OAK RIDGE NATIONAL LABORATORY
operated by
UNION CARBIDE CORPORATION
for the
U. S. ATOMIC ENERGY COMMISSION

ORNL - TM - 548

A REMOTELY OPERATED MEASURING DEVICE

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Metals and Ceramics Division

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ABSTRACT

In order to detect dimensional changes due to irradiation, a rather simple device has been developed to accurately measure irradiated specimens of various sizes and shapes. It consists merely of a motor-activated dial indicator assembly with a standardized control box for remote operation within the hot cell. The detailed design of this portable and versatile equipment is presented along with available operating experience. Potential applications are discussed.

A remotely operated device to measure a variety of shapes and thicknesses was designed and tested for hot-cell use by the Postirradiation Examination (PIE) Group, Metals and Ceramics Division. The purpose of this report is to present the design and construction of the device in sufficient detail so that other experimenters may easily duplicate the unit without additional design effort. The report covers both the in-cell measuring mechanism and the out-of-cell motor control box. Since a certain amount of unique jigging or fixturing is required for each specific measuring operation, these items are not included in this report. The measuring head described can be used with a large number of such fixtures.

Figure 1 is a cutaway sketch of the remote measuring head. A dial indicator and Bodine motor are mounted on an aluminum block drilled with two 3/4-in.-diam mounting holes and corresponding threaded holes for locking handles. Two such holes are provided to permit either horizontal or vertical mounting of the measuring head on a supporting rod. The unit is enclosed in a 6 × 6 × 6 in.-metal "Budd" box to provide protection to the measuring head during in-cell handling. The box also

