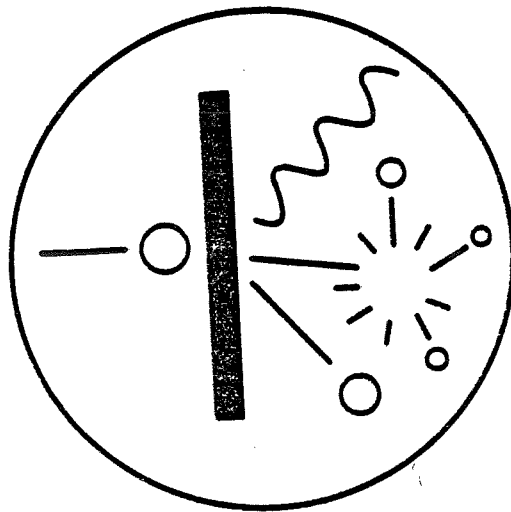


**INTERNATIONAL NUCLEAR  
TARGET DEVELOPMENT SOCIETY**

**NEWSLETTER**



**DECEMBER 1983**

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The INTDS Newsletter is an informal source of information for and from the Membership.

The INTDS assumes no responsibility for the statements and opinions advanced by the contributions.

Editorial

From 7th to 9th September 1983 the first local Workshop of the INTDS has been held since it was decided to have the International World Conferences only every two years. The Workshop took place in Argonne National Laboratory, was organized by George Thomas and was attended by 39 participants (32 USA, 4 Eur, 3 Can.). We can state that this meeting intensified in an important way the direct exchange of information and ideas between target makers and users as well as between target makers and those doing development work into isotope separation techniques.

With the start of the new heavy ion facilities several physicists explained and stressed the need for better and new types of targets and stripper foils. It is clear that there is a permanent interest in new avenues of target development.

Several papers and discussions on new and improved isotope separation techniques increased our understanding in the problems, costs and feasibility of enriching isotopes.

Some traditional subjects on target preparation techniques have been highlighted by several speakers.

From this Workshop we realize that there remains an important challenge for fulfilling more sophisticated target requests.

The abstracts of the papers presented at this Workshop can be found in this Newsletter.

We thank George Thomas and his Colleagues as well as the Direction of ANL for organizing and sponsoring this important Workshop.

Wishing you a HAPPY NEW YEAR

J. VAN AUDENHOVE  
Central Bureau for Nuclear Measurements  
B - 2440 Geel (Belgium)

Excerpt of the Vote of Thanks to E.H. Kobisk, leaving President, given during the Banquet of the Society (7th September 1983) in Argonne

Ed Kobisk, now that you are retiring as the President of the INTDS, we want to express our recognition and appreciation for what you performed for our Society not only through your exceptionally competent leadership during these last years, but also through your early initiatives since 1962.

You started and kept alive worldwide cooperation between target makers and users.

The target laboratory at ONRL, you led and expanded during about 22 years, has always been considered as the one with the highest standards in the world. Many of us had the opportunity to visit and learn from you and your co-workers how to start business or tackle difficult problems.

What I personally consider as even more important is the fact that you have set a permanent example of some qualities a good target maker needs in order to get recognition and respect from his management and clients.

He or she should be service minded with as objective to do the requested job correctly. He needs patience and his knowledge should be sufficient to understand and discuss the requested specifications with the target users.

Furthermore his dignity must be demonstrated through correct reporting of his results in form of valuable scientific publications.

I think we all agree that Ed Kobisk, for many years, has set an example in this respect.

We all know how important it is to have one's wife's understanding in our job. We therefore thank Dolly for her everlasting support and patience.

Although we are convinced that it will be the case, we wish you continued success in your new activities.

J. VAN AUDENHOVE  
President INTDS



PRESENTED TO

*E. H. Kobisk*  
*President, INTDS*  
*1979 - 1983*

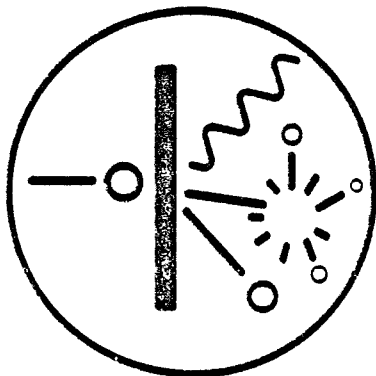
AT THE SEPTEMBER 1983  
ANL INTDS MEETING

IN RECOGNITION OF HIS MANY CONTRIBUTIONS  
TO INTDS AND THE RESEARCH COMMUNITY

E. H. KOBISK WILL LONG BE REMEMBERED FOR HIS  
UNTIRING EFFORTS IN ASSISTING TARGET MAKERS  
AND EXPERIMENTERS THROUGHOUT THE WORLD.

HIS MOTTO

*"The impossible just takes a little longer"*  
HAS INSTILLED INTO MANY TARGET MAKERS  
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ISOTOPE RESEARCH MATERIALS LABORATORY\*

H. L. Adair, W. S. Aaron and M. Petek

Operations Division  
Oak Ridge National Laboratory  
Oak Ridge, Tennessee 37830

The Oak Ridge National Laboratory (ORNL) operates the Isotope Research Materials Laboratory (IRML) to provide special research forms (targets) of various enriched stable and radioisotope materials that are not available from private suppliers in the United States. These special forms include, but are not limited to, thin films, foils, bulk metal, bars, wires, metal sheets as well as various compounds. Some specific examples of recent IRML target making activities that involved the fabrication of metallic mercury targets, reduction-distillation of high purity plutonium metal and electrodeposition of  $^{230}\text{Th}$  are described below.

A request for mercury targets for use in electron scattering experiments resulted in the fabrication of a 90 a/o Li - 10 a/o Hg amalgam that was suitable for rolling into thin foils and permitted operation at experimental temperatures of up to  $160^{\circ}\text{C}$ . The amalgam was prepared in one gram batches by RF melting inside a stainless steel crucible that in turn was sealed inside a stainless steel can. The RF heating provided stirring of the molten mixture when it was heated to approximately  $600^{\circ}\text{C}$  and cooled slowly. The amalgam was then rolled in an open stainless steel sandwich inside an argon glove box to

---

\*Research sponsored by the Office of Basic Energy Sciences, U. S. Department of Energy under contract W-7405-3ng-26 with the Union Carbide Corporation.



the final dimensions of 7.6 cm diameter by 65  $\mu\text{m}$  thick. This corresponds to an areal density of 12.08  $\text{mg}/\text{cm}^2$  or 8.75  $\text{mg}/\text{cm}^2$  mercury. The foil was then sealed with 1.55  $\text{mg}/\text{cm}^2$  thick aluminum foils that were attached to a 7.9 cm diameter aluminum frame. This package protected the target from both reaction with the atmosphere and loss of mercury due to beam heating in a vacuum environment of  $10^{-3}$  to  $10^{-4}$  Pa during the experiments. Thus far one normal mercury target has been prepared and has performed satisfactorily during electron scattering experiments. Similar mercury amalgam targets will be prepared using enriched mercury isotopes.

Frequent requests are received by IRML for the preparation of high purity plutonium metal in batches ranging from 500 mg to 20 g. The vacuum reduction-distillation technique, using thorium metal powder as the reductant for  $\text{PuO}_2$ , is used to obtain the plutonium metal. Compatibility problems between molten plutonium and crucible materials are a major limitation, especially at the 1550-1650°C temperature range required to obtain a suitable plutonium distillation rate. However, the compatibility problem is minimized if the  $\text{PuO}_2/\text{Th}$  mixture is pressed into a pellet before the beginning of the distillation process. The cold pressed  $\text{PuO}_2/\text{Th}$  pellet maintains its integrity following the reduction reaction since most of the plutonium metal is contained within the pellet which is not in intimate contact with the tantalum carbide crucible walls. Appropriate heat shielding and water cooling of the quartz collector minimize heat-related equipment problems and any reaction between the plutonium metal and the quartz collector. Alpha-plutonium metal with less than 1000 ppm impurities, primarily thorium, has been prepared by the vacuum reduction-distillation technique. Efforts are now directed at reducing the thorium contamination which accounts for approximately 70% of the impurities.

The electrodeposition technique is frequently used by target makers to prepare targets of very expensive and/or very rare isotopic materials since plating efficiencies of >90% are not uncommon. Recently, IRML has used the electrodeposition technique to prepare four  $^{230}\text{Th}$  targets for experimental studies of the subthreshold fission resonance of  $^{230}\text{Th}$ . The procedure used was very similar to the one described by J. E. Evans, et al., in a 1972 volume 102 Nuclear Instruments and Methods article. The  $^{230}\text{Th}$  was electrodeposited on both five and eight microinch nickel substrates to a thickness of 20-100  $\mu\text{g}/\text{cm}^2$ . In general, the electrolysis is performed from isopropanol solutions ( $\sim 3$  ml) to which less than 0.1 ml of  $^{230}\text{Th}$  as a thorium nitrate solution has been added. Maintaining a current density of 10  $\text{ma}/\text{cm}^2$  for one hour resulted in approximately 85% of the  $^{230}\text{Th}$  being plated on the nickel cathode substrates. The cell voltage varied between 400 and 500 V. Uniform, adherent deposits were obtained when very little aqueous phase was added to the isopropanol. When more than five percent water was present in the plating solution, the deposits appeared dull and tended to flake off. In addition, the plating voltage decreased with increasing water content. In the next few months the same plating procedure will be used in an attempt to fabricate suitable  $^{252}\text{Cf}$  fission fragment sources that contain  $\leq 0.5$   $\mu\text{g}$  of  $^{252}\text{Cf}$ .

K.O. Zell

Institut für Kernphysik der Universität zu Köln  
Zülpicher Straße 77, D-5000 Köln 41, West Germany

1. 0.5 mg/cm<sup>2</sup> Mo foils for plunger measurements

This foils were made from Russian isotopes. The powder material was molten by an electron gun, the resulting sphere pressed. If one rolls this material cold it gets many holes and is at the required thickness like a net. As we do not have the equipment to roll it hot <sup>1</sup> we tried the following process: Each time after increasing the area by a factor two the foil was annealed by heating it with the electron gun to about 1000 °C for some minutes. We found also that we could improve the results by rolling it not in one direction but turning it by 90° for each pass through the rolling mill. In this way a 0.5 mg/cm<sup>2</sup> target without any holes was prepared.

