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THE CHEMICAL TECHNOLOGY DIVISION, 10,000 CURIE COBALT-60 SOURCE DESCRIPTION, OPERATING PROCEDURES, AND SAFETY PROCEDURES

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ABSTRACT

A description is given of the 10,000-curie cobalt-60 source operated by the Chemical Technology Division. Operating procedures, hazards, and safety procedures and equipment are described. Administrative control, supplemented by radiation monitor alarms, is used to minimize the probability of the maximum credible accident, which is exposure of personnel to gamma radiation at a level of the order of 10 r/sec.

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1.0 INTRODUCTION

The purpose of this memo is to describe the Chemical Technology Division's cobalt-60 source, its method of operation, its associated safety features, and the responsibilities of those using the source. This radiation source contains about 10,000 curies of Co-60 and has a radiation level of about 10^7 r/hr at its center. Since exposure to such a high radiation level for a few minutes even at several feet distance could cause death, it is important that users of the source understand its construction and correct operation.

2.0 DESCRIPTION OF THE SOURCE

The 10,000-curie cobalt-60 source is located in basement room BG-71 of Building 4501. Its pertinent features are shown in Fig. 1, which is a copy of a 30 x 40 in. colored drawing placed in the source room for quick reference by users of the source. Briefly, the assembly consists of a source capsule, item 1, which is stored in the movable shield, item 6, when not in use or which is lowered into one of the cavities, item 11, for irradiation of samples. When in use the source capsule is normally contained within the centering device, item 2, in which case samples of less than 1 in. dia, item 4, can be placed in the inner cylinder of item 2 for irradiation at the highest dose rates. If larger samples are to be irradiated, these must be placed outside the enclosing cylinders of the centering device as indicated by item 3. In special cases, and if approved by the person to whom the source is assigned, the centering device may be removed to permit irradiation of samples of unusual shapes.

The source capsule is raised and lowered by use of the positioning control, item 10. When it is in the raised position, the plug locking screw, item 12, is normally screwed into place as an additional safety measure.

3.0 METHOD OF OPERATION

Operation of this source is very easy and very simple. Anyone having any difficulty in raising or lowering the source should contact the source assignee immediately (W. Davis, Jr., phone 6-1296). Generally, the movable shield, item 6, is moved over the cavity that will not be used in an experiment. This operation uncovers the other cavity, item 11, in which samples are placed. If it is necessary to connect the samples to external equipment, the appropriate conductors—wire, tubing, etc.—are pushed through curved holes in the stationary shield, item 5. There are four such holes into the east cavity (left cavity of Fig. 1) and two into the west cavity as well as a larger hole, normally plugged with lead, between the two cavities. The four access holes into the east cavity and the two into the west cavity are between 1/4 and 3/8 in. dia. A larger access slot, item 16,

is available at the west cavity. This slot is normally filled with a two-section plug, the lower section being about 1 in. wide and 5 in. high; the upper is shown as item 15. If large equipment leads are needed, this lower section of the slot is available. When it is used, the standard lower section of lead plug must be replaced by a cloth bag of lead shot, which will fill the volume not occupied by the equipment leads.

If cooling water is needed to prevent the gamma radiation heating the sample to 50-100°C, the west cavity (the right one in Fig. 1) will normally be used in the experiment. The necessary copper tubing inlet and exit lines occupy one of the two access holes.

After the samples have been positioned, for example, as item 3 or 4, and appropriate conductors to external apparatus passed through the access holes, the movable shield is moved over the sample-containing cavity by use of the dolly drive, item 8. A stop on the southern dolly track, item 9—upper track in Fig. 1—permits the user to roll the dolly to the only position from which the source capsule can subsequently be lowered. After rolling the dolly into position, the plug locking screw, item 12, is unscrewed and withdrawn about 3 in. The capsule, item 1, may then be lowered into the space between the two cylinders that constitute the central section of the centering device, item 2.

When an irradiation has been completed, the capsule is raised, the plug-locking screw is rescrewed into the movable shield, and the latter may then be rolled away from the sample-containing cavity.

