

*Please return to college*

FOR THE DETAILED STUDY OF NEUTRON RADIATION AND EFFECTS  
IN THE CLASSROOM OR LABORATORY

*Low cost scale - \$300*



"Visiflux I" Neutron Howitzer  
Model ND-327



"Visiflux II" Neutron Howitzer  
Model ND-342

3-DIMENSIONAL WATER-MODERATED  
**"Visiflux" NEUTRON HOWITZERS**  
**ACTIVATION FOILS**  
**and NEUTRON SOURCES**

- A dynamic, new approach to teaching and experimentation with neutron sources... combining versatility and economy.
- Completely SAFE for teacher and student use.
- "Instructor-oriented" design for training in radiochemistry, nuclear engineering, neutron physics...with a comprehensive experiment manual and visual aids.

The LEADER  
in the NUCLEAR SCIENCE  
EDUCATION FIELD

**ATOMIC** *ACCESSORIES INC.*  
Subsidiary of Baird-Atomic, Inc.

811 WEST MERRICK RD., VALLEY STREAM, NEW YORK • CURTISS 5-9300

Represented Nationally by BAIRD-ATOMIC sales offices



## "VISIFLUX I"

NEUTRON HOWITZER, Model ND-327

Model ND-327 "Visiflux I" operates with a sealed neutron (or gamma) source surrounded by water in a transparent plexiglas container. Since the water is an effective moderator, it serves both as the protective shield and as a thermalizing medium for those experiments requiring thermal neutrons. A unique feature of the unit is the ease of performing experiments at any point within the moderator itself. Two horizontal exposure ports make it possible to obtain a source of fast neutrons.

For neutron activation experiments, a partial list of the radionuclides that can be produced in significant quantities includes Manganese-56, Bromine-80, Silver-108, Iodine-128, Indium-192 and Gold-198.

- **Complete Visibility**—Students actually see what they are doing and obtain a better feel for working with radioactive sources. "Visiflux" Neutron Howitzers are water-moderated units of heavy transparent plexiglas. All experimental arrangements are completely visible.
- **Greater Accessibility**—Experiments are easy to set up, change, and take down, with the highest degree of safety. Detecting probes and foils may be positioned in three dimensions. The water moderator becomes a part of the experimental apparatus.
- **Remarkable Versatility**—A much wider range of experiments can be performed than with the usual solid moderator type of howitzer. It can be used for research as well as for teaching ... for activation analysis, production of short-lived tracers for low level studies, and determination of nuclear constants for various moderators. It handles Po-Be or Pu-Be sources up to 5 curies and may also be used for gamma experiments by substituting a sealed gamma source for the neutron source.

### Additional Features

**Experiment Manual.** Contains 23 stimulating experiments on radiochemistry, nuclear engineering and neutron physics. Each includes a complete theoretical discussion, detailed procedures, pertinent questions and references. See list of experiments on page 3.

**Operating Manual.** Describes in detail the various accessories that are included with the "Visiflux I" and tells how to use them.

**Training Charts.** Fifteen visual aid charts, each 22" x 34", include illustrations and diagrams covering a great variety of important subjects in nuclear science. Chart titles are listed on page 4.

**Activation Foils.** Includes 10 silver foils and 10 indium foils, 1" in diameter, plus 10 sets of cadmium covers. See page 6 for a discussion of neutron activation foils and other foils available.

## "Visiflux I" Components

**Tank.** The basic component of the "Visiflux I" is a rugged cylindrical plexiglas tank, 24" D. x 28" high, with two horizontal beam exposure ports and a vertical central source tube. A source holder rod contains the neutron source and fits inside the vertical tube.

**Source Holder.** An adjusting ring on the source holder permits positive positioning of the source anywhere in the central tube, including the storage position. The source holder rod also provides a safe, convenient way of handling the neutron source outside the tank.

**Traverse Guide.** Serves to position the straight foil holders and detector probe. By means of this guide, a foil holder detector probe may be swung in a 360° arc, adjusted to any desired depth, and set at any horizontal distance from the center. 1 cm. index marks indicate distance from the source.

**Source Drive Motor.** Mounted on the traverse guide, this motor rotates the source holder in order to provide a uniform flux pattern from the neutron source which will ordinarily have a non-isotropic flux distribution.

