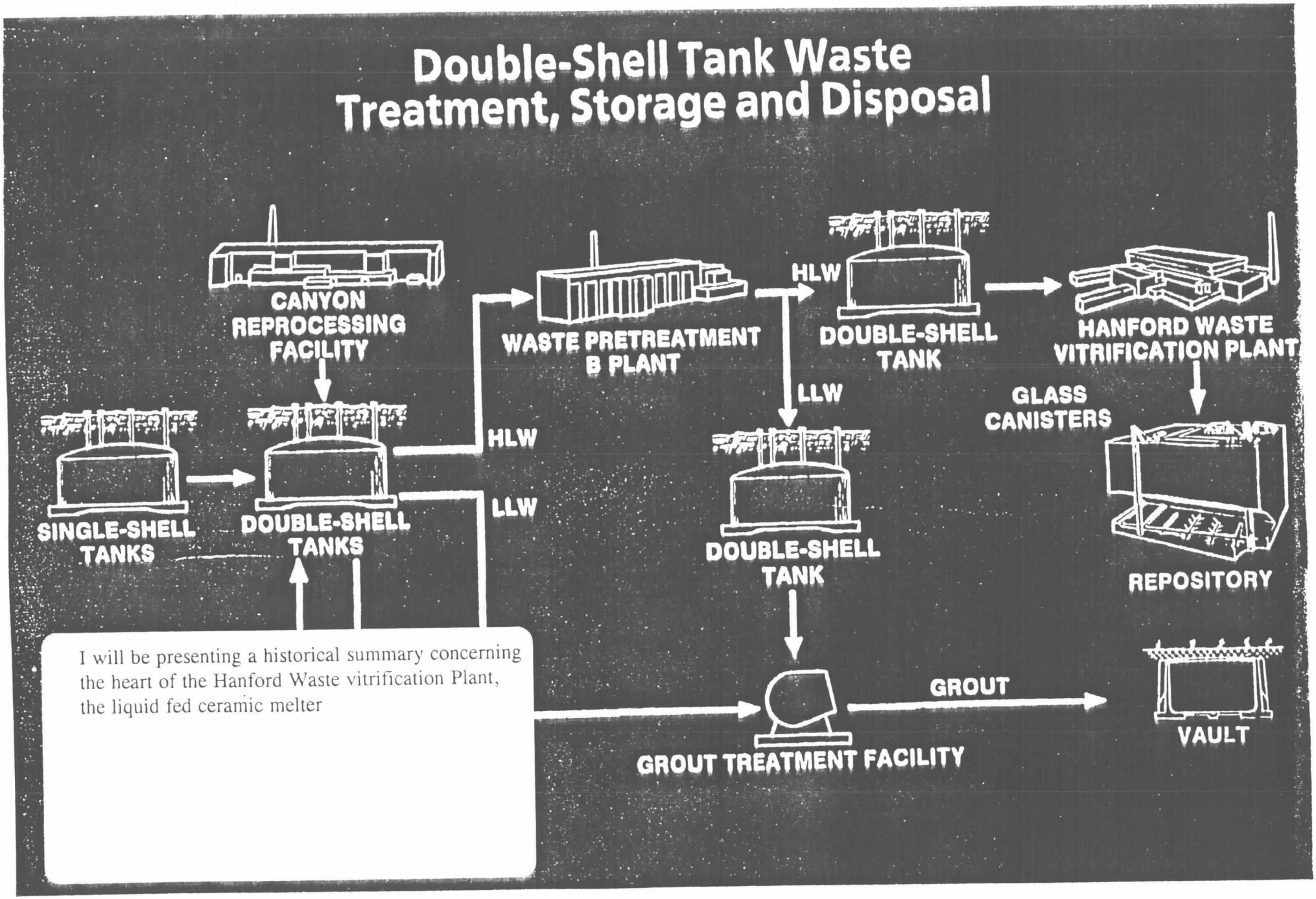
DEVELOPMENT OF THE LIQUID FED CERAMIC MELTER

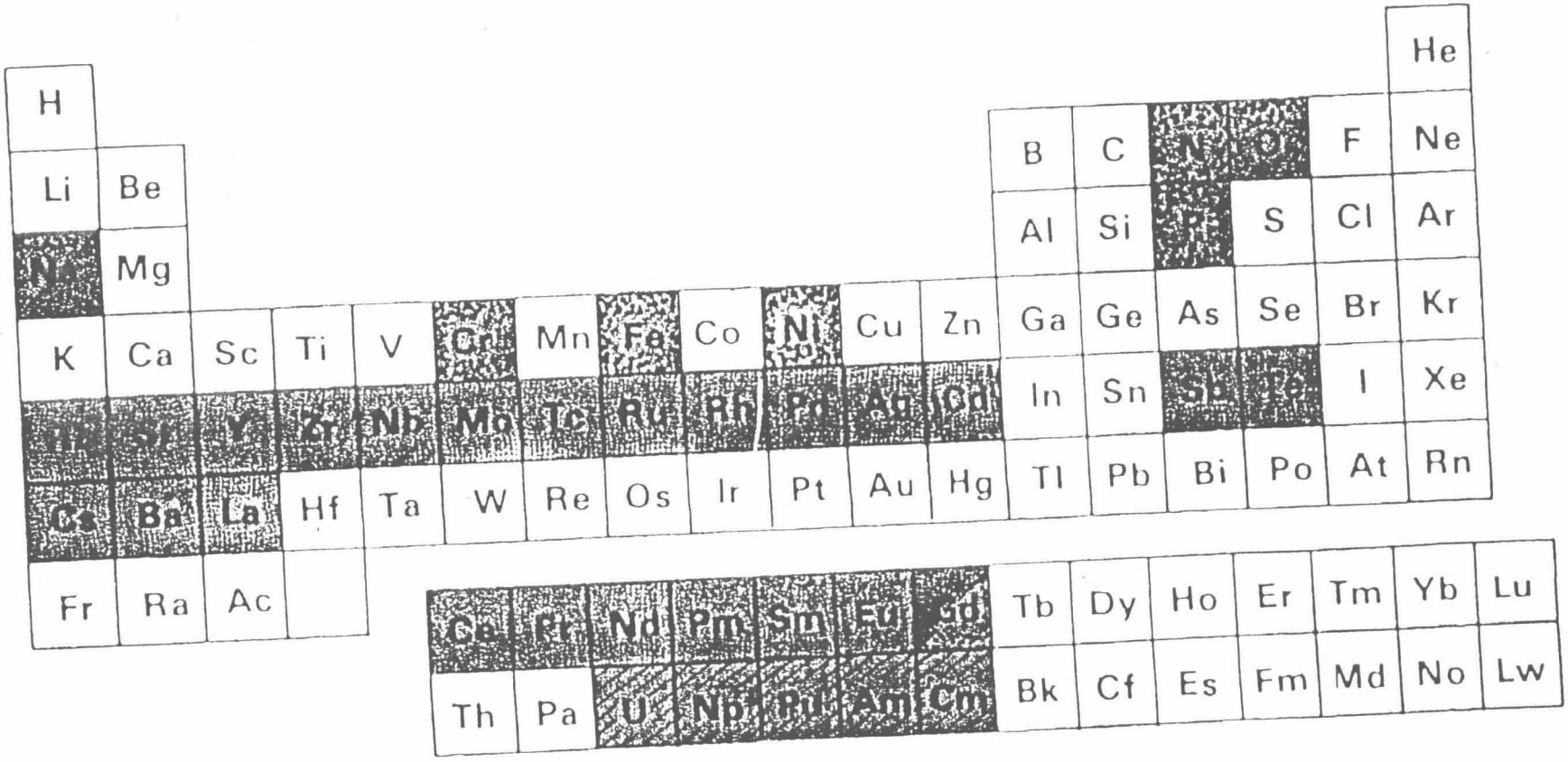
Presented by
Chris Chapman
Pacific Northwest Laboratory

UNITED STATES
NUCLEAR WASTE TECHNOLOGY REVIEW BOARD

May 11, 1992


Double-Shell Tank Waste
Treatment, Storage and Disposal
CANYON
REPROCESSING
FACILITY
WASTE PRETREATMENT
B PLANT
HLW
DOUBLE-SHELL
TANK
HANFORD WASTE
VITRIFICATION PLANT
GLASS
CANISTERS
SINGLE-SHELL
TANKS
DOUBLE-SHELL
TANKS
HLW
LLW
LLW
DOUBLE-SHELL
TANK
REPOSITORY
I will be presenting a historical summary concerning the heart of the Hanford Waste vitrification Plant, the liquid fed ceramic melter
GROUT
VAULT
GROUT TREATMENT FACILITY

ELEMENTS IN HIGH-LEVEL WASTE

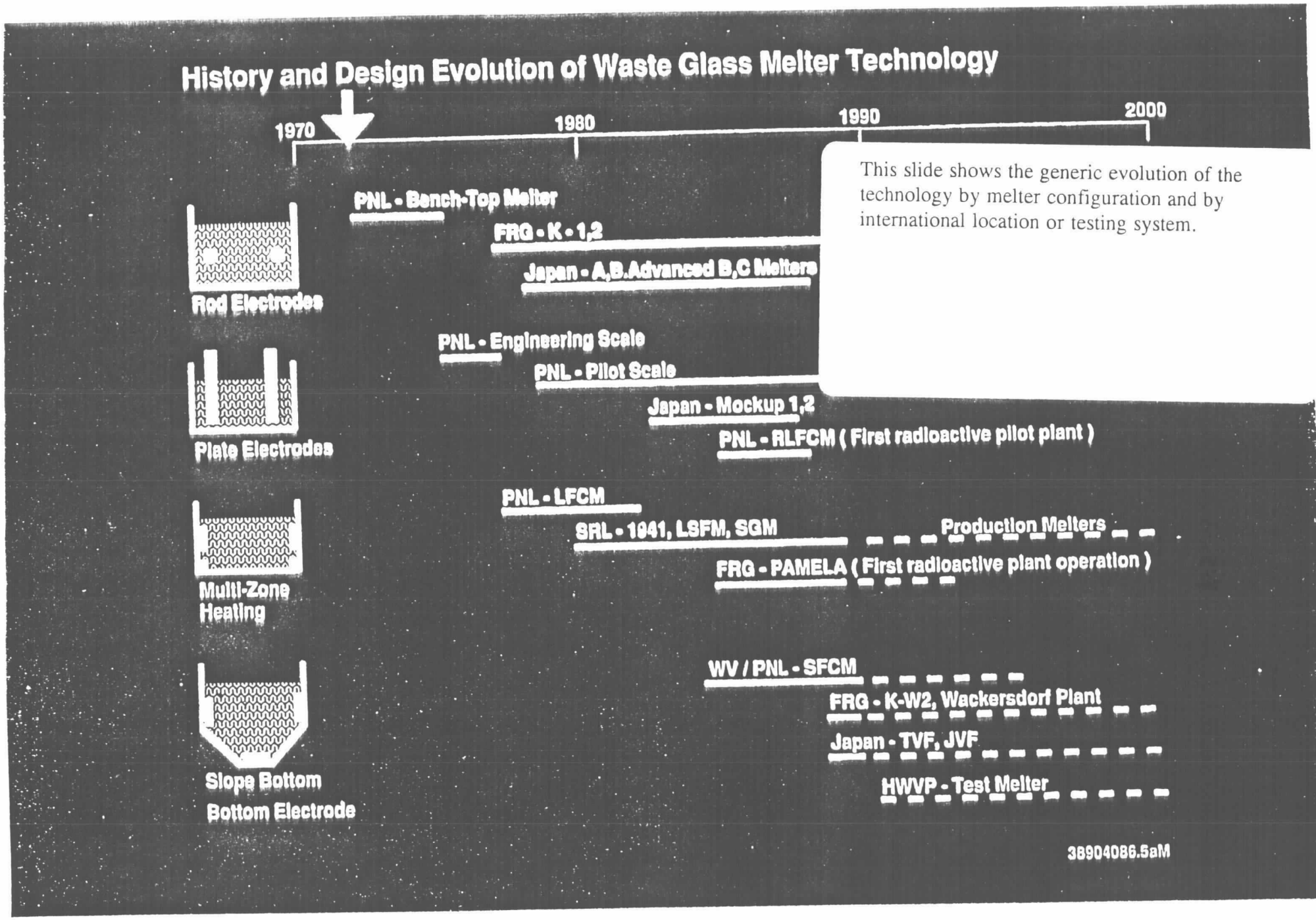


PRINCIPAL FISSION PRODUCTS

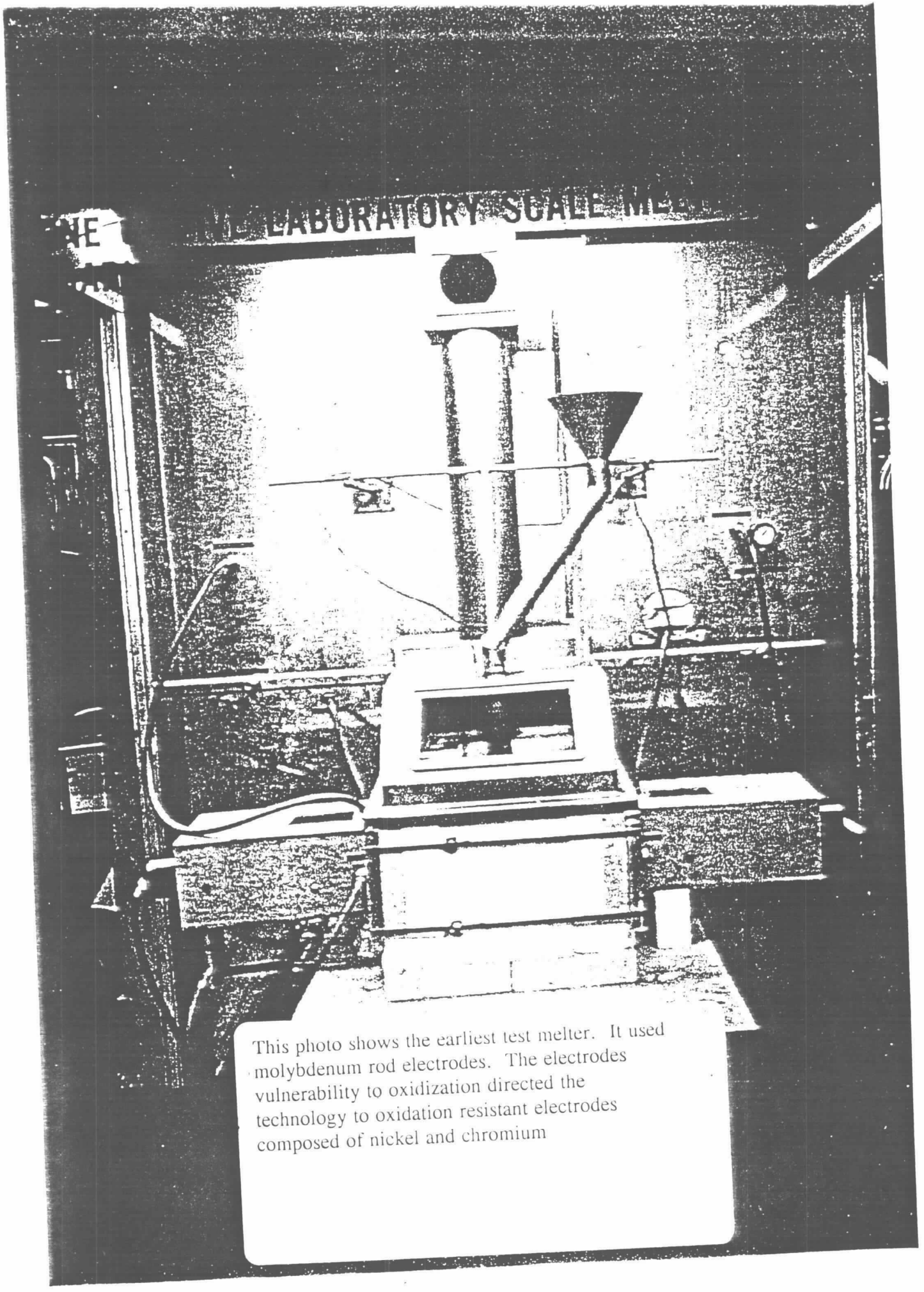
ACTINIDES

REPROCESSING CHEMICALS

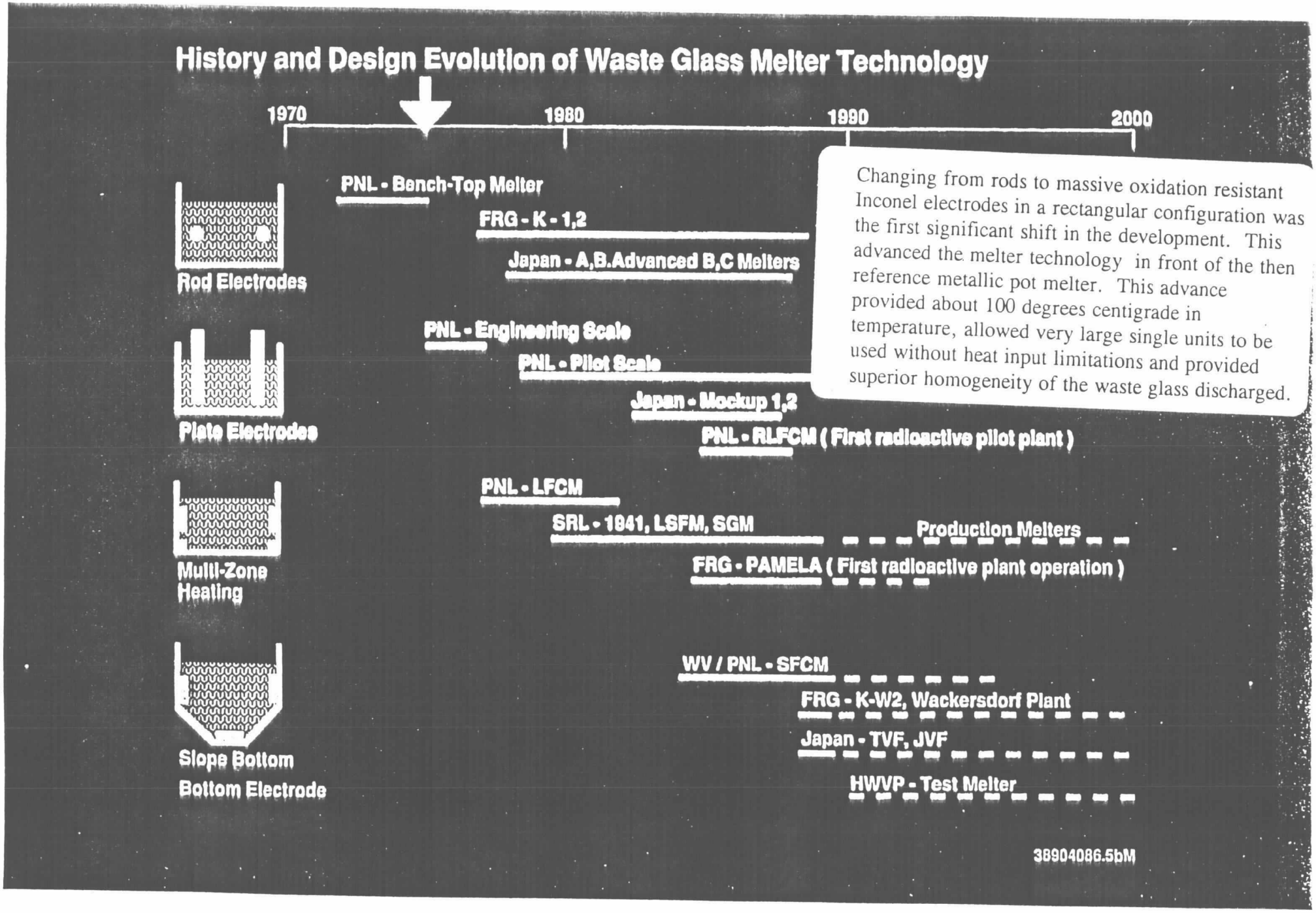
High Level waste is composed of nearly the entire periodic table. Glass represents the only practical means for immobilizing the wastes into a durable waste form while incorporating a large number of elements which will vary during processing.



This slide shows the generic evolution of the technology by melter configuration and by international location or testing system.