4.0 ATMOSPHERIC AND SAMPLE CONTROL

The source capsule, item 1, Fig. 1 is constructed of titanium, the quill, item 13 (see also Fig. 2), of stainless steel, and the centering device, item 2, of stainless steel and Mohr's metal. To ensure that these components will not be deleteriously, and perhaps dangerously, corroded, solutions that will evolve corrosive gases (HNO_3, HCl, Cl_2, etc.) must not be placed in an open container in a cavity, but must be enclosed in a vapor-tight container having an off-gas, and possibly purge gas, line leading through the stationary shield to an appropriate scrub system. This same type of procedure applies to samples that will evolve hydrogen or other noncorrosive, but potentially dangerous, gases except that an air purge of the cavity during irradiation may be accepted as sufficient control of such hazard. This air purge is obtained by flowing plant air or appropriate tank gas into the cavity through rubber tubing that passes through one of the curved holes in the stationary shield. The air or other gases will leak out of the cavity through the horizontal area between the stationary and movable shields. Any radioactive solutions irradiated in the source must be in a closed, vented container that is contained within a secondary metal

vessel, such as a stainless steel beaker, that could hold all the contents of the primary container if the latter should break.

5.0 HAZARDS AND SAFETY FEATURES

5.1 Hazards

The hazards associated with the use of the 10,000-curie cobalt-60 source are all derived from the possibility of personnel exposure. Such exposure could occur if some of the individual cobalt pellets dropped out of the source capsule, thereby falling into a cavity, and the movable shield was then rolled away from the cavity. The same hazard, on a larger scale, would exist if the source capsule fell into the cavity and was then uncovered by the movable shield being moved from above the cavity. Personnel exposure could also occur to a lesser, but still hazardous, degree if the movable shield was located over the west cavity (right cavity of Fig. 1) and the source capsule was then lowered while the curved plug, item 15, and the shield for access slot 16 were not in place.

The radiation from the source originates from 121 nickel-plated cobalt metal pellets, each about 1 cm dia and 1 cm high and having a specific activity of cobalt-60 in the range 6-16 curies/g. Eleven of these pellets are stacked in each of the eleven cylindrical holes* in the titanium source capsule, Fig. 2. Containment of the pellets is achieved by a screw plug in the bottom of each cylindrical hole. Each plug is secured to the capsule by soft solder through intermediate electroless nickel-electro silver plates, Fig. 2. Hence, individual pellets could drop out only if the plug was completely corroded or if all the solder was corroded or dissolved. It is very probable that any atmosphere that could cause such corrosion would first cause breakup of the whole source capsule.

The possibility of the whole source falling off the holding quill, item 13 of Fig. 1, into a cavity and then being uncovered is the most likely maximum credible accident. It is credible since the capsule once did fall from the quill; however, the capsule was not uncovered. A number of steps, including redesign of the safety shaft within the quill and the placing of automatic radiation monitors in the room, have been taken to reduce the probability of occurrence of the maximum credible accident.

5.2 Design and Operational Safety

The 12 in. of lead of the stationary and movable shields, items 5 and 6 of Fig. 1, maintain the background radiation level well below working tolerance. For example, the radiation level immediately around the stationary shield is $\leq$0.2 mr/hr when the capsule is properly located within the movable shield; the maximum level under this condition is 18 mr/hr along the line of contact of

*The slot in the capsule, Fig. 2, occupies a position equivalent to a twelfth hole.

the movable shield with the top of the stationary shield. Similarly low levels occur when the capsule is lowered into a cavity. Since the shielding is known to be adequate if the capsule is fixed at the end of the quill, item 13, Fig. 1, the only significant question from a safety design standpoint is the adequacy of the method of fastening capsule and quill together. This question arises from the fact that if the capsule becomes detached from the quill and falls into a cavity and if the movable shield is then rolled over the other cavity, the capsule would be unshielded at the top. The quill and safety cable, Fig. 2, are the two components designed to minimize the possibility of detachment of capsule from quill.

The quill, Fig. 2 and item 13 of Fig. 1, is a 1/2-in.-o.d. tube that screws into the top plate of the source capsule; the safety cable consists of 1/8-in.-o.d. stainless steel wire rope that terminates at one end in a 1/2-in.-dia x 1/2-in.-high cylinder, to which it is welded, on the under side of the source capsule top plate and which is anchored at the top of the quill by split bolt connectors, Fig. 2. This safety cable-cylinder combination, which was tested with 500 lb pull for 5 min, is designed to reduce the possibility of the quill and capsule becoming unscrewed and to prevent the capsule falling into a cavity if quill and capsule do come unscrewed. It is most important that users, other than the source assignee, never under any conditions touch any of the adjustments of the quill or safety cable.

