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FABRICATION OF ^{137}Cs SOURCES

J. A. Jones

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Isotopes Division

SEPTEMBER 1964

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CONTENTS

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ABSTRACT

Sealed sources containing $^{137}CsCl$ suitable for medical, industrial, and research applications have been developed at Oak Ridge National Laboratory. The ^{137}Cs, separated from reactor fuel processing wastes, is prepared as $^{137}CsCl$ powder and pelleted under pressure into suitable shapes. The pellets are doubly encapsulated in stainless steel, sealed by fusion welding, and tested for leaks greater than 2×10^{-6} ml/sec.

INTRODUCTION

Medical, industrial, and research organizations require ^{137}Cs in a safe, sealed form. Techniques have been developed at Oak Ridge National Laboratory for fabricating $^{137}CsCl$ sources of high integrity. Since 1958 more than 600,000 curies of ^{137}Cs have been fabricated as sealed sources and sold for use in a great variety of applications. Cesium-137 is separated from other radioactive isotopes and inactive chemicals present in spent reactor fuel wastes by the Decalso-Alum-Oxalate (DAO) process.[1]

PREPARATION OF PURE, DRY $^{137}CsCl$

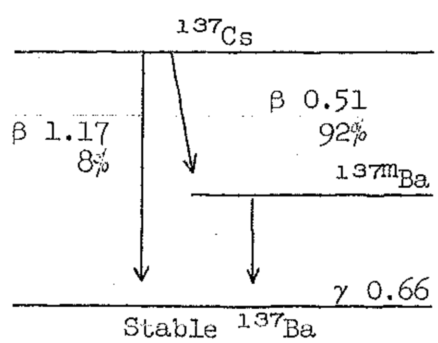
An aqueous solution of $^{137}CsCl$ previously purified by the DAO process is converted to the powder by evaporation[1] (Fig. 1). To assure the formation of a workable powder, the temperature is kept between 80 and 100°C, and the solution is stirred occasionally while the crystals are forming. When the powder is "dry," the temperature is raised to 400°C for 2 hr to bake out any remaining moisture and/or free acid. In order to preserve its anhydrous condition, the powder is maintained at a temperature of 80 to 100°C during the periods when it is stored.

An aliquot of the powder is analyzed[2] (Fig. 2) for radionuclides other than those associated with cesium by scanning with a gamma-ray spectrometer. By the same method, a separate determination of the $^{134}Cs/^{137}Cs$ ratio is made. A high-pressure gamma ionization chamber is used for assaying the total ^{137}Cs content.

PROPERTIES OF $^{137}CsCl$ USED FOR MAKING SOURCES

The ^{137}Cs is invariably accompanied by ^{134}Cs, with the amount of ^{134}Cs dependent upon reactor power, fuel burnup, and age of the waste. Waste aged at least two years since the fuel was discharged from the reactor is used as a source of material for source grade ^{137}Cs.

The specifications for ^{137}Cs sources are given in the following table:

Half-life:[3]	^{137}Cs, 29.7 ± 0.5 years ^{137m}Ba, 2.6 min
Radiation: (MEV)	^{137}Cs - Beta - 0.51 (92%), 1.17 (8%) - Gamma - None ^{137m}Ba - Beta - None - Gamma - 0.662
Decay Scheme:	
Chemical Form:	CsCl
Concentration:	>22 curies/g solid
Purity:	^{137}Cs ~35% of total cesium isotopes (except for ^{134}Cs, the other isotopes do not contribute gamma rays)
^{134}Cs	Maximum ratio <5 curies of ^{134}Cs to 100 curies ^{137}Cs

$^{85,87}Rb$	Maximum ~15% by weight
Other	Traces of Na, K, Si, etc., from reagents

FABRICATION OF SOURCES

An amount of CsCl powder suitable for a particular source is weighed, and the powder is transferred to a tool-steel die for compression into a pellet. A remotely operated hydraulic press is used to form the pellet at 50,000 psi; the pellet has a final density between 3.0 and 3.3 g/ml.

To reduce costs, as many as 50 sources of assorted sizes and weights are prepared in a single production run. The source pellets range in size from 4 to 36 mm in both diameter and length and vary in ^{137}Cs content from 5 to 2000 curies. Although most pellets are right cylinders, square wafers (Fig. 3) or segments of a ring can also be made. The square wafers lend themselves to encapsulation in flat plates, and the ring segments can be used in hollow cylindrical sources. Equipment required for forming right cylinders is shown in Fig. 4.

The pellets are placed in an inner source container fabricated from type 316 stainless steel. The remaining free space in the capsule is filled with a custom-fit spacer of stainless steel to prevent movement of the pellet within the capsule. A plug which has been machined to a light press fit with the capsule is then inserted and pressed into place hydraulically, and the capsule is sealed by fusion welding.[4] The completed inner capsule is checked for leaks and then inserted in an outer stainless steel capsule which in turn is welded. This procedure assures safe containment as a result of double encapsulation. Typical capsules are shown in Fig. 5. The welding equipment is shown in Figs. 6 and 7, and capsules which have been sealed by the remote welding techniques are shown in Figs. 8 and 9.