2. Sandwiching of Ce and Sm targets to reduce oxidation

For ( $\alpha, n\gamma$ ) experiments we needed oxygen free 2 mg/cm<sup>2</sup> Ce and Sm targets on 150 mg/cm<sup>2</sup> Bi which was stucked to a thick Cu foil. Enriched Sm was evaporated on this backing from a Ta tube in 1.5 cm distance and Ce from a Ta boat in 8 cm distance. This layer was then without breaking the vacuum coated with 0.5 mg/cm<sup>2</sup> Bi which prevented the oxidation during the period of some minutes when the targets were put into the chamber. In this way it is also possible to store the targets for several weeks in an exsiccator pumped at the beginning to 10<sup>-3</sup> mbar. The process did not work with Nd as it does not stick to the Bi backing but peels off.

3. Other targets

Self supporting 40 µg/cm<sup>2</sup> Cr and 10 µg/cm<sup>2</sup> Ti targets on 10 µg/cm<sup>2</sup> C were made by evaporation from an electron gun. Plunger targets of 0.5 mg/cm<sup>2</sup> Sn evaporated from a W-tube in 3 cm distance onto 2 mg/cm<sup>2</sup> selfsupporting Au were made.

<sup>1</sup> F.J. Karasek: Nucl. Instr. Meth. 167 (1979) 165

Judith C. Gursky  
MS D456  
Los Alamos National Laboratory  
Los Alamos, NM 87545  
U.S.A.

Much of recent activity has involved sputtering of large-area deposits of  $^{238}\text{U}$  onto various substrate foils: titanium, copper, nickel, pyrolytic graphite, polypropylene. Deposit thicknesses have ranged from 50 to  $1000\ \mu\text{g}/\text{cm}^2$ , with areas of 15-20  $\text{cm}^2$ .

Several other groups at LANL have developed techniques which may be of interest to targetmakers.

#### Thin saran:

Saran wrap is dissolved in tetrahydrofuran at 30-50°C. A 6x6-inch glass plate is dipped in the solution and brought to its temperature, then pulled out. The concentration of the solution and the rate of pull determine film thickness. The film is scribed, tape is laid across the end and the film is pulled off. Films of  $100\ \mu\text{g}/\text{cm}^2$  and up have been made. The use of release agent on the plate would probably make thinner films possible.

Robert Ripple  
Frank Ameduri  
MS D410, LANL

#### Oxygen- and nitrogen-containing films:

Polyformaldehyde for high oxygen content.

Aminoborane on polyacrylonitrile for high nitrogen content.

#### Publications:

##### 1. Oxygen- and nitrogen-containing films:

Fluorescers and Filters of Unusual Chemical Composition for Low-energy x-ray Measurements.

B. Jorgensen, R. Liepins, R. A. Geanangel and R. Komm.  
J. Vac. Sci. Technol. A. I (2) Part II, 894 (1983).

##### 2. Oxygen-containing films:

Unusual Chemical Composition Fluorescers and Filters for Low Energy X-Ray Diagnostics. Part I. Oxygen Compositions.

B. Jorgensen, R. Liepins, R. H. Day. Rev. Sci. Instr. To be published.

Betty Jorgensen  
MS E549, LANL

J.B. REYNOLDS  
9, Appleton Drive  
Greasby. Wirral.  
UK - Merseyside, L49 1S5  
England

Since taking early retirement from Liverpool University, I have been helping at Daresbury N.S.F. with Mr. R. Darlington. The activities recently covered by us are :

The reduction of Dy 163 oxide to metal and rolling  $0.1 \text{ mg/cm}^2$  foils from this metal, also Dy 161 + Dy 164.

The preparation of self supporting, thin Ni, Mn and U targets by evaporation. The preparation of Calcium 48, from the carbonate, for the ion source. The preparation of Iron, Cadmium, Tellurium targets by various methods. The investigation of several Telluride targets.

We are thoroughly investigating the reduction of small amounts (200 mgs) of Silicon Dioxide to Silicon as our yields are apparently low.

IMPROVEMENT OF ADHERENCE OF ELECTROSPRAYED DEPOSITS FOR NUCLEAR MEASUREMENTS

J. TJOONK

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The preparation of uranium deposits on metallic substrates by means of electro-spraying and the improvement of the adherence of such deposits by spraypainting of subsequent cellulose nitrate layers is described. The advantages of combining these two methods, compared to spraypainting or electro-spraying, are that good adhering layers of same quality as spraypainted layers can be obtained with good yield.

1. Introduction

The loss of starting material by applying the spraypainting method for the preparation of good adhering uranium deposits on metallic backings was a reason to investigate the combination of spraypainting (1) and electro-spraying (2, 3).

2. Description of the Method

Uranium deposits have been made by means of the electro-suspension-spraying and electro-solution-spraying method. After every spray operation the obtained deposit was heated at  $\pm 120^{\circ}$  C and a cellulose nitrate layer applied on top of it by means of an aerograph. The deposits were ignited for 15 minutes at 500 to 550 $^{\circ}$  C. After cooling to 20 $^{\circ}$  C the amount of uranium was determined by low-geometry alpha counting. Then the non-adhering particulates were removed with a hard brush and the remaining uranium measured again. Subsequently the layer was wiped off by means of a kleenex-tissue moistened with ethanol and remeasured again. These operations enable to test the stability of the layer.

#### a. Electro-suspension-spraying

16 different uranium deposits were prepared using the electro-suspension-spraying method (Fig. 1 to 15). The used suspension consisted of  $U_3O_8$  and methanol. A solution of 3 % cellulose nitrate in iso-amylacetate was used as paint. 14 of them were more or less unsuccessful. The deposits could entirely or partly be removed by brushing off and or wiping with a kleenex-tissue moistened with ethanol (See Figure 16).

The operations were carried out at different concentrations of uranium and with different quantities of cellulose nitrate solution, and the backings were heated at  $120^\circ$  or  $170^\circ$  C. When the deposited layer was not thicker than  $40 \mu\text{g}/\text{cm}^2$ , the adherence of the layer was rather good. However, for thicker layers, the combination of electro-suspension-spraying and spraypainting is not very suitable, as this method requires very much time.

#### b. Electro-solution-spraying

6 different uranium deposits were prepared using the electro-suspension-spraying method, with 5 of them using an uranium-acetate solution. For uranium layers not thicker than  $75 \mu\text{g}/\text{cm}^2$ , the adherence was rather good (See Figures 17 to 21).

The last deposit was prepared using uranium-nitrate solution. Layers of  $250 \mu\text{g}/\text{cm}^2$  could be prepared in one single spraying operation. Its adherence was good.

The advantages of using uranium-nitrate solution are :

1. Making an uranium-nitrate solution takes less time than preparing an uranium-acetate solution.
2. In one spraying operation a rather important layer-concentration can be obtained (See Figure 22).

### 3. Conclusion

The results of the different experiments show, that combination of electro-spraying and spraypainting is very well possible, but preference must be given to the combination electro-solution-spraying + spraypainting, using preferably uranium-nitrate dissolved in methanol (See Figure 23).

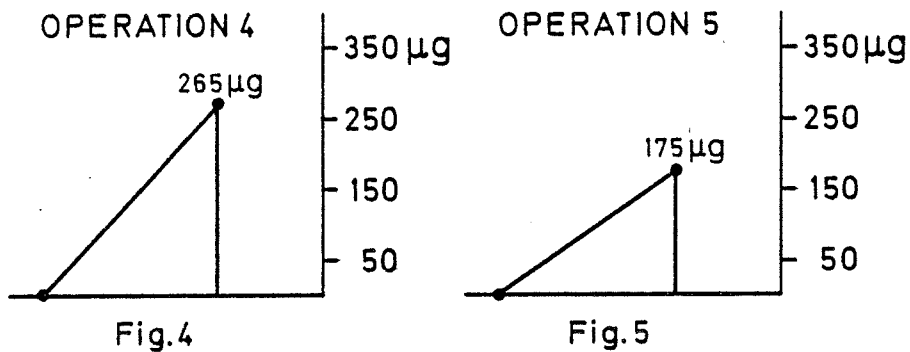
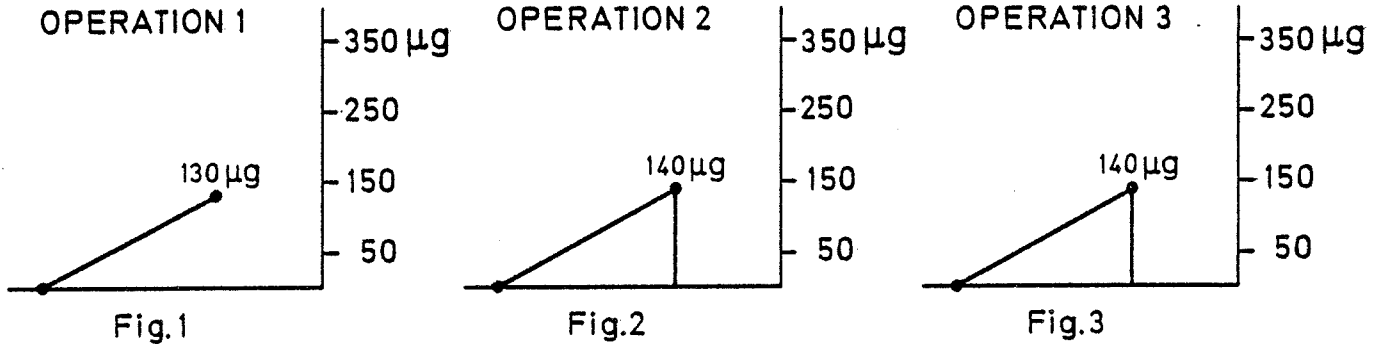
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Spraypainting of deposits for nuclear measurements  
Nuclear Instruments and Methods 167 (1979) 77 - 79
  
- (2) K.F.Lauer and V. Verdingh  
Preparation by electro spraying of thin uranium, plutonium and boron  
samples for neutron cross section measurements in  $4\pi$  geometry  
Nuclear Instruments and Methods 21 (1963) 161 - 166
  
- (3) V. Verdingh  
The preparation of layers by electro spraying and electrophoresis  
Nuclear Instruments and Methods 102 (1972) 497 - 500