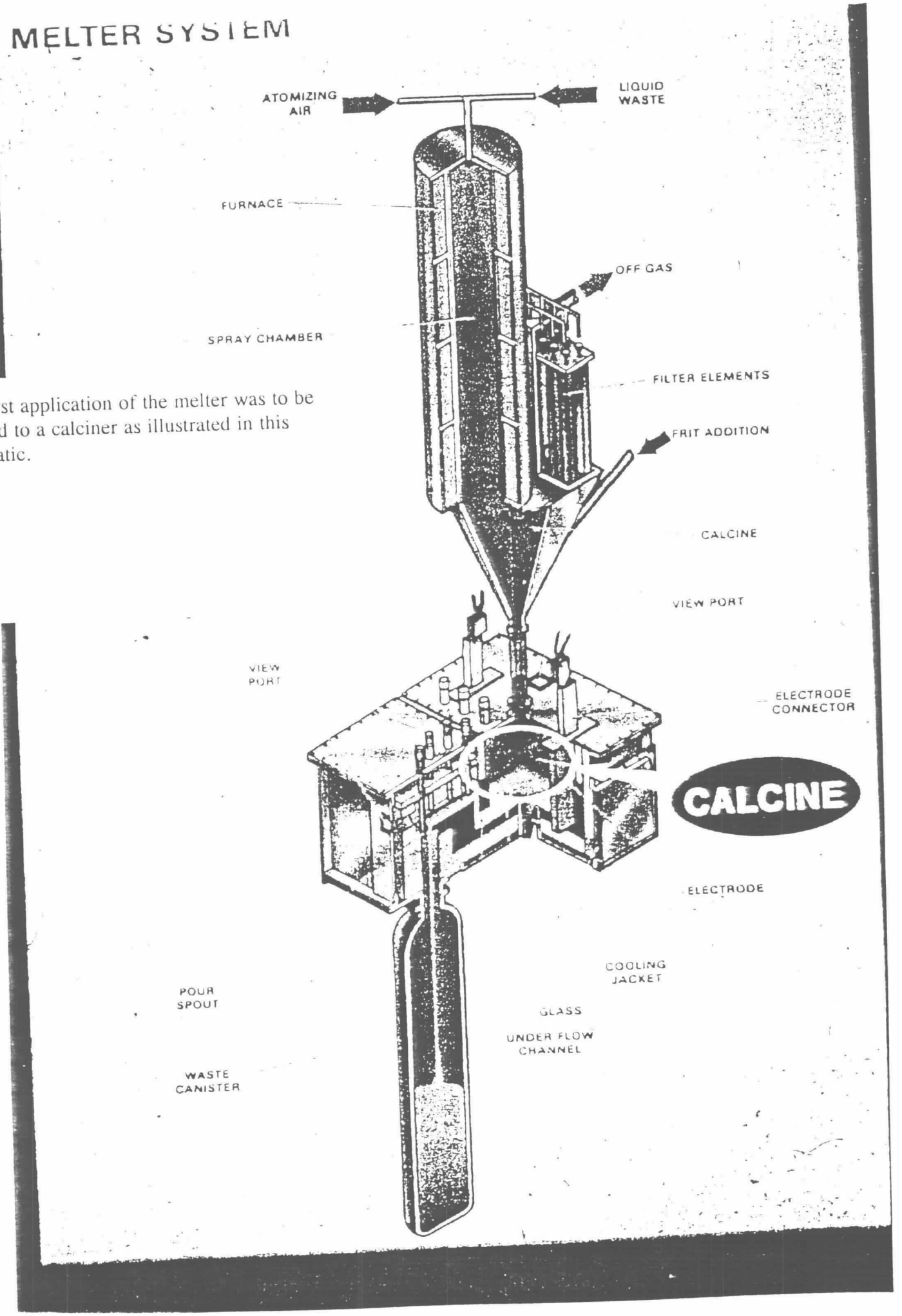


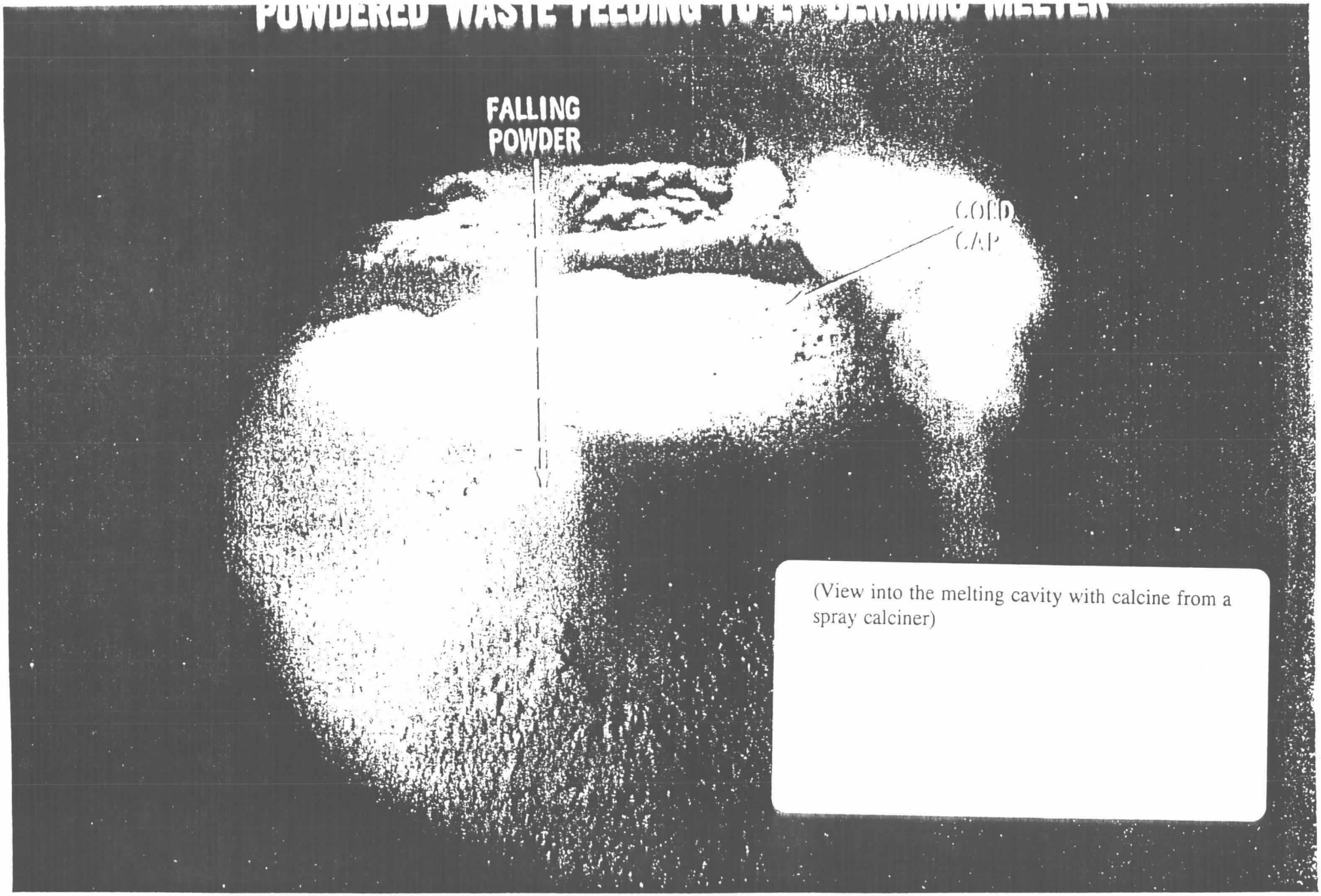
This photo shows the earliest test melter. It used molybdenum rod electrodes. The electrodes vulnerability to oxidization directed the technology to oxidation resistant electrodes composed of nickel and chromium


History and Design Evolution of Waste Glass Melter Technology
1970
1980
1990
2000
PNL - Bench-Top Melter
FRG - K - 1,2
Japan - A,B.Advanced B,C Melters
Rod Electrodes
PNL - Engineering Scale
PNL - Pilot Scale
Japan - Mockup 1,2
Plate Electrodes
PNL - RLFCM (First radioactive pilot plant)
PNL - LFCM
SRL - 1941, LSFM, SGM
Production Melters
FRG - PAMELA (First radioactive plant operation)
Multi-Zone Heating
WV / PNL - SFCM
FRG - K-W2, Wackersdorf Plant
Japan - TVF, JVF
HWVP - Test Melter
Slope Bottom
Bottom Electrode
38904086.5bM
Changing from rods to massive oxidation resistant Inconel electrodes in a rectangular configuration was the first significant shift in the development. This advanced the melter technology in front of the then reference metallic pot melter. This advance provided about 100 degrees centigrade in temperature, allowed very large single units to be used without heat input limitations and provided superior homogeneity of the waste glass discharged.

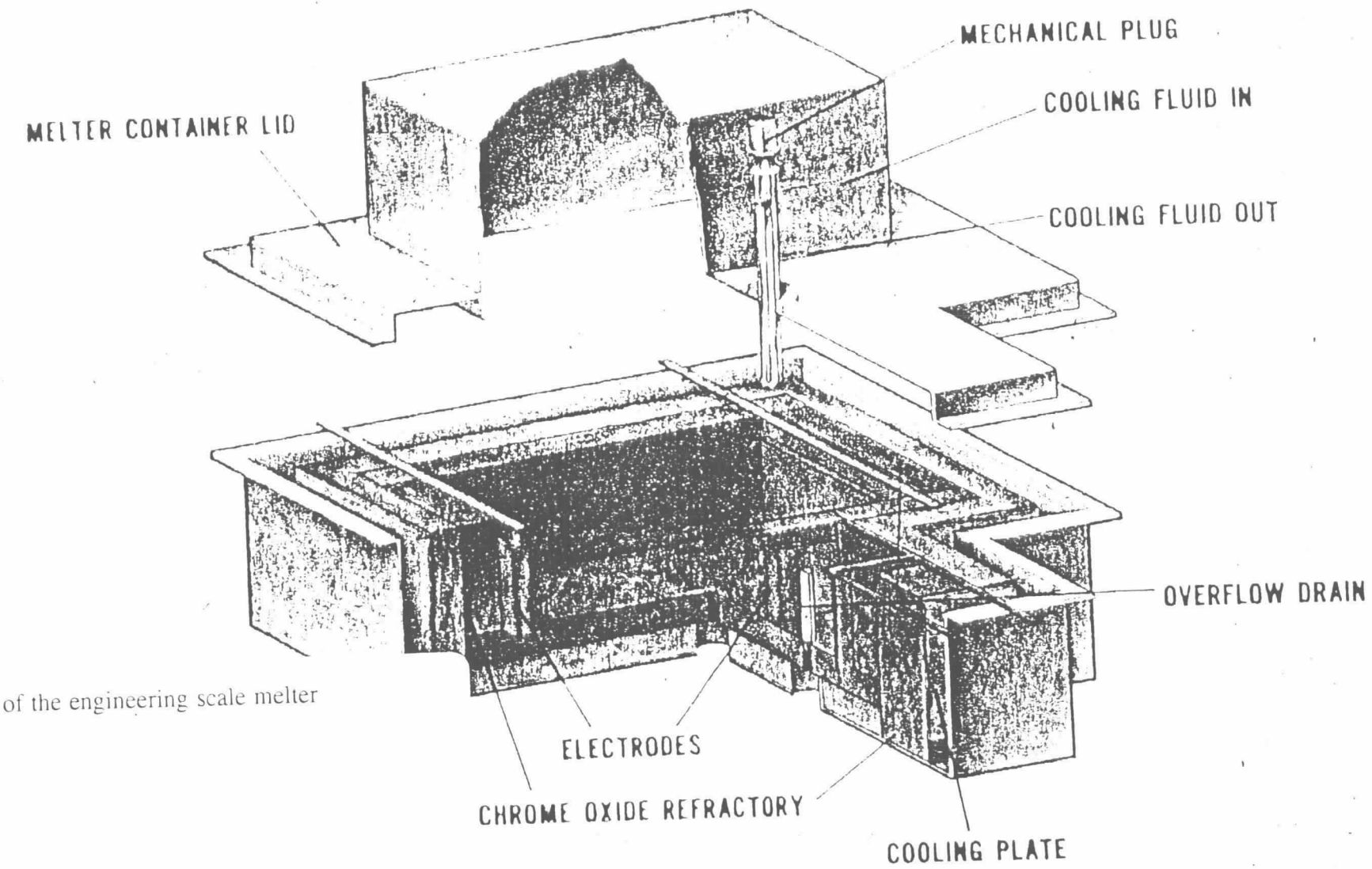
MELTER SYSTEM

The first application of the melter was to be coupled to a calciner as illustrated in this schematic.




POWDERED WASTE FEEDING TO A CERAMIC MELTER
FALLING
POWDER
COLD
CAP
(View into the melting cavity with calcine from a spray calciner)

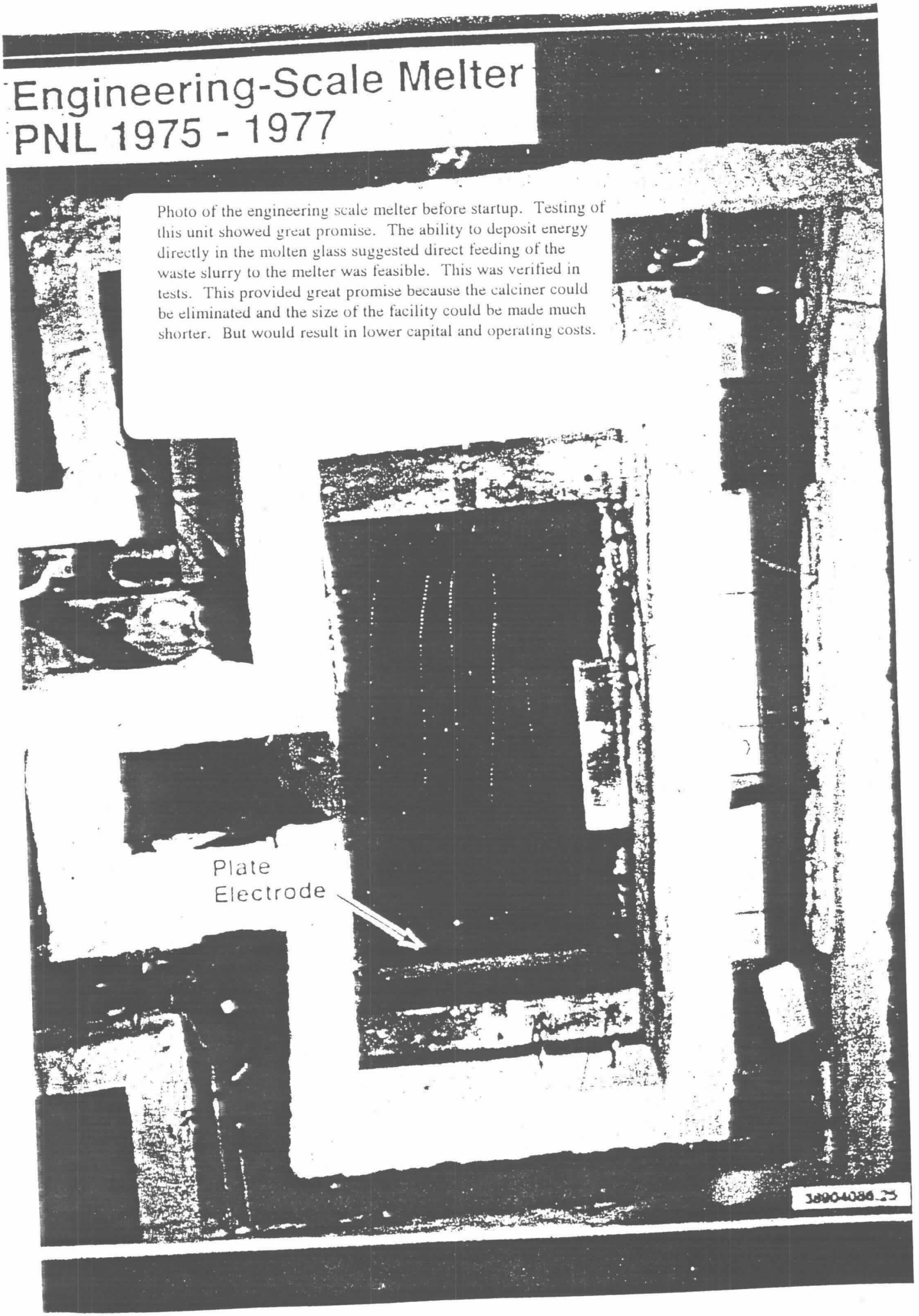
ENGINEERING SCALE CERAMIC MELTER

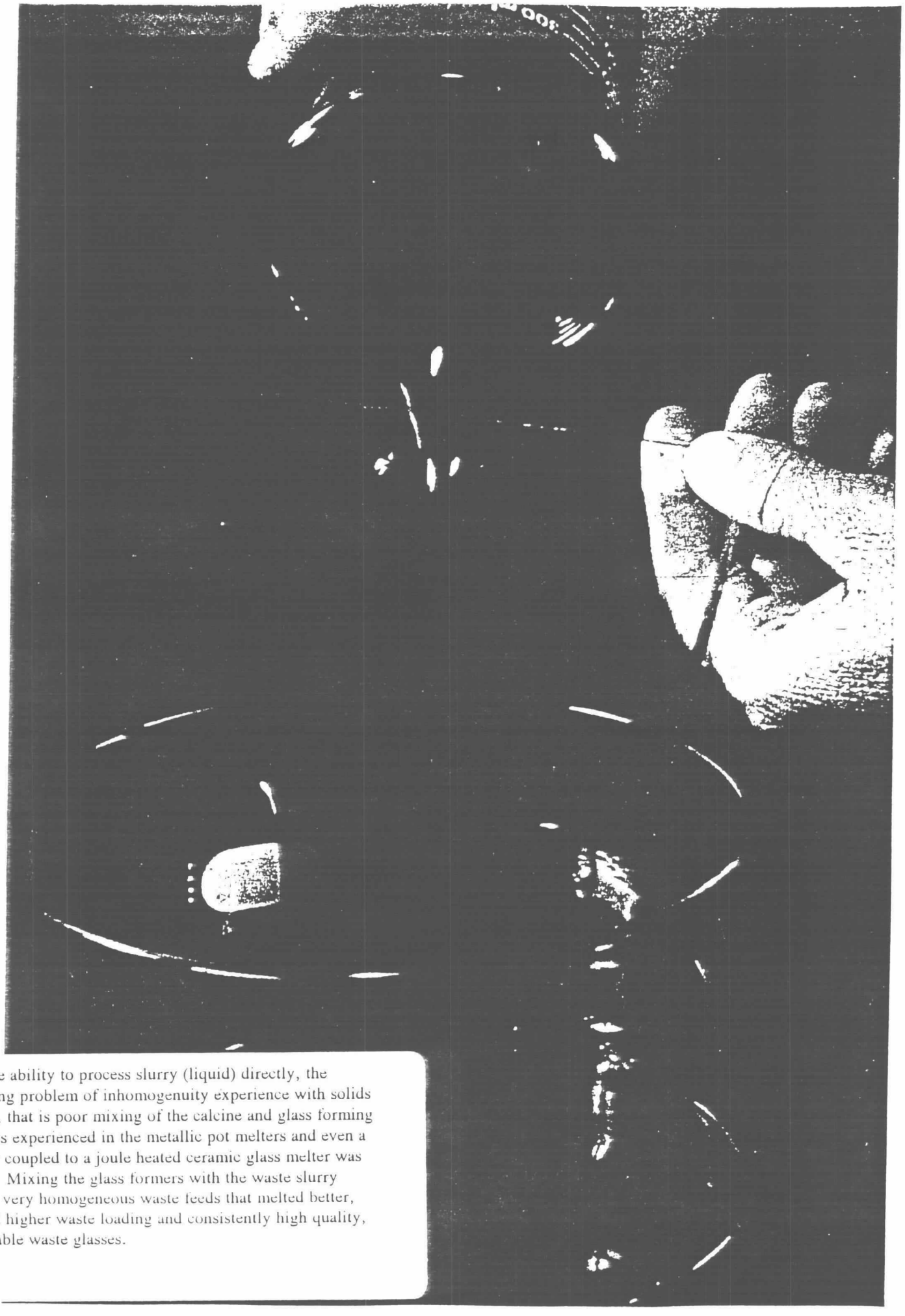


Schematic of the engineering scale melter

Engineering-Scale Melter
PNL 1975 - 1977

Photo of the engineering scale melter before startup. Testing of this unit showed great promise. The ability to deposit energy directly in the molten glass suggested direct feeding of the waste slurry to the melter was feasible. This was verified in tests. This provided great promise because the calciner could be eliminated and the size of the facility could be made much shorter. But would result in lower capital and operating costs.