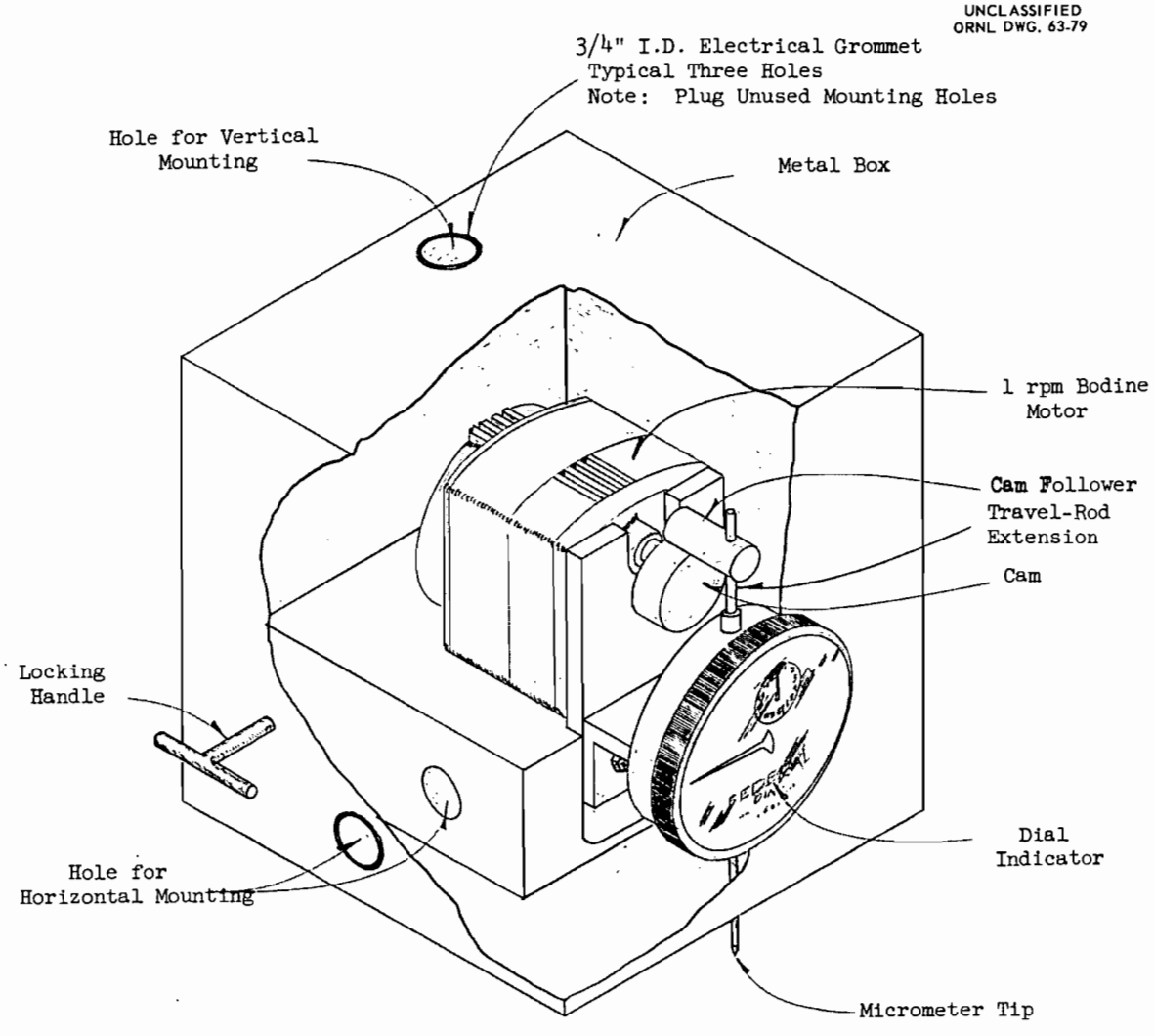


Fig. 1. Measuring Head Assembly.

acts as a barrier to dust and dirt to protect the measuring head and to reduce decontamination difficulties when maintenance is required.

A 3 1/2-in.-diam dial indicator calibrated to 0.0001 in. with a range of 0.4000 in. (Federal Products Corporation Model E3BS-2) was modified and used as the nucleus of the measuring device. A dial indicator was chosen because it is relatively inexpensive, sufficiently accurate for a large majority of hot-cell measurements, and easily read through the hot-cell windows. The use of a dial indicator for in-cell measurement is not a unique application, but in developing the design, certain basic limitations of the dial indicator were recognized. For example, care must be taken not to damage the measuring tip or the internal bearings by dragging the tip over a piece or moving the piece while in contact with the tip. To eliminate this, a simple cam operation was included to raise and lower the measuring tip and thus provide clearance for piece movement. The travel rod of the dial indicator to which the tip is fastened was extended out the top to accommodate the cam follower. The cam is 1 1/4 in. in diameter and provides 3/8 of an inch travel when rotated. Figure 2 shows the various fabricated components used in this device. It includes sufficient details so that a machinist can fabricate the travel rod extension, cam, cam follower, and all of the parts for the basic mounting block. A 1-rpm Bodine motor was chosen to provide power to rotate the cam.

Figure 3 shows a completed assembly, including the measuring head mounted on a vertical support rod over a simple Vee block with the control box alongside. Figure 4 shows a similar unit installed in a hot cell for measuring the external diameters of irradiated molten-salt reactor experimental capsules.

The remote unit can be positioned, horizontally or vertically, at different distances from a fixed reference, to measure a variety of diameters and thicknesses. If the piece to be measured is out of dial indicator's range (0.4000 in.), the measuring head must be calibrated by using an object of known diameter or thickness close to the size of the unit to be measured.

