

**LUDLUM MODEL 42-5  
NEUTRON BALL CART**

**February 2023  
Serial Number PR149512  
and Succeeding Serial Numbers**

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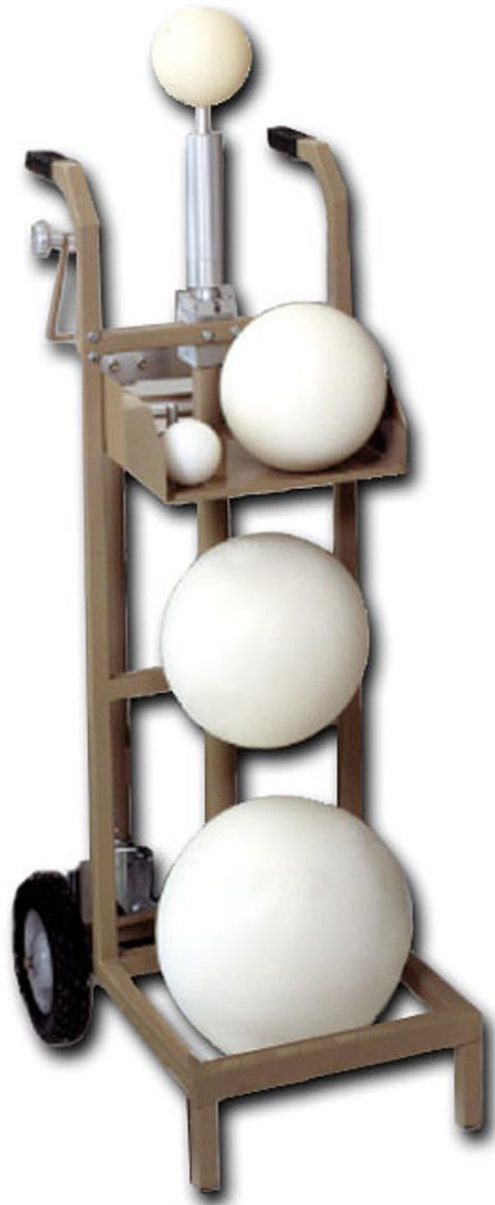


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## 1. GENERAL

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The Model 42-5 Neutron Detector consists of a  $^6\text{LiI}$  crystal coupled to a photomultiplier tube. The unit is designed so that the center of the crystal will be positioned in the center of the Model 42-5 moderator spheres. The detector is mounted on the Model 42-5 ball cart and secured with set screws.

The height of the detector is adjustable to allow the sphere to be positioned correctly.

For further information, see the report, Hankins, D. E., "A Method Of Determining The Intermediate Energy Neutron Dose," IDO-16655, March 10, 1961.

## 2. SPECIFICATIONS

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**DETECTOR:** 4 mm x 4 mm  $^6\text{LiI}$  (Eu) crystal (lithium used is 96% enriched lithium), coupled to 3.8 cm (1.5 in) photomultiplier tube

**TUBE:** 1.2 cm (0.5 in.) diameter magnetically shielded photomultiplier

**MODERATORS:** high-density polyethylene spheres in the following diameters: 30.5 cm, 25.4 cm, 20.3 cm, 12.7 cm, 7.6 cm, 5.1 cm (12 in., 10 in., 8 in., 5 in., 3 in., 2 in.)

**CART:** tubular steel construction, provides a mobile storage unit for the moderators. The crank-operated elevator assembly adjusts the detector center from 112 cm (44 in.) to 185 cm (73 in.) from the floor.

**CONNECTOR:** series "C"

**SENSITIVITY:** typically 45 cpm/mrem/hr (AmBe) (with 25.4 cm [10 in.] moderator)

**GAMMA REJECTION:** 10 cpm or less through 100 mR/hr

**ENERGY RESPONSE:** continuous response from thermal to approximately 12 MeV

**COMPATIBLE INSTRUMENTS:** any instrument capable of detecting negative pulses and supplying high voltage of up to 1500 volts and a discrimination threshold of approximately 10 mV

**OPERATING VOLTAGE:** typically 400-900 volts

**TEMPERATURE RANGE:** -20 to 50 °C (-4 to 122 °F); may be certified to operate from -40 to 65 °C (-40 to 150 °F)

**SIZE:** 119 x 45.7 x 58.3 cm (44 x 18 x 23 in.) lowered (H x W x L); 185 cm (73 in.) in length fully extended

**WEIGHT:** 27.2 kg (60 lb), not including moderators

### 3. OPERATING PROCEDURES

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Before using the instrument, verify that the instrument has been calibrated according to Section 4.