SOURCE TESTING

After encapsulation each source is cooled to room temperature and immersed in water just below the boiling point. The sealed capsule is illuminated from the side and is observed through a monocular and a magnifying glass for the presence of escaping bubbles (Fig. 10). If no bubbles appear while the source is heated for 2 min, the capsule is considered to be leak-tight. A more sensitive test can be made by submerging the sealed source in ethylene glycol and reducing the pressure over the liquid to 5 in. Hg absolute. This method has been evaluated[5] and is known to be capable of detecting leaks as small as 2.3 x 10^{-6} ml/sec.

After the initial leak test, the finished source is thoroughly washed with a detergent solution, rinsed with hot water, and dried. The source is wiped on all surfaces with a 1.75 in. diameter filter paper disc, and the paper disc is removed from the manipulator cell for counting. The cleaning and wipe-testing operations are repeated until the contamination level is below 1000 d/min of beta-gamma and 30 d/min alpha. When the source is found to be free of leaks and has surface contamination below the prescribed limits, it is placed in storage for a seven-day period. At the end of the storage period, the source is returned to a manipulator cell, and the tests for leaks and contamination are repeated. After passing these tests, the source is considered to be ready for shipment.

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2. ORNL Master Analytical Manual, TID 7015, procedure No. 9 0733191.

3. R. E. Lewis, and R. E. McHenry, Private communication, 1964 (data to be published).

4. E. E. Pierce, Remote welding of stainless steel capsules, Rpt. ORNL-2280, Oak Ridge National Laboratory (March 22, 1957).

5. Clyde R. King, Vacuum leak testing of radioactive source capsules, Rpt. ORNL-3664, Paducah Gaseous Diffusion Plant, (to be published).

APPENDIX

This section includes Figs. 1 through 10 described in the report.

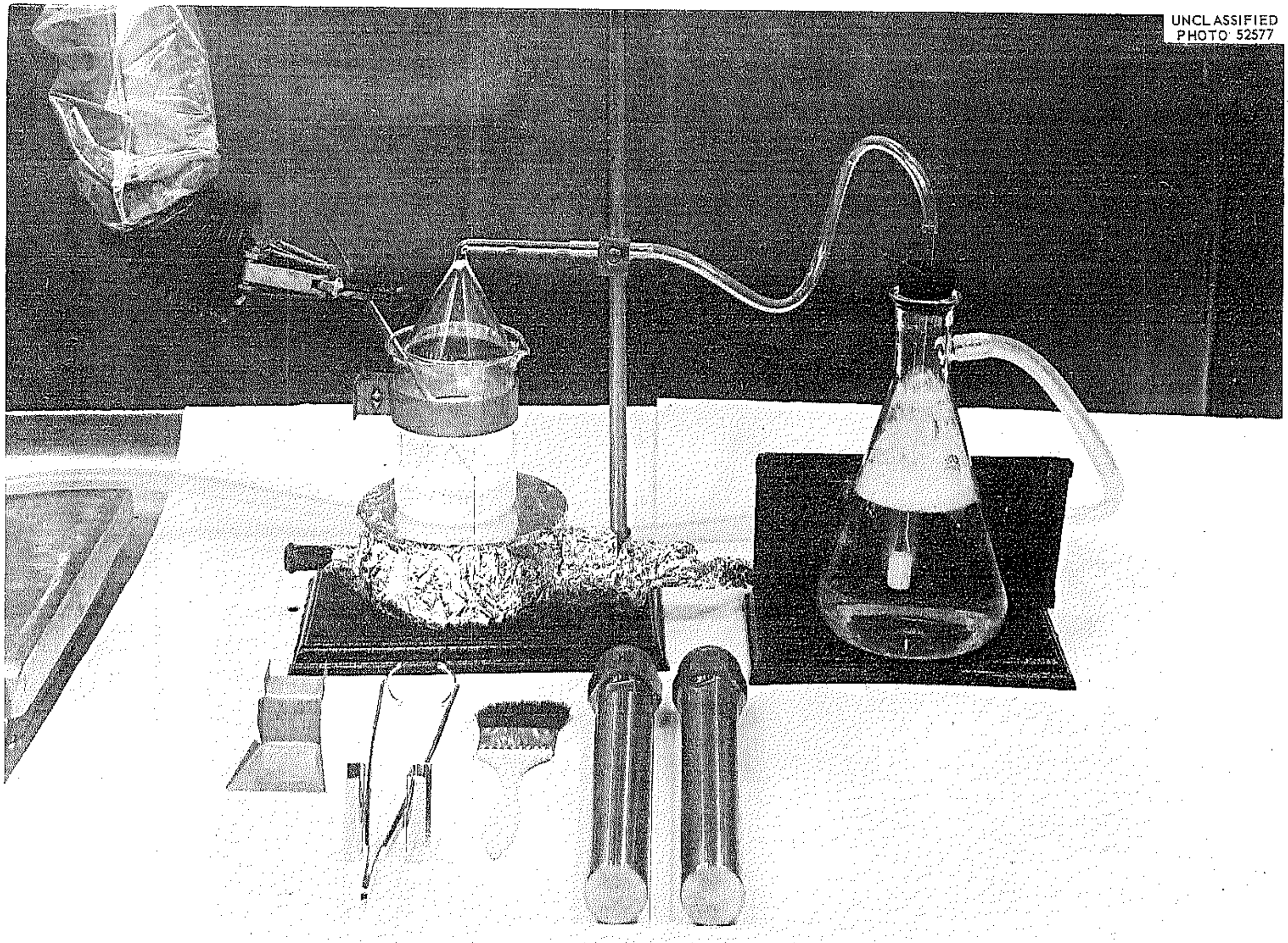

Fig. 1. Evaporation of cesium chloride solution.