**Removable Lid.** It covers the tank when the howitzer is not in use and may be locked in place.

**Inner Shelf.** This shelf is removable so that an entire experiment can be set up on the shelf outside the unit and then lowered into position. This permits a number of experiments within the moderator where there is no air gap to perturb the neutron flux in the region of the foils or detector. There is a circular groove for positioning the ring foil holder.

**Straight Foil Holders.** There are two straight foil holders, each containing 20 foil slots with centimeter spacing for obtaining flux profiles. One is for bare foils, the other for cadmium-covered foils. Bare or covered, the foils are in identical positions during irradiation.

**Ring Foil Holder.** This 12" D. holder fits into a circular groove in the inner shelf. All foils are kept the same distance from the source, permitting relative calibration of the foils.

**Beam Tubes and Fillers.** The beam tubes slide into the horizontal beam ports and contain removable plexiglas fillers of various lengths. These fillers are bright red so that it is apparent at a glance whether or not they are in position. By removing all of the fillers from a tube, a beam of fast neutrons may be obtained. The ratio of fast-to-thermal neutrons may be varied by using fillers of different lengths.

**Exterior Shelf.** Constructed of sturdy aluminum plate and mounted on the tank directly below one of the beam ports. The shelf has tracks for the ring stand which provides a neutron detector mounting at the beam port opening. The shelf is also used for experiments utilizing a neutron beam from the port.

**Heavy Duty Cart.** Made of heavy gauge steel, it supports the filled "Visiflux" and permits movement from place to place. The cart has locking brakes and a convenient storage shelf. The top of the tank is at optimum working height.

## Teacher Tested EXPERIMENT MANUAL

"Visiflux" Neutron Howitzers permit a wide range of experiments on the properties of neutrons and their interaction with matter. The manual provides the following for the teacher, with complete theory, calibration and detailed experimental procedures. The following experiments are included:

### Radiochemical Experiments

1. Spectrum of Carrier-Free Radioisotopes
2. Interaction Between Bombardment and Radioisotopes
3. Measurement of Time from Radioisotope Bombardment
4. Activation of Radioisotopes with Different Neutron Energies
5. Comparison of Count Rate vs. Distance from Source
6. Spectroscopy of Active Material and Measurement of Half-Life of Radioisotopes
7. Calibration of the Gamma Source with Radioisotopes
8. Measurement of Neutron Energy by Scintillation Counter
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There is an additional section on radiological considerations in using the "Visiflux." Appendix also suggests advanced radiochemical experiments and types of activation analysis that can be made with the "Visiflux."

*Dr. Alley*

## SPECIAL SAFETY FEATURES

Heavy 3/8" plexiglas is used. Annealed to eliminate any strains, "Visiflux I" is thoroughly tested for leakage. All beams and penetrations are overlapped with additional strips of material to form double seals. Extensive use under the most rigorous classroom conditions, for extended periods of time, has demonstrated the complete reliability and watertight integrity of the unit.

A source-handling tool is provided for transferring the neutron source. A locking rod and lock are also included for locking the cover and retaining the source in its storage position when the unit is not in use.

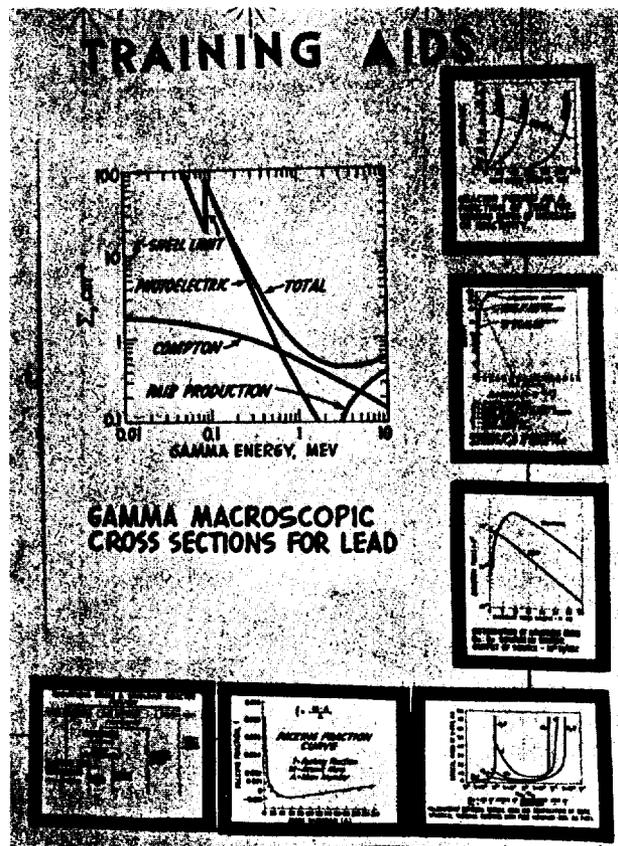
"Visiflux I" provides ample shielding for Pu-Be sources up to 5 curies. Even if the unit were empty of water, the radiation levels outside the tank would not be excessive. Typical radiation readings are shown in the table and are based upon experimental data taken along the outer surface of the tank. The values shown are for a 5-curie Pu-Be neutron source.

