

UNCLASSIFIED

LIBRARY COPY

JANUARY 12, 1948

1357

General

21-418(a,b); MDAV

ORGANIZATION AND FUNCTION
of the
CMR-CONTAMINATED CLOTHES LAUNDRY

by: James F. Tribby

TH-21
p. 1

UNCLASSIFIED



10002

ABSTRACT

The organization and function of the CMR-Contaminated Laundry is described in this document. Emphasis is placed on the development of the laundry decontamination process cycles, and on the development of a particular design of a laundry structure in which the laundering and decontamination of contaminated clothing can be done safely and practically. Research into finding the best types of decontaminating materials and process cycles was carried out during the period April 1945 to June 1946. From the results of these experiments have emerged six different processing cycles for laundering the protective clothing. Each process cycle is a particularly effective procedure for decontaminating a specific type of contamination. We believe this laundry is unique and that the laundry methods in use here are different from those of any laundry anywhere.

We also believe, that by supplying laboratory personnel with the proper types of clean uncontaminated clothing, the laundry personnel have contributed more than most of us realize to the radiation health program at Los Alamos.

TABLE OF CONTENTS

	<u>Page</u>
I. Introduction	1
II. Protective Equipment	4
III. Dispensaries	7
IV. Laundry Identification and Control Measures	5
V. Design of the Laundry Building	7
VI. Organization and Personnel	8
VII. Laundry Processes	10
VIII. Pre Pick-Up Monitoring	11
IX. Monitoring and Inspection of Clothing	23
X. Protection of the Laundry Workers Health	25
XI. Research and Development of Laundry Processes	26
XII. Appendices	
1. Health-Safety Rules	27
2. Laundry Stock	27
3. Laundry Machinery	27
4. Supplies	55

TABLE OF CHARTS, PRINTS AND PHOTOGRAPHS

	<u>Page</u>
1. Charts of Process Cycles	12
2. Experimental Procedures	35
3. North Entrance to Laundry	56
4. Tumbler Loading	57
5. Tumbler and Extractor Unloading	58
6. Driers	59
7. Clothes Monitoring	60
8. Respirator Monitoring	61
9. Clothes Folding	62
10. Nose Swiping	63
11. Hand Counting	64
12. Lunchroom	65
13. Floor Plan of Laundry Building	66

I. INTRODUCTION

Attention is given to the types of protective clothing and equipment issued to workers at Los Alamos who are involved in handling radioactive materials, and to workers in allied operations. It is obvious that protective clothing for wear by such personnel is vital in order to prevent contamination of their personal clothing and also to provide adequate protection from over exposure of the body to radioactive contamination.

Certain radioactive materials handled at this project are known to be highly toxic in minute quantities. Consequently, extreme precautions have been set up to reduce to a minimum the possibility of these materials being taken internally by way of the mouth, the respiratory tract, and through open wounds. Daily changes into protective clothing and the wearing of respirators, protective devices, is considered to be one of the most important protective measures in effect at Los Alamos. Such clothing, however, may become highly contaminated when worn in laboratories processing radionuclides and become hazardous to be handled by untrained personnel.

The contaminated laundry was organized and developed under the direction of the H.I. Group. The laundry personnel were thoroughly trained, not only in the methods of operating an ordinary laundry, but also in the intricacies of the safe handling of highly contaminated garments. Considerable time and attention was devoted to the development of efficient decontaminating procedures for removing the various types of contaminants from the fibers of the garments.

In addition to issuing clothing changes to exposed personnel auxiliary protective devices such as respirators, pressure hoods, rubber gloves, and divers suits are issued to persons working under extra-hazardous conditions.

Seven decontaminating and laundering processes are now in use at the contaminated laundry. These are:

1. "COLD BATCH" PROCESS CYCLE. Washing process used for washing soiled clothing not contaminated with radioactive materials.
2. "SEMI HOT BATCH" PROCESS CYCLE. Process used for washing and decontaminating clothes carrying 0 - 1000 d/m/150 sq. cm of alpha-contaminants.
3. "HOT ALPHA BATCH" PROCESS CYCLE. Process used for washing and decontaminating clothing carrying greater than 1000 d/m/150 sq. cm of Pu contamination.
4. "POLONIUM BATCH" PROCESS CYCLE. Process used for decontaminating and washing clothing carrying more than 1000 d/m/150 sq. cm of Polonium.
5. "BOOTY BATCH" PROCESS CYCLE. Process used for washing and decontaminating booties worn in all areas.
6. "BETA-GAMMA BATCH" PROCESS CYCLE. Process used for laundering and decontaminating laundry carrying beta and gamma contamination.
7. RESPIRATOR PROCESS. Process used for decontaminating, cleaning, and sterilizing respirators used in all areas.

Fortunately it has been possible to arrange operations in such a manner that clothing worn in any one area would not usually be contaminated with more than any one type of contaminant. Thus it has been the custom to label and mark the clothing according to areas, each area handling the following materials.

- AREA I - Plutonium and chemical dusts.
- AREA II - Polonium and chemical dusts.
- AREA III - Uranium and chemical dusts.
- AREA IV - Beta and gamma radionuclides.

In addition to the above divisions of areas, each area is broken down into laundry stations.

The restricting of contaminants to individual areas has made it easier to process, control, and account for protective equipment and to protect the laundry workers during the handling of clothing. The decreasing degree of surface and air contamination throughout all areas, and improvements in methods of handling radioactive substances in the laboratories have reduced the degree of clothing contamination to a point where only decontamination processes 1, 2, 5, 6 are now in general use.

The complete processing of a batch of contaminated clothing includes:

1. Incoming sorting and receiving.
2. Laundering and decontamination.
3. Extracting.
4. Drying.
5. Monitoring clothing and respirators. (alpha, beta, gamma) Inspection.
6. Respirator decontamination and monitoring.
7. Rewashes.
8. Ironing and pressing.
9. Folding, sorting, and preparing for delivery.
10. Sewing, repair of garments.
11. Pick-up and delivery.
12. Stenciling and marking.
13. Monitoring warehouse.

The monitoring of clothing at the laundry to assure that tolerances are met is supervised by the H.I. Group. The H.I. Group also specifies alpha, beta, gamma tolerance levels for clothing, conducts daily instrument surveys of laundry facilities and floors, and pre-processing surveys of clothing before the clothing is picked up by the laundry truckers.

To assure the wearing of the complete clothing changes desired clothing dispensaries or store rooms are set up in all areas processing radioactive materials. Changes of clothing, respirators, rubber gloves, and booties are issued to all personnel entering the buildings. When leaving the building personnel throw their clothing into separate bins into laundry hamper bags marked (a) respirators, (b) gloves, (c) coveralls, (d) underclothes and caps, (e) booties. All equipment is laundered and reprocessed except rubber gloves.

The details of the organization and functions of the laundry are given in the following sections.

II. PROTECTIVE EQUIPMENT REQUIRED

The types of protective clothing and equipment required to be worn in any area are specified by local area rules. These rules are formulated jointly by the laboratory staff and the H.I. and Medical Groups staff. In general that equipment believed to give the maximum protection under usual working conditions is required to be worn in the area. Unsafe conditions developing in a laboratory, such as contaminating accidents, or uncontrolled spread of contamination, will require that any person entering the area wear equipment best suited for the degree of hazard. Laboratory personnel are, at all times, provided with any other type of protective equipment, over the minimum required, at their request. Thus the minimum clothing requirements might change if unusual conditions develop or accidents occur.

III. LAUNDRY DISPENSARIES

Dispensaries are located at the entrance to the buildings in the Pu and Po processing areas. Store rooms are located in all other buildings and laboratories ^{personnel} draw out their own clothing. All persons entering the buildings must draw the required protective clothing, respirators, and gloves before

proceeding to the cold locker room. Each dispensary is staffed with an attendant who issues the equipment, makes up stock lists, and notifies the laundry stockroom man of clothing requirements. Also part of the duties of the attendant is to record the names of visitors, craftsmen, etc. who visit the area. All craftsmen and visitors are required to submit to the attendant a "health clearance" slip before they are permitted to draw protective equipment. The clearance slip is signed by the H.I. Group section leader in charge of the area H.I. section and the section leader lists the minimum clothing requirement on the slip.

IV. LAUNDRY IDENTIFICATION AND CONTROL MEASURES

1. STATIONS, DISPENSARIES, AND IDENTIFICATION CODE NUMBERS

All areas, either separate buildings, sites, or departments receiving laundry service are recognized as laundry stations. A dispensary is located at each station. At some of the sites the clothing dispensary is a small storeroom and each person working in the area draws his clothing from the storeroom. At the areas in which the clothing requirements are large the dispensary is operated by an attendant. Each station is given a code letter or number and its number or letter is its own individual laundry number. Clothing belonging to one station is not issued to any other station. The code letter is for the laundry's identification to assure accurate delivery of clean clothing to the proper station. The code letter also serves as an identification of the type of radioactive contamination contained on the clothing. The identification of clothing is most important from a health standpoint since it serves to warn the laundry incoming sorting personnel of the probable health hazards involved in handling the clothing.

2. STENCILING OF CODE NUMBERS OR LETTERS

All garments are stenciled with the code number of the station for which they are destined in a conspicuous spot before issue. At the time the marking of garments was initiated the laundry was a section of the H.I. Group (CMR-12) under the supervision of the H.I. Group Leader. The laundry was appropriately called the CMR-12 Contaminated Laundry and the stencil numbers were set up with CMR-12, to identify the laundry property or property of the CMR-12 group.

3. CODE LETTERS

<u>Letter</u>	<u>Area</u>
(a) CMR-12	Plutonium area
(b) <u>CMR-12</u>	Polonium area
(c) CMR-12-M	For "M" Station
(d) CMR-12-Σ	For "Σ" Station
(e) CMR-12-H	For "H" Station
(f) CMR-12-HT	For "HT" Station
(g) Etc. (11 stations in all)	- - - - -

4. CLOTHING CONTROL

To discourage the theft of clothing from a station, the clothing stocked at each station storeroom or dispensary is inventoried periodically. Protective clothing is assigned to some responsible person at each station and it is his responsibility to make sure that clothing issued to him does not leave his station, except to go to the laundry for washing. The guard at each station or area is instructed to allow no protective clothing to leave his post.