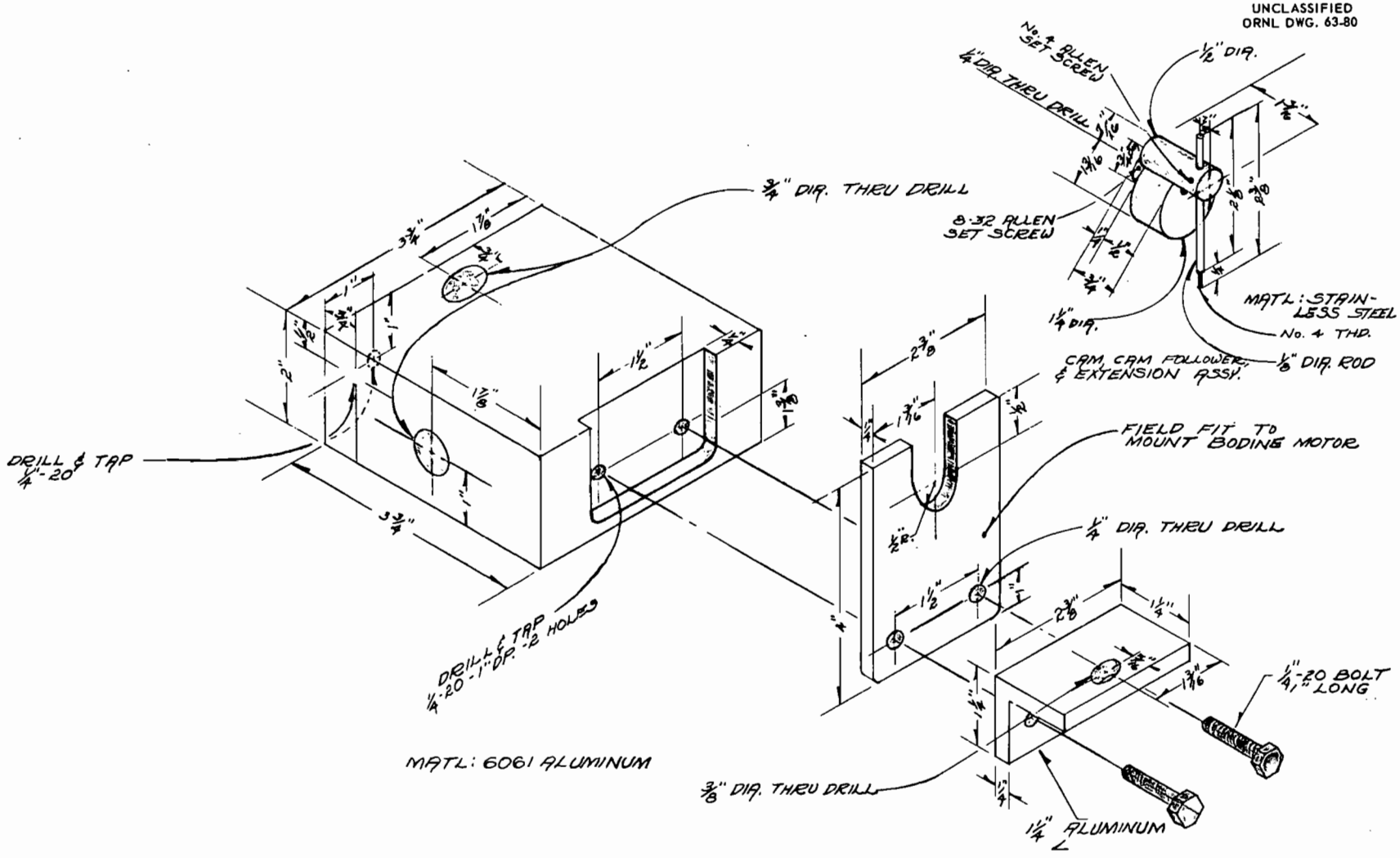


Fig. 2. Fabricated Component Design Details.