Type of Radiation	"Visiflux I" Filled	"Visiflux I" Empty	Max. Permissible Exposure Levels (40-Hr. Work Week)
Gamma	1.5 mr/hr	1.8 mr/hr	2.5 mr/hr
Slow Neutrons	210 n/cm <sup>2</sup> /sec.	70 n/cm <sup>2</sup> /sec.	1160 n/cm <sup>2</sup> /sec.
Fast Neutrons	25 n/cm <sup>2</sup> /sec.	525 n/cm <sup>2</sup> /sec.	55 n/cm <sup>2</sup> /sec.
Stay Time (Next to Tank)	Greater Than 40 hr/wk	4.2 hr/wk	40 hr/wk

## TRAINING AID CHARTS

The 22" x 34" visual aids include graphical representations and diagrams covering the following important subjects in nuclear science and engineering:

- Fission Neutron Energy Spectrum (linear and log plots).
- Radiations from a Nuclear Reactor.
- Thermal Flux Distribution in Fuel Rod.
- Approximate Thermal Neutron Flux Distributions in Bare and Reflected Reactors.
- Packing Fraction Curve.
- Reflector Savings for Infinite Slab Reactor.
- Xenon Poisoning After Shutdown.
- Relationship between Critical Mass and Composition of Bare, Spherical Thermal Reactors with Pure U-235 as Fuel.
- Reactor Period as a Function of Time for Various Rates of Increase of Reactivity.
- Build-up of a 4-minute Activity in a Reactor.
- Distribution of Neutrons from a Ra-Be Source in Water.
- Gamma Microscopic Cross Sections for lead.
- Fission Yield Curve.
- Typical Beta-ray Absorption Curve in Aluminum with a Gamma-ray Component.
- Potential Energy Well of Nucleus.



Model ND-327 "Visiflux I" Neutron Howitzer includes:

- |                           |                                 |
|---------------------------|---------------------------------|
| Plexiglas Tank            | 1" Indium Foils (10)            |
| Source Holder             | 1" Silver Foils (10)            |
| Beam Tubes (2)            | 1 1/4" Cadmium Foil Covers (10) |
| Beam Tube Fillers (7)     | Foil Forceps                    |
| Exterior Shelf            | Removable Lid                   |
| Ring Stand                | Heavy-Duty Cart                 |
| Inner Shelf               | Experiment Manual               |
| Traverse Guide            | Operating Manual                |
| Source Drive Motor        | Training Aid Charts (15)        |
| Straight Foil Holders (2) | Lock                            |
| Ring Foil Holder          | Source Handling Tool            |

## PRICES

Model	Description	Price*
ND-327	"Visiflux I" Complete	\$1,375.00
<b>Accessories</b>		
117A	Gamma Source (1 mc of Cs-137)	135.00
502	1" D. Natural Uranium Foils (Box of 10)	65.00
520	1" D. Gold Foils (Box of 10)	55.00

\*FOB Valley Stream, N. Y., freight allowed and prepaid.

Shipping Weight: 125 lbs. (without water)

# "VISIFLUX II"

NEUTRON HOWITZER, Model ND-342

- Slightly smaller than "Visiflux I", yet retains most of its capabilities.
- Ideal for schools with limited budgets.
- Handles Pu-Be sources up to 5 curies safely.
- Comprehensive "teacher-tested" experiment manual (see page 3).