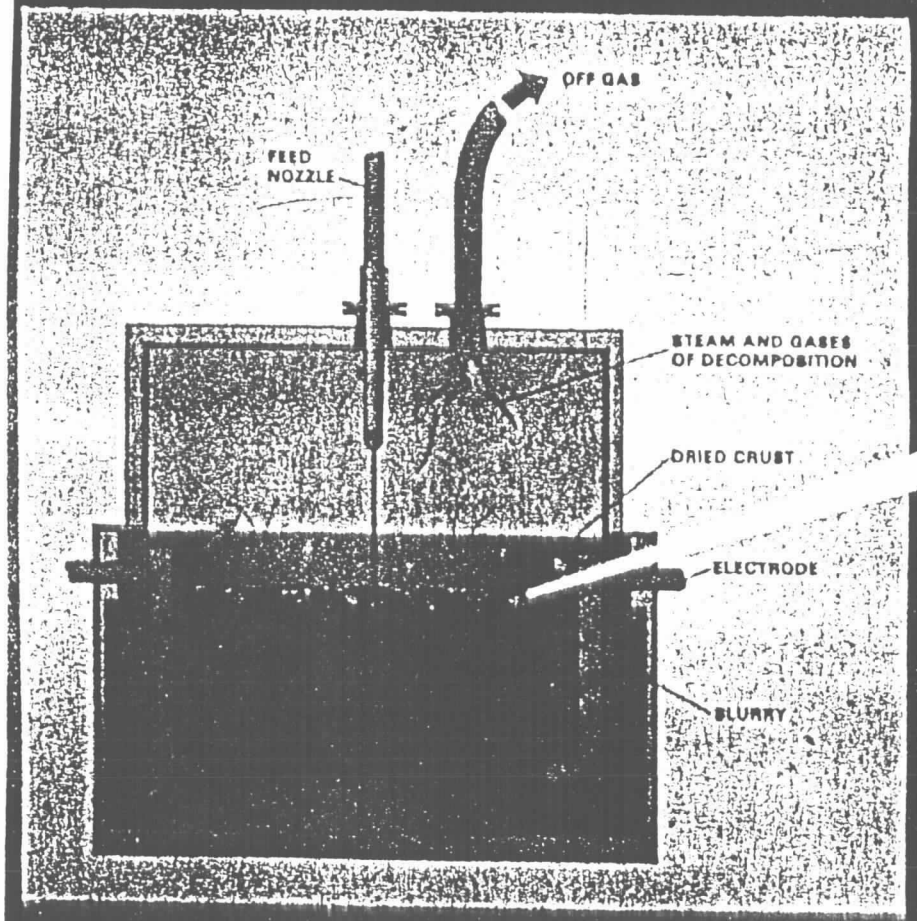


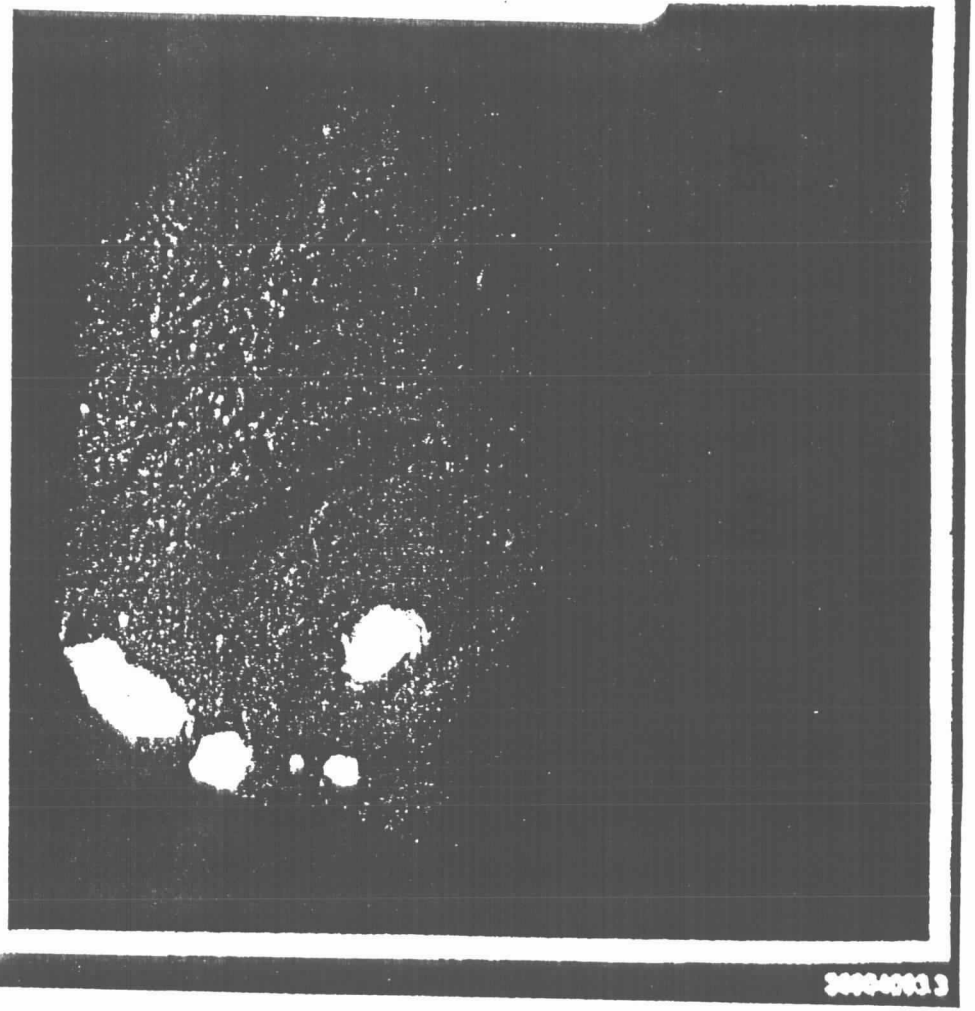


With the ability to process slurry (liquid) directly, the remaining problem of inhomogenuity experience with solids feeding, that is poor mixing of the calcine and glass forming additives experienced in the metallic pot melters and even a calciner coupled to a joule heated ceramic glass melter was solved. Mixing the glass formers with the waste slurry assured very homogeneous waste feeds that melted better, allowed higher waste loading and consistently high quality, predictable waste glasses.

LFCM with Cold Cap

Schematic of liquid feeding of a joule heated ceramic lined vessel and photo of an operating system. View through a view port onto the "cold cap"





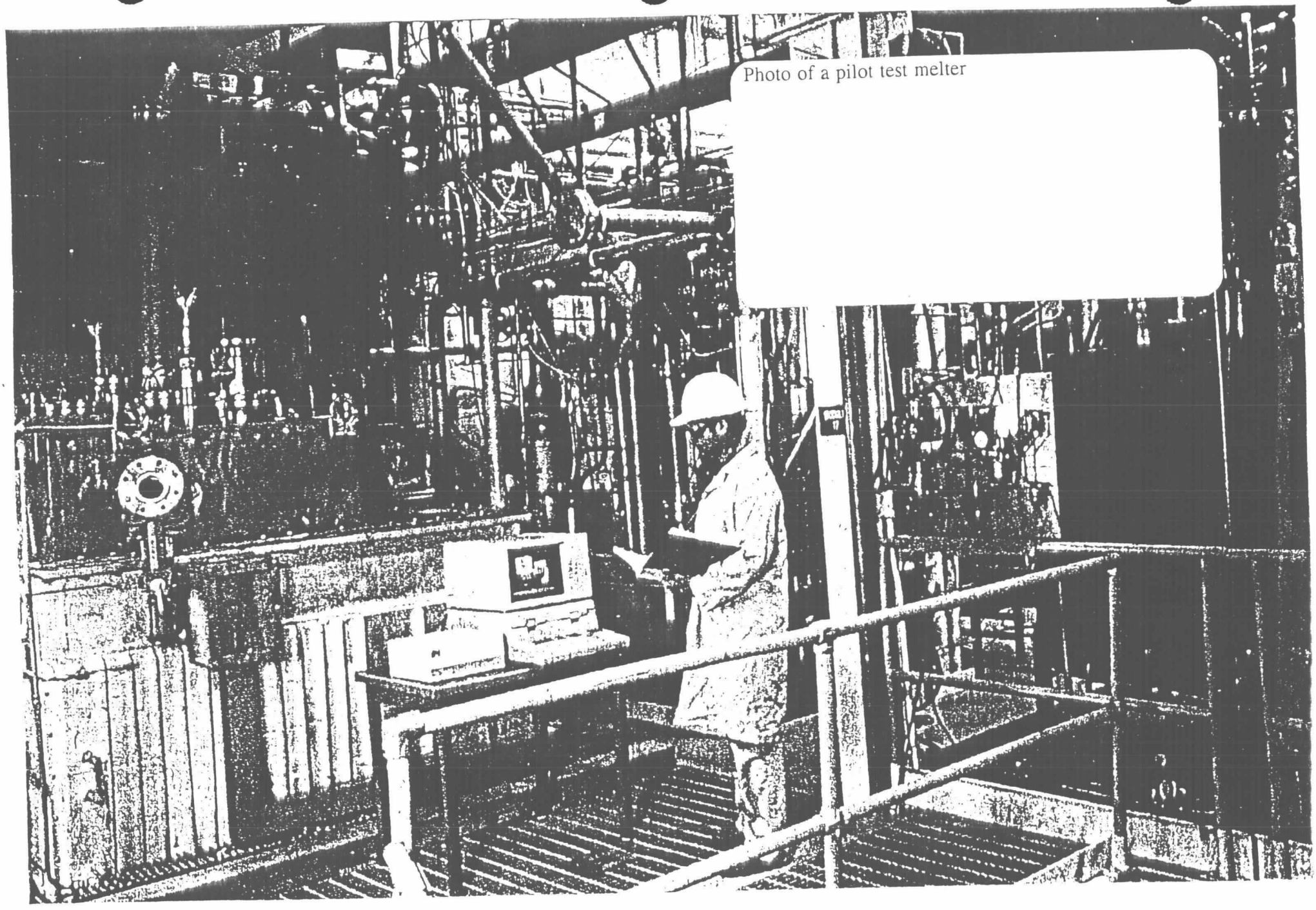
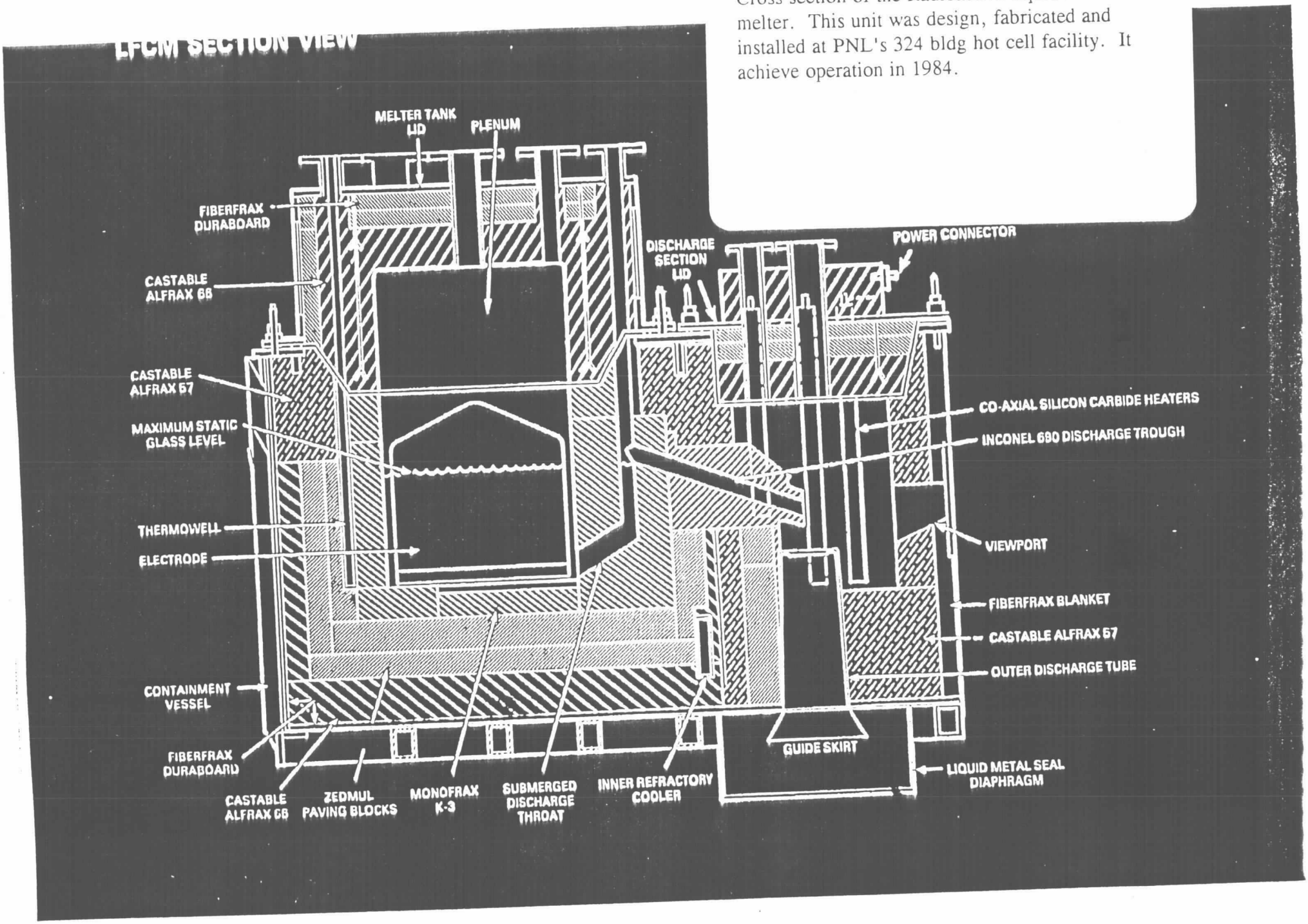


Photo of a pilot test melter

Cross section of the Radioactive liquid fed ceramic melter. This unit was design, fabricated and installed at PNL's 324 bldg hot cell facility. It achieve operation in 1984.



Radioactive Liquid-Fed Melter
PNL 1984 - 1987

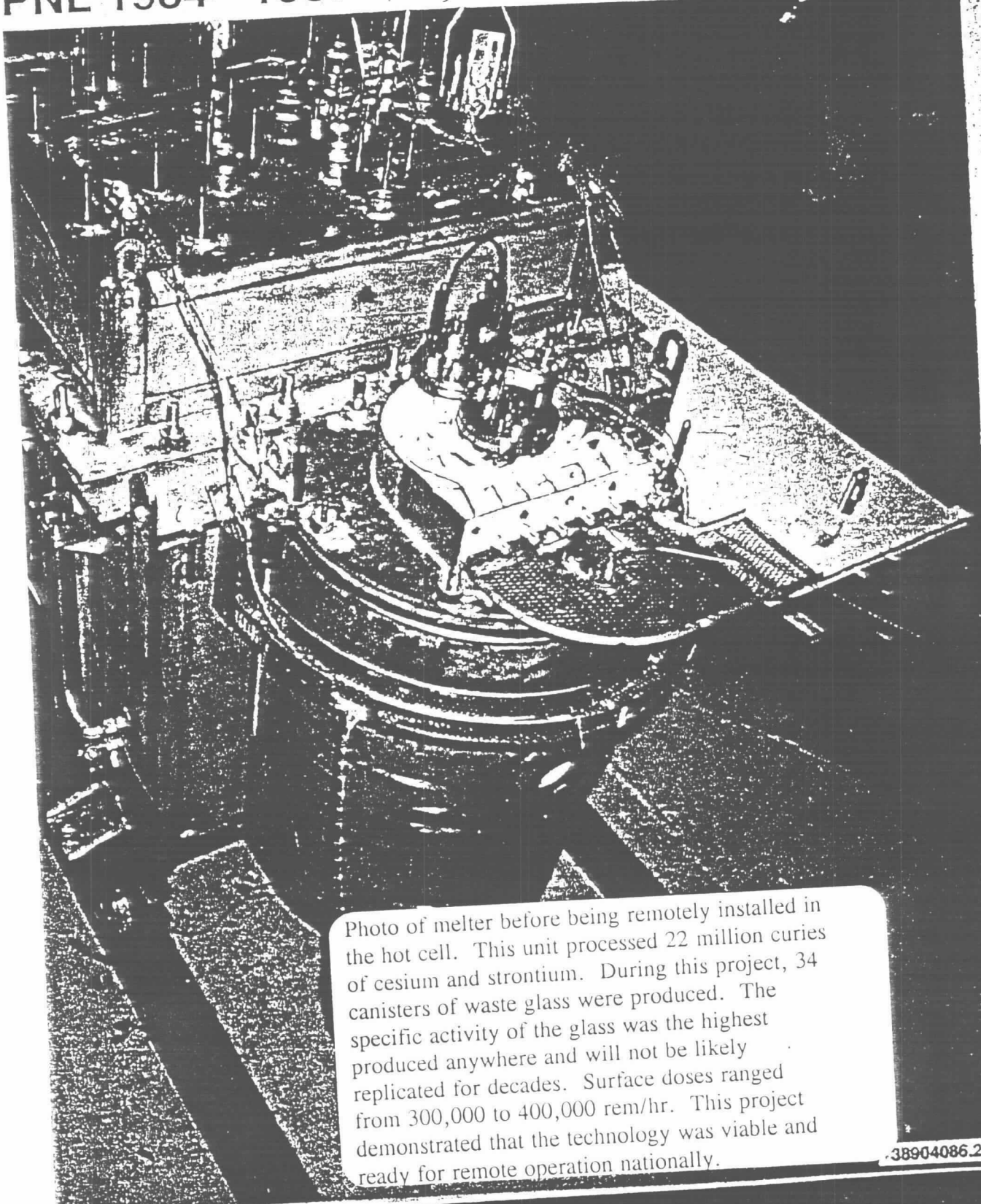


Photo of melter before being remotely installed in the hot cell. This unit processed 22 million curies of cesium and strontium. During this project, 34 canisters of waste glass were produced. The specific activity of the glass was the highest produced anywhere and will not be likely replicated for decades. Surface doses ranged from 300,000 to 400,000 rem/hr. This project demonstrated that the technology was viable and ready for remote operation nationally.

