LA-UR - 79-3091

TITLE: HISTORY OF REMOTE HANDLING AT THE LOS ALAMOS SCIENTIFIC LABORATORY

AUTHOR(S): Mahlon T. Wilson, AT-DO
Warren T. Wood, CMB-14
John W. Barnes, CNC-11

SUBMITTED TO: The 27th Conference of Remote Handling Systems, sponsored by the American Nuclear Society, San Francisco, CA
November 12-15, 1979

By acceptance of this article, the publisher recognizes that the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or to allow others to do so, for U.S. Government purposes.

The Los Alamos Scientific Laboratory requests that the publisher identify this article as work performed under the auspices of the U.S. Department of Energy.

University of California

LOS ALAMOS SCIENTIFIC LABORATORY
Post Office Box 1663 Los Alamos, New Mexico 87545
An Affirmative Action/Equal Opportunity Employer

Form No. 836 R3
St. No. 2629
12/78

UNITED STATES
DEPARTMENT OF ENERGY
CONTRACT W-7405-ENG. 36

History of Remote Handling at the Los Alamos Scientific Laboratory

Mahlon T. Wilson, Warren T. Wood, and John W. Barnes
Los Alamos Scientific Laboratory

14 pages of text, 7 figures, 0 tables

Paper No. MP-12-1
Log No. 230

Remote Handling at Los Alamos.

ABSTRACT

The handling of high levels of radioactive materials began at Los Alamos in 1944 with the receipt of ^{140}Ba sources that were milked to extract the ^{140}La daughter for use as a tracer in hydrodynamical experiments. Remote-handling techniques and facilities have been used to support research programs in reactor development and radiochemistry, and in support of an accelerator.

High levels of radioactive materials have been handled at the Los Alamos Scientific Laboratory (LASL) during essentially its entire existance. This work has been in support of the various research programs of the laboratory and is described in four categories; the preparation and use of sources as hydrodynamic tracers, the handling of developmental reactor fuel and components, general purpose hot cells, and remote-handling features associated with specialized facilities.

RALA

The RALA (RAdioactive LAnthanum) program utilized ^{140}La as a tracer to follow the hydrodynamic motion of explosively driven systems. The sources were first prepared at Bayo Canyon Site and later in facilities constructed at Ten Site. The experiments using the sources were all fired at Bayo Canyon.

Bayo Canyon Source Separation

The handling of high levels of radioactive materials began in Los Alamos during the winter of 1944-45 with the receipt of batches of ^{140}Ba from Oak Ridge. The chemical process building was a wooden structure located at TA-10 Bayo Canyon Site (Fig. 1). The sources were stored within the shipping casks and the process apparatus was lowered into the source containers to effect chemical separation of the ^{140}La daughter. Figure 2 shows a setup used for chemical process development that utilized the same process apparatus concept as that employed for production source separation. Long tongs and mirrors

were utilized to pour reagents into the process apparatus protruding above the head-high casks. Crank actuated cables, compressed-air valving, and electrical motor switches located 27 meters from the casks were used by the operators to perform the chemical separations, which were observed through telescopes and mirrors.[1,2,3] A few hundred thousand curies of ^{140}Ba were handled in batches that grew from 50 to 5,000 curies as the techniques and experimental program improved.[1,4] One hundred fifty ^{140}La sources whose stengths varied from 40 to over 3000 Ci were prepared and used in experiments from September 1944 until July 1950.

Ten Site

Early in 1947 design work began on a new facility for the chemical separation of ^{140}La from ^{140}Ba, and the packaging of the ^{140}La sources. This facility was erected at TA-35 Ten Site and was completed in 1951, at a cost of $2.8 million. The facility consisted of two 3-m-deep, 6-m-wide by 2.5-m-high cells serviced by a jib crane and trolley assembly, one end of which was pivoted from the center of the front wall and the other end was supported on a semicircular track. (Fig. 3) The trolley was moved in or out on the crane. The trolley housed a rotatable spindle that had a vertical travel of 0.6 m. The lower end of the spindle had a cross pin that mated with bayonet slots in various tools, vessels, and equipment components. All manipulations were performed with the jib crane assembly. Viewing was accomplished through mirror systems mounted in three shielded labyrinths, supplemented by retractable periscopes. The view of the cell interior was

quite adequate. Figure 4 is a mosaic of photographs taken at various periscope mirror angles. A sizable auxiliary building contained air and liquid filtration and treatment equipment.[5]

This is believed to be the first hot cell designed, after the end of the war, to handle high-level radioactive materials; it contained innovative features such as contamination-free fluorescent light fixtures that permitted external bulb insertion, cell washdown sprays, collimated ports for radiation experiments, and hydraulic rams for automatically opening and positioning the shipping casks.[6] The cell was decontaminated annually for hands-on equipment modifications, maintenance, and replacement.

A concrete block cave, equipped with a zinc bromide viewing window and a pair of LASL fabricated Model 4 over-the-wall manipulators, was erected in a room above the cell in later years to provide added flexibility in final source packaging.

