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REMOTE FABRICATION OF ^{137}CESIUM SOURCES AT HANFORD

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ABSTRACT

Gamma sources of ^{137}Cesium that are double encapsulated in stainless steel may be used in nuclear instruments calibration, in medical blood irradiators, and in various research applications. The production of such gamma sources in the U.S. was reestablished by the U.S. Department of Energy at the Hanford Site in Richland, Washington. This paper describes 1) the assembly process used at Hanford to encapsulate radioactive ^{137}Cesium in a remote environment, and 2) the equipment and process used to assemble and test two types of double-encapsulated sources.

I. INTRODUCTION

Sealed gamma sources, containing ^{137}Cesium (^{137}Cs) in the form of ^{137}Cesium Chloride (^{137}CsCl) salt, are each composed of a primary and a secondary stainless steel capsule. The total activity of these sources typically ranges from tens to thousands of curies of ^{137}Cs. These gamma sources are used in applications such as nuclear instruments calibration, medical blood irradiators, and research irradiators. Production of sealed ^{137}Cs gamma sources was originally established during the mid-1950s at the U.S. Department of Energy's (DOE) Oak Ridge National Laboratory (ORNL). Production in dedicated hot cells at the ORNL continued until operations were halted in 1989 for facility decommissioning. The new location selected by the DOE to continue gamma source manufacturing operations was the Shielded Materials Facility (SMF), Figure 1, located at the Hanford Site in Richland, Washington.

Before production began, the SMF south cell was modified by installation of four shielded compartments numbered 1 through 4. These compartments provide the process control boundaries. Each compartment was isolated from the others to control contamination between the process stages. Transfer ports were installed to facilitate intercompartment transfers and transfers between the SMF south cell proper and the process boundary.

Production of the double-encapsulated ^{137}Cs gamma sources includes preparation of the feed material (sectioning, dissolution, and filtration), forming pellets, loading capsules, helium backfilling, welding, and helium leak testing. Innovative solutions were required to develop the remotely operated equipment used in the assembly process. Two distinct source designs, a 22-TBq (600-Ci) source and a 66-TBq (1,800-Ci) source, are presently being produced. Both source designs consist of a stack of ^{137}CsCl pellets double encapsulated in stainless steel cylinders. The two types of sources are shown in Figure 2. Other than the size and mass loading, the only significant difference between the sources is that the 66-TBq source features an interference fit end cap instead of the slip fit end cap used by the 22-TBq source.

Assembly requires loading a stack of ^{137}CsCl pellets into an inner capsule, filling the void space with helium, seating an end cap in the capsule, and performing a closure weld. After meeting requirements for visual weld examination, leak testing, and surface contamination, the inner capsule is loaded into an outer capsule, the void space is filled with helium, the end cap is seated, and the final closure weld is performed. The outer capsule must then meet the same requirements as the inner capsule, plus a more stringent acceptance criteria for surface contamination.

During assembly, smearable contamination on the external surface of the inner capsule is required to be less than 167 Bq (10,000 dpm) per 100 cm^2 beta-gamma. The smearable surface contamination on the external surface of the outer capsule is required to be less than 17 Bq (1,000 dpm) per 100 cm^2 beta-gamma. Smearable contamination levels in each of the SMF compartments are maintained with respect to each assembly stage. Compartment 1 is the most contaminated, and the level of contamination decreases as the process moves from Compartment 1 through Compartment 4.

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II. FABRICATION DESCRIPTION

The assembly of gamma sources begins in Compartment 1 where the $^{137}CsCl$ is processed. The $^{137}CsCl$ feed material is retrieved primarily from WESF capsules, which are double-encapsulated, stainless steel containers. These capsules contain up to 1,850 TBq (50,000 Ci) of ^{137}Cs [approximately 2.5 kg (5.5 lb) of ^{137}Cs], and measure 52.8 cm (20.8 in.) long by 6.9 cm (2.7 in.) in diameter. The WESF capsules are retrieved from WESF storage and transferred to the SMF. Each capsule is opened and the $^{137}CsCl$ removed. The $^{137}CsCl$ is then dissolved, the insolubles filtered, and the solution evaporated. The processed $^{137}CsCl$ is dried further and is either stored for future use or pelletized.

