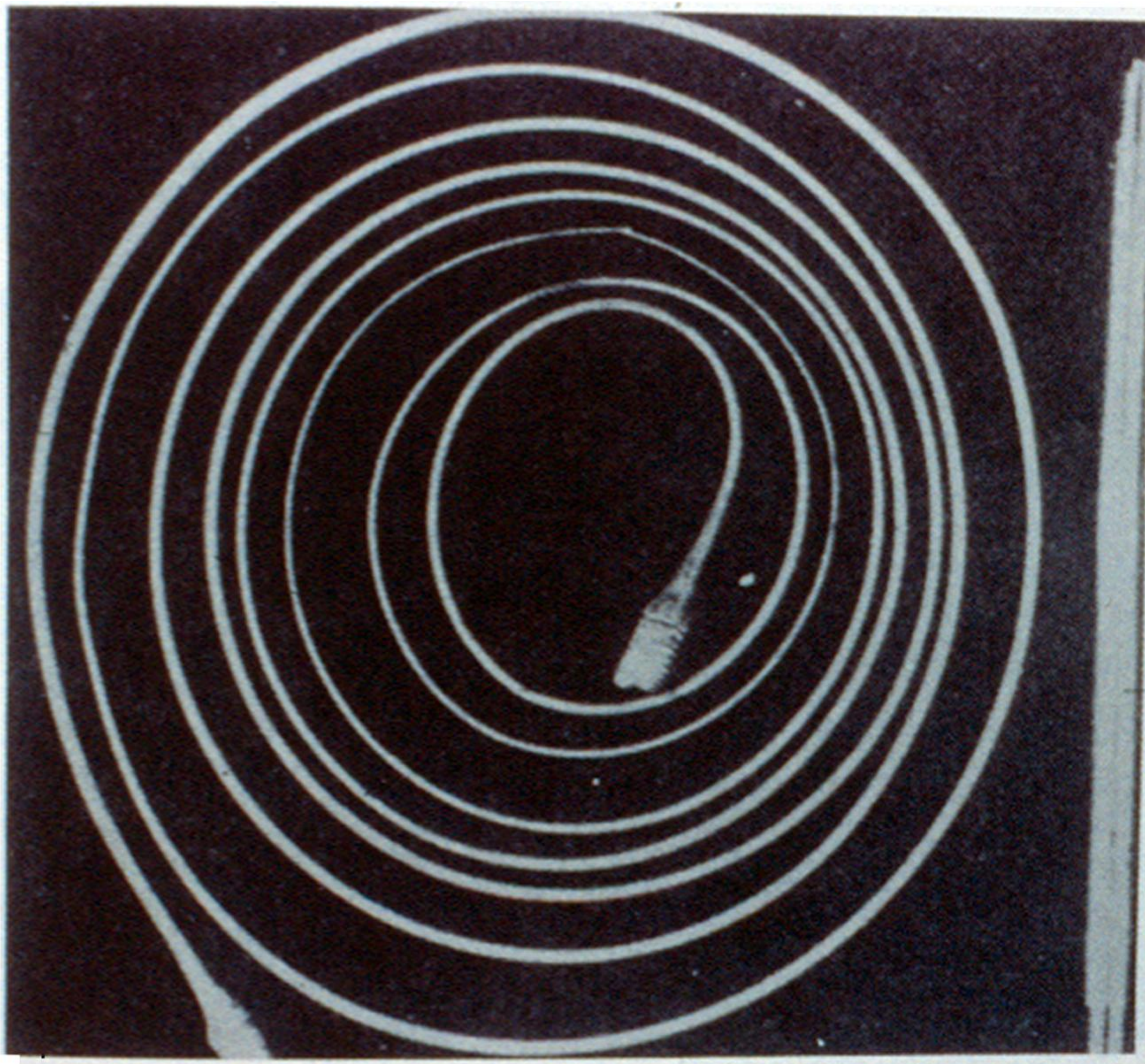
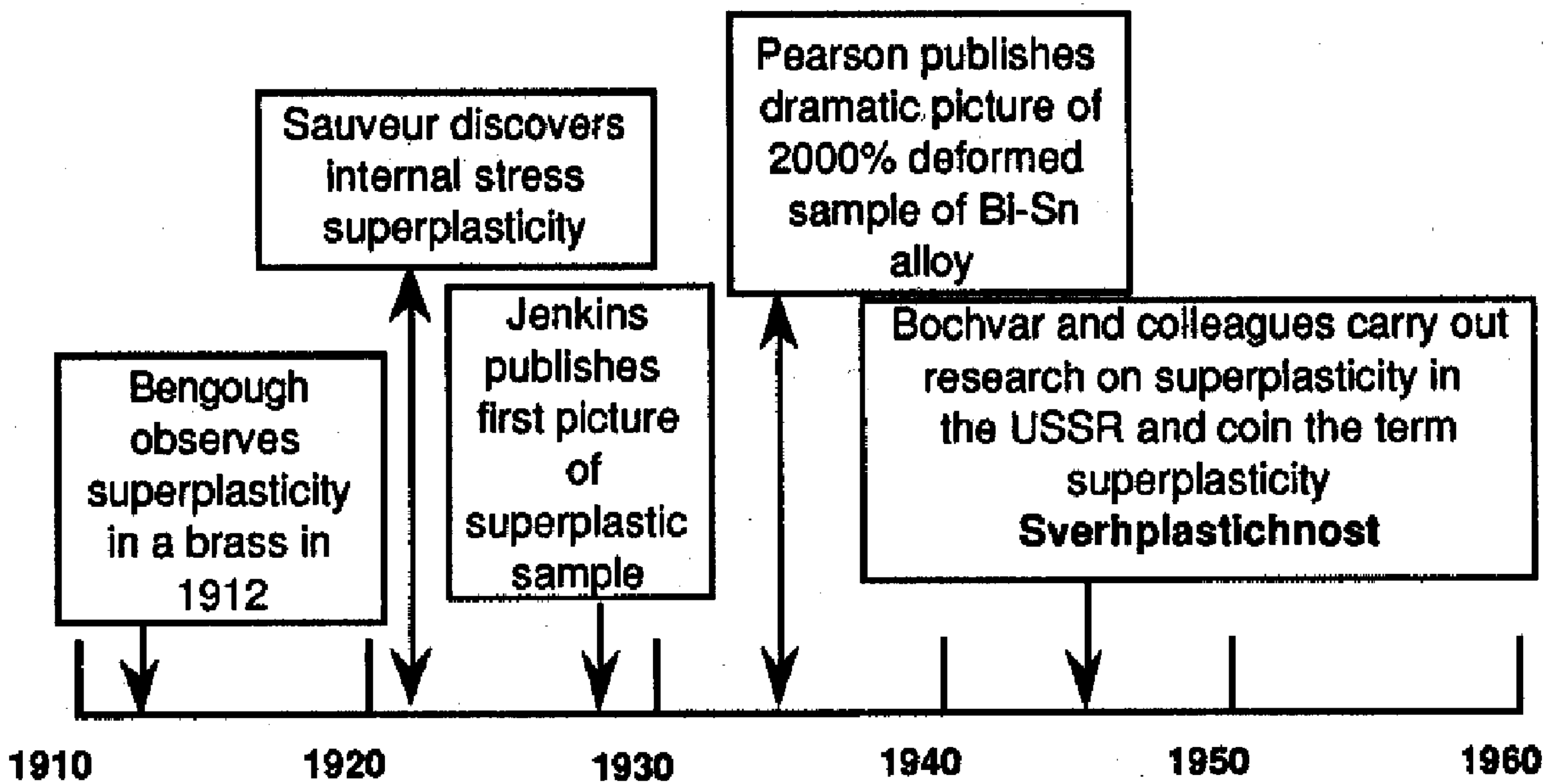
SUPERPLASTICIDAD

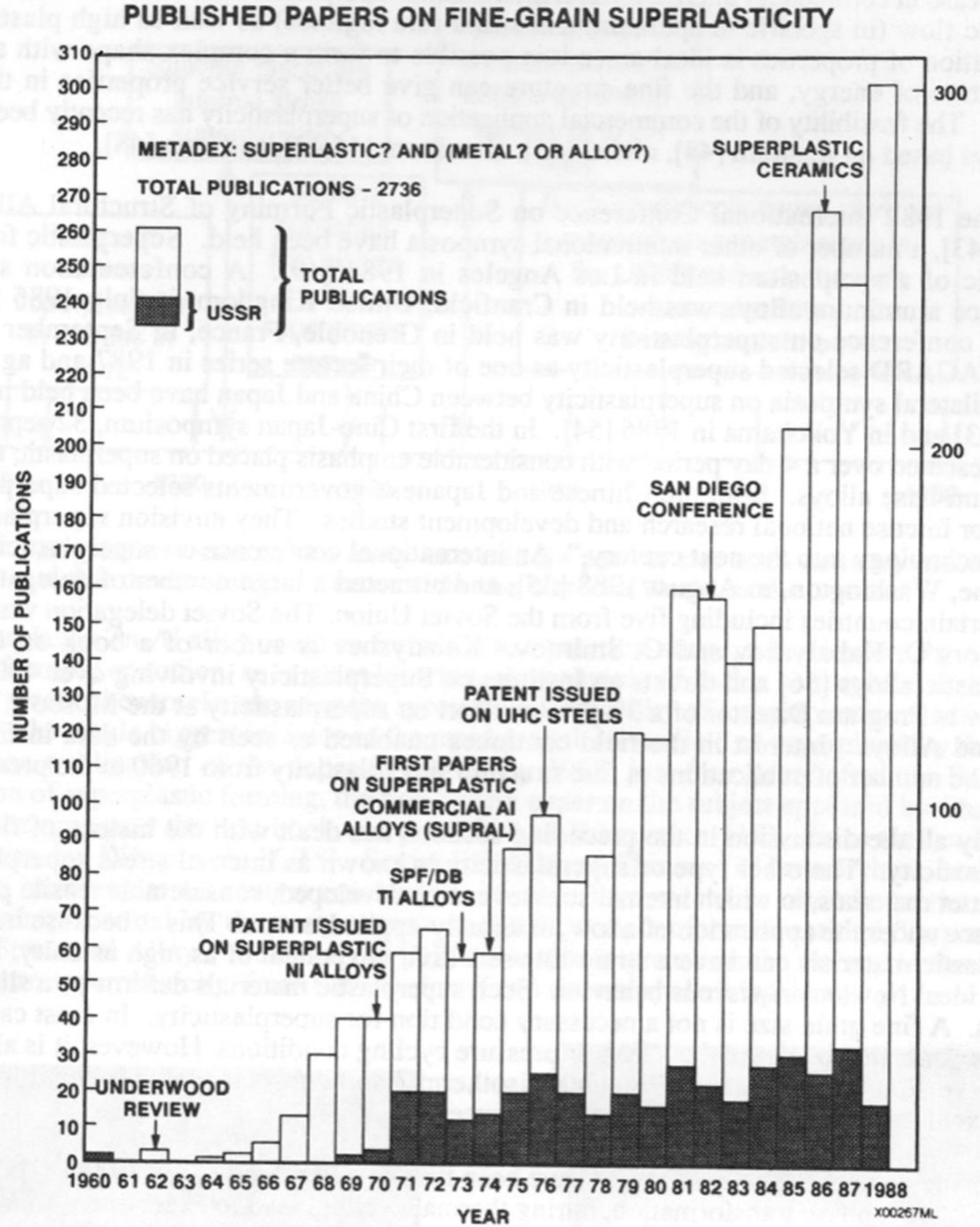
- Superplasticidad es la capacidad que tienen ciertas aleaciones policristalinas (tamaño de grano $< 10\mu m$) para soportar extensas deformaciones (>1000%) a una dada temperatura.