The Chemical Processing Plant at Idaho Falls became the source of purified ^{140}Ba in 1956, and a typical shipment was about 40,000 Ci ^{140}Ba. The ^{140}La sources prepared at Ten Site were usually in the range of 2,000 to 4,000 Ci. Almost 2 million curies of ^{140}Ba had been handled at Ten Site by 1963 when the RALA program was terminated.[4] The cell was decontaminated and stripped, then the basic building was enlarged and is being utilized for other programs.

Bayo Canyon Experiments

The early sources were deposited in cups residing within a transfer cask which was then trucked approximately a half mile to the experiment. The cups were removed from the transfer cask and loaded into the experiment using a clothesline and pulley arrangement operated by pulling strings from a distance. This operation is shown in Fig. 5, where the turnip-shaped source container can barely be seen suspended above the bed of the pickup truck. As techniques for both source preparation and experimental utilization improved, the remote handling sophistication also progressed.

After 1951, the ^{140}La source packages were placed in a small, spherical uranium cask at the Ten Site laboratory and this cask was placed within a tight-fitting lead cask for trucking to Bayo Canyon Site for the experiment. Depending on the package type, most sources required constant cooling, either through conduction to a heat sink or by being sprayed with a refrigerant, to prevent oxidation or melting of the package. The transfer of the increasingly more-active source packages from the transport cask into the experiment evolved into a variety of manipulative equipment, depending upon the package configuration and the needs of the experiment. The most sophisticated device received the small, spherical uranium cask, reading a few roentgen; remotely removed its lid; picked up the source with a tong; and placed it on a holder mounted on an elevator. Figure 6 shows the tong reaching into the cask to pick up a source. A television camera confirmed that the source package was actually placed on the holder. The elevator accurately positioned the source

package within the experiment. This wheel mounted device was remotely withdrawn to a shelter because the experiment involved a considerable amount of explosives. The retrieval of the source from an aborted experiment was a traumatic occasion, which fortunately occurred infrequently. One also had the option of walking away from a mishap for a few days while the 40-hour half-life ^{140}La decayed away. Another frequently used manipulative method involved a lead shadow shield mounted over the rear axle of an Army 6 x 6 truck. A man crouching behind this wall handled the source package with clothes pin or vacuum pickup devices postioned and actuated with string or sticks. Viewing was with mirrors and later through lead glass windows mounted in the wall. A master slave manipulator mounted on the wall in 1957 provided additional manipulative options.

The Bayo Canyon work in the latter part of the fifties was extremely exciting and challenging because experiments would be conceived, designed, fabricated, and executed within a few weeks. The engineer involved also handled the sources and many ingenious schemes were used. Annual dosage limits were seldom exceeded; however, biweekly dosages were often received during the tens of seconds required for the actual source manipulations. Bayo Canyon operations ceased in 1963 and the site was stripped, cleaned up, and opened for public use.

REACTORS

The reactor known as Clementine commenced operation in November 1946. It was the first fast reactor and the first to have ^{239}Pu as the fuel. The mercury-cooled core contained vertical fuel rods, clad with steel, occupying a cylindrical volume 15 cm high and 15 cm diameter.[7] In late 1952, corrosion of the steel cladding released a considerable amount of alpha activity into the mercury coolant, and the reactor was disassembled. Plastic bagging techniques were used, with alpha boxes, shadow shields, casks, long tongs, and electromagnets to disassemble the reactor.[8] Those involved take justifiable pride in the fact that no detectable alpha contamination was released or remained after the disassembly of this reactor system whose coolant and core were highly contaminated.[9] The Omega West Reactor was constructed over the spot where Clementine was removed and it is still used in supporting research programs.

A series of very compact reactors were assembled and tested at Ten Site in the 1950's and early 60's. These were the plutonium dissolved in phosphoric acid fueled LAPREs (Los Alamos Power Reactor Experiment). LAPRE I was a forced-convection, high-pressure, water-cooled reactor that was later drained and removed. It was followed by LAPRE II that used natural convection currents within a low-pressure plutonium solution for heat transfer to the water cooled heat exchanger. The fuel was removed at the completion of testing and the reactor hardware remains in its outdoor pit. A third reactor, LAMPRE (Los Alamos Molten Plutonium Reactor Experiment), was assembled within

the Ten Site cell adjacent to the one used for ^{140}La separation. It used molten plutonium contained within dozens of tantalum capsules, located within a sodium-cooled cylindrical core region approximately 40 cm high by 44 cm diameter.[10] The fuel was transferred to storage at Wing 9. The sodium was removed, and the reactor hardware remains in place. The defueling of these small reactor experiments was accomplished with inconsequential contamination and reasonable personnel dosages.[11,12]

A metallography cell was assembled in the laboratory over the reactor control room adjacent to the ^{140}La stacked cell. LAMPRE fuel capsule examination was performed in these cells, which are shown in Fig. 7. These cells have since been removed.

GENERAL PURPOSE HOT CELLS

There exist at Los Alamos thirty-six hot cells in four facilities that can best be described as general purpose cells, in that their design permits considerable flexibility in their usage.

DP-West

Construction was started in March 1958 on the DP-West,[13,14] hot-cell facility. It consists of four cells capable of handling kilogram quantities of irradiated plutonium containing kilocuries of gamma activity. The facility was created for the purpose of evaluating plutonium fuel reprocessing schemes

and was used for this purpose until 1967. It lay dormant until 1970 and since then has supported the LMFBR testing program by performing in-depth postirradiation examinations of reactor-fuel elements.