V. DESIGN OF THE LAUNDRY BUILDING

The laundry is located on the DP Site mesa. The various sections and rooms are described. (See print of floor plan)

1. Office. The office of the section leader and the assistant section leader.
2. Women's room. Locker room, shower, and washroom for women employees.
3. Men's room. Locker room, shower, washroom for men employees.
4. Wet Laundry. Washing and extracting operations. 7 washers and ³ extractors in use. Air lock with boot and shoe lockers at entrance to this room. Ventilation separate from rest of building.
5. Incoming sorting room. Sorting of incoming clothing. Preparing clothing for laundering.
6. Drying room. Drying of clothing and respirators. 6 driers.
7. Respirator Processing room. Washing and scrubbing respirators in stainless steel vats. Monitoring of respirators after washing. 5 stainless steel vats and one monitoring bench 3' x 10'. 3 Poppies and one G.M. probe counter for monitoring.
8. Clothes Monitoring room. Monitoring of clothing after washing and drying. One monitoring bench 3' x 15'. 3 Poppies and one GM probe counter for monitoring.
9. Folding and Sewing room. Folding, sewing, mangling. One table 6' x 15' for folding. 6 electric sewing machines.
10. Lunch room. The lunch room. Air lock at entrance to the lunchroom. Separate ventilation from rest of the laundry.
11. Stencil room. Stencil code numbers on clothing. Bench for repairing electronic counters.

12. Stock room. Stock clothing.
13. Stock room. Stock. Preparation of outgoing orders.
14. Stock room. Stock. New addition to building.
15. Barrel and Supply room. Stock soaps and laundry supplies.
16. Dock. An unloading dock is located at the west end of the laundry by the incoming sorting room. Incoming soiled clothing is unloaded from the laundry truck on this dock. The loading dock is located at south side of building next to the stockroom (13). Outgoing orders to the dispensaries are loaded into the laundry truck.
17. Contaminated Effluent Drains. Four drains. Pipe lines run south of building to a sand seepage pit.
18. Boiler room. Supplies steam to building and driers and hot water to the tumblers.

VI. ORGANIZATION AND PERSONNEL

The functional organization of the laundry is given:

1. Group Leader (CNR-Administration) (effective July 1947)
2. Section Leader (1)
 - (a) Responsible for proper functioning and organization of the laundry.
3. Supervisor of Laundry Operations (1)
 - (a) Assists section leader.
 - (b) Office and records.
4. Dispensary attendant (2)
 - (a) Operates dispensaries
5. Warehouse man, foreman (1)
 - (a) Charge of laundry stockrooms and storerooms.

6. Warehouseman (2)
 - (a) Maintain laundry stockrooms and storerooms.
 - (b) Prepare laundry orders.
 - (c) Checking, receiving, and inventory.
7. Clothes Monitor (2)
 - (a) Monitor outgoing clothing.
8. Contaminated Clothes Sorter (1)
 - (a) Sort incoming clothing.
9. Foreman, Tumbler and Extractor Operator (1)
 - (a) Charge of wet laundry.
10. Tumbler and Extractor Operator (3)
 - (a) Wash, extract, and transfer clothing to drying room.
11. Drier (1)
 - (a) Operate driers.
12. Respirator decontaminator (4)
 - (a) Decontaminate respirators.
13. Foreman, Laundry Flatpiece folder (1)
 - (a) Charge of folding, sewing, mangling, and sorting.
14. Laundry Flatpiece Folder (4)
 - (a) Folding, sorting, sewing, mangling.
15. Laundry Truck Driver (1)
 - (a) Pick up and delivery of clothing.
16. Laundry Truckdriver, helper (1)
 - (a) Aids truckdriver.

TOTAL PERSONNEL IN LAUNDRY - 26

VII. LAUNDRY PROCESSES

All wash and decontamination processes constitute the most important procedure of the laundry. The processes used here are unique.

Processes used in this laundry cannot be compared with those of an ordinary public laundry, nor can they be compared with those of any other contaminated laundry at any other project. The problem facing this laundry is to decontaminate clothing, respirators, etc. exposed principally to plutonium, and polonium contamination. Decontamination must be complete or at least the degree of contamination contained in the clothing must be reduced to the point where the clothing is absolutely safe for reuse.

The first objective is to remove contamination. To do this in an efficient manner, dirt and other foreign matter must be laundered from the fiber. If clothing is highly contaminated it may necessitate a predecontamination process. By uniting the predecontamination cycle with the decontamination cycle, a compound wash cycle results. In some instances the predecontamination cycle is sufficient for the decontamination process. Such a predecontamination cycle is used here for mildly alpha contaminated clothing.

Most of the decontaminating processes were worked out during the year 1945. Process cycles using acetic, citric, tartaric acids and hydroxide sulfates for decontaminating highly Pu contaminated clothing were tried and found to be moderately effective. Process cycle "Hot alpha batch" using citric acid can be used for decontaminating Pu contaminated clothing. Since the "Semi Hot batch" process cycle is an effective process for mildly plutonium contaminated clothing, this is the process in general use at the laundry. Agents used for all processes however are selected so that it is possible to keep the pH of the solutions at about 5 or below. Results of experiments

indicated that tartaric, citric, and acetic acids (and other organic acids) were also effective decontaminating agents for polonium and beta, gamma emitters. Consequently a polonium process cycle and a beta, gamma process cycle was worked out utilizing a citric acid treatment. Alkali soaps should be avoided in treating moderately and highly plutonium contaminated clothing because the alkali solutions tend to "set" the contamination. Respirators from all areas are washed by hand in large stainless steel vats by using a wire scrub brush. Respirators are sterilized by soaking in a hypochlorite solution before reassembling and reissue.

A description of all operating cycles and processes that are used in this laundry is given on the following pages. Decontamination process cycles are illustrated by the chart form.

PROCESS CYCLE I "COLD BATCH"

(This process used for all uncontaminated clothing)

TYPE OF OPERATION	COLD RINSE	HOT RINSE	SOAP	HOT RINSE	SOAP	HOT RINSE	HOT RINSE	SPLIT RINSE	COLD RINSE		
Water Level (Inch)	6	6	6	6	6	6	6	6	6		
Degrees of Temperature	100	150	150	120	150	150	150	120	100		
Washing Agents			Ivory Soap		Ivory Soap						
Treatments	Lbs. Qtz.		3#		3#						
Time - minutes	2	3	8	3	10	3	3	2	Cold rinse 1 repeated 3 times.		

Notes:Total time 37 minutes.Pounds 70 lbs. dry clothing.**PROCESS CYCLE I "COLD BATCH"**

(This process used for all uncontaminated clothing.)

PROCESS CYCLE II "SEMI HOT BATCH"

(Process used for mildly contaminated clothing from all areas. Underwear and socks are washed separately from coveralls, smocks, and booties.)

TYPE OF OPERATION	COLD RINSE	HOT RINSE	IGEPAL	HOT RINSE	IGEPAL	HOT RINSE	HOT RINSE	IGEPAL SOAP	HOT RINSE	SPLIT RINSE	COLD RINSE
Water Level (Inch)	6	6	6	6	6	6	6	6	6	6	6
Degrees F Temperature	100	120	130	120	120	120	120	150	150	120	100
Washing Agents			Igepal		Igepal			Igepal Ivory Soap			
Treatment	Lbs.		3#		3#			1# Igepal 3# Ivory Soap			
Time - minutes	2	3	8	3	8	3	3	8	3	2	Cold rinse repeated 3 times.

Notes:

Total Time 46 minutes.

Pounds 70 lbs. dry clothing.

PROCESS CYCLE II "SEMI HOT BATCH" (This process used for mildly contaminated clothing from all areas. Underwear and socks are washed separately from coveralls, smocks, and booties.)

PROCESS CYCLE III "HOT ALPHA BATCH"

(Process used for decontaminating clothing from plutonium areas that contain more than 1000 d/m/150 cm² or Pu clothing that cannot be decontaminated by Process II.)

TYPE OF OPERATION	COLD RINSE	CITRIC ACID	IGEPAL	HOT RINSE	HOT RINSE	CITRIC ACID	IGEPAL	SPLIT RINSE	COLD RINSE	COLD RINSE	
Water Level (Inch)	6	6	6	6	6	6	6	6	6	6	
Degrees F Temperature	100	180	120	150	150	180	120	120	100	100	
Washing Agents		Citric Acid	Igepal			Citric Acid	Igepal				
Treatment	LBS. QTS.	6#	3#			6#	3#				
Time - Minutes	5	8	8	3	3	8	3	3	2	2	

Notes:

Total Time 45 minutes.

Pounds 70 pounds dry.

PROCESS CYCLE III "HOT ALPHA BATCH" (Process used for decontaminating clothing from plutonium areas that contain more than 1000 d/m/150 cm² or Pu clothing that cannot be decontaminated by Process II.)

TYPE OF OPERATION	COLD RINSE	SOAP IGEPAL	HOT RINSE	HOT RINSE	HOT RINSE	CITRIC ACID	IGEPAL	HOT RINSE	SPLIT RINSE	COLD RINSE	
Water Level (Inch)	6	6	6	6	6	6	6	6	6	6	
Temperature Degrees F	95	120	120	120	120	180	120	130	120	100	
Treatment	Lbs. Qts.	Ivory 1# Igepal 2#				6#	4#				
Washing Agents		Ivory Soap Igepal				Citric Acid	Igepal				
Time - Minutes	5	8	3	3	3	15	8	3	3	2	

Notes:

Total Time 53 minutes.
Pounds 70 lbs. dry.

PROCESS CYCLE IV "POLONIUM BATCH" (Process for decontaminating clothing from Po area that contains 1000 d/m/150 cm² or clothing from Po area that is not decontaminated by Process Cycle II.)

TYPE OF OPERATION	COLD RINSE	HOT RINSE	IGEPAL	HOT RINSE	HOT RINSE	IGEPAL	HOT RINSE	HOT RINSE	IGEPAL	HOT RINSE	SPLIT RINSE	COLD RINSE
Water Level (Inch)	6	6	6	6	6	6	6	6	6	6	6	6
Degrees F Temperature	100	130	130	130	130	130	130	130	130	130	120	10 ⁵ 10
Treatment	Lbs.		3#			3#			3#			
	Qts.											
Washing Agent			Igepal			Igepal			Igepal			
Time - minutes	2	3	8	3	3	8	3	3	8	3	3	2

Notes: Booties from each area are washed separately, and separate from all other clothing. Booties not decontaminated in this cycle are processed by Cycle III or Cycle IV.

Total Time 49 minutes.
Pounds 70 lbs. dry.

PROCESS CYCLE V "BOOTIES" (Process used for decontaminating and laundering booties from all areas.)

TYPE OF OPERATION	HOT RINSE	CITRIC ACID	IGEPAL	HOT RINSE	HOT RINSE	HOT RINSE	CITRIC ACID	HOT RINSE	IGEPAL	HOT RINSE	SPLIT RINSE	COLD RINSE	COLD RINSE	COLD RINSE
(Inch)														
<u>Water Level</u> Degrees F	6	6	6	6	6	6	6	6	6	6	6	6	6	6
<u>Temperature</u> Lbs.	120	180	150	150	150	150	180	150	150	150	120	100	100	100
<u>Treatment</u> Qts.		6#	3#				6#		3#					
<u>Washing Agents</u>		Citric Acid	Igepal				Citric Acid		Igepal					
<u>Time</u> minutes	3	8	8	3	3	3	8	3	8	3	3	2	1	1

Notes:

Total Time 57 minutes.