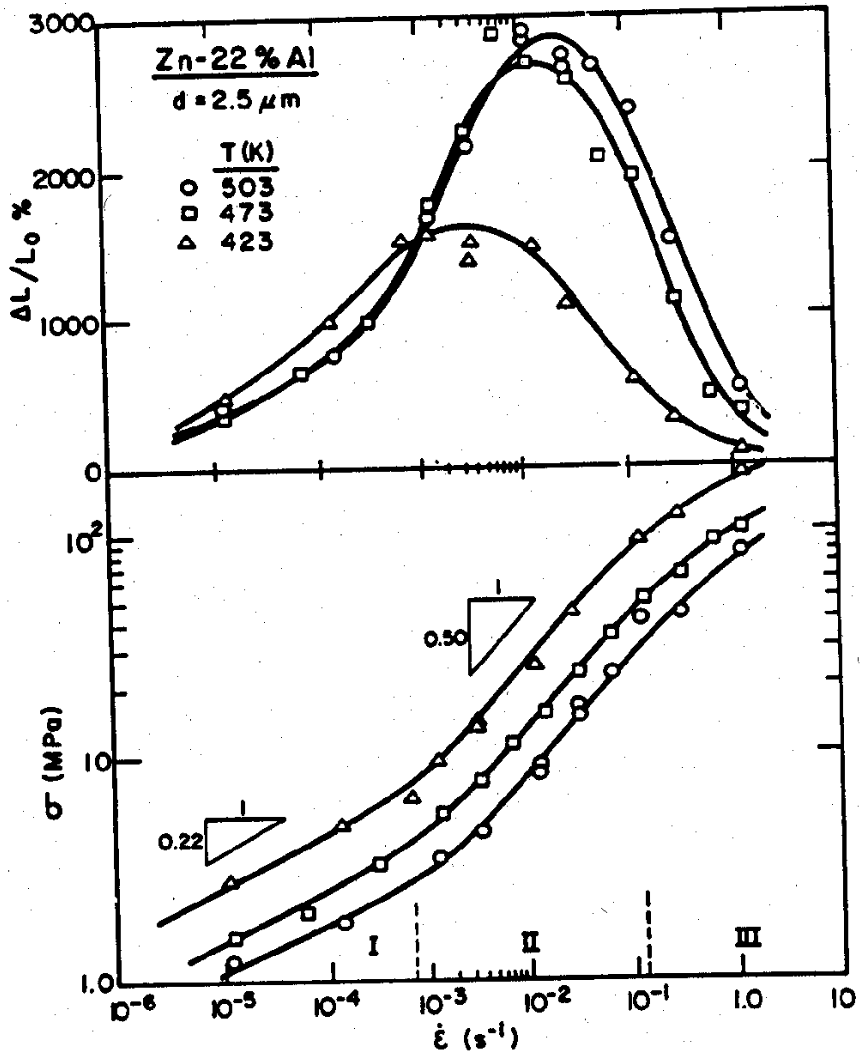
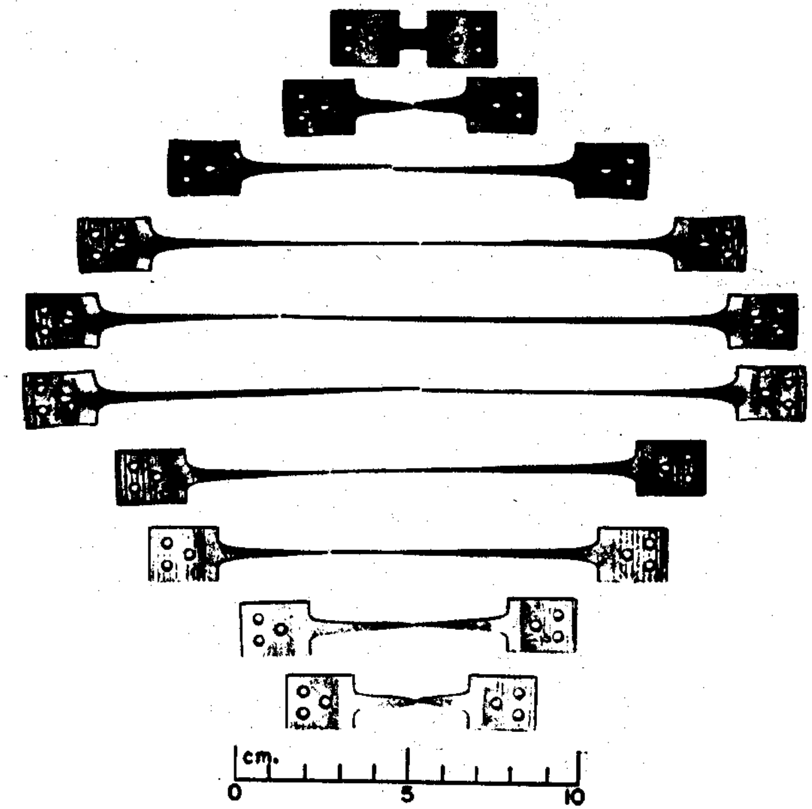


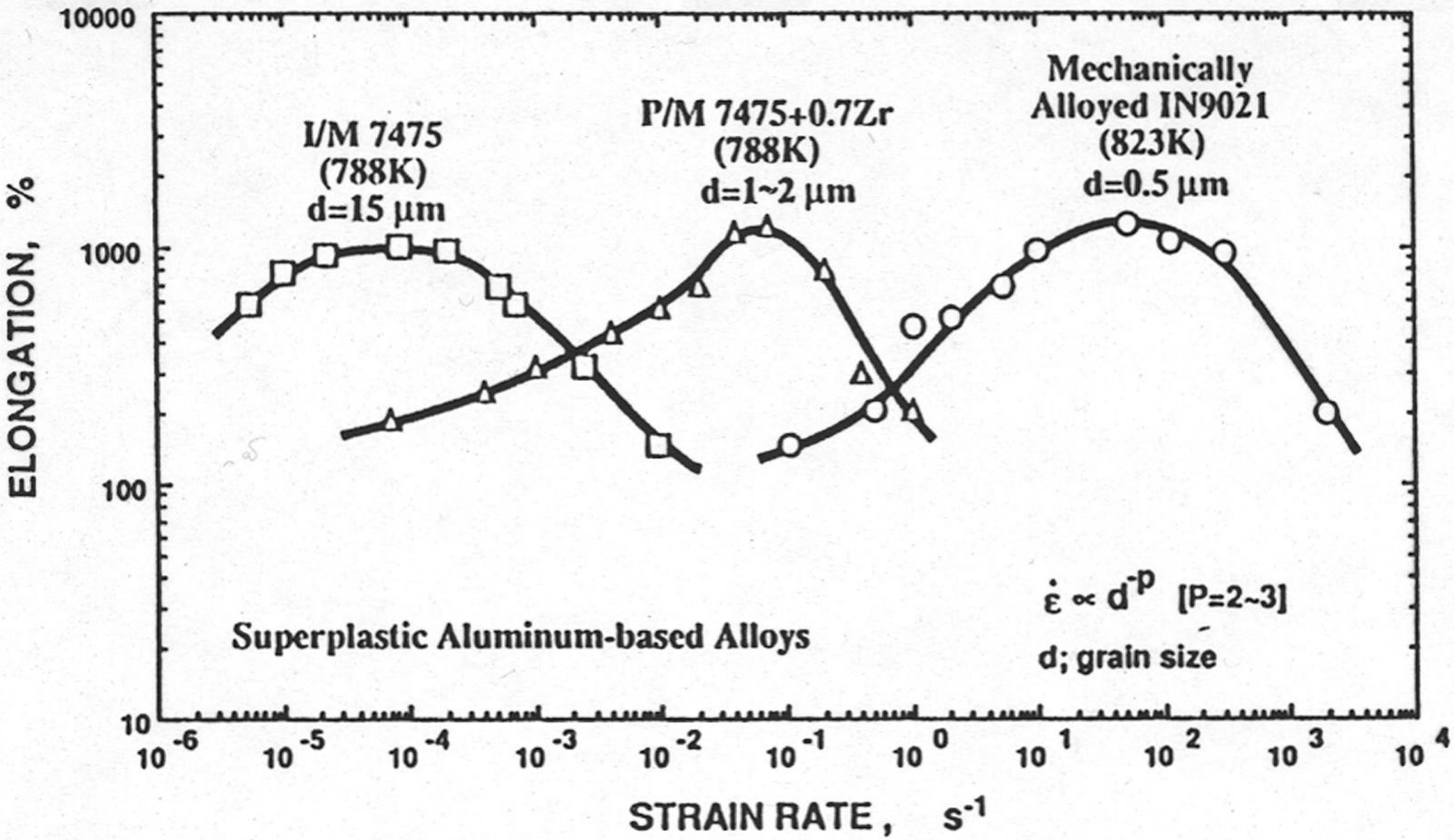
Famous photograph by Pearson [9] in 1934 of a Bi-Sn alloy that has undergone 1950% elongation. Note the undeformed specimen on the right hand side.



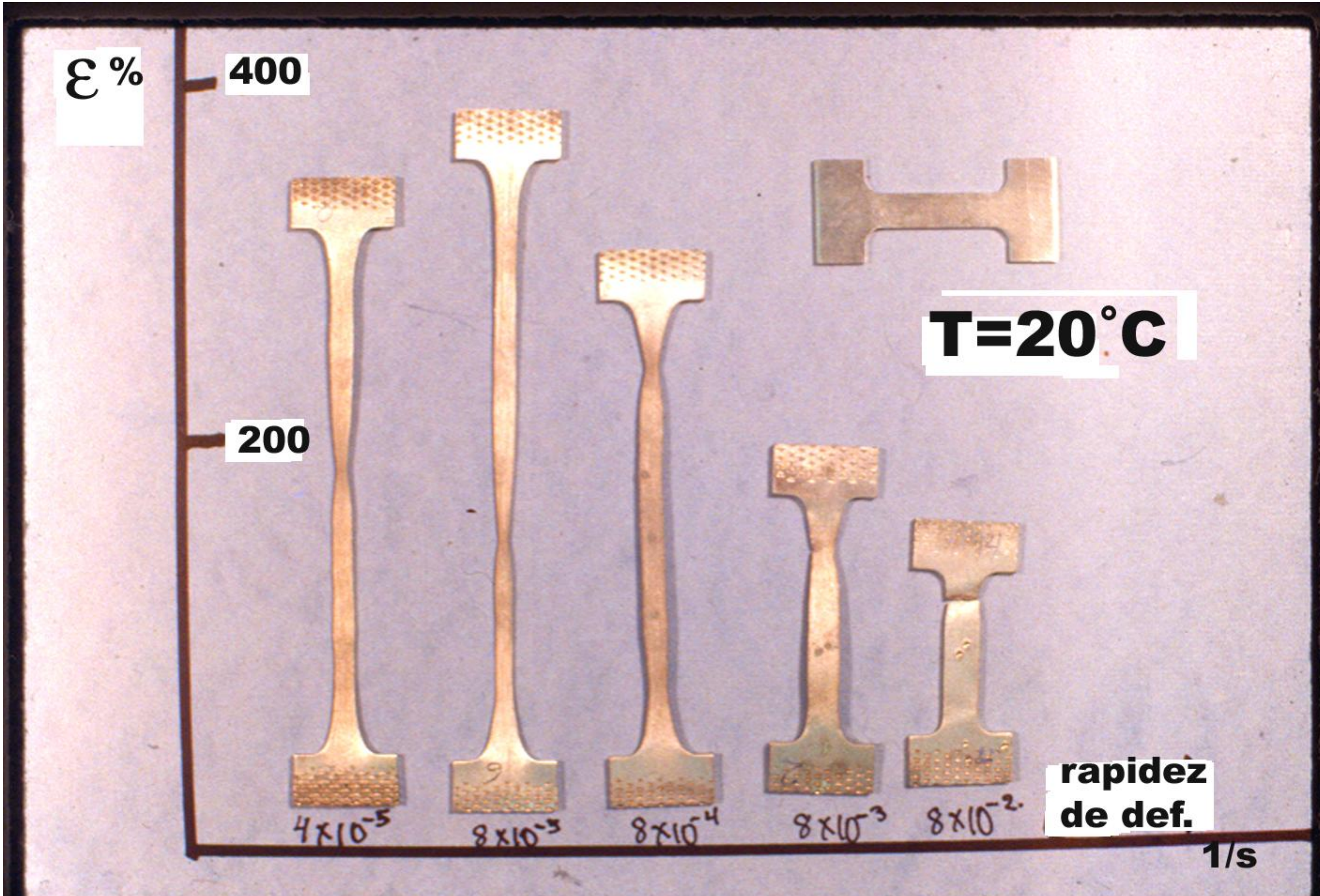
Key discoveries in the early and middle part of the 20th century prior to the major development of interest in the Western World in the 1960s.


