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More than 60 Years VON ARDENNE Electron Beam Technology - From the Roots to Today's Components and Applications. In Memoriam Dr. Robert Bakish (* 1926, +2019)

Matthias Neumann, VON ARDENNE GmbH, Dresden, Germany

With the development of the first electron beam melting furnace and EB gun in 1959, the former VON ARDENNE Research Institute marked a milestone for continuing success in high power electron beam technology. Besides the well-established position in the eastern hemisphere Dr. Robert Bakish recognized the unique features of the VON ARDENNE EB guns and opened the door to the North American market. Leading metal producers take advantage of the robust and reliable equipment while coating and other special EB applications benefit from the wide variety of EB components and complete systems.

The presentation will focus on the North American development of high-power electron beam technology and the contribution of Dr. Robert Bakish, who over several decades was a major promoter as well as nucleus of the high-power EB technology community in the United States.

<https://www.svc.org>

DOI: <https://doi.org/10.14332/svc23.proc.0015>

VON ARDENNE

More than 60 Years VON ARDENNE
Electron Beam Technology
From the Roots to Today's Components
and Applications

*In Memoriam Dr. Robert Bakish *1926 +2019*

Matthias Neumann

VON ARDENNE GmbH, Dresden, Germany



AGENDA

Introduction

Manfred von Ardenne – Research Related to Electrons and Electron Beams

VON ARDENNE Electron Beam Technology

-  **First Electron Beam Gun and Melting Furnace**

-  **Historical Review of Electron Beam Equipment**

Dr. Robert Bakish

Key Person to Establish VON ARDENNE Electron Beam Systems in North America

VON ARDENNE Today

State of the Art Equipment and Competence

MANFRED VON ARDENNE

Scientist, Inventor & Entrepreneur

1907 – 1997

Key Inventions

- 1964** Installations for evaporation coating of thin films in a high vacuum for industrial applications
- 1959** The 45 kW electron beam multi-chamber furnace (EMO) for vacuum melting and refinement of reactive and refractory metals
- 1948** Duo-plasmatron ion source of high charge carrier density
- 1937** First scanning electron microscope
- 1930** First fully electronic television

His inventions laid the foundation for our work today in the fields of vacuum, plasma and electron beam technology.



HISTORY

VON ARDENNE Company History

Established 1928



Company Campus in Dresden, Germany

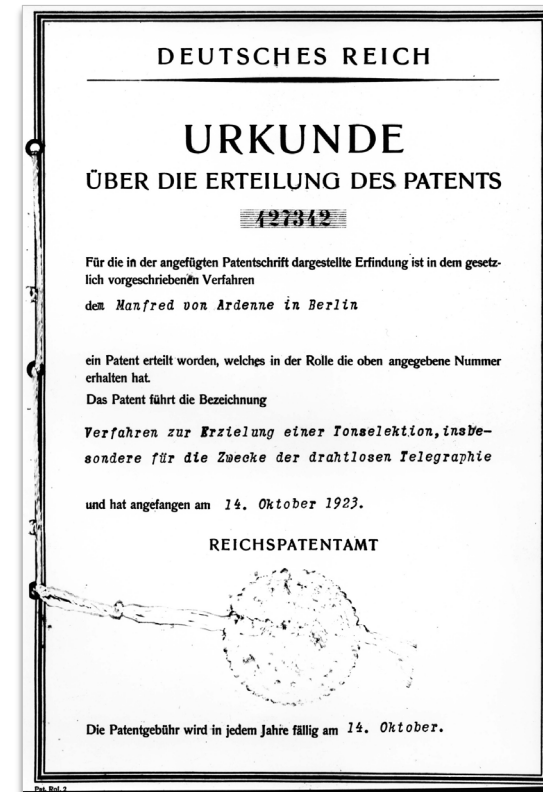
Milestones

- Today** VON ARDENNE Group (Dresden)
- 1991** VON ARDENNE Anlagentechnik GmbH (1991 - 2013)
- 1955** Manfred von Ardenne Research Institute (Dresden)
- 1945** Institute for Industrial Isotope Separation (Suchumi)
- 1928** VON ARDENNE Laboratory for Electron Physics (Berlin)

MANFRED VON ARDENNE

First Patent at Age of 16 Years

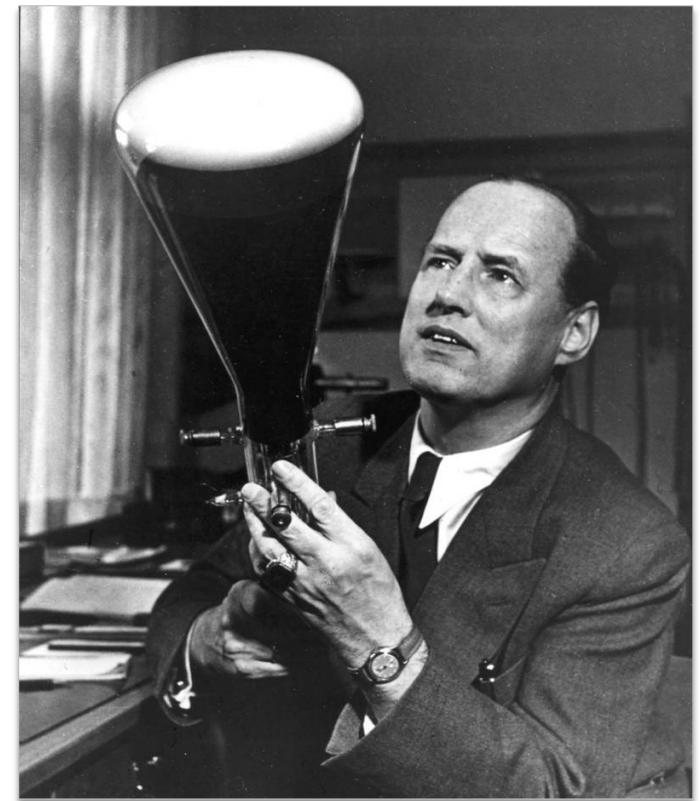
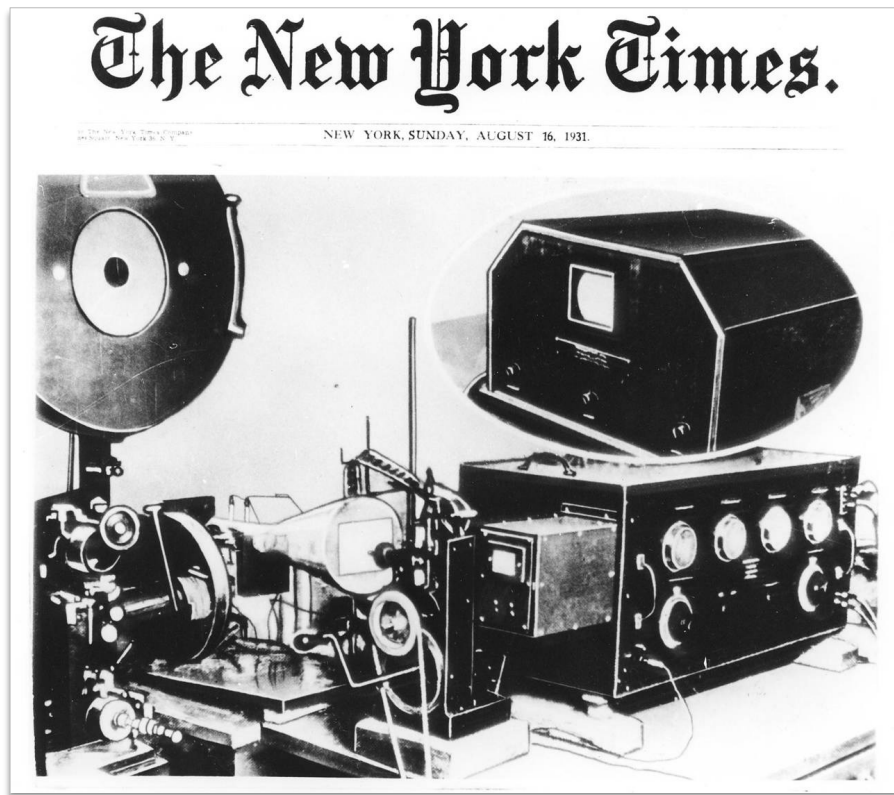
1923



MANFRED VON ARDENNE

World Premiere of Fully Electronical Television – „Flying Spot Scanner“

1931

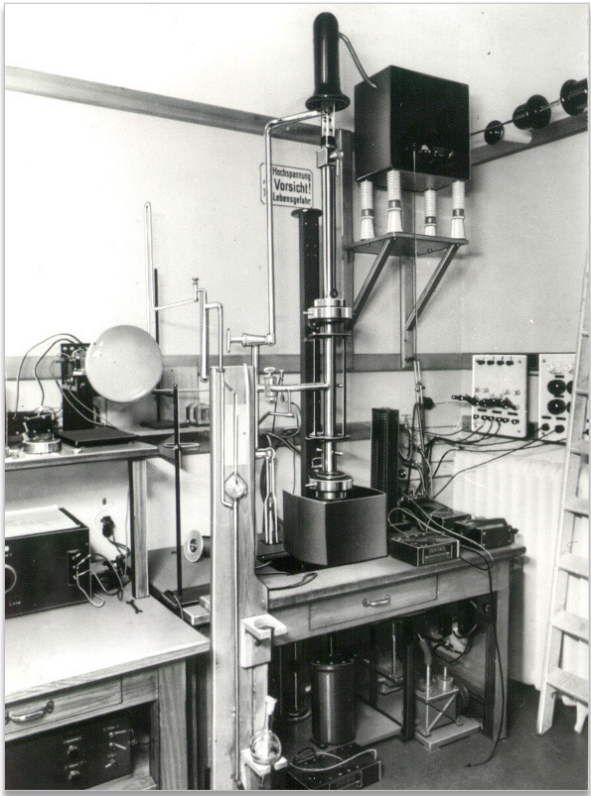
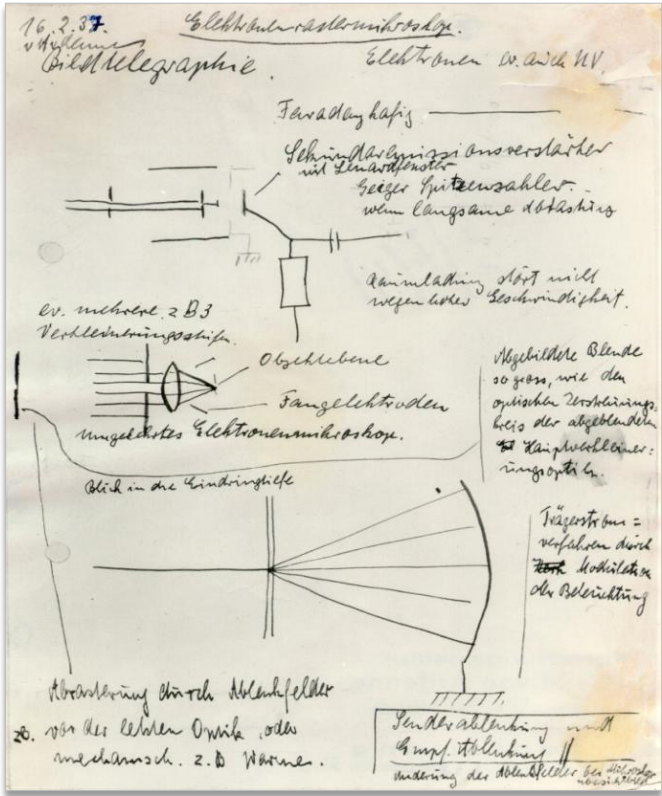


