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A compact and efficient mechanism, simple to operate, for welding aluminum capsules containing various elements to be reactor-irradiated has been developed by the Health Chemistry Department at Lawrence Radiation Laboratory, Berkeley. This system assures an atmosphere of helium within the finished capsule, for heat-transfer and leak-detection purposes. The mechanism was designed primarily for remote operation with master-slave manipulators, but works equally well on the bench top for encapsulation of nonradioactive material. The capsule collet accommodates capsule diameters of $\frac{1}{2}$ to 1 in. and capsule lengths of $1\frac{1}{2}$ to $3\frac{1}{2}$ in.

INTRODUCTION

Purpose and Prime Problem of the Capsule-Welding Mechanism. The problem of welding capsules containing radioactive material has always been a serious one. With production of multicurie amounts of the transplutonium elements and the need to re-irradiate these materials, the problem of remote encapsulation became more acute. When it became necessary to re-encapsulate three possibly damaged capsules which had been irradiated for a year at high flux at Materials Testing Reactor in Idaho Falls, Idaho, our problem of remote encapsulation became immediate and a solution imperative. These three capsules contained 500 mg of Cm^{244}, 800 mg of Am^{243}, and 800 mg of Pu^{242}, with approximately 200 curies of mixed fission products. Our experience with screw-type joints and hydraulically pressed seals indicated that a welded-type seal would be more satisfactory. This capsule-welding mechanism is the result of these basic thoughts and of the prime problem.

DESIGN PARAMETERS AND SOLUTIONS

The Ideal Capsule. First and foremost, the ideal capsule should have a capsule-to-lid joint of high integrity, i.e., mechanical strength, and be vacuum-tight. This then would indicate that a weld-type seal would be superior over a screw-type joint or hydraulically pressed seal. The capsule should also include features as follows.

1. The capsule-to-lid joint should be conducive to remote welding without the need for additional weld metal, and the joint should minimize the possibility of the weld metal's rolling over the side, thereby increasing the original diameter of the capsule. Fig. 1 illustrates our standard weld-type capsule. The capsule and lid are each beveled 25 degrees and the lid, when inserted, sits up 1/16 in. higher than the capsule. The bevel minimizes the possibility of increasing the capsule diameter and the 1/16 in. excess material in the lid height supplies the additional material necessary for the weld bead.

*Work done under the auspices of the U. S. Atomic Energy Commission.

2. The welded capsule should contain approximately 1 atmosphere of helium for heat-transfer purposes in the reactor and for joint-testing purposes with a helium-sensitive leak detector. With our capsule-welding mechanism (Fig. 2) we can assure an atmosphere of helium within the finished capsule.

3. Since the conduction of heat, while welding, causes a build-up of internal pressure in a capsule, it is difficult to prevent a blowhole at the point of juncture between the start and finish of the weld. This problem is minimized through capsule design. The capsule lid is made as deep as we feel practicable (3/8 in.) and counter-bored to reduce mass. Moving the capsule weld joint away from the capsule cavity, and the reduction in mass, by counter-borihg, of the lid minimizes the conduction of heat to the interior of the capsule. This problem is further alleviated by refrigerating the capsule-collet in the welding mechanism (Fig. 2).

Having established what we consider to be the ideal capsule for the containment of material for reactor irradiation, we can now go on to describe the welding mechanism, which is remotely operable and lends itself to producing a capsule with the qualities we desire.

Operating Area. For radioactive operations the welding mechanism is located in the primary enclosure of the water-shielded cave facility with master-slave manipulators described elsewhere. (1). The mechanism occupies about 1 ft^2 of floor space and about 25 in. in height.

Since most of our encapsulations are nonradioactive until reactor irradiation, this mechanism is designed to be equally operable on the bench top.

Capsule Size Limitations. The capsule collet (Fig. 2) accommodates capsule diameters of $\frac{1}{2}$ to 1 in. and capsule lengths of $1\frac{1}{2}$ to $3\frac{1}{2}$ in. The capsule diameter limitations are dictated by the reactor facilities in use by us. The length limitations are established by past experience with maximum lengths requested.

Contamination Consideration. Because of contamination possibilities in packaging radioactive isotopes and the inherent decontamination problems, the bell jar chamber where the welding takes place has a minimum amount of surface and mechanism exposed.

Collet Drive or Electrode Drive. For mechanical simplification it was deemed more expedient to drive the capsule under a stationary electrode rather than to drive the electrode over a stationary capsule, which would require a more complicated drive mechanism.