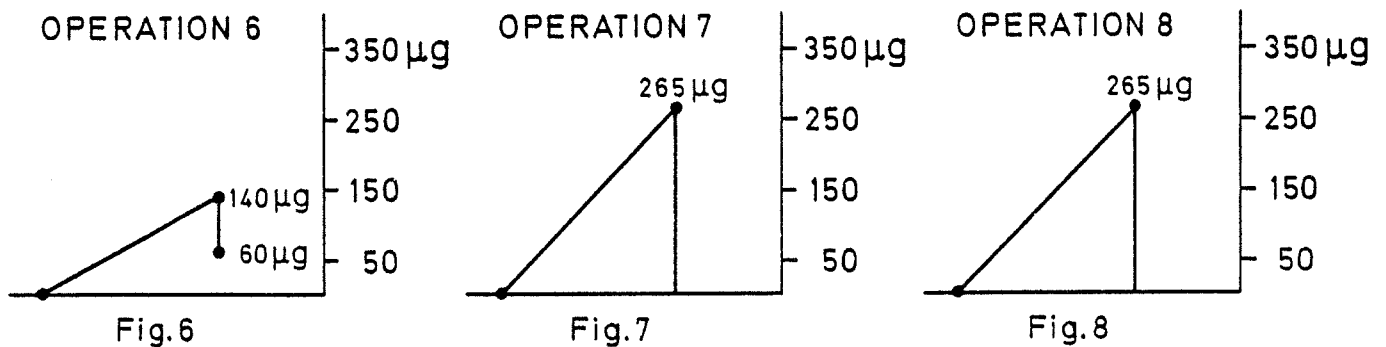


## SUSPENSION-SPRAYING

0.2 cc cellulosenitrate solution was sprayed on a backing heated up to 120° C.  
Ignition temperature 550° C.

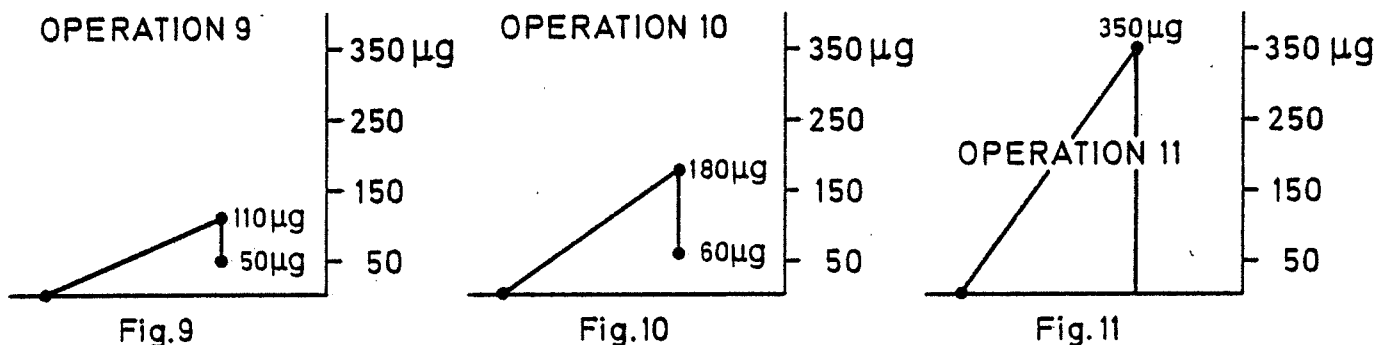


0.5 cc cellulosenitrate solution was sprayed on a backing heated up to 120° C.  
Ignition temperature 550° C.

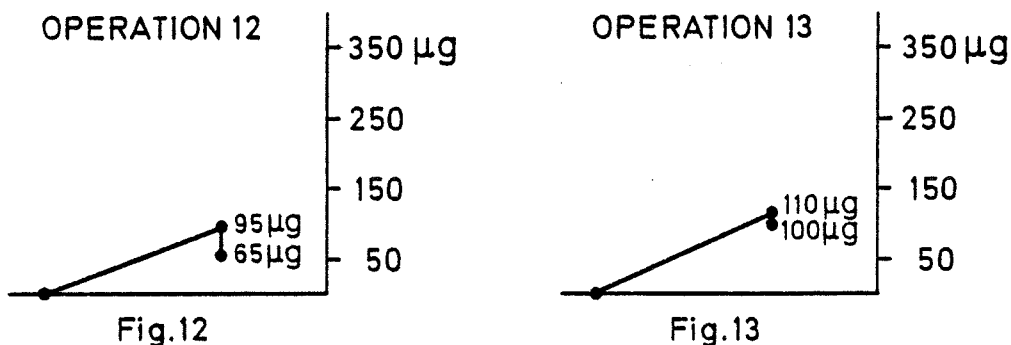


## SUSPENSION-SPRAYING

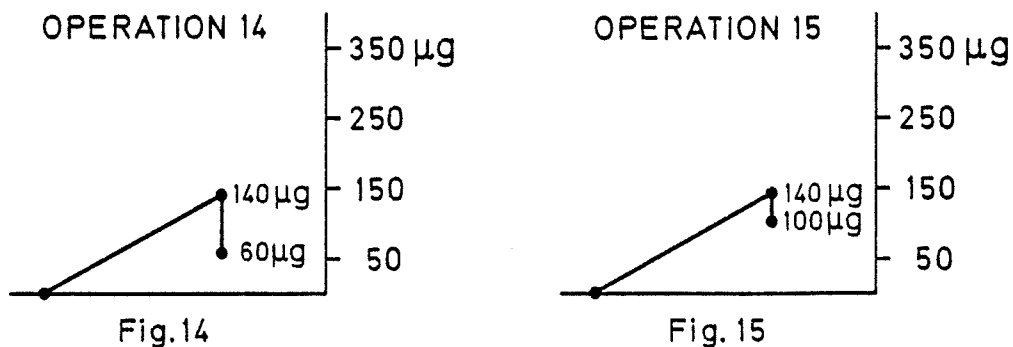
0.5 cc cellulosenitrate solution was sprayed on a backing heated up to 170° C.  
Ignition temperature 550° C.



0.3 cc cellulosenitrate solution was sprayed on a backing heated up to 170° C.  
The backing was roughend with steelwool.  
Ignition temperature 550° C.



0.5 cc cellulosenitrate solution was sprayed on same kind of backings as used with operation 12 and 13.  
The backings were again heated up to 170° C.  
Ignition temperature 550° C.



### SUSPENSION - SPRAYING

Every spray-operation 0.5 cc cellulosenitrate solution was sprayed.  
Temperature backing during spraying cellulosenitrate solution 170°C.  
Temperature during igniting 550°C.

OPERATION 16

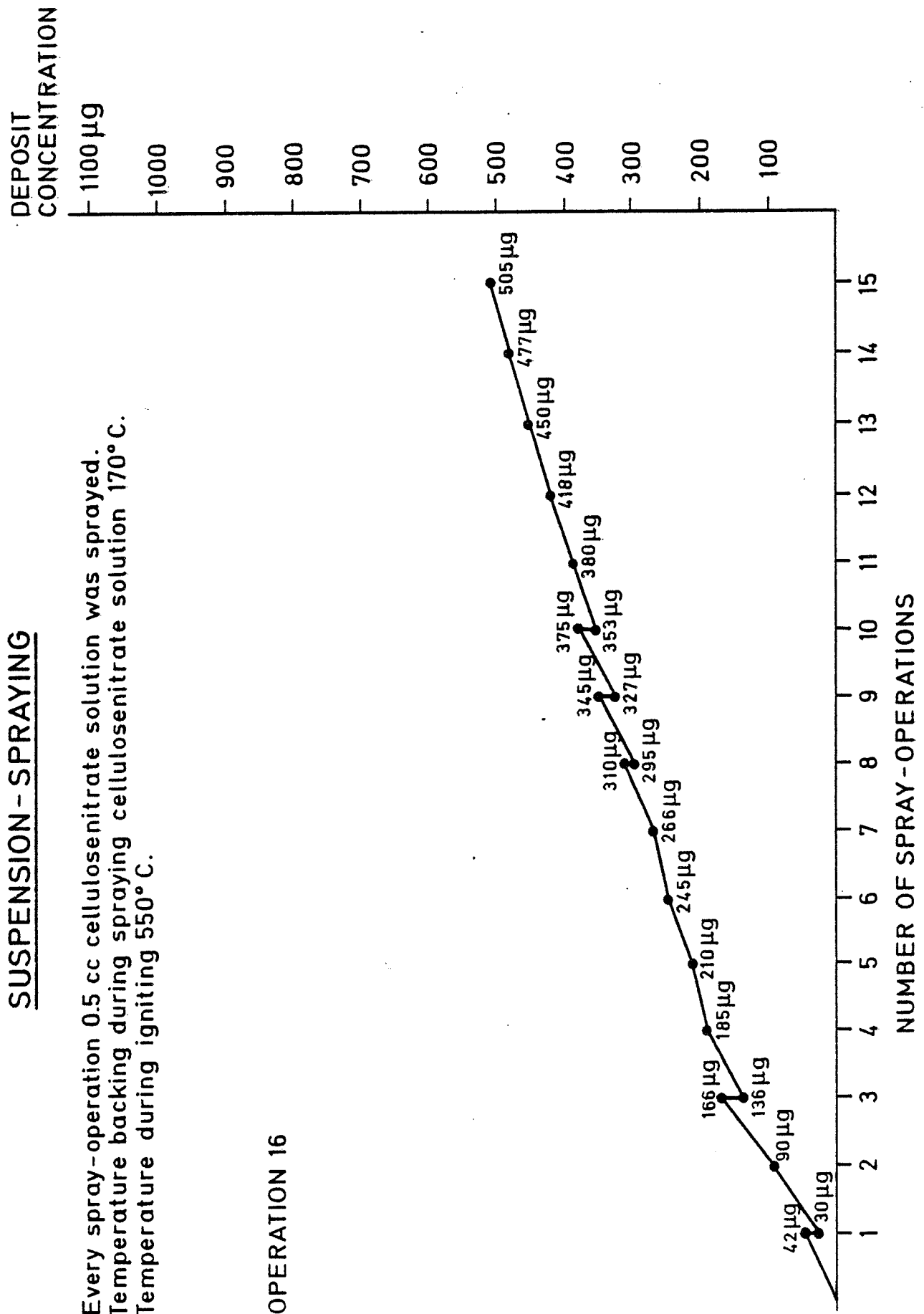
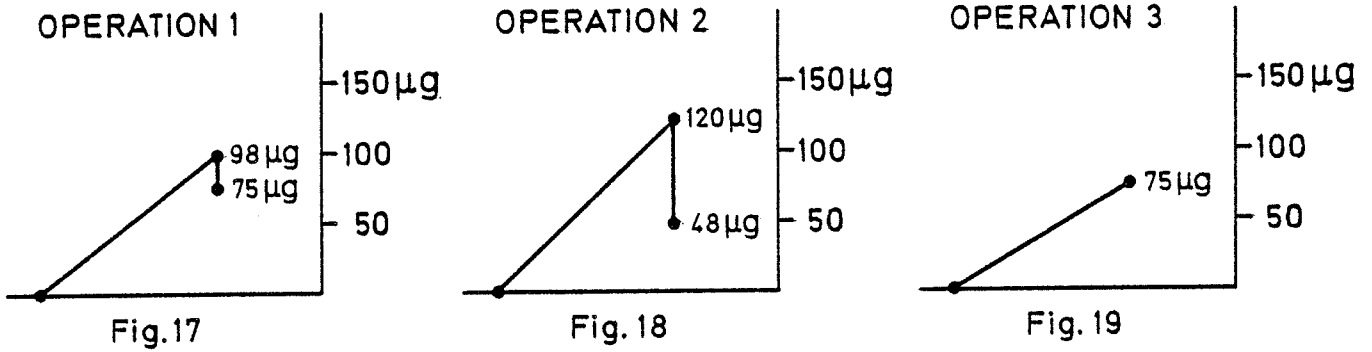