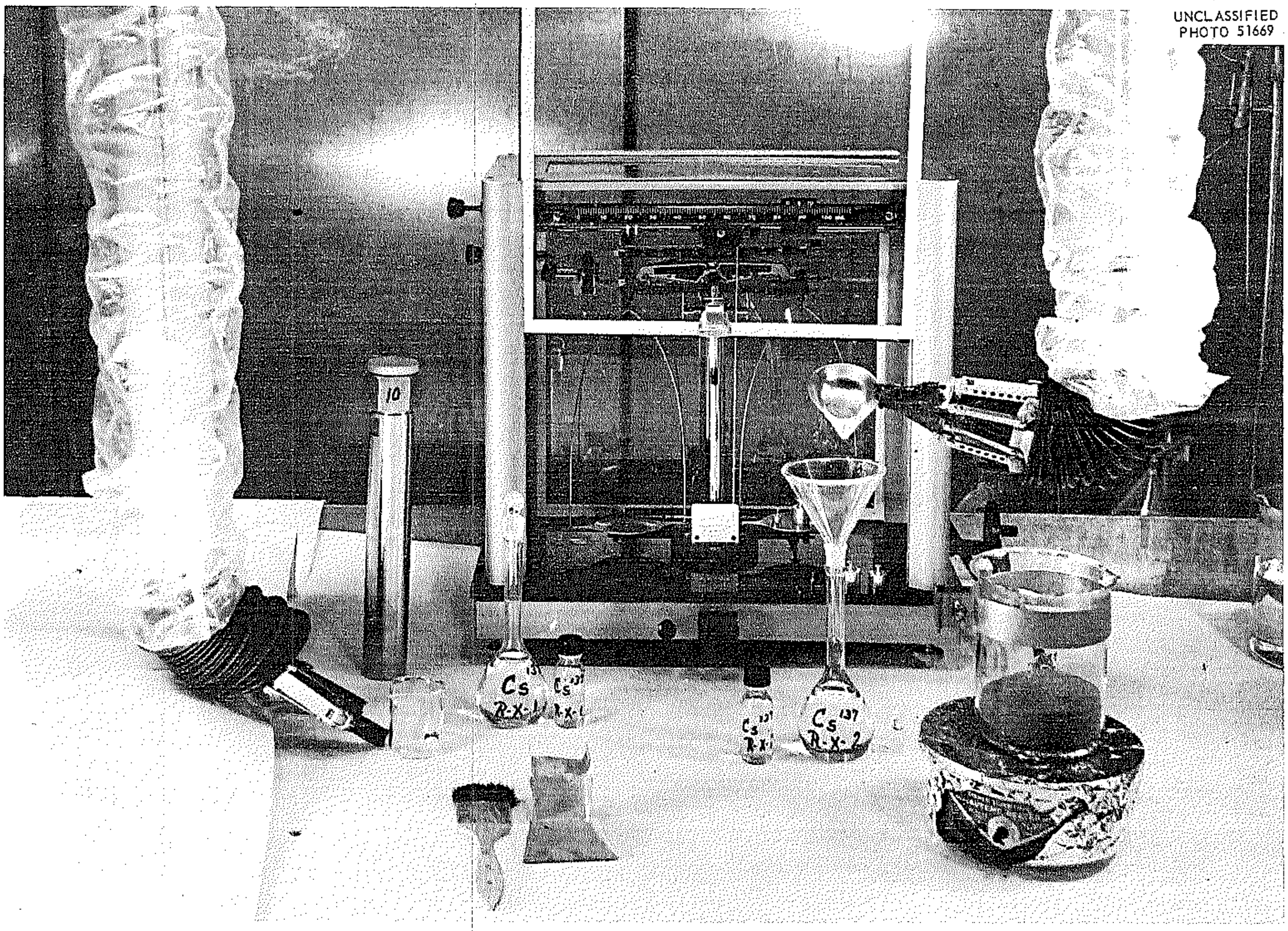

Fig. 2. Preparation of powder aliquot for analysis.