## Specifications

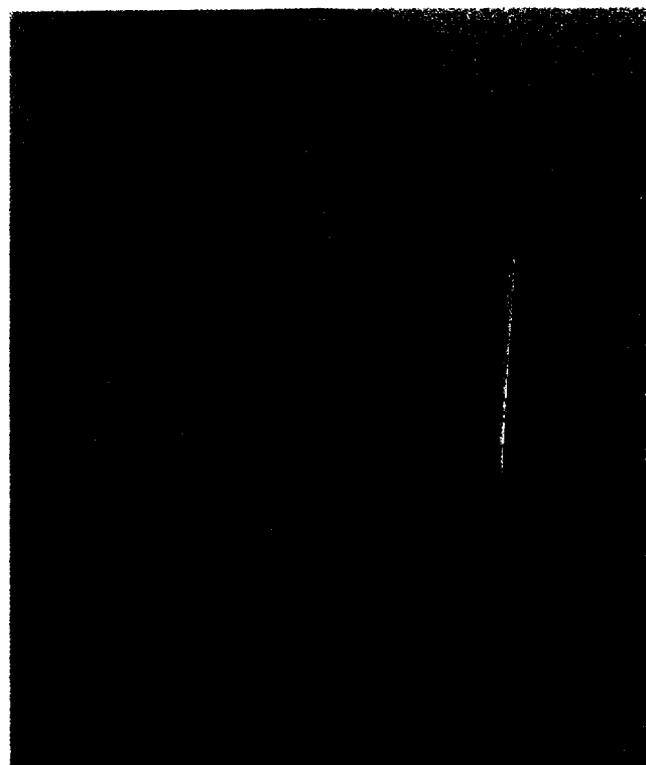
**Tank.** Rugged, plexiglas, 18" D. x 24" high. Vertical central source tube is held by two sets of horizontal braces, the upper set of which also serves as a shelf for the foil holders.

**Source Holder—Beam Tube.** The vertical source holder holds the Pu-Be source which is stored in the tank by locking the holder in position. The source holder is also a safe, convenient way of handling the neutron source outside the tank. Removable red plexiglas fillers can be positioned in the holder directly above the source. By removing these fillers from the tube, a beam of fast neutrons may be obtained. The ratio of fast-to-thermal neutrons may be varied by using fillers of different lengths.

**Foil Holders.** There are two holders, each containing 10 foil slots with centimeter-spacing for obtaining flux traverses. One Foil Holder holds bare foils, the other holds cadmium-covered foils.

**Activation Foils.** Ten 1" D. Indium foils, 10 sets of cadmium covers, and a pair of foil forceps. The foils are accurately weighed to 0.0001 gram, with the weight and foil type marked on the foil or its aluminum backing.

**Shipping Weight:** 75 lbs. (without water).



## PRICES

Model	Description	Price*
ND-342	"Visiflux II" complete with tank, source holder, beam tube fillers, 2 foil holders, 1" D. Indium foils (10), 1 1/4" Cadmium foil covers (10 sets), foil forceps, removable lid, lock, experiment manual.	\$675.00

## Accessories

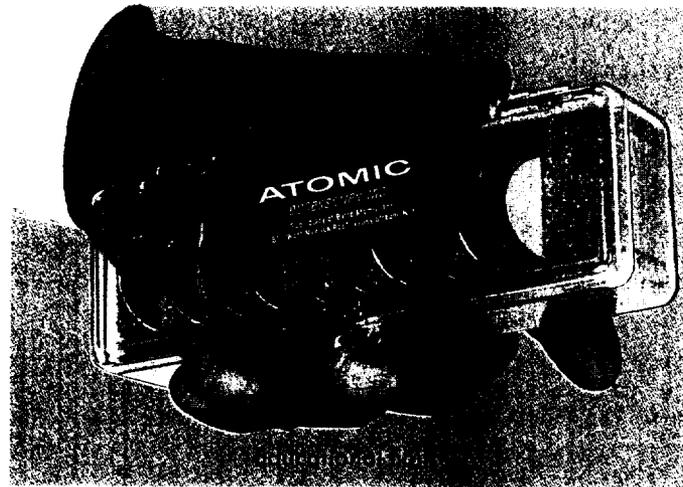
117A	Gamma Source (1 mc of Cs-137)	135.00
502	1" D. Natural Uranium Foils (10)	65.00
510	1" D. Silver Foils (10)	30.00
520	1" D. Gold Foils (10)	55.00
118	15 Training Charts (22"x34")	35.00
R-211	Source Handling Tool	15.00
119	Heavy-Duty Cart	65.00

\*FOB Valley Stream, N. Y., freight allowed and prepaid.