Pellets are loaded through a specially tooled transfer tube located in the wall adjoining Compartments 1 and 2. The primary encapsulation then occurs in Compartment 2. Completed inner capsules are loaded into outer capsules and passed through a specially tooled transfer tube located in the wall adjoining Compartments 2 and 3. The secondary encapsulation then occurs in Compartment 3. Following decontamination, completed outer capsules are passed into Compartment 4 for surveillance and to await shipment.

Airflows within the SMF were established to limit the movement of contamination from the more contaminated compartments to the less contaminated compartments, and outside of the process boundary. Intercompartment pressure differentials are approximately 2.54×10^{-4} Kgs/sqcm (0.1 in.) H_2O between Compartments 1 and 2 and between Compartments 2 and 3. The pressures are approximately equal between Compartments 3 and 4. These pressure differentials have proven effective in decreasing ^{137}Cs migration between assembly stages. Additionally, there has been no detectable migration of $^{137}CsCl$ outside of the process boundary.

A. Compartment 1

In processing $^{137}CsCl$, the following operations are performed in Compartment 1, which is the most highly contaminated: (1) retrieval of $^{137}CsCl$ from the WESF capsules, (2) $^{137}CsCl$ dissolution and filtering, (3) $^{137}CsCl$ drying and storage, (4) $^{137}CsCl$ pellet pressing, and (5) inner capsule loading through a transfer port into Compartment 2. The dissolution and filtering equipment has not been installed to date because the first series of capsules were fabricated using powder previously obtained from WESF capsules by ORNL. The powder had been stored in a "Type IV" can and was transferred to Hanford from ORNL. The can was opened using a modified tubing cutter. To prevent the powder from absorbing moisture, it was stored in a temperature controlled oven at 210° C (450° F).

A predetermined amount of powder, depending on the type of capsule to be fabricated, is weighed and placed in a die. The die, shown in Figure 3, is transferred to a hydraulic press where a preset pressure is applied. After the newly formed $^{137}CsCl$ pellets are pressed from the die, their dimensions and weight are checked to verify consistency. The pellets are then stored in one of two ovens.

Finished pellets are removed from the oven and loaded into an inner capsule through a transfer tube in the wall adjoining Compartments 1 and 2. Within Compartment 1, pellets are positioned on a funnel that is engaged with the transfer tube. Within Compartment 2 an inner capsule is loaded onto a slide and positioned in front of the transfer tube. The capsule slide is then pushed through the transfer tube until it engages with the funnel within Compartment 1. Pellets are slid into the capsule, the capsule is retracted into Compartment 2 and stored in a drying oven to await further assembly.

B. Compartment 2

After the primary pellet encapsulation is accomplished in Compartment 2, the following operations are also performed: (1) heating of the loaded inner capsule, (2) backfilling inner capsule with helium and end cap insertion, (3) welding the end cap in place, (4) inspection and testing, (5) decontamination, and (6) loading the completed inner capsule into the outer capsule. Remote equipment in Compartment 2 consists of a cap press used to evacuate the capsule, backfill it with helium, and press the cap into the capsule.

Before sealing, the loaded inner capsule is heated in an oven within Compartment 2 to remove any residual moisture. The capsule is then placed in the cap press and backfilled with helium before the end cap is inserted and welded in place. The capsule is transferred from the cap press to the welder shown in Figure 4. The cap is welded to the capsule using the gas tungsten arc welding (GTAW) process. Once welded, the capsule is transferred to a helium leak test chamber. Welds are helium leak tested, visually and dimensionally inspected, and the capsule is weighed. Completed capsules are then wiped for smearable contamination and decontaminated as necessary.

Between Compartments 2 and 3, the inner capsule is loaded into an outer capsule. From Compartment 3, an empty outer capsule is positioned on a slide and pushed through a specially designed transfer port until the capsule engages Compartment 2. The inner capsule is then placed in the waiting outer capsule. The slide holding the outer capsule is retracted into Compartment 3, and the capsule is inserted into a drying oven. This secondary encapsulation is identical to primary encapsulation, except that the function of the funnel used to transfer pellets is replaced by a guide to direct the inner capsule into the outer capsule. The transfer ports and loading equipment are frequently decontaminated.