The facility was built within an existing structure, at a cost of $392,000. The 2-m by 2-m by 6.5-m-high cells communicate through rolling steel doors with a 3-m by 10-m shielded corridor that has 22 floor-storage wells 1.5-m deep. The cell faces are poured magnetite concrete. Removable plastic, gas-tight containment boxes were originally installed in each cell. Manipulators were sealed with boots having large diameter gauntlets to permit manipulator movement and entered through the top of the removable plastic boxes. Material was moved into and out of the boxes through a transfer can system designed to keep the external surface of the can contamination free. The cans were handled with a General Mills manipulator mounted in the corridor. A unique service to the containment boxes was a negative pressure circulating water system. Water was sucked through the coolant passages from a refrigerated reservoir by a vacuum pump capable of handling mixtures of air and water. With such a design, any discontinuities in the coolant passages would permit air to leak into the system rather than let water leak out. This minimized the chance of a nuclear accident caused by water tamping and also lessened the possibility of having to dispose of large volumes of contaminated water from a flooded containment box.

Prior to modifying the facility to support the LMFBR testing program in 1970, the containment boxes were removed successfully. The cells were then setup to perform in-depth, nondestructive, postirradiation examinations on irradiated reactor fuel elements. The primary tests presently being performed at this facility are optical profilometry, gross and spectral gamma scanning, and fission gas sampling.

Wing 9

Design work began in 1956 on what evolved to become the Wing 9 hot cell facility.[15] Construction was started in July 1959, and completed in December 1961, at a cost of $4.5 million. The facility supported the Civilian Power Reactor Program from 1961 to 1967, the Rover (Nuclear Rocket) Program from 1961 to 1973, and the LMFBR Program since 1967. The facility also provides assistance to many LASL programs by performing a variety of experiments involving high levels of gamma radiation. This facility contains 16 general-purpose cells 2 m by 2 m by 3.6 m high, arranged around two shield corridors with 4 cells on either side. The ferrophosphorous walls and lead-glass windows can shield 30kCi of fission products. A storage area consists of 364 shielded holes that are cooled and maintained at a negative pressure. Decontamination, mock-up, machine shop, manipulator repair, cold laboratory, dark room, and office areas are provided. The operating cells have a large number of penetrations of various configurations and are accessible through lowered steel doors or by removing the cell roof plugs. The cells are equipped with close-fitting, removable, stainless-steel

containment boxes[16] for alpha-gamma work and head-high tubs or tables for gamma work. Systems were developed for remotely handling and transferring alpha emitters[17] into and out of the containment boxes. Equipment installed in the cells originally consisted of remotized lathes, tension testers, impact testers, sectioning saws, potting, polishing, metallographs, chemical analysis, gas sampling, arc spectrometer, gamma counting, weighing, and a variety of other laboratory equipment. This equipment has been phased in and out of the cells as various programs have evolved.

New designs that were unique to this facility when it was constructed were shield doors that lowered into the basement, a fuel storage area, and the installation of removable, stainless steel containment boxes for handling of alpha emitters. The shield doors, which are hydraulic operated, have required very little maintenance over the years, and the convenience of not having the doors in the operating area during transfers has been an asset. However, a disadvantage of the design was the dragging of loose beta-gamma contamination into the basement when the doors were lowered. Sheet-metal containment boxes had to be built in the basement around each door and periodically washed down. The storage area consists of 364 holes, which are cooled and maintained at a negative pressure. The capacity of the storage area has been adequate in support of the various programs. However, the maximum, usable height of each storage hole is about 20.5 cm and this has prevented the convenient storage of longer items such as full-length fuel pins. The containment boxes satisfied the original design requirements in that 9 boxes have been removed in what is believe to have been an economical expenditure of personnel exposure and

time.[18] The facility presently supports the LMFBR testing program by performing in-depth, postirradiation, examinations of irradiated fuel elements. Both nondestructive and destructive examinations on steady-state and transient-fuel test elements are performed. Primary tests include betatron radiography, fuel element deencapsulation, optical and mechanical profilometry, fission gas sampling, optical microscopy, autoradiography, burnup analysis, clad density, eddy current tests, scanning electron microscopy, microhardness, electron microprobe, and analytical chemistry.

The overall design of this facility has been very satisfactory in support of the various programs during the past 18 years. Two basic changes in design however, would have made the facility much more versatile: (1) one large operating cell with the height sufficient to handle much longer items and (2) storage holes capable of accepting longer items.

Radiochemistry

The Radiochemistry hot cell facility began with the design in 1957 of a three-station, shielded cell complex within an existing building. This facility was operational by 1959 at a cost of $128 thousand. The walls are ferrophosphorus concrete and steel. Viewing is through 6.2 density lead glass dry windows. Model 8 manipulators supported by one-quarter ton and 5-ton hoists provide handling capability. Sealed boxes are used within two of the cells to control contamination. Hundreds of curies of activity could be handled in these cells and they were heavily used until the completion of

adjacent cells in 1963. They have been used only intermittently until the recent installation of a fuel-rod leach experiment.