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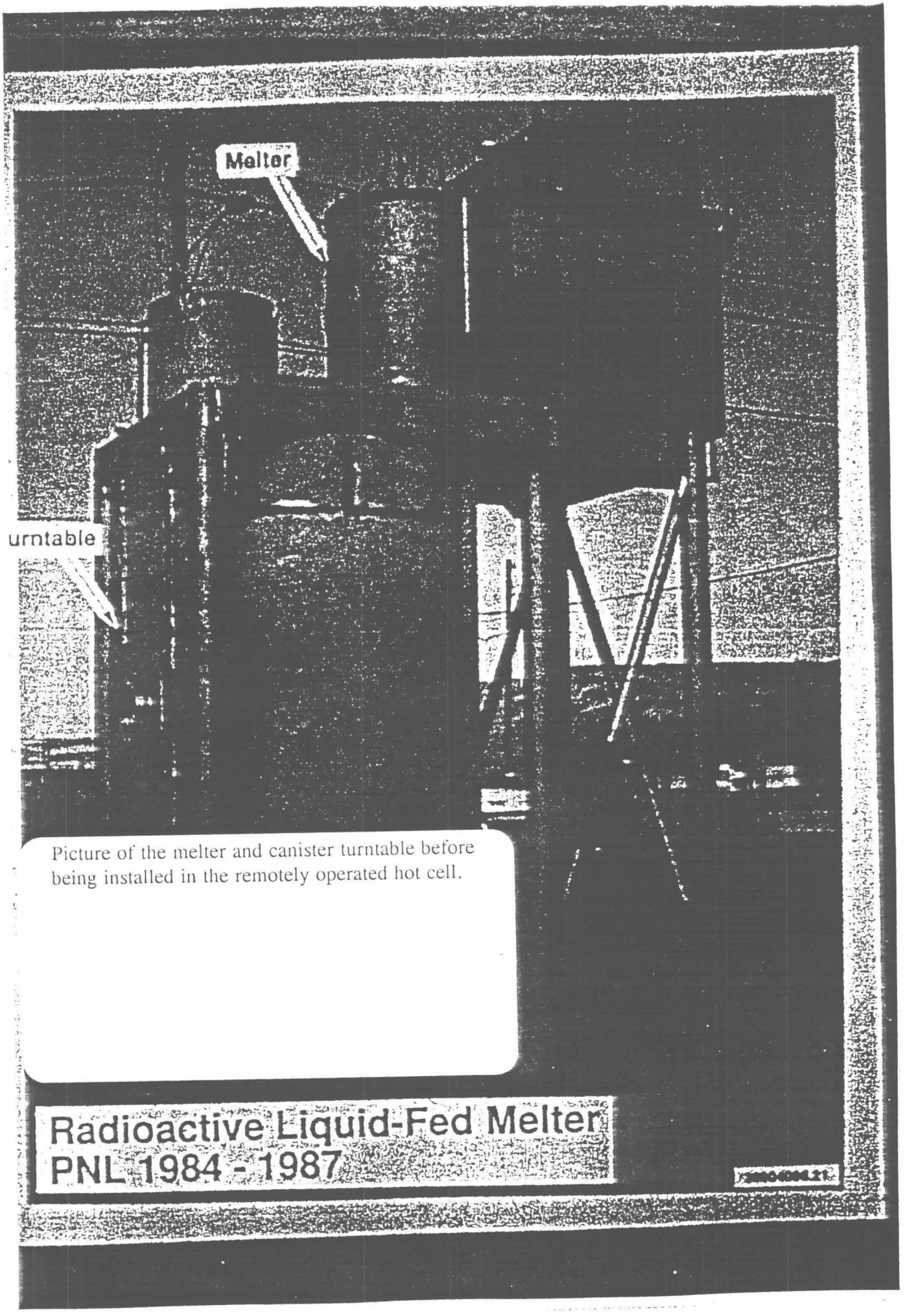
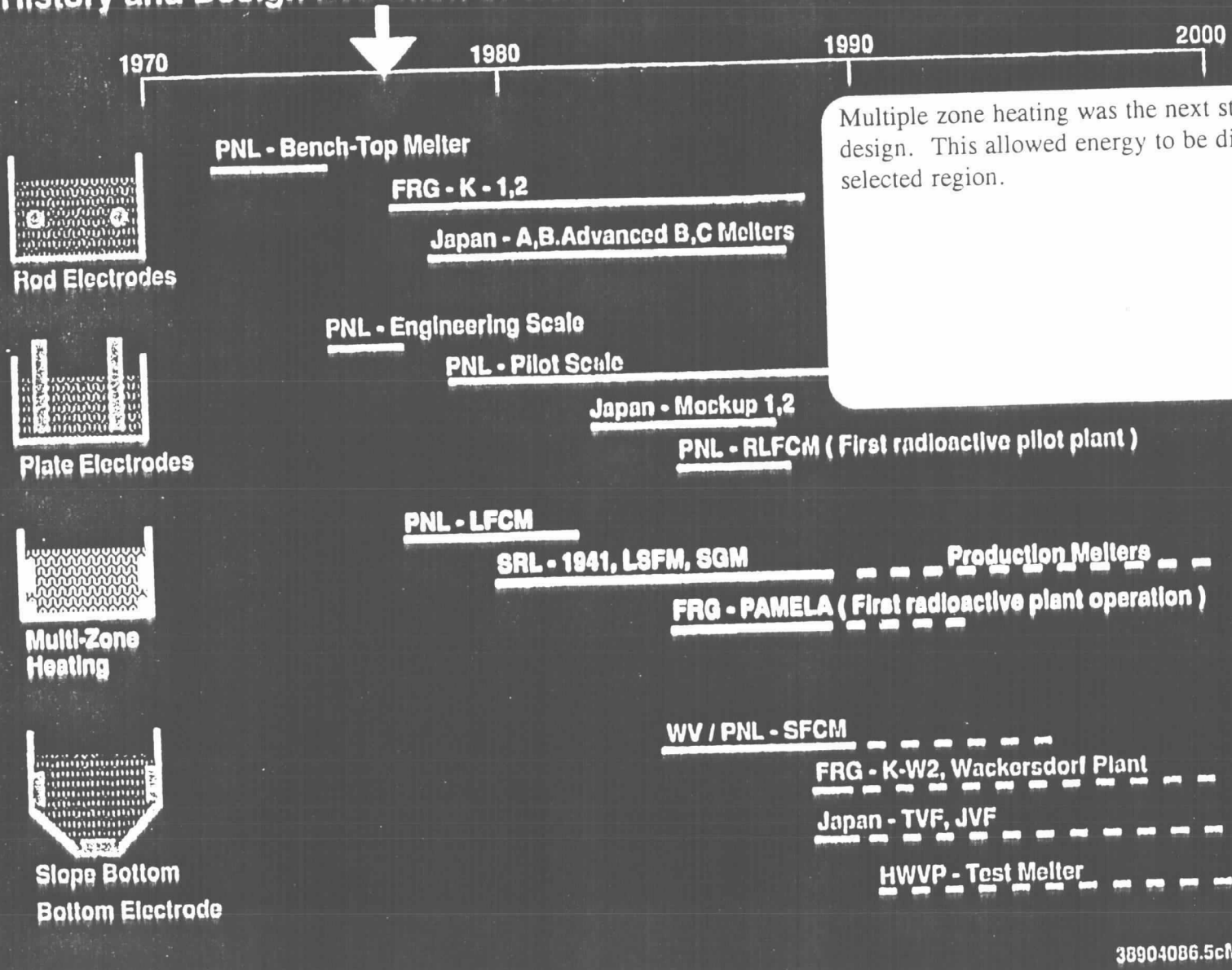


Picture of the melter and canister turntable before being installed in the remotely operated hot cell.

Radioactive Liquid-Fed Melter PNL 1984 - 1987

History and Design Evolution of Waste Glass Melter Technology



Multiple zone heating was the next stage of melter design. This allowed energy to be dissipated in a selected region.

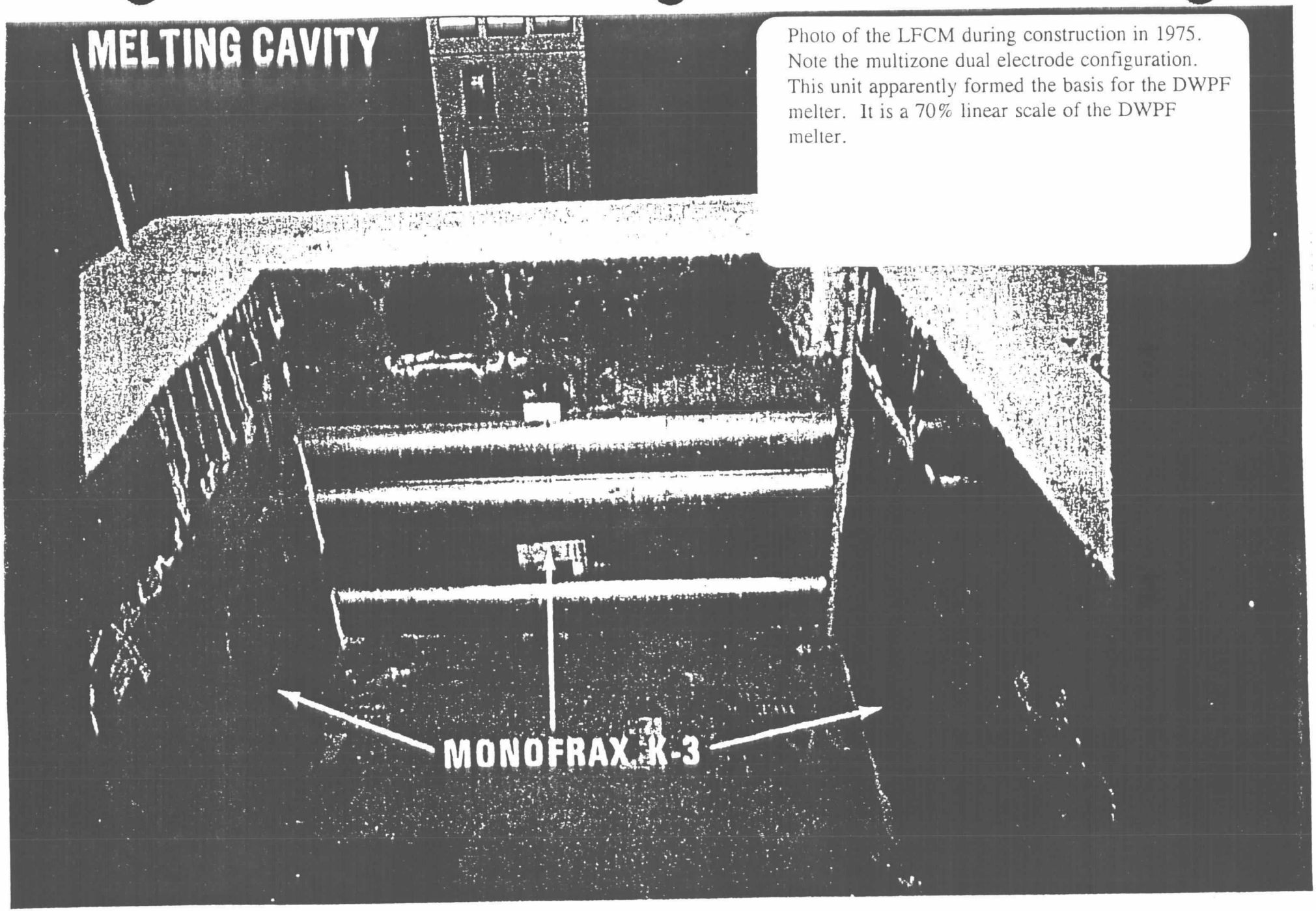
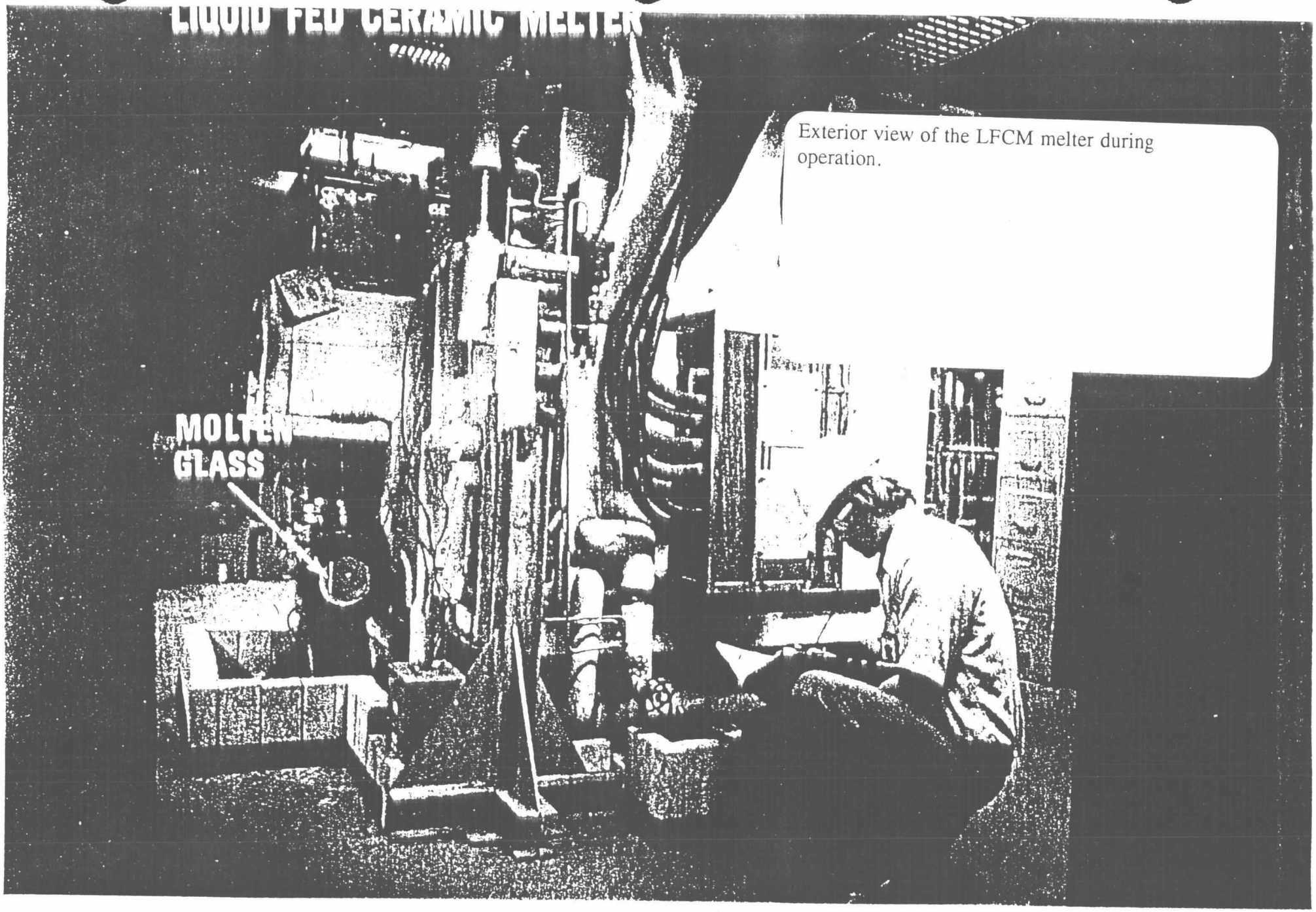


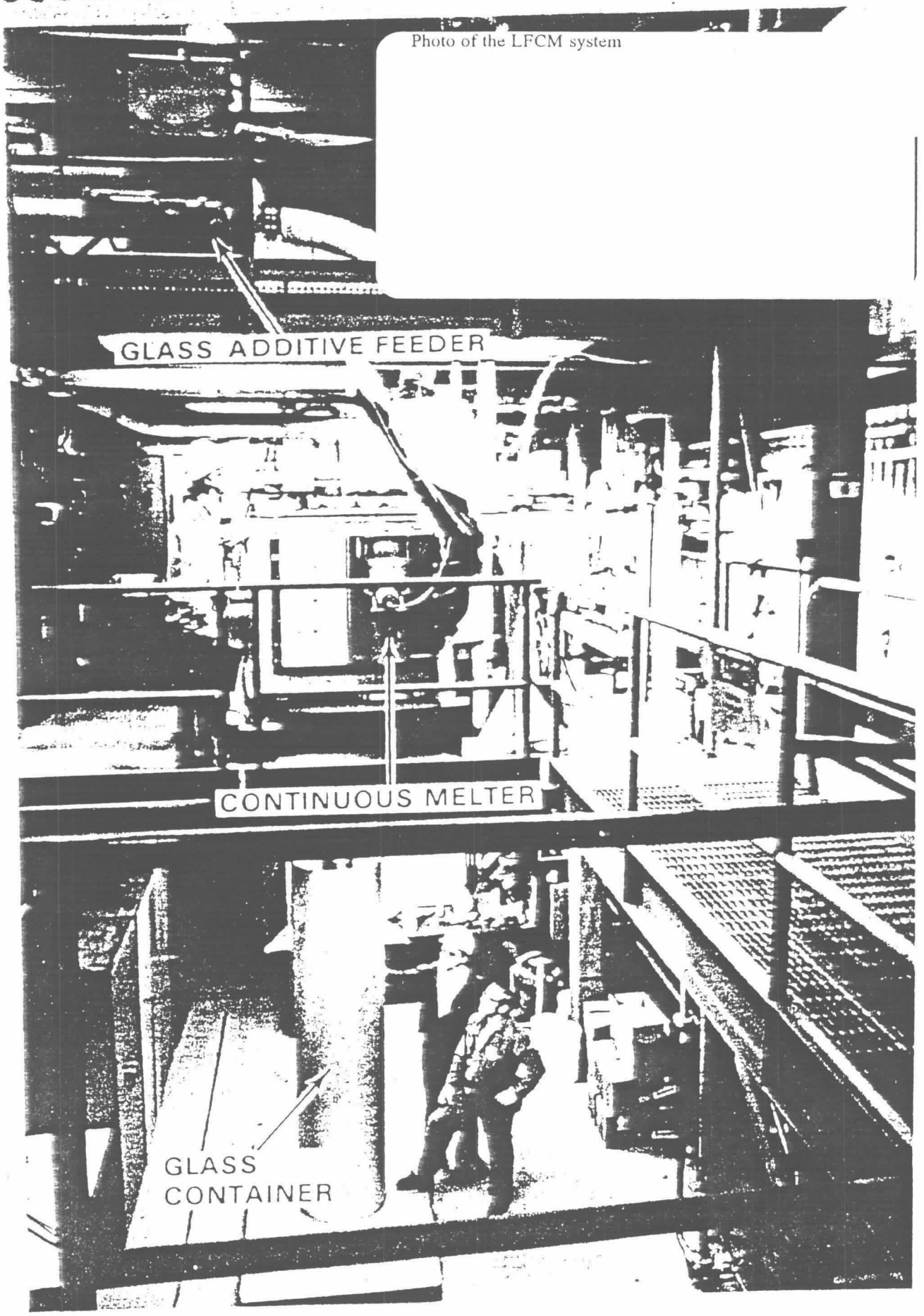
Photo of the LFCM during construction in 1975. Note the multizone dual electrode configuration. This unit apparently formed the basis for the DWPF melter. It is a 70% linear scale of the DWPF melter.



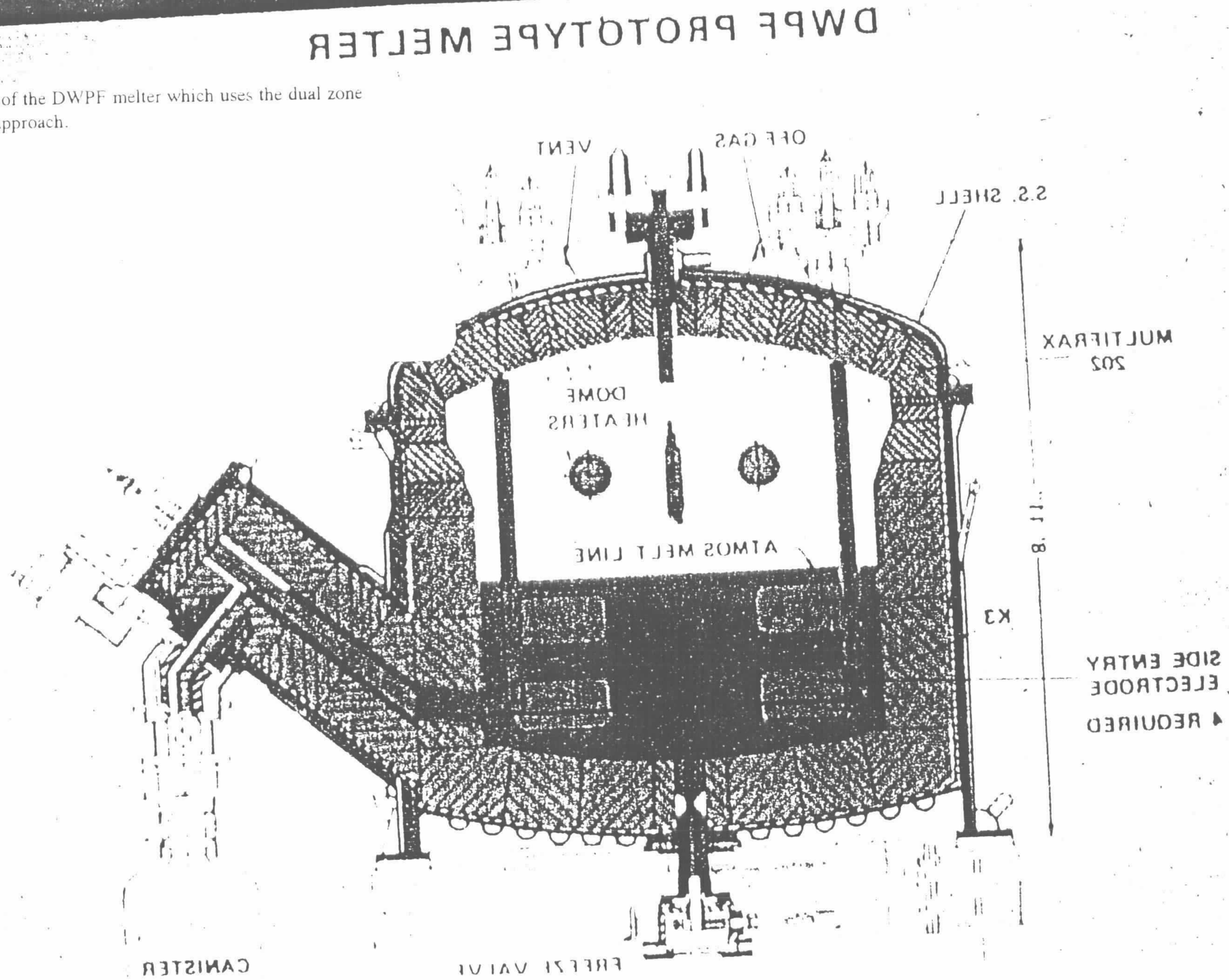
Exterior view of the LFCM melter during operation.

