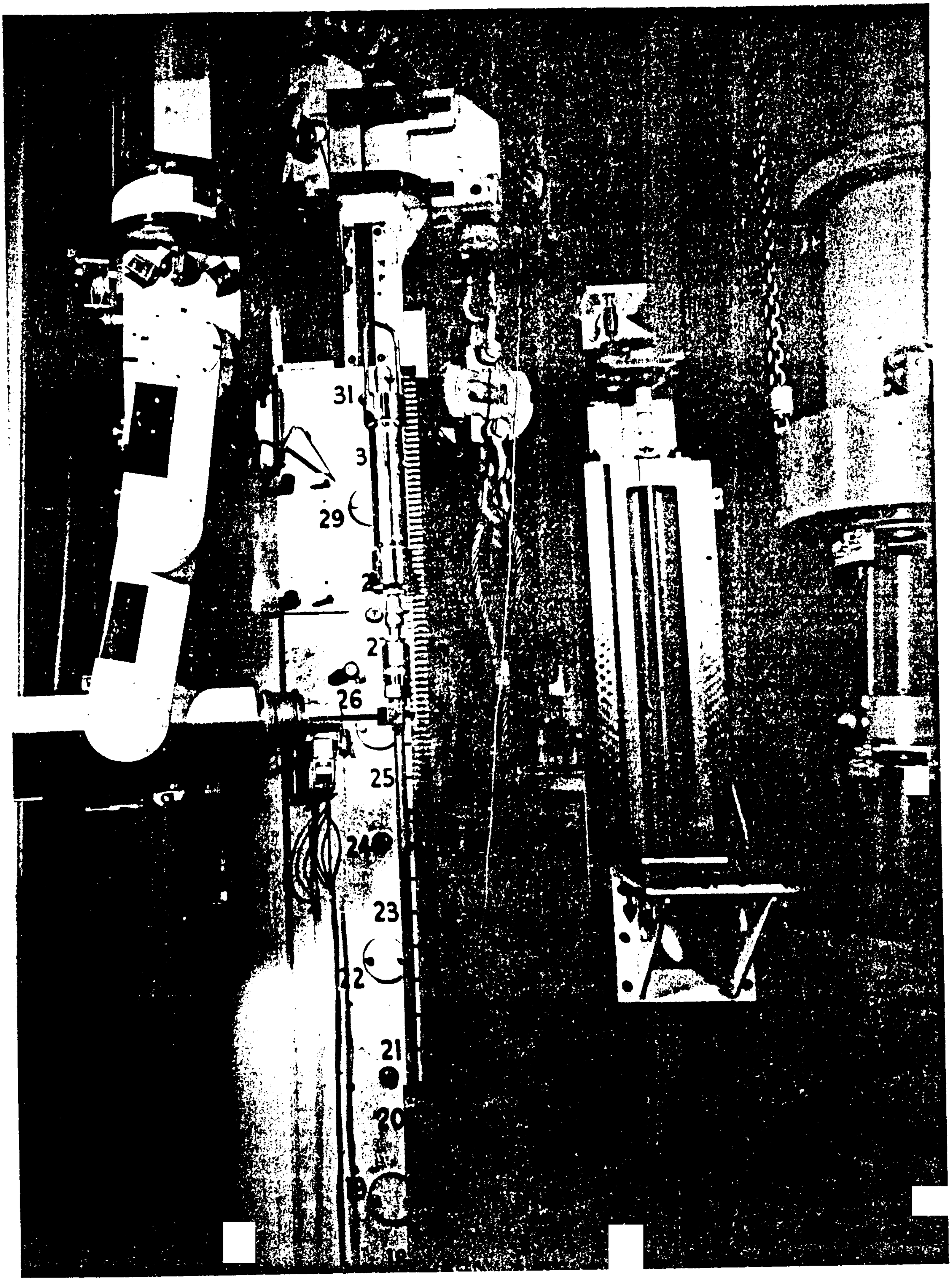
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