Pounds 70 lbs. dry.

PROCESS CYCLE VI "BETA, GAMMA BATCH" (Process used to decontaminate and clean clothing from beta, gamma processing areas.)

PROCESS VII: DECONTAMINATION OF RESPIRATORS

1. Disassemble respirator, discard the rubber valves and filters. Remove the straps, and fasteners and wash separately.
2. Rinse in luke warm water.
3. Soak in 2% hot Igepal solution.
4. Scrub thoroughly all parts with stiff brush.
5. Rinse in luke warm water.
6. Sterilize by allowing to soak for 2 minutes, in 3% solution of Showersan or 3% solution of NaOCl.
7. Drain off water and place on rack to dry.
8. Assemble parts after monitoring, replace rubber valves and filters with new.

1. DECONTAMINATION OF TUMBLERS AND EXTRACTORS

Each morning (8:00 A.M.) before washing operations begin, all tumblers and extractors are surveyed for contamination by an H.I. monitor. Before operations begin each washer is washed with 2% Igepal solution for 3 minutes and rinsed with warm water. Extractors are washed down inside and outside with soap and water if any contamination is detected.

2. DECONTAMINATING WET LAUNDRY FLOORS

Each morning and afternoon the floors of the wet laundry are scrubbed thoroughly with Igepal and hot water (3%). Floors are monitored daily by an H.I. monitor. High counts are decontaminated immediately by scrubbing with soap and water, or by hand by washing the contaminated area with 1N HCl solution.

3. DECONTAMINATING HAMPERS AND LAUNDRY BAGS

Laundry hampers and bags used for delivery and pick-up of clothing are washed in the tumblers using the Process Cycle described for decontaminating clothing from the area in which the hampers are used.

4. REWASHES

All clothing that does not pass the decontamination process is added to other batches from the same station and reprocessed. Or, it may be necessary to add it to batches going into Process Cycle III (if Pu contaminated) or into Process Cycle IV (if Po contaminated). A red cloth tag is clipped to the garment each time it is sent for rewashing. After four retreatments, if the clothing cannot pass the health tolerance levels, the clothing is destroyed by burying at the contaminated dump.

5. IMMERSION AND SOAKING OF HIGHLY CONTAMINATED COVERALLS.

Special coveralls used by craftsmen engaged in repairing process hoods and precipitrons may become unusually contaminated. It has been the practice to allow such clothing to soak overnight in a bath containing 3% Igepal or 3% citric acid solution prior to washing the next day.

6. INCOMING RECEIVING

When clothing is received at the laundry's receiving room, it is prepared for washing. Each garment is checked for proper marking and identification. Garments having pockets are searched for tools and miscellaneous property or articles which may prove dangerous to laundry machinery. The clothing is usually spot checked for degree of contamination. Clothing is brought to the receiving room from the contaminated station in Laundry hamper bags, clearly stamped with station number.

Clothing from the various areas is separated into batches and placed in laundry hampers. Clothing from the Pu, Po, and beta, gamma areas is processed separately. In addition, clothing is washed separately according to types of garments as follows: (a) is one batch (b) is a separate batch.

<u>Uncontaminated Area</u>	<u>Contaminated Area I</u>	<u>Contaminated Area II</u>	<u>Contaminated Area III</u>	<u>Contaminated Area IV</u>
(a) All clothing.	(a) Booties (b) Coveralls and smocks (c) Underwear, socks, brassieres, towels, caps. (d) Respirators (e) Shoes	Same as I	Same as I	Same as I

Clothing is not ordinarily weighed before taking to the wet laundry. Usually no permanent record is kept of clothing passing through the receiving room.

7. WASHING

The washing operations are described on the Process Cycle Charts. One tumbler (No. I) is reserved for laundering only uncontaminated clothing. One tumbler (No. II) is reserved for laundering clothing from the Po area. One tumbler (No. III) is reserved for (beta, gamma) clothing. Two tumblers (No. IV, V) are reserved for laundering clothing from the Pu and U areas, and one tumbler (No. VI) is reserved for processing booties from all areas.

8. EXTRACTING

This work is the drawing of excessive moisture from the clothing. This is done in 3 extractors by centrifugal force (1700 R.P.M.). Clothing is loaded to about 2 inches from top and distributed evenly.

9. DRYING

After clothing is extracted, it is placed in the tumbler drier. The drier tumbles and rolls the clothing in a cylindrical basket. The machine is equipped with a coil that is heated by steam pressure of approximately 100 pounds. The load weight of clothing is about 35 pounds (dry weight). The drying time is about 25 minutes. To test for dryness, the door can be opened, which will automatically shut off the safety switch, and the clothing can be tested by feeling. Clothing should be absolutely dry before removing from the drier. An experienced operator can easily tell the degree of dryness by feeling the garments while they are still hot. Six driers are in operation in the laundry drying room. From the driers the clothing is sent to the monitoring room.

10. PRESSING AND IRONING

Clothing is not ironed or pressed as part of the regular laundry procedure. Three ironing machines are available for use in the laundry.

11. FOLDING

The object of folding is to prepare for delivery or storage. The garments are folded in such a manner that they will be neat and compact and so the station code number is clearly visible on each garment.

12. SEWING

When the garments are being folded, all garments needing mending or buttons are withheld. A record of all sewing work required is kept. The sewing crews also sew on zippers, smock fasteners, etc. on special coveralls used in extra-hazardous operations.

13. PREPARATION FOR DELIVERY

After the garments are folded, they are assorted and placed in the warehouse on shelves. When the warehouseman receives an order from a dispensary he loads the laundry delivery bags with the proper types of clothing required on the order and places the delivery bag on the loading dock. Each delivery bag is clearly stamped with the station number.

14. WAREHOUSE AND STORAGE OF EQUIPMENT

Three rooms at the laundry are reserved for storage space. A large stock of protective clothing, respirators, pressure hoods, gloves, and accessory apparatus is kept in stock. All equipment in the warehouse, as well as the equipment stocked in all dispensaries, is inventoried monthly.

15. PICK-UP AND DELIVERY

Two men are assigned to pick up the hamper bags and deliver the delivery bags to all station dispensaries. In some areas it is necessary to make two trips daily to the dispensary in order to keep the dispensaries thoroughly stocked with equipment and to pick up the soiled clothing before the hampers overflow. The laundry truck is a two ton covered pick-up truck and is kept in the laundry parking lot under lock and key when not being used.

VIII. PRE-PICK-UP MONITORING

1. H.I., PO AND U AREAS

Before the laundry hampers are removed from the clothing disposal bins they are monitored by the H.I. Group for external contamination. If no counts are found on the outside of a hamper it is drawn shut with the strap attached to it and locked. An OK is then given to the building janitors to remove the hamper to the station loading dock. If the bag is contaminated it is tagged with a red card. The card is stamped clearly with the degree of contamination.

The laundry truckers are thus warned of any hazards connected with handling the hampers. The laundry truckers at all times wear full changes of protective clothing and wear respirators and rubber gloves when handling the hampers.

2. BETA-GAMMA AREAS

Clothing, respirators, etc. used at these areas are thrown into hampers and the hampers into bins set outside all buildings (bins are colored red and marked "HOT GAMMA CLOTHING"). The bins are monitored once a week by an H.I. section leader. If the gamma radiation level at the surface of the bins does not exceed $12\frac{1}{2}$ mr/hr. (calibrated by UKII standard) the bin is tagged "OK for pick-up". The laundry truckers lock up the hampers and throw them on the truck and transfer the clothing to the laundry loading dock. The laundry is again monitored by the laundry section leader at the loading dock. The laundry truckers are required to wear film badges when making trips to all stations.

3. MONITORING OF TRUCKERS

The laundry truckers are required to check their clothing and hands with counters when they return to the laundry. The results of these checks are recorded on a card.

IX. MONITORING AND INSPECTION OF CLOTHING AFTER DECONTAMINATION

1. CLOTHES MONITORING

After drying, the clothing is placed in hampers and taken to the clothes monitoring room. The clothing is taken from the hampers and laid out on the monitoring table. The clothing is then assorted as to type.

(a) Coveralls. Coveralls are laid out on the table and laid on top of each other to about 20 deep. The top coverall is monitored carefully over the top surface. If it passes the tests, it is removed from the top and laid out (turned over) on the table to the right of the pile. The second coverall

is monitored, turned over, and laid on top of the first coverall and so on until the entire pile has been monitored on one side. Then the pile of coveralls is monitored on the opposite side. At any time a spot is located over tolerance, the coverall is removed from the pile and thrown into a rewash hamper.

(b) Smocks, Underclothing, Towels. All other articles of clothing are monitored in the same manner.

2. RESPIRATOR MONITORING

After drying the respirators are carefully monitored using a Poppy pencil (1 cm by 10 cm) probe and a G.M. probe counter. If any count is detected on the inside face the respirator is thrown into a rewash hamper. If the respirator passes all tests it is handed over to the assembly girl who puts on new filters, straps, fasteners, and rubber valves.

3. MONITORING STANDARDS AND TOLERANCES

All monitoring operations, maintenance of counters, calibration of instruments, specification of tolerance levels and specification of health procedures are supervised and directed by the H.I. G_{cup}. Tolerance levels for clothing from the various areas follows:

A. COVERALLS (Pu Areas)

- (a) < 500 d/m/150 sq cm by Poppy (Pass)
- (b) 10,000 - 500 d/m/150 sq cm by Poppy (Tag and Rewash)
- (c) \geq 10,000 d/m/150 sq cm by Poppy (Condemn and Destroy)
- (d) > 500 d/m/150 sq cm by Poppy after 4 rewashes (Destroy)
- (e) < 1.5 mrep/hr at surface by G.M. Probe Counter (Pass)

B. COVERALLS (Po Areas)

- (a) 1000 d/m/150 sq.cm. by Poppy (Pass)
- (b) 10,000 - 1000 d/m/150 sq.cm. by Poppy (Tag and Rewash)
- (c) >1000 d/m/150 sq.cm. by Poppy after 4 rewashes (Destroy)
- (e) < 1.25 mrep/hr. at surface by G.M. Probe Counter (Pass)

C. SMOCKS AND LABORATORY GOWNS (Pu Areas)

- (a) < 200 d/m/150 sq.cm. by Poppy (Pass)
- (b) > 200 d/m/150 sq. cm. by Poppy (Tag and Rewash)
- (c) > 200 d/m/150 d/m/150 sq. cm. by Poppy after 4 rewashes (Destroy)
- (d) < 1.25 mrep/hr. at surface, G.M. Probe counter (Pass)

D. UNDERWEAR, SOCKS, BRASSIERES (Pu and Po Areas)

- (a) < 50 d/m/150 sq. cm. by Poppy (Pass)
- (b) > 50 d/m/150 sq. cm. by Poppy (Tag and Rewash)
- (c) > 50 d/m/150 sq. cm. by Poppy after 4 rewashes (Destroy)
- (d) < 1.25 mrep/hr., at surface, GM Probe Counter (Pass)