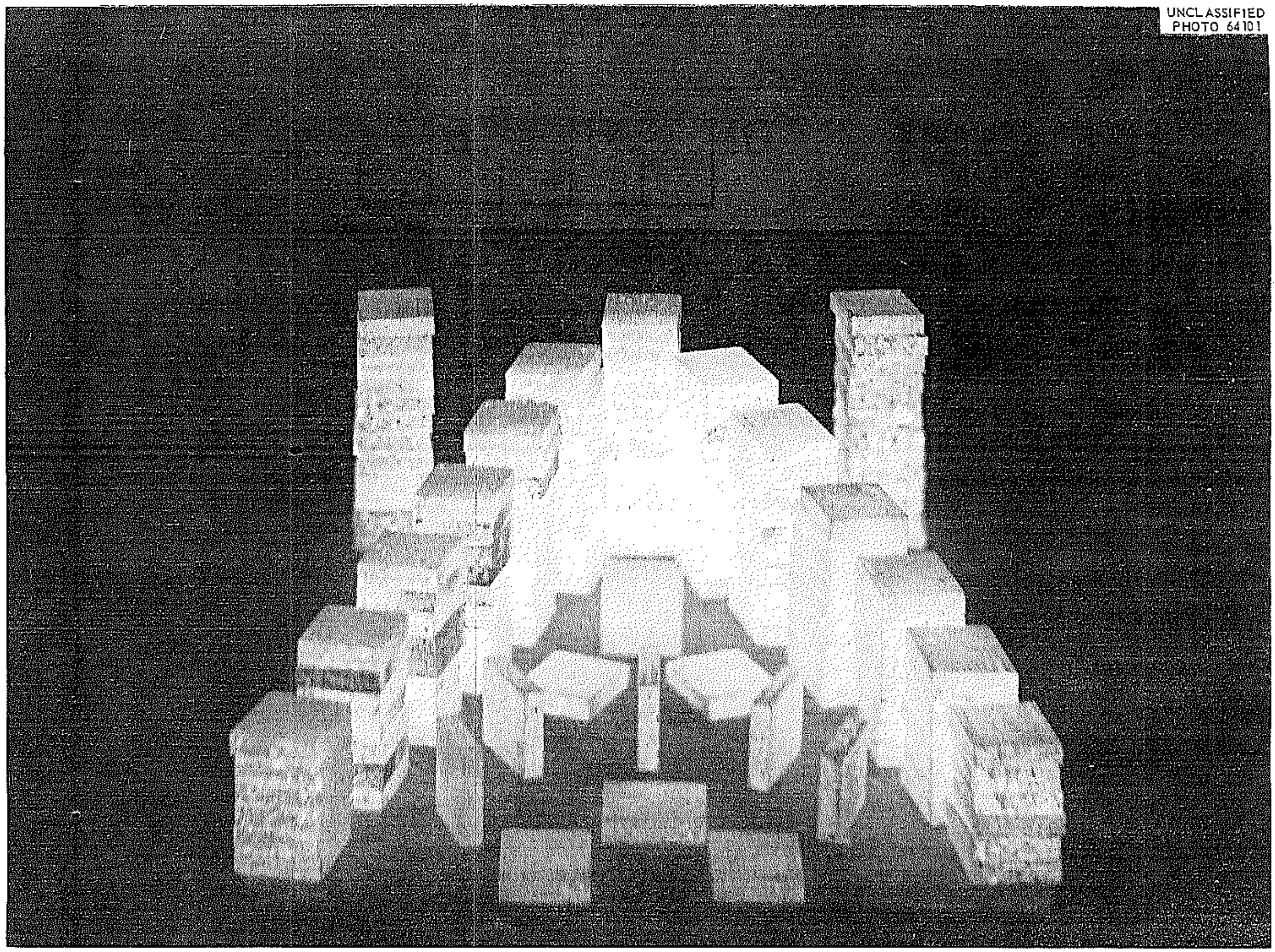

Fig. 3. Square wafers of $^{137}CsCl$.