PUBLISHED PAPERS ON FINE-GRAIN SUPERLASTICITY
METADEX: SUPERLASTIC? AND (METAL? OR ALLOY?)
TOTAL PUBLICATIONS - 2736
TOTAL PUBLICATIONS
USSR
SUPERPLASTIC CERAMICS
SAN DIEGO CONFERENCE
PATENT ISSUED ON UHC STEELS
FIRST PAPERS ON SUPERPLASTIC COMMERCIAL Al ALLOYS (SUPRAL)
SPF/DB Ti ALLOYS
PATENT ISSUED ON SUPERPLASTIC NI ALLOYS
UNDERWOOD REVIEW
NUMBER OF PUBLICATIONS
YEAR
1960 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 1988
100
200
300
X00267ML

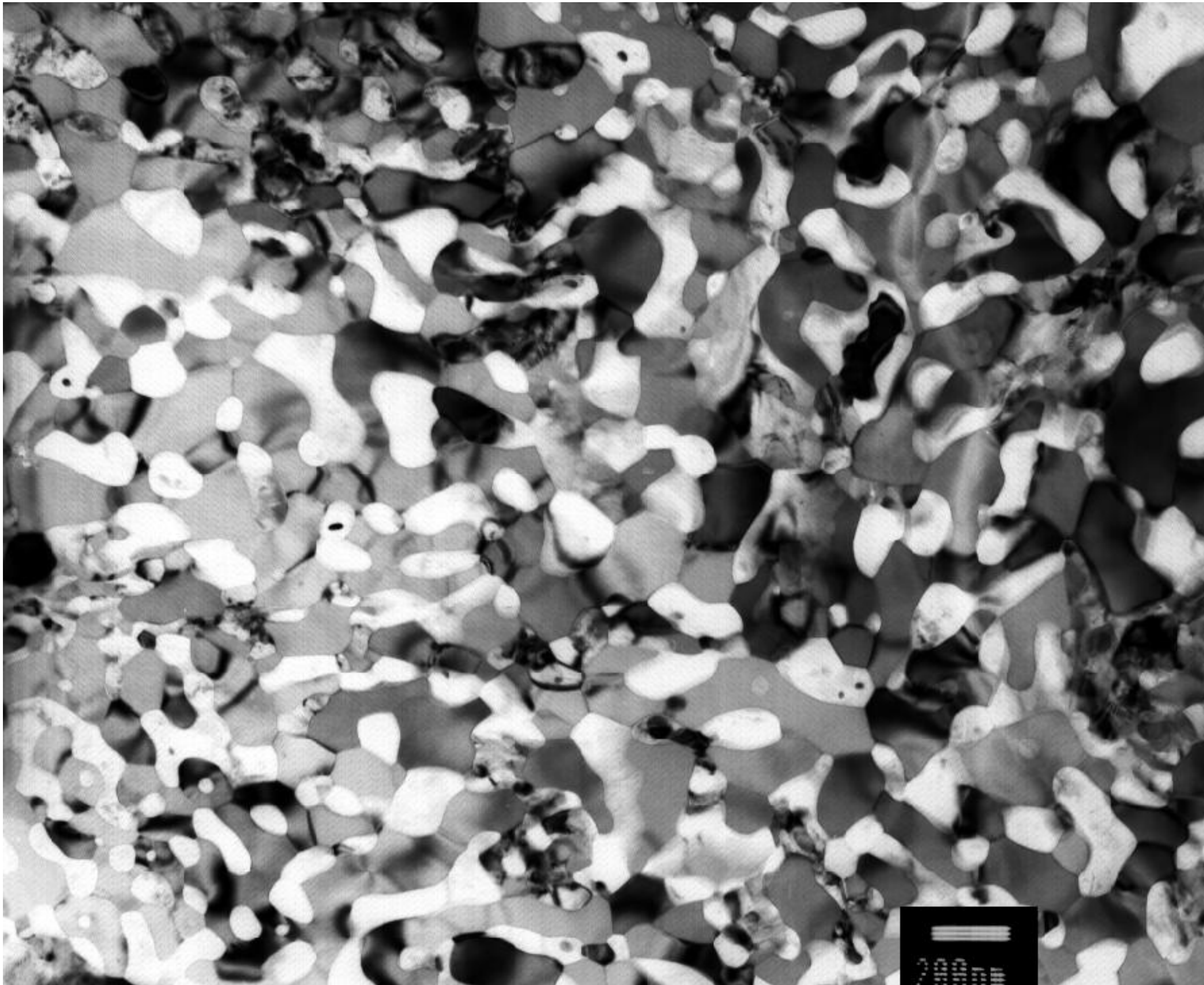

Zn-22 % Al
d = 2.5 μm
T (K)
503
473
423
ΔL/L₀ %
3000
2000
1000
0
σ (MPa)
10²
10
1.0
0.50
0.22
I
II
III
10⁻⁶
10⁻⁵
10⁻⁴
10⁻³
10⁻²
10⁻¹
1.0
10
ε̇ (s⁻¹)

cm.
0
5
10

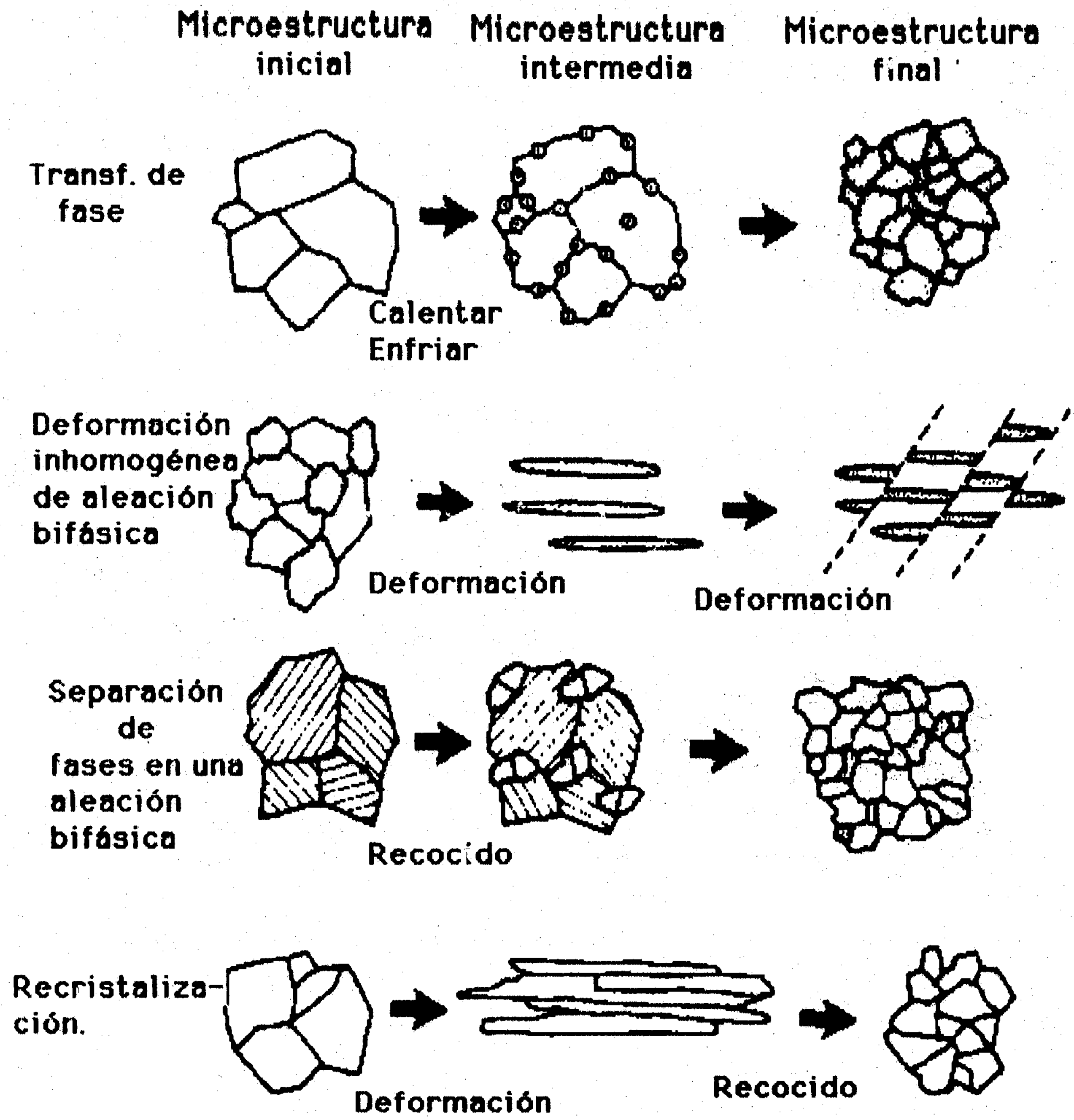


Elongation as a function of strain rate for various superplastic I/M 7475, P/M 7475+0.7Zr and IN9021 alloys with different grain sizes.



ε %
400
200
T=20°C
4x10^-5
8x10^-5
8x10^-4
8x10^-3
8x10^-2.
rapidez
de def.
1/s


200nm



Microestructura inicial
Microestructura intermedia
Microestructura final
Transf. de fase
Calentar
Enfriar
Deformación inhomogénea de aleación bifásica
Deformación
Deformación
Separación de fases en una aleación bifásica
Recocido
Recristaliza-ción.
Deformación
Recocido