## Safety Features

"Visiflux II" offers the same high degree of safety as "Visiflux I" and ample shielding for Pu-Be sources up to 5 curies. Typical radiation readings (representing values at the outer surface of the tank) are shown.

Type of Radiation	Pu-Be Source Strength					Max. Permissible Exposure Levels (40-Hr. Work Week)
	1c	2c	3c	4c	5c	
Gamma (mr/hr)	0.76	1.52	2.28	3.04	3.8	2.5 mr/hr
Slow Neutrons (n/cm <sup>2</sup> sec.)	184	368	552	736	920	1160 n/cm <sup>2</sup> sec.
Fast Neutrons (n/cm <sup>2</sup> sec.)	16	32	48	64	80	55 n/cm <sup>2</sup> sec.
Stay Time (hours/week) Next to tank	40	40	40	33	26	40 hr/wk



## ACTIVATION FOILS

- For education and/or research.
- Manufactured under strictest quality control using ultra-high purity materials.
- Available individually or in kit form.

Activation foils are probably the most widely used type of neutron detector. They provide an extremely reliable and convenient method of obtaining neutron flux levels and spectra. The educational foils have many applications for training purposes, while the research foils are used extensively in industrial, government and university research laboratories. Though made under strict quality control with the finest of materials, they are reasonably priced.

## EDUCATIONAL FOILS

Educational foils are used in sub-critical assemblies, neutron howitzers, critical assemblies, training reactors, and particle accelerators. Their weight (to within 0.0001 grams) and foil type are marked on the foil backing. They come in two standard diameters: one inch and one-half inch. In general, one inch foils are used in low neutron fluxes such as those from neutron howitzers and sub-critical assemblies, while the one-half inch type is used in the higher fluxes obtained with reactors and accelerators.

The foils are packaged in transparent plastic boxes which may be used for storage. The experiment manual contains material on thermal, intermediate, and fast neutron flux measurement; counting techniques and corrections; cadmium ratio, difference, and fraction; resonance activation; self-absorption techniques; experiments, data sheets and extensive references.

In addition to supplying individual foils, we offer complete foil kits for training purposes:

### Model 1500A FOIL KIT

Quantity	Material	Diameter	Thickness
12 each	Silver	1"	0.005"
12 each	Gold	1"	0.002"
12 each	Indium	1"	0.010"
12 each	Uranium (natural)	1"	0.006"
24 each	Cadmium Covers	1 1/4"	0.020"
1 each	Foil forceps		
1 each	Experiment manual		

### Model 1501A FOIL KIT

Same as Model 1500A except that the diameter is 1/2 inch.

## EDUCATIONAL FOIL KITS

Model	Contents of Foil Kit	Price
1500A	1" dia. foils: Ag, Au, In, U (nat), Cd cover sets	\$240.00
1501A	Same as Model 1500A except 1/2" dia. foils	175.00
1502A	Includes all items in Kits 1500A and 1501A	375.00
1503A	Plexiglas foil holders (36" long) for kits	65.00

## EDUCATIONAL FOILS Available Separately

Model	Material	Thickness	Diameter	Purity	Price per Box of 10
500	In	0.010"	1"	99.95%	40.00
502	U (Natural)	0.006"	1"	99.94%	65.00
510	Ag	0.005"	1"	99.97%	30.00
520	Au	0.002"	1"	99.99%	55.00
530	Cd Cover Sets	0.020"	1 1/4"	99.9+%	20.00