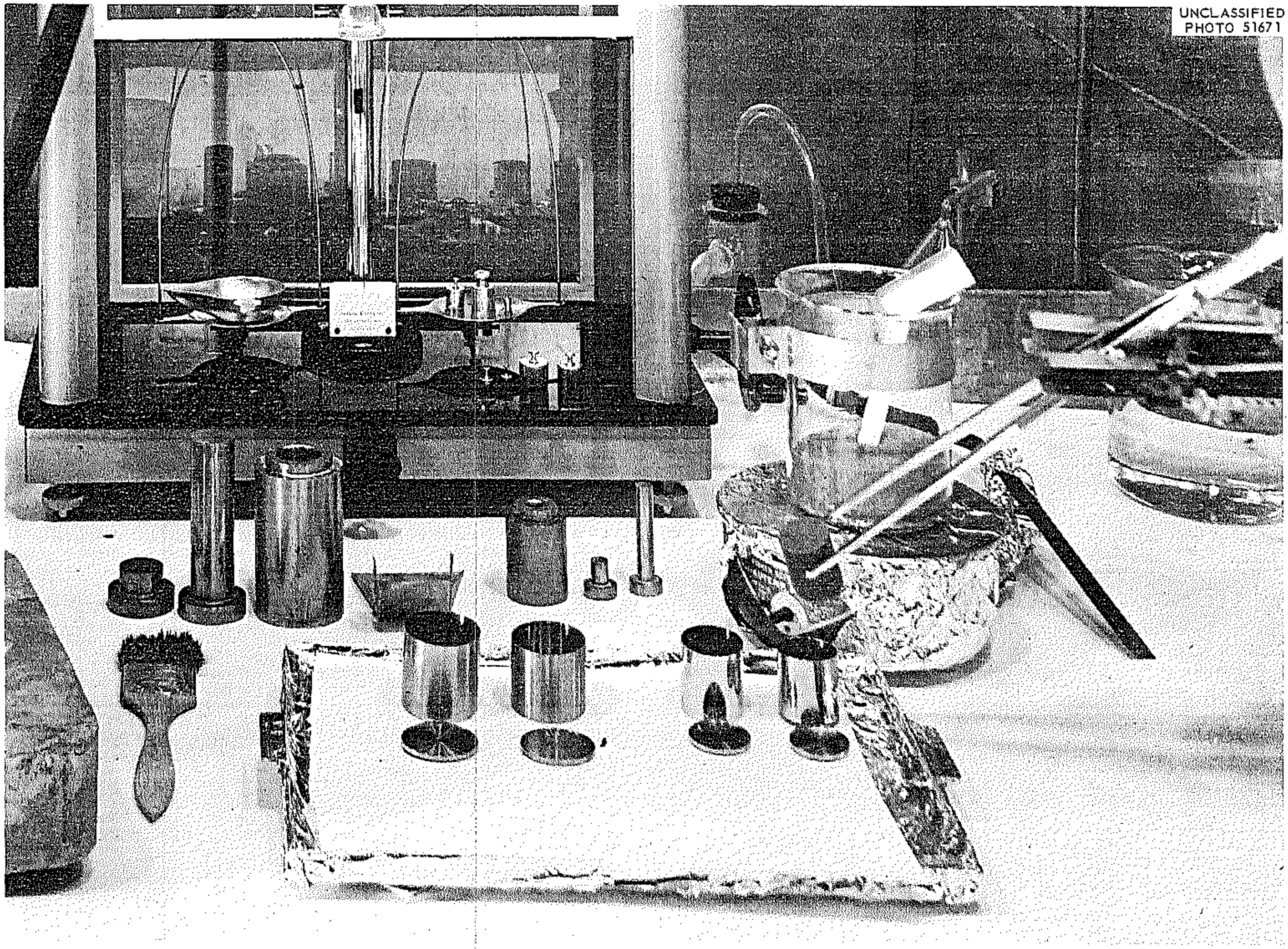

Fig. 4. Equipment for forming and encapsulating pellets.

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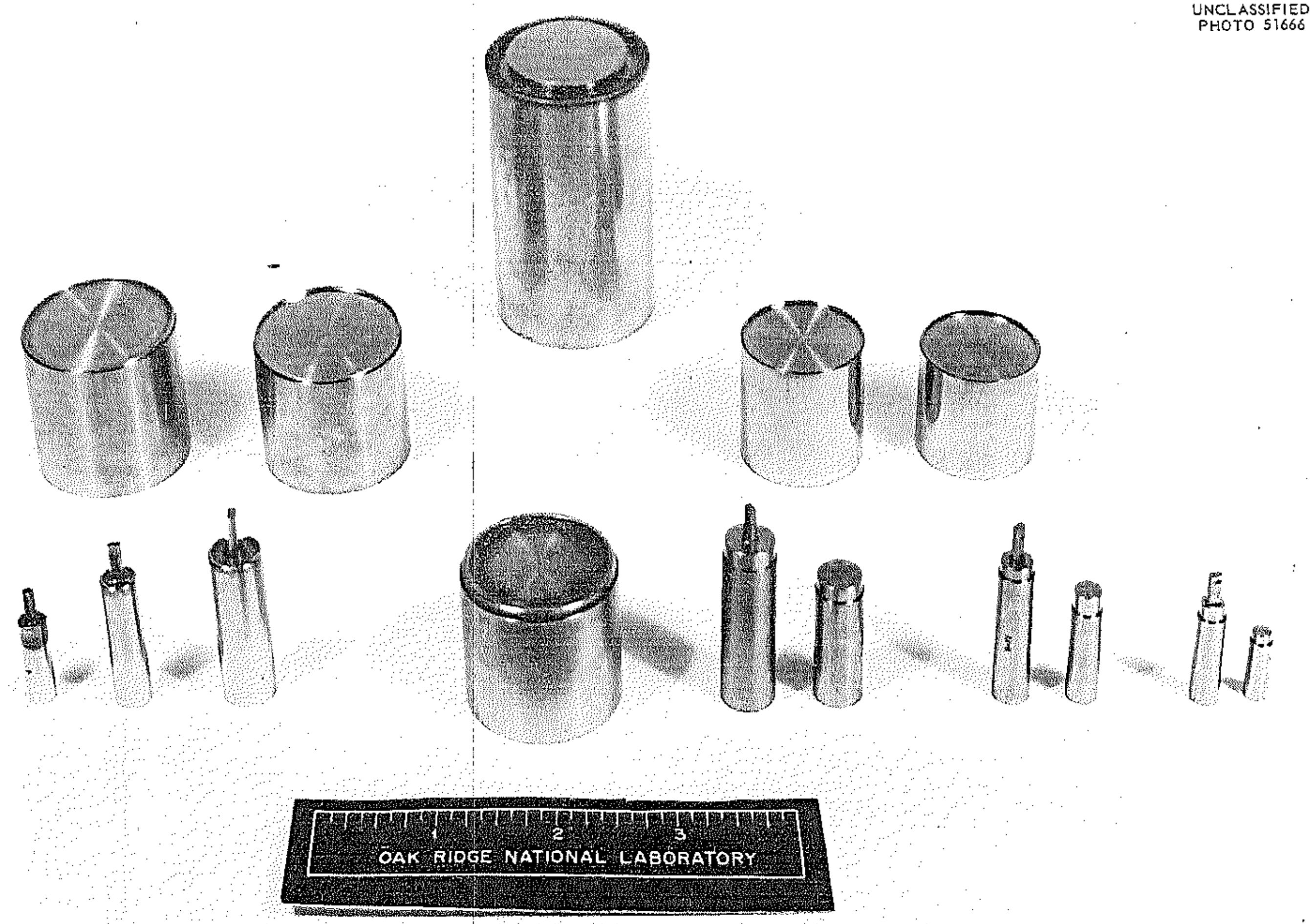

Fig. 5. Typical capsules before and after welding.