E. BOOTIES (all areas)

- (a) < 500 d/m/150 sq. cm. by Poppy (Pass)
- (b) > 500 d/m/150 sq. cm. by Poppy (Tag and rewash)
- (c) > 500 d/m/150 sq. cm. by Poppy after 4 rewashes (Destroy)
- (d) < 1.25 mrep/hr., surface, G.M. Probe Counter (Pass)
- (e) > 1.25 mrep/hr., surface, G.M. Probe Counter (Tag and rewash)

F. SHOES (all areas)

- (a) Inside of shoe - 50 d/m by Poppy (Pass)
- (b) Outside and sole of shoe - 500 d/m/150 sq. cm. by Poppy (Pass)
- (c) All parts of shoe - 1.25 mrep/hr., surface, G.M. Probe Counter (Pass)
- (d) All parts of shoe - 500 d/m/150 sq. cm. by Poppy) (Destroy)
4.0 mrep/hr., surface, G.M. Counter

G. COVERALLS, UNDERWEAR, BOOTIES (Beta, gamma area)

- (a) < 50 d/m/150 sq. cm. by Poppy (Pass)
 - (b) < 1.25 mrep/hr., surface, G. M. Probe Counter (Pass)
 - (c) > 50 d/m/150 sq. cm. by Poppy
 - (d) > 1.25 mrep/hr., surface G.M. Probe Counter
- } (Tag and Rewash)

H. TOWELS, WASHCLOTHES (all areas)

- (a) < 50 d/m/150 sq. cm. by Poppy
 - (b) < 1.25 mrep/hr. surface, G.M. Probe Counter
 - (c) > 50 d/m/150 sq. cm. by Poppy
 - (d) > 1.25 mrep/hr. surface G.M. Probe Counter
- } (Pass)
- } (Destroy)

I. RESPIRATORS (all areas)

- (a) < 50 d/m/150 sq. cm. by Poppy
 - (b) < 1.25 mrep/hr., surface, G.M. Probe Counter
 - (c) $> (500 - 50)$ d/m/150 sq. cm. by Poppy - (Rewash)
 - (d) > 500 d/m/150 sq. cm. by Poppy
 - (e) > 3 mrep/hr., surface, G.M. Probe Counter
- } (Pass)
- } (Destroy)

4. INSTRUMENTATION

(a) Routine monitoring of incoming laundry and Pre-pick-up monitoring of clothing for beta and gamma radiation is done with a G.M. Probe counting rate meter. Finished laundry is monitored with G.M. Probe scalars. Glass walled Kreb and Ecks type G.M. chambers are employed.

(b) Alpha monitoring, pre-pick-up and incoming clothing is done by proportional alpha-survey counting rate meters using pencil probes. Finished laundry monitoring is done with A.C. operated Poppies with audio systems. (4" x 6") and (pencil) probes are used, whichever is most convenient for the specific job.

5. CALIBRATION OF POPPIES

Calibration of alpha Poppies is done by comparison of the readings on the instrument to the known d/m of the plutonium standards.

$$(a) \text{ Geometry factor } = \frac{\text{c/m on instrument}}{\text{d/m of standard}} = G.$$

$$(b) \text{ d/m (over effective survey area)} = \frac{\text{c/m (instrument reading)}}{G}$$

(c) Checks of the hot spots found on clothing should be done by comparing the meter reading (and popping rate) when the probe is 1/4 inch over the spot to the meter reading (and popping rate) when the same probe is placed 1/4 inch over known plutonium reference standards.

6. CALIBRATION OF G.M. PROBE SCALER COUNTERS

Uranium metal samples to be used as standards. The radiation from the whole standard is determined by comparing it with radiation from a known area of the metal.

$$(a) \text{ } z = \text{mrep/hr} = \frac{1}{260} \times \frac{\text{c/m from standard (x)}}{\text{c/m from known area of U metal (y)}}$$

$$\frac{\text{area on which calculation is based (b)}}{\text{known area of U metal (a)}}$$

OR

$$\text{mrep/hr} = \frac{1}{260} \times \frac{x}{y} \times \frac{b}{a}$$

7. STATISTICAL ANALYSIS OF INSTRUMENTS

At regular intervals the statistical reliability of the scalers is checked by taking a series of (n) measurements (1 minute counting intervals) on a source (around 500 - 1000)d/m.

If:

C_i = counts (c/m) of (i)th measurement.

t = time in minutes (1 minute

ρ = difference between any observation and the numerical average.

From theory of statistics:

$$E_p = 0.6745 \frac{\sqrt{\sum C_i}}{\sum t}$$

$$E_{(R)} = 0.6745 \frac{\sqrt{\sum \rho^2 \cdot t}}{(\sum t)}$$

When $E_{(R)}$ is greater than E_p consistently, the counter is not counting effectively.

I. PROTECTION OF THE LAUNDRY WORKERS HEALTH

1. HEALTH HAZARDS TO LAUNDRY WORKERS

The function of this laundry is to decontaminate and launder contaminated clothing. The types and quantities of radioactive materials handled at this project are many and varied. The laundry workers must be constantly on guard against the possibility of bodily harm from contacting clothing which is carrying large quantities of hazardous radioactive materials or hazardous chemical dusts. Hazards to personnel are given:

- (a) Ingestion, by way of mouth and G.I. tract, of radioactive materials. (Pu, Po, U, radioisotopes)
- (b) Hazards from external radiation. (gamma-rays from radioisotopes.)
- (c) Inhalation of radioactive dusts which may enter the body by way of the respiratory tract.
- (d) Puncture and cut of some part of the body while handling radioactive materials. A cut may introduce the materials into the body.

(e) Inhalation or swallowing toxic non-radioactive dusts.

The following procedures, examinations, and special monitoring methods have been introduced to insure that the health hazards listed above are either eliminated or are reduced to a minimum.

2. CONSTRUCTION OF THE LAUNDRY

The laundry is divided into (a) a contaminated section, which includes the incoming receiving and sorting operations, the wet laundry operations, the drying operations, and the respirator washing and monitoring operations, and (b) the uncontaminated sections, which include all the rest of the laundry functions. The contaminated section is separated from the uncontaminated section by a double door air lock. Both sections have separate ventilating systems to prevent air-borne radioactive dusts from passing from the contaminated to the uncontaminated section. The air locks also tend to prevent the spread of air and surface contamination from one side to the other side. Personnel entering into the contaminated section are required to enter through the air lock and put on booties, complete change of clothing, "hot shoes", caps which cover the hair, rubber gloves, and rubber overshoes. In addition, persons handling clothing or machinery in the contaminated section are required to wear respirators.

A lunch room is set up in the uncontaminated section of the building. Before personnel may enter the lunchroom they are required to remove all protective clothing and wash thoroughly. They are required to record their hand counts before entering the lunchroom. This is thoroughly monitored before the noon hour.

Smoking, eating, or drinking fluids is not allowed in any part of the contaminated section. Smoking is allowed in the uncontaminated section, but eating and drinking is restricted to the lunchroom and the section leader's office.

7 Equipment is not allowed to be taken from one section to the other section. Equipment is never removed (except the clothing itself) from the contaminated section to the outside, without special supervision from the H.I. Group.

3. PROTECTIVE EQUIPMENT WORN BY THE LAUNDRY WORKERS

The specifications for protective clothing to be worn in each operation are given:

(a) Incoming receiving and sorting operations

Respirators, full change of clothing, "Hot" shoes, rubber gloves, caps to cover the hair and booties. Personnel are required to wear film badges.

(b) Wet Laundry

Respirators, full change of clothing, "Hot" shoes, rubber gloves, caps to cover the hair, rubber apron and rubber overshoes. Required to wear film badges.

(c) Drying room

Respirators, full change of clothing, "Hot" shoes, rubber gloves, when operating the driers or when handling clothing, booties, and caps to cover the hair. Required to wear film badges.

(d) Respirator washing and monitoring

Respirator, full change of clothing, rubber apron, "hot" shoes, booties, rubber gloves and caps to cover the hair.

(e) Clothes monitoring

Smock, rubber gloves, and caps to cover the hair. Required to wear film badges.

(f) Pick-up and delivery of clothing

Full change of clothing, "hot" shoes, caps to cover the hair, wear respirators and rubber gloves when handling soiled clothing. Required to wear film badges.

(g) Remainder of the laundry personnel wear smocks or gowns, and caps to cover the hair, except when entering the lunchroom.

4. LAUNDRY INSTRUMENT SURVEY

The laundry is surveyed daily by H.I. monitors equipped with health survey instruments to detect contamination of equipment and surface and floor contamination. "Hot" spots located must be decontaminated to tolerance levels immediately.

A. SURFACE TOLERANCE LEVELS

(a) Contaminated section

500 c/m - portable alpha survey meter (4' x 6') probe

300 c/m - portable G.M. survey counting rate meter

(b) Uncontaminated section

0 - c/m (alpha) - alpha survey meter

0 - c/m (beta, gamma) - G.M. survey meter

(c) Inside Hoods (Incoming receiving)

1000 c/m - alpha survey meter

Air test units are run continuously in the contaminated section to detect (alpha, beta, gamma) air contamination levels. Any operation found to be spreading air contamination is shut down until the cause of the trouble is found and eliminated.

5. PERSONNEL MONITORING

All laundry personnel working in the contaminated section are required to wear film badges and/or gamma pencil chambers.

6. MEDICAL AND HEALTH TESTS

To keep accurate account of the exposure of laundry personnel to radioactive materials, the following health and medical tests are given to all employees.

(a) Hand Counts (a hand counter is installed in the hall by the lunchroom). Persons are required to record their hand counts before lunch and before leaving for home.

(b) Nose Counts. Both sides of the nose of each laundry worker are swiped daily, and the swipes are counted on a proportional alpha scaler.

(c) Body and Clothing checks. An instrument is available for monitoring any part of the body and clothing at any time.

(d) Urine assays. Radicassays of urine specimens are done every three months. The urine is radicassayed to detect the presence of plutonium and polonium.

(e) Albuminalysis. Done weekly to detect unusual quantities of albumin and cest cells. This would indicate primary kidney damage from heavy metals.

(f) Blood tests. Done every three months to detect primary radiation damage to the blood system.

II. RESEARCH AND DEVELOPMENT OF LAUNDRY PROCESSES

1. PLUTONIUM DECONTAMINATION STUDIES

The purpose of the following experiments was to investigate the effectiveness of various agents for removing plutonium contamination from laundry and to determine which of the materials investigated would be most suited for use at the laundry, in a washing process.

Preliminary experiments (April to August 1945) (suggested by H.A. Moulthrop) were conducted using large 50 gallon G.I. cans as a container. The cans were made up to about 20 gallons of the following solutions.