JOULE-HEATED CONTINUOUS MELTER

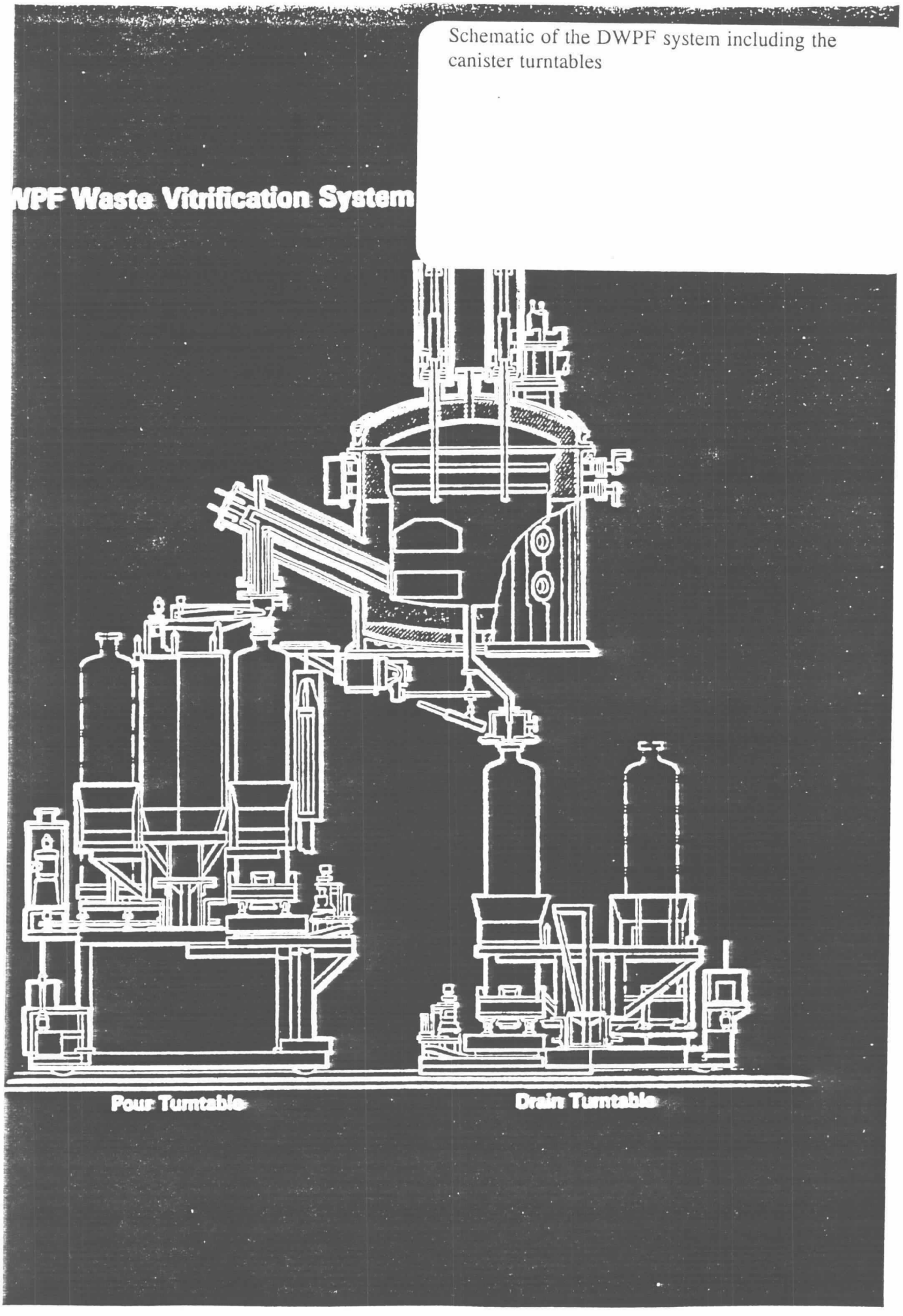
Photo of the LFCM system



Schematic of the DWPF melter which uses the dual zone electrode approach.



Schematic of the DWPF system including the canister turntables



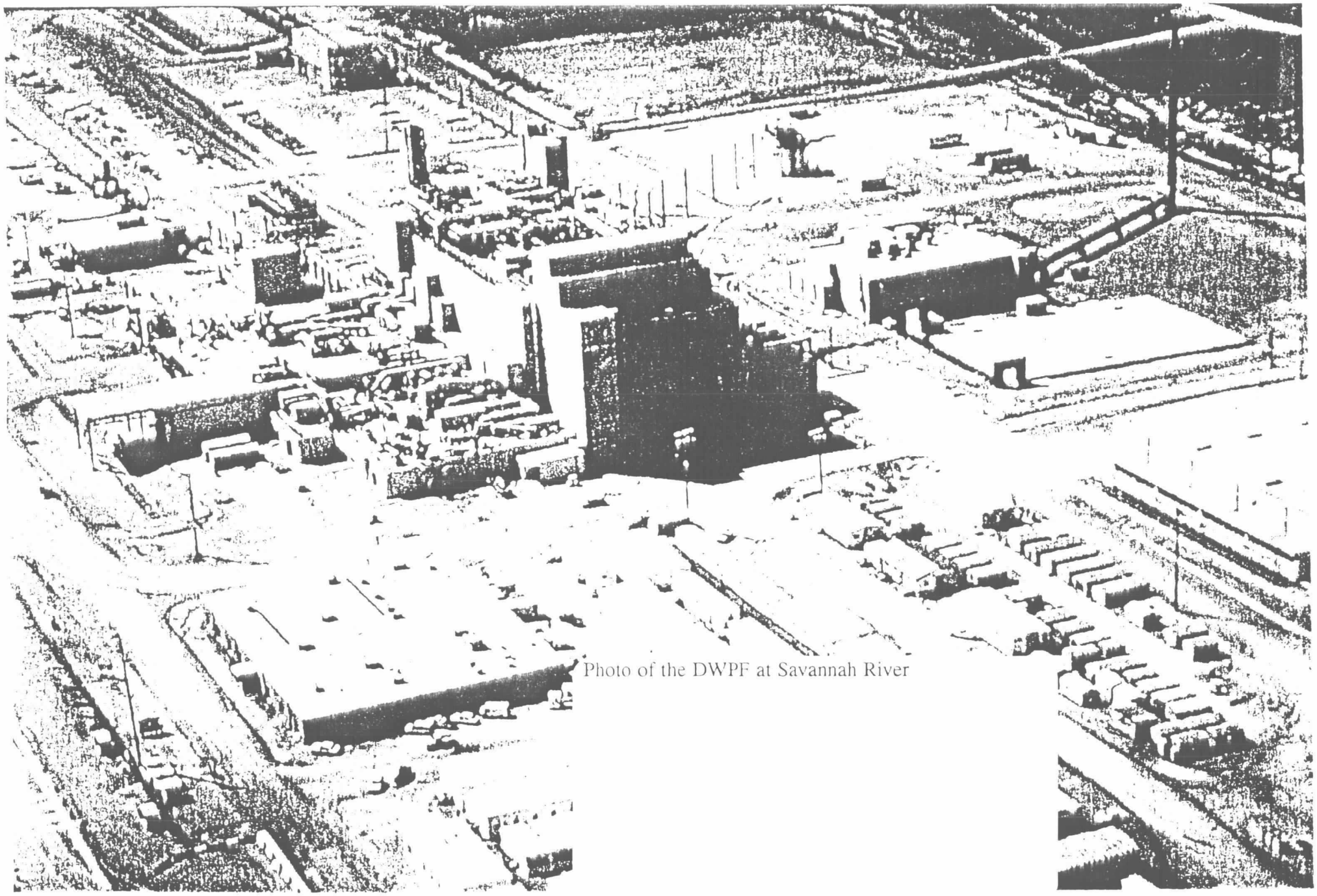
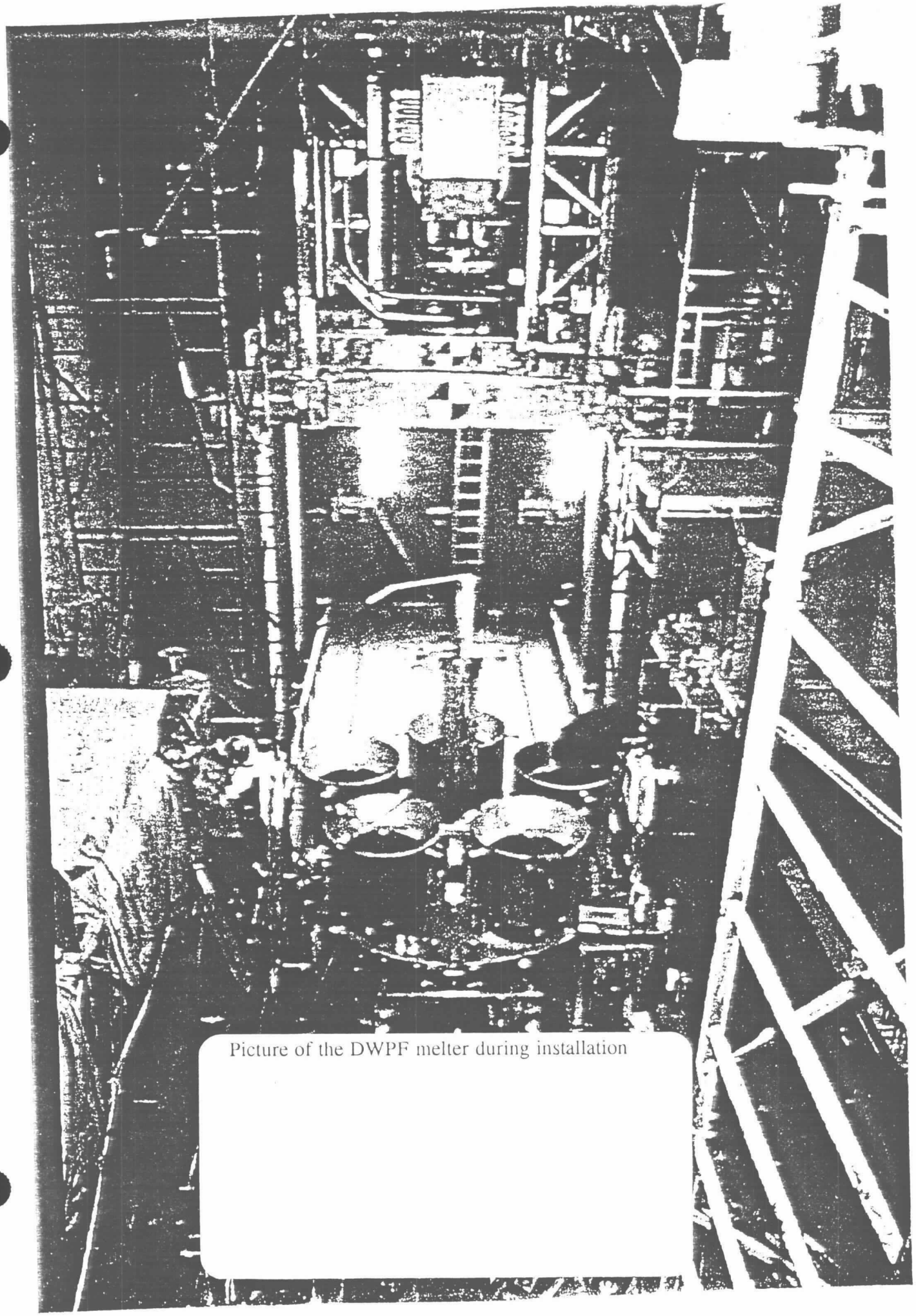
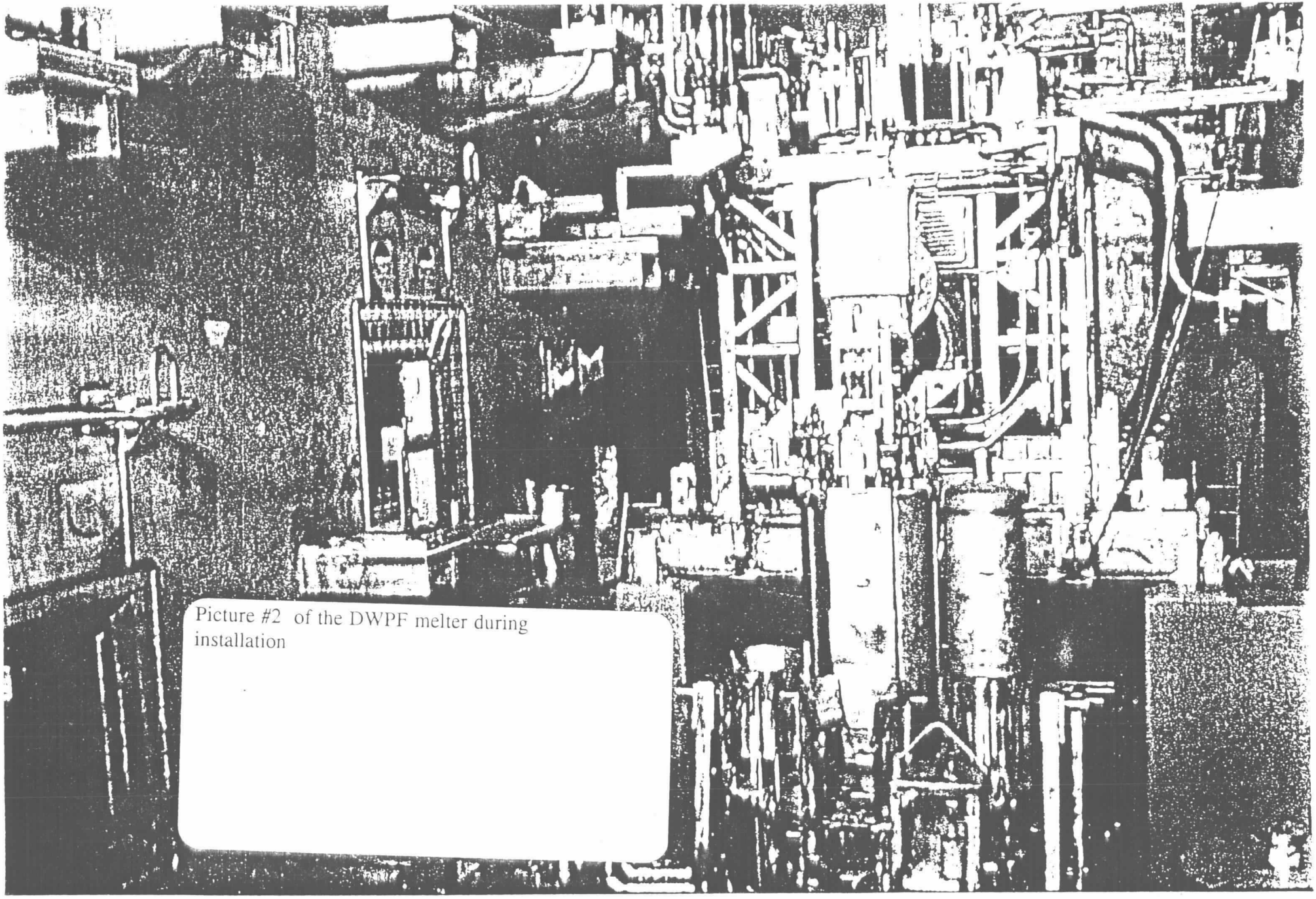


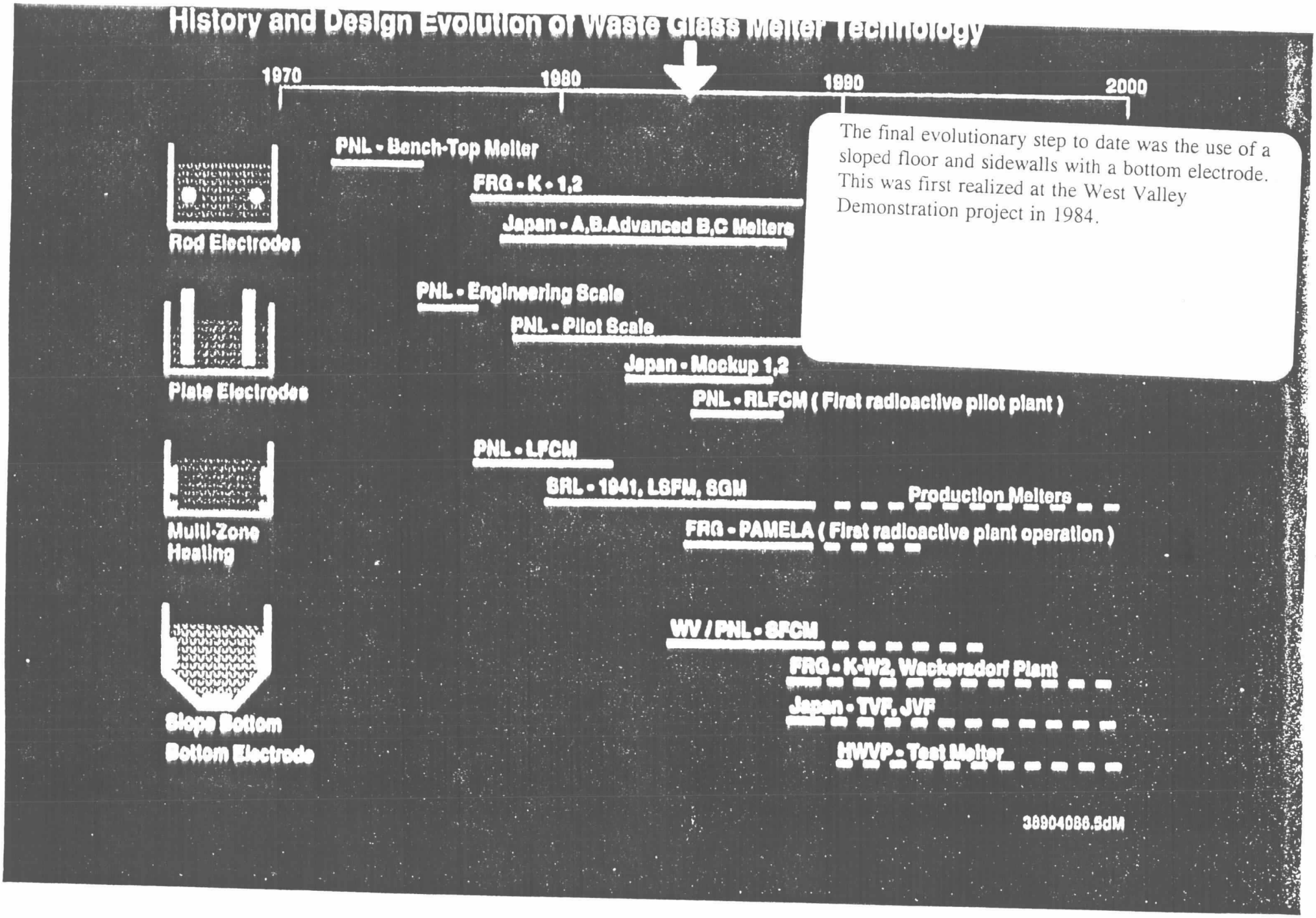
Photo of the DWPF at Savannah River



Picture of the DWPF melter during installation



Picture #2 of the DWPF melter during installation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SRL - 1941, LSFM, SGM
Production Melters
FRG - PAMELA (First radioactive plant operation)
Multi-Zone Heating
WV / PNL - SFCM
FRG - K-W2, Wackersdorf Plant
Japan - TVF, JVF
HWVP - Test Melter
Slope Bottom
Bottom Electrode
The final evolutionary step to date was the use of a sloped floor and sidewalls with a bottom electrode. This was first realized at the West Valley Demonstration project in 1984.
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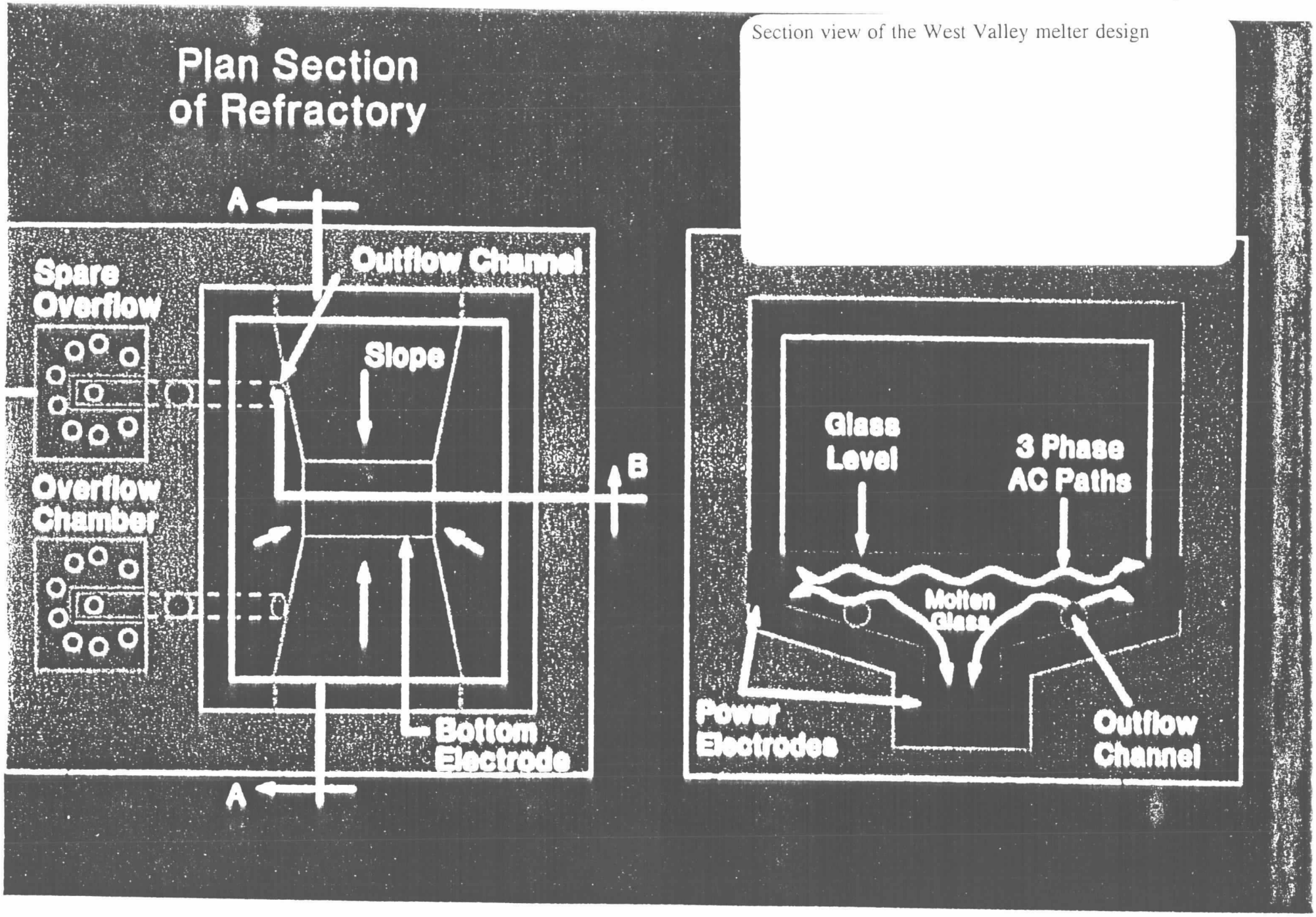