#### CAUTION!

**DO NOT move the cart with a moderator sphere mounted on the detector. The moderator could fall off causing damage and/or injury.**

Step 1> Move cart into the location that will be surveyed.

Step 2> Mount the detector into the top of the adjustable rod between the handles of the ball cart. Attach cable to instrument.

Step 3> Remove the desired moderator from its storage position and set on top of the detector.

Step 4> Turn the crank handle on the side of the cart to raise the detector into position. To lower the detector, press in on the locking lever on the lower rear of the gear box.

Step 5> Turn on the instrument and proceed to take readings.

Step 6> Varying the diameter of the spheres or using a different source will change the response of the unit. See chart in the back of this manual.

### 4. CALIBRATION

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The following calibration procedures assume the following:

- Counting instrument is Ludlum Model 2200 Scaler/Ratemeter
- <sup>241</sup>AmBe neutron source (Note that the Model 42-5 is energy dependent.)
- <sup>137</sup>Cs gamma source for gamma rejection check

#### 4.1 Operating Voltage Plateau

Connect the Model 42-5 to a Model 2200.

Set Model 2200 input sensitivity to 10 mV.

Expose the detector to a 20 mrem/hr <sup>241</sup>AmBe neutron source.

“Run a plateau” as follows: Taking one-minute counts, record the count rate for 25-volt incremental steps from 450 volts through a region in which the count rate steadily increases, becomes relatively

constant (“flattens out”), and then increases again. (A typical range will be 400-1000 volts.) The flattest portion of this region is the desired plateau. The value in the middle of this region is the assumed operating voltage of the detector, subject to the sensitivity and the gamma rejection checks.

Calculate the sensitivity (cpm/mrem/hr) for the assumed operating voltage as follows:

$$\text{Sensitivity} = \frac{\text{Count Rate}}{\text{Dose - Equivalent Rate}}$$

For example, an assumed operating voltage is 900 volts, based upon the flattest part of the plateau. The count rate at that voltage is 1311 counts per minute (cpm), and the neutron field dose-equivalent rate is 20 mrem/hr. The sensitivity is calculated as:

$$\text{Sensitivity} = \frac{1311 \text{ cpm}}{20 \text{ mrem / hr}}$$

$$= 65.55 \text{ cpm / mrem / hr}$$

This value should be approximately 60 cpm/mrem/hr.

#### 4.2 Gamma Rejection Check

With the Model 42-5 connected to the Model 2200, adjust the Model 2200 HV to the assumed operating voltage determined above.

Remove the Model 42-5 detector from the moderator and place in a 100 mR/hr <sup>137</sup>Cs gamma radiation field.

Take a one-minute count. If more than 10 counts are observed for the one-minute period, decrease the operating voltage until the count rate drops below 10 cpm; however, ensure that the HV remains in the plateau region determined above.

Ensure that sensitivity for the selected operating voltage is approximately 60 cpm/mrem/hr.

Return the Model 42-5 to the moderator.

#### 4.3 Conversion Chart

Expose detector to <sup>241</sup>AmBe neutron source at the dose-equivalent rate of 400 mrem/hr. Take a one-minute count and record value, including range/scale setting of counting instrument.

Repeat for the dose-equivalent rates shown in Table 1.

The values in Table 1 and their corresponding measured values represent a conversion chart for use in relating other measured values to actual dose-equivalent rates.