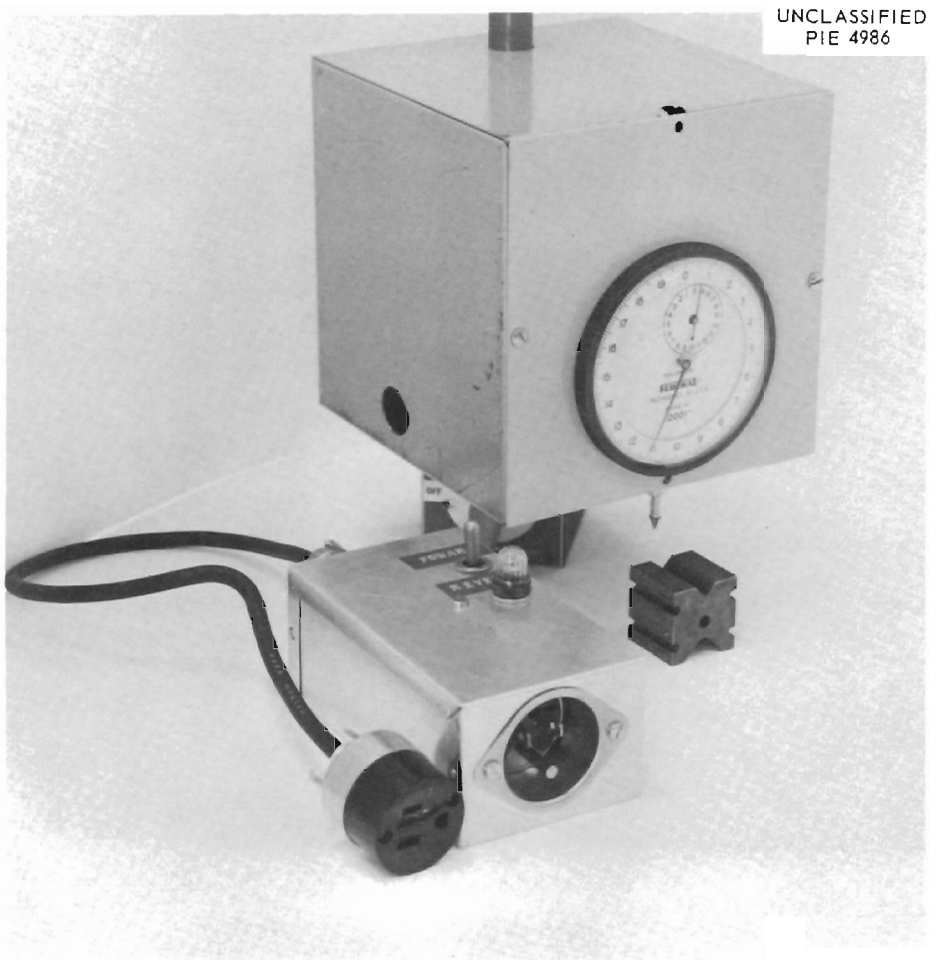


Fig. 3. Completed Measuring Head and Motor Control Box.

