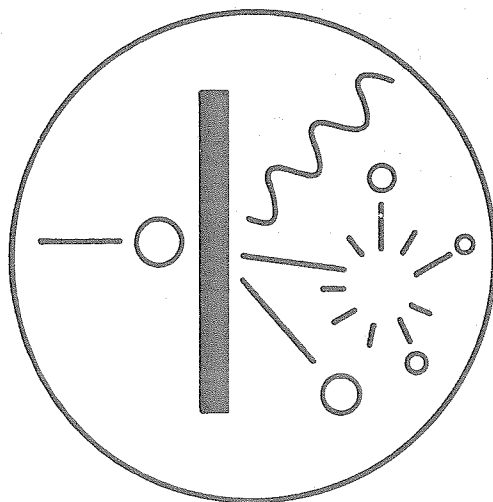
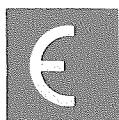


**INTERNATIONAL NUCLEAR
TARGET DEVELOPMENT SOCIETY**

NEWSLETTER



JUNE 1982



Dear colleagues,

I just received the enclosed letter from E.H. Kobisk announcing his retirement from ORNL and his resignation as President of the INTDS.

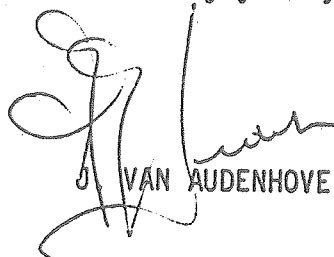
We all know how much he has contributed to our society particularly as the person who, in 1961, already took initiatives to stimulate cooperation between world wide target makers and users.

We are also aware of the high standards of work performed under his leadership by his division in ORNL. They did exceptional development work in practically the entire target field and their scientific communications are a standing guideline for all of us.

The departure of Ed Kobisk will be a great loss for the INTDS, not only from the scientific and managerial point of view but also from the human point of view. We all appreciated him as a "good friend" during the many years of collaboration.

On your behalf I have wished him and his family much success and happiness in the future.

Sincerely yours,



J. VAN AUDENHOVE

Enclosure

INTDS NEWSLETTER

JUNE 1982

This Newsletter is an informal method of information exchange between the members of the International Nuclear Target Development society.

If sufficient contributions are received the Newsletter is published twice a year.

The following items are of interest :

1. Description of recent work of the Society members.
2. Requests for advice on, for example :
 - making specific targets
 - obtaining specific material
(e.a. enriched isotopes)

Our thanks are due to the Direction of the Central Bureau for Nuclear Measurements for their support in producing the Newsletter.

Editor :

Jan Van Audenhove
Central Bureau for Nuclear Measurements
B - 2440 GEEL (BELGIUM)

K.O. Zell

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Sn targets on Bi backings were made. To improve the bad heat conductance of Bi this was connected with a copper backing. The targets were made in the following way: Sn 2.5 mg/cm^2 was rolled together with Bi 75 mg/cm^2 to 2 mg/cm^2 Sn and 50 mg/cm^2 Bi. In 1 mg/cm^2 was evaporated on Cu 20 mg/cm^2 as a glue and finally the Cu+In was rolled with slight pressure on the Bi+Sn.

Other rolled targets were: Sm 0.3 mg/cm^2 , Nd 0.3 mg/cm^2 , Er 12 mg/cm^2 , La 2 mg/cm^2 , Tl 5 mg/cm^2 , and Pr 0.16 mg/cm^2 . In the case of Pr this is the average thickness. It had many holes and looked more like a net. All targets were rolled between polished steel plates $5 \times 5 \text{ cm}^2$, 1 mm thick, and welded at their corners. They were moved through the mill only in one direction and used until they had double their original length.