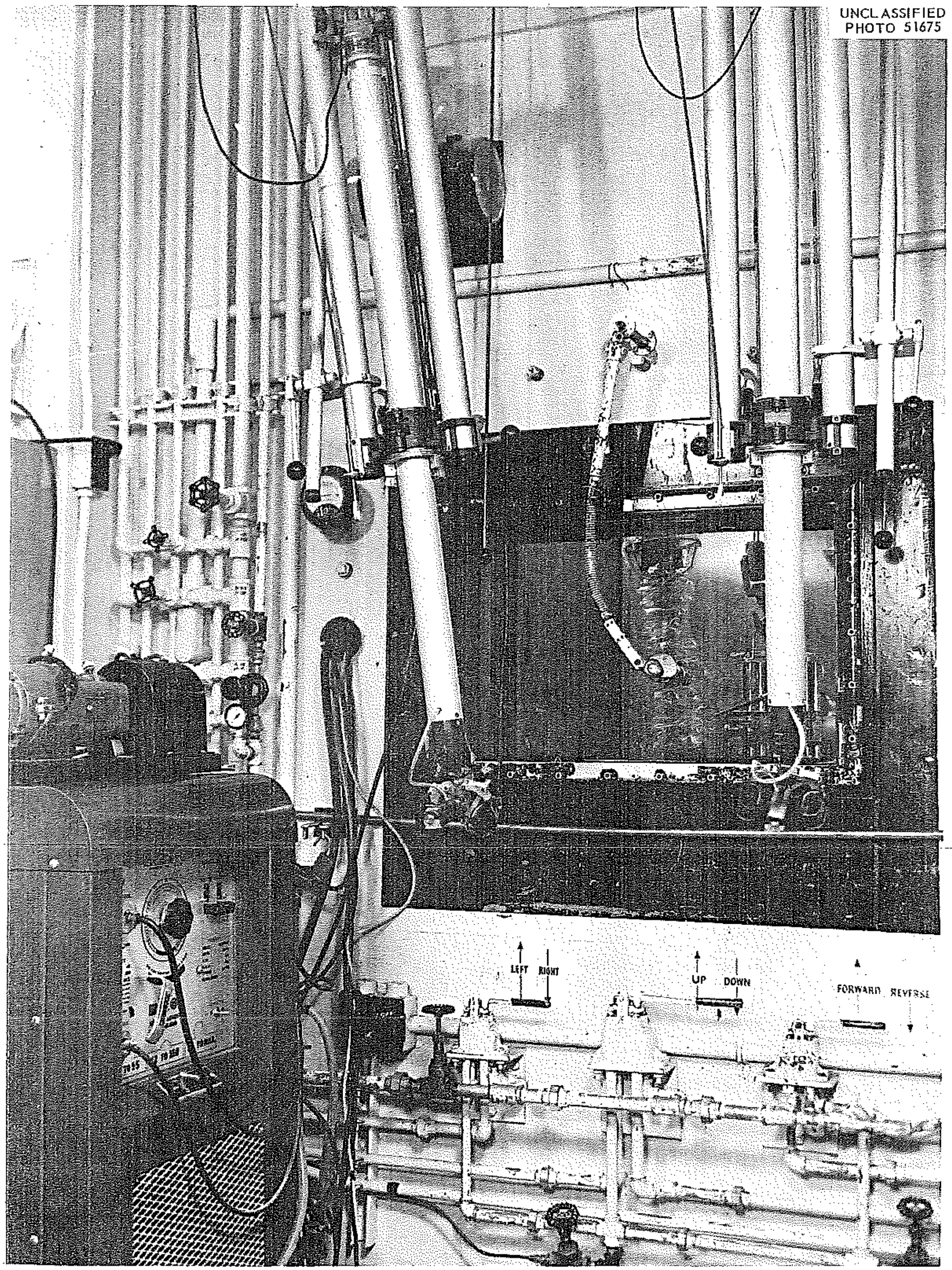

Fig. 7. Power supply and controls for remote welding.