Section view of the West Valley melter design

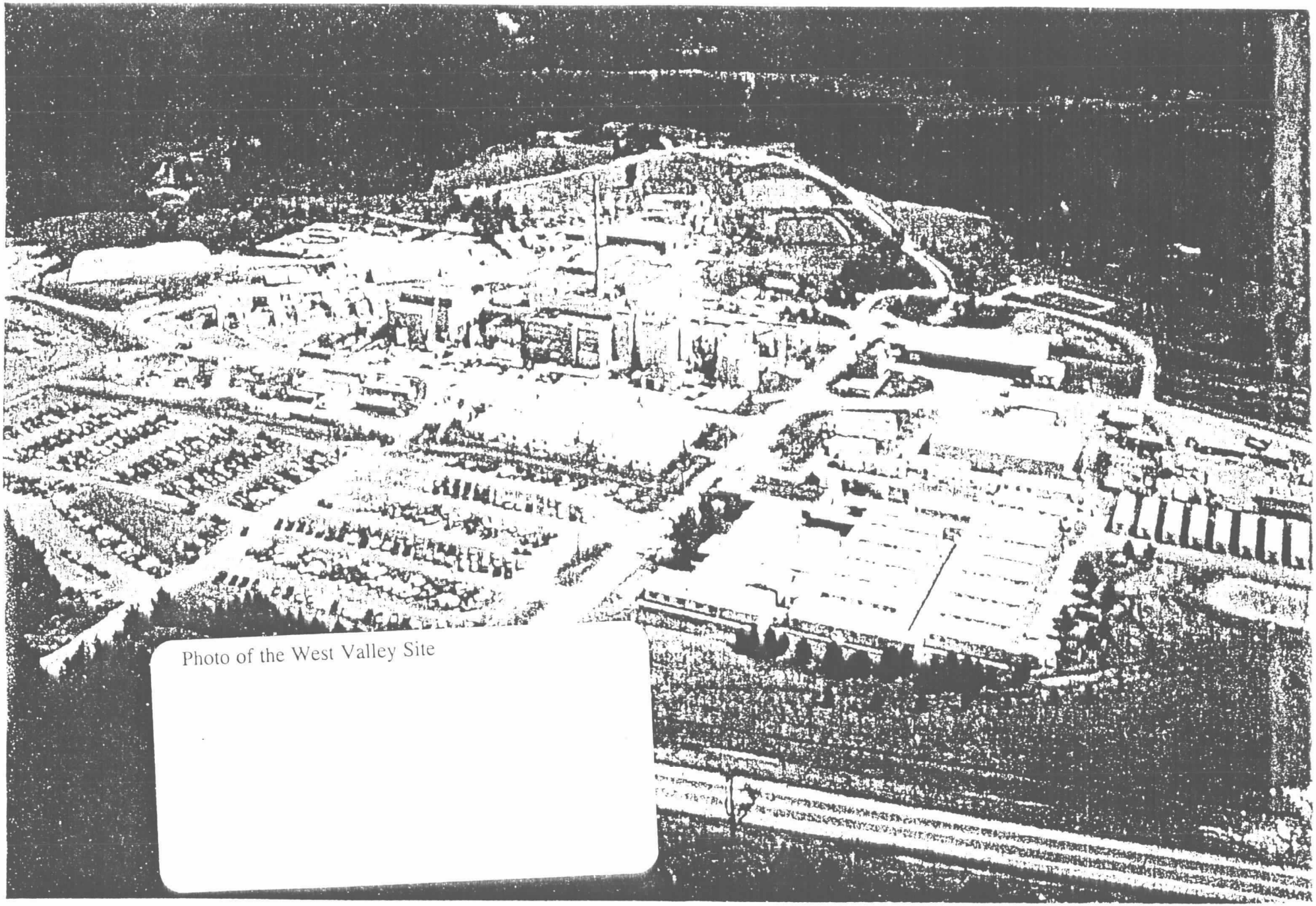
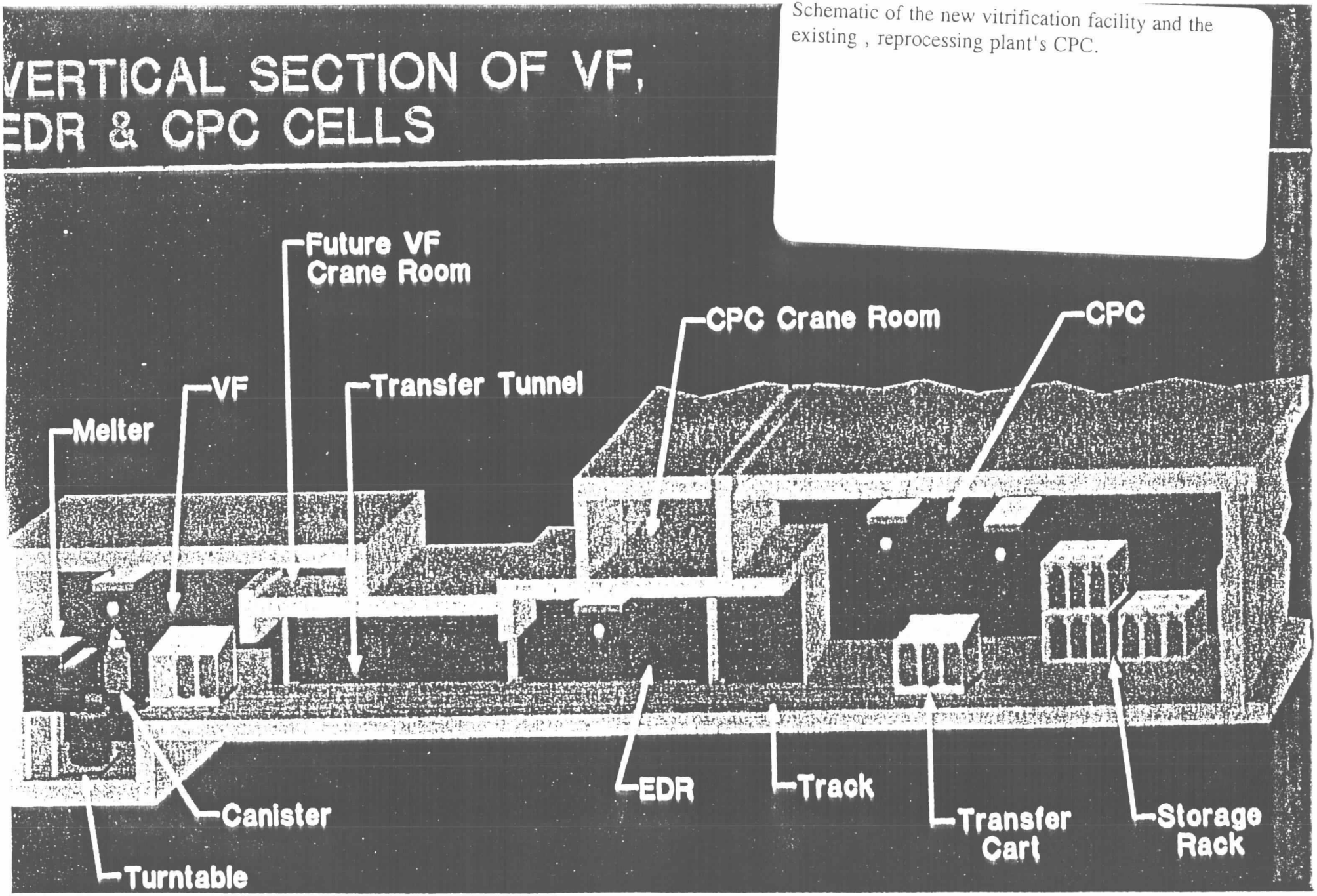
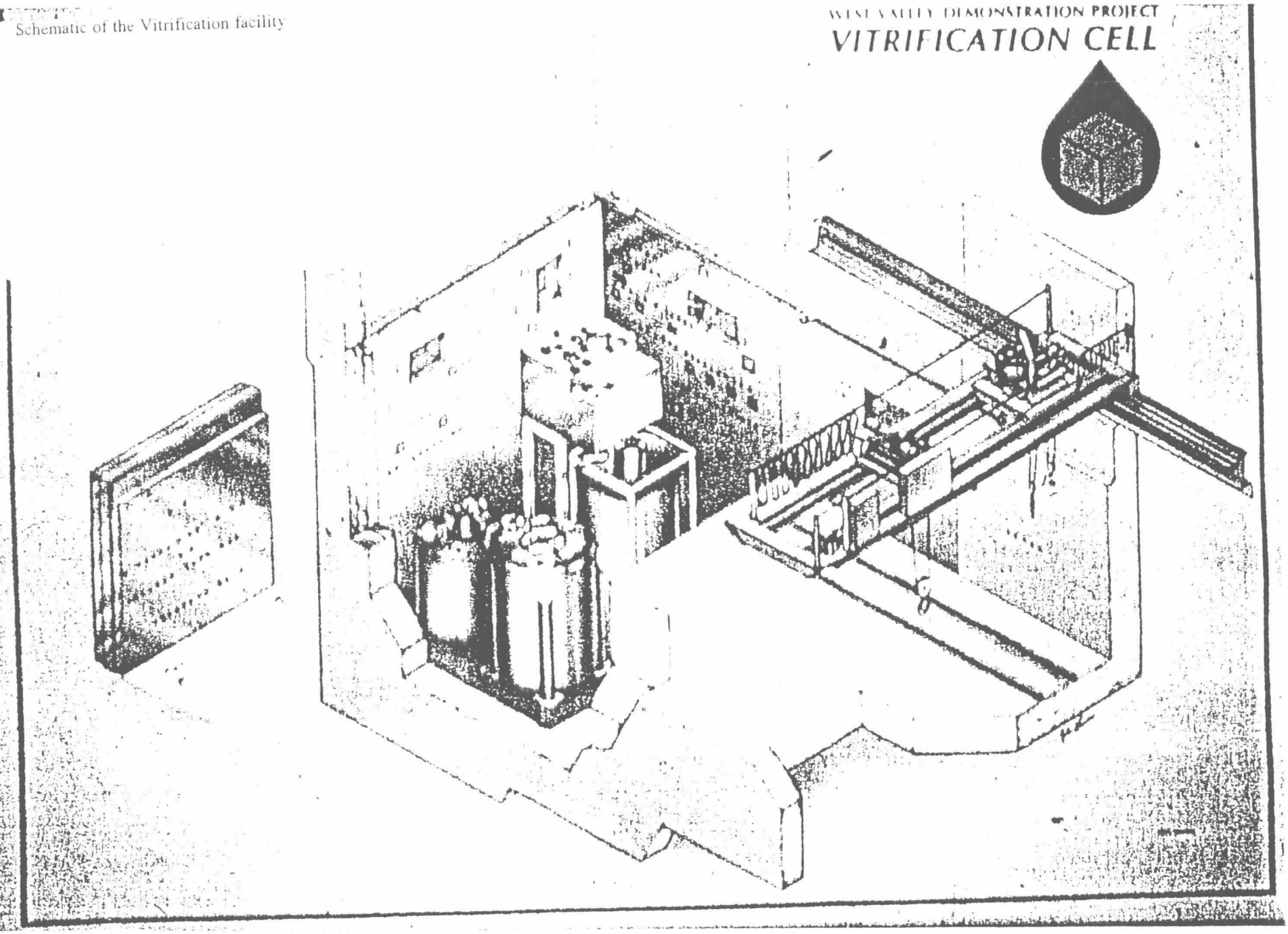


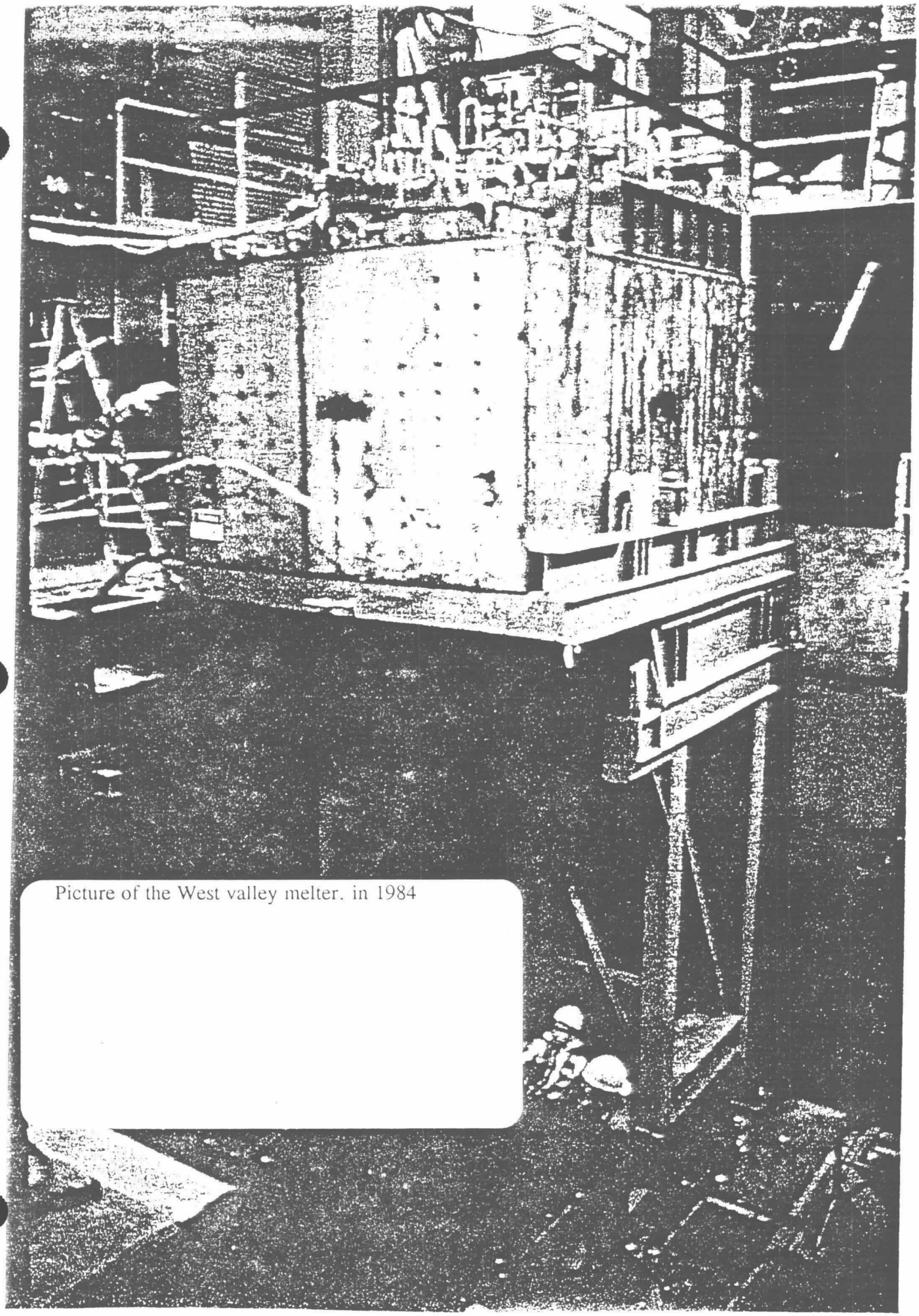
Photo of the West Valley Site



Schematic of the new vitrification facility and the existing , reprocessing plant's CPC.