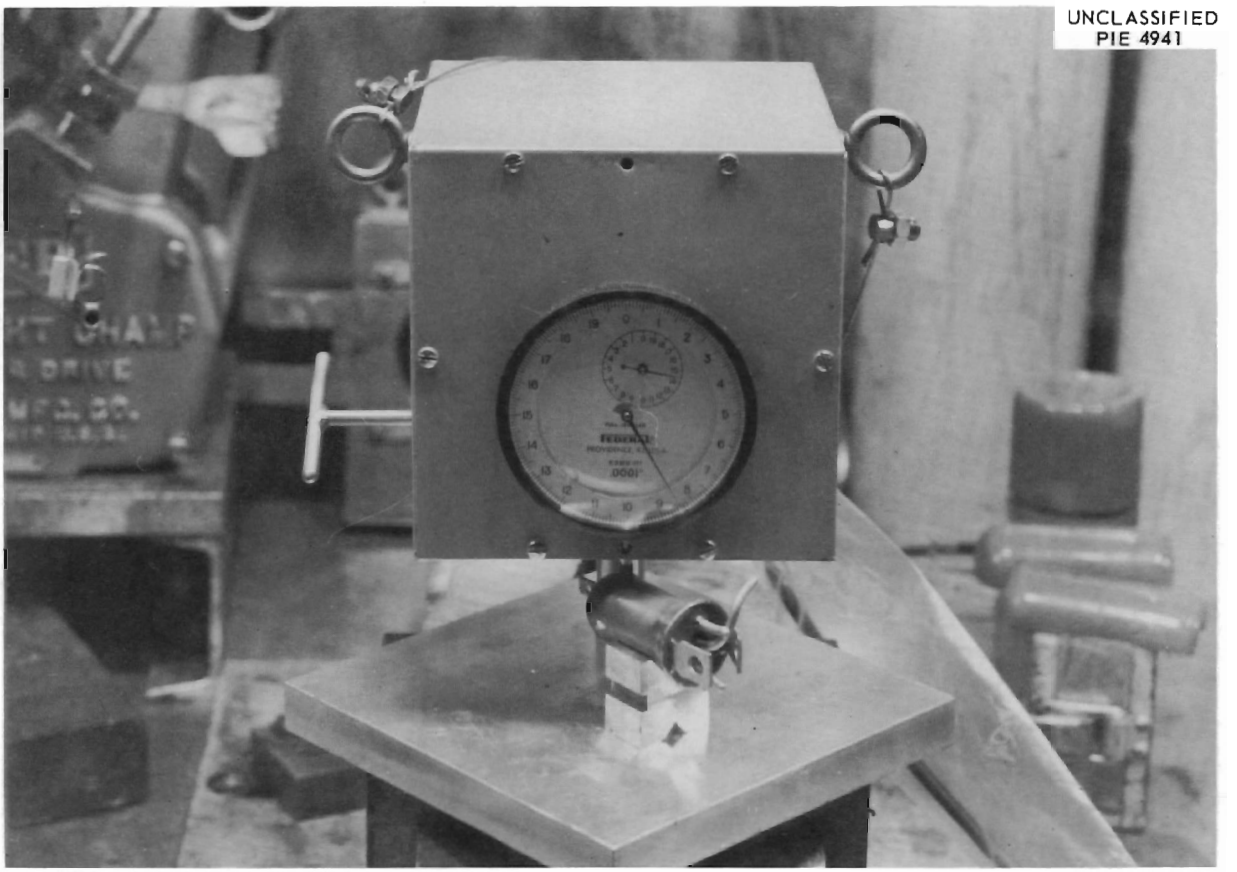


Fig. 4. Measuring Head in Cell — Being Used for Diameter Measurements on Irradiated Molten-Salt Reactor Experimental Capsule.

Where external diameters are being measured within the range of travel of the indicator and a 90-deg Vee block is used as a positioning fixture, a common calibration piece can be used with the following formula to provide accurate measurements:

$$D_V = D_S + K(B-A)$$

where

D_V = the diameter of the piece being measured,
D_S = the diameter of the standard,
K = 0.8285 (a conversion constant developed from the geometrical analysis of the 90-deg Vee block support),
B = the maximum dial indicator reading obtained with the piece being measured, and
A = the maximum dial indicator reading obtained with the standard.

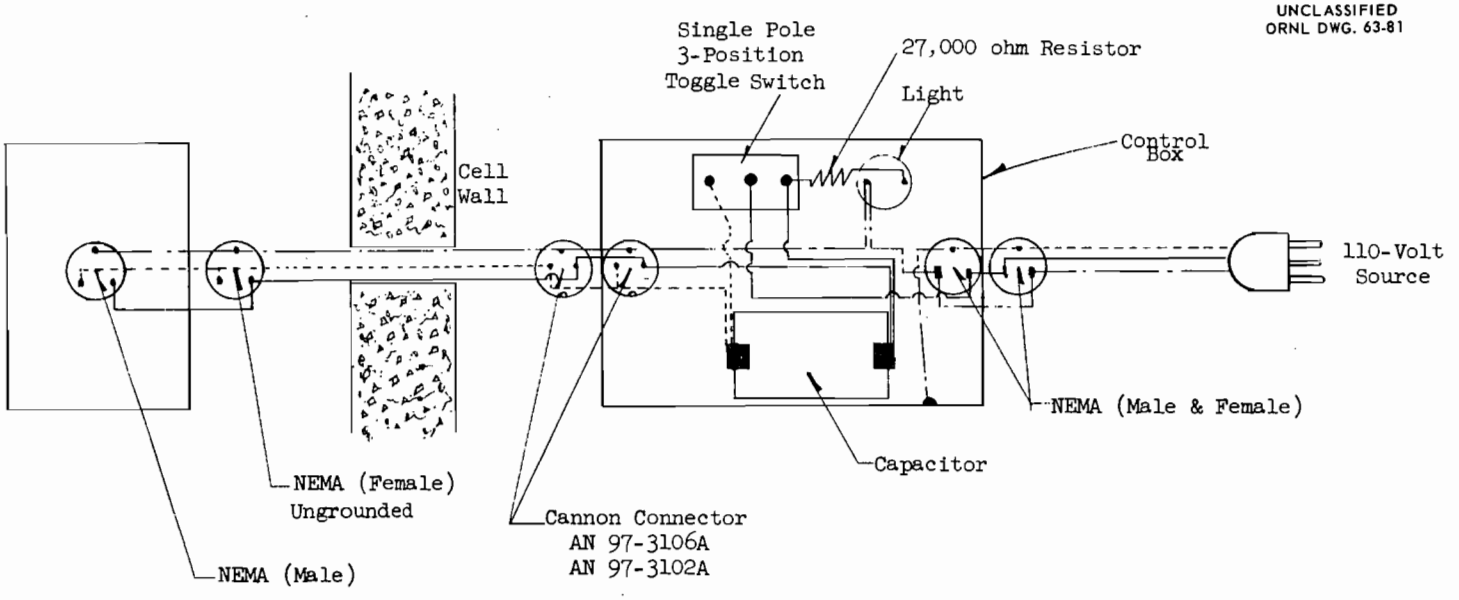
Note: The sign of the quantity (B–A) must be carefully preserved and K(B–A) subtracted from D_S for pieces smaller in diameter than the standard and added for pieces larger in diameter.