Fig. 16

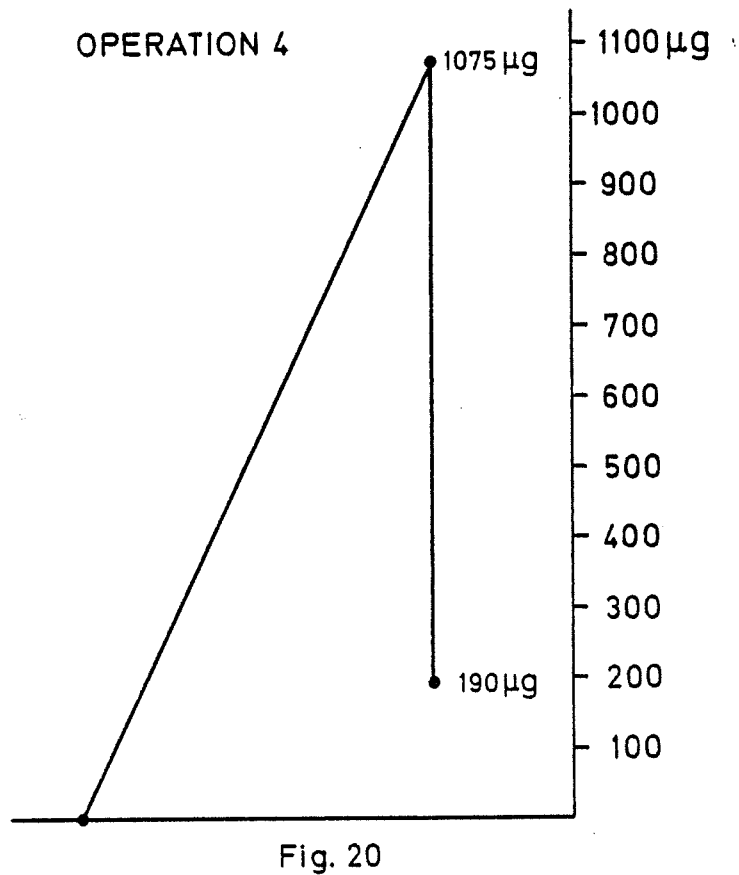
## SOLUTION-SPRAYING

Uraniumacetate was sprayed.

Every spray-operation 0.5 cellulosenitrate solution was sprayed on a backing which was heated up to 120° C.  
Ignition temperature 550° C.



0.5 cc cellulosenitrate solution was sprayed on a backing heated up to 170° C.  
Ignition temperature 550° C.



### SOLUTION - SPRAYING

Uraniacetate solution was sprayed.  
Every spray-operation 0.5 cc cellulosenitrate solution was sprayed.  
Temperature backing during spraying cellulosenitrate solution 170° C.  
Temperature during igniting 550° C.

OPERATION 5

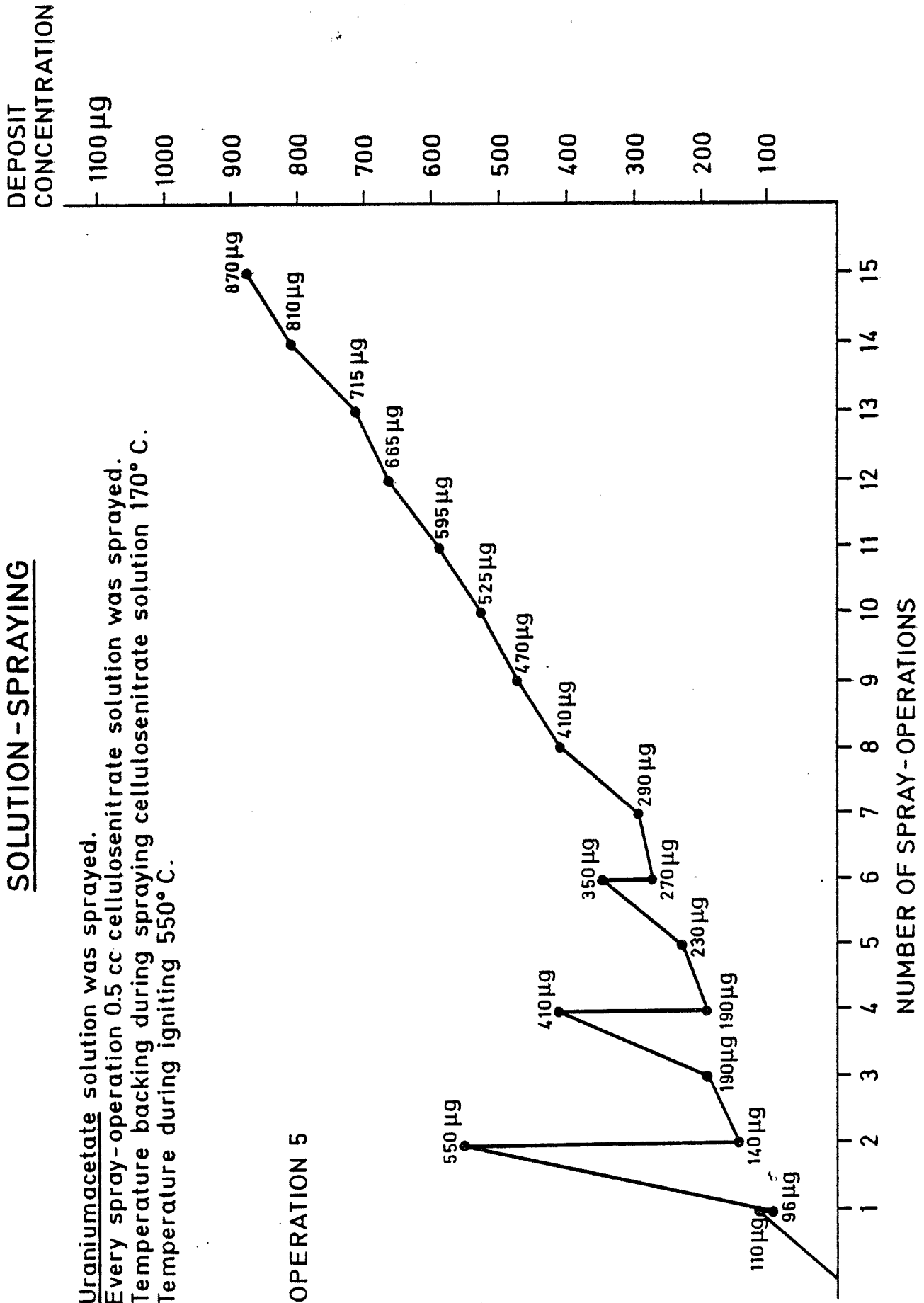


Fig. 21

### SOLUTION - SPRAYING

Uraniumnitrate was sprayed.  
Every spray-operation 0.5 cc  
cellulosenitrate solution was  
sprayed on a backing  
heated up to 170° C.  
Ignition temperature 550° C.