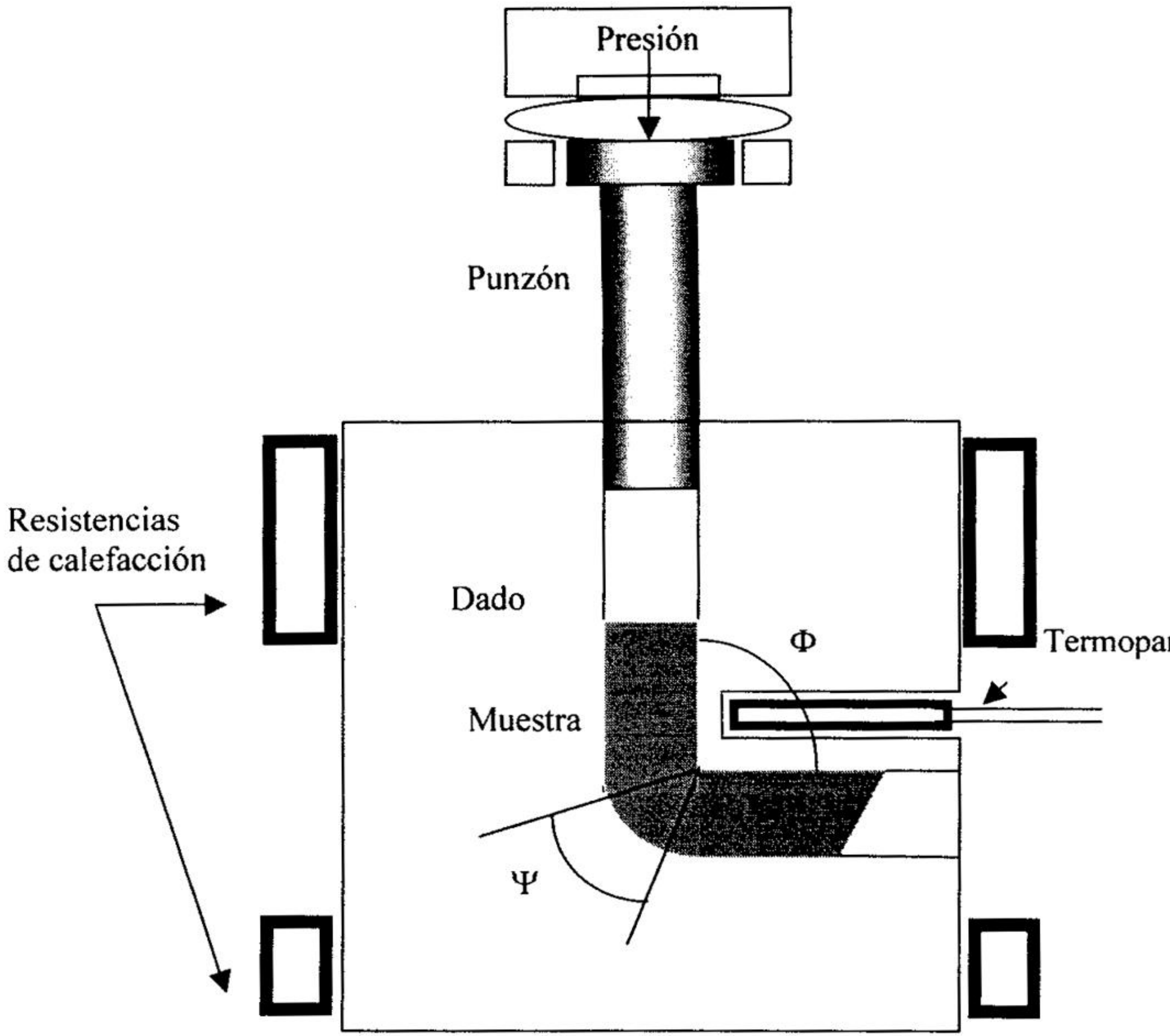
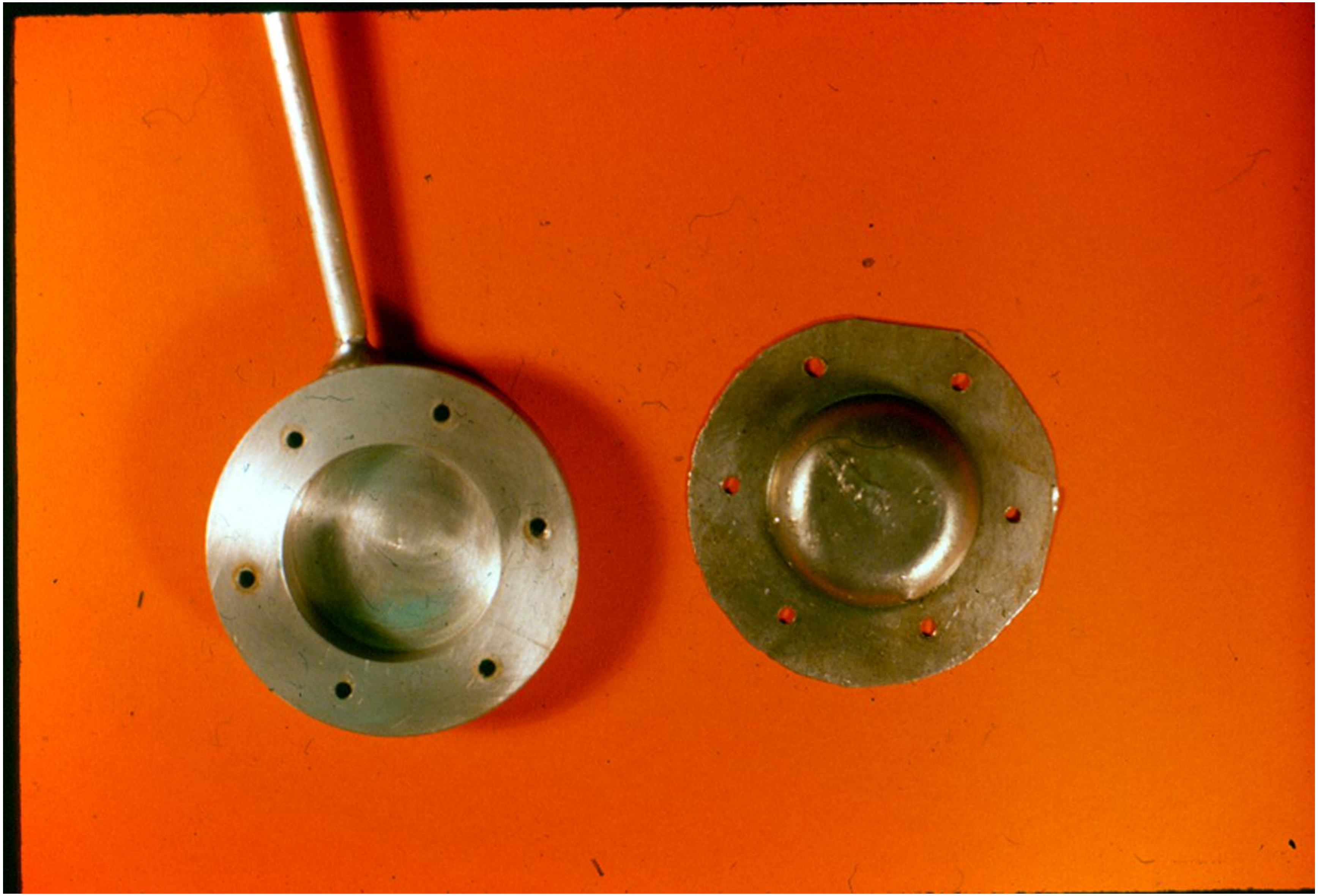
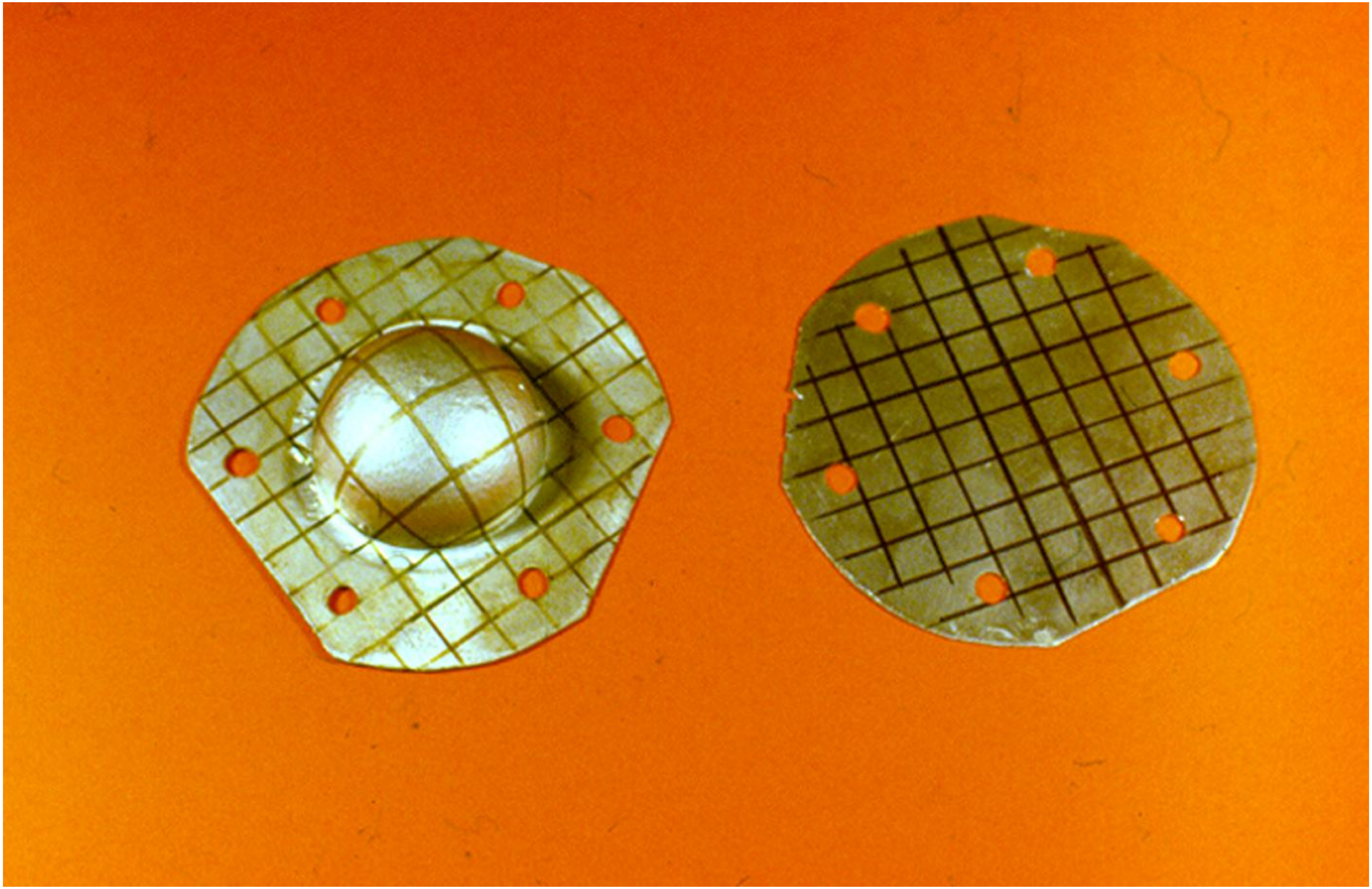


Figura 3.1. Ilustración esquemática para el proceso ECAC a altas temperaturas

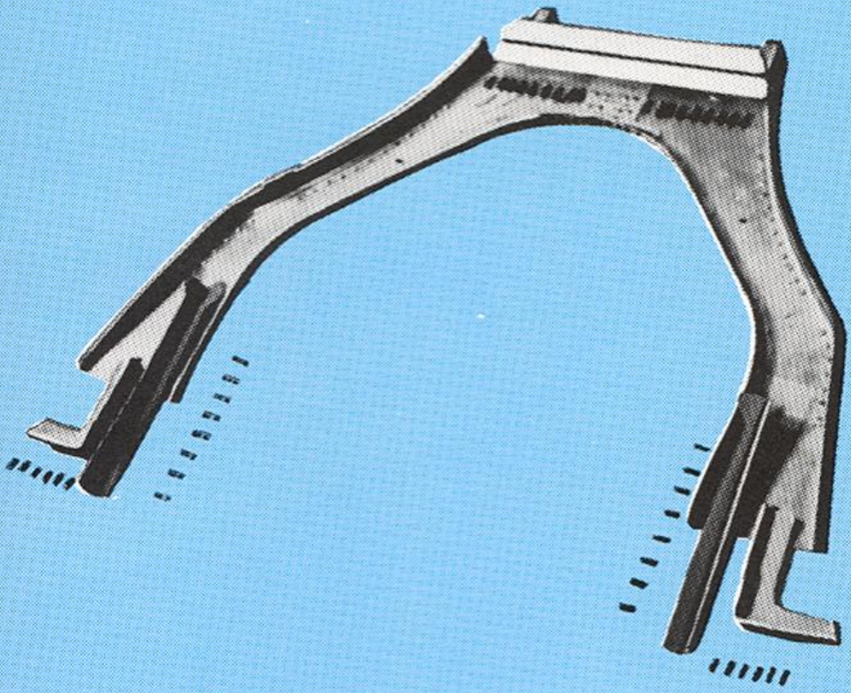
Material	Temp (K)	Strain Rate (/s)	Flow Stress (MPa)	m	Elongation (%)	Grain Size (μm)	References
Consolidation of Amorphous or NanocrystallinePowder							
Al-Ni-Mm	885	1	15	0.5	650	1	Higashi; Higashi et al.
Al-Ni-Mm-Zr	873	1	15	0.5	650	0.8	Higashi
Mg-Al-Ga	573	10^{-2}	8	0.5	1080	2	Uoya et al.
Mechanical Alloying							
IN9021	723	7×10^{-1}	5	0.3	300		Nieh et al.
IN90211	748	2.5	40	0.3	505	0.5	Bieler et al.
IN9052	863	10	15	0.6	330	0.5	Higashi, Nieh & Wadsworth
IN905XL	848	20	12	0.6	190	0.4	Higashi, Nieh & Wadsworth
IN9021	823	50	18	0.5	1250	0.5	Higashi, Nieh & Wadsworth
SiC_p/IN9021	823	5	5	0.5	600	0.5	Higashi, Nieh & Wadsworth
Physical Vapour Deposition							
Al-Cr-Fe							
Intense Plastic Straining							
Al-Mg-Li-Zr	623	10^{-2}	85		1180	1.2	Valiev
Al-Cu-Zr	573	10^{-2}			970	0.5	Valiev
Zn-Al	473	3×10^{-2}	27		1970	0.6	Furukawa et al.