1. Citric acid (3%)
2. Tartaric acid (3%)
3. Acetic Acid (3%)

4. Oxalic Acid (2%)
5. Hydrazine sulfate (3%)
6. Igepal solution (3%)
7. Zoleo solution (3%)

Sections of coveralls were cut from coveralls worn in the plants and contaminated under plant conditions. The sections cut out were highly contaminated with plutonium. The pieces of cloth were immersed in each of the seven types of solutions and left over night. In the morning the can was agitated for 20 minutes, the cloth sections were removed, rinsed in warm water, dried, and counted with a Pluto meter.

The results of these experiments can be summarized as follows:

Agent	<u>% of Sections Counts reduced 10% or over</u>	<u>% of Sections Counts reduced 50% or over</u>	<u>% of Sections Counts reduced 90% or over</u>	<u>% of Sections Counts reduced to zero</u>
Citric Acid	95	50	20	12
Tartaric Acid	93	65	25	19
Acetic Acid	45	22	7	1
Oxalic Acid	53	27	6	0
Hydrazine Sulfate	80	52	15	1
Igepal solution	12	3	0	0
Zoleo solution	10	2	0	0

The experiment was repeated using section of coveralls cut from coveralls which were still "hot" but which had been laundered for 30 minutes in an Igepal laundry solution. The results were a little better.

Agent	<u>% of Sections Reduced 10% or better</u>	<u>% of Sections Reduced 50% or better</u>	<u>% of Sections Reduced 90% or better</u>	<u>% of Sections Reduced to Zero counts</u>
Citric Acid	98	83	71	47
Tartaric Acid	94	77	71	41
Acetic Acid	27	22	9	1
Oxalic Acid	15	12	0	0
Hydrozine Sulfate	77	50	13	10
Igepal	--	--	--	--
Zoleo	23	14	0	0

The experiment was again repeated using sections of "hot" coveralls carrying Pu contamination and which had been worn in the plant. The clothing was soaked as before, rinse, and then put into the laundry tumbler and washed for 30 minutes in a 3% Igepal solution. They were removed, dried, and counted with a Pluto meter.

Agent	% of Sections Reduced 10% or better	% of Sections Reduced 50% or better	% of Sections Reduced 90% or better	% of Sections Reduced to zero counts
Citric Acid	98	88	82	63
Tartaric Acid	89	86	83	61
Acetic Acid	20	10	8	2
Oxalic Acid	18	12	2	0
Hydrazine sulfate	70	50	21	14

From the above experiment we could say that citric and tartaric acids as decontaminating agents would be our best starting point toward setting up an efficient laundry Pu decontamination scheme.

10 Experimental Process Cycles were outlined and tried. Clothing was monitored before and after each process and the results were tabulated. In general all procedures were effective in decontaminating the clothing. Each experimental procedure was repeated. More than 300 coveralls were surveyed and marked according to "hot spots" and counts. After washing, the spots were again counted and the results tabulated.

Summarizing:

- (a) All procedures were effective.
- (b) Procedures I, II, V, VII, and VIII were the most effective in decontaminating clothing containing 20,000 d/m/Pu/150 sq. cm.
- (c) Processes IX and X were as effective as all other processes in reducing the counts on clothing which initially contained less than 1000 d/m/Pu per 150 sq. cm.

Charts showing the experimental Laundry Pu Processes I - X are shown on the following pages.

Laundry Procedure No. I HOT BATCH (Pu)

Type of Clothing _____ No. of Items _____

	1	2	3	4	5	6	7	8	9	10				
Type of operation	Deterg. Decont.	Cold Rinse	Deterg. Decont.	Split Rinse	De-cont.	Hot Rinse	Deterg.	Split Rinse	Cold Rinse	Cold Rinse				
Water Level (In.)	6	6	6	6	6	6	6	6	6	6				
Temperature F°	120	95	120	120	140	140	120	120	95	95				
Washing Agents	Igepal Citric Acid		Igepal Citric Acid		Citric Acid		Igepal Ivory Soap							
Treatment	Citric Lbs. Qts.													
		6#	6#		10#									
Time	10	5	20	10	10	15	15	10	10	5				
pH	3	6	3	6	2	6	7	6	6	6				

Notes: Igepal used - 2½ pounds in all deterg. (sols. 1, 3, 7)

EXPERIMENTAL PROCEDURE NO. I HOT BATCH (Pu)

Ivory Soap - 1½ pounds in deterg. (sol. 7)

6" level = 38 gal./330 pounds/H₂O

Estimated Total time required for treatment - 1 hour, 50 minutes

Laundry Procedure No. II HOT BATCH (Pu)

Type of Clothing No. of Items

	1	2	3	4	5	6	7	8	9	10				
Type of operation	Deterg. Decont.	Split Rinse	Decont. Split Rinse	Decont. Split Rinse	Decont. Hot Rinse	Hot Rinse	Deterg. Rinse	Hot Rinse	Cold Rinse	Cold Rinse				
Water Level (In.)	6	6	6	6	6	6	6	6	6	6				
Temperature F°	120	120	140	120	140	140	120	140	95	95				
Washing Agents	Igepal Citric Acid		Citric Acid		Citric Acid		Igepal Ivory							
Citric Lbs. Treatment Ots.	5#		10#		10#									
Time	15	10	20	10	20	15	15	10	10	2				
pH	3	6	2	6	2	6	7	6	6					

Notes: Igepal used in Sols. 1, 7 2½ lbs.

EXPERIMENT PROCEDURE NO. II (Hot Batch Pu)

Ivory soap 1½ lbs. in sol.

Total time for running 2 hrs. 5 min.

Laundry Procedure No. III HOT BATCH (Pu)

Type of Clothing _____ No. of Items _____

Type of operation	Deterg. Decont.	Split Rinse	Deterg. Decont.	Split Rinse	Decont.	Hot Rinse	Deterg.	Hot Rinse	Split Rinse	Cold Rinse				
Water Level (In.)	6	6	6	6	6	6	6	6	6	6				
Temperature F°	120	120	120	120	140	140	120	140	120	100				
Washing Agents	Igepal Citric Acid		Igepal Citric Acid		Citric Acid		Igepal Ivory							
Treatment	Lbs. Citric 6#		Lbs. Citric 6#		Lbs. Citric 10#									
Time	10	10	10	10	20	10	10	15	10	2				
pH	3	6	3	6	2	6	7+	6	6					

Notes: Igepal used in Sols. 1, 3, 7 - 2½ #

EXPERIMENTAL PROCEDURE NO. III HOT BATCH (Pu)

Ivory Soap used in sols. 7 - 2#

Total time for running - 1 hr. 45 min.

Procedure no. IV HOT BATCH (Pu)

Type of clothing No. of Items

	Rinse Cold	Deterg.	Split Rinse	Deterg. Split Rinse	Deterg. Split Rinse	Deterg. Hot Rinse	Deterg. Hot Rinse	Deterg. Hot Rinse	Deterg. Hot Rinse	Split Rinse	Split Rinse					
Type of Detergent																
Water Level (In.)	6	6	6	6	6	6	6	6	6	6	6					
Temperature F°	95	120	120	120	120	120	140	120	140	120	120					
Washing Agents		Igepal Ivory		Igepal Ivory		Zolec		Zolec								
Treatments																
Lbs. ts.																
Time	10	20	15	20	15	20	10	10	15	10	5					
pH	6	7	6	7	6	6	6	6	6	6	6					

Notes: No citric acid used

EXPERIMENTAL PROCEDURE NO. IV HOT BATCH (Pu)

Igepal used in Sols. 2

^ Total time for running - 2½ hrs.

Laundry Procedure no. V HOT BATCH (Pu)

Type of clothing No. of Items

Type of Use Section	Deterg Decent	Split Rinse	Decent Rinse	Split Rinse	Deterg Decent	Split Rinse	Deterg Decent	Split Rinse	Gold Rinse	Cold Rinse				
Water Level (In.)	6	6	6	6	6	6	6	6	6	6				
Temperature F°	120	120	140	120	120	120	120	120	120	95				
Washing Agents	Igepal Citric Acid		Citric Acid		Igepal Citric Acid		Zelco							
Citric Lbs. ts.	2#		10#		2#		8#							
Time	15	10	20	10	15	10	20	10	10					
pH	3	6	2	6	3	6	6	6	6					

Notes: Igepal used in Solutions 1, 5 - 2 $\frac{1}{2}$ lbs.

EXPERIMENTAL PROCEDURE NO. V

Zelco used in Solutions 7 - 8 lbs.

HOT BATCH (Pu)

Total time for running - 2 hours.

Estimate Cost of Citric Acid - 14#

Laundry Procedure no. VI HOT BATCH (Pa)

Type of clothing No. of Items

Type of Use Section	Bleach Decent	Deterg Decent	Split Rinse	Deterg Rinse	Split Rinse	Deterg Rinse	Split Rinse	Split Rinse	Cold Rinse						
Water Level (In.)	6	6	6	6	6	6	6	6	6						
Temperature F°	140	120	120	140	120	120	120	120	95						
Washing Agents	Sodium Hypo- Chlorite	Igepal Citric Acid		Citric Acid		Zelco									
Treatments Lbs. to.	10#	5#		10#											
Time	20	20	10	20	10	20	15	10	10						
pH															

Notes: Bleach used - 10# Solution 1

Igepal used in Sol. 3 - 5#

Zelco used in Sol. 7 - 8#

Total time for running - 2 hours 10 min.

EXPERIMENTAL PROCEDURE NO. VI

HOT BATCH (Pa)

Laundry Procedure no. VII Semi-hot batch (500-1500 e/m) Pa

Type of clothing _____ No. of Items _____

Type of Operation	Deterg Decent	Rinse	Decent	Rinse	Deterg	Rinse	Rinse	Cold Rinse						
Water Level (in.)	6	6	6	6	6	6	6	6						
Temperature F°	120	120	140	120	120	140	120	100						
Washing Agents	Igepal Citric Acid		Citric Acid		Igepal Ivory									
Treatments Lbs. ts.	2#		6#		3# each									
Time	15	10	10	10	20	15	10							
pH	3	6	2	6	7 plus	6	6							

Notes: Igepal used in Solutions 1, 5 - 2 1/2#

Ivory Soap used in Sol. 5 - 2#

Total time of running - 1 1/2 hours

Estimate cost of citric acid - 8¢/

EXPERIMENTAL PROCEDURE NO. VII

Semi-Hot Batch (500-1500 e/m) Pa

Laund: Procedure no. VIII SEMI-HOT BATCH (Pu)

Type of clothing No. of Items

Type of Use Solution	Deterg Decent	Rinse	Deterg Decent	Rinse	Deterg	Rinse	Rinse	Rinse							
Water Level (In.)	6	6	6	6	6	6	6	6							
Temperature F°	120	120	120	120	120	140	120	120							
Washing Agents	Igepal Citric Acid		Igepal Citric Acid		Igepal Ivory										
Citric Lbs. Treatments	2#		2#												
Time	10	10	20	10	20	15	10	5							
pH	3	6	3	6	7 Plus	6	6	6							

Notes: Igepal used in Solutions 1, 3, 5 - 2 $\frac{1}{2}$ lbs.