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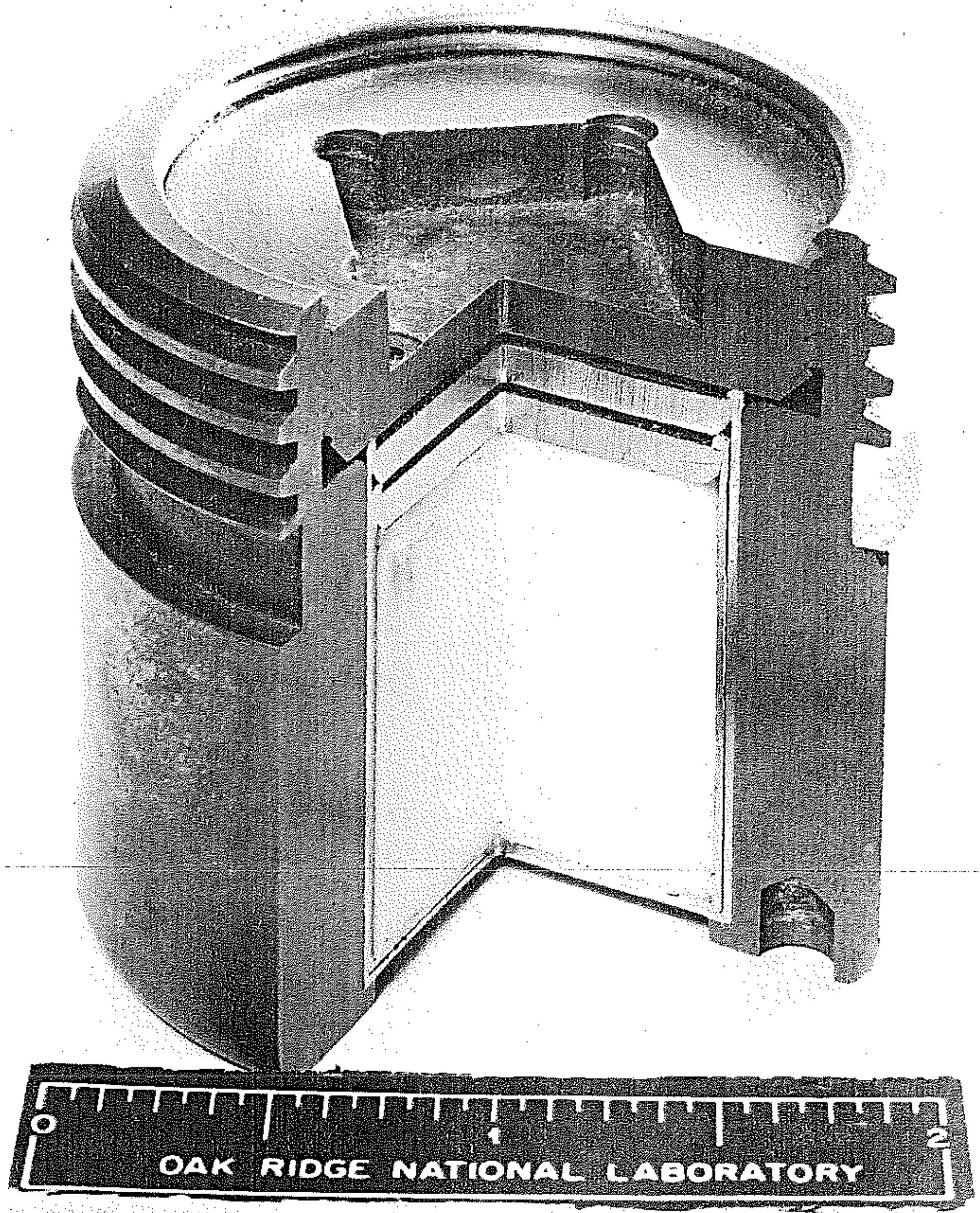

Fig. 8. Section of dummy international standard teletherapy source capsule.

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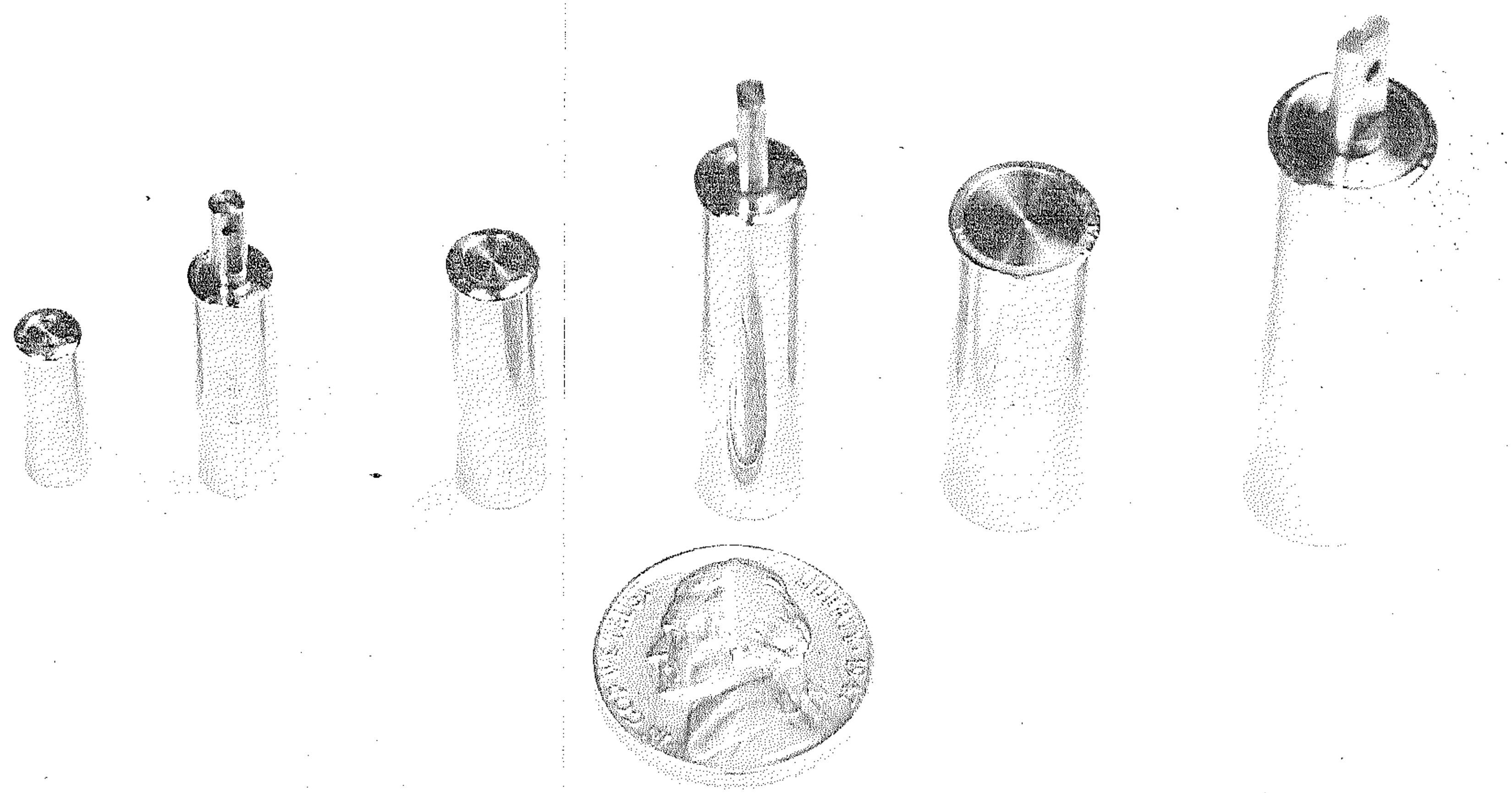