C. Compartments 3 and 4

Following secondary encapsulation and drying, the capsule, now in Compartment 3, is wiped for smearable contamination and decontaminated if necessary. Then a simple slide, mounted in a transfer port within the wall adjoining Compartments 3 and 4, is used to transfer the capsule to Compartment 4. Compartment 4 serves as an interim storage and contamination surveillance area. The finished gamma sources are loaded for shipment from this compartment.

III. CONCLUSION

The use of specialized remote equipment and contamination control techniques ha· proven very effective in the fabrication of $^{137}CsCl$ sources. The ability to successfully pelletize and double encapsulate $^{137}CsCl$ into gamma sources has been demonstrated at Hanford. To date, thirty-four 22-TBq sources have been produced and shipped to a commercial blood irradiator manufacturer. All of the sources meet the stringent special form specification requirements.

IV. ACKNOWLEDGEMENT

The authors would like to acknowledge all of the Pacific Northwest Laboratory and Westinghouse Hanford Company staff who contributed to the success of this program.

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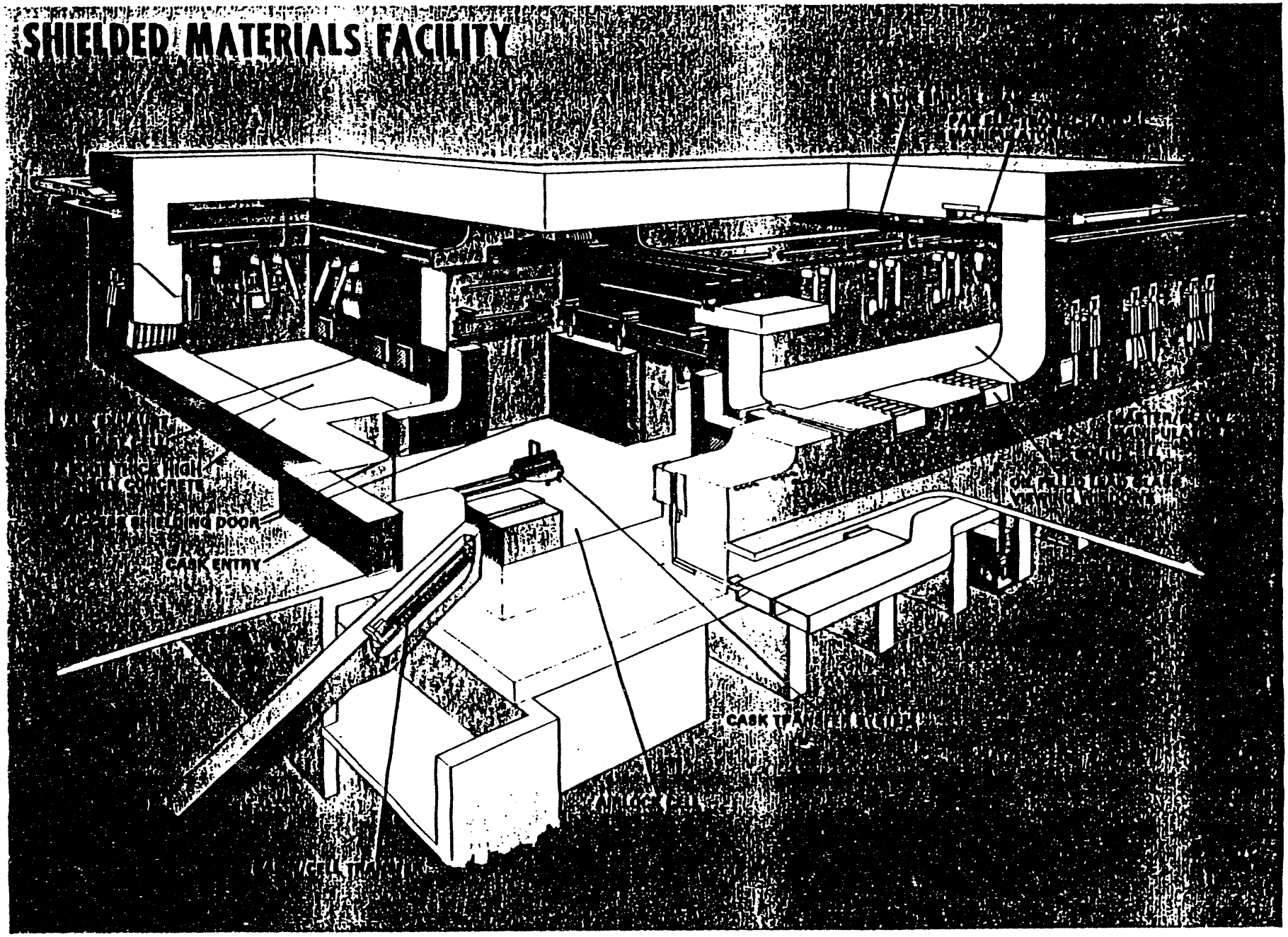