Ivery soap used in Sol. 5 - 2 lbs.

Total time of running - 1 hour 40 min.

EXPERIMENTAL PROCEDURE NO. VIII

SEMI-HOT BATCH (Pu)

Laundry Procedure no. IX COLD BATCH

Type of clothing No. of Items

Type of the Section	Cold Rinse	Hot Rinse	Soap	Hot Rinse	Soap	Hot Rinse	Hot Rinse	Split Rinse	Cold Rinse	Cold Rinse	Cold Rinse			
Water Level (lb.)	6	6	6	6	6	6	6	6	6	6	6			
Temperature °	100	150	150	120	150	150	150	120	100	100	100			
Washing Agents			Ivory Soap		Ivory Soap									
lbs. to.			3#		3#									
Time	2	5	8	3	10	3	3	2	1	1	1			
min														

Notes: Ivory Soap - 3# in col. 3 and 5

Total time of running - 37 minutes.

EXPERIMENTAL PROCEDURE NO. IX

Cold Batch

Laundry Procedure no. X (Pu)

Type of clothing No. of Items

Type of clothing	Cold Rinse	Hot Rinse	Igopal	Hot Rinse	Igopal	Hot Rinse	Igopal Soap	Hot Rinse	Split Rinse	Cold Rinse					
Water Level (in.)	6	6	6	6	6	6	6	6	6	6					
Temperature F°	100	120	120	120	120	120	150	150	120	100					
Washing Agents			Igopal		Igopal		Igopal Ivery Soap								
Treatments Lbs. ts.			3#		3#		Ig-1# Ivery 3#								
Time	2	3	8	3	8	3	8	3	2	2					
PH															

Notes: Total time - 42 minutes.

EXPERIMENTAL PROCEDURE NO. X

(Pu)

2. EXPERIMENTAL PROCEDURES FOR DECONTAMINATING POLONIUM CONTAMINATED CLOTHING.

Four trial methods for decontaminating polonium contaminated clothing were tried. Coveralls which had been worn in the polonium area were monitored and the hot spots were marked with indelible ink as to location and count. The clothing was washed by Experimental Po Processes I, II, III, IV, dried, and recounted. Ten 70 pound batches each were run through each process.

All of these processes seem to work. The processes involving Citric Acid appeared to be the most effective in decontaminating highly Po contaminated clothing. However, "hot spots" less than 5,000 c/m (by Pluto meter) apparently were decontaminated as well by the processes using no citric acid cycle as those using citric acid. The experimental processes are given:

A. EXPERIMENTAL WASHING PROCEDURE XI (Po)

1. Hot rinse. Temperature water 130° F, 3 minutes.
2. Igepal Soap. Temperature water 130° F, 4# Igepal soap, 8 minutes.
3. Hot rinse. Temperature water 130° F, 3 minutes.
4. Hot rinse. #3 repeated.
5. Hot rinse. #3 repeated.
6. Citric Acid. Temperature water 200° F, 7 $\frac{1}{2}$ # Citric Acid, 10 minutes.
7. Igepal Soap. Temperature water 130° F, 4# Igepal, 8 minutes.
8. Hot Rinse. Temperature water, 130° F, 3 minutes.
9. Split Rinse. Temperature water 120° F, 3 minutes.
10. Cold Rinse. Temperature water 100° F, 2 minutes.

Total Time - 46 minutes

B. EXPERIMENTAL WASHING PROCEDURE XII (Po)

1. Cold Rinse. Temperature water 95° F, 10 minutes.
2. Soap and Igepal. Temperature water 100° F, 20 minutes, Igepal 2#, Ivory Soap 1#.
3. Cold Rinse. Temperature water 95°, 15 minutes.
4. Citric Acid. Temperature water 140° F, citric acid 3#, 20 minutes.
5. Warm Rinse. Temperature water 120° F, 15 minutes.
6. Soap. Temperature water 120° F, Ivory Soap 2#, 20 minutes.
7. Hot Rinse. Temperature water 150° F, 10 minutes.
8. Soap. Temperature water 120° F, Ivory Soap, 2#, 20 minutes.
9. Warm Rinse. Temperature water 130° F, 20 minutes.
10. Cold Rinse. Temperature water 95°, 10 minutes.
11. Cold Rinse. Temperature water 95° F, 5 minutes.

Total Time - 165 minutes

C. EXPERIMENTAL WASHING PROCEDURE XIII (Po)

1. Hot rinse. Temperature water 140° F, 3 minutes.
2. Citric Acid. Temperature water 200° F, 6# - C.A., 8 minutes.
3. Igepal Soap. Temperature water 160° F, 2# Igepal, 8 minutes.
4. Hot rinse. Temperature water 180° F, 3 minutes.
5. Hot rinse. Repeat #4
6. Hot rinse. Repeat #4
7. Citric Acid. Temperature water 200° F, 3# - C.A., 8 minutes.
8. Split Rinse. Temperature water 150° F, 3 minutes.
9. Cold Rinse. Temperature water 120° F, 3 minutes.
10. Cold Rinse. Temperature water 120° F, 2 minutes.

Total Time - 43 minutes

D. EXPERIMENTAL WASHING PROCEDURE XIV (Po). No Citric Acid.

1. Cold Rinse. Temperature water 100° F, 2 minutes.
2. Hot Rinse. Temperature water 130° F, 3 minutes.
3. Igepal and Ivory Soap. Temperature water 150° F, 2# Igepal, 2# Ivory soap, 10 minutes.
4. Hot Rinse. Temperature water 150° F, 3 minutes.
5. Hot Rinse. Temperature water 150° F, 1 minutes.
6. Hot Rinse. Repeat #5.
7. Soap. Temperature 150° F, 3# Ivory Soap, 8 minutes.
8. Hot Rinse. Temperature 150° F, 3 minutes.
9. Split Rinse. Temperature 120° F, 3 minutes.
10. Cold Rinse. Temperature 100° F, 1 minute.
11. Cold Rinse. Temperature 100° F, 1 minute.
12. Cold Rinse. Temperature 100° F, 1 minute.

Total Time - 37 minutes.

3. EXPERIMENTAL PROCEDURES FOR DECONTAMINATING BETA-GAMMA CLOTHING.

Six agents for washing beta, gamma contaminated clothing were tried. These agents were acetic acid, citric acid, oxalic acid, tartaric acid, sodium citrate and sodium tartrate.

A document from Chicago had suggested using 3% citric acid wash for 10 minutes. This was tried (using solution at room temperature 85° F) giving the following results:

<u>Trial No.</u>	<u>Count (before wash)</u> <u>(beta-gamma) mrep/hr.</u>	<u>Count (after wash)</u> <u>(beta-gamma) mrep/hr.</u>
1	2.5	2.8
2	2.2	2.1
3	2.5	4.2
4	10.0	

A 6% solution was made up (150° F) and more experimental clothing was washed. The clothing was agitated in the solution by hand. After 10 minutes of agitating, the clothing was removed and transferred to a 3% Igepal solution and washed for 10 minutes, rinsed, dried, and counted. Results are given:

<u>Trial No.</u>	<u>Count (before washing)</u> <u>(beta, gamma) mrep/hr.</u>	<u>Count (after washing)</u> <u>(beta, gamma) mrep/hr.</u>
1	7.2	1.3
2	6.5	2.1
3	4.3	1.3
4	2.6	1.3

Counts were made with a G.M. survey meter, glass walled Kreb and Ecks chamber using a (UXII standard) for comparison of counts.

Clothing from Omega was separated into 6 parts and monitored. A 20 minute wash (130° F) was made in each of the six experimental solutions and then laundered in 3% Ivory Soap solution and the before and after decontamination counts recorded.

<u>Solution (6%)</u>	<u>Average Count before wash</u> <u>mrep/hr.</u>	<u>Average Count after wash</u> <u>mrep/hr.</u>
1. Na Citrate	2.0	1.8
2. Acetic Acid	2.0	0.025
3. Citric Acid	2.25	0.020
4. Oxalic Acid	2.25	0.020
5. Tartaric Acid	2.2	0.02
6. Sodium tartrate	2.1	0.02

From the results of these experiments and from the results of experiments at Oak Ridge, citric acid was adopted as a decontaminating agent for beta and gamma clothing.

APPENDIX I

HEALTH-SAFETY RULES

I. General Laundry Rules.

1. All laundry personnel, including janitorial personnel, are required to submit to the following health tests.

- a) Record hand counts at noon and at night before leaving for home.
- b) Take nose counts daily.
- c) Submit a weekly urine sample for albuminanalysis.
- d) Report for all urine radiocassay tests as scheduled.
- e) Report for blood counts and tests as scheduled.
- f) A complete physical examination, and other medical tests as determined by the medical group are required of all personnel upon termination from employment or transfer from work in a contaminated area.
- g) Any other medical tests that are considered necessary for the protection of the health of any individual.

2. Smocks, or coveralls, as directed, will be worn in all laundry areas.

3. Rubber gloves will be worn in the respirator processing room during washing and disassembling operations, and in the clothes monitoring room during processing of clothing and booties.

4. It is advisable that all persons wash their hands before eating, and drinking cokes, and shower before leaving for home.

5. No food will be eaten or kept in any part of the laundry except the lunchroom. Cokes will be drunk only in the lunchroom, or in the laundry main office.

6. Smoking will not be permitted in the wet laundry, drying room, receiving room, respirator room, clothes monitoring room, or the stockroom. Smoking will be permitted in the lunchroom, laundry main office, wash room, clothes sorting and folding room and hallways.

7. In case of a cut received while in any laundry area:

- a) Flush wound immediately with clean tap water from wash room basins for one minute.
- b) Stimulate flow of blood by massaging area around the wound.
- c) Report cut to Laundry Section Leader.
- d) Report immediately to the first-aid room, Building 51, D.P.West.
- e) Apply no antiseptics.

8. In case of major injury, burns, etc., take the person directly to the Post Hospital. If person cannot be moved call Hospital Emergency.

9. Laundry pick up and delivery personnel will wear coveralls, rubber gloves and project issued shoes while on pickup and delivery runs.

10. Clothing received from Bayo, Pajarito, and Omega Canyon will be monitored for gamma radiation with a Victoreen upon arrival. Any batch of clothing indicating a radiation reading of more than $12\frac{1}{2}$ mr/hr. will be left on the loading docks and the CMR-12 Group Leader notified immediately.

11. Wet laundry and receiving room will be monitored daily for alpha contamination, and the remainder of the laundry will be monitored once a week.

12. Any position indicating an over tolerance room count will be decontaminated at once to a tolerance level or below. Personnel assigned in the immediate area will be responsible for decontamination.

13. If any air contamination count is found over 0.035 c/m/L by the filter queen test the area in which the count is found will be closed to all normal operations until the cause of the high air count is found and remedied.