The following targets were made by evaporation:
A sandwich C $5 \mu\text{g/cm}^2$ + Te 0.5 mg/cm^2 + C $5 \mu\text{g/cm}^2$, both C layers were made by ethylen cracking, Nd $150 \mu\text{g/cm}^2$ on C $10 \mu\text{g/cm}^2$ CsCl 2 mg/cm^2 on Bi 0.5 mg/cm^2 , Er 5 mg/cm^2 which was prepared from Er_2O_3 . It was reduced with Th and in the same process evaporated on 50 mg/cm^2 Ta which was later removed by 40% HF and 65% HNO_3 . As most of our materials are precious enriched isotopes and homogeneity is not important for us we evaporate from Ta and W tubes of 1 cm length and 3 mm inner diameter. The wall thickness is 0.5 mm. The thickness in mg/cm^2 of the target is then about the weight of the material (mg) x 0.6 divided by the square of the distance (cm). Typical distances are 1-8 cm. The tube is heated either by electron bombardment in a set up like that of Westgaard and Bjornholm¹ for temperatures higher than 1000°C or by resistance heating.

¹L. Westgaard, S. Bjornholm: Nucl. Instr. Meth. 42 (1966) 77

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Nuclear Target Making and Development

The Physics Division has a facility which produces very thin targets for experiments at the tandem-linac and dynamitron accelerators, for experiments of other members of the Division, any other division at the Laboratory needing this service and occasionally for other laboratories and universities.

This year at the facility we produced targets varying in thickness from a monolayer to several mg/cm^2 . The different elements, isotopes or compounds evaporated, rolled, anodized or oxidized included, Al, Au, Al_2O_3 , $^{10,11,\text{nat.}}\text{B}$, Bi, BaCl_2 , Be, C, $^{63,\text{normal}}\text{Cu}$, CaF_2 , $^{40,\text{nat.}}\text{Ca}$, $^{58,\text{nat.}}\text{Fe}$, $^{6,7,\text{nat.}}\text{LiF}$, MgO, $^{24,\text{nat.}}\text{Mg}$, MgF_2 , $^{95,100}\text{Mo}$, Ni + Au, $^{58,\text{nat.}}\text{Ni}$, $^{15}\text{NH}_4\text{NO}_3$, NaCl, ^{93}Nb , $^{208,\text{nat.}}\text{Pb}$, $^{112,116,118,120,122,124}\text{Sn}$, Si, $^{126,130}\text{Te}$, Ta, WO_3 , $^{90,92,94}\text{Zr}$. Standards were produced from $^{10,11}\text{B}$ and Ni consisting of 2.5, 5, 25, 50 and 100 monolayers deposited on $50 \mu\text{g cm}^{-2}$ of Al.

Targets which are made for experiments at the heavy-ion facility are now often much more complex and time consuming to produce. They may be multilayer targets or isotopes $\sim 1 \text{ mg cm}^{-2}$ evaporated onto very tautly stretched 1 mg cm^{-2} Au. New techniques have been developed for making various other types of targets. Also we are actively involved in producing longer-lived carbon stripper foils for the accelerator.

Our third evaporation system has been completed and is now in routine use and performs quite well, giving us a much more flexible facility. Plans for the future include the conversion of one evaporation system for use in making actinide targets. The fabrication of the multitarget evaporation system is also in the future. One objective is to continually improve target quality.

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Recent activities at Liverpool include.

Targets by Rolling

Uranium and Thorium - 10 mg/cm^2

Targets by electroplating

Platinum 198 (Self Supporting)

Tin 118 on 2 mg/cm^2 Au. (Plunger target)

Targets by Evaporation (Resistance Heated)

Lead 208 (Self Supporting) $500 \text{ } \mu\text{g/cm}^2$

Thallium 205 (on carbon) " "

Bismuth (Self Supporting) " "

Samarium 149 on Gold (Plunger target)

Chromium 50 on Gold 1 mg/cm^2

The preparation of a special target for
induced and spontaneous fission studies

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Experiments were carried out at CBNM (1) to intercompare the ^{241}Pu neutron induced and ^{242}Pu spontaneous fission characteristics, and more especially the energy and mass distributions of the fission products and their correlations. Therefore, a uniformly mixed ^{241}Pu - ^{242}Pu deposit of 30 to 50 $\mu\text{g}/\text{cm}^2$ is required.