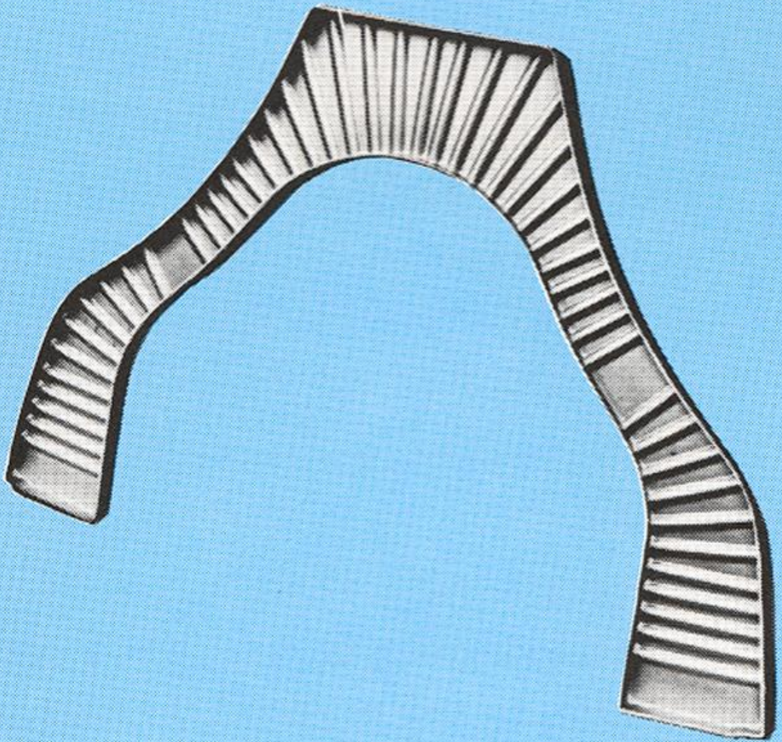
APLICACIONES

- Industria aeroespacial
- Industria del transporte
- Comunicaciones
- Aplicaciones arquitectónicas
- Energía



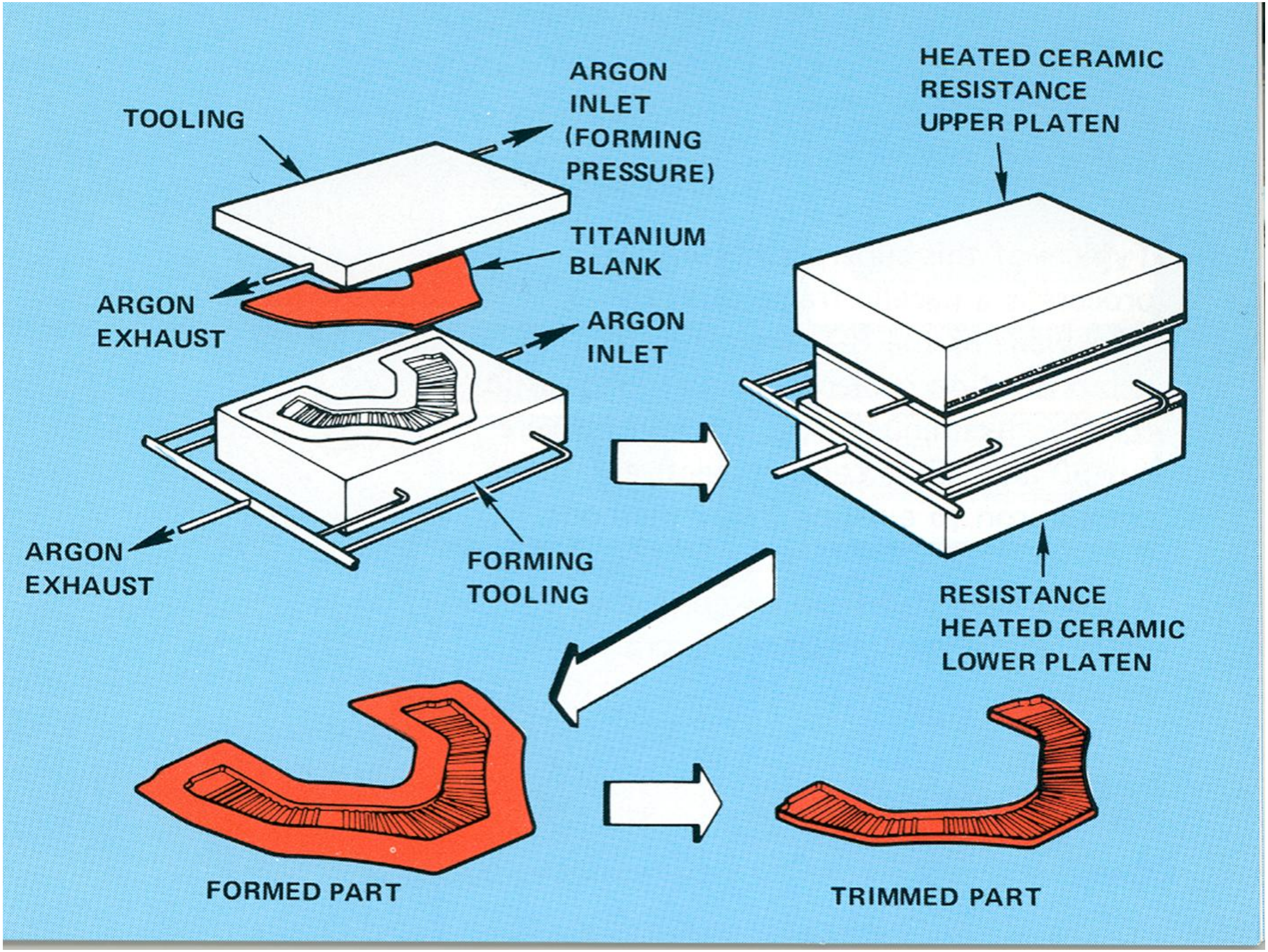
CURRENT FRAME

- SHEET METAL AND MACHINED TITANIUM
- 8 PARTS
- 96 FASTENERS
- MANY TOOLS
- COST $2600 AVERAGE



REDESIGNED FRAME

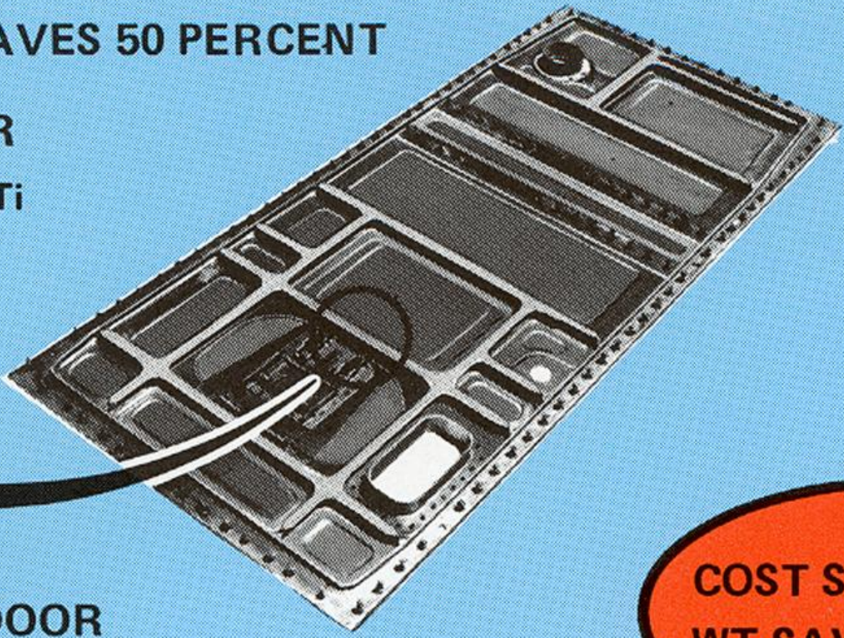
- SUPERPLASTICALLY FORMED
- ONE PART
- NO FASTENERS
- ONE “TOOL”
- COST $1100 AVERAGE

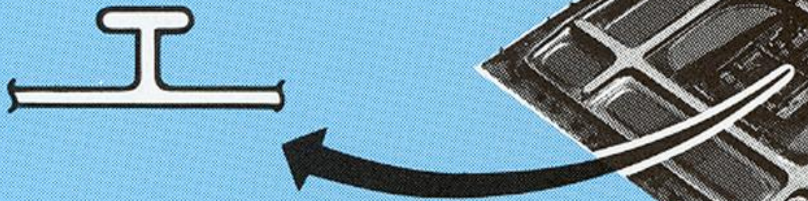

TOOLING
ARGON INLET (FORMING PRESSURE)
HEATED CERAMIC RESISTANCE UPPER PLATEN
TITANIUM BLANK
ARGON EXHAUST
ARGON INLET
ARGON EXHAUST
FORMING TOOLING
RESISTANCE HEATED CERAMIC LOWER PLATEN
FORMED PART
TRIMMED PART