14. All trash and waste materials in the laundry area will be considered contaminated and disposed of by daily "pick up" by the contaminated trash disposal truckers.

CMR-12-LAUNDRY HEALTH SAFETY RULES

II. Special Rules for Wet Laundry and Receiving Room

1. No person will enter the wet laundry or receiving room except through the air lock.
2. The following protective clothing will be put on in the airlock before entering the area.
 - a) Visitors will put on rubber overshoes provided in the airlock.
 - b) Assigned personnel who work in wet laundry and receiving room will put on "project issue" shoes, rubber overshoes, coveralls, and rubber gloves.
 - c) Personnel working in receiving room will wear respirators during the time the sorting operations are carried on.
3. The above clothing (except coveralls) will be removed in the air lock when leaving. Coveralls will be removed in the locker rooms.
4. No person will enter or leave the drying room through the airlock. Wet, washed clothing only will be transferred from the wet laundry room to the drying room through the airlock.
5. Protective paper will be placed on floor of receiving room and will be changed daily.
6. No smoking or eating will be allowed in the wet laundry and drying room.

CMR-12 LAUNDRY HEALTH-SAFETY RULES

III. Special Rules for Laundry Lunchroom

1. All personnel will remove all protective clothing, gloves, etc. before passing the airlock.
2. No equipment used in the rest of the laundry or any other contaminated equipment or material will be allowed in the lunchroom. Food may be brought into the laundry lunchroom but all other articles, cooking utensils, etc. must have the Section Leader's approval.
3. Personnel will have thoroughly washed their hands, and checked them for contamination on the hand counter. Hand counts must be below 500 c/m (total on both side of hand) before entering the lunchroom.
4. All eating, and drinking of cokes will be done only in the lunchroom.
5. If any detectable contamination is found in the laundry lunchroom it will be closed until complete decontamination is effected.
6. The Laundry lunchroom is for the convenience of the laundry employees only, and should be used only by laundry personnel.

APPENDIX 2

LAUNDRY CLOTHING STOCK

<u>Article</u>	<u>Stock Inventory Items</u>	<u>No. of Items processed in Laundry each month (aver)</u>
1. Booties	38,713	41,962 (singles)
2. Brassieres	211	2
3. Caps, surgeon	2,803	3,820
4. Coveralls	4,200	4,589
5. Shorts (men's)	4,584	2,518
6. Gloves (cotton)	2,544	1,696
7. Gloves (rubber, surgeons)	7,944 (dozen)	0
8. Gloves (OB)	2,820 pr.	0
9. Gloves (drybox)	500 pr.	0
10. Panties	471	2
11. Smocks and Lab coats	2,822	451
12. Smocks (plastic)	141	
13. Socks (men and women)	8,325 prs.	2,616
14. Towels (bath)	1,838	2,171
15. Undershirts	5,786	2,640
16. Respirators	2,937	3,865
17. Laundry delivery bags (cloth)	40	
18. Laundry Hamper bags (cloth)	84	

APPENDIX 3

LAUNDRY MACHINERY

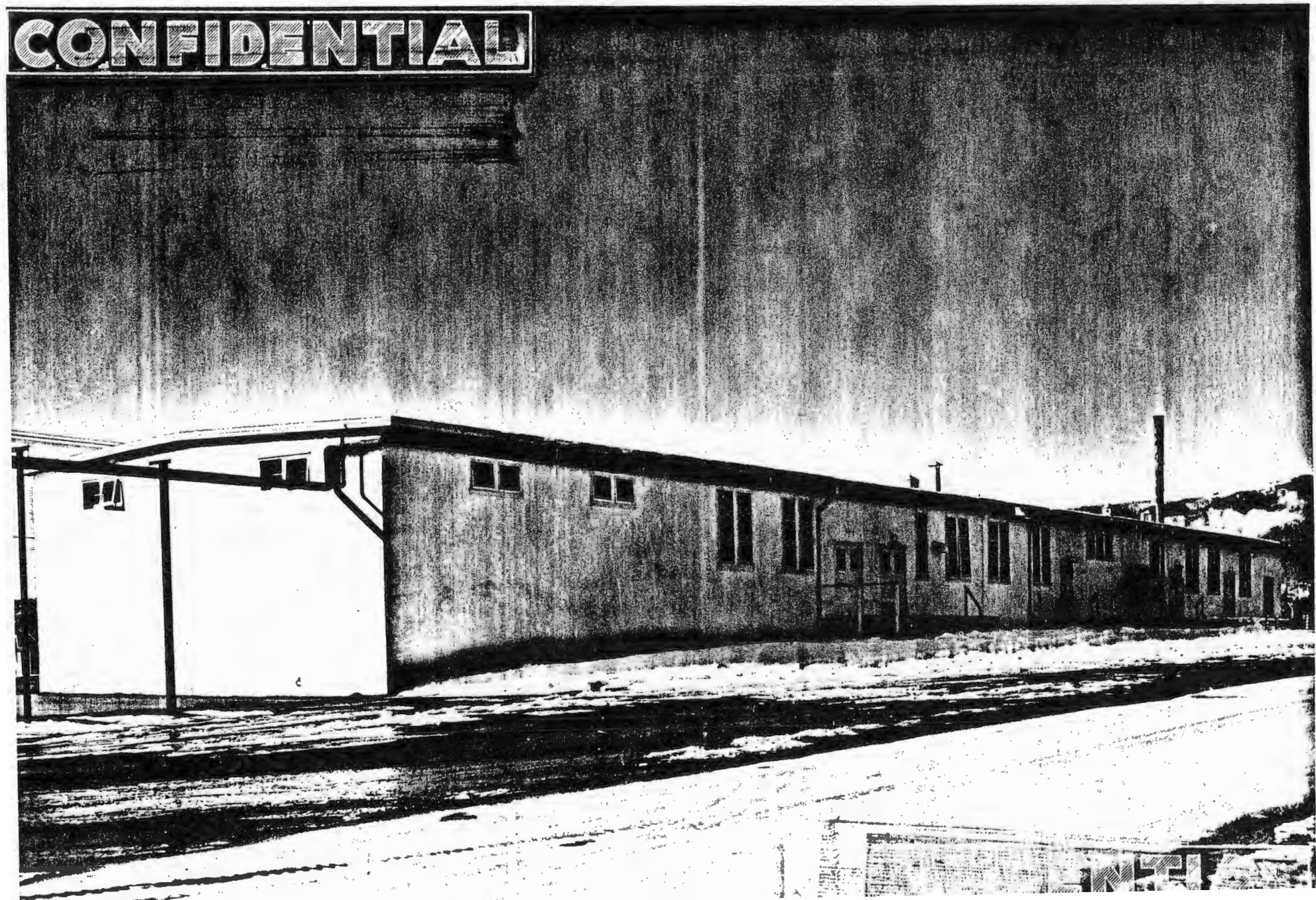
1. Washing Machines (Tumblers) 36' x 36' - American Laundry Machine Company.
2. Extractors - 30 inch - Troy Marathon Company.
3. Driers - tumblers, 36# capacity, 100# steam for heating - Hoffman Company.
4. Electric Sewing Machines - 1 (1-92-4) Singer S.M. Co.
3 (111-W-150) Singer S.M. Co.
2 (61-W-156) Singer S.M. Co.
5. Ironing Machines - 2 Super simplex (American Ironing Machine Co.)
1 Doall Co. - Presser
1 Horton Co. - Presser.

APPENDIX 4

LAUNDRY SUPPLIES

1. Soap, Ivory, bbl.	7
2. Turgitol, drum	1
3. Acid, Citric, bbl., 25#	12
4. Igepal, bbl.	48
5. Zoleo, bbl.	5
6. Soap, sulfa, bbl. (hand washing)	8
7. Sodium tartrate (hand washing) bbl.	35
8. Acid, tartaric, lbs.	25