5.3 Radiation Monitors and Alarms

Two types of radiation detector are contained in the source room: (1) continuously indicating, automatic alarm monitors, Fig. 3, which are checked for operation by a member of Health Physics Division on a weekly schedule; and (2) standard radiation measuring instruments that require manual setting or use. The first group has three purposes: (1) stating that the source capsule is properly attached to the quill; (2) warning that the source capsule has fallen into a cavity and giving this warning before the radiation level has increased to a dangerous value; and (3) giving a rapid warning if the curved plug, item 15, or the plug for access slot 16 are not in place when the capsule is lowered into the west cavity, the right cavity of Fig. 1. The warning will be given by both alarms in this event.

Automatic Alarm Monitors. There are two radiation alarm monitors in room BG-71, Fig. 3, one on the west wall and one on the east wall. These positions were chosen so that there would be an unobstructed path between a cavity, into which the source capsule might have fallen, and its monitor. On the west wall, Fig. 3, there is a Nuclear Measurements Company gamma alarm, Model GA-2, that uses a Geiger-Mueller tube for detection. This instrument contains an internal source so it never reads zero if it is operating. At the date of this memo this instrument reads 2.7 mr/hr of which about 2.5 mr/hr is due to the internal source and 0.2 mr/hr to the cobalt-60. This instrument is set to show its own failure with a red light if its reading drops to 1 mr/hr; it is set to alarm by bell if the radiation level at its location reaches 30 mr/hr. On the east wall, Fig. 3, is a

Radiation Counter Laboratories, Inc., Remote Monitron, Model Q-1154, that uses an ionization chamber for detection. It is also set to alarm by bell if the radiation level at its location reaches 30 mr/hr.

As stated above, these automatic alarms have a dual purpose, the first of which is stating that the capsule is properly located at the end of the quill. This statement is given by the alarm bell every time the capsule is raised or lowered. Each automatic alarm rings a bell when the radiation level reaches 30 mr/hr; when the lower half of the source capsule is located in the plane of near-contact of movable and stationary shields, Fig. 1, the radiation level rises to 75 mr/hr at the monitor. Thus, if the movable shield is located over the east cavity, then every time the capsule is raised or lowered the west monitor will momentarily see 75 mr/hr. This will cause the west bell to ring; the east bell will not ring since the movable shield is between the beam of radiation and the east monitor. Note that if the positioning control is raised or lowered without the accompanying bell plainly ringing, then the capsule certainly was not moved or the alarm is not working properly.* In either case, the source should not again be touched until the source assignee (W. Davis, Jr.) has returned the unit and monitors to proper working conditions. If the movable shield is located over the west cavity, then every time the capsule is raised or lowered the east monitor bell will ring momentarily.*

If a user of the source failed to note that he had not heard a bell (these bells are very loud) when he raised the source capsule and if he now started to uncover a cavity without recognizing that the capsule had fallen into the cavity, then the monitors fulfull their second purpose as follows: With the capsule in the east cavity, if the movable shield is moved 2 in. toward the west, then the east monitor will ring continuously. This alarm occurs before the radiation has reached a dangerous level and continues until the movable shield has been moved back over the cavity into which the capsule has fallen, the east cavity in this example.

Standard Radiation Detectors. Required standard radiation detectors, including those stored in BG-71, are pocket dosimeters, "Pocket Screamers," and "Cutie Pies."

5.4 Proof of Containment of Cobalt-60

All surfaces of both cavities, item 11 of Fig. 1, have been thoroughly washed and have a wipe test activity of less than 10 cpm/cavity. The continued containment of the cobalt within the capsule will be checked by a member of the Health Physics Division by weekly wipe tests. This test will also show whether radioactive materials have accidentally been spilled in a cavity.