In practice however, the preparation of such a mixed target poses important cross-contamination problems to the target maker as in general the facilities used are reserved for single nuclides with a well defined enrichment, and the set-up of a special facility would cause high investment costs for a single use.

Therefore, a combined target was conceived as schematically presented in figure 1. It consists of two individual nearly identical targets, which have been positioned the one onto the other (plutonium onto plutonium).

The individual targets were prepared and characterized as follows :

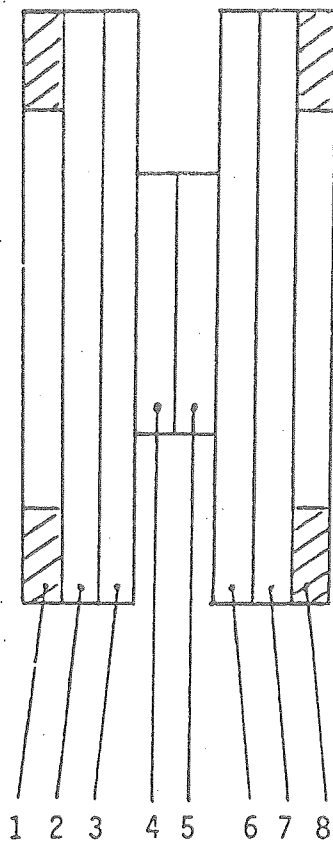
- The substrates are polyimides prepared by in situ-polycondensation (2).
Their thickness was determined spectrophotometrically (3). They were gold coated by vacuum deposition. The gold coating was monitored using an oscillating quartz.
- The plutonium was deposited by solution spraying of plutonium acetate (4) and characterized by thermal ionization mass spectrometry (isotopic composition) and low-geometry alpha counting (amount of Pu).

The positioning of the targets is carried out according to Fig. 2. Contact is first made at one side (a), and then the two targets are slowly brought together (b) until the two foils touch each other completely (c). During this operation the two foils attract each other in such a way that the air in between them is completely removed. At the end they fully stick to each other and can be brought in vacuum without any risk of destruction.

This conception has two advantages. Firstly no cross-contamination can occur as they are prepared individually, and secondly both ^{241}Pu (n_{th}, f) and ^{242}Pu (s, f) measurements can be carried out under quasi-identical energy loss conditions by just turning the sample over 180° when switching over from the neutron induced to the spontaneous fission measurements. As shown in Fig. 3 in both measurements the fission fragments have to cross a PI-Au layer to reach detector 1 and a Pu-PI-Au layer to reach detector 2.

A further advantage is that the plutonium is completely confined, which also decreases health physics risks and contamination problems for the detectors during the use of the target.

- (1) E. Allaert, C. Wagemans, G. Wegener-Penning, A.J. Deruytter and R. Barthélémy
Nuclear Physics, A 380 (1982) 61
- (2) J. Van Gestel, J. Pauwels and J. Van Audenhove
Preparation of Nuclear Targets for Particle Accelerators,
Plenum Press, New York and London (1981), 117
- (3) J. Pauwels, J. Wesenbeek, M. Pauwels and J. Van Gestel
EUR-7985 (1982)
- (4) K.F. Lauer and V. Verdingh
Nucl. Instr. Meth. 21 (1963) 161



- (1) Al-ring
- (2) Polyimide foil : $31.3 \mu\text{g}/\text{cm}^2$
- (3) Gold coating : $22 \mu\text{g}/\text{cm}^2$
- (4) Pu 241 deposit ($\emptyset 25$) : $26.5 \mu\text{g}/\text{cm}^2$ Pu
- (5) Pu 242 deposit ($\emptyset 25$) : $19.8 \mu\text{g}/\text{cm}^2$ Pu
- (6) Gold coating : $20 \mu\text{g}/\text{cm}^2$
- (7) Polyimide foil : $31.7 \mu\text{g}/\text{cm}^2$
- (8) Al-ring

Figure 1 : Schematic presentation of the combined ^{241}Pu - ^{242}Pu target.