CONFIDENTIAL



CONFIDENTIAL

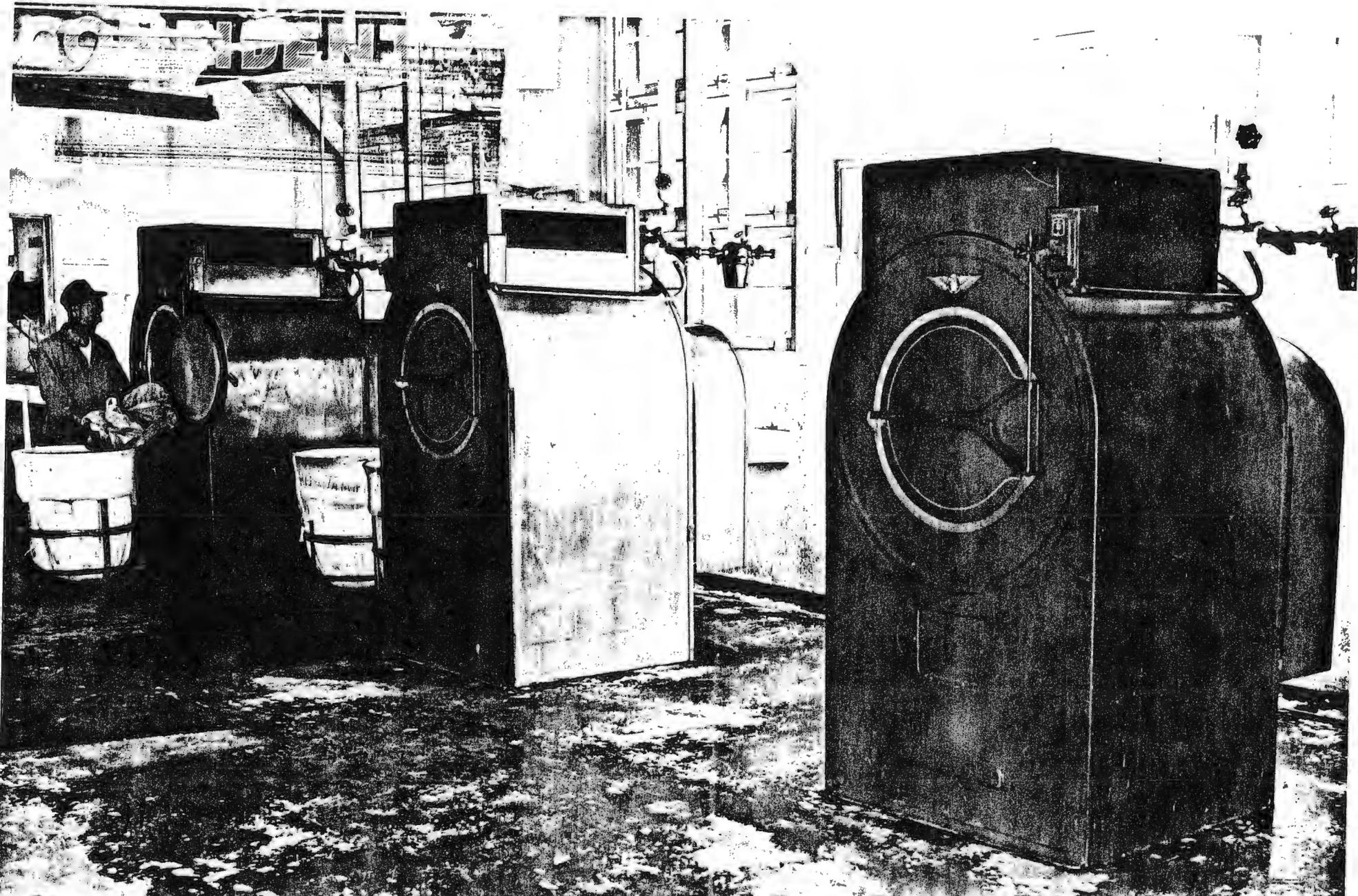


CONFIDENTIAL

CONFIDENTIAL



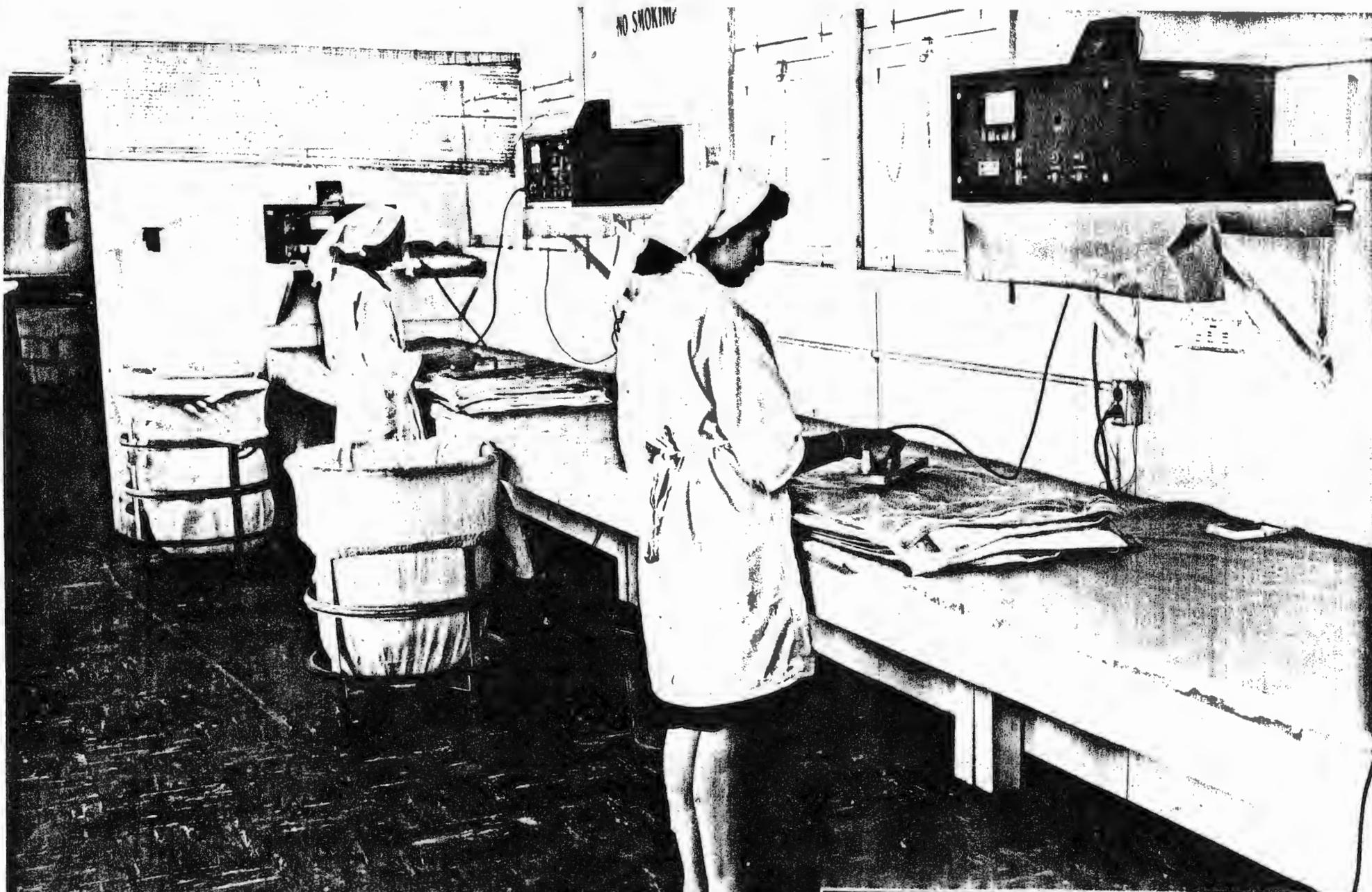
CONFIDENTIAL

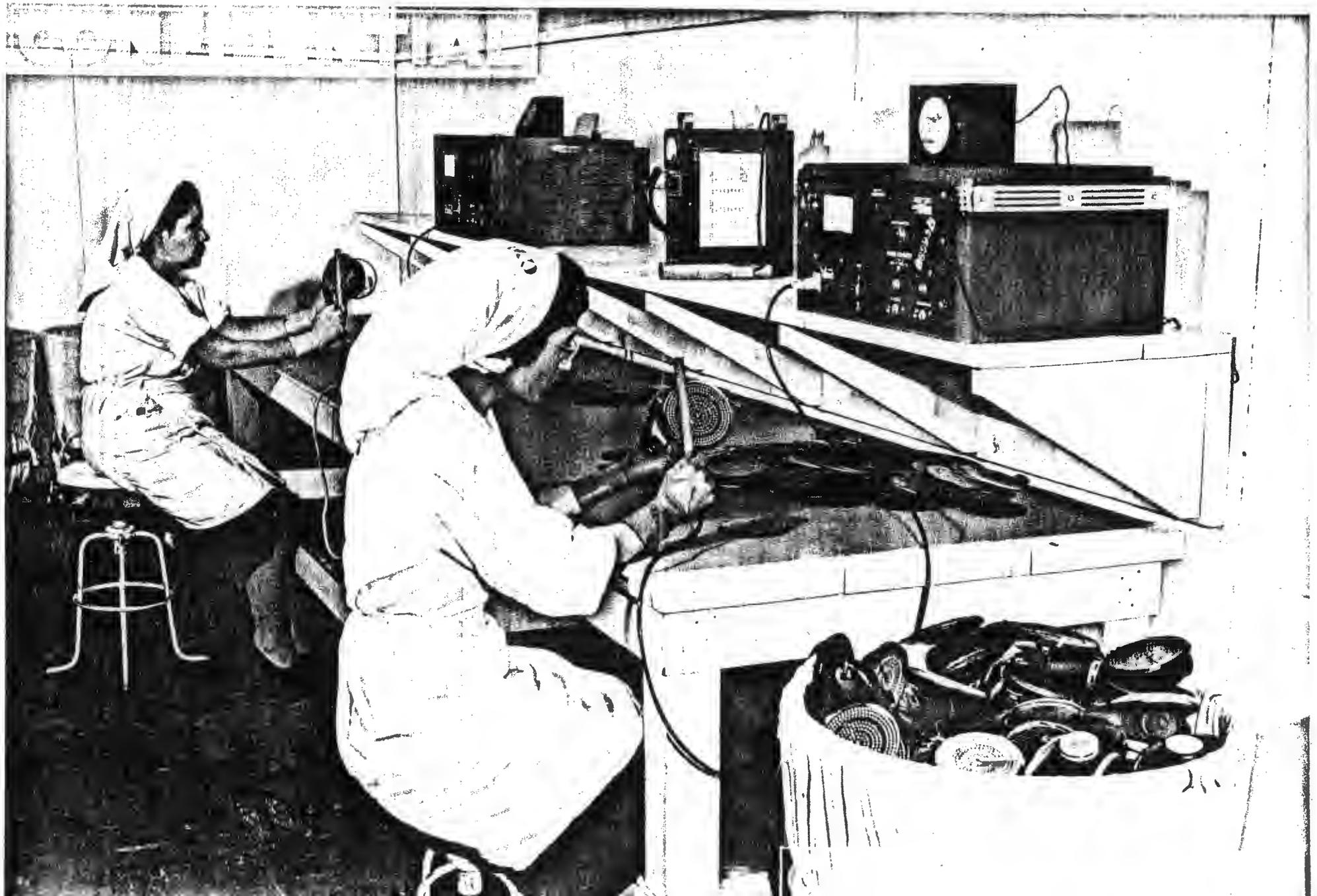


CONFIDENTIAL

NO SMOKING

CONFIDENTIAL





CONFIDENTIAL

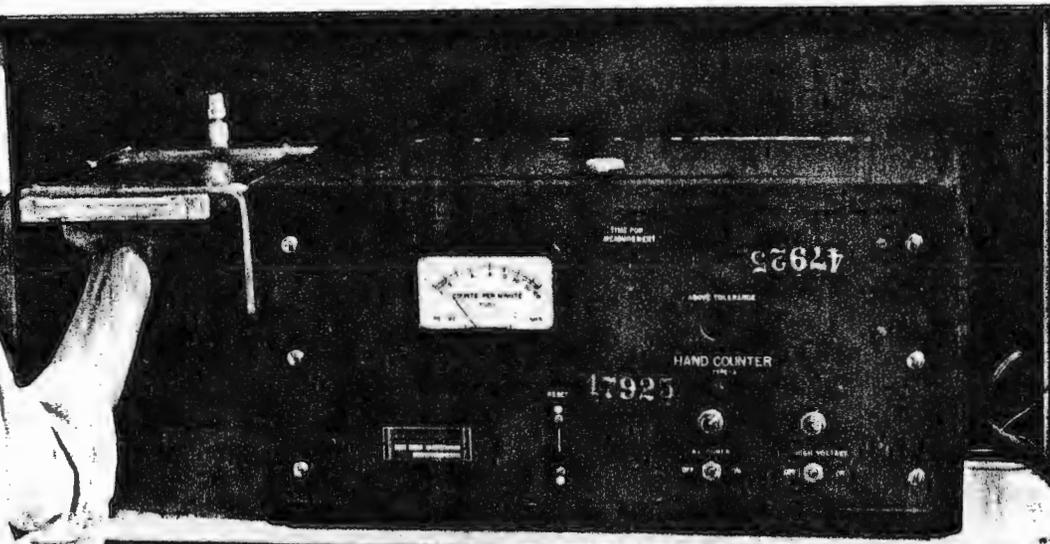


CONFIDENTIAL

CONFIDENTIAL



C



Handwritten notes on a vertical strip of paper, possibly a checklist or log. The text is mostly illegible due to the high contrast and grain of the image.

216

221

222

223

GENERAL FINES



CONFIDENTIAL