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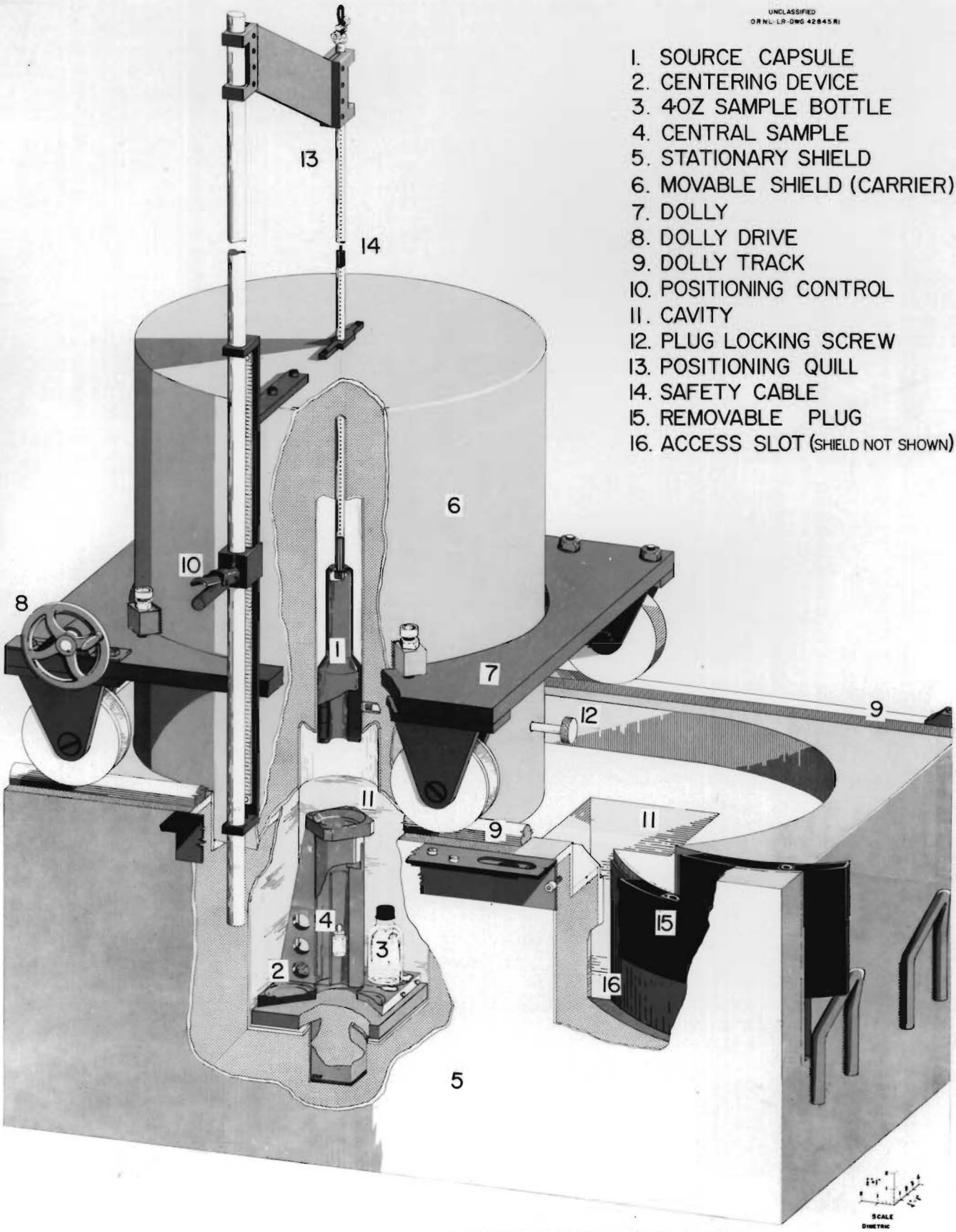
*In all cases the capsule should be raised and lowered slowly to avoid unnecessarily jarring it. Slow movement is particularly necessary at the west cavity since the Remote Monitron on the east wall has a slow response time.