Other measurements on odd-shaped objects, such as curved fuel plate thickness measurements, where a common reference point is difficult to arrange, can best be made by the use of two such measuring heads. The heads are positioned so that the measuring tips move along a common axis and the cam drives are synchronized. The null point reading on both dials is read simultaneously, the two values are added together, and then the calibration readings are subtracted to provide an accurate point separation reading or thickness value. This technique has proven exceptionally useful in determining minimum thickness in badly pitted specimens. This arrangement has the added advantage of permitting the use of a relatively simple holding fixture, particularly where a number of measurements are to be made on a single item. The item is moved by the manipulators from spot to spot when the tips have been retracted by the cams.

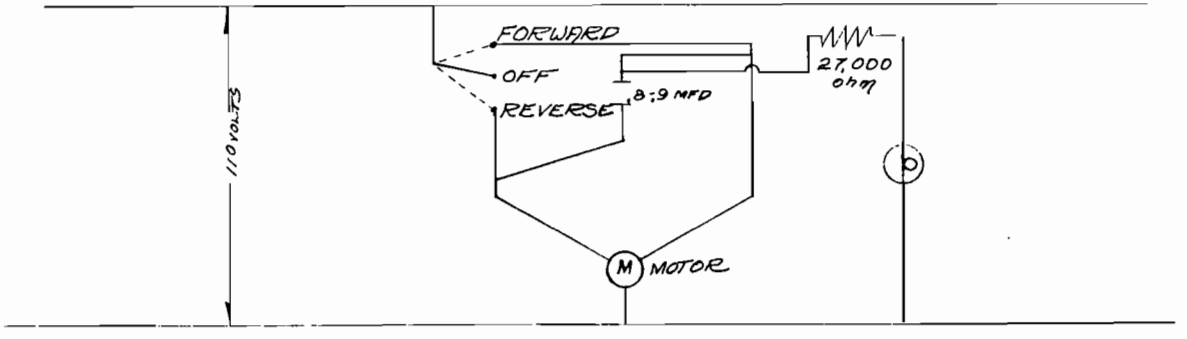
In the PIE hot cells various applications have been found for the small, reversible, fractional horsepower Bodine motors. Because of the

number of these applications, a standardized control box and wiring arrangement has been established. With this standardization, a single control box can be used to operate several such motors on different devices, thus greatly reducing the number of electrical wires penetrating the cell walls and the number of wires cluttering up the working cell surface. A single control cable can be quickly transferred from one remote device to another. Figure 5 is an electrical, schematic, and complete wiring diagram for the standardized system. All of the components are normally stock items in an electrical maintenance shop. Figure 6 is a graphical representation of a typical control box assembly and wiring arrangement. The moter on the remote measuring head is controlled by one of these units.

In summary, a simple measuring device has been designed, fabricated, and tested in remote operations. It can be used with a large variety of jigs and fixtures specifically designed for the piece to be measured. The unit is portable and versatile. It has been successfully used to obtain reliable dial indicator measurements during hot-cell examination of a variety of irradiated hardware.