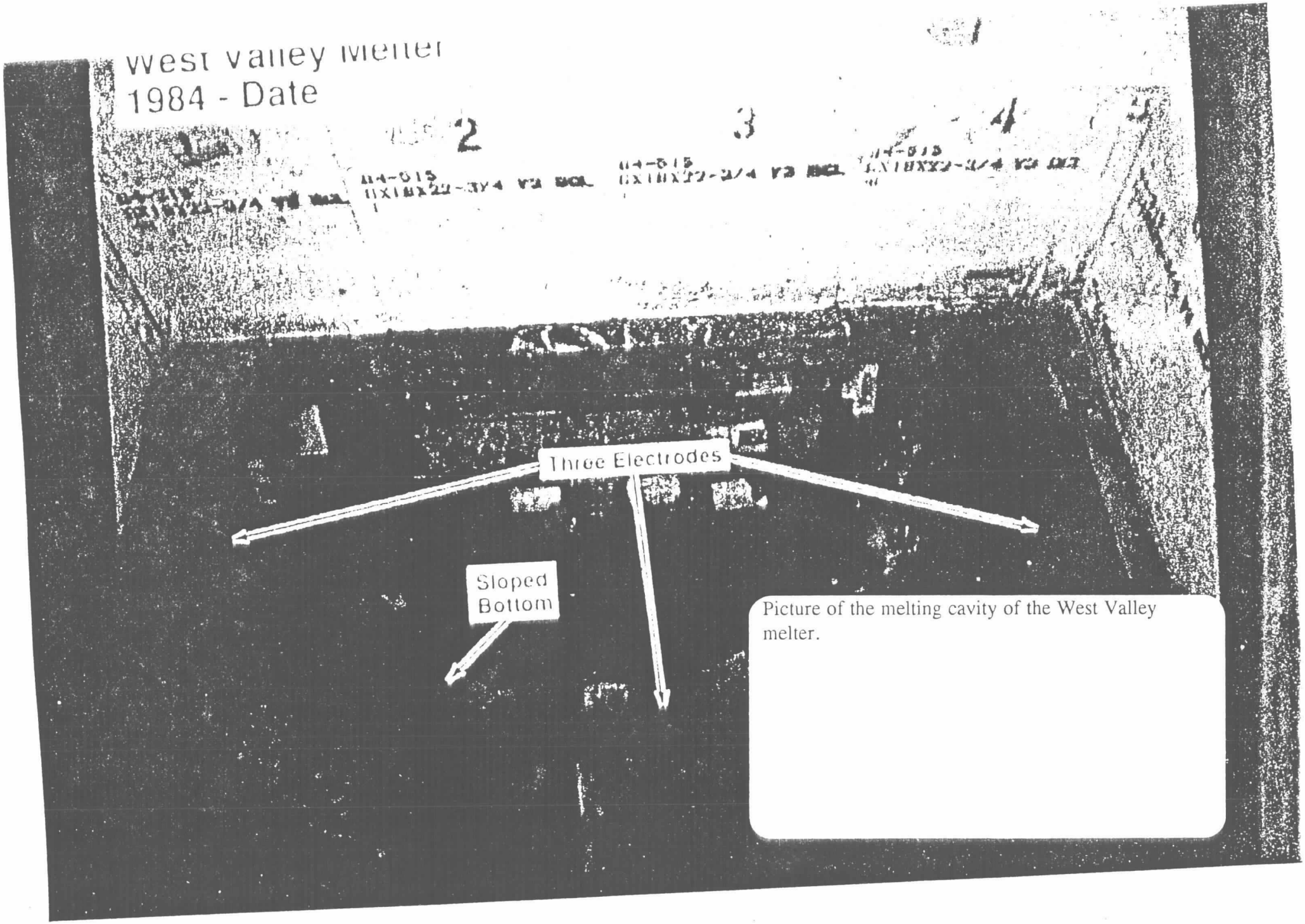
Schematic of the Vitrification facility



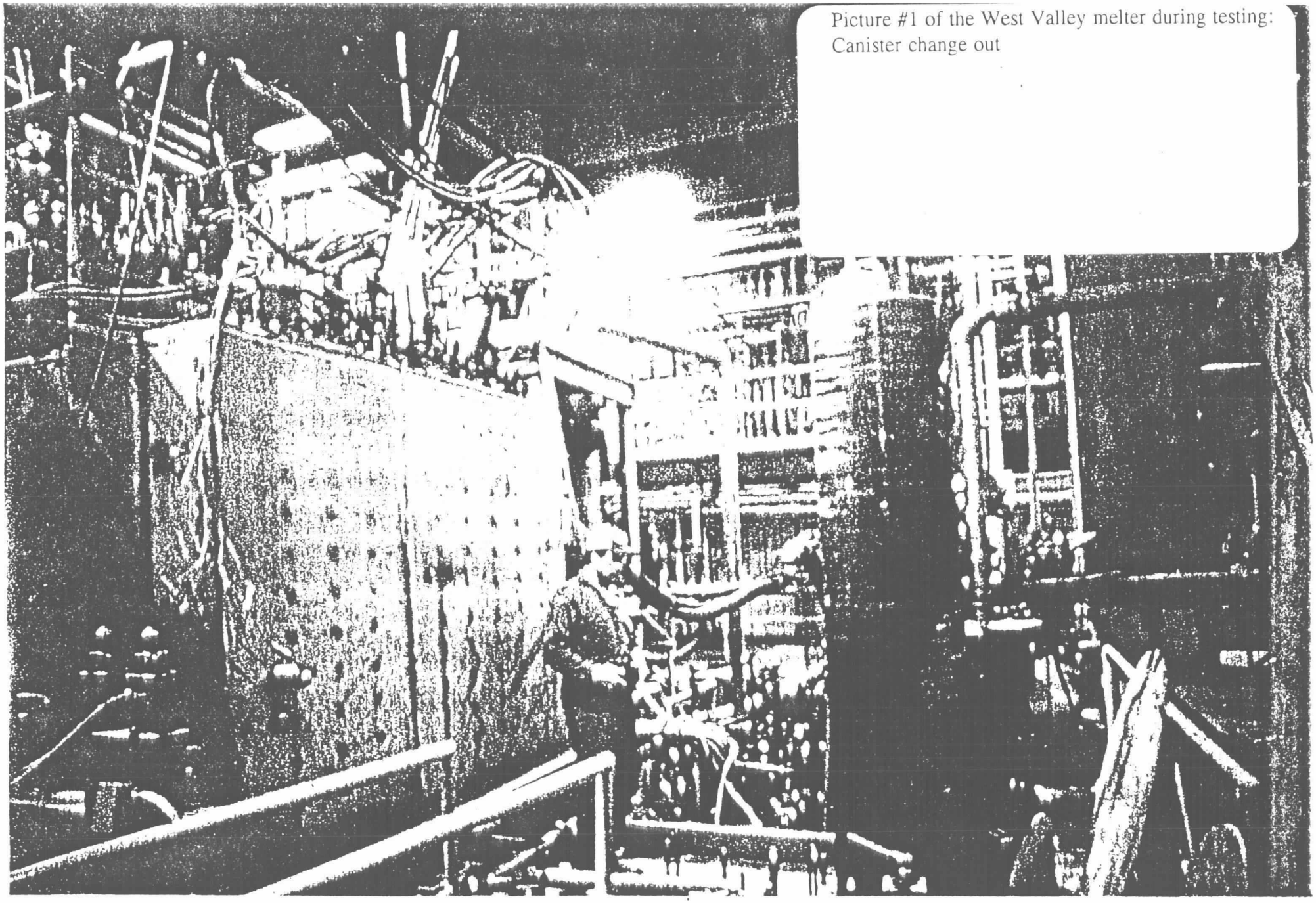


Picture of the West valley melter. in 1984

West Valley Melter
1984 - Date

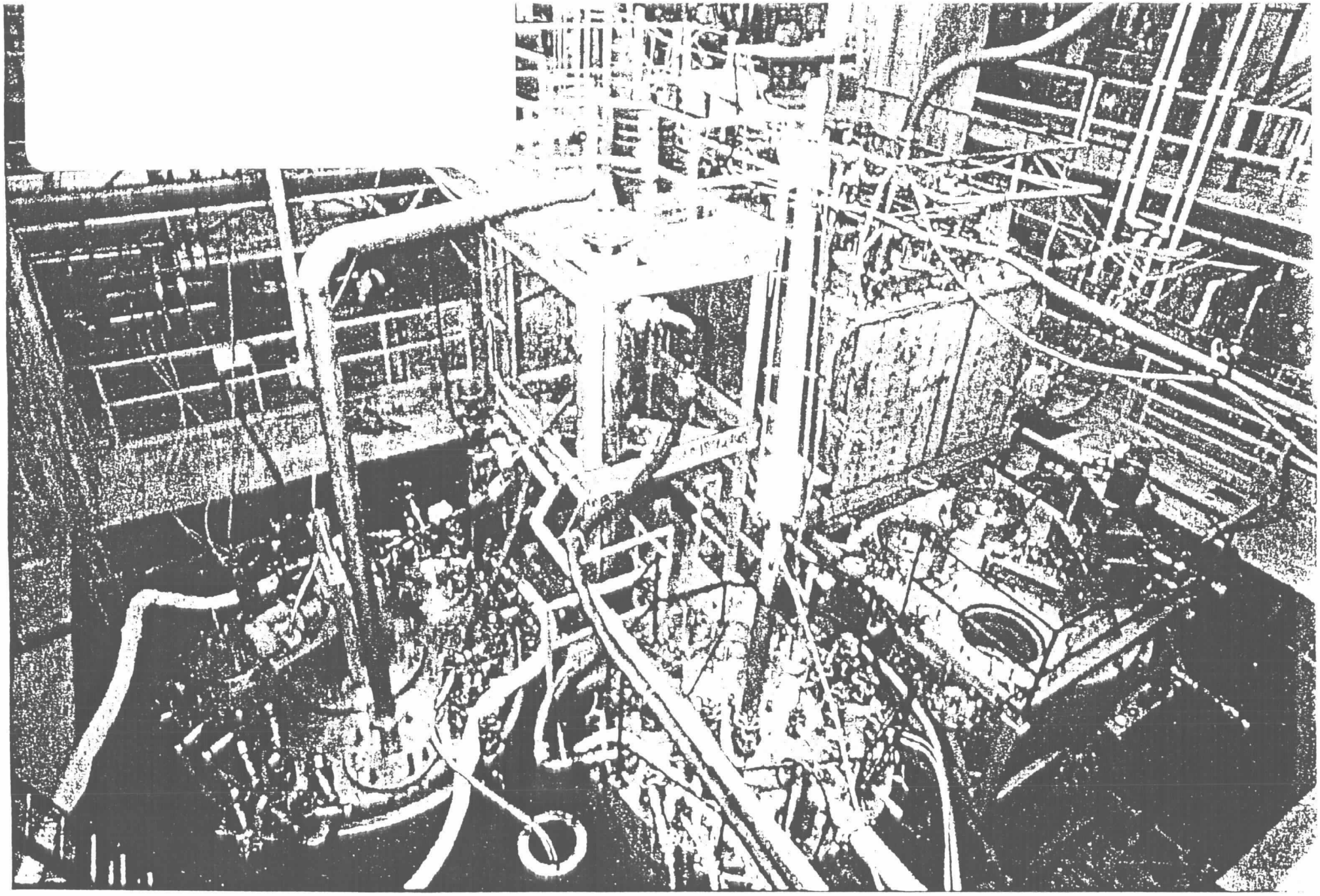


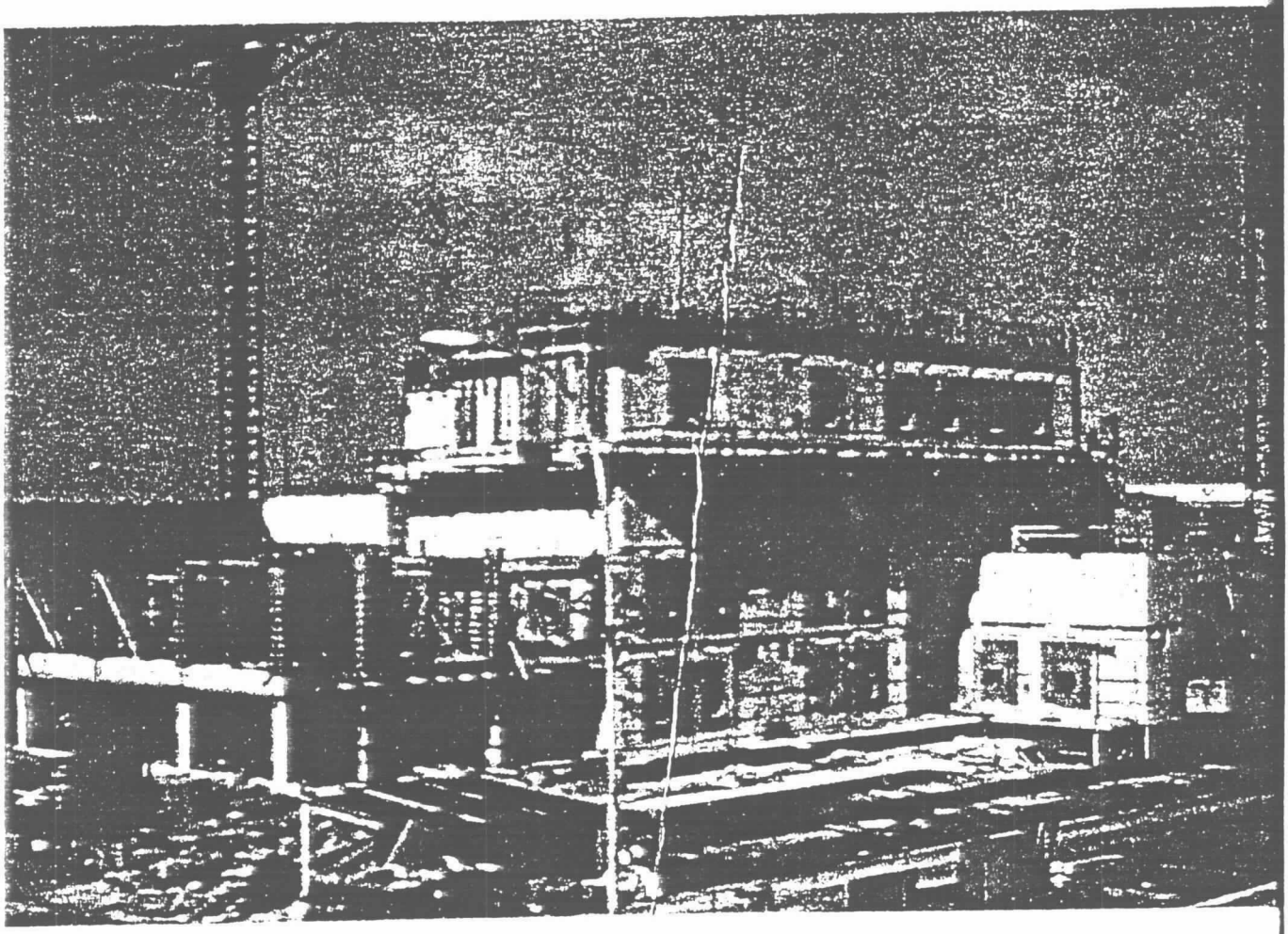
Picture of the melting cavity of the West Valley melter.



Picture #1 of the West Valley melter during testing:
Canister change out

Picture # the West Valley melter system including feed and off gas systems





Germany's PAMELA Plant in Mol, Belgium during construction

Germany's PAMELA Plant in Mol, Belgium
construction completed.

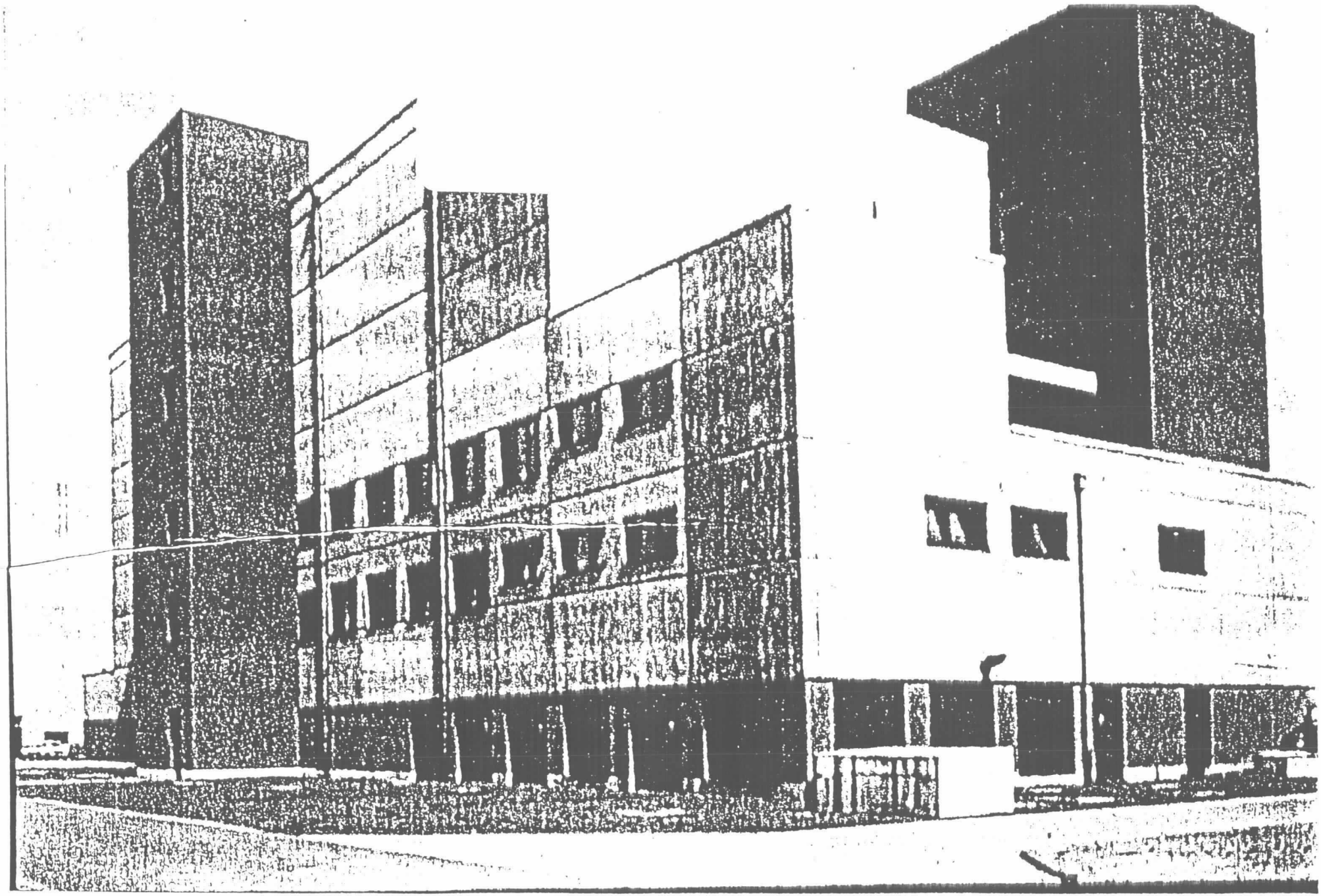
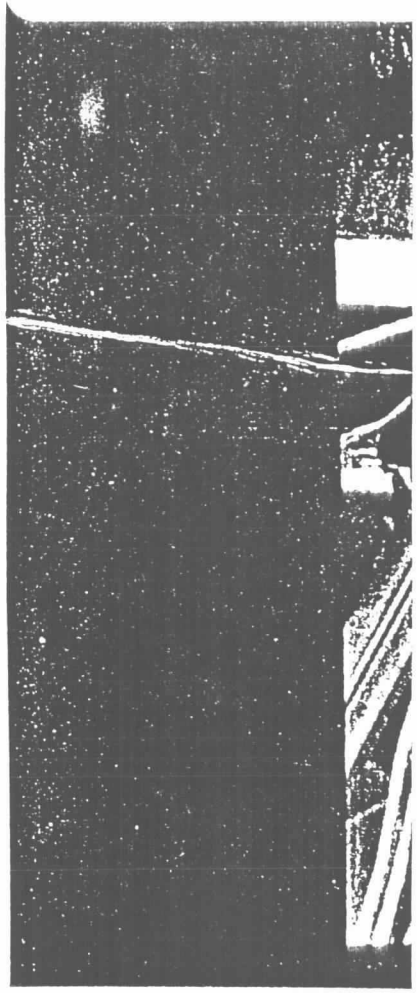
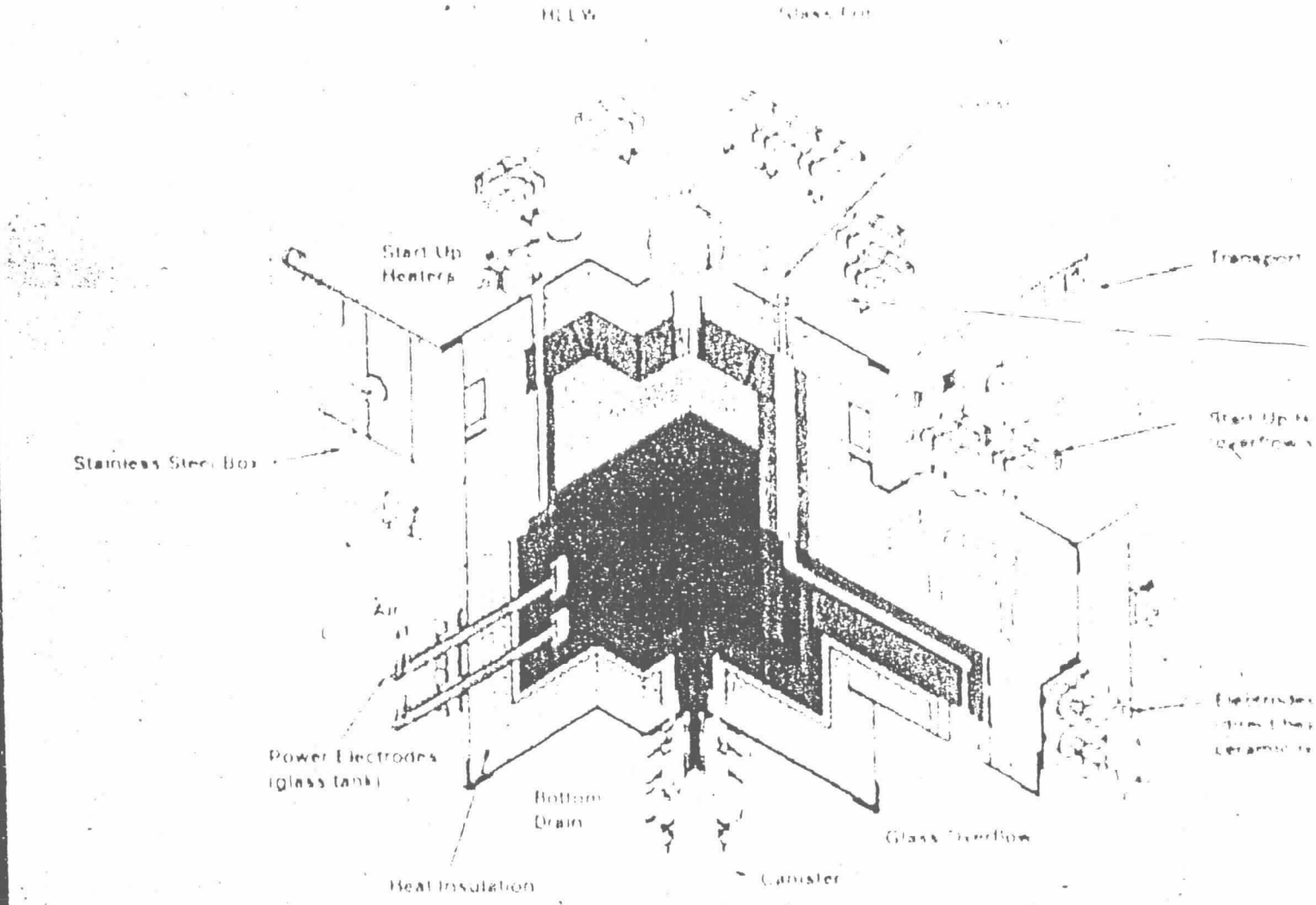


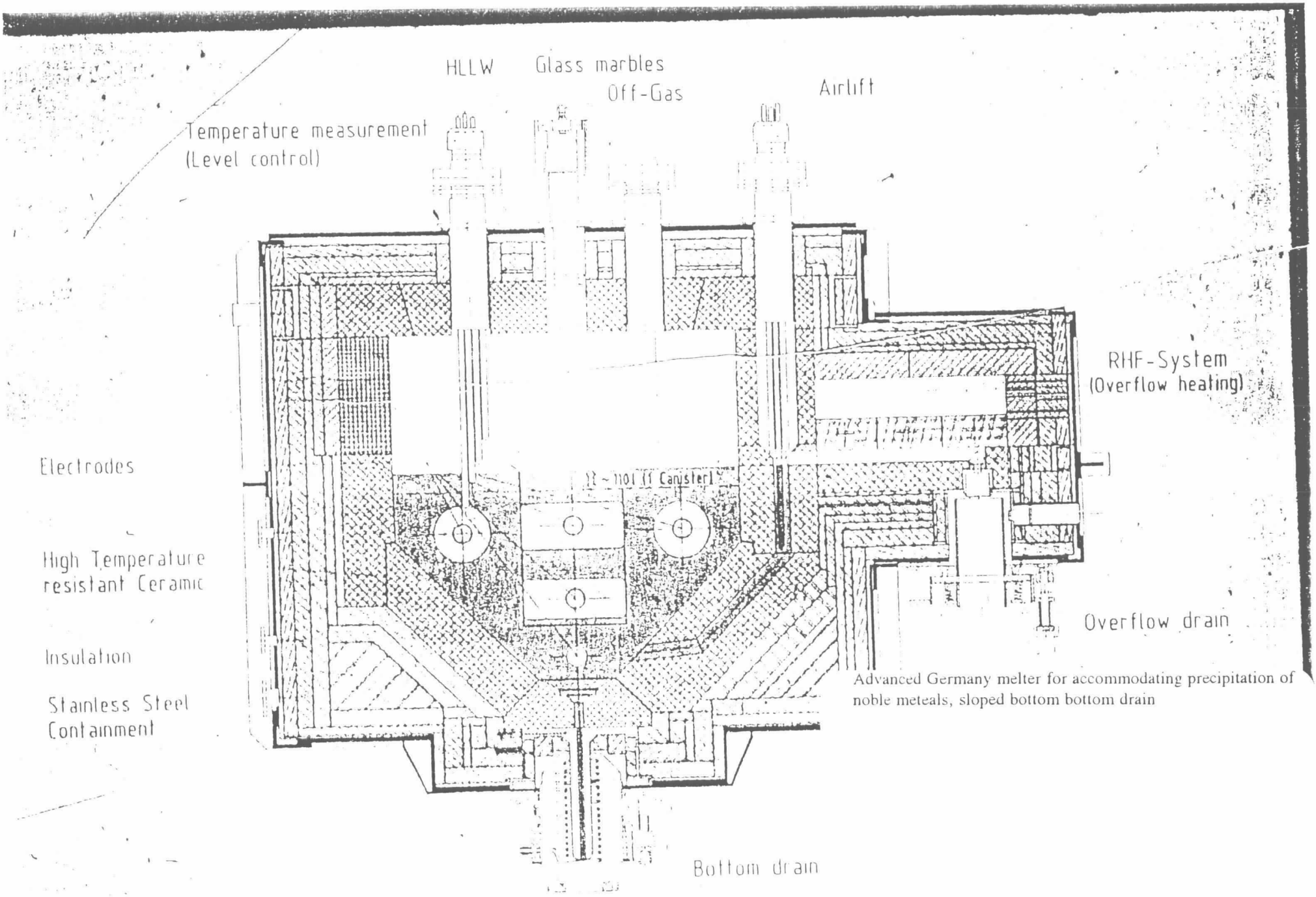
Photo of PAMELA melter fro
This melter design started ope
processed the LEWC, HEWC
without any major problems.
efficiency was nearly flawless
the plant has been completed a
down.