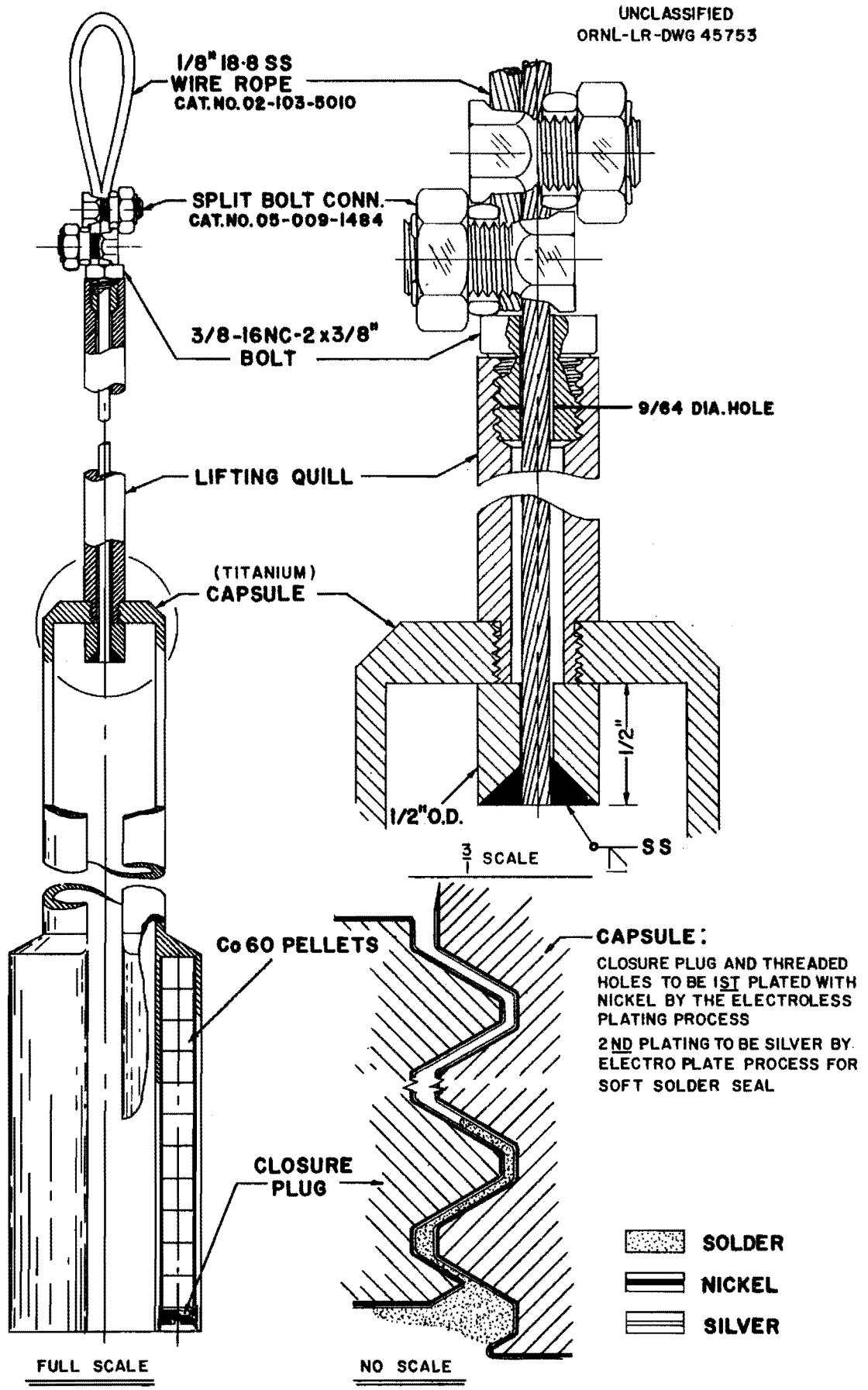
6.0 ENTRANCE TO THE SOURCE ROOM

To obtain entry to the source room requires that a person obtain a key from the assignee (W. Davis, Jr.) and then be accompanied on opening the door by a member of the Health Physics Division or by the assignee. Either of the latter will ascertain that the curved plug is properly placed in the slot to the west cavity and will check the integrity of the source with a Cutie Pie detector and of the automatic monitors before any work in the room may be started. At this same time, the source assignee or health physicist will ascertain that source users are wearing pocket dosimeters and will also place the two "Pocket Screamers" on the movable shield dolly, item 7, Fig. 1, after appropriate recharging of the latter.

When the person to whom the key to room BG-71, Bldg. 4501, was loaned has completed his experiment, he will return the key to the source assignee. If the experiment lasts for more than one day, the key must be returned to the source assignee at the end of each day unless other arrangements are made. Such other arrangements must include a room and source check by a member of the Health Physics Division or by the source assignee when the room is first opened on any day. If the room has to be left unoccupied for any reason during the course of an experiment, the door must be relocked. It will normally be sufficient that the room and monitors are checked by the source assignee or health physicist on the first entrance to the room on any day of its use.