**Table 1**

<b>Ref. Point (mrem/hr)</b>	<b>Reading (cpm)</b>	<b>Range/Scale</b>
<b>400</b>		
<b>200</b>		
<b>80</b>		
<b>20</b>		
<b>8</b>		

**Model 42-5 Neutron Ball Cart**

**5. PARTS LIST**

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<b>Ref. No.</b>	<b>Description</b>	<b>Part No.</b>
<b>Model 42-5 Neutron Ball Cart</b>		
UNIT	Completely Assembled Model 42-5 Neutron ball cart	47-1505
<b>Detector Probe</b>		
1 ea.	M42-5 Detector Probe	47-1507
1 ea.	Crystal Holder Assembly	7014-002
1 ea.	Crystal – 4 mm x 4 mm	01-5131
1 ea.	Model 42-5 Crystal Spacer	7014-538
1 ea.	Model 42-5 Detector Main Body	7014-001
1 ea.	Model 42-5 End Plug	7014-003
1 ea.	Model 42-5 Connector Ring	7014-004
1 ea.	Model 42-5 Light Pipe	7014-376
6 ea.	Model 44-3, 44-2, 43-5 Sponge	7002-029-05
1 ea.	Tube/Skt Assy.	4002-510
1 ea.	0.5 inch Photomultiplier Tube	01-5349
1 in.	Wire-Teflon Wht #22 HV	21-8993
1 in.	Wire #26 Black 0 UL1429*	21-9432
1 ea.	RECPT –UG706/U “C” LMI	4478-011
1 ea.	Tube Shield	40-4006
1 ea.	Lug-1497; 707-1774	18-8776
<b>Ball Cart</b>		
*	Model 42-5 Less Detector	47-1506
1 ea.	Model 42-5 Ball Cart	47-1110
1 ea.	Model 42-5 2-inch Ball Holder	7014-004-01
1 ea.	Model 42-5 3-inch Ball Holder	7014-004-02
1 ea.	Model 42-5 5-inch Ball Holder	7014-004-03
1 ea.	Model 42-5 8-inch Ball Holder	7014-004-04
1 ea.	Model 42-5 10-inch Ball Mount	7014-017-06
1 ea.	Model 42-5 12-inch Ball Mount	7014-017-05
<b>Spheres</b>		
1 ea.	Model 42-5 2-inch Sphere	7014-009-05
1 ea.	Model 42-5 3-inch Sphere	7014-009-04
1 ea.	Model 42-5 5-inch Sphere	7014-009-03
1ea.	Model 42-5 8-inch Sphere	7014-010-01
1 ea.	Model 42-5 10-inch Sphere	7014-009-02
1 ea.	Model 42-5 12-inch Sphere	7014-009-01