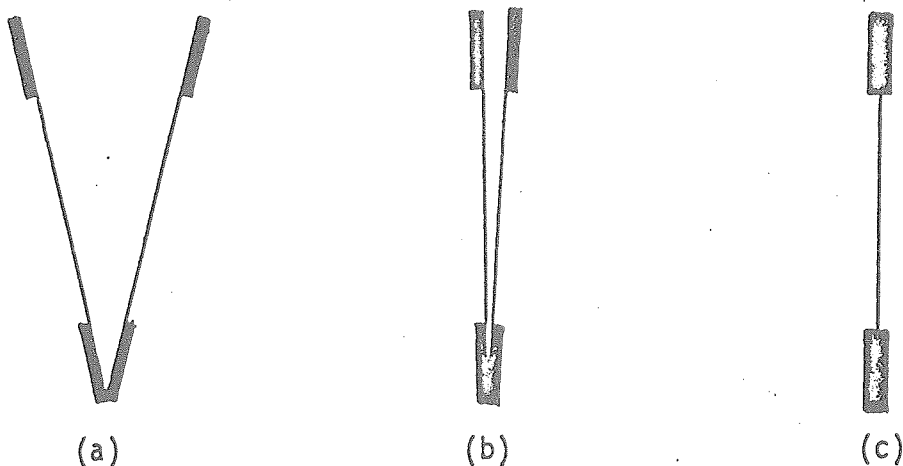


Figure 2 : Fixing of the individual targets

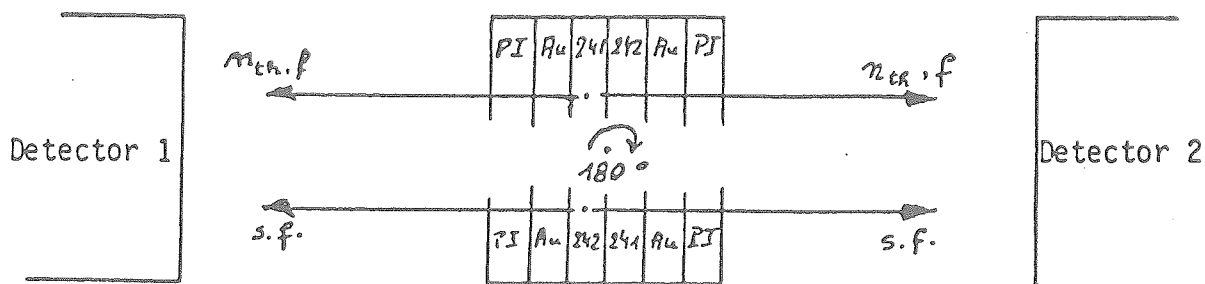


Figure 3 : Experimental set-up to carry out the measurements

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Our main activity is the production of highly enriched stable isotopes in our e.m.i. separator MEIRA. Presently, we develop techniques to improve production efficiency in order to reduce the costs of our products. Actually, we are producing Tellurium isotopes in relatively large quantities, which are used as targets for the production of I-123 for medical applications.

We are interested in widening the scope of our activity to other elements and would welcome any advice on future needs for highly enriched isotopes in relatively large quantities and their potential users.

Fabrication of Stepped Foil Targets

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Stepped foil targets for studying the effects of laser induced shocks in materials are being produced by using chemical etching and electrolysis. Well defined steps were produced by precision masking.