SPF/DB APU DOOR SAVES 50 PERCENT

PRESENT DOOR

- MACHINED Ti

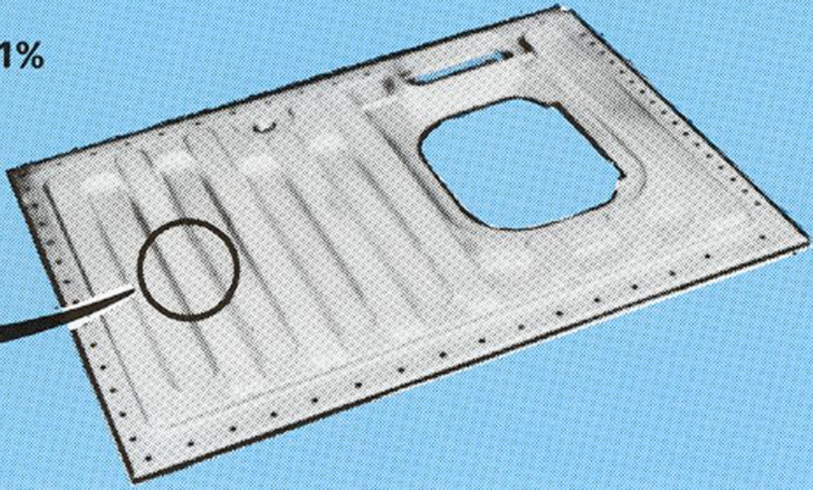


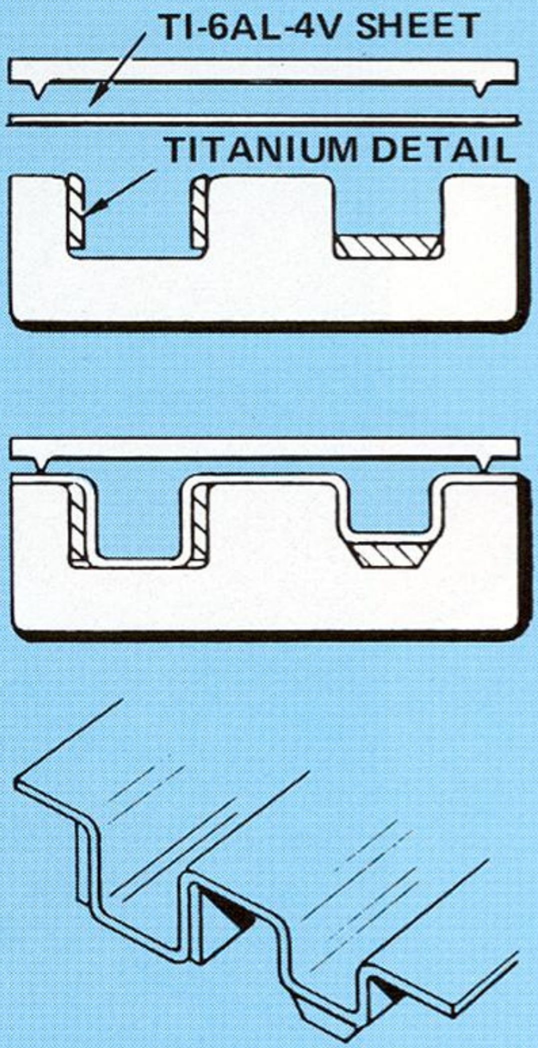


REDESIGNED DOOR

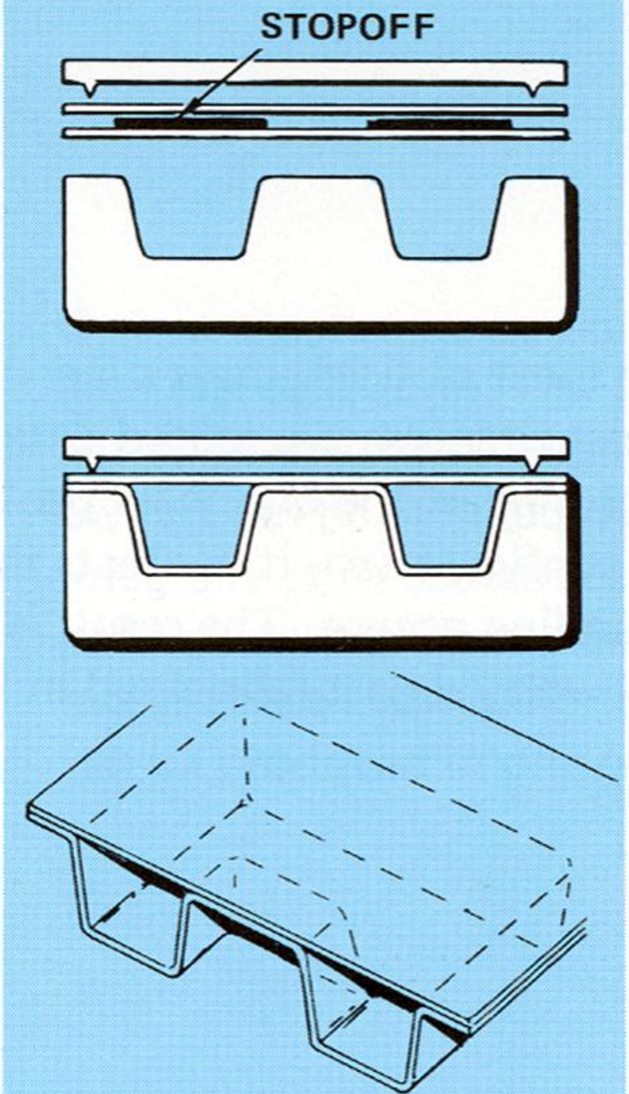
- SUPERPLASTIC-FORMED/ DIFFUSION-BONDED Ti
- WT SAVINGS: 31%

COST SAVINGS 50%
WT SAVINGS 31%

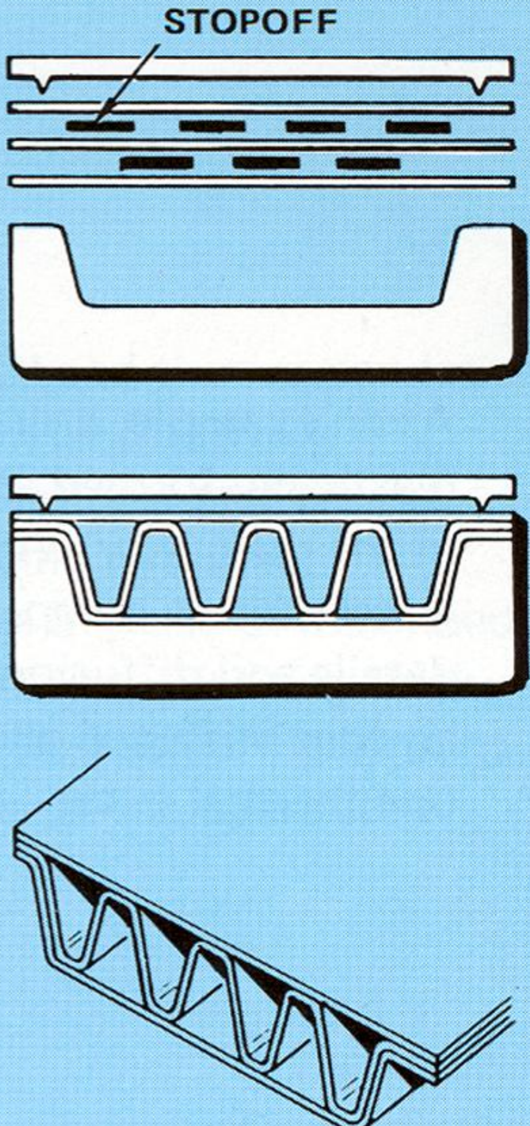




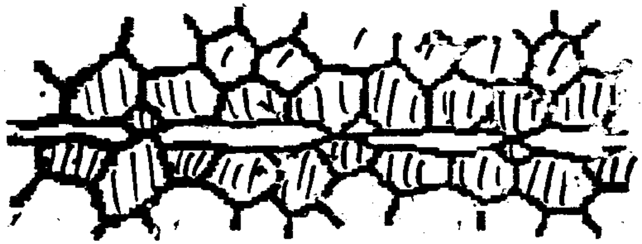
REINFORCED SHEET



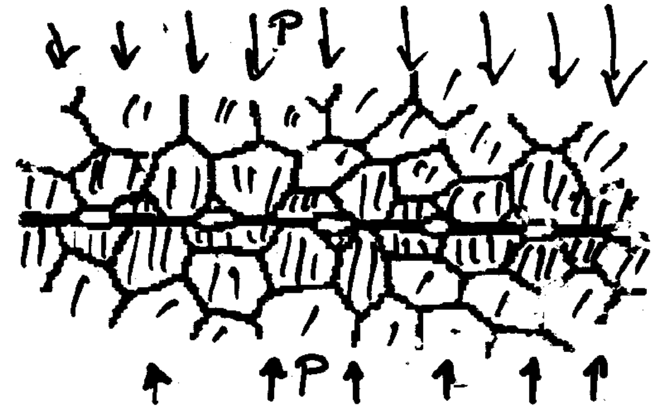
INTEGRALLY STIFFENED



EXPANDED SANDWICH

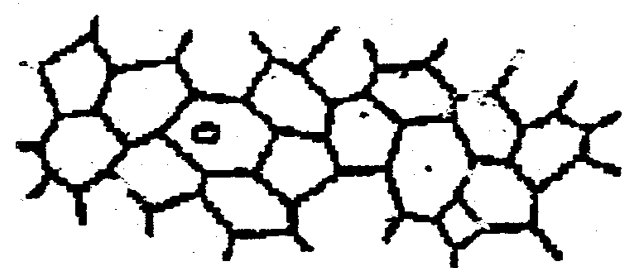


CONTACTO INICIAL



DEFORMACION

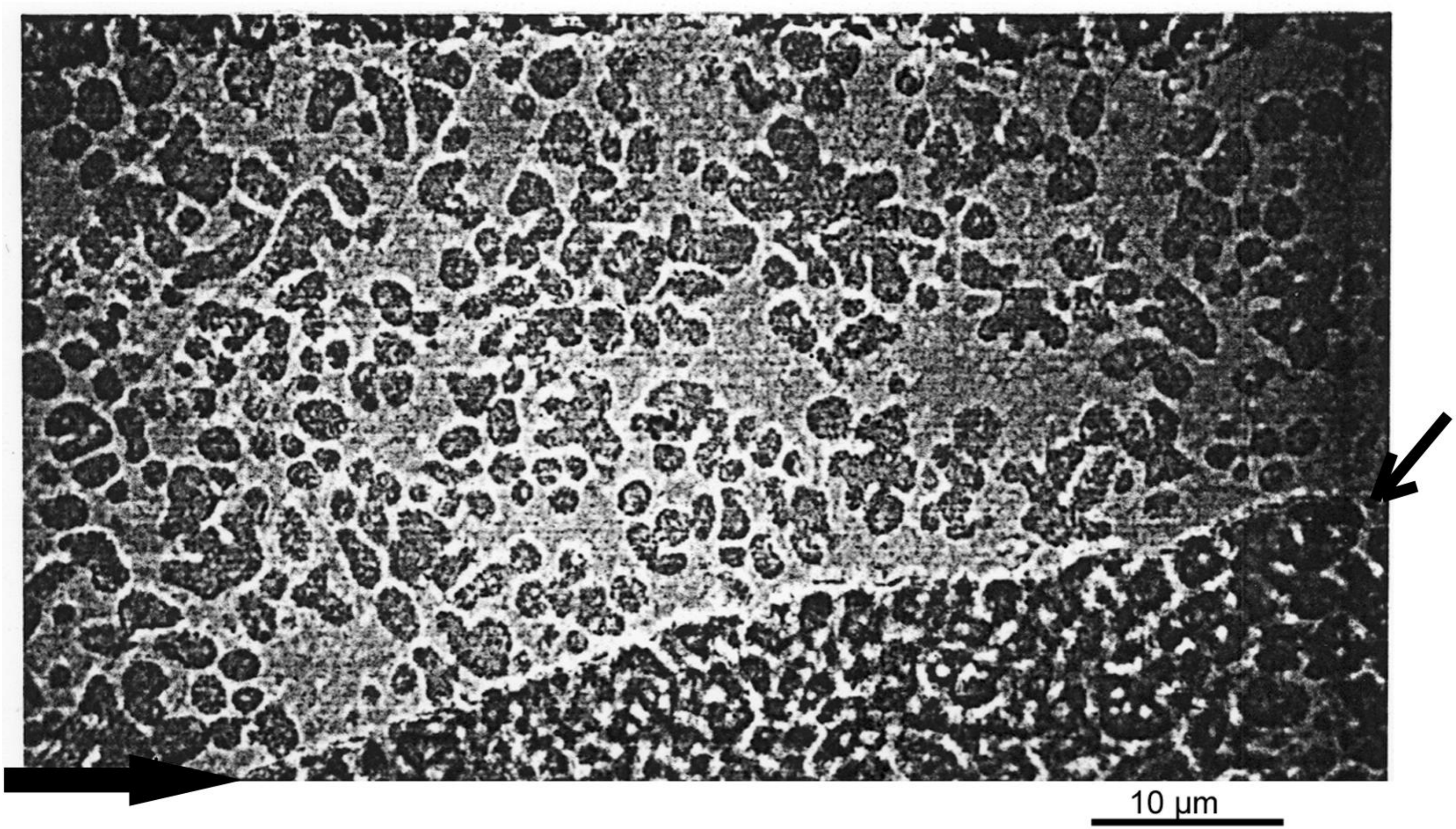
ELIMINACION DE POROS

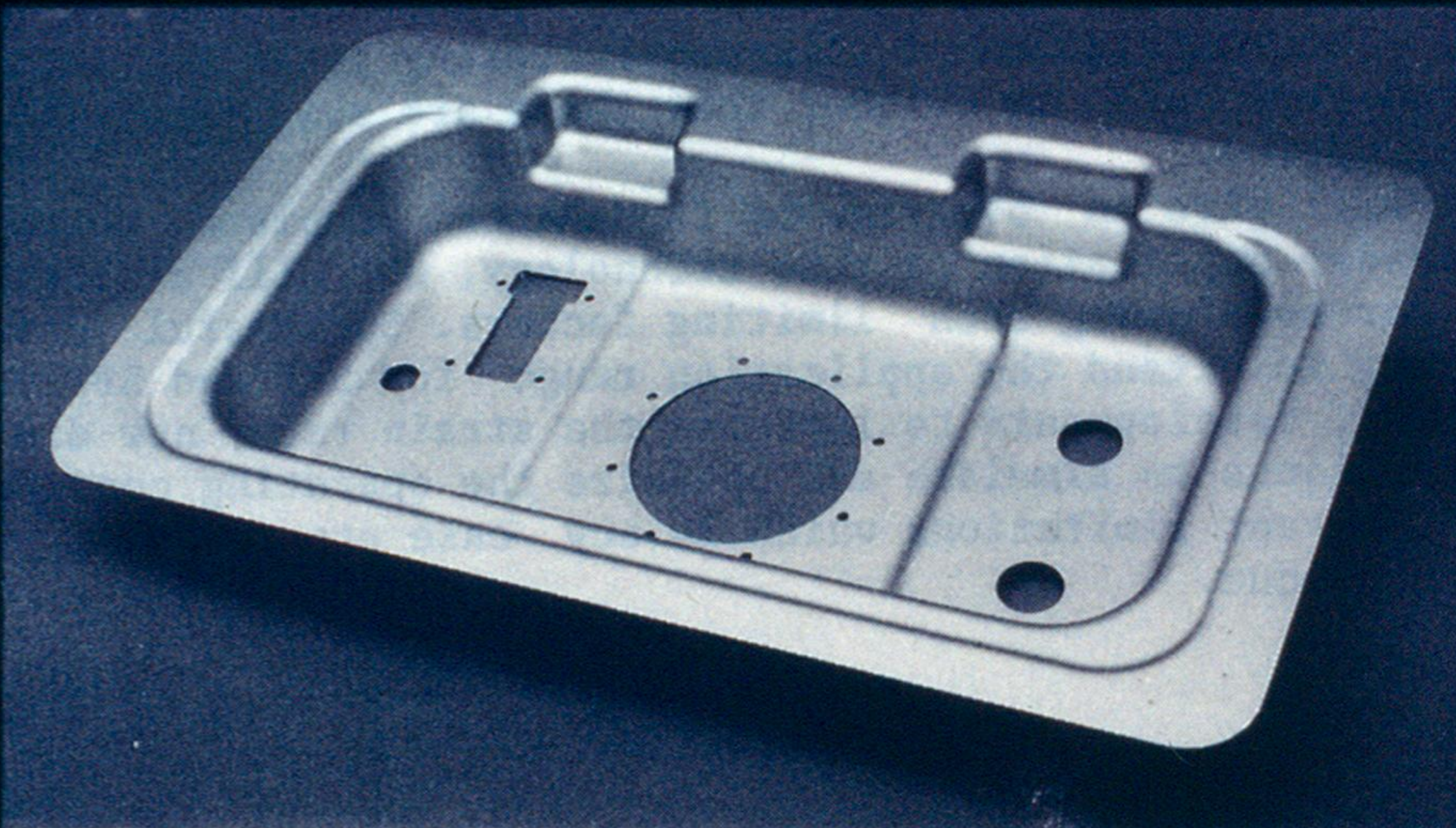


DIFUSION

SOLDADURA POR DIFUSION DEL ZINALCO

T = 300 ·C

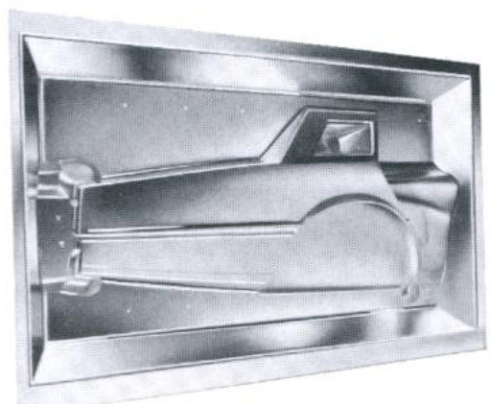




Service panel made of Ti6Al4V for the Airbus A300/A310

An attractive design strong enough to withstand harsh industrial environments. Screening against electrical noise and valuable heat sink properties were important benefits gained by SALTER INDUSTRIAL MEASUREMENTS on a weigh display unit.

SUPRAL panels form most of the external body work of the ASTON MARTIN LAGONDA giving distinctive lines and a reduction in hand finishing compared with rubber die pressed panels.



SPF Sample Parts ´Aluminium´*

Fuel Reservoir

Viper

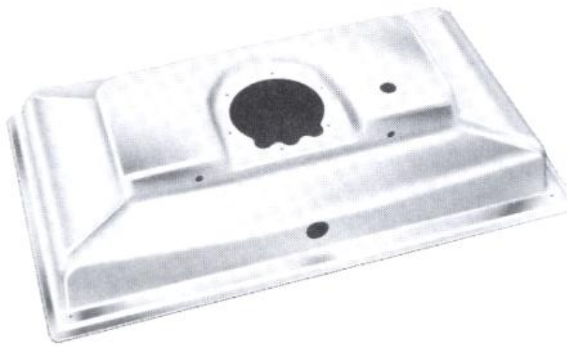
Door inner panels Panoz Esperante

Door outer panels Panoz Esperante

Morgan Cars – Front- and Rear Fender

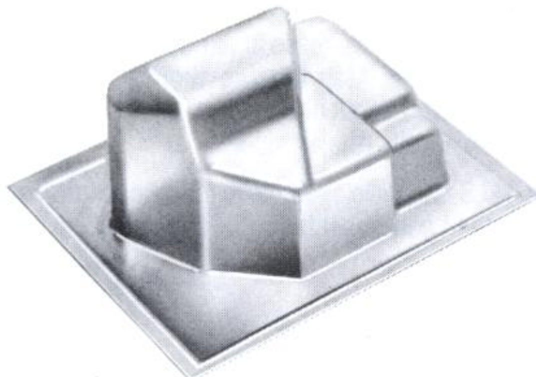
* Photographies of parts by courtesy of Superform Ltd.

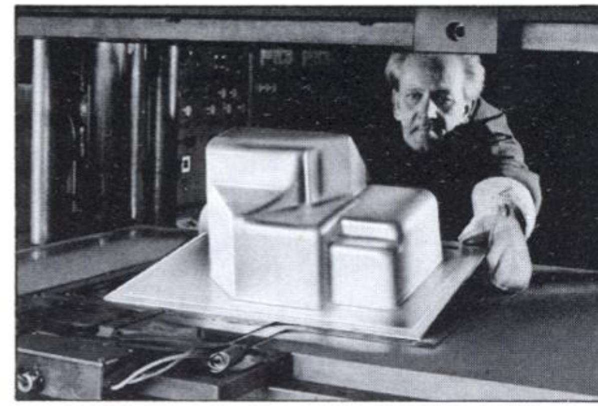
Increased life, simpler assembly and reduced costs were benefits gained by VICKERS MEDICAL when switching from glass fibre to SUPRAL inner bodies on infant incubator units.



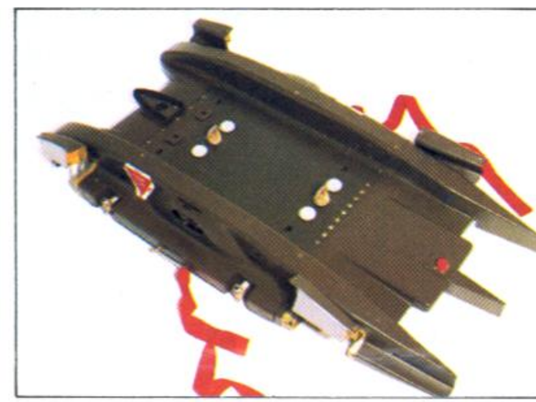