MANFRED VON ARDENNE

First Scanning Electron Microscope with High Depth of Focus and Resolution

1937

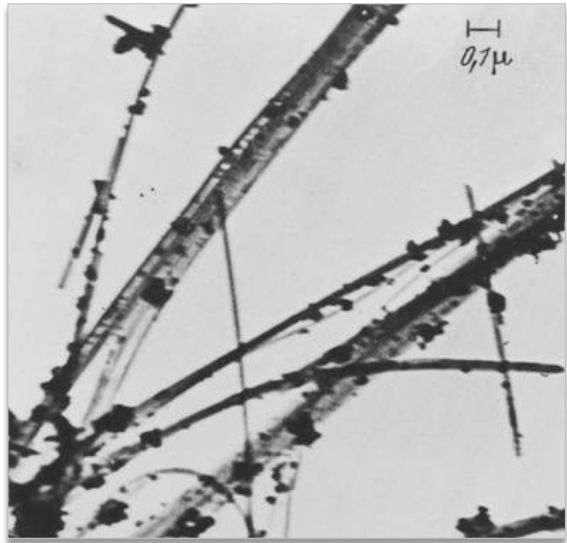
- Electron beam diameter of 10 nm



MANFRED VON ARDENNE

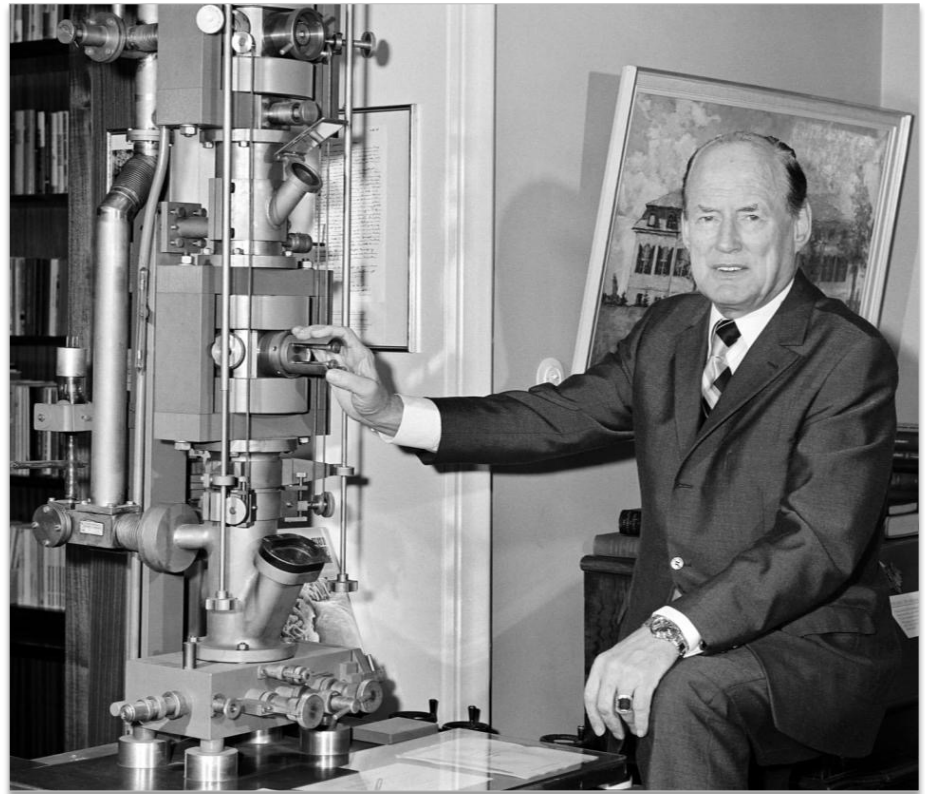
Universal Electron Microscope of Very High Resolution

1939



- Image Resolution of **1.2 nm**
- Between 1940 and 1953 Microscope of Highest Resolution Worldwide

(Photograph made in 1979)



MANFRED VON ARDENNE

Cooperations

□ 1934

Foundation „Leybold-von-Ardenne-Oszillographen-Gesellschaft“,
Cologne
→ Manufacturing of Parts for Electron Tubes
later relocated to Berlin

□ late 1930's

Transfer of Company
into Siemens Property
→ Requirements for More Capital

□ mid 1980's

Cooperation with Leybold,
Hanau
→ High Rate Magnetron Sputtering



VON ARDENNE ELECTRON BEAM TECHNOLOGY

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- **Historical Review of Electron Beam Equipment**

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Key Person to Establish VON ARDENNE Electron Beam Systems in North America

VON ARDENNE Today

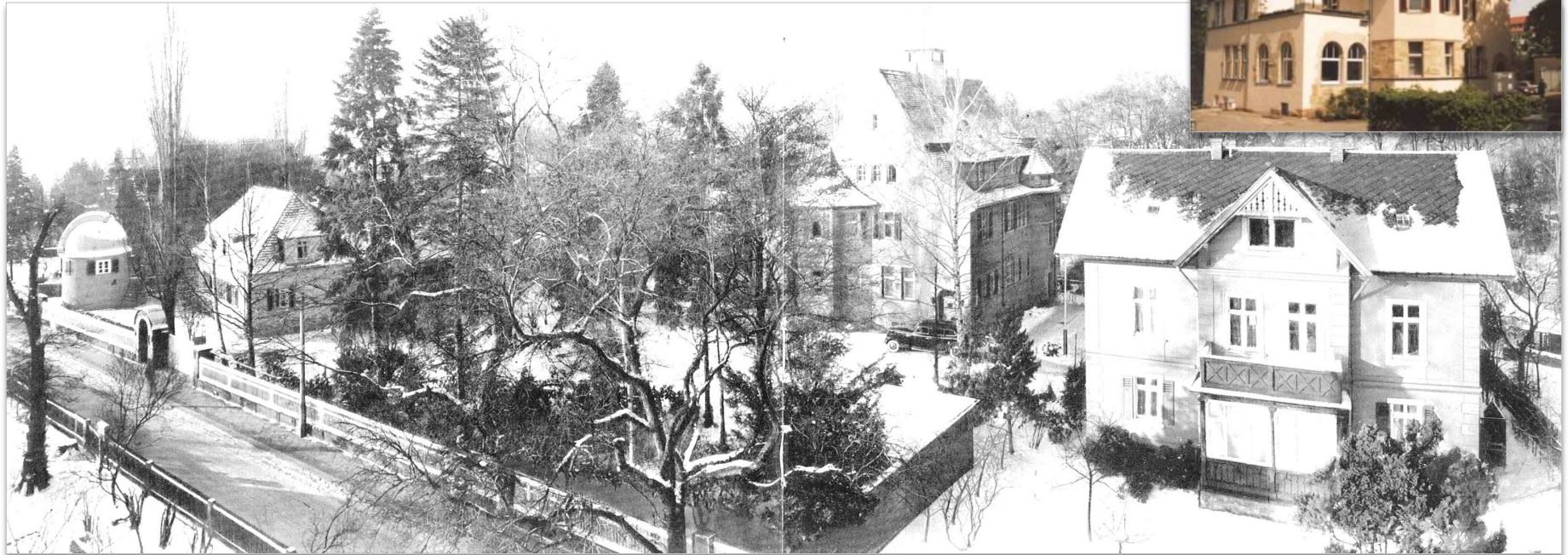
State of the Art Equipment and Competence

VON ARDENNE ELECTRON BEAM TECHNOLOGY

Manfred von Ardenne Research Institute Established in Dresden

1955

Former Main
Administration Building



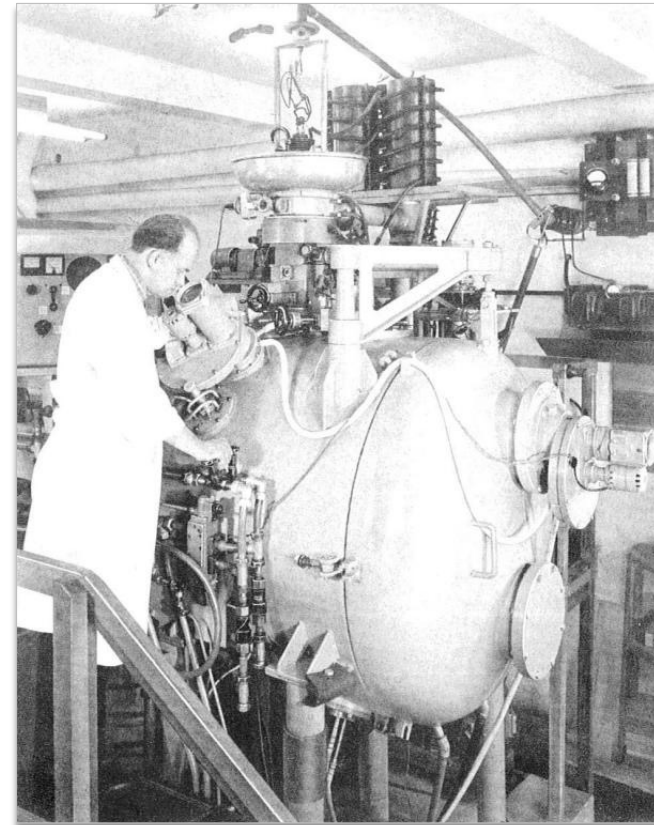
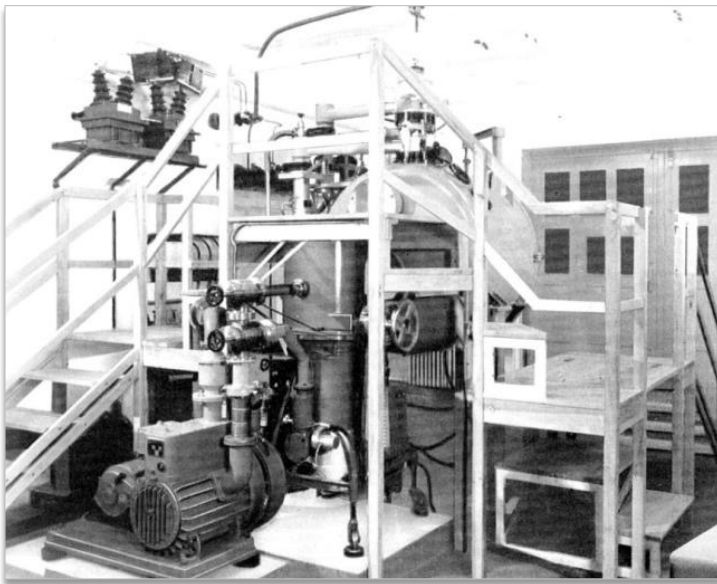
VON ARDENNE ELECTRON BEAM TECHNOLOGY

First 45 kW Multi-Chamber Furnace

1959

Highlights

- Whole Project Time: 7 months
- EB Gun: 45 kW, 24 kV
- Minimum Beam Diameter on Target: 3 mm at Beam Current of 2 A