FIGURE 1

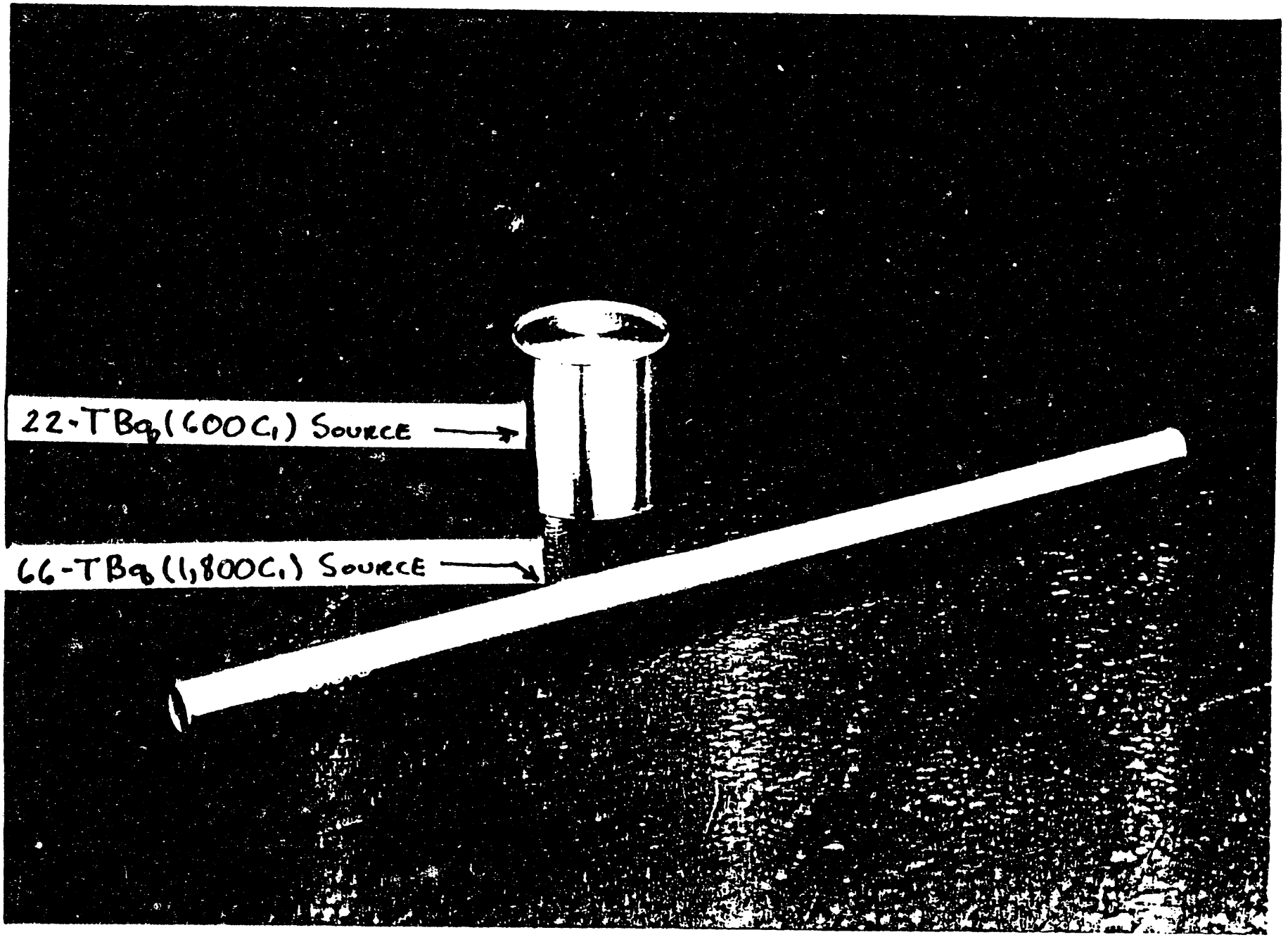

FIGURE 2