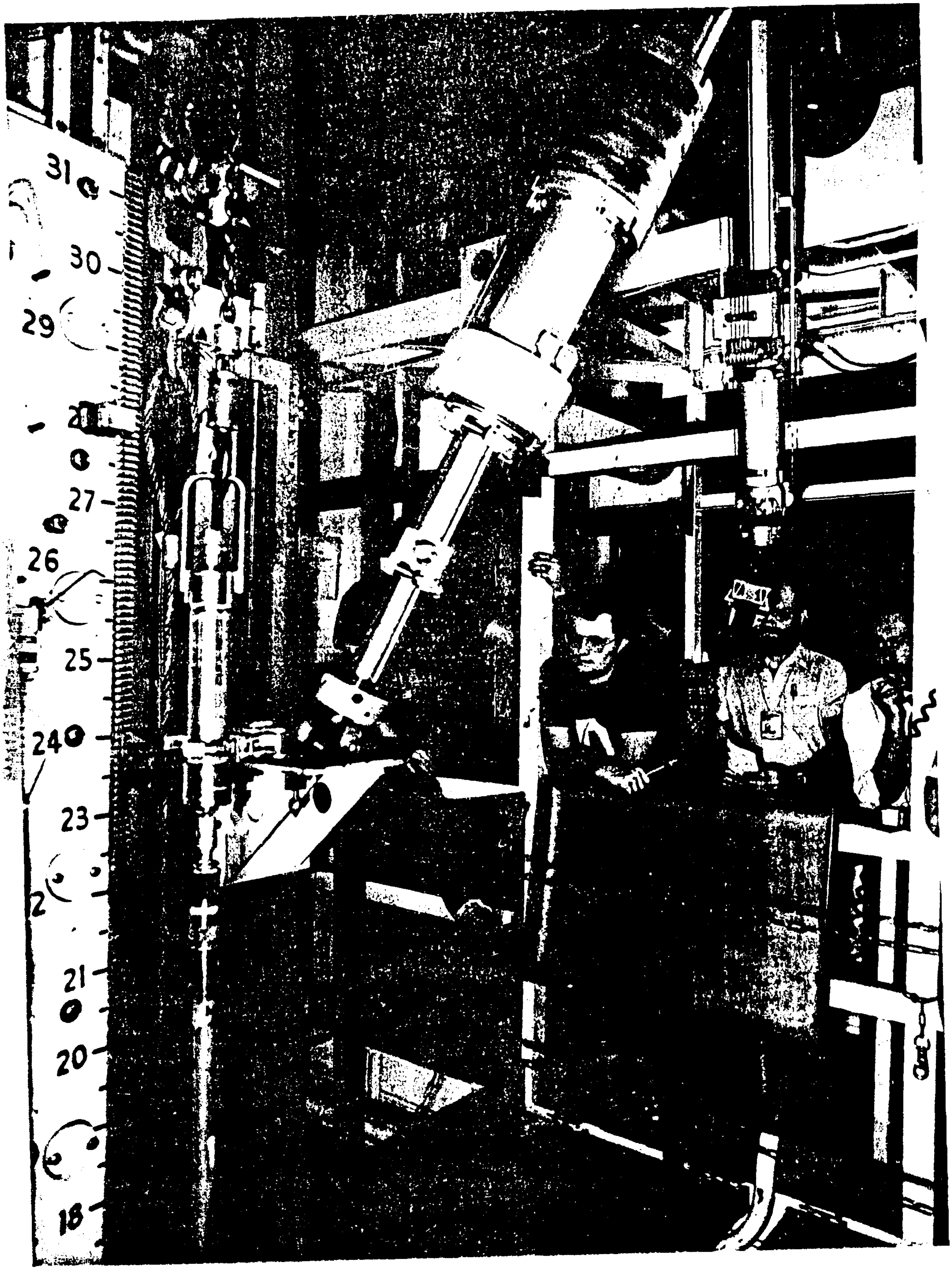
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