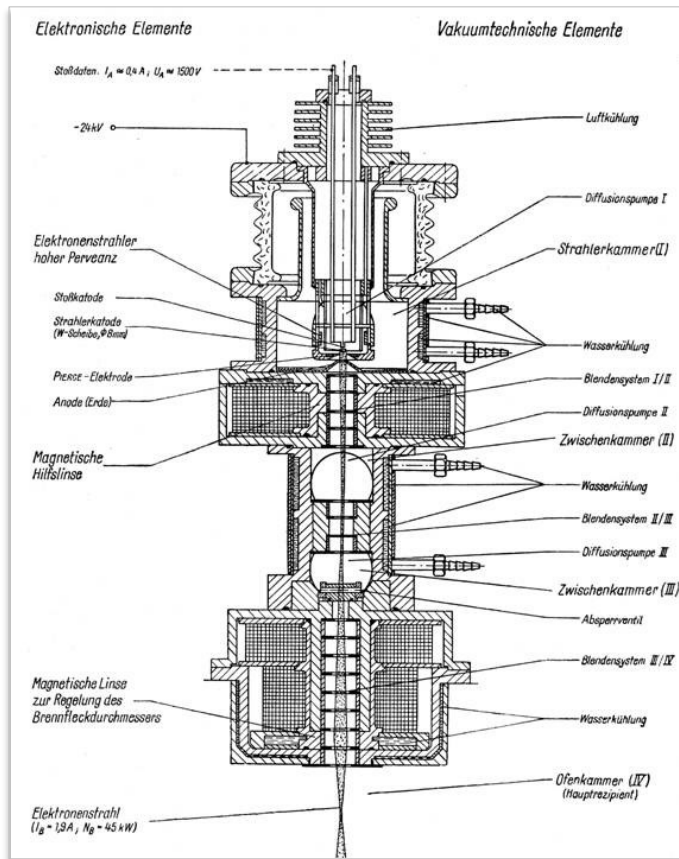


VON ARDENNE ELECTRON BEAM TECHNOLOGY

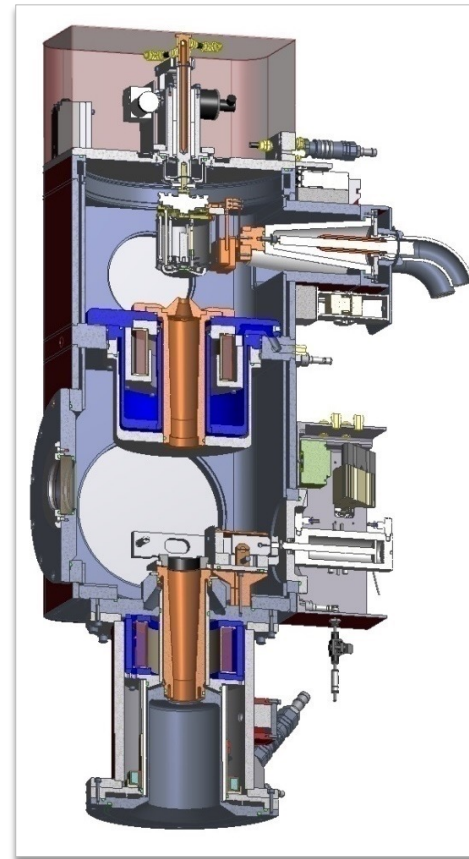
First Electron Beam Gun 45 kW / 24 kV

to 800 kW / 60 kV

1959



2004



VON ARDENNE ELECTRON BEAM TECHNOLOGY

First EMO 200 - Installed at Steel Mill in Freital (close to Dresden)

1963

Technical Parameters

EB Gun

200 kW, 30 kV

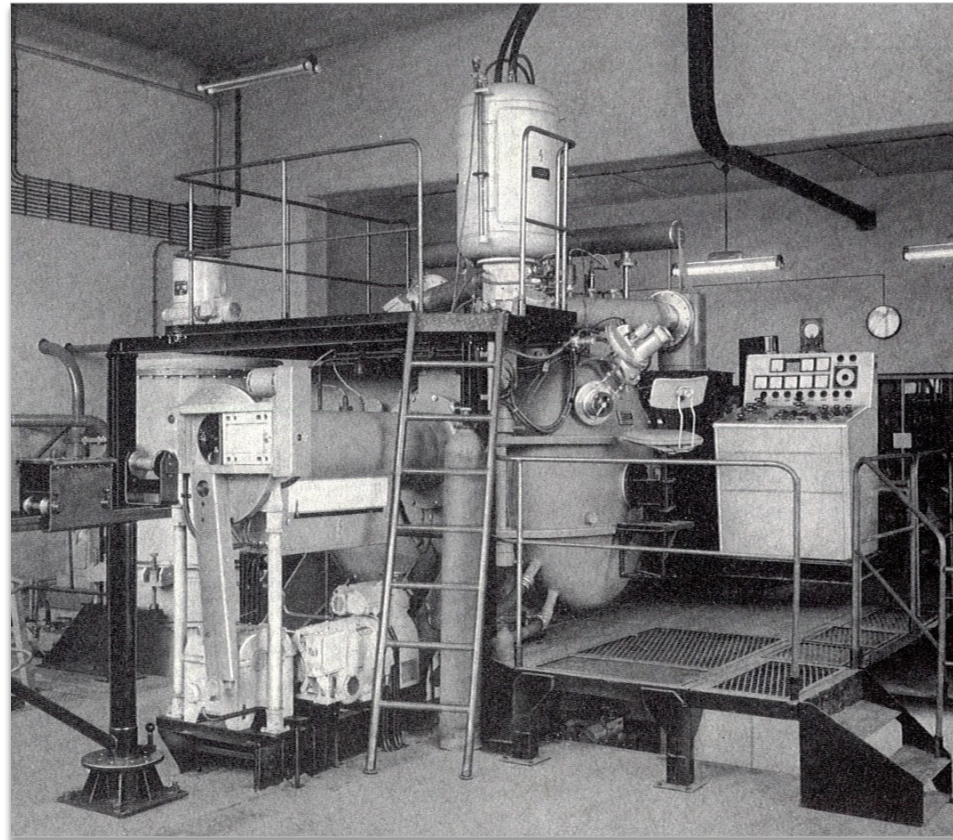
Productivity

Remelt of Steel Ingot

diameter	250 mm
length	1500 mm
weight	480 kg
melt rate	150 kg/h

Remelt of Tungsten Ingot

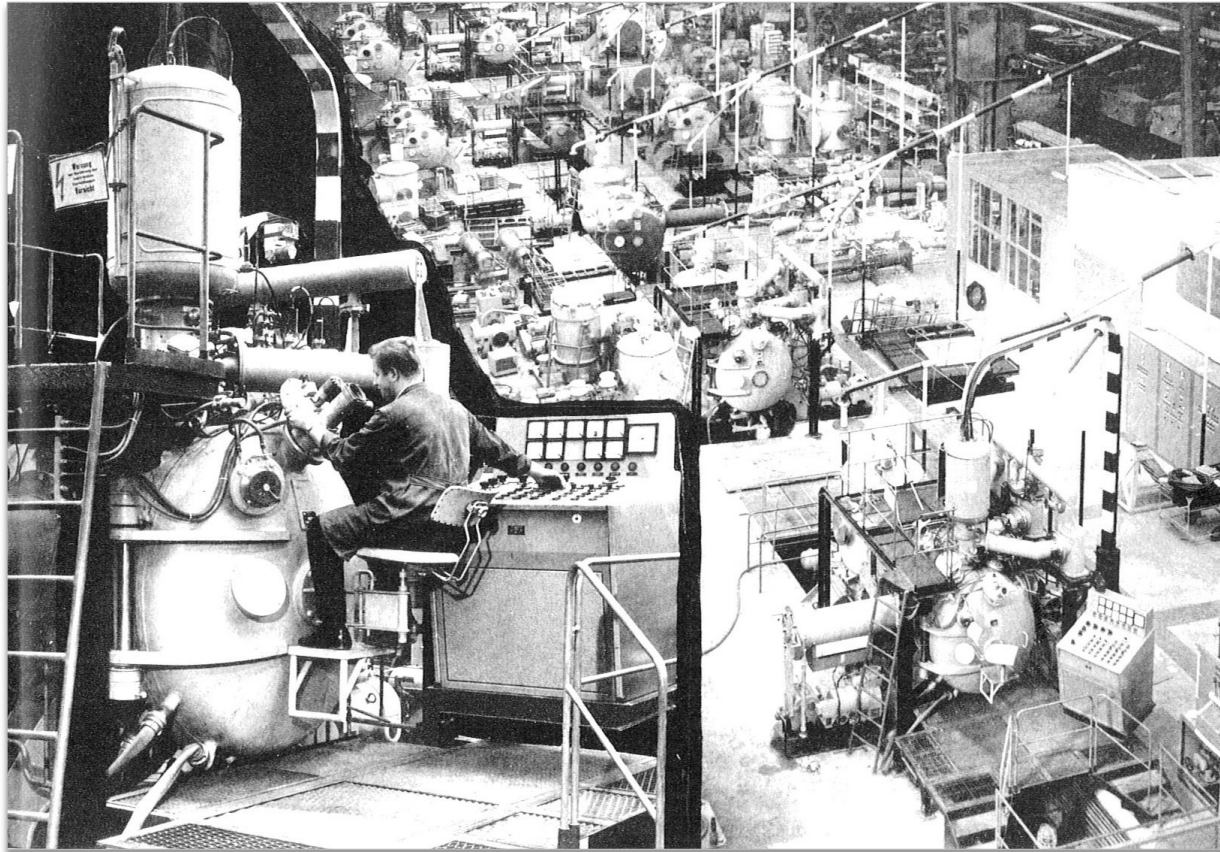
diameter	80 mm
length	1500 mm
weight	150 kg
melt rate	12 kg/h



VON ARDENNE ELECTRON BEAM TECHNOLOGY

Series Manufacturing of EMO 200 in Cooperation with LEW Hennigsdorf

1963



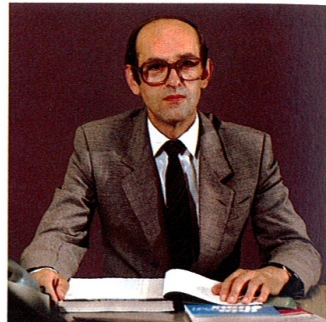
VON ARDENNE ELECTRON BEAM TECHNOLOGY

EB Equipment for Vacuum Metallurgy in Cooperation VON ARDENNE – LEW Hennigsdorf

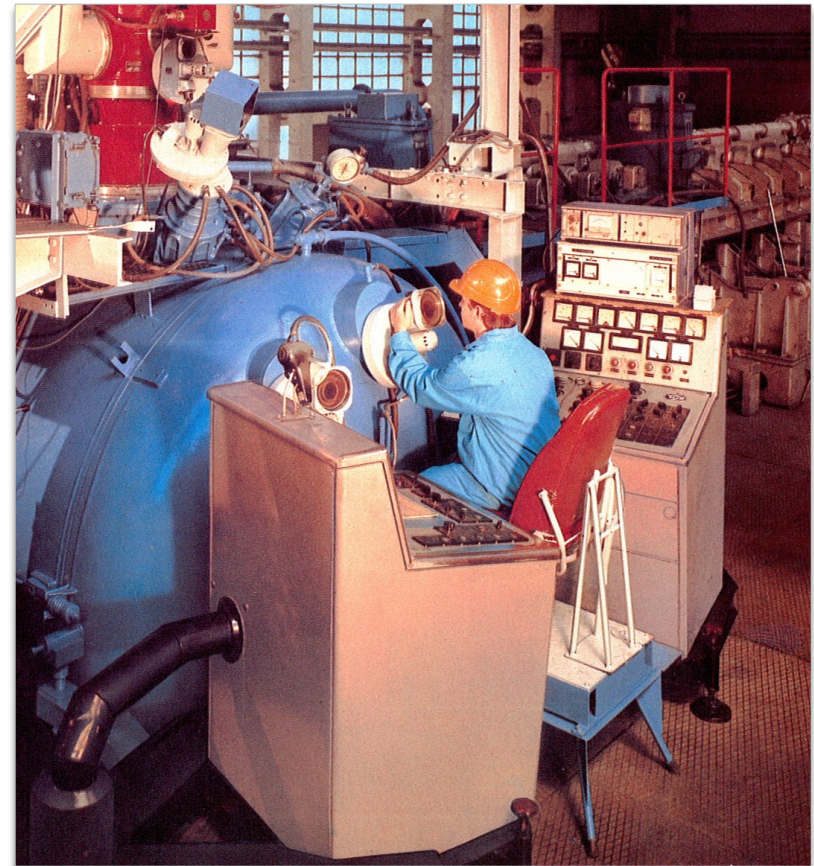
1963 - 1990



Oberingenieur Günter Hoffmann
Generaldirektor
Kombinat
VEB LEW Hennigsdorf



Prof. Dr. Siegfried Schiller
Stellvertreter des Institutsdirektors
Forschungsinstitut
Manfred von Ardenne