A scanning electron microscope, microbalance and a Sloan Daktek surface profile measuring system were used to determine the characteristics of the targets.

Procedure for Aluminum Targets

Stepped aluminum targets were produced from 6,9,12,15, 18 and 24 μ thick pure aluminum foils. Foils were mounted on flat glass supports previously coated with a thin layer of photoresist. The mounted foil was spin coated with 2 μ thick layer of photoresist (Shipley AZ-111) and baked for 20 minutes at 90 $^{\circ}$ C. The foils were attached to photolithographic masks and exposed to U.V. light. After developing, the uncoated areas were etched with aluminum etchant solution (Transene). The etching rate is temperature dependent. At 45-50 $^{\circ}$ C the etching rate was reasonably fast enabling step or pattern formation in a few minutes.

The foil was lifted from the glass support by soaking in acetone. Complete photoresist removal was checked with a microscope.

Target Characterization

Step thickness was calculated from weight loss measured with a Mettler microbalance. Thickness calculation accuracy was better than 2%.

Scanning electron microscopy and profile depth measurement are destructive measurements so they were used only for confirmation and control of results obtained by the microbalance. After characterization, the foils were mounted on target holders and inserted in the laser target chamber.

Procedure for Nickel Targets

Nickel foils and patterns were formed by electrolysis on a polished copper support. We used nickel chloride-sulphate solution with brightener (Reflecta) which ensured bright pit-free deposits. Current density was $0.03\text{A}/\text{cm}^2$ at 65°C and the pH was controlled with boric acid. After the desired foil thickness was deposited, the masking was obtained with photoresist as mentioned above. The pattern was then deposited. The photoresist was dissolved in acetone and the copper support was dissolved in trichloroacetic-ammonia mixture.

Target characterization was similar to that for the aluminum foils.

THIN SELF-SUPPORTING MONOCRYSTALLINE GOLD FILMS

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Thin self-supporting monocrystalline film is necessary for studying the beam-foil interaction and the lifetime of compound nucleus produced by nuclear reaction. We prepared special self-supporting monocrystalline Au (111) films by vacuum evaporation onto some monocrystalline Ag (111) films deposited on mica substrates and then stripped off the Au films by dissolving silver in diluted nitric acid.

For making high quality monocrystalline films, it is found that both silver and gold bulk materials must be very pure ($>99.999\%$) and the pressure during evaporation must be maintained low enough ($\leq 1 \times 10^{-5}$ Torr). The substrate temperature during deposition must be $275^\circ \pm 5^\circ\text{C}$. For both films the optical transmittance of a light beam with wavelength 6328Å is used for film thickness monitoring during deposition. It can be shown by calculation that the transmittance at 6328Å of a silver film with thickness of 1100Å is $T_{\text{Ag}}=0.148\%$ and that of a gold film of 500Å is $T_{\text{Au}}=6.75\%$.

The degree of continuity of the self-supporting gold films is determined by a scanning electron microscope (SEM). No discontinuity is detectable. The monocrystallinity of the films is excellent as measured by both X-ray and electron diffraction methods. An Au film with a thickness 500Å has been examined by Rutherford back-scattering (RBS) method and the normalized yield on the (111) direction is 30% of that on a random direction.

Proposed Compact Multiple Target-Foil Holder

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It often happens that the progress of an experiment is interrupted by the necessity of replacing target foils. Conventional methods of introducing new foils involve mounting them on a single wheel or belt so that they can be moved successively into the path of an ion beam. These methods usually are inadequate to store a sufficient number of foils and are often inefficient in their use of space.

We suggest a simple improvement to make it possible to mount a large number of wheels (perhaps 20 or more), each with foils mounted around its perimeter, on a common axle aligned parallel to the ion beam direction. In addition to the usual foil positions, each wheel would have a sector cut out of it (see Figure 1). "Fresh" wheels would be loaded onto the upstream portion of the axle and would be indexed with a key on the axle and mating slot on each wheel so that the ion beam would pass unimpeded through the cutout sector of each wheel not in use.