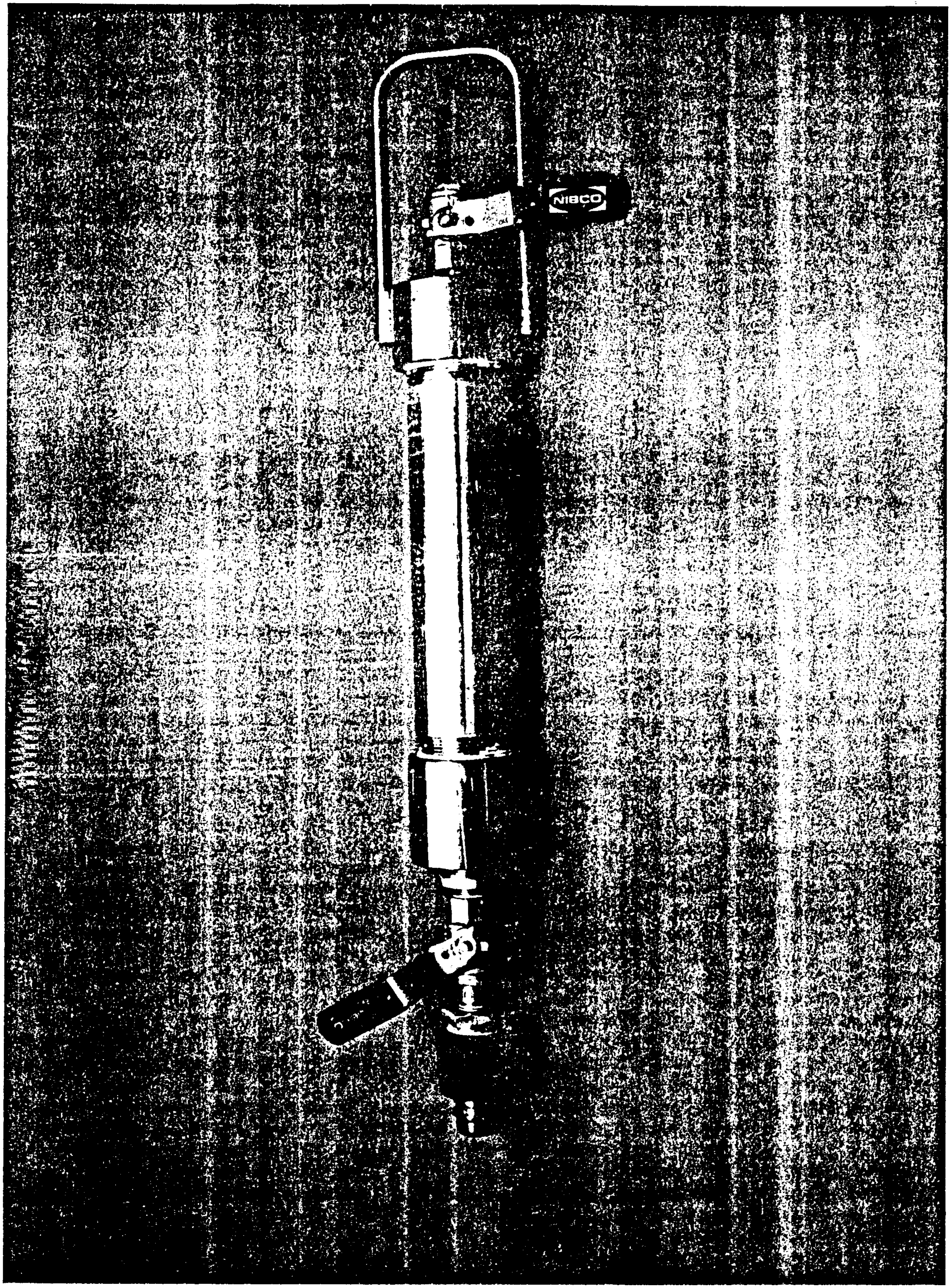
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