Kombinat
VEB Lokomotivbau-Elektrotechnische Werke
„Hans Beimler“, Hennigsdorf
Stammbetrieb
DDR – 1422 Hennigsdorf
Telefon: Hennigsdorf 50
Telex: 015 8531 lokh dd
Telegramm: Elektrok Hennigsdorf

 Mitglied im
Warenzeichenverband VEM

 Volkseigener Außenhandelsbetrieb
der Deutschen Demokratischen Republik
DDR – 1026 Berlin, Alexanderplatz 6, Haus der Elektroindustrie

VON ARDENNE ELECTRON BEAM TECHNOLOGY

EMO 1200 Drip Melt Furnace - Installed at Steel Mill in Freital (close to Dresden)

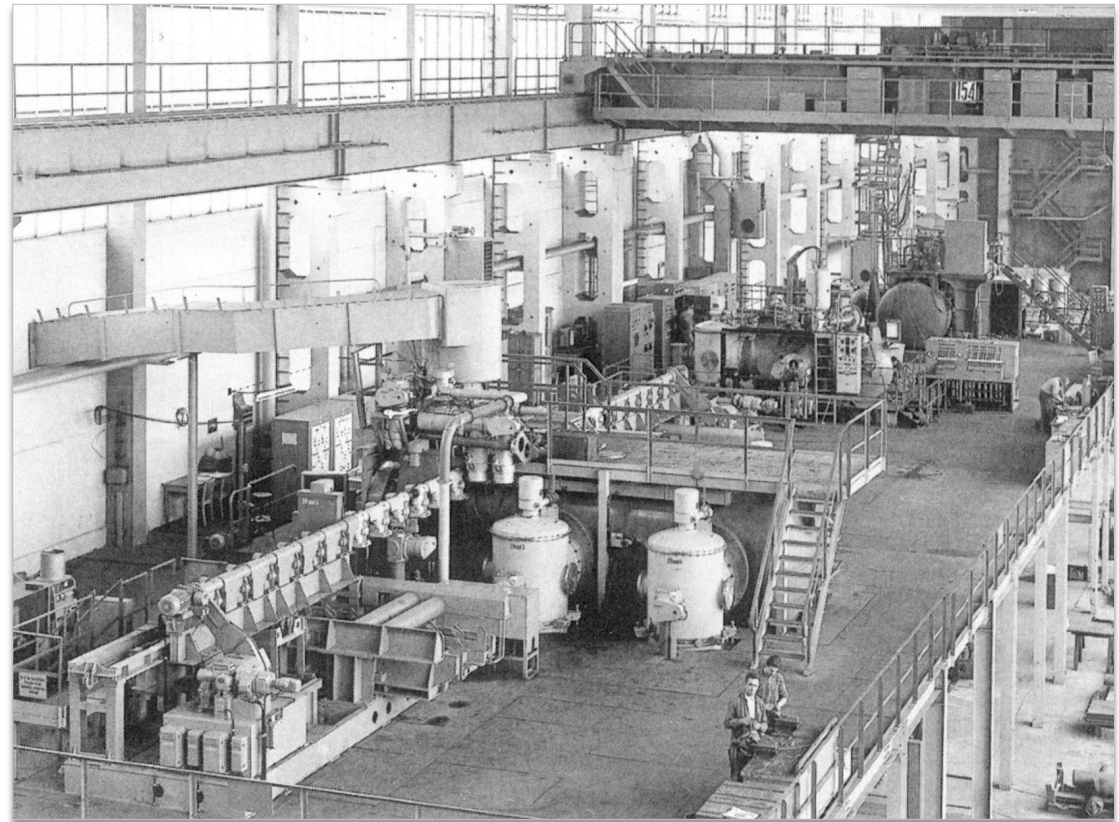
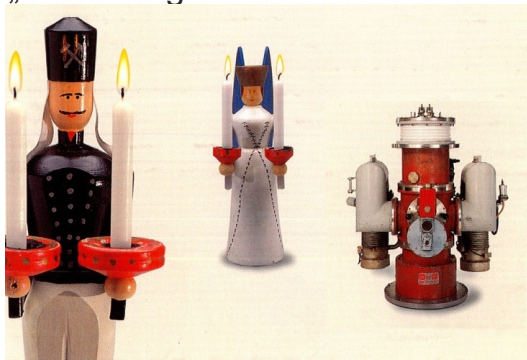
1964 - 1966

Cathode System

- Weight \approx 80 kg
- Cathode \varnothing 25 mm
- Filament with Support Wires
- Water Cooled

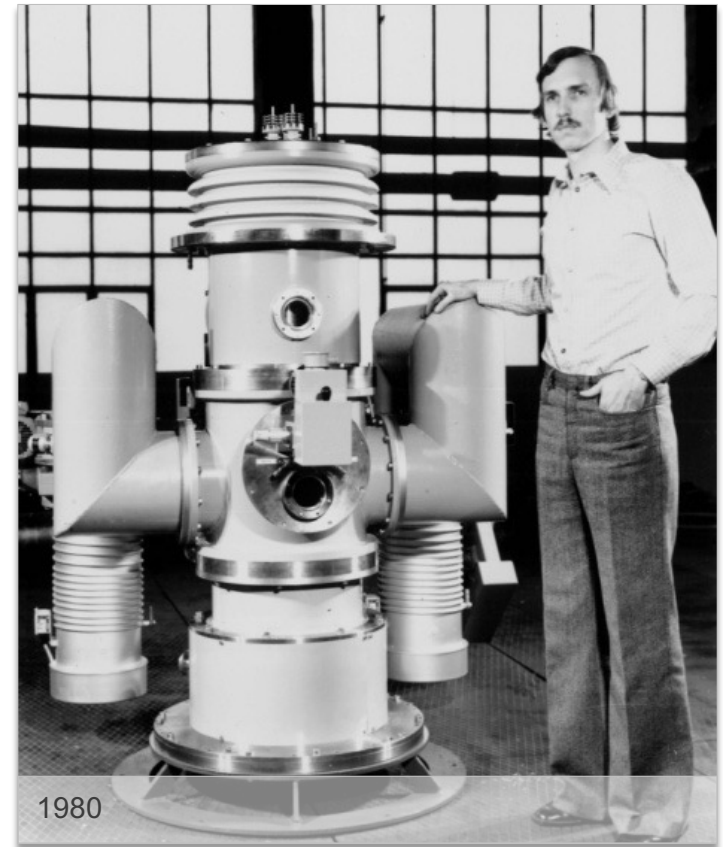
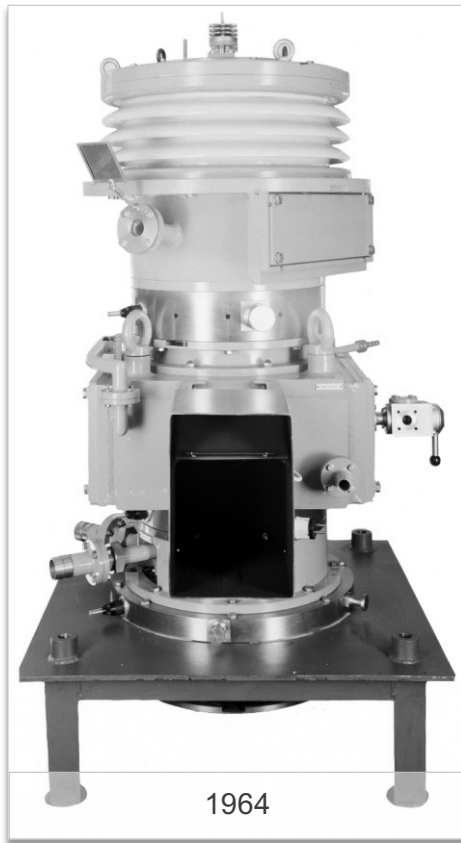


Nickname:
„Freital Angel“



VON ARDENNE ELECTRON BEAM TECHNOLOGY

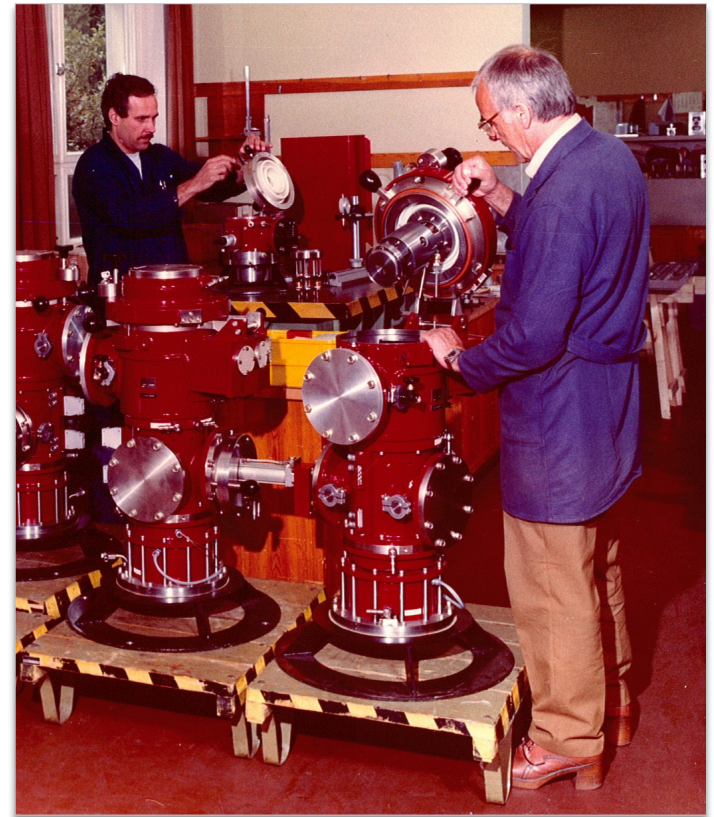
Electron Beam Gun EH1200/50 - Most Powerful EB Gun For Vacuum Metallurgy