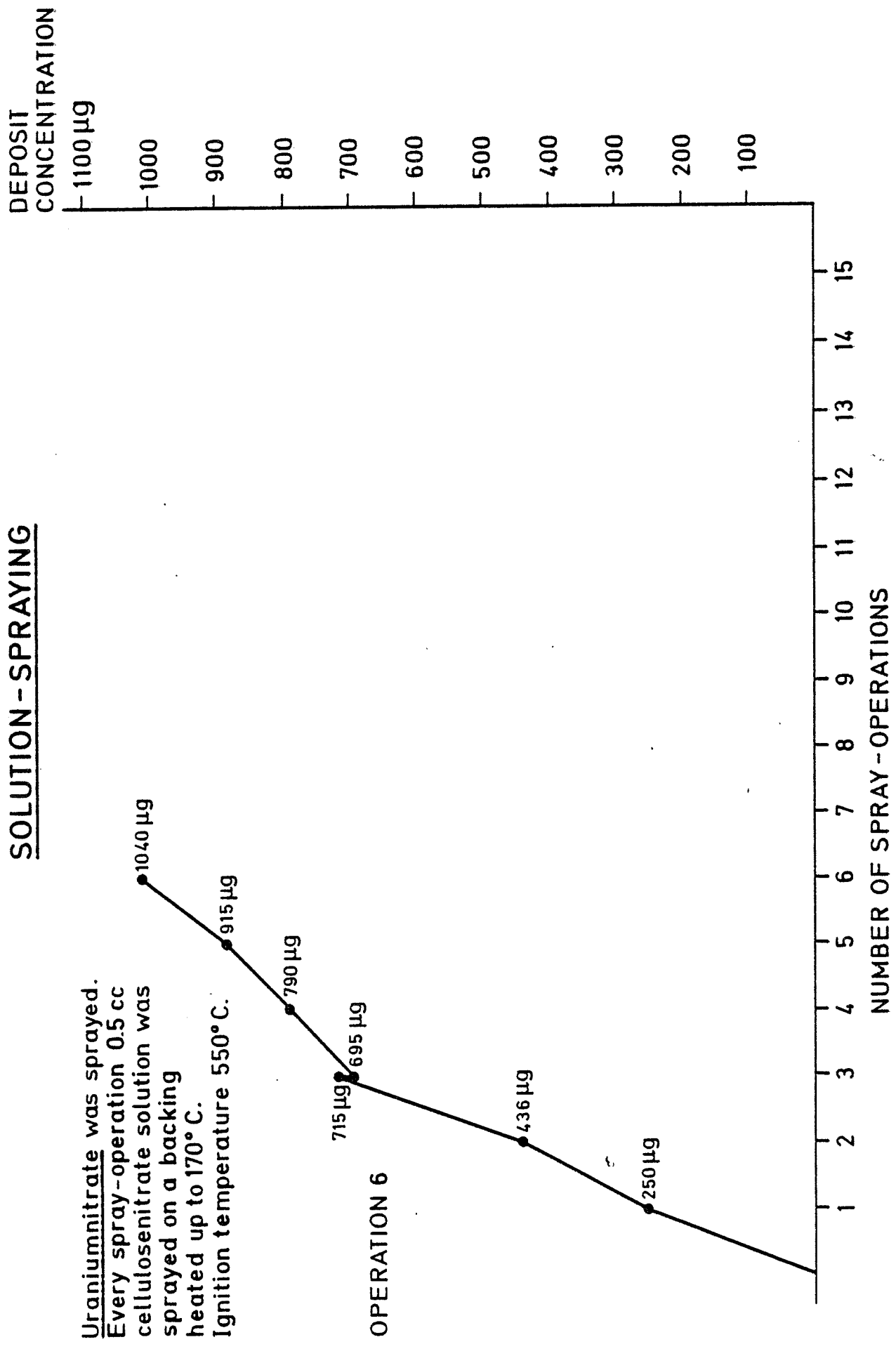


Fig.22

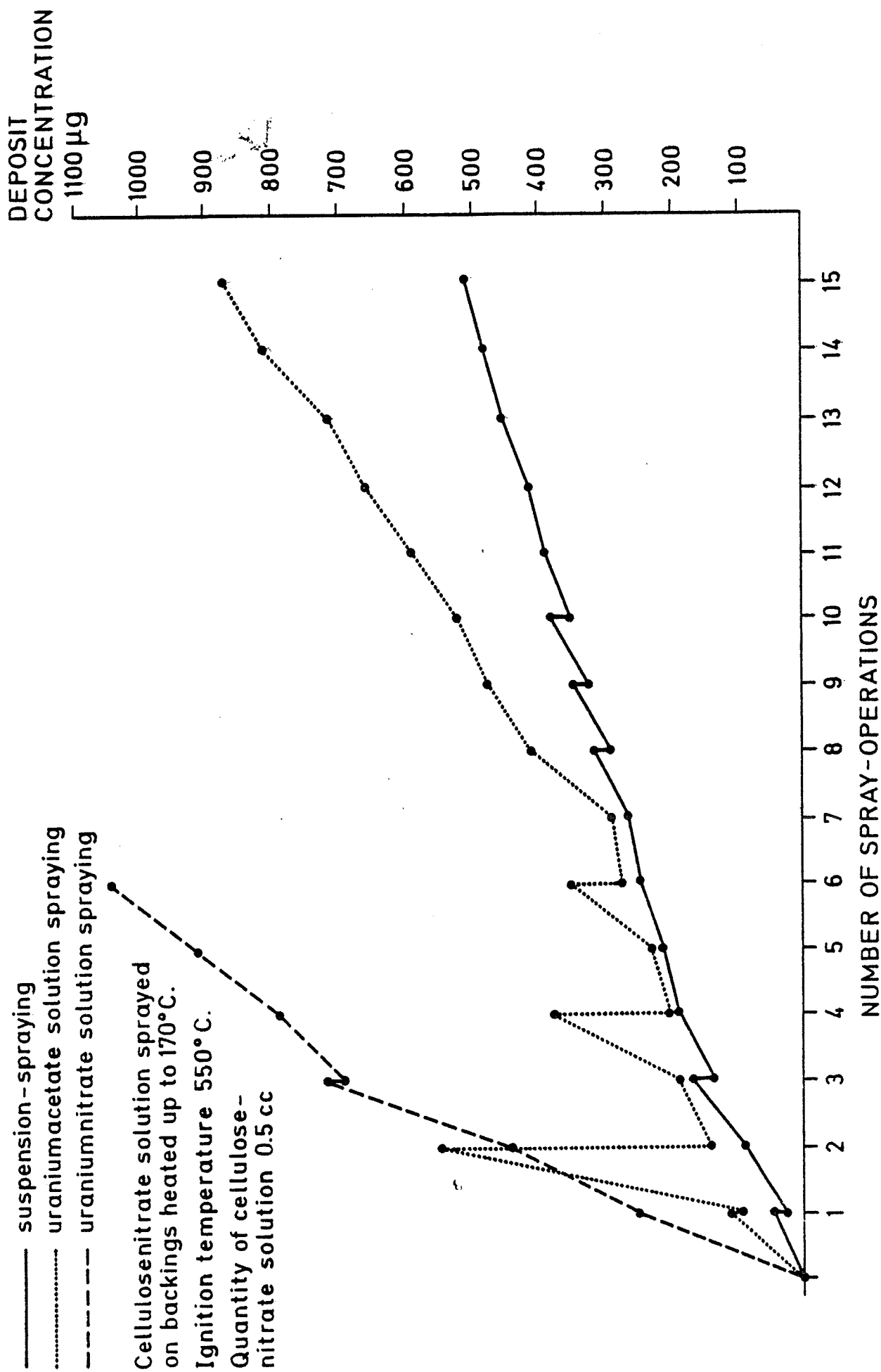


Fig. 23

UDEL POLYSULFONE P - 1700 THIN FOILS :

An interesting substrate material for nuclear targets ?

J. PAUWELS and J. VAN GESTEL

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1. INTRODUCTION

Nuclear target preparation laboratories have a permanent interest in the development of new thin substrate foils having good mechanical-, thermal-, chemical-, and radiation damage properties, and causing minimal energy loss to nuclear particles. A widely used material in nuclear physics experiments is carbon, which has the advantage to be conducting and can be prepared at thicknesses as low as a few micrograms per square centimeter. Its major inconvenience is however its extreme fragility. Plastic foils of vinylchloride - vinylacetate copolymer (VYNS), vinylformal - vinylacetate - vinylalcohol copolymer (FORMVAR) and especially polyimide are much better from a mechanical point of view, but have other drawbacks : vyns and formvar show poor resistance to radiation while polyimides can only be prepared with difficulty at thicknesses below  $30 \mu\text{g}/\text{cm}^2$  and furthermore lose their good mechanical properties below that limit (1).

As polysulfones are known as tough, rigid, high strength thermoplastics, which maintain their properties over a wide temperature range ( $-100^\circ \text{C}$  to  $150^\circ \text{C}$ ) and which resistance to radiation is claimed to be the highest known among plastics (2), we have attempted to prepare thin foils from UDEL Polysulfone P 1700 (Union Carbide) and to compare their properties with other thin substrate materials.



## 2. FOIL PREPARATION

Foils were prepared by dissolution in an organic solvent, centrifugation on cleaned glass plates and floating-off in a water bath. It should be noted that dissolution of UDEL P 1700 is very slow.

### 2.1. Dissolution of the dry pellets

A weight quantity of UDEL P 1700 is dissolved in a calculated volume of cyclohexanone under magnetic stirring during several days. After complete dissolution, the concentration is readapted with some drops of cyclohexanone to compensate for solvent evaporation. After filtration a completely transparent solution is obtained, which can be stored in a closed vessel.

The relation between the concentration of the initial solution and the foil thickness is given in Fig. 1.

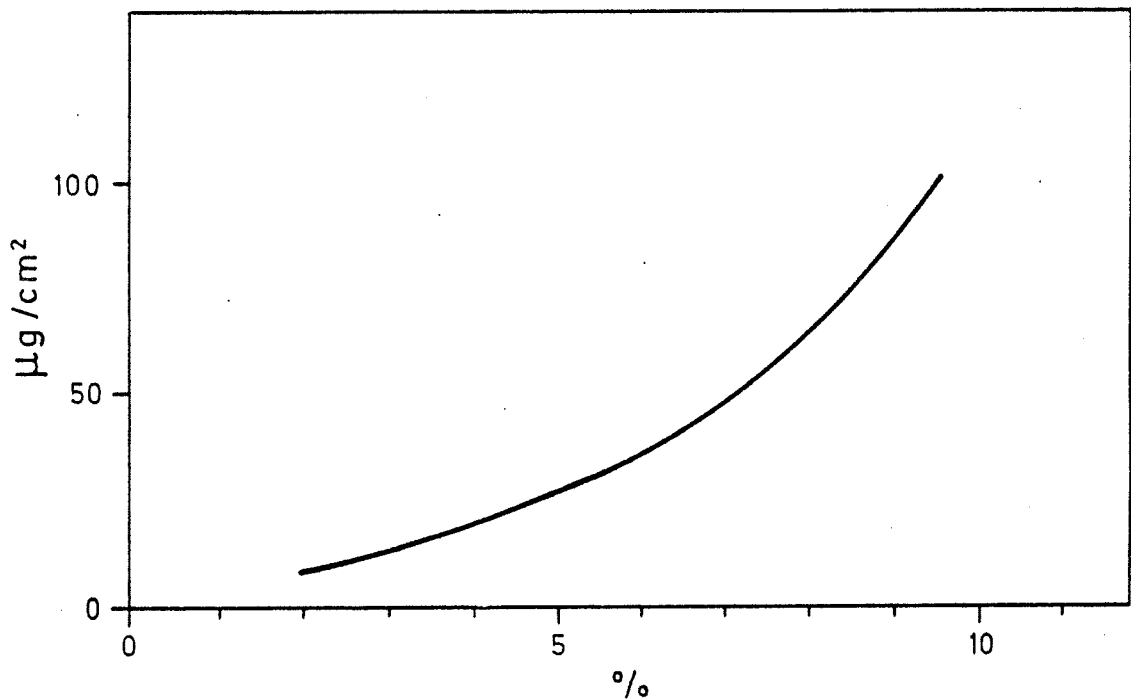


Fig. 1 : Foil thickness ( $\mu\text{g}/\text{cm}^2$ ) versus concentration of the initial solution (%)

## 2.2. Cleaning of glass plates

A glass plate (10 x 10 cm<sup>2</sup>) of minimal rugosity is degreased and thoroughly rinsed with tap water, distilled water and methanol. During this operation it is important to eliminate all dust particles from the plate : therefore the glass plate is put onto a centrifuge and further rinsed with methanol.