Short lead times and ease of assembly were benefits gained when WESTLAND HELICOPTERS designed a new configuration engine intake for an experimental programme. The 35 piece rivetted and welded construction was trimmed from just 11 pressings which faithfully reproduced the master pattern.

40% cost savings and improved dimensional accuracy compared with welded assemblies were achieved by the French Company, MESSIER HISPANO BUGATTI, by changing to SUPRAL. Four painted SUPRAL covers protect hydraulic pipework on the A300 Airbus undercarriage.





By selecting SUPRAL, M.L. AVIATION achieved greater consistency and interchangeability on the fairings for the Alpha Jet Store Carrier. More complex one piece shapes reduced hand finishing and avoided the distortion which could occur when welding drop-hammered or rubber pressed parts.



a

b

The first in Russia commercial articles (suggar-basins) produced by SPF

a - thin relief b - deep relief

Superplasticidad Estructural

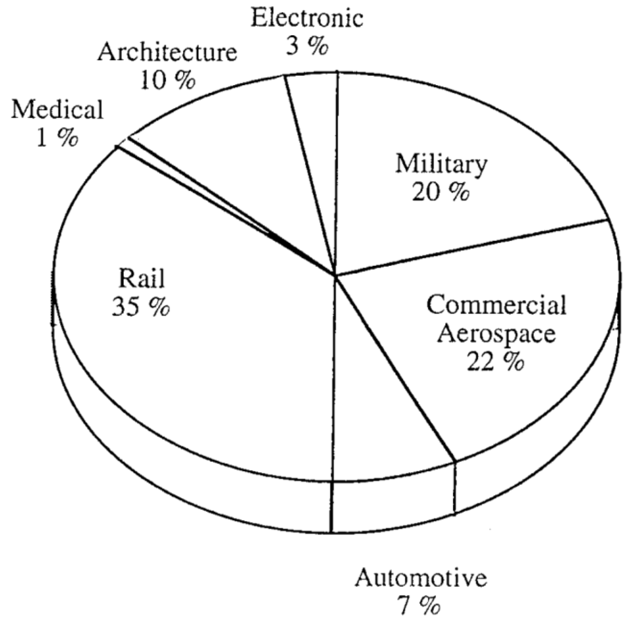
Existen dos tipos de superplasticidad: a) la superplasticidad estructural, cuyo origen es la estructura de granos finos y b) la superplasticidad ambiental originada durante una transformación de fase.

Para producir superplasticidad estructual, se requiere que :

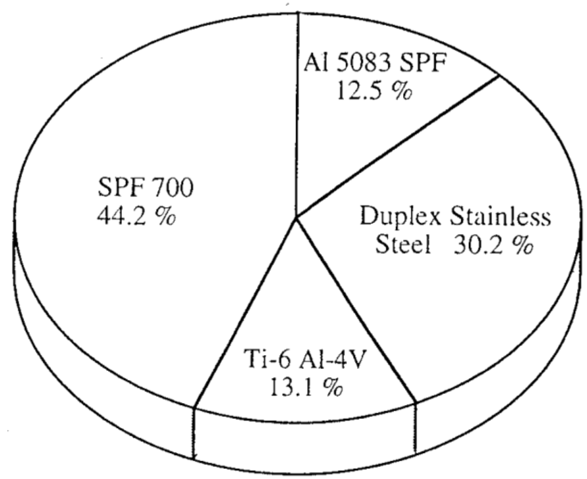
a)el material este formado por granos menores a 10µm.

b) Que la deformación se realice con una rapidez de deformación entre 10^{-5} y 10^{-1}/s.

c) Temperaturas arriba de $0{,}5T_f$. T_f se toma en grados K.



Aplicaciones del Al superplástico



Aplicaciones de la SP en Japón

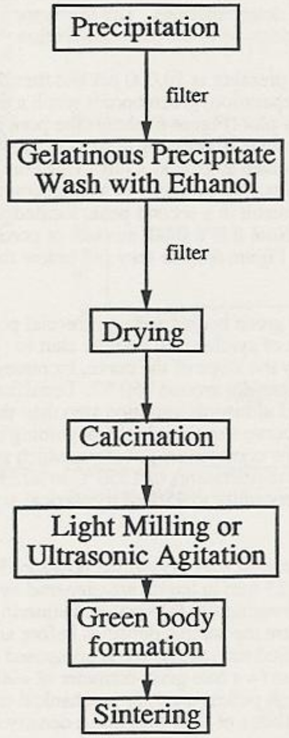


Figure 1. Powder processing flowsheet for the 3 mol% yttria-stabilized zirconia powder

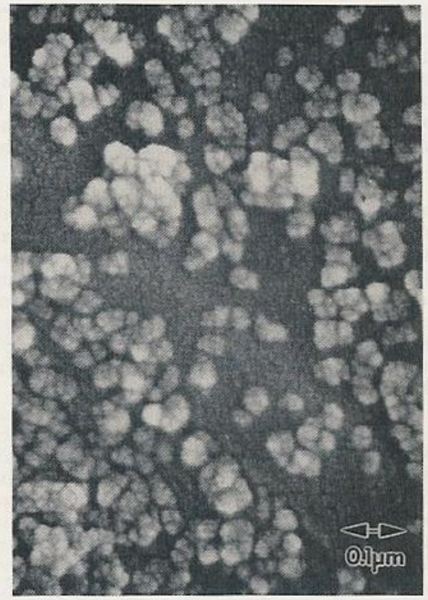
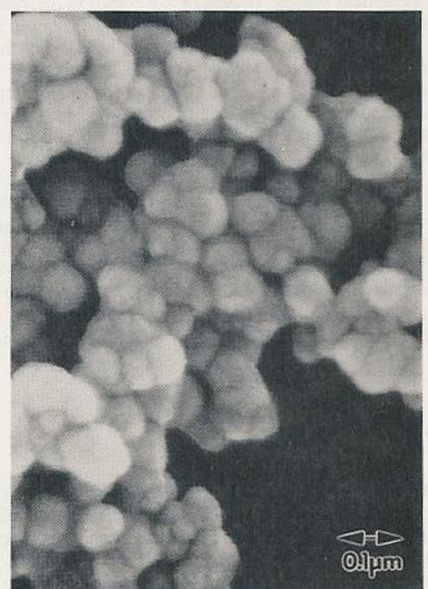


Figure 2. SEM photograph of the calcined 3 mol% yttria-stabilized zirconia powder