Fig. 9. Typical capsules sealed by remote welding.

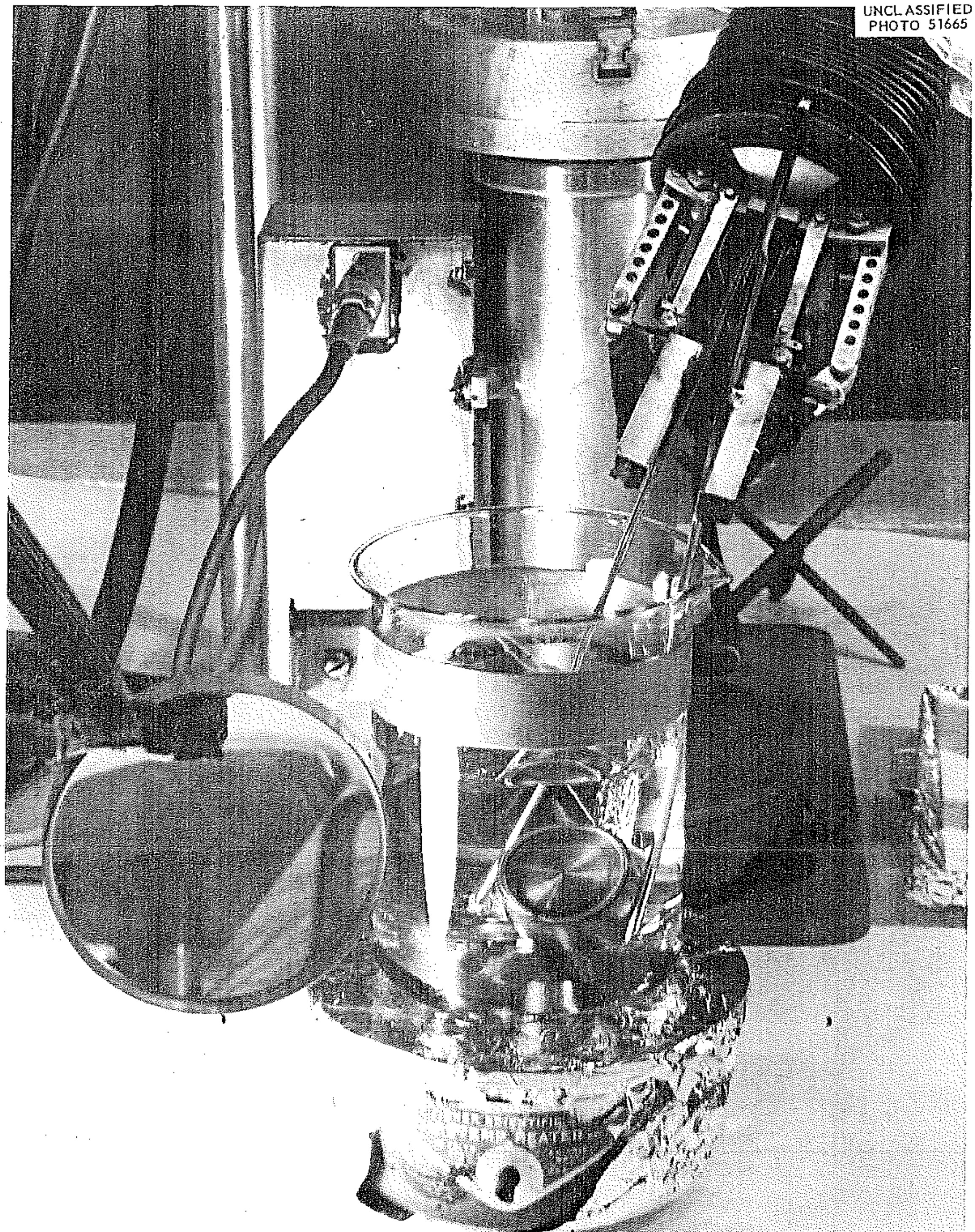

Fig. 10. Testing welded capsule for leaks.

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