## 2.3. Foil preparation

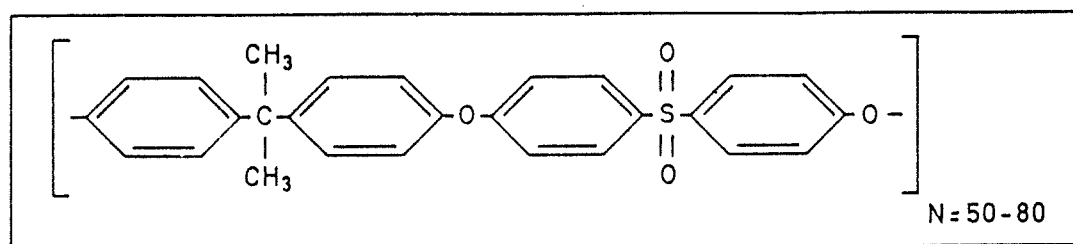
Approximately 5 ml polysulfone solution of appropriate concentration are deposited in the middle of a clean glass plate and spread over it by centrifuging during 1 minute at 6500 rpm. The foil is then floated off in a distilled water bath and picked up on a target ring.

Since the foil can be released very easily soon after centrifuging, no reason was found to use a release agent. Note that the foil release becomes completely impossible if the foil is left on the glass plate for an extended time period.

## 3. PROPERTIES

### 3.1. Composition

UDEL polysulfone (C<sub>27</sub>H<sub>22</sub>O<sub>4</sub>S) contains 73.3 wt. % carbon, 5.0 wt. % hydrogen, 14.5 wt. % oxygen and 7.2 wt. % sulfur. Its structural formula corresponds to (2) :



### 3.2. Production yield

Polysulfone foils were prepared as described above, cut into 9 squares of 3 x 3 cm<sup>2</sup>, released from the glass plate and picked up on Al rings of 20 mm internal diameter. When 9 correctly stretched foils without pinholes were recovered, the production yield was considered to be 100 %. This was generally the case, even at a thickness of only 5 µg/cm<sup>2</sup>.

### 3.3. Mechanical strength

To investigate the mechanical strength of the foils, pressure- and dropping tests were carried out as described by Van Gestel e.a. (1). Compared to other thin substrate foils, polysulfone foils show pressure-test scores (Fig. 2) between vyns and formvar and dropping-test scores (Fig. 3) comparable to those of formvar and polyimide. Rupture constants determined according to Chen (4) are given in Table II.

Comparison with other foils is made in Table II.

Table I : Rupture constant of UDEL  
Polysulfone P 1700 vs thickness

Film thickness ( $\mu\text{g}/\text{cm}^2$ )	Rupture constant ( $\text{cm Hg} \times \text{cm}/\text{mg} \cdot \text{cm}^{-2}$ )
6.6	61 $\pm$ 9
9	60 $\pm$ 10
20	66 $\pm$ 13
24	76 $\pm$ 18
28	67 $\pm$ 9
41	82 $\pm$ 14
77	65 $\pm$ 13
105	57 $\pm$ 2
110	55 $\pm$ 9

Table II : Comparison of rupture constants of different foils

Film Material	Rupture constant
Polyimide	122 $\pm$ 21
Formvar	100 $\pm$ 9
Polysulfone	65 $\pm$ 9
Parylene C	59 $\pm$ 11
Vyns	54 $\pm$ 8
Carbon	10 $\pm$ 4

Contrary to most other foils polysulfone foils remain relatively strong at very low thicknesses : in the pressure test they are superior to the other foils below  $20 \mu\text{g}/\text{cm}^2$  and in the dropping test below  $30 \mu\text{g}/\text{cm}^2$ . Even at thicknesses as low as  $10 \mu\text{g}/\text{cm}^2$  they reach scores, equivalent to  $50 \mu\text{g}/\text{cm}^2$  carbon for the pressure test and higher than  $100 \mu\text{g}/\text{cm}^2$  carbon for the dropping test. A  $20 \mu\text{g}/\text{cm}^2$  polysulfone foil shows twice the strength of a polyimide foil of the same thickness. The different evolution of the rupture constant of polysulfone- and polyimide foils for thickness below  $40 \mu\text{g}/\text{cm}^2$  is illustrated in Figure 4.

#### 3.4. Resistance in chemicals

The resistance of the foils to chemicals used in target preparation ( $\text{HNO}_3$ ,  $\text{CH}_3\text{COOH}$ ,  $\text{CH}_3\text{OH}$ ) is good. They are however soluble in acetone.

#### 3.5. Resistance to heat

The properties of foils are not changed significantly up to a temperature of about  $200^\circ \text{C}$ . Rupture tests are not significantly affected by 15 minutes heating at  $180^\circ \text{C}$  in air, which means that in this respect they are by far superior to vynes, formvar and parylene.

#### 3.6. Resistance to radiation

Several types of radiation experiments have been carried out to compare the relative resistance of different foils used in target preparation (5).

If the foils are irradiated by an Am-241 source in air, polysulfone behaves rather well compared to vynes, formvar and polysulfone, but significantly less well than polyimide. This effect is still more emphasized if 6 MeV alpha-particles produced by an accelerator are used. On the contrary of all other foils the behaviour of polysulfones is not improved if the Am-241 irradiation is carried out in primary vacuum.

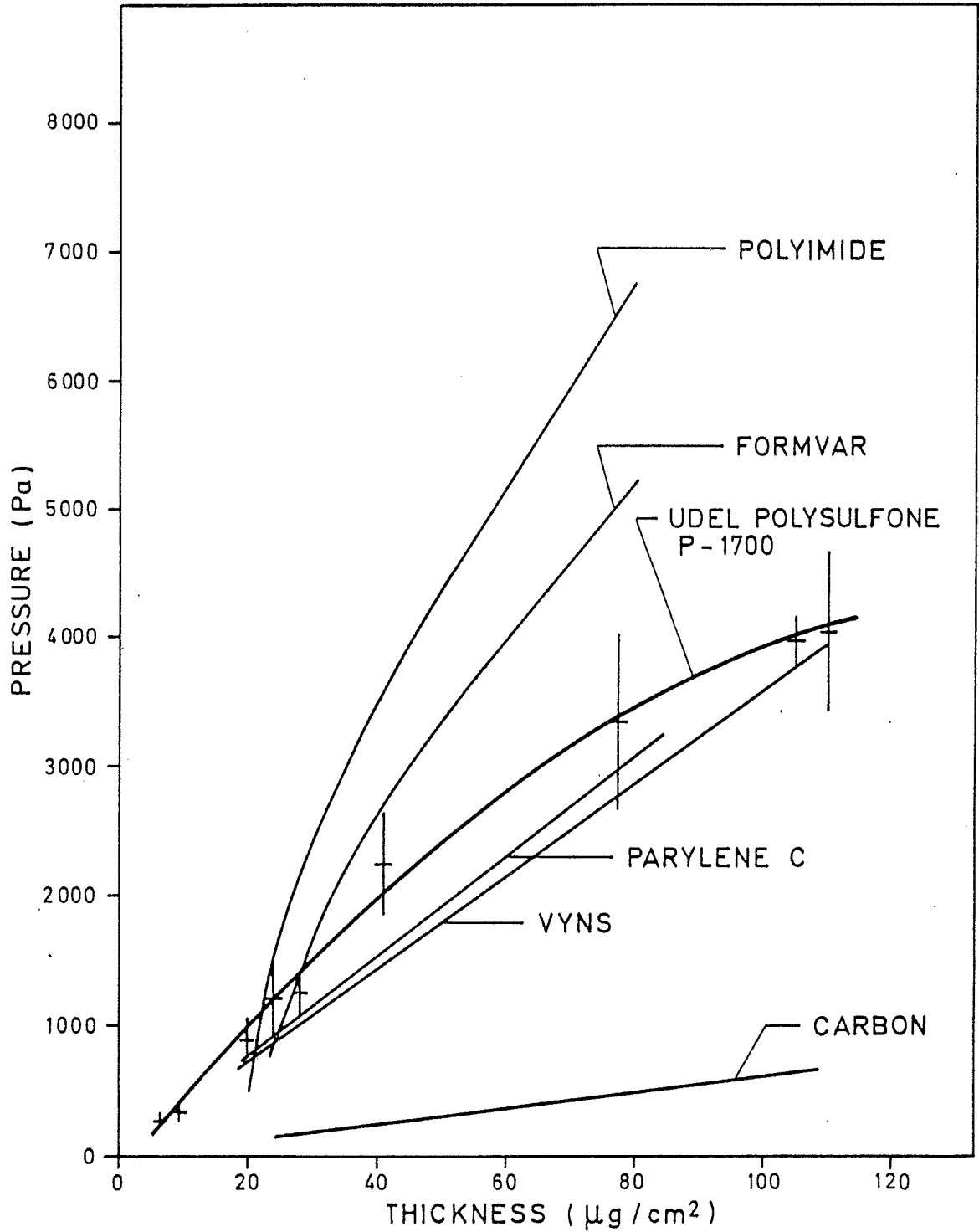


Figure 2 : Results of pressure tests on foils mounted on Al-rings of 20 mm internal diameter