The drive mechanism as it exists consists of a single shaft through the center of the base, to which is attached a distribution gland for the refrigerant, and the adjustable refrigerated capsule collet. The shaft, together with the distribution gland and collet, is driven by an integrated mechanism below the bell jar chamber. The left-hand crank drives the collet up or down and the right-hand crank rotates the collet in either direction.

During welding, the electrode is stationary, but can be swung away in the horizontal plane for easy access to the collet and adjustment to various diameters of capsules. The helium supply standpipe can also be swung aside for collet access.

Operational Viewing. Remote welding is viewed through a model 301 Kollmorgen periscope with a circle of standard #8 welding glass inserted in the rubber eye guard. This periscope has a 10-power magnification, which is satisfactory for the working distance of approximately 7 ft between welder and operator.

For bench-top operation, no magnification is generally necessary. However, a standard 4-in. reading glass is mounted on the bell jar support column and can be swung into position for operational viewing or visual inspection of the weld.

Excess Weld-Metal Removal. Since there is a possibility of excess weld metal increasing the diameter of the capsule there is provision for the removal of this unwanted material. A grinder motor is mounted on the bell jar support column and can be swung into position when needed. Position is maintained with a gross adjustment clamp and fine adjustment in the horizontal plane with a micro adjustment screw.

Because of the fine control over the weld metal, it has not been necessary to use this attachment to date, but the possibility still exists.

Bell Jar Chamber. The bell jar is counterweighted in the bell jar support column. When the bell jar is in the up position it can be swung to the side in the horizontal plane for easy access to the capsule collet. When the bell jar is in the down position the chamber is sealed by an O ring between the chamber platform and the ground flange of the bell jar. No clamps are necessary, as the vacuum holds the bell jar down throughout the welding operation.

Accessory Equipment. For maintenance, adjustment, and freedom from possible contamination, the equipment accessory to this welding mechanism is located on the operator's side of the shielded facility. This equipment includes:

1. Welding machine (P and H ac - dc machine Model DA 200 HF GW with high-frequency variable control for arc stabilization and a remote-controller foot switch).

2. Vacuum pump.

3. Centrifugal water pump and reservoir. (We find ice water gives us sufficient heat exchange for the capsule collet.)

4. Helium supply with regulator.

5. Helium-sensitive leak detector for testing the welded capsule joint.

OPERATING PROCEDURE

Radioactive Material Encapsulation. A capsule is generally loaded with its radioactive material in an enclosure other than the welding chamber, with care taken to prevent external contamination of the capsule. This procedure helps to prevent the capsule-welding mechanism from becoming contaminated. Upon determination that the external capsule surface is free of contamination it is then inserted in the capsule collet and the collet tightened. The capsule is then welded by the following steps:

1. The electrode holder is swung over the capsule into the electrode-holder-arm-stop which has been preset for the diameter of the capsule to be welded.

2. The helium supply pipe is swung into position over the capsule (about $\frac{1}{4}$ in. from the electrode).

3. The counterweighted bell jar is swung over the mechanism and pulled down to the chamber platform.

4. The vacuum pump is turned on and the chamber is evacuated to approximately -29 in. of mercury.

5. The vacuum pump is turned off and helium is bled into the chamber until a gauge reading of -5 in. of mercury is reached.

6. Steps 4 and 5 are then repeated twice to assure a maximum replacement of air by helium within the capsule.

7. The vacuum pump is left on and a constant flow of helium (approximately 8 liters per minute) is maintained in the welding chamber for the rest of the operation. The gauge reading should be -5 in. of mercury.

8. The left-hand crank of the mechanism is then turned to adjust the height between the electrode and capsule (about 1/32 in.).

9. The capsule is now ready for welding. The operator controls the arc with the welding machine foot controller switch and the capsule is rotated under the electrode via the right-hand crank.

10. Upon completion of the weld, and there are no visible imperfections in it, the capsule is inserted into a vacuum chamber connected to a helium-sensitive leak detector for final leak testing.

CONCLUDING REMARKS

Operating History. This apparatus has been in use since June 1961 and we have not experienced a failure to date. It has been used to package both radioactive and nonradioactive capsules containing many different materials for reactor irradiation.

Operating Skill Required. Once the proper welding machine settings are made, there is relatively little skill required on the operator's part. He should become reasonably proficient after welding perhaps 6 to 10 capsules.

REFERENCE

(1) P. W. Howe et al., "The Water-Shielded Cave Facility for Totally Enclosed Master-Slave Operations at Lawrence Radiation Laboratory," Lawrence Radiation Laboratory Report UCRL-9657 (October, 1961).