VON ARDENNE ELECTRON BEAM TECHNOLOGY

Production of EB Guns - Assembly Workshop in Dresden

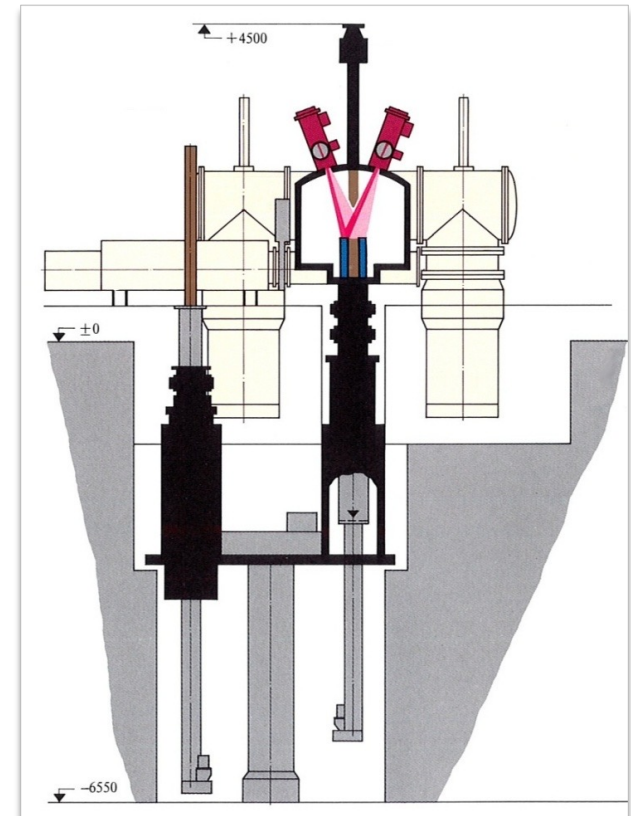
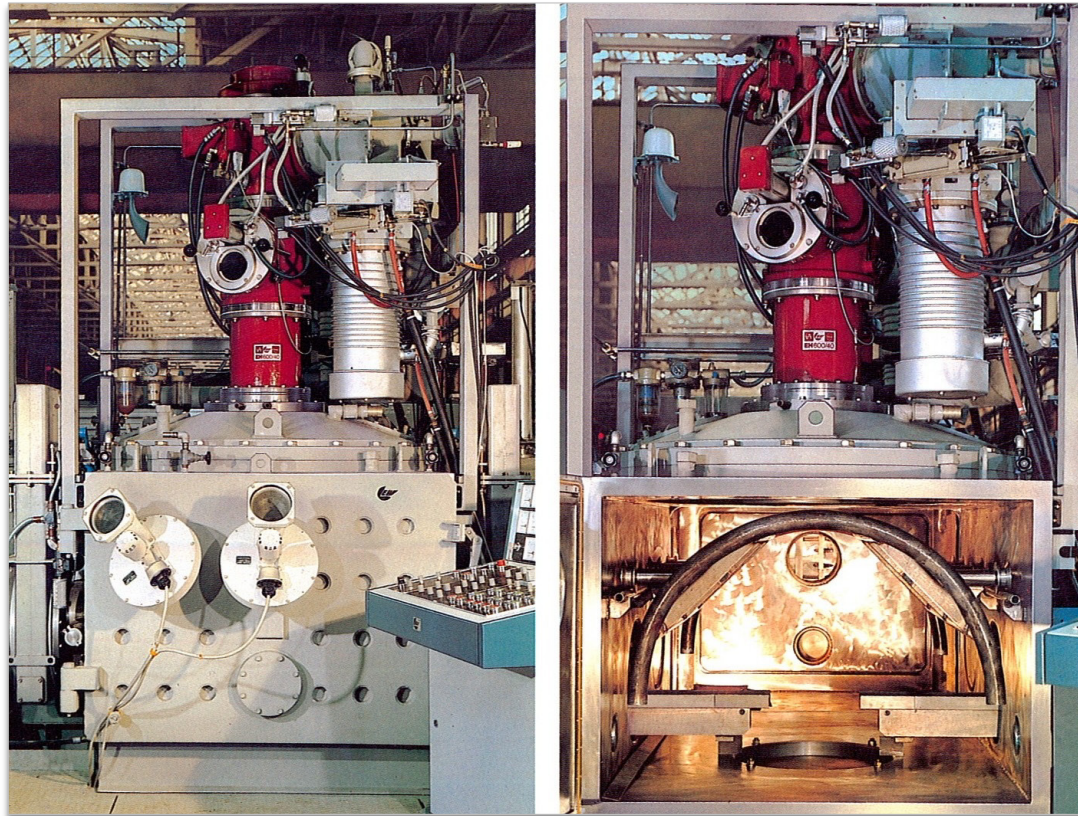
1985 - 1990



VON ARDENNE ELECTRON BEAM TECHNOLOGY

EMO 600 - Drip Melt Furnace with EB Gun EH600/40

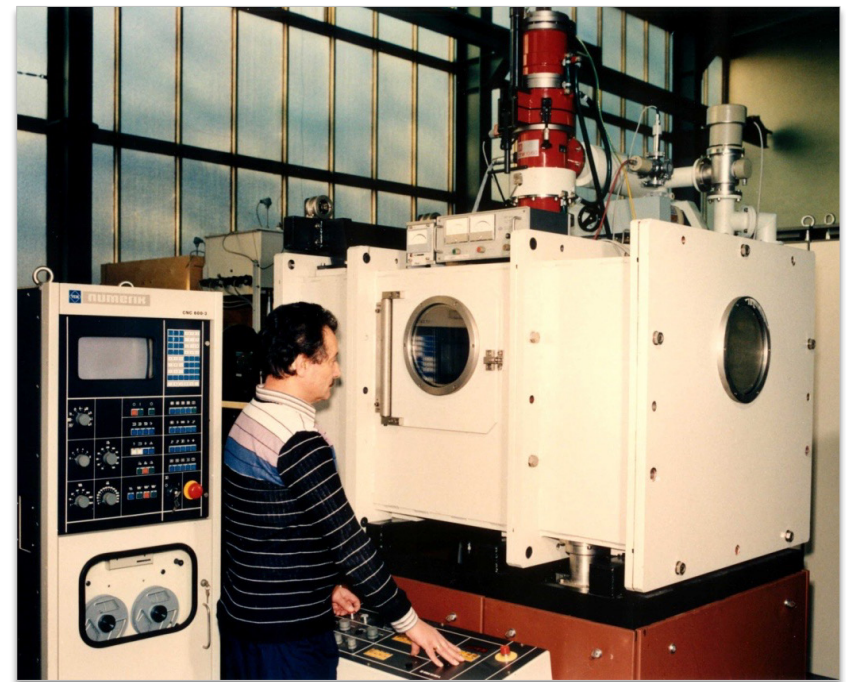
Since 1986



VON ARDENNE ELECTRON BEAM TECHNOLOGY

Electron Beam Welding

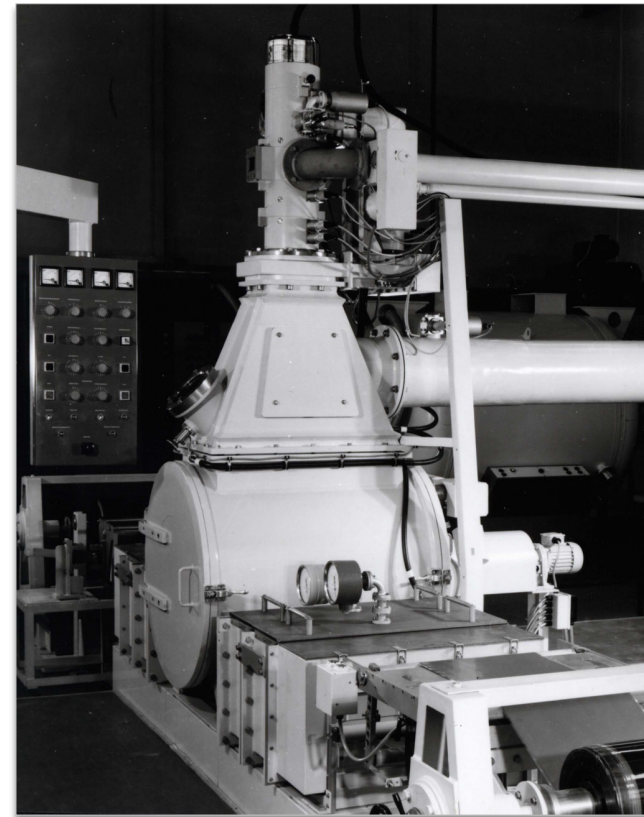
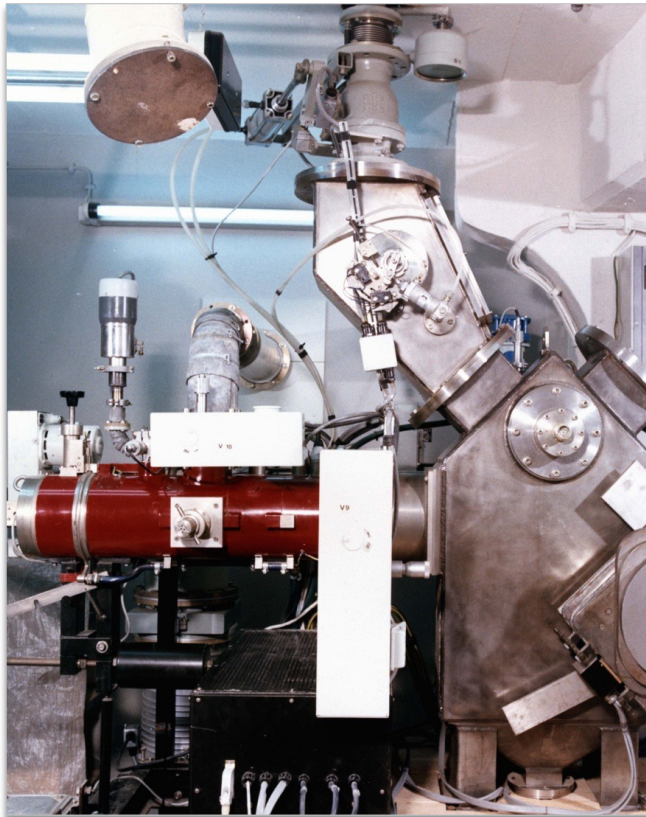
1970's - 1990