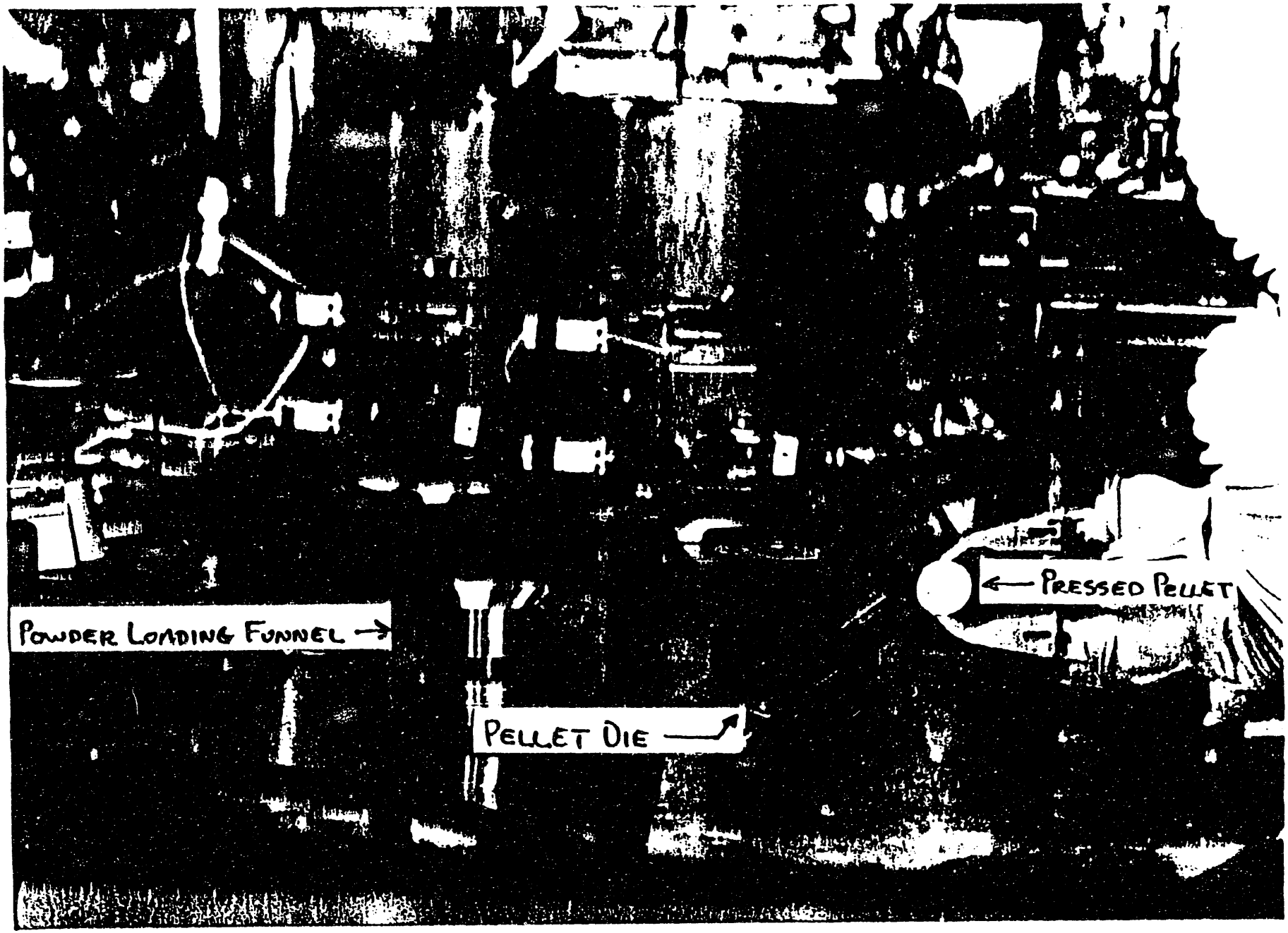

FIGURE 3

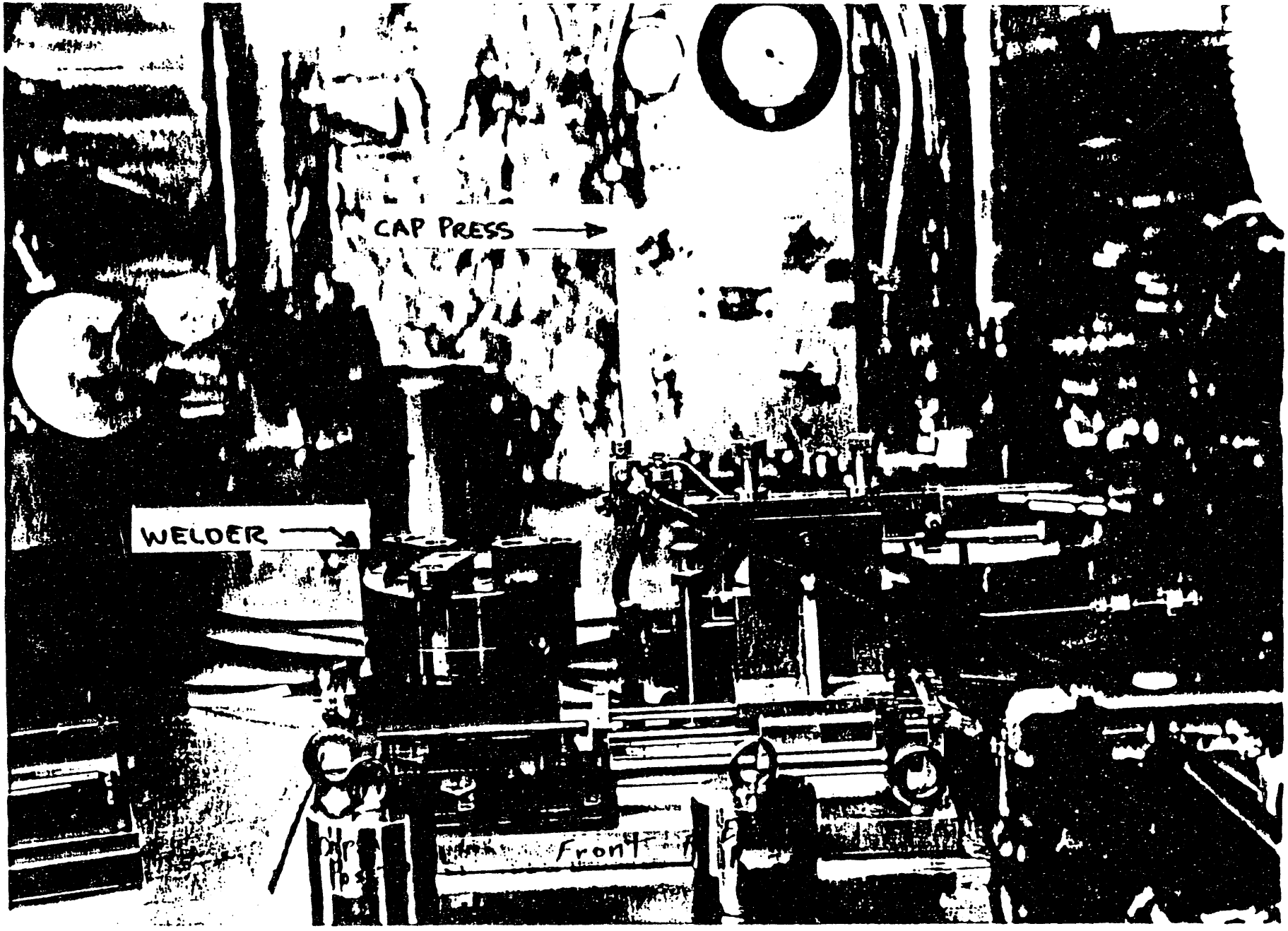

FIGURE 4

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