An adjacent building housing twelve dry-box cells was completed in 1963, at a cost of $1 million.[19,20] The cells are 1.5 m by 1.7 m by 2.7 m high and arranged in 2 rows of six, separated by a shielded corridor. A 6-m by 2-m by 4-m high dispensary cell forms one end of the rows of cells, the other end contains an airlock access room connected to the corridor. The cells are fitted with removable boxes that are sized for samples up to about 500 g, and solution volumes up to 20 liters. The use of the removable boxes has proved extremely satisfactory. The magnetite concrete shielding is adequate for 1 kCi of gamma activity. The lead glass windows and light-duty manipulators originally installed have required extensive rebuilding. The facility was created for the examination and dissolution of samples of graphite fuel used in the Rover program and, since its demise in 1973, these cells have been utilized in various other programs. Two cells have been converted for use with plutonium.

Contaminated Waste Hot Cell

Design work began in 1960 on a hot cell facility for the handling of high level beta-gamma waste being generated by several groups at Los Alamos. The facility is part of the Contaminated Waste Treatment Plant located at TA-50 Liquid Disposal Site and became operational in 1963. The hot cell was built primarily for neutralizing liquid waste and packaging it for permanent

storage. The facility consists of a cask unloading dock, transfer area, operating area, and one cell 2 m by 3 m by 4 m high. The cell contains 2 storage wells, 0.3 m by 0.3 m by 1.2 m deep, a 2 ton crane, and a pair of heavy duty, extended-reach manipulators.

The waste, which was received in a shielded cask, was transferred into the cell for processing by placing the cask on a remotely controlled cart, then remotely rolling two 20-cm-thick steel doors to the side of the cell entrance so that the cart could be moved under the crane for unloading.

This cell can safely handle kilocurie levels of gamma activity and has only seen occasional use. At present, the cell is completely operational but is not committed to any ongoing program.[21]

SPECIALIZED FACILITIES

High-level remote handling areas and equipment were constructed within the UHTREX (Ultra High Temperature Reactor Experiment) facility.[19] A hot cell was provided for fuel-element changing and examination. The reactor and the coolant gas systems were remotely maintainable using a bridge-mounted manipulative device known as MINOTAUR.[22] Construction began in 1961 and the reactor commenced operation in 1965. The program was terminated in 1968 and UHTREX was mothballed. Some cannibalism has occurred to the remote handling equipment.

Construction began in 1963 on the Fast Reactor Core Test Facility, which was designed to accommodate test runs of a variety of fast-neutron cores up to 20-MW thermal power.[19] Sodium-cooled, plutonium-fueled reactor cores were to be the first to be tested and the facility contained dissassembly, sample transfer, gas cleanup, and sodium-plutonium cells shielded with 1.5-m-thick magnetite concrete walls and ceilings. Welded-steel cell liners and gas-tight service openings formed the alpha containment. Each cell was equipped with oil-filled lead glass windows, traveling-bridge and wall-mounted manipulators, and traveling-bridge cranes. Construction was completed in 1966 at a cost of $3.5 million. The project was terminated before any process systems were installed and the building has been converted into office and laboratory space for other projects. Two large cells with three operating stations each are partially equipped and are presently used for neutron source storage and as irradiation facilities.[11]

The slightly less than 1-mA, 800-MeV proton beam at LAMPF (Clinton P. Anderson Meson Physics Facility) creates kilocuries of activity in targets, beam stops, and adjacent materials. Access is gained to the activated components by rolling aside roof shielding that is 4.3 m thick and weighs hundreds of tons.[23] The beam-line components and shielding were installed in phases from 1973 to 1976. It was originally planned that activated components would be remotely removed by using a portable hot cell, and one (MERRIMAC) was assembled by 1973.[24] By the time the shielding had been completed and beam intensity had increased to the point that remote handling was required, another handling system (MONITOR) had been instituted.[25,26]

MONITOR consists of a pair of servo-feedback electromechanical arms mounted on the boom of a truck self-loader. Viewing is by television. The LAMPF facility also contains a two-cell, nine-station, hot-cell complex.[27] The four stations of one cell are used in radiochemical experiments, and house the switchgear for a pneumatic rabbit sample handling system. The five stations of the second cell are used for servicing LAMPF components such as targets and magnets. Cell access is through rolled-aside roof slabs, hand operated 0.5-by 0.5-by 2.0-m steel swinging personnel doors, or by way of removable window boxes that contain essentially all the cell-wall pentrations and support the manipulators.

EPILOGUE

No new general purpose hot cells have been constructed at Los Alamos since the mid 60's and none are anticipated in the foreseeable future. The basic designs of the existing cells provide sufficient versality to accommodate most conceivable programs.

References

1. Private communication, Alfred H. Zeltmann, LASL, 1979.

2. Private communication, David S. Shaffer, LASL, 1979.

3. Private communication, Francis Fitzgibbon, LASL, 1979.

4. Private communication, John W. Schulte, LASL (retired), 1973.

5. James R. Lilienthal, "A Los Alamos Laboratory for High Level Gamma Processing and Research," 193, Hot Laboratories and Equipment, ANL-4670, (1951).