PAMELA Melter
West Germany 1985 - 1988

PAMELA melter sch





Advanced Germany melter for accommodating precipitation of noble meteals, sloped bottom bottom drain

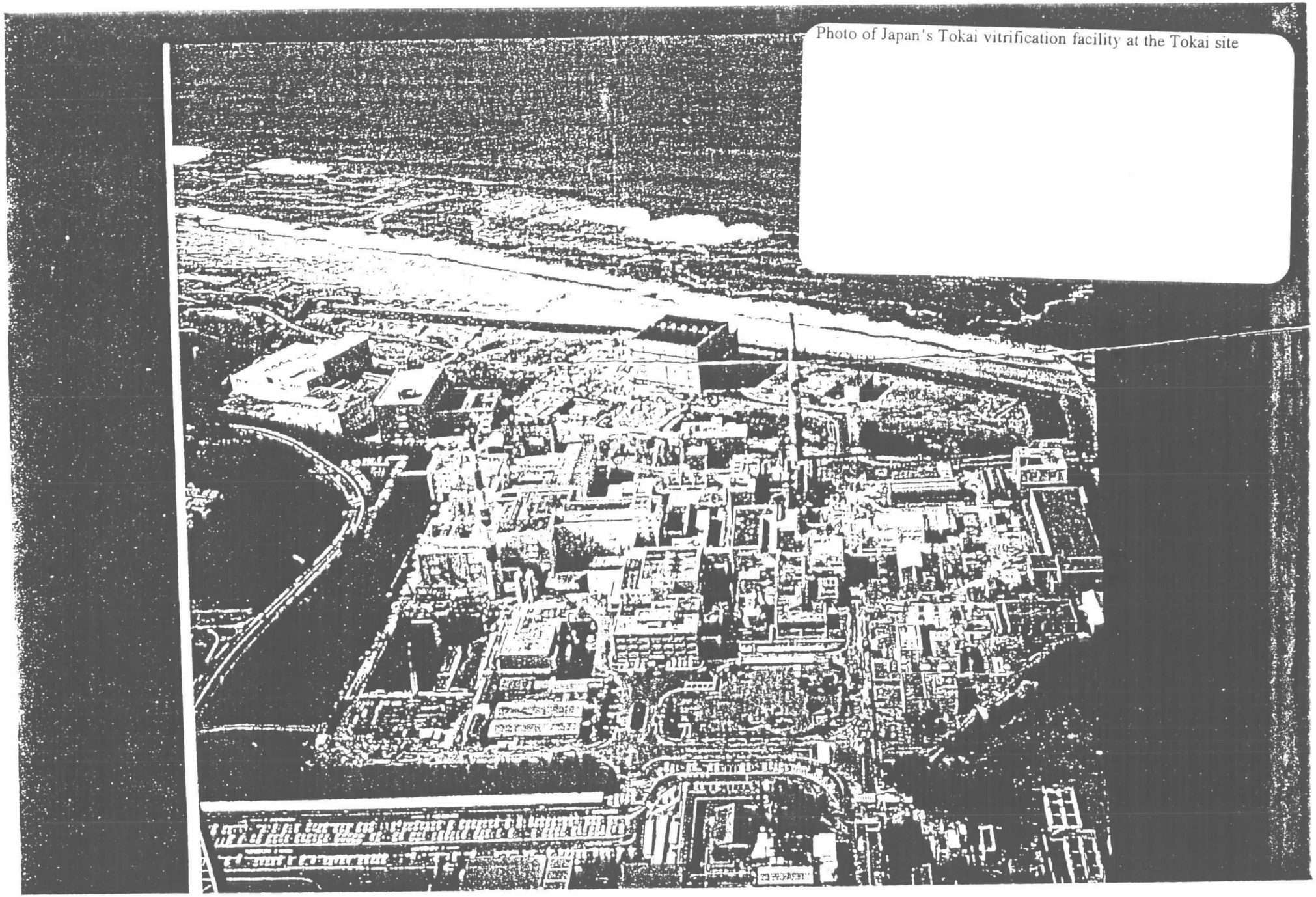
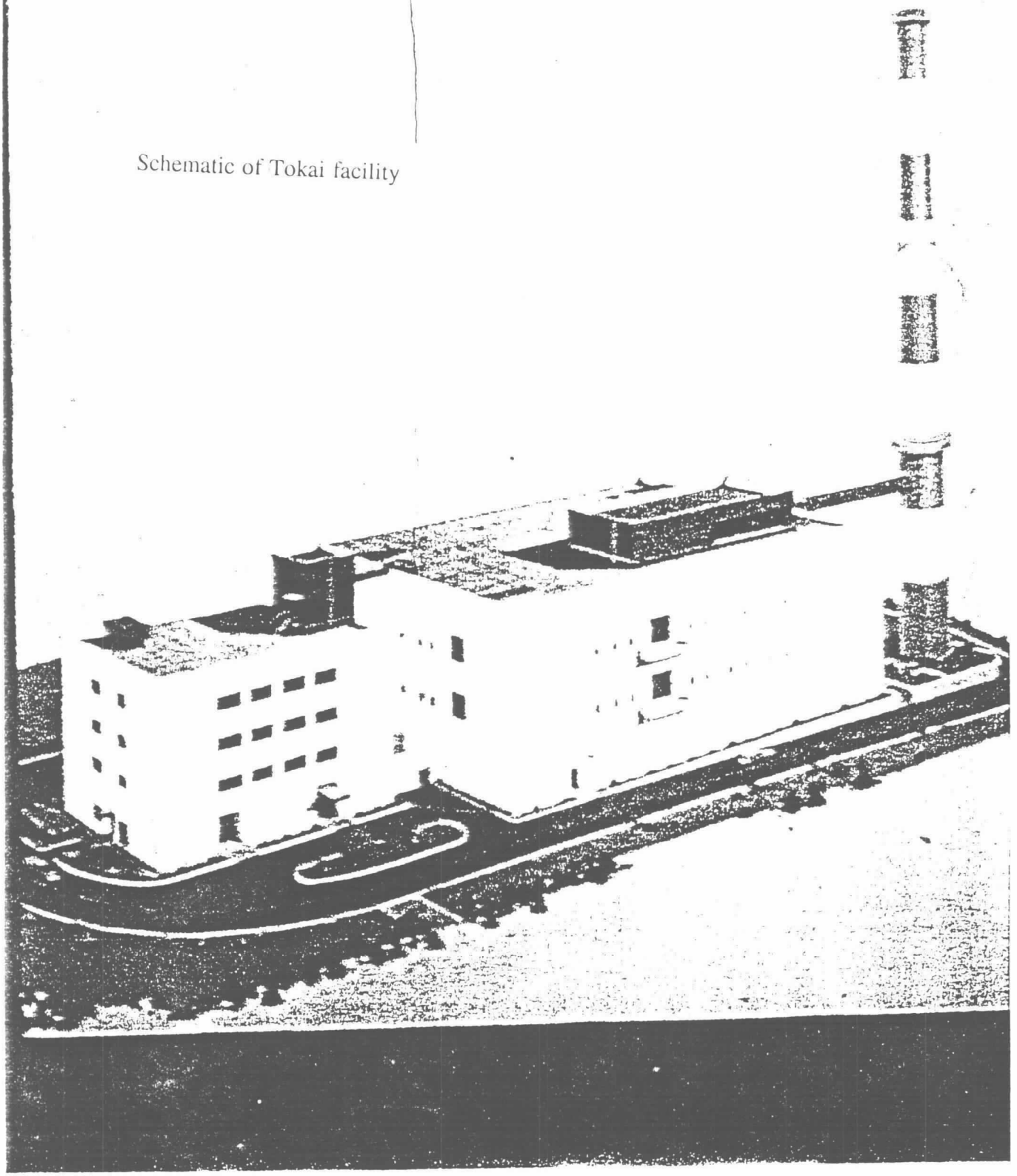


Photo of Japan's Tokai vitrification facility at the Tokai site

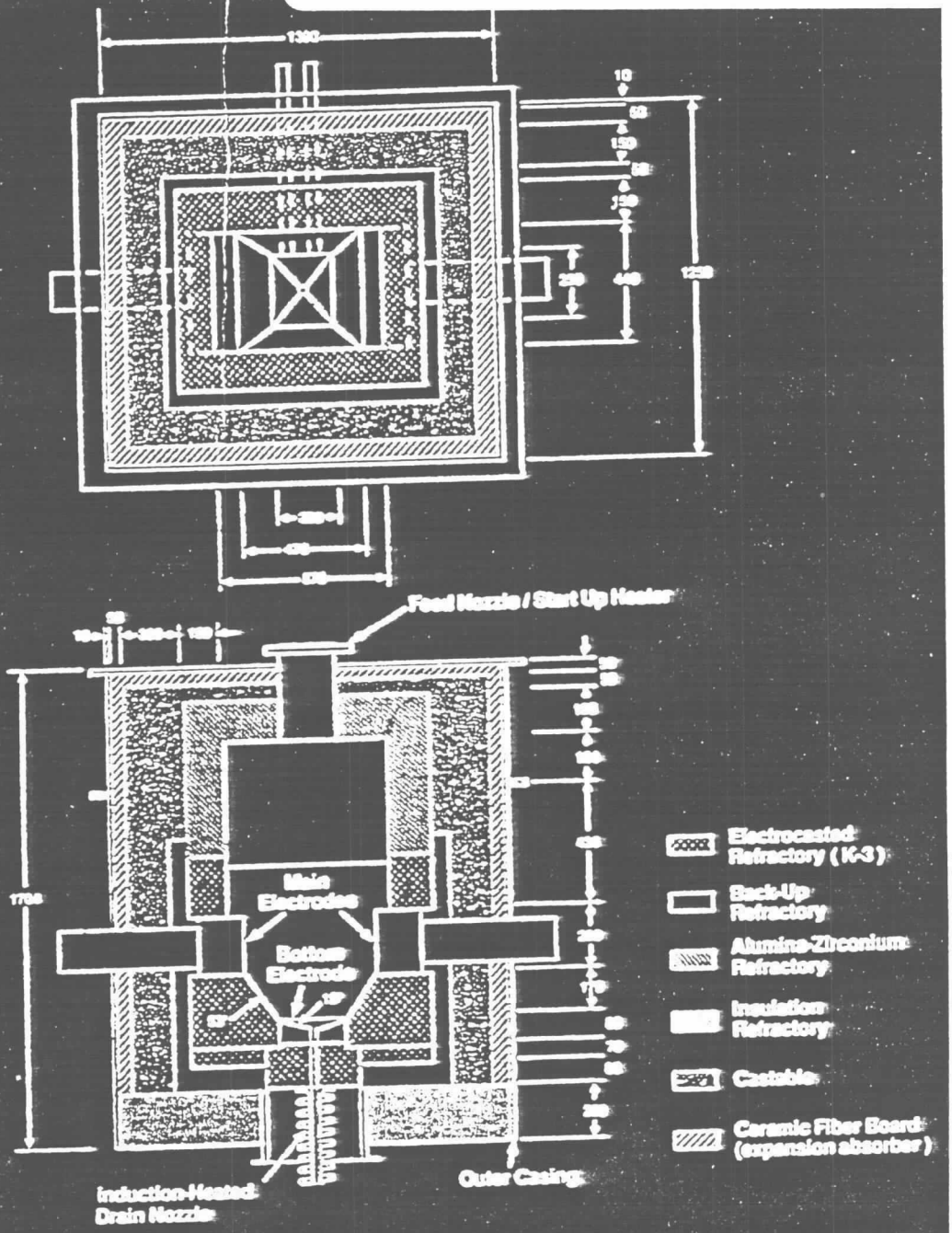
Tokai Vitrification Facility (TVF)

Schematic of Tokai facility



Schematic of Tokai's and commercial plant melter design.

Japan's Commercial Vitrification Melter Design



Glass Pouring

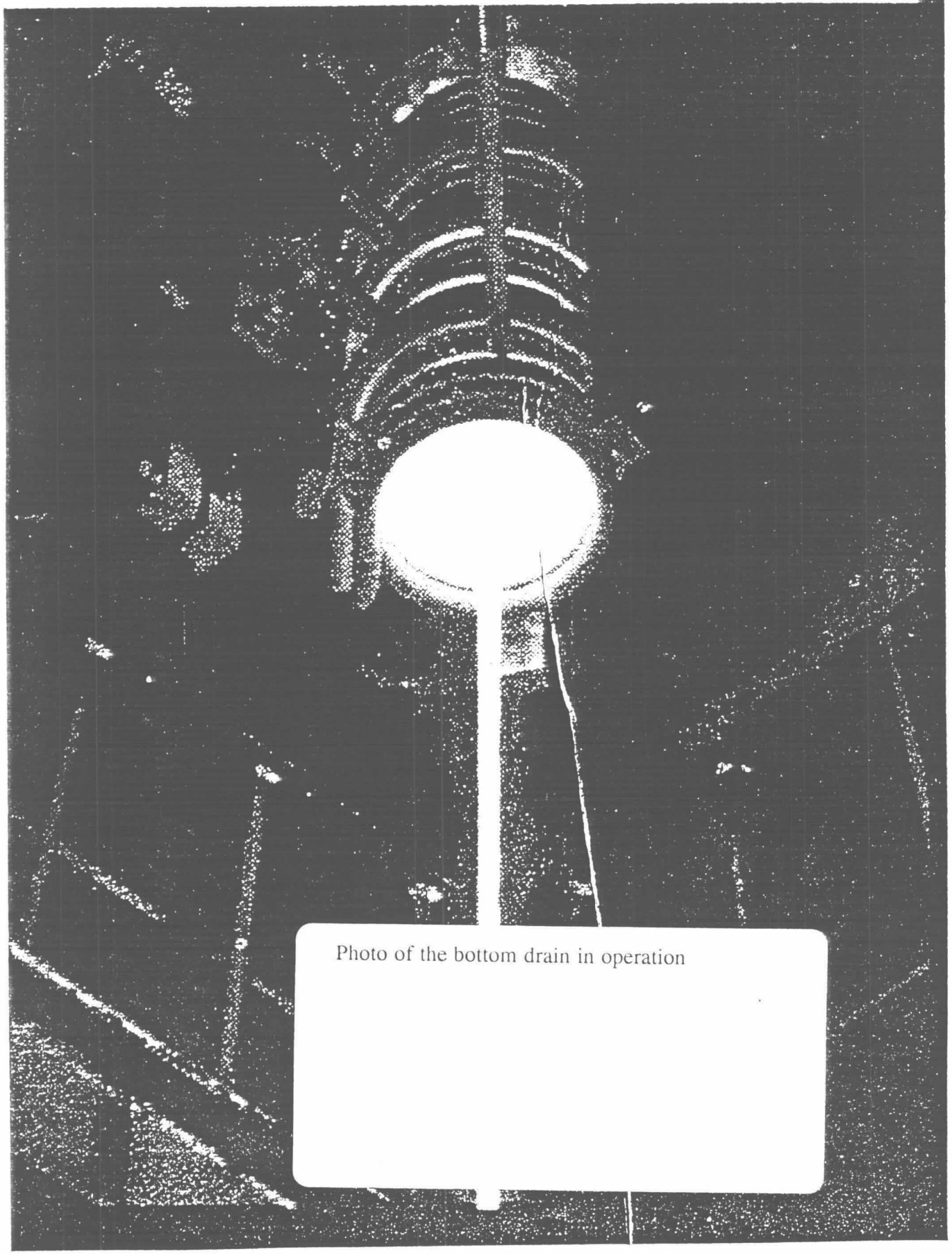
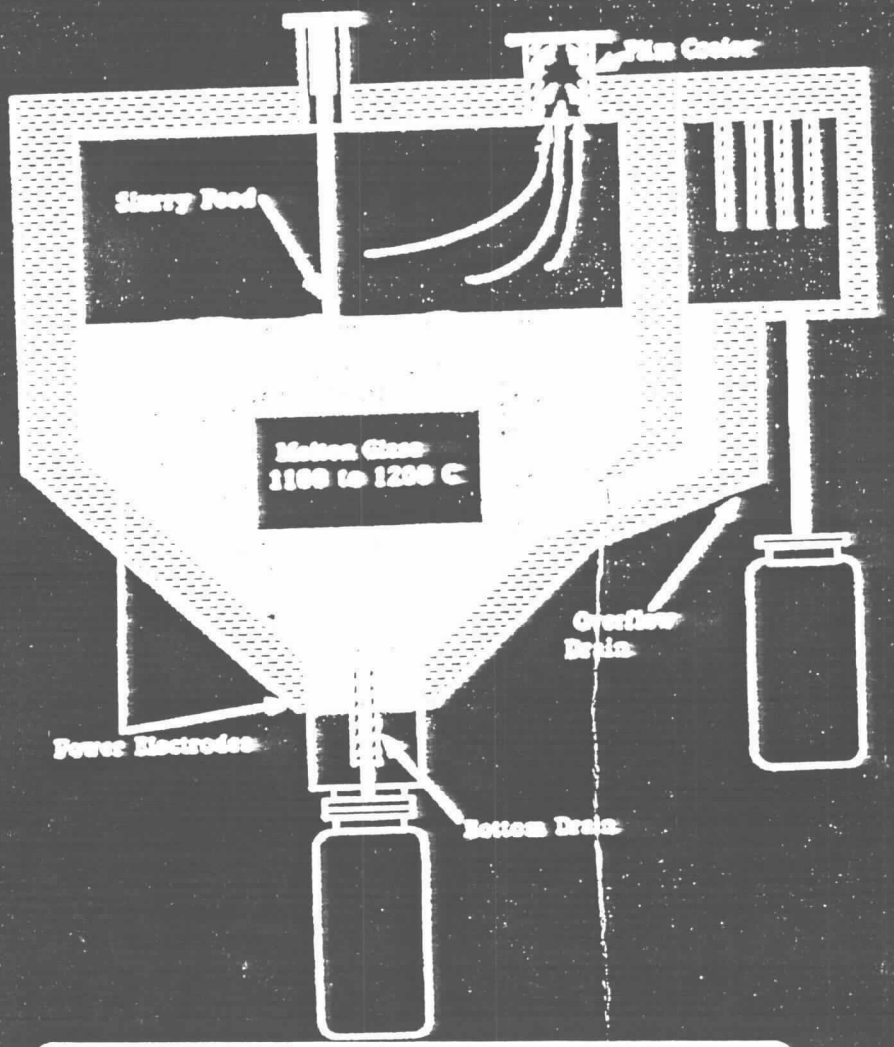


Photo of the bottom drain in operation

High Level Waste Glass Melter Design Consensus

- Sloped Bottom and Bottom Electrode
- Bottom and/or Overflow Drains



Current HLW melter design consensus for general operations