FIGURE LEGENDS

Fig. 1. Typical welded capsule.

Fig. 2. Capsule-welding mechanism.

Fig. 1

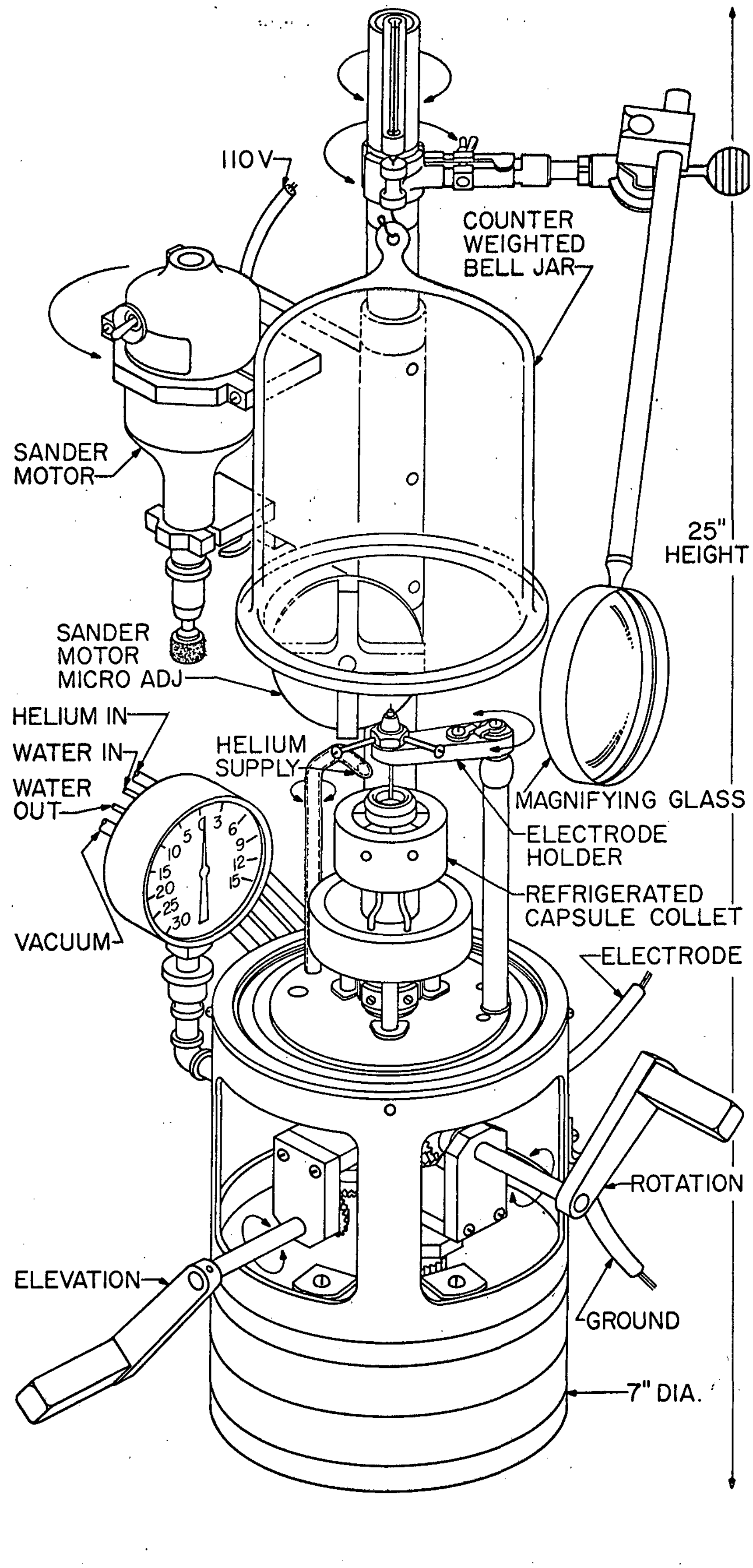
110V
COUNTER WEIGHTED BELL JAR
SANDER MOTOR
25" HEIGHT
SANDER MOTOR MICRO ADJ
HELIUM IN
WATER IN
WATER OUT
HELIUM SUPPLY
MAGNIFYING GLASS
ELECTRODE HOLDER
REFRIGERATED CAPSULE COLLET
VACUUM
ELECTRODE
ROTATION
ELEVATION
GROUND
7" DIA.

Fig. 2