Figure 3. SEM photograph of the Tosoh TZ-3Y powder. ⇨



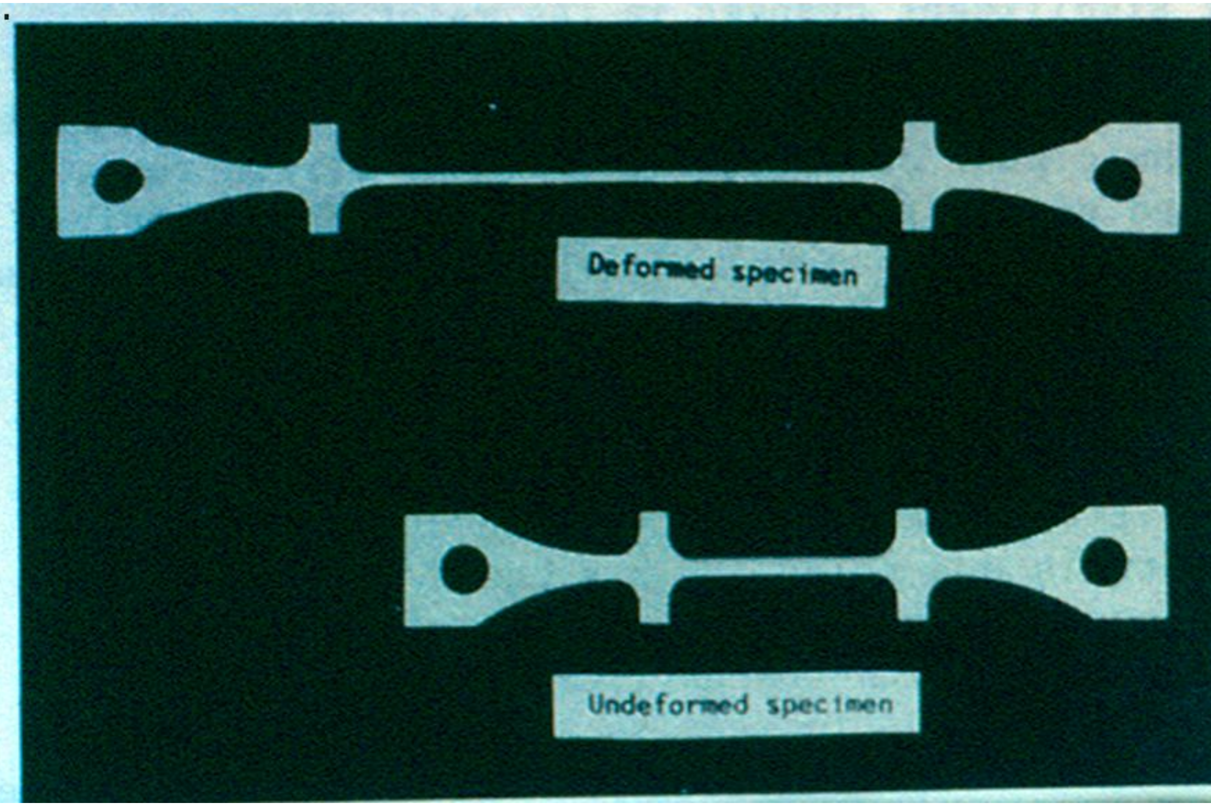
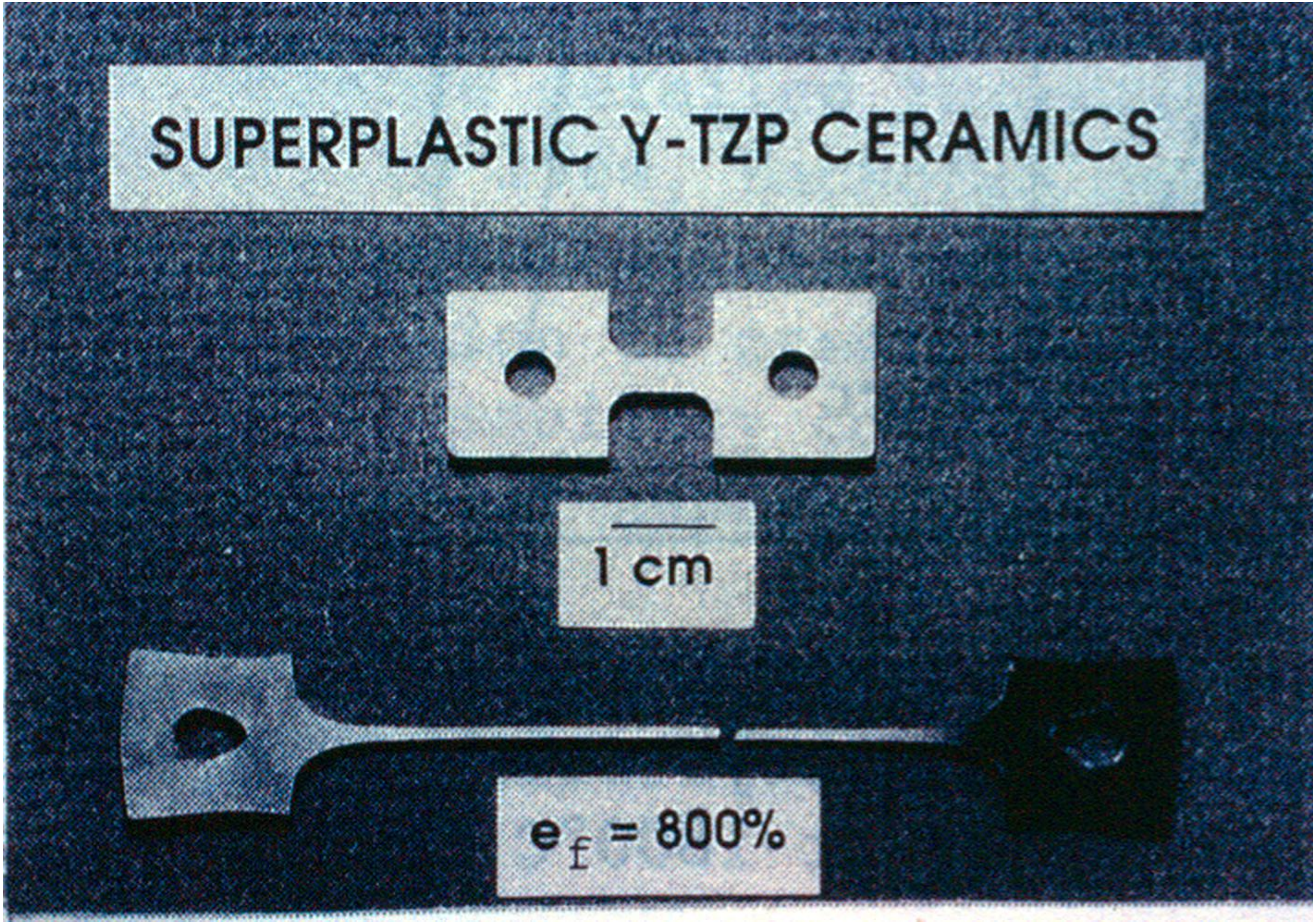


Fig. 7

The first example of tensile superplasticity in a ceramic: 3Y-TZP deformed to >120% at 1723 K [18].


SUPERPLASTIC Y-TZP CERAMICS
1 cm
e_f = 800%

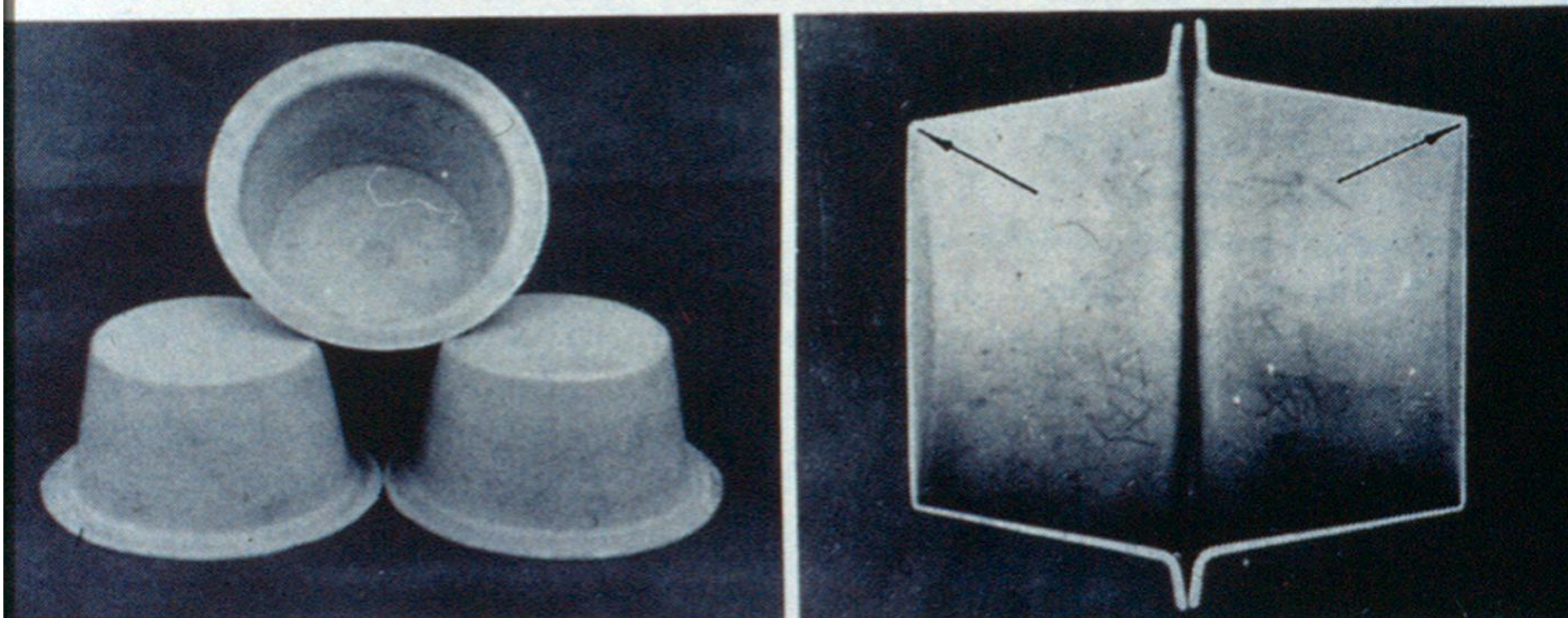
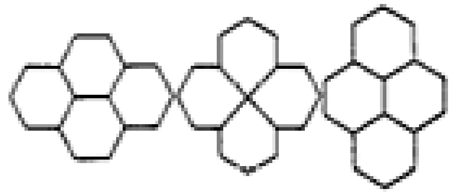
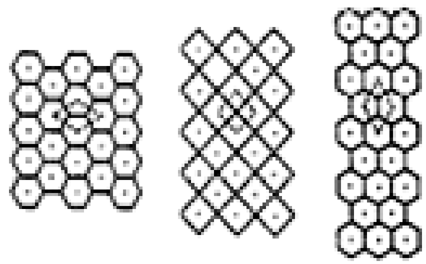
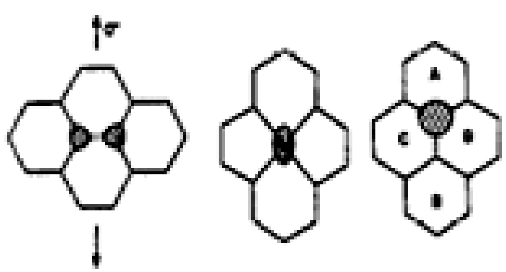


Fig.4: The SPF D/W=0.62 cone part and its cross section.

Diffusion accommodation

Ashby and Verrall [3]		There is some experimental confirmation of this model. The deformation pattern of the surrounding grains is not clear. No explanation of further deformation
Ashby et al. [4]		Model is applied to large number of grains. Multiple triple/quadruple point transformations are not observed experimentally
Chung and Davies [5]		Modification of A–V model in compression for a material with cavities. No explanation of cavity growth
Pundy and Embury [6]		Extension of A–V model for particle-strengthened materials

SPF Technology, Advantages

FORM TECH

- Single sheet structures with high complexity due to high SPF strain
- Sheet forming verified for thickness range between 0.1 and 22mm
- One – step forming process
- Stress relieving and/or aging heat treatment included in the SPF process
- Forming die inexpensive. Only one cavity and a flat top die necessary
- Ceramic die concept for rapid prototyping verified
- Short lead time for feasibility studies, prototypes and small volume production
- SPF-Production cost effective up to ~20 000 parts per year

Advantage SPF-Process:

- **Cost reduction**
- **Weight reduction**
- **Rapid prototyping**
- **Integral design of complex shapes**

Cost savings up to 40 %