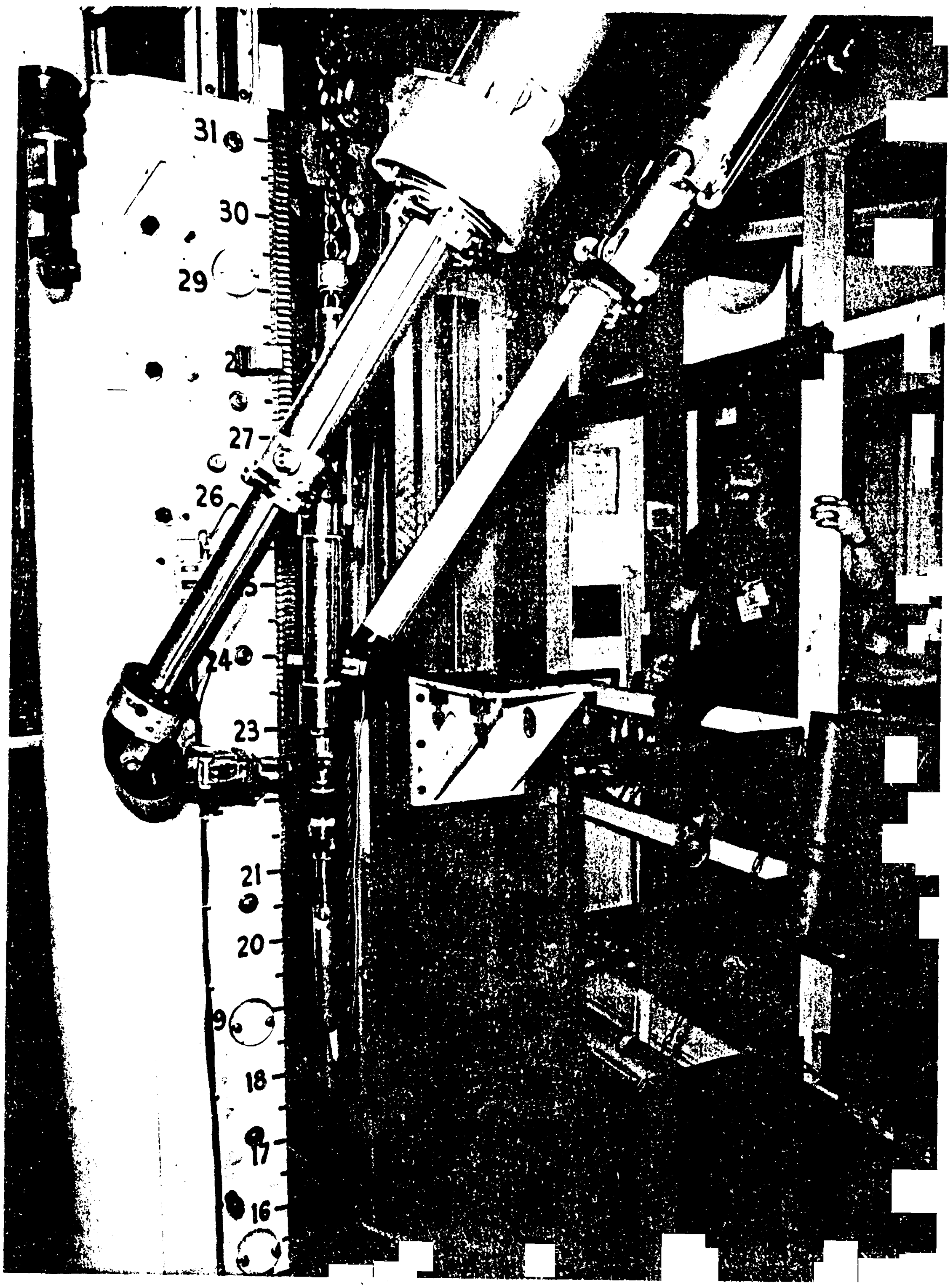
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