2  
80  
60

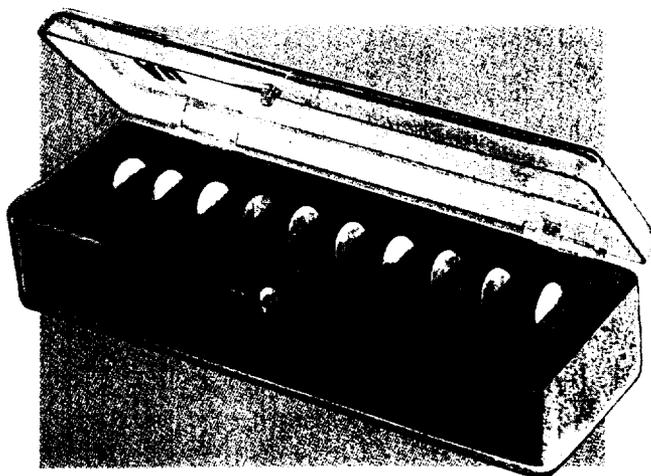
## RESEARCH FOILS

- Extremely reliable and convenient to use.
- The only practical method for obtaining measurements such as specific neutron energies in an operating reactor.
- Cover a very wide range of flux levels.
- No interference from gamma or other radiation.
- Measurements can be made at one's convenience after the irradiation is complete. No need to operate detection equipment during irradiation.

Our high-purity foils are used extensively in nuclear reactors, particle accelerators, critical assemblies, and in nuclear research... as thermal neutron detectors, resonance detectors, threshold detectors [(n, p), (n, 2n), (n, a), (n, fission)]... for obtaining data on neutron spectra and flux profiles... for neutron flux monitoring... and many other applications.

All foils are weighed to within 0.0001 grams. In some cases, they are mounted on 0.007" high-purity aluminum backing for purposes of identification. If desired, they can be furnished without backing.

The instruction manual contains the following material: counting techniques and corrections; thermal neutron flux measurement; cadmium ratio, difference, and fraction; resonance activation; self-absorption techniques; threshold detectors;



corrections for cadmium resonance absorption, flux depression, higher resonances, foil thickness, and temperature; data sheets on foils; extensive references.

**Also Available:** Diameters other than those listed above. High-purity materials including B-10, 1% As-Al, Ti, 1% Co-Al, Te, Sc, Bi, Ta, Pb, Nb, rare earths, and others. Flux Wires including Ni, Au, Co, 0.5% Co-Al, 0.1% Au-Al, 10% Dy-Al, 80% Mn-Cu; Cd. Details on request.

## RESEARCH ACTIVATION FOILS

Model	Material*	Diameter	Thickness	Type of Measurement	Price Per Box of 10
501	In	1/2"	0.010"	Thermal, Resonance, Threshold	\$35.00
503	U (natural)	1/2"	0.006"	Threshold	50.00
504	U (depleted)	1/4"	0.020"	Threshold	45.00
505	Al	1/2"	0.030"	Thermal, Resonance, Threshold	25.00
505A	Al	1/2"	0.007"	Thermal, Resonance, Threshold	25.00
506	Co	1/2"	0.004"	Thermal, Resonance	55.00
507	5% Dy-Al	1/2"	0.005"	Thermal	55.00
508	3.8% Lu-Al	1/2"	0.005"	Thermal, Resonance	115.00
509	Cu	1/2"	0.005"	Thermal, Resonance, Threshold	37.50
511	Ag	1/2"	0.005"	Thermal, Resonance, Threshold	27.50
512	Th	1/2"	0.010"	Resonance, Threshold	50.00
513	Ni	1/2"	0.005"	Threshold	35.00
514	Mg	1/2"	0.005"	Threshold	30.00
515	Fe	1/2"	0.005"	Thermal, Threshold	30.00
516	80% Mn-20% Cu	1/2"	0.003"	Thermal, Resonance, Threshold	35.00
517	V	1/2"	0.003"	Thermal, Resonance, Threshold	45.00
521	Au	1/2"	0.002"	Thermal, Resonance	40.00
522	S	1/2"	0.375"	Threshold	25.00
526	W	1/2"	0.005"	Thermal, Threshold	40.00
527	Mo	1/2"	0.003"	Thermal, Threshold	30.00
531	Cd Cover Sets	.63"	0.020"	Thermal Cutoff	20.00
533	1% Co-Al	1/2"	0.005"	Thermal, Resonance	35.00

\*Purity: Approximately 99.9% for all materials.