**6. DRAWINGS, DIAGRAMS, CHARTS**

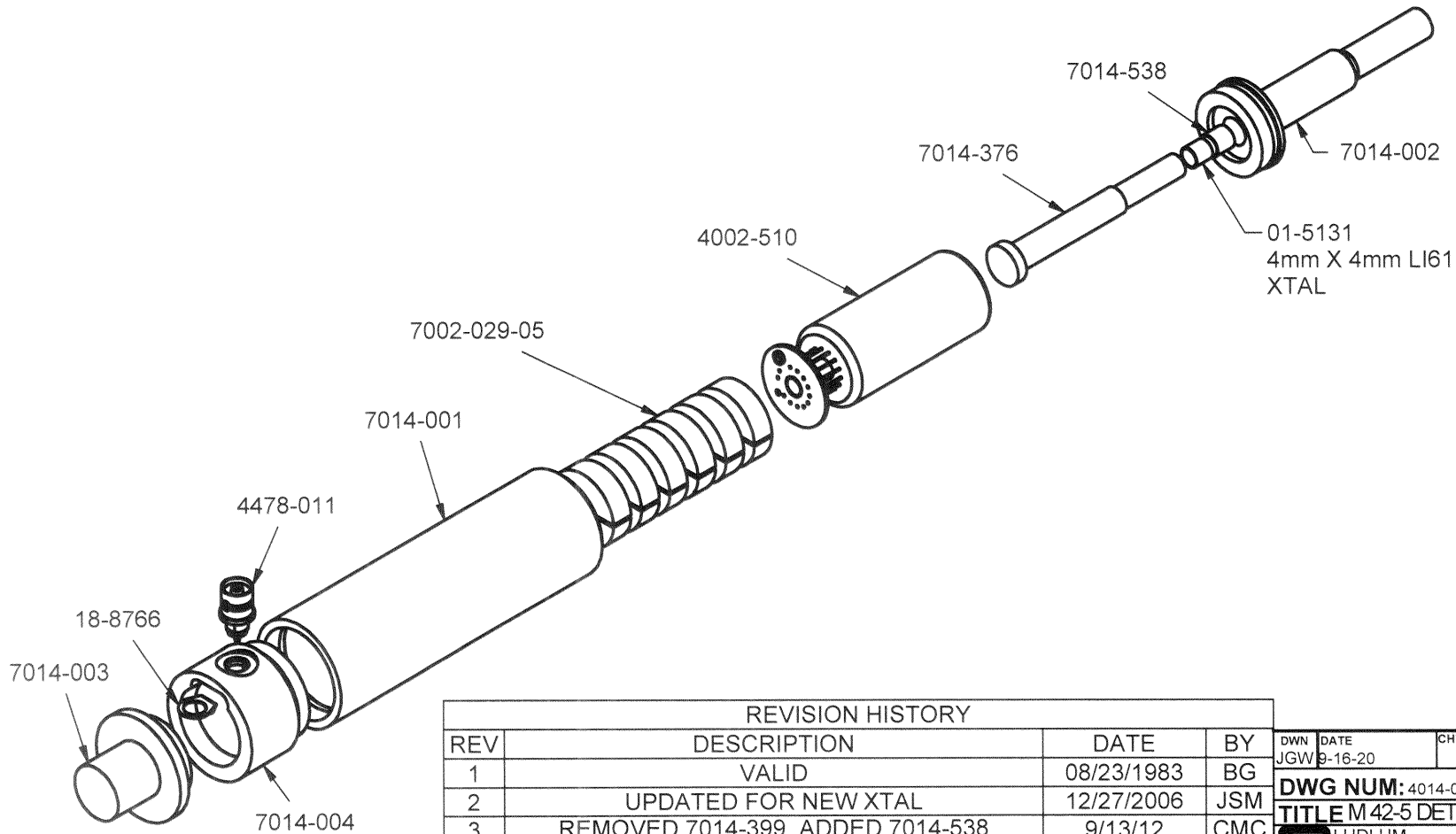
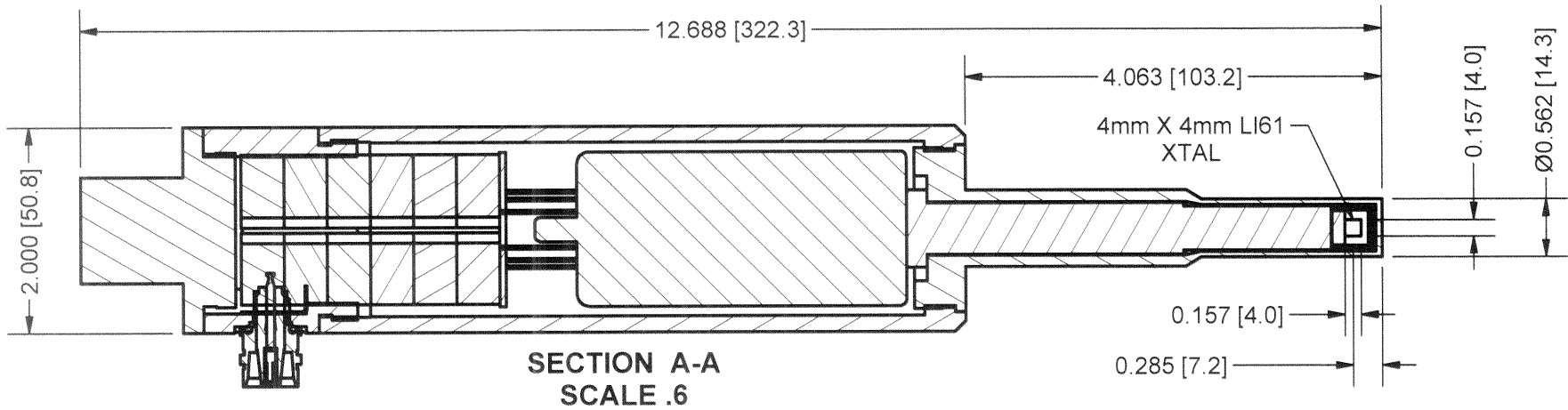
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Model 42-5 Probe Assembly, Drawing 14 x 32A