A spring would press the wheels together and load the foremost wheel onto a rotatable keyed actuator. This actuator would present the foils on that wheel as needed to the ion beam. When the wheel had been rotated almost one complete turn it would slide off the actuator onto the downstream position of the axle, indexed by a key having slightly different orientation from that of the upstream portion of the axle. The cutout sectors of such "used" wheels would be still aligned to permit the unimpeded passage of the ion beam.

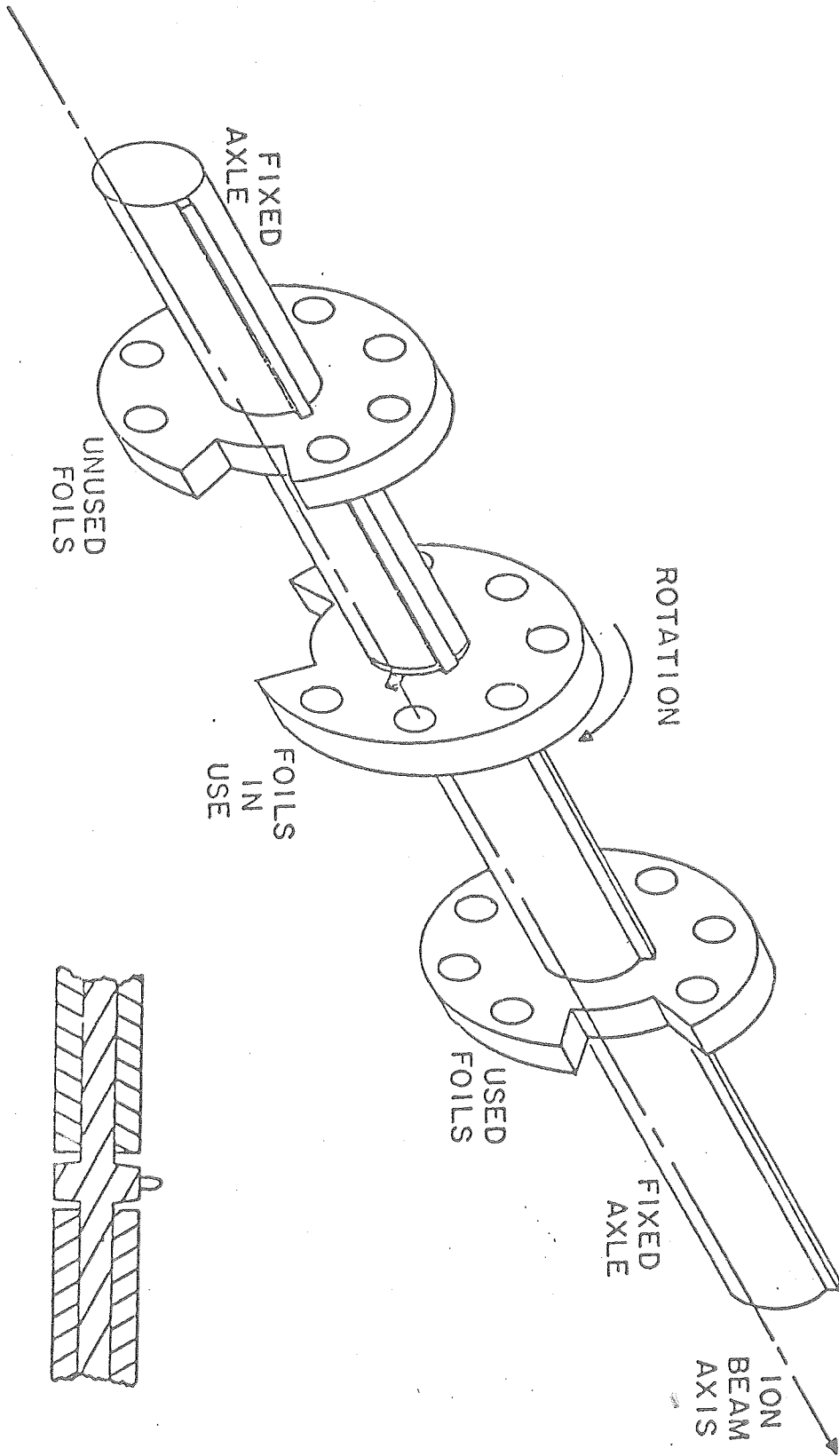
Continued rotation of the actuator would cause each wheel in succession to be loaded and rotated as needed. The system has several advantages: All