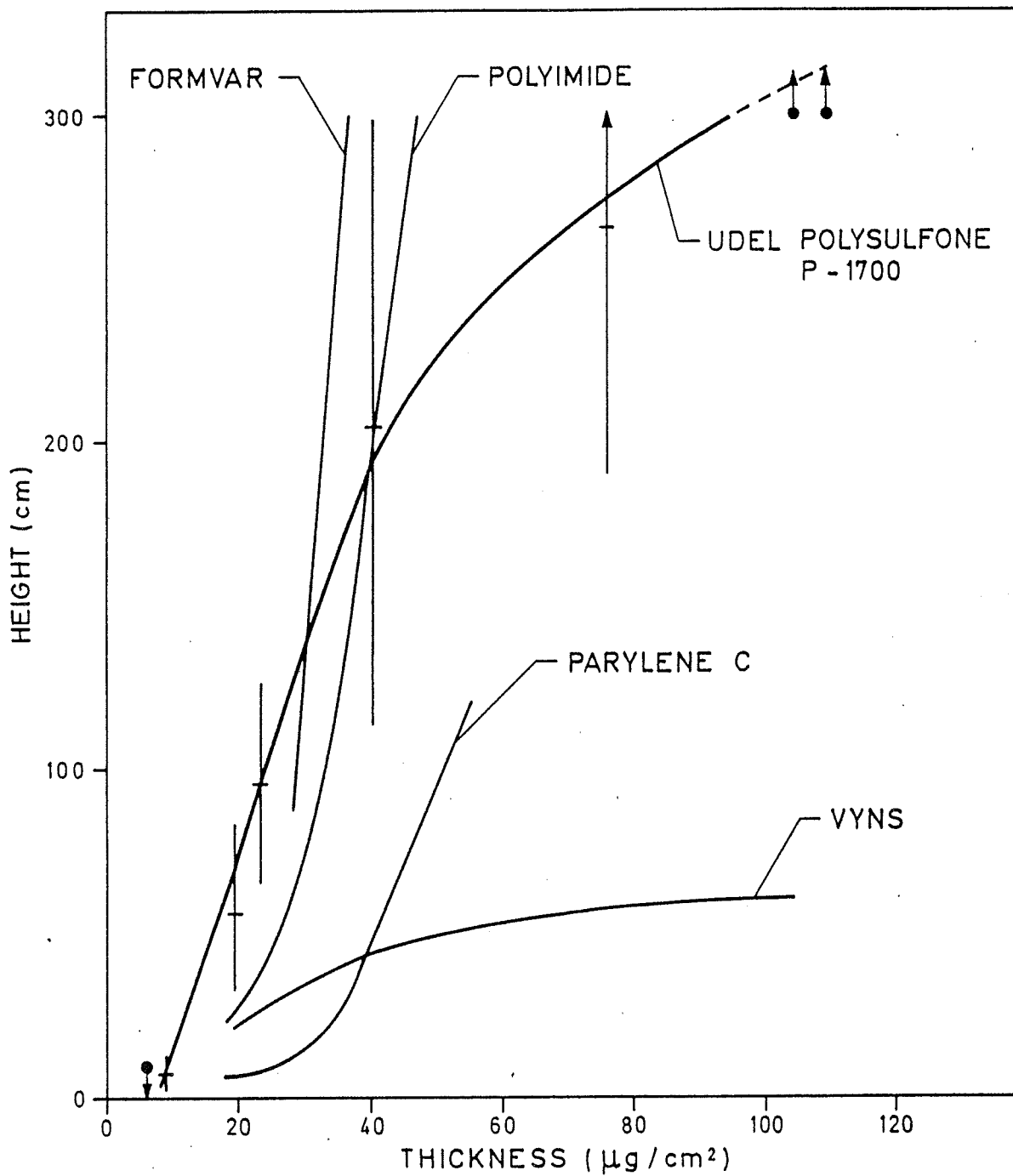


Figure 3 : Results of dropping tests on foils mounted on Al-rings of 20mm internal diameter

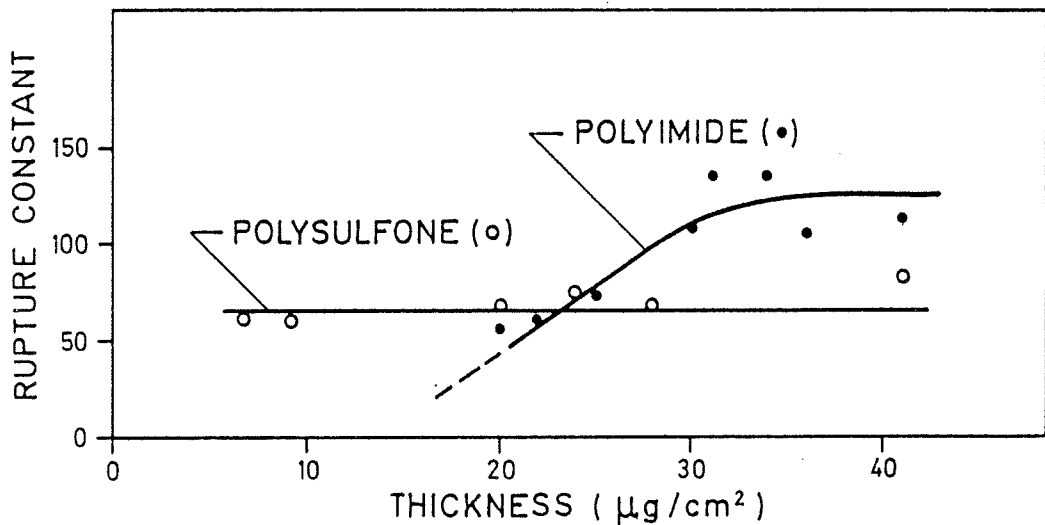


Figure 4 : Rupture constant of polysulfone and polyimide vs foil thickness

### 3.7. Particle energy losses

An important requirement of thin substrate foils is that the energy loss of nuclear particles traversing the foil is small. To compare foils it is not only important to know their chemical composition, but also to consider the thicknesses at which they can be used as substrate for actinide deposits, and, if they have to be conducting, the supplementary energy loss which will be due to the application of a conducting layer (Al or Au).

Considering these different factors, energy losses were calculated for 5 MeV alpha-particles and 70 MeV  $^{141}\text{Pr}$ - and 98 MeV  $^{98}\text{Tc}$  ions, which are typical fission fragments (Table III).

They show that if no conducting layer is required (e.g. targets prepared by vacuum evaporation), the energy losses caused by polysulfone foils are 2 - 3 times smaller than those caused by other foils. If a conducting layer is required (targets prepared by electro spraying or  $4\pi$  -  $\alpha$  counting sources) this difference still remains a factor 1.5 to 2.

Table III : Energy loss of alpha-particles and fission fragments in different foils used in target preparation

Substrate material	Foil thickness ( $\mu\text{g}/\text{cm}^2$ )	Energy loss in keV		
		5 MeV $\alpha$	70 MeV $^{141}\text{Pr}$	98 MeV $^{98}\text{Tc}$
Polysulfone	10	8	750	660
Polysulfone + Au	10 + 20	13	1010	960
Vyns	20	15	1300	1140
Vyns + Au	20 + 20	20	1560	1440
Formvar	20	17	1640	1440
Formvar + Au	20 + 20	22	1900	1740
Parylene C	20	16	1420	1260
Parylene C + Au	20 + 20	21	1680	1560
Polyimide	30	24	2160	1920
Polyimide + Au	30 + 20	29	2420	2220
Carbon	30	24	2010	1830

### 3.8. Target preparation behaviour

Trials to use very thin polysulfone foils to prepare targets for nuclear measurements led to the following conclusions :

The lower limit for use is of the order of  $10 \mu\text{g}/\text{cm}^2$ . Below that thickness it becomes difficult to evaporate materials on self-supported foils, and even in electro-spraying, problems arise due to the fact that the foils tend to fix themselves on the masks when the high-voltage (5 to 6 kV) is applied. On foils of 30 mm diameter, spots ranging from 10 to 30 mm could be sprayed without problems, even at deposit thicknesses up to  $2 \text{mg}/\text{cm}^2$ . Vacuum deposition of gold on self-supporting foils is no problem if deposition is done carefully. Metallisation with gold can however be done, when the foil is still on the glass plate, provided that the foil is released immediately after deposition.

Evaporations of  $\text{LiF}$ ,  $\text{NpF}_4$  and  $\text{PuF}_3$  were carried out, up to thicknesses of  $100 \mu\text{g}/\text{cm}^2$ . The depositions have however to be carried out carefully, taking into account that the source-to-deposit distance must be high to avoid excessive heating.



Table IV : Examples of deposits realised on polysulfone foils of 12.5  $\mu\text{g}/\text{cm}^2$

Self supported foil Diameter (mm)	Preparation method	D E P O S I T		
		Material	Diameter (mm)	Thickness
14	VD	Au	> 14	20 $\mu\text{g}/\text{cm}^2$
30	VD	Au	> 30	20 $\mu\text{g}/\text{cm}^2$
30	ES	CrO <sub>2</sub>	10	2 mg/cm <sup>2</sup>
30	ES	CrO <sub>2</sub>	30	2 mg/cm <sup>2</sup>
30	VD	PuF <sub>3</sub>	20	20 $\mu\text{g}/\text{cm}^2$
14	VD	NpF <sub>4</sub>	5	95 $\mu\text{g}/\text{cm}^2$
20	VD	LiF	17	30 $\mu\text{g}/\text{cm}^2$
20	VD	LiF	25	30 $\mu\text{g}/\text{cm}^2$

VD = Vacuum deposition ; ES = Electro spraying

#### 4. CONCLUSION

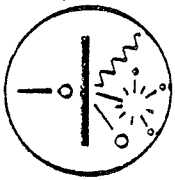
UDEL polysulfone P-1700 can be transformed into ultra thin films which - especially below 20  $\mu\text{g}/\text{cm}^2$  - show interesting properties as substrate foils for nuclear targets. Their mechanical, chemical, thermal and radiation properties are excellent in comparison with other useful foils, and moreover they can be prepared at such small thicknesses, that the energy loss of traversing nuclear particles can be reduced to a minimum.

#### ACKNOWLEDGEMENTS

The authors are grateful to Union Carbide Benelux N.V. for providing the base material for this study. They also acknowledge the assistance of Messrs. H. Mast and R. Eykens, who prepared the deposits by electro spraying and vacuum deposition.