Model 42-5 12-inch Sphere and Detector, Drawing 14 x 32B

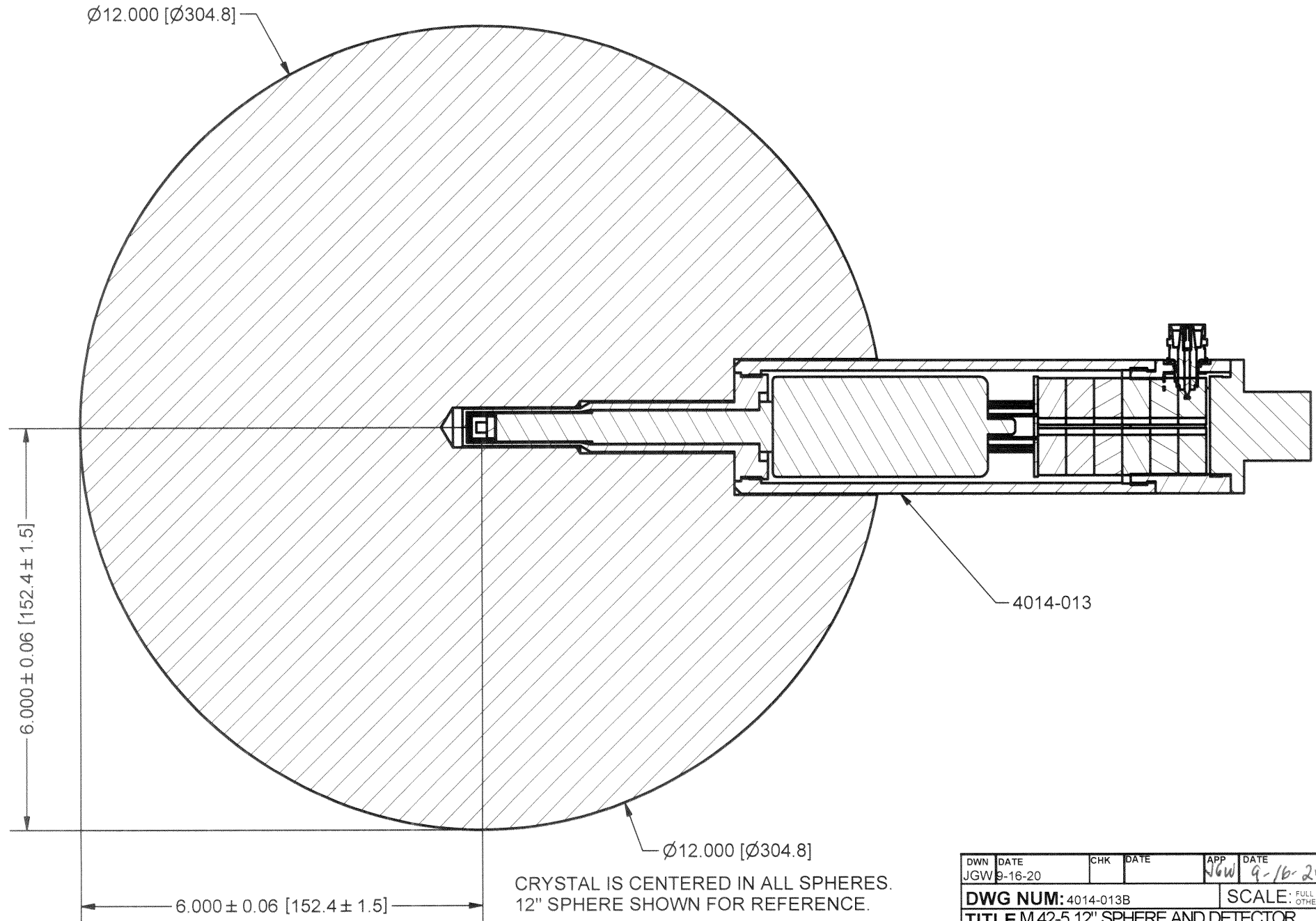
Tube Basing Diagram, Drawing 2 x 147

Relative Counting Rate vs Energy for Moderating Spheres, Chart

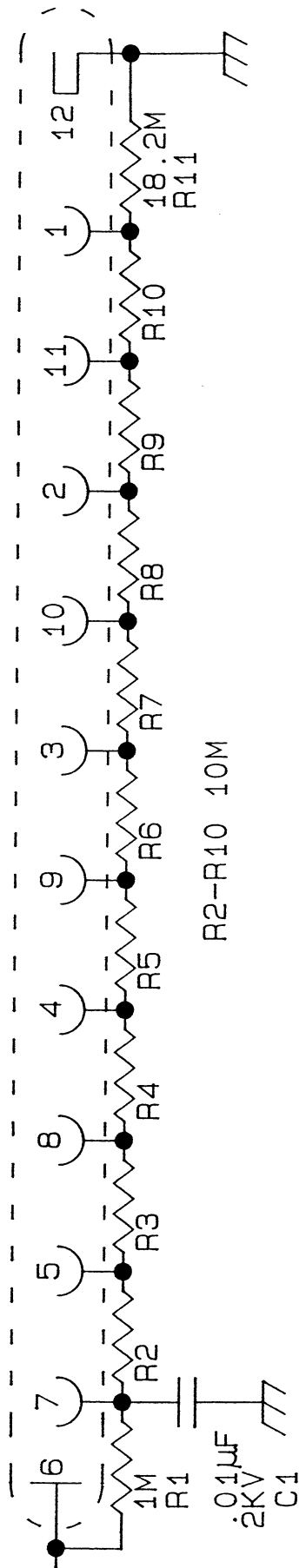


REVISION HISTORY				DWN	DATE	CHK	DATE	APP	DATE
REV	DESCRIPTION	DATE	BY	JGW	9-16-20			JGW	9-16-20
1	VALID	08/23/1983	BG	DWG NUM: 4014-013				SCALE: FULL <input type="checkbox"/> OTHER <input type="checkbox"/>	
2	UPDATED FOR NEW XTAL	12/27/2006	JSM	TITLE M 42-5 DET. PROBE ASSY.					
3	REMOVED 7014-399, ADDED 7014-538	9/13/12	CMC	LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556		SERIES 14		SHEET 32A	
4	REPLACED 2014-008 WITH 7014-002	9-15-20	CMC						

REVISION HISTORY			
REV	DESCRIPTION	DATE	BY
1	VALID	9-15-20	CMC



DWN	DATE	CHK	DATE	APP	DATE
JGW	9-16-20			JGW	9-16-20
<b>DWG NUM:</b> 4014-013B				<b>SCALE:</b> FULL <input type="checkbox"/> OTHER <input type="checkbox"/>	
<b>TITLE</b> M 42-5 12" SPHERE AND DETECTOR					
LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556		<b>SERIES</b> 14	<b>SHEET</b> 32B		



DESC: EBY SOCKET #9058 TUBE BASING	
MODEL: 44-2	
PART #: 40-4039	
DWN: PW	DATE: 7/5/89
DSGN:	DATE:

CHR NO.		DWN	CHK	APP	
DWN	DATE	CHK	DATE	APP	DATE
PW	7/5/89				
TOL: SHOP STD <input type="checkbox"/>			SCALE: FULL <input type="checkbox"/>		
OTHER			OTHER		
TITLE 40-4039 BASING DIAGRAM					
LUOLUM MEASUREMENTS, INC. 824 DAK STREET SHERMANTON, TEXAS 76066		SERIES	SHEET		
		2	147		

Relative Counting Rate vs Energy for Moderating Spheres  
(REPRODUCED FROM IDO-16655, REF. 3)