foils are used in the same target plane; a large number can be stored; optical access to each foil while in use and to the ion beam is maintained.

We suggest that such arrangements may be useful for mounting foils used as strippers, for exciter foils in beam-foil spectroscopy, and for targets used in trace-element analyses by particle-induced x-ray emission.

Figure Caption

1. Isometric view of a proposed multiple foil wheel. Unused foils on wheels are loaded onto the fixed axle on the left side and pressed by a spring (not shown) onto a rotatable actuator in the center (see inset). After nearly one full turn of a wheel on the actuator, it slides onto the fixed axle on the right side; further rotation of the actuator picks up the next wheel of unused foils.



A NEW TABLE ABOUT PROPERTIES OF ELEMENTS AND INORGANIC COM-
POUNDS FOR EVAPORATION PURPOSES

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In 1981 I prepared such a table in charge of Materials Research Corporation, Orangeburg - N.Y., USA. This table, however, was only published so far in its German version by Materials Research GmbH, Hansastr. 17, 8000 München 21, W-Germany in their catalog.

Since it is not known, when MRC will publish the English version, let me give additional information for all target makers, who are not familiar with the German language.

There are tabulated the properties of more than 400 elements and compounds. Especially the vapor pressure data were corrected or calculated on the basis of the latest literature. But in addition you will find also some information about target rolling. In the last column (remarks) $D = \dots \text{mg/cm}^2$ means the minimum achievable thickness for a rolled target foil of 1 cm^2 area. In the first column the elements are printed in bold together with their Z-number and followed by their compounds.

Some names of the elements have different initials in the German language, which was the basis for the alphabetic order: Bismuth-Wismut; Carbon-Kohlenstoff; Cobalt-Kobalt; Copper-Kupfer; Iron-Eisen; Lead-Blei; Mercury-Quecksilber; Potassium-Kalium; Sodium-Natrium; Tin-Zinn; Tungsten-Wolfram.

In the second column is the chemical symbol or formula and the molecular weight.

In the third column are above the melting- and below the boiling point.

In the 4th column are the density and the crystal structure.

In the case of the elements the second line of the second to fourth column is reserved for ΔH_F , which is the heat of melting, and ΔH_V , which is the heat of vaporization, and λ , which is the coefficient of thermal conductivity.

The 5th column is for the vapor pressures. It gives the temperature for a specific vapor pressure, e.g. 1630-2 means, the material has a vapor pressure of 10^{-2} Torr at 1630°C .

In the 6th column are the evaporation sources indicated. The first subcolumn shows the experiences with electron beam evaporation: 1 means excellent; 2 means good; 3 means no problems; 4 means problematic. The second subcolumn is for the materials of possible evaporation crucibles. The third subcolumn shows boat materials to be used and the fourth column gives materials for coils or baskets.

In the 7th column the sputtering possibilities are indicated.

In the case of the elements the second line of the 6th and 7th column is reserved for ρ , which is the specific resistance; and $\Delta\rho$, the thermal gradient of the specific resistance; and α , the coefficient of linear thermal expansion; and β , the coefficient of volume thermal expansion; and U, which is the temperature for an allotropic transformation. The knowledge of U is especially necessary for all annealing processes.