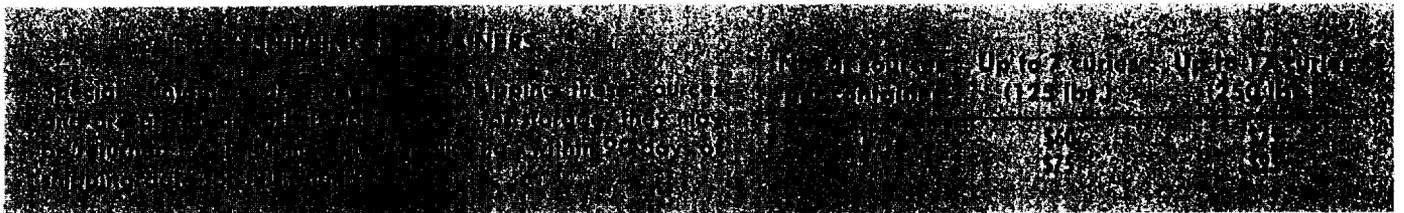
# NUMEC® Pu-Be NEUTRON SOURCES

The long half-life of Pu-239 (24,400 years) permits sources of essentially constant neutron emission, about  $1.8 \times 10^6$  nps per curie (16 grams of Pu). Made by the world's largest processor of plutonium. For further details on sources and the procuring of licenses (as well as education grants), please contact your local Baird-Atomic office shown below.

Model	Curie Strength	Approximate Yield (nps)	Grams of Pu	Diameter of Cylinder*	Length of Cylinder*	PRICE (less container)**
I. Sources whose length includes 0.250" cap and 10/32 tapped hole:						
NUMEC-A	1	$1.8 \times 10^6$	16	1.020"	1.445"	\$665
NUMEC-B	2	$3.6 \times 10^6$	32	1.020"	2.190"	\$765
NUMEC-M	3	$5.4 \times 10^6$	48	1.020"	2.935"	\$865
NUMEC-P	5	$9.0 \times 10^6$	80	1.020"	4.425"	\$1065
NUMEC-K	10	$1.8 \times 10^7$	160	1.550"	3.390"	\$1550

\* All standard dimensions are  $\pm .002$  inches.

Other curie strengths and cylinder sizes are also available. Details on request.



## PILE OSCILLATOR

### Model PO-301

Model PO-301 Pile Oscillator is designed for reactor study wherein the reactor is treated essentially as a "neutron amplifier" with phase and gain characteristics analogous to those of electronic amplifiers. The reactivity can be varied sinusoidally over a wide frequency range. The resulting changes in phase and gain make it possible to determine the transfer function, which in turn can be used to obtain many important reactor parameters.

The system consists basically of a series of specially-shaped cadmium absorbers mounted on a rotating aluminum drive

shaft. This assembly rotates within an aluminum housing such that the absorbers are alternately exposed and shuttered. The shaft is rotated by a drive unit consisting of an electric motor, variable speed hydraulic transmission, and removable speed reduction gear boxes. A continuous sine wave potentiometer, coupled to the drive shaft, permits the recording of the input coincidentally with the output.

Model PO-301 can be operated over a range of .002 to 120 cycles per second...the actual range will depend to some extent on the design requirements of the reactor. The Pile Oscillator has been operated with shafts up to thirty-five feet in length.

Complete details available on request.

## ATOMIC accessories inc.

Subsidiary of Baird-Atomic, Inc.

811 WEST MERRICK RD., VALLEY STREAM, NEW YORK • CURTISS 5-9300

Representatives of NUMEC® Pu-Be Neutron Sources and Pile Oscillators are available through the following Baird-Atomic sales offices in:

BOSTON	1100 Beacon St., Boston, Mass.	BU 4-7420	ATLANTA	3122 West Drive N.E., Atlanta, Ga.	CA 5-2200
NEW YORK	811 West Merrick Rd., Valley Stream, N.Y.	CU 5-9300	CHICAGO	2512 Primrose Ave., Chicago, Ill.	HI 5-0475
PHILADELPHIA	615 Locust St., Philadelphia, Pa.	WA 7-4276	DETROIT	26155 Minton, Livonia, Mich.	DA 7-7189
CINCINNATI	4818 Glenway Ave., Cincinnati, Ohio	BR 1-3981	DALLAS	4635 Yale Blvd., Dallas, Texas	EM 5-3607
WASHINGTON, D. C.	4829 Calhoun Ave., Bethesda, Md.	OL 6-1200	LOS ANGELES	2312 W. Redondo Beach Blvd., Gardena, Calif.	FA 1-4466
RALEIGH	406 N. Hargett St., Raleigh, N.C.	TE 4-5414	SAN FRANCISCO	1486 Bayshore Blvd., San Francisco 24, Calif.	DE 4-0515
CANADA		35 Wellington Way, Ottawa, Ontario			PA 2-7954