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targets  
(To be published)



Abstracts of the Papers presented at the  
INTDS Workshop in Argonne National Laboratory  
(Sept. 7 - 9, 1983)



The proceedings will be published as an ANL report

ATLAS Beam Properties: Some Implications for  
Target Making\*

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The expansion of the tandem-linac booster into the Argonne Tandem-Linac Accelerator System, ATLAS, is approximately 40% complete. When completed, the facility will provide beams of heavy ions from lithium to tin with energies eventually, to 25 MeV/amu. The existing facility continues to provide beams for the experimental program in nuclear and atomic physics during the construction phase. The booster system is capable of accelerating ions as heavy as selenium with energies of 10 MeV/amu for the lighter ions.

The good beam quality provided by the linac means that multiple scattering, energy straggling, and target inhomogeneities are major factors in the resolution attainable in experiments. The beam properties that can be expected from ATLAS will be discussed and the present state of high resolution experiments will be reported.

\*This research was supported by the U. S. Department of Energy under Contract W-31-109-Eng-38.

SPECIAL ASPECTS OF TARGETS FOR HIGH  
INTENSITY HEAVY ION ACCELERATOR BEAMS

H. Folger, G.S.I.

Heavy Ions, Targets and Research at HHIRF

J. L. C. Ford

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The Holifield Heavy Ion Research Facility (HHIRF) typifies a new generation of heavy ion accelerators capable of producing high resolution beams with sufficient energy to study nuclear reactions across the periodic table. Exploiting the capabilities of the machine depends on the availability of thin foils at each stage of the experimental process. Rugged carbon foils are needed in the tandem and cyclotron to strip injected ions up to high charge states. Experimental success largely depends on the availability of a suitable target for bombardment which imposes new demands on the target maker. Many experiments use large solid angle gaseous counters with very thin foils as windows. The accelerators, experimental apparatus, and beam characteristics will be described. Target requirements demanded by different types of experiments will be discussed. These requirements have led to the construction of specialized apparatus such as the supersonic gas jet target and the single crystal goniometer for blocking measurements.

\*Operated by Union Carbide Corporation under contract W-7405-eng-26 with the U.S. Department of Energy.

"SOME METHODS AND PROBLEMS ASSOCIATED WITH MAKING THICK  
( $1\text{MG}/\text{cm}^2$ )<sup>28,29,30</sup> SILICON TARGETS"

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University of Washington, Seattle, WA 98195

The unique difficulties of evaporating enriched silicon starting with the oxide are cited and the literature reviewed and discussed briefly. A procedure is reported which has shown some degree of success.

ECONOMICAL TARGET PREPARATION PROCEDURES

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Techniques for target preparation with a minimum consumption of isotopic material are described. The rotating substrate method is discussed in some detail.

EXPERIMENTS WITH HEAVY ION ACCELERATORS\*

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Studies of nuclear structure at high excitation energy and very large angular momentum are currently one of the main research topics at the Argonne Superconducting Linac. Using  $\gamma$ -ray spectroscopy techniques, collective and single-particle degrees of freedom are investigated. In this presentation, some of the techniques used in the experiments will be described and some of the more recent results will be presented. Special emphasis will be placed on the present knowledge of the evolution of nuclear shapes with rotational frequencies.

\*This research was supported by the U. S. Department of Energy under Contract W-31-109-Eng-38.

A NEW FOIL STRETCHER FOR RECOIL DISTANCE TARGETS  
AND STOPPERS\*

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A new design for a target holder to produce stretched foils for recoil-distance ("plunger") lifetime measurements is described. The foil tension is obtained by compression of an O-ring in contact with the foil, which is thereby stretched over an aluminum ring, one end of which has been optically polished. The new stretchers have been used in an actual measurement with the ANL plunger apparatus, and were found to be fully satisfactory. Using two gold foils, a minimum distance of 3  $\mu\text{m}$  before electrical contact has been obtained. The main advantage of the new holders is the ease and reliability with which good quality stretched foils can be produced. Using evaporated gold foils of about 2  $\text{mg}/\text{cm}^2$  thickness, a success rate of close to 100% can be achieved with a little practice.

\*This research was supported by the U. S. Department of Energy under Contract W-31-109-Eng-38.

"COMPUTER CONTROLLED TARGET STORAGE SYSTEM"\*

Bruce G. Nardi and J. N. Worthington

Argonne National Laboratory, Argonne, IL 60439

A description of a computer controlled target storage system for hygroscopic or readily oxidized targets is given. Computer control will alleviate problems caused by power failure or user error. A low power, battery backup, CMOS computer will control and report errors. System status and integrity can be verified or reported via phone lines.

\*This research was supported by the U. S. Dept. of Energy under Contract W-31-109-Eng-38.

LASER ISOTOPE SEPARATION TECHNIQUES FOR TARGET AND  
OTHER MATERIALS\*

William H. McCulla

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An overview of both atomic and molecular laser isotope separation techniques will be presented. With the exception of uranium, most experimental efforts have been concentrated on isotopes of  $Z < 18$ . Some of these efforts will be reviewed along with successful methods on isotopes of elements of  $Z \geq 18$ . The general application of laser isotope separation to isotopes of interest in target and other materials preparation will be discussed.

\*This research was supported by the U.S. Department of Energy under Contract W-7405 eng 26.

ALTERNATIVE ISOTOPE ENRICHMENT PROCESSES\*

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Alternative processes such as gas centrifugation, plasma separation, and laser excited separation are evaluated for use at the ORNL Stable Isotope Enrichment Facility. The applicability of each process to the isotopic enrichment of the calutron feed material and to the selective production of isotopes is determined. The process labor and energy demands are compared to those of the existing facilities. The isotopic enrichment of the feed material prior to a first-pass through the calutrons can result in a significant saving in both labor and energy.

\*Research sponsored by the Office of Basic Energy Science, U. S. Department of Energy under contract W-7405-eng-26 with the Union Carbide Corporation.

"THE PREPARATION OF  $^{235}\text{U}\text{Ir}_2$  TARGETS FOR USE IN g-FACTOR MEASUREMENTS OF FISSION ISOMERS"\*

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G. Schatz, G.D. Sprouse, S. Vajda and S.Y. Zhu

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The cubic, nonparamagnetic alloy,  $^{235}\text{U}\text{Ir}_2$ , was found to be a good host for the preservation of nuclear alignment in the g-factor measurement of the  $\tau=122(10)$  ns fission isomer of  $^{237}\text{Pu}$ . This paper discusses, in detail the preparation of the thin-film targets used in this measurement. These techniques were found to apply to other similar actinide alloys such as  $\text{NpRu}_2$ .

\*Supported in part by the National Science Foundation.

THE CONVERSION OF  $^{41}\text{KCl}$  TO  $^{41}\text{KOH}$  OR  $^{41}\text{KF}$  FOR PRESSED POWDER TARGETS\*

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After much effort to convert  $\text{KCl}$  to chlorine-free  $\text{KOH}$  by forming a mercury/potassium amalgam, we abandoned the pursuit in favor of a simple electro-chemical cell in which silver foil was used as a sacrificial anode. This procedure and the method we used to make pressed powder targets from  $^{41}\text{KOH}$  and  $^{39}\text{KF}$  will be described.

\*Work supported in part by the National Science Foundation



THE ROLE OF THE NUCLEAR PHYSICS TARGET LABORATORY IN THE  
NEW CHALK RIVER HEAVY ION FACILITY

By

J.L. Gallant

ABSTRACT

The new Chalk River Tandem Accelerator Superconducting Cyclotron Complex (TASCC) will consist of a 13 MV MP Tandem injecting into a K-520 (ME/q<sup>2</sup>) Superconducting Cyclotron. Physics research will be carried out in such fields as the study of nuclei far from beta stability, heavy ion reactions, study of nuclei at very high spin, atomic physics, etc. The laboratory will supply not only the targets needed for the experiments, but also the large quantity of carbon stripper foils for the cyclotron, and large polypropylene windows needed for various detectors. It will supply other laboratories, on a limited basis, with materials such as carbon-14 and tritium targets.

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PREPARATION OF CONDUCTIVE POLYPROPYLENE FILMS FOR PARALLEL  
PLATE AVALANCHE COUNTERS

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A technique is described for evaporating a conductive coating on stretched polypropylene films. These are used as electrodes in a parallel plate avalanche counter for heavy ions. The films also have applications as windows for high vacuum isolation, soft x-ray proportional counters, gas absorption cells and energy loss nuclear detectors.

"THIN SELF-SUPPORTING Dy, Er, Gd AND Yb TARGETS FOR CHARGED PARTICLE SPECTROSCOPY"

Donald J. Yaraskavitch and Y.K. Peng

Tandem Accelerator Laboratory, McMaster University,  
Hamilton, Ontario, Canada L8S 4K1

A technique is described for the production of 100 to 300  $\mu\text{g}/\text{cm}^2$  self-supporting Dy, Er, Gd and Yb targets. The targets are prepared by a simultaneous metallothermic reduction of the oxide and vapour deposition onto a NaCl substrate. Special techniques are described for stripping and mounting of the self-supporting targets. Examples of the improvement in the results for self-supporting compared with carbon backed targets are shown.

FABRICATION OF SELF-SUPPORTED OXIDE TARGETS BY CATIONIC ADSORPTION IN CELLULOSIC MEMBRANES AND THERMAL DECOMPOSITION\*

Thomas C. Quinby

Oak Ridge National Laboratory, Oak Ridge, TN 37830

Techniques for producing relatively durable oxide films of various elements will be described. Areal densities of films produced to date have ranged from 150  $\mu\text{g}/\text{cm}^2$  to 2.5  $\text{mg}/\text{cm}^2$ , many being virtually transparent. Films produced by this technique were weighed directly and mounted on frames. General parameters for use of this technique will be discussed.

\*Research sponsored by the Office of Basic Energy Sciences, U. S. Department of Energy, under contract W-7405-eng-26 with the Union Carbide Corporation.

EXPERIENCE USING A SADDLE FIELD ION SOURCE FOR  
SPUTTERING\*

George E. Thomas

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A discussion will be presented concerning the method of setting up a saddle field ion source for sputtering thin films. Preliminary results will be presented for sputtering rates of different materials.

\*This research was supported by the U. S. Department of Energy under Contract W-31-109-Eng-38.