VON ARDENNE ELECTRON BEAM TECHNOLOGY

Treatment of Grain - Polymerization of Plastics

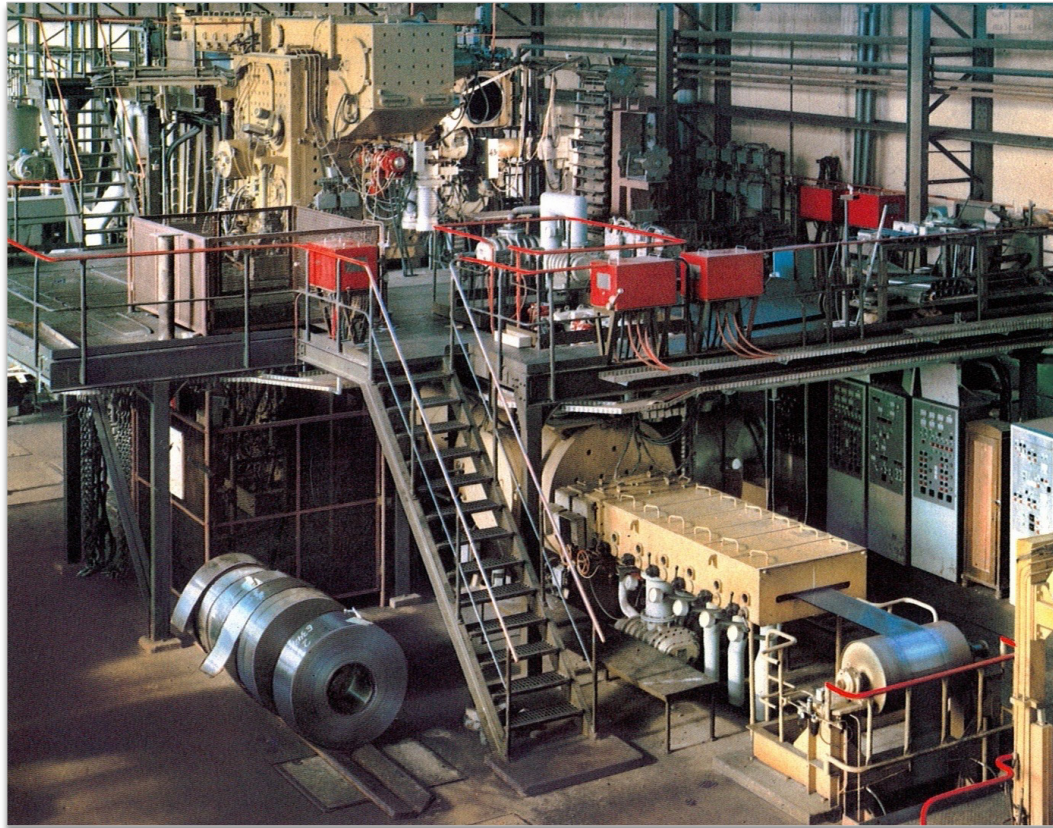
1970's - 1990



VON ARDENNE ELECTRON BEAM TECHNOLOGY

Steel Strip Coater

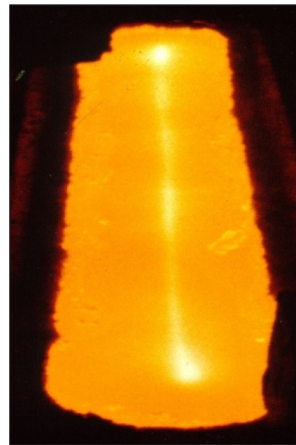
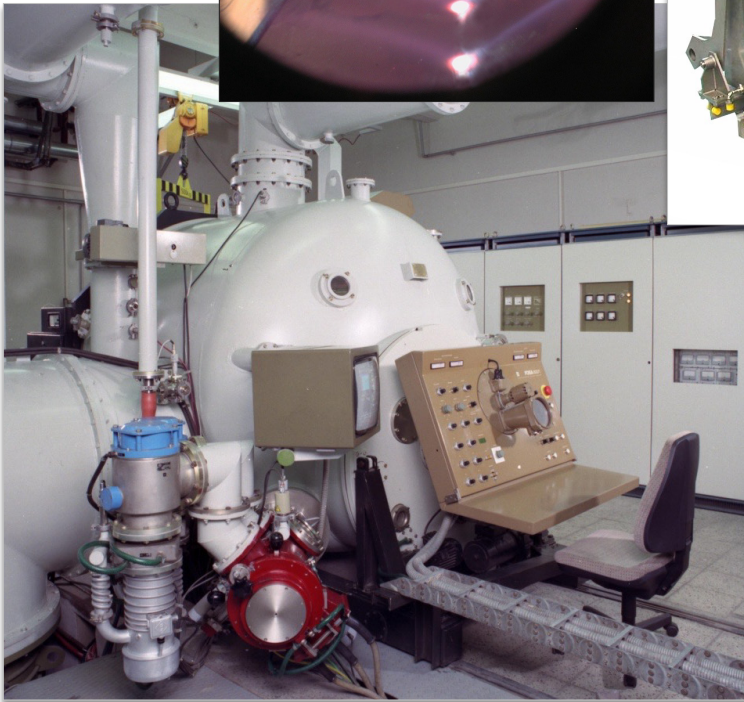
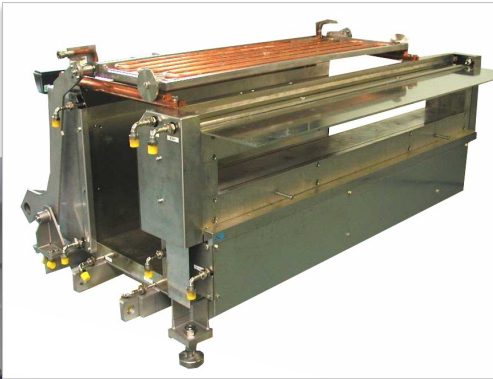
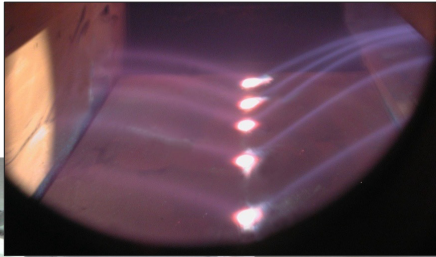
Since 1979



VON ARDENNE ELECTRON BEAM TECHNOLOGY

FOBA 800 – Web Coater with Magnetic Trap MT 1000

1986 - 2000



VON ARDENNE ELECTRON BEAM TECHNOLOGY

Coating Plants and Complete VON ARDENNE EB Melt Furnaces

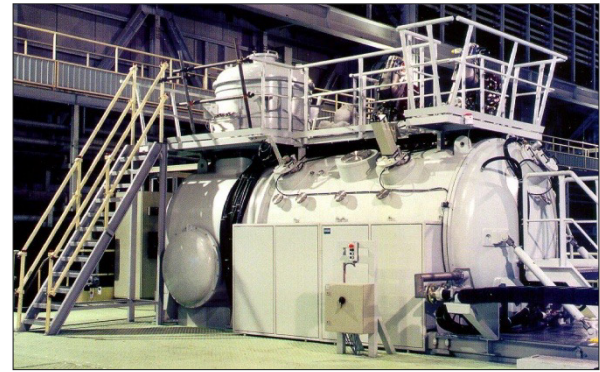
1990 - 2003



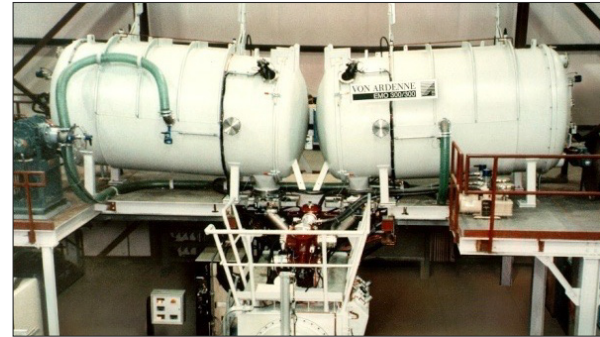
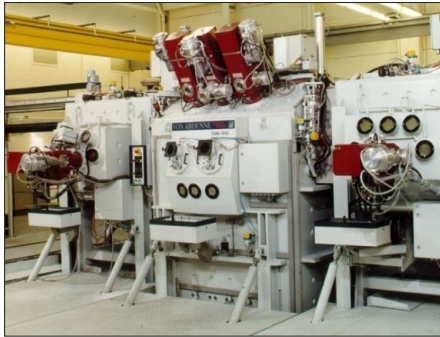
Strip and Web Coater



TBC Coater



EB Furnaces



DR. ROBERT BAKISH

Introduction

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Dr. Robert Bakish

Key Person to Establish VON ARDENNE Electron Beam Systems in North America

VON ARDENNE Today

State of the Art Equipment and Competence

DR. ROBERT BAKISH

Life Data and Education

- 04.01.1926** Born in Sofia, Bulgaria as Isi Ruben (Izzy Reuben) Bakish
- July 1944** Registered as immigrant in Haifa, Palestine
- May 1947** Arrival with family as immigrants at Ellis Island, New York
Documents issued under the name **Robert Bakish**
- 1952** Bachelor's degree in Metallurgy at
Columbia University School of Engineering
- 1953, 1955** Master's degree and PHD in Metallurgical Engineering
from Yale University
- 15.10.2019** Passed away in Englewood, NJ



DR. ROBERT BAKISH

Business Career

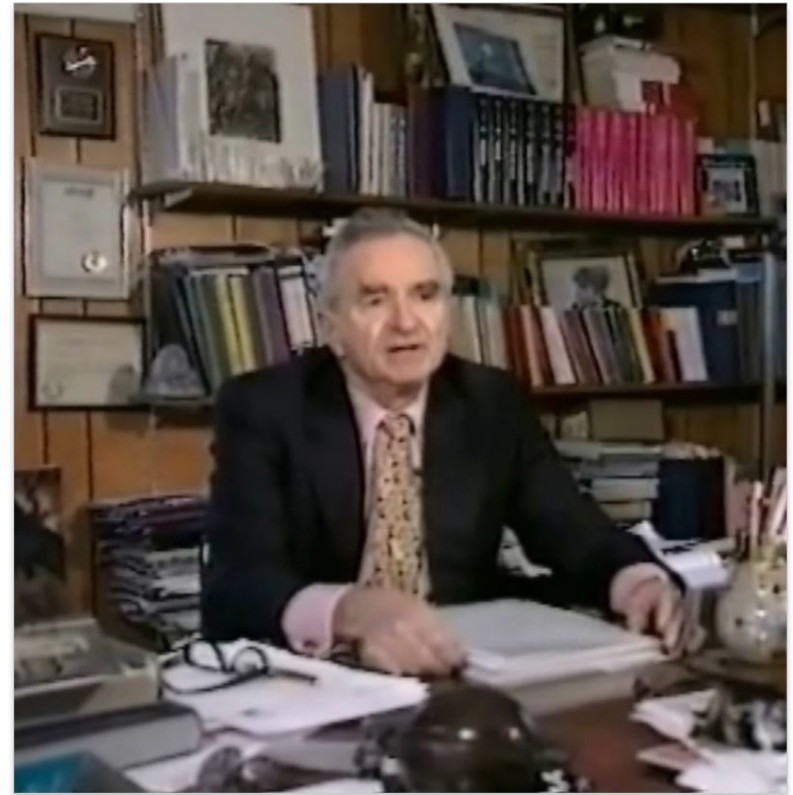
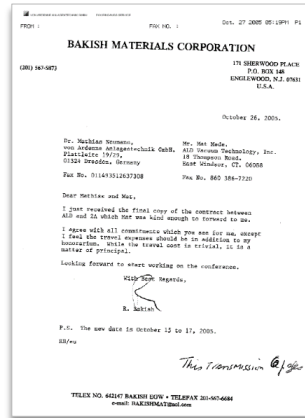
- (1955)** Senior metallurgist for Sprague Electric Co.
- (1957)** Consultant in charge of physical metallurgy for CIBA Basel, Switzerland
- (1958)** Vice president and director of research and development for Alloyed Electronics Corp.
- (1959)** Executive vice president of Electronics and Alloys Inc.
- 1960** Consultant for the Electro-Chemical Division of Republic Foil Inc., Danbury
- (1962)** Director of research and development Republic Foil Inc., Danbury



DR. ROBERT BAKISH

Bakish Materials Corporation

- 1961** First meeting with Prof. Manfred von Ardenne in Dresden
- (1966)** Foundation of Bakish Materials Corp., Englewood, NJ
- 1978** Import of first VON ARDENNE EB Guns into USA
- 2010** Formal retirement and closure of business activities further available as agent and consultant
- 2016** Business closed of Bakish Materials Corp.