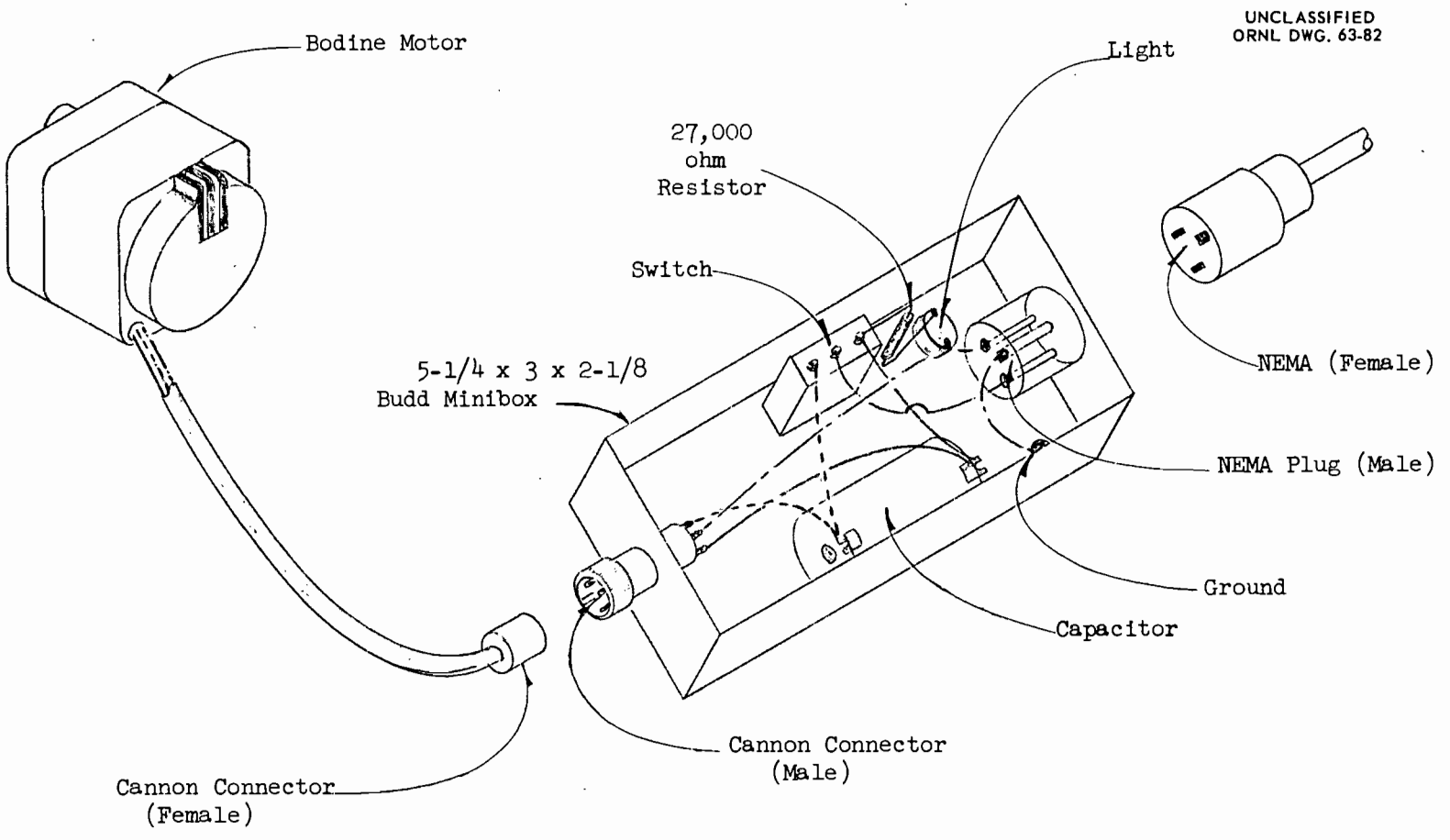


Wiring Diagram of Bodine Motor Hookup



Electrical Schematic

Fig. 5. Wiring Layout for Reversible Bodine Motors.



Key

Common - ——— -

Forward - - - - -

Reverse ———

Wiring Layout for Reversible Bodines

Fig. 6. Graphical Representation of Typical Control Box Assembly, Showing Component Arrangement and Interconnecting Wiring.

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