10,000 CURIE COBALT 60 SOURCE



CAPSULE, LIFTING QUILL & SAFETY CABLE FIG. 2

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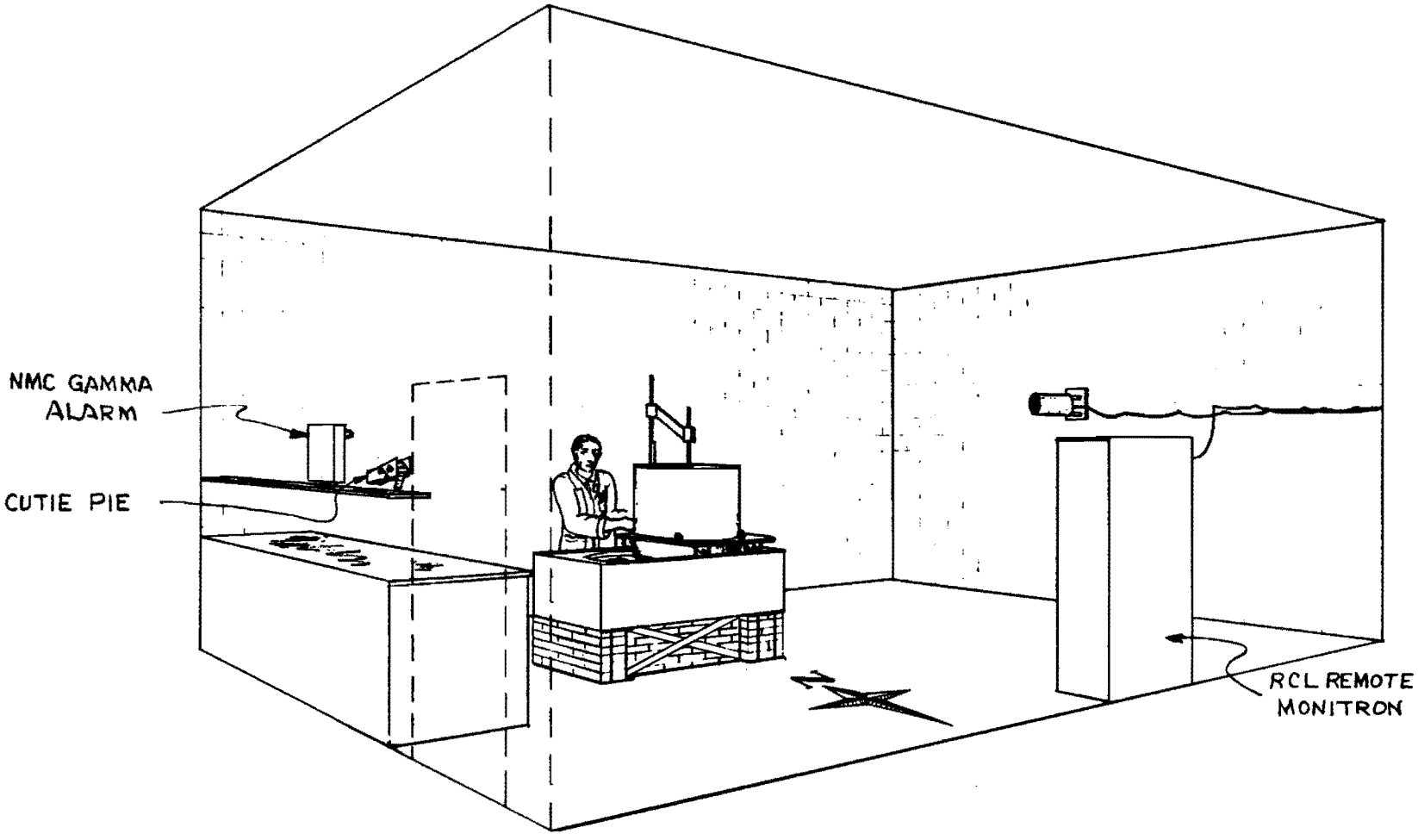

FIG. 3
PERSPECTIVE OF ROOM BG-71
10,000 CURIE Co 60 SOURCE

2/18/60
R.R. MANIGOLD

SCALE: ½" = 1'-0"
BLDG. 4501

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