DR. ROBERT BAKISH



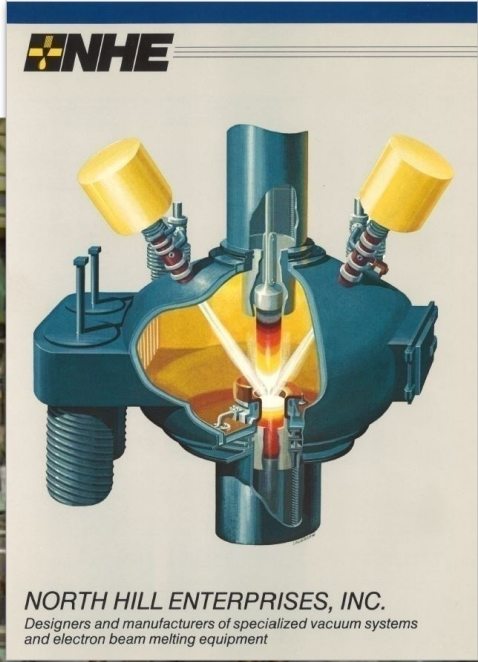
DR. ROBERT BAKISH

Bakish Materials Corporation

EB Systems for Vacuum Metallurgy



Cold Hearth Furnace (Ti)

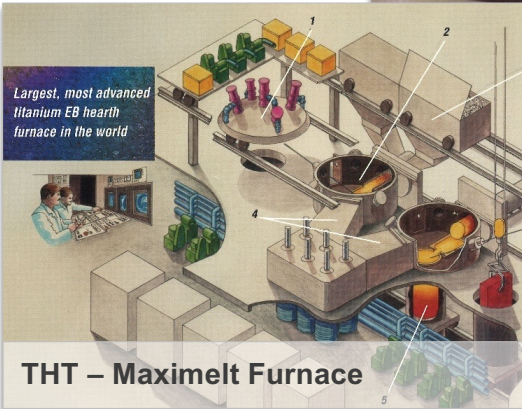


Drip Melt Furnace (Zr, Nb, Hf)

DR. ROBERT BAKISH

Bakish Materials Corporation

EB Systems for Vacuum Metallurgy



Largest, most advanced titanium EB hearth furnace in the world

THT - Maximelt Furnace

2.4 MW EB Titanium Cold Hearth Furnace



Titanium Slab

DR. ROBERT BAKISH

Teacher and Promoter

- Professor and Researcher at Fairleigh Dickinson University
- Assistant Professor at Columbia University
- Initiator and Organizer of Various International Technical Conferences
 - Electron and Ion Beam Science and Technology (1964 – 1980)
 - Pervaporation Processes in the Chemical Industry (1983 – 1989)
 - Electron Beam Melting and Refining (1983 – 2000)
continued as ebeam 2002 to ebeam 2016
 - The Laser vs (and) the Electron Beam in Welding, Cutting and Surface Treatment (1985 – 1991)
 - Web Coating (1987 – 1992), co-sponsored by BVT, Galileo, Vadeko
- Supporter of the US Titanium Industry
 - Axel Johnson – Titanium Hearth Technologies (THT) – Timet – PCC
 - Oremet – Allvac – ATI
- Promoter for Bulgarian Academy of Sciences, Sofia
 - Prof. Mladenov – EBT conferences Varna, Bulgaria



DR. ROBERT BAKISH

Teacher and Promoter

Conferences and Publications



DR. ROBERT BAKISH

Tributes for Lifetime Achievements



2007 - Manfred von Ardenne Memorial Colloquium, Dresden
Dr. Robert Bakish together with his wife Ellen and
Dr. Alexander von Ardenne



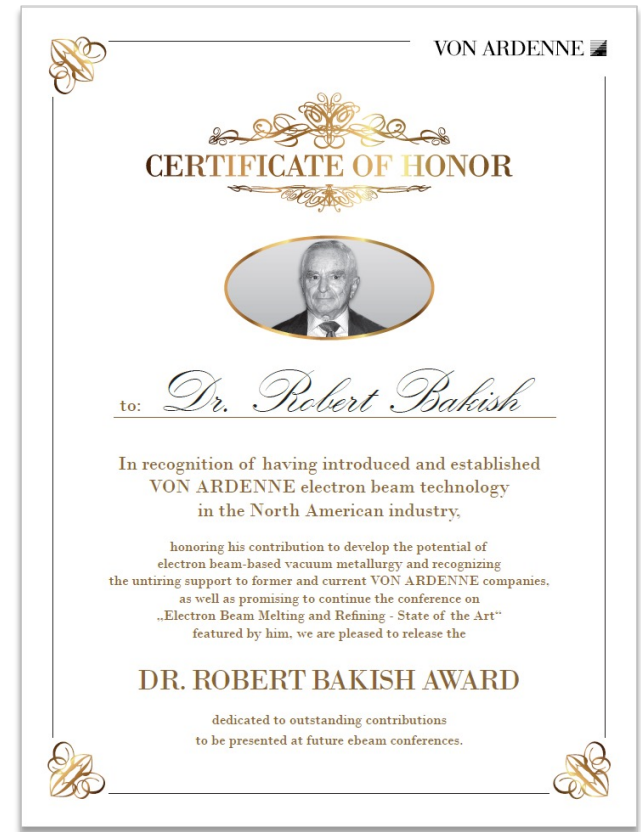
2009 - Dedication of Timet Melt Shop to Howard R. Harker

DR. ROBERT BAKISH

Tributes for Lifetime Achievements

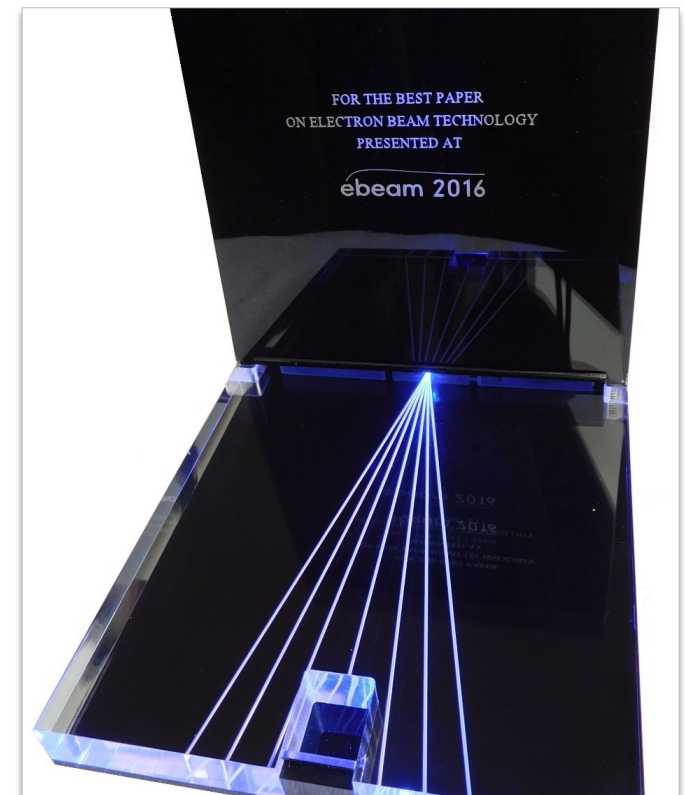


2011 – Celebration of Dr. Bakish’s 85th Birthday at the restaurant “Le Chateau”, former J.P. Morgan’s home in Connecticut



DR. ROBERT BAKISH

Tributes for Lifetime Achievements



DR. ROBERT BAKISH

Public Recognition

... in Israel



Ben Kish Lookout
 Dedicated on King Saul Mountain- The Bible Trail
 in Memory of
Robert (Izzy Reuben) Bakish
 1926-2019

From a family of underground fighters against the Nazis in Bulgaria.
 The Gilboa mountain range, at an altitude of 536 meters, in the north of the Samaria mountains, overlooking the Harod Valley, The Jordan Valley and the Moab Mountains in Jordan and the Nazareth Mountains. The Gilboa mountain is mentioned in the Bible in the book of Samuel, in the story of the fall of king Saul and his son Jonathan in the war against the Philistines and the mourning of David for them. Mount Saul (part of the Gilboa Mountain) is named after King Saul son of Kish, the first king of the kingdom of Israel in the 11th century BC.

"Ye mountains of Gilboa, let there be no dew nor rain upon you, neither fields of choice fruits. For there, the shield of the mighty was vilely cast away, the shield of Saul, not anointed with oil".
 Samuel 2, chapter 1, 21.

Tout commence ici • מאכן הכל צומח • The source of it all

Tutto inizia qui • כאן הכל צומח • Zaczęło tutaj

מצפור בן קיש
 הוקם ביוזמת משרד התרבות והעניינים ויוזמתו של
 מ.ב. כהנא. המצפור נמצא ברכס הגלבוה שבגליל
 ונשקף אל עמק חרוד, עמק הירדן ועמק המואב. המצפור
 נקרא על שם המלך שאול בן נחש, המלך הראשון של ישראל.
 המצפור נבנה על ידי משרד התרבות והעניינים ויוזמתו של
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 על שם המלך שאול בן נחש, המלך הראשון של ישראל.

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JEWISH NATIONAL FUND • יסודות לאומיים • KEHEN KAVEMETH LEISRAEL

The source of it all • מאכן הכל צומח • Tout commence ici

... in USA

American Foundation for Bulgaria presents
BULGARIAN CONCERT EVENINGS in NEW YORK
OPENING NIGHT GALA
 OCTOBER 28, 2021 | 7:30 PM EST
 in Memory of Robert Bakish

Thursday, OCTOBER 28, 2021 | 7:30 PM
OPENING NIGHT GALA
 in Memory of Robert Bakish
 Weill Recital Hall at Carnegie Hall
 154 West 57th Street, New York, NY 10019

BULGARIAN CONCERT EVENINGS in NEW YORK
 P. O. Box 231160
 New York NY 10023

Mariana Karpatova, mezzo-soprano
 Tereasa Payne, flute
 Billy Hunter, trumpet
 Alexandrina Boyanova, Stanichka Dimitrova, Georjy Valtchev, violin
 Anna Stoytcheva, Lora Al-Ahmad, Lora Tchekorotova, piano

Works by:
RACHMANINOFF, PIAZZOLLA, MINKIN, HOHNE, AL-AHMAD, KREISLER, LOEB

Tickets are \$30, \$50 and \$75 available at Carnegie Hall's Box Office, located at 57th Street and 7th Avenue, at www.carnegiehall.org.

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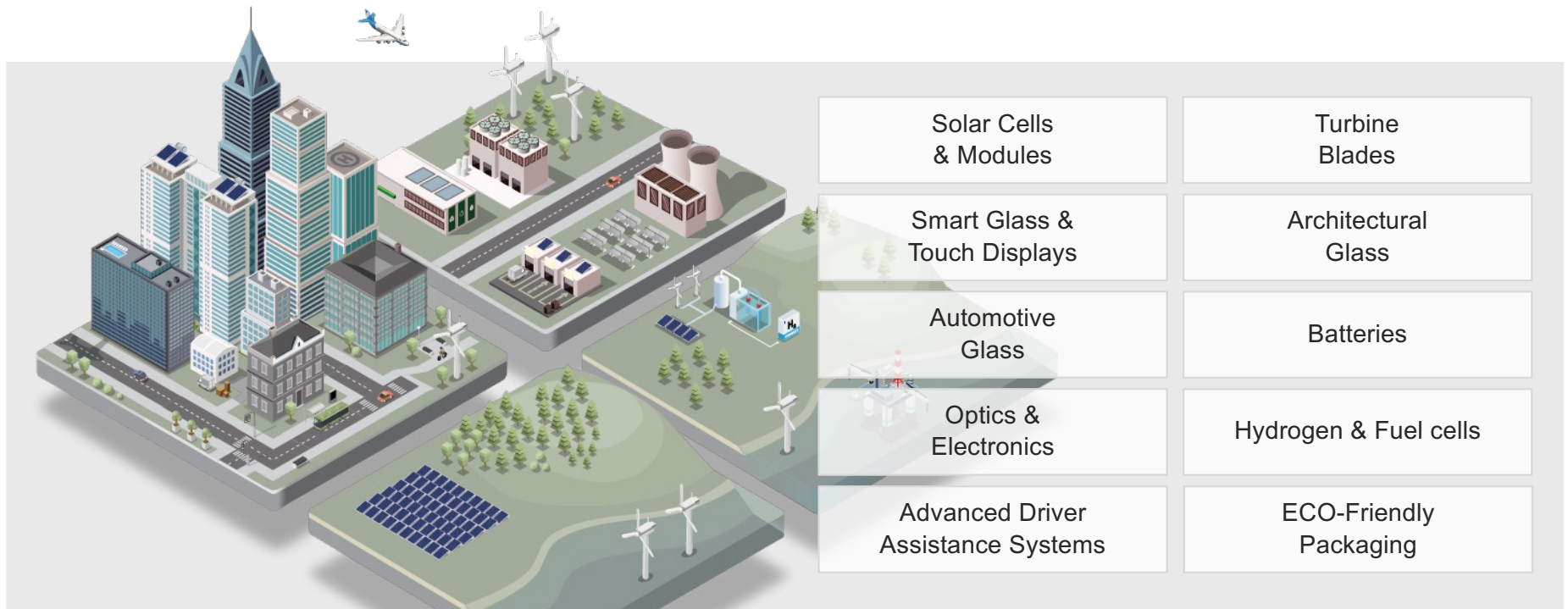
VON ARDENNE Today