6. Private communication, James R. Lilienthal, LASL (retired), 1979.

7. S. Glasstone, Principles of Nuclear Reactor Engineering, D. Van Nostrand, Princeton, 832.

8. E. T. Jurney, "Disassembly of the Los Alamos Fast Reactor," LA-1575 (Declassfied) and Nucleonics, 12, No. 9, 28 (1954).

9. Private communication, E. T. Jurney, LASL, 1979.

10. Earl O. Swickard, Los Alamos Molten Plutonium Reactor Experiment (LAMPRE) Hazard Report, LA-2327 (1959).

11. Private communication, Earl O. Swickard, LASL, 1979.

12. Private communication, James A. Bridge, LASL, 1979.

13. P. J. Peterson, R. L. Thomas, and J. L. Green, "Hot Cells for Plutonium Reactor Fuel Research," Los Alamos Scientific Laboratory Report LA-2230 (1958).

14. P. J. Peterson and J. L. Green, "Operation of a Plutonium Hot Cell," Proc. 8th Conf. on Hot Lab. and Equip., 297 (1960).

15. J. R. Lilienthal, "Los Alamos Alpha-Gamma Cells," Proc. 7th Conf. Remote Syst. Technol., 292 (1959).

16. C. C. Burwell, J. W. Schulte, and M. T. Wilson, "The Los Alamos Wing 9 Alpha-Gamma Box System," Proc. 12th Conf. Remote Syst. Technol., 329 (1964).

17. M. T. Wilson and L. L. Thorn, "Alpha-Gamma Transfer Systems," Proc. 9th Conf. on Hot Lab. and Equip., 344 (1961).

18. F. J. Fitzgibbon, D. S. Shaffer, J. M. Ledbetter, and W. T. Wood, "Removable Hot Cell Liners," Proc. 26th Conf. Remote Syst. Technol., 152 (1978).

19. C. R. Wherritt, P. Franke, R. E. Field, and A. R. Lyle, "New Hot Laboratory Facilities at Los Alamos," 10th Hot Lab Proceedings, ANS, 55 (1962).

20. P. F. Moore and J. D. Allen, "Los Alamos Radiochemistry Hot Cells," Proc. 11th Conf. Remote Syst. Technol., 11 (1963).

21. Private communication, Ludgard A. Emelity, LASL, 1979.

22. R. W. Wiesener, "The Minotaur-I Remote Maintenance Machine," 11th Hot Lab Proc. ANS, 197 (1963).

23. M. T. Wilson, "Kiloton Shield Doors at LAMPF," Proc. 22 Conf. Remote Sys. Technol., 43 (1974).

24. M. T. Wilson, "Remote Maintenance Concepts for the Los Alamos Meson Physics Facility," IEEE Trans. on Nuclear Sci., 588, Vol. NS-16 #3 (June 1969).

25. R. A. Horne and E. L. Ekberg, "Monitor - A Versatile Remote Handling System," Proc. 23 Conf. Remote Sys. Technol. 242 (1975).

26. D. L. Grisham, E. L. Ekberg, J. E. Lambert, R. E. Meyer, P. J. Stroik, and M. D. Wickham, "Monitor Update, 1979" this conference.

27. M. T. Wilson, "Los Alamos Meson Physics Facility Hot Cell Complex," Proc. 17 Conf. Remote Sys. Technol., 105 (1969).

Figures

Figure 1. Chemical Process Building ca 1945 (negative number 26406)

Figure 2. Chemical separation apparatus in place in ^{140}Ba container. ^{140}La container is being lifted by cable powered tong. (negative number 12136, crop to include central portion of left half of figure, ie cask #7 and the one to the right of it, include the top of the table the casks are on and the lower rail of the two tracks above it).

Figure 3. Ten Site hot cell for the separation of ^{140}La from the parent ^{140}Ba. (negative number 57-1043)

Figure 4. Ten Site hot cell interior as viewed from operator station. Figure is a mosaic taken at various periscope mirror angles. (negative number CN 60311)

Figure 5. Transfer of ^{140}La source from cask to experiment utilizing clothesline trolley ca 1945. (negative number 79-10486).

Figure 6. Tong reaching into cask preparatory to transferring the source into the experiment (negative number 23830).

Figure 7. Metallography cell for the examination of plutonium fuel, ca 1960. (negative number 60452)

Fig 1

MP-12-1 WILSON

FIG 2 MP-12-1

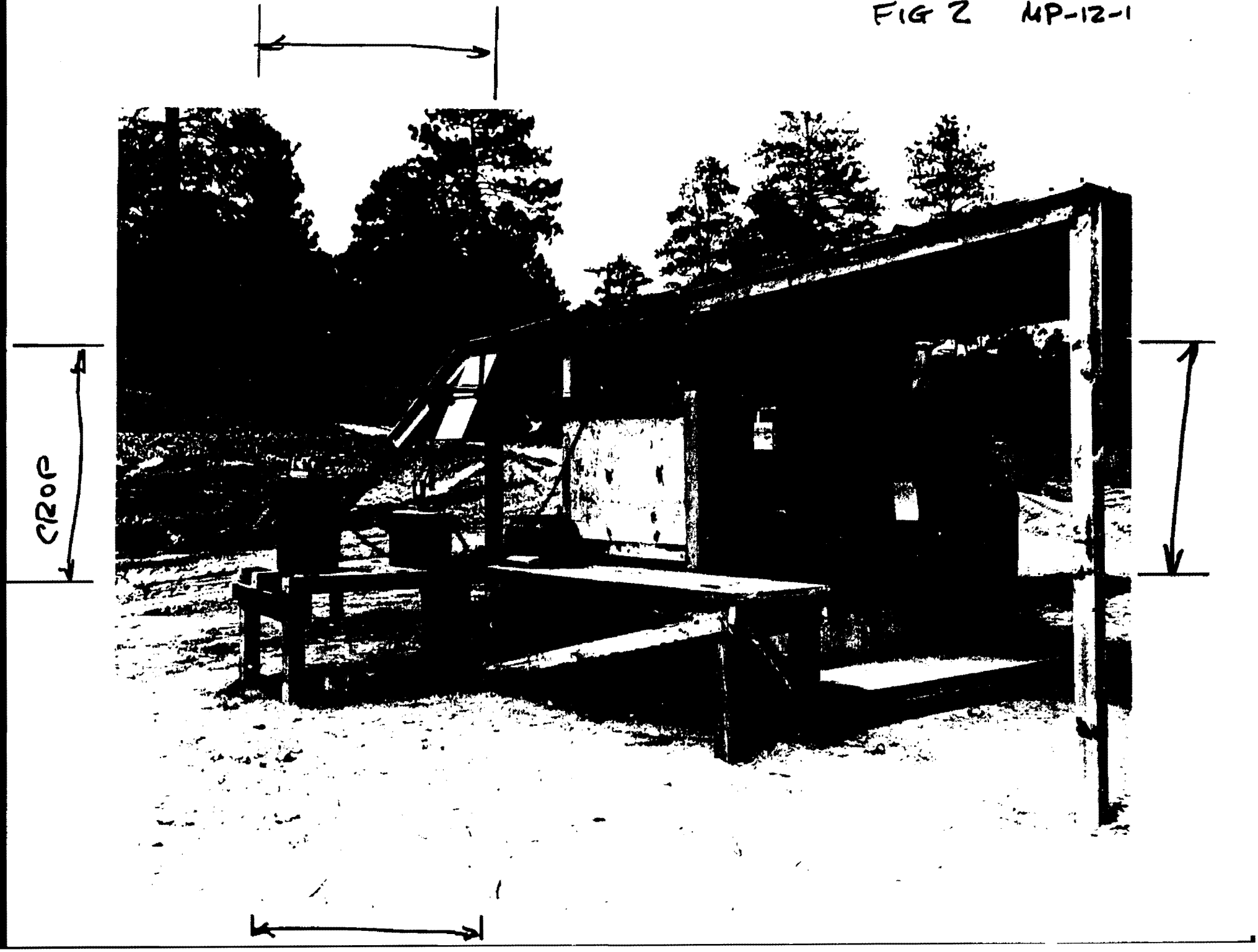
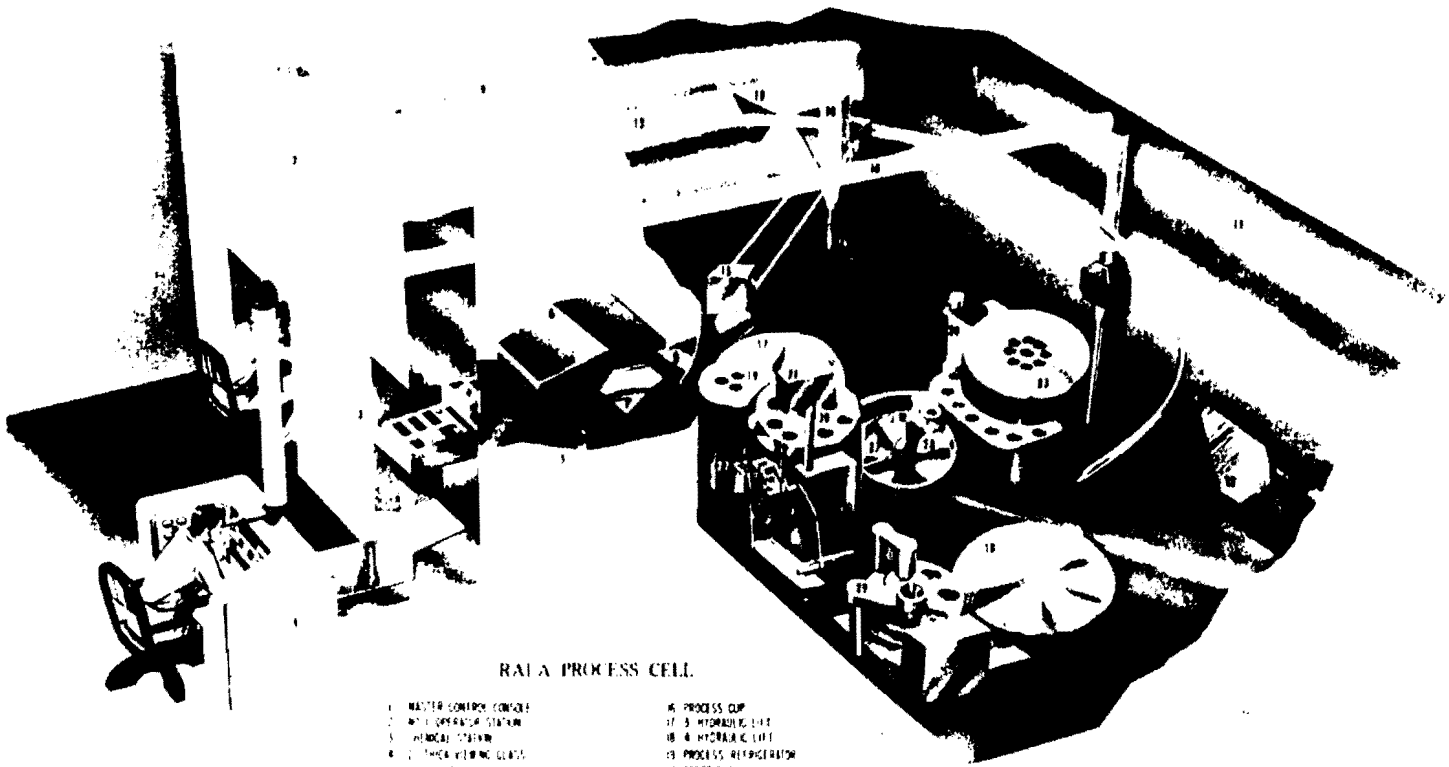


FIG 3 MP-12-1



RALA PROCESS CELL

1 MASTER CONTROL CONSOLE
2 [illegible] OPERATOR STATION
3 CHEMICAL STATION
4 [illegible] VIEWING GLASS
5 VIEWING PORT
6 [illegible] SHIELDING
7 MIRROR
8 [illegible] DUST SHIELD
9 [illegible] REINFORCED CONCRETE SHIELDING
10 SCANNING PERISCOPE
11 [illegible] STEEL CLAD ROOM
12 [illegible]
13 [illegible]
14 [illegible]
15 [illegible]
16 PROCESS CUP
17 3 HYDRAULIC LIFT
18 4 HYDRAULIC LIFT
19 PROCESS REFRIGERATOR
20 CENTRIFUGE
21 STIRRER
22 DOUBLE DECANTING ASSEMBLY
23 STORAGE REFRIGERATOR
24 DECONTAMINATION STATION
25 PROCESS CUP TOOL RACK
26 DUMPING DECANT
27 [illegible] CUP SPRAY
28 WASH PAN AND DRAIN
29 PELLETING MACHINE

FIG 4 MP-12-1

CROP

CROP

FIG 5 MP-12-1

FIG 6 MP-12-1

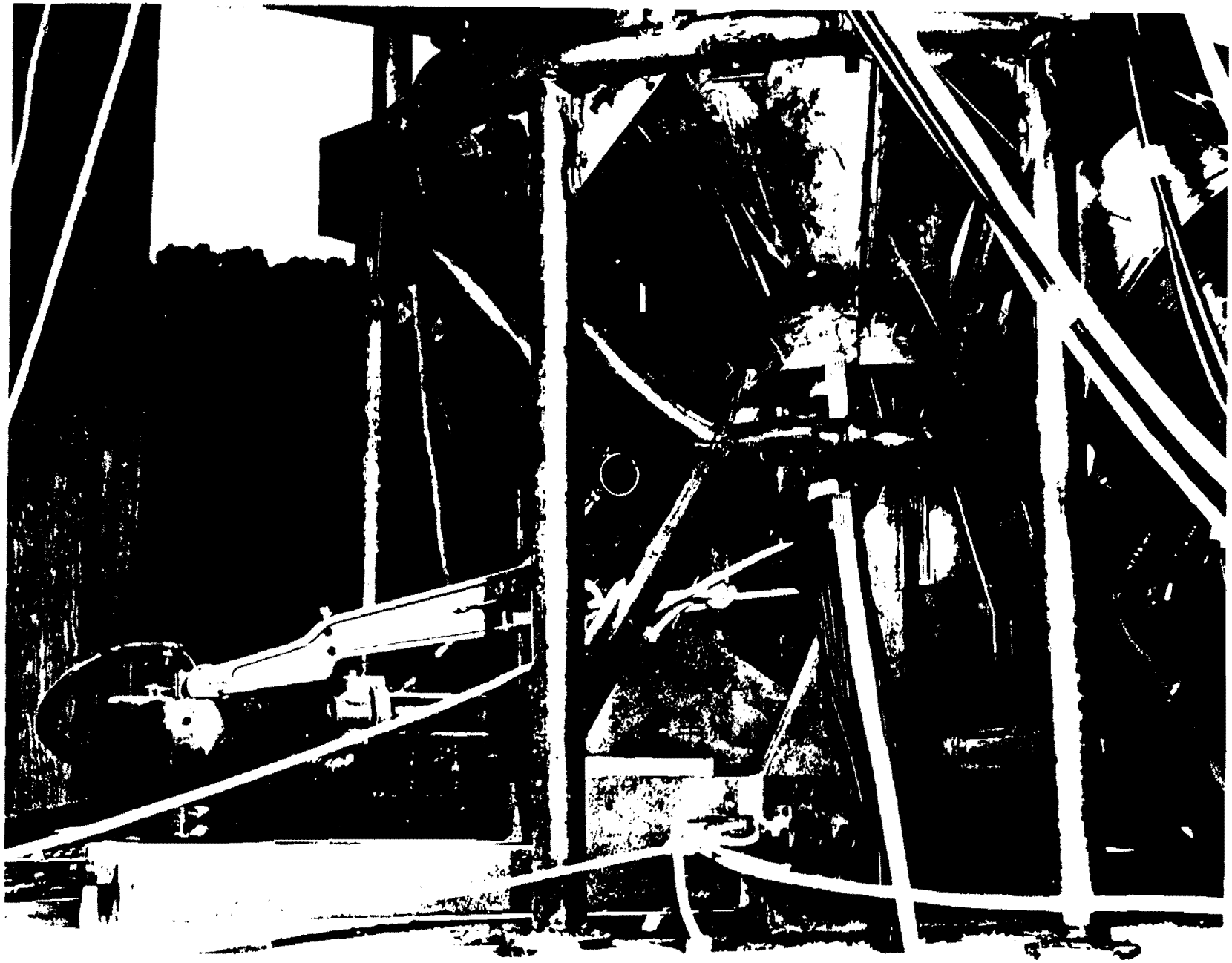
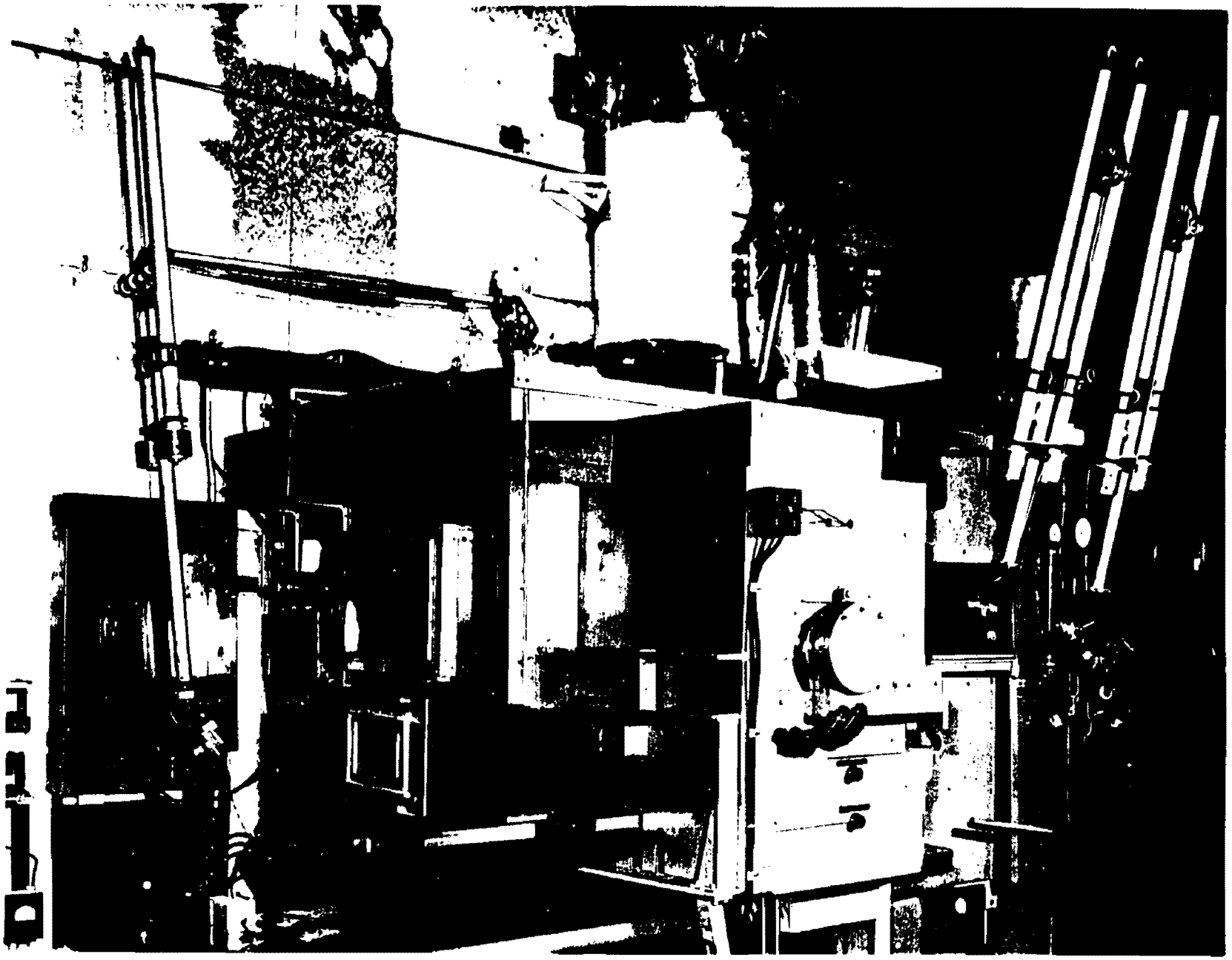



FIG 7 MP-12-1