State of the Art Equipment and Competence

COMPETENCE FOR GLOBAL MARKETS

Tackling Global Challenges Today

Energy - Mobility - Connectivity



OUR EQUIPMENT



Small (CSS8500S, Lab Tool)



Mid-size (VISS400S, Pilot Tool)



Large (GC330H, Mass Production)

KEY TECHNOLOGIES

Technology Competence Through Experience & Innovation

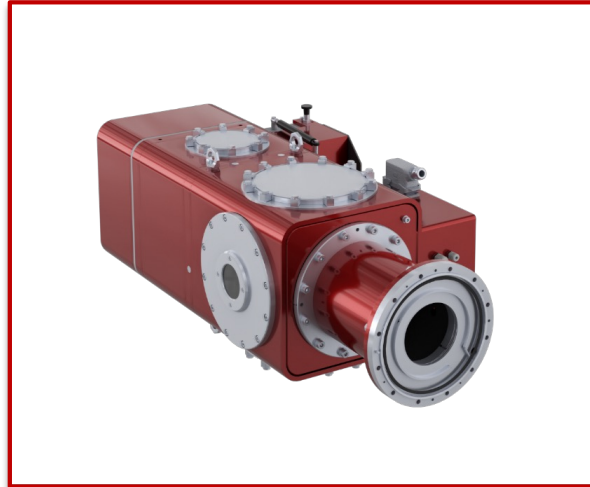
More than 60 years of experience in electron beam processes and over 45 years of know-how in vacuum coating

Magnetron Sputtering



Rotatable Dual Magnetron

Electron Beam Technology



High-Power Electron Beam Gun

Evaporation Technology



Co-/Evaporation Unit

ELECTRON BEAM SYSTEMS AND TECHNOLOGY

High Power Electron Beam Guns

1995 - 2023

235 High Power Electron Beam Guns
of Actual Model Series installed



EH150V

max. 150 kW
max. 35 kV



EH300V

max. 300 kW
max. 45 kV

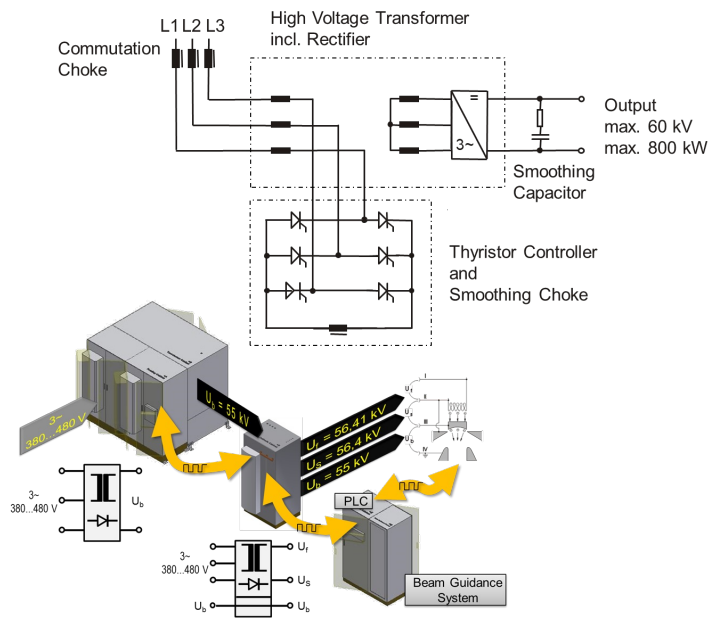


EH800V

max. 800 kW
max. 60 kV

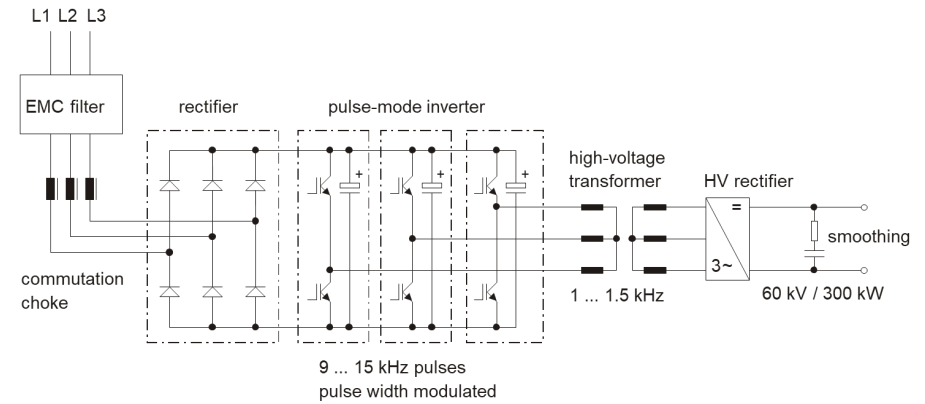
ELECTRON BEAM SYSTEMS AND TECHNOLOGY

High Voltage Power Supplies



Mains Frequency Technology

Thyristor controlled
max. 800 kW, 60 kV



- arc handling time ≈ 1 ms
- low arc energy
- usable as pulsed power supply

Mid-Frequency Technology

IGBT controlled
max. 400 kW (600 kW), max. 60 kV

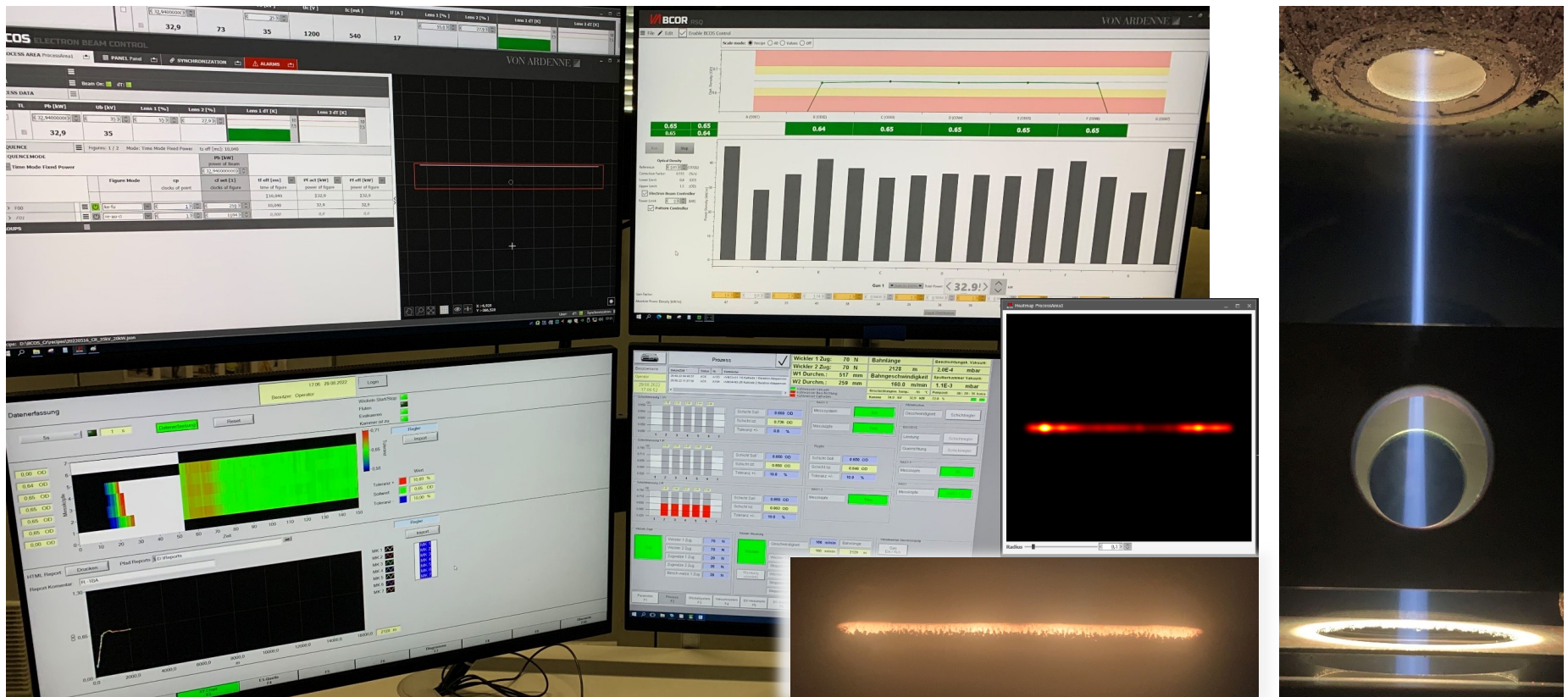
ELECTRON BEAM SYSTEMS AND TECHNOLOGY

BCOS – Beam Control System

- Transformed DAC Signals
- HMI process area
- Heat Map (calculated preview)
- Oscilloscope (output signal of deflection amplifier)

ELECTRON BEAM SYSTEMS AND TECHNOLOGY

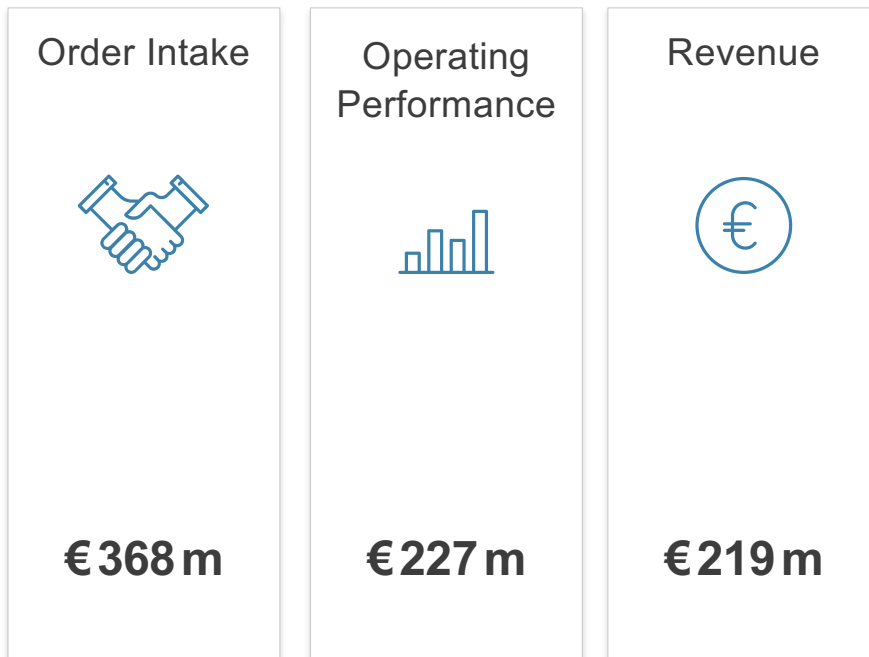
BCOR – Beam Process Controller



VON ARDENNE TODAY

Operating Figures 2021

VON ARDENNE Group



Management



Pia von Ardenne, CEO

- **Family-owned company** based in Dresden
- **> 550 coating systems** installed in 50 countries
- **~ 1000** employees
- **> 650 patents** worldwide

VON ARDENNE TODAY – A GLOBAL COMPANY



THANK YOU



Email

neumann.matthias@vonardenne.biz



Phone

+ 49 351 2637 310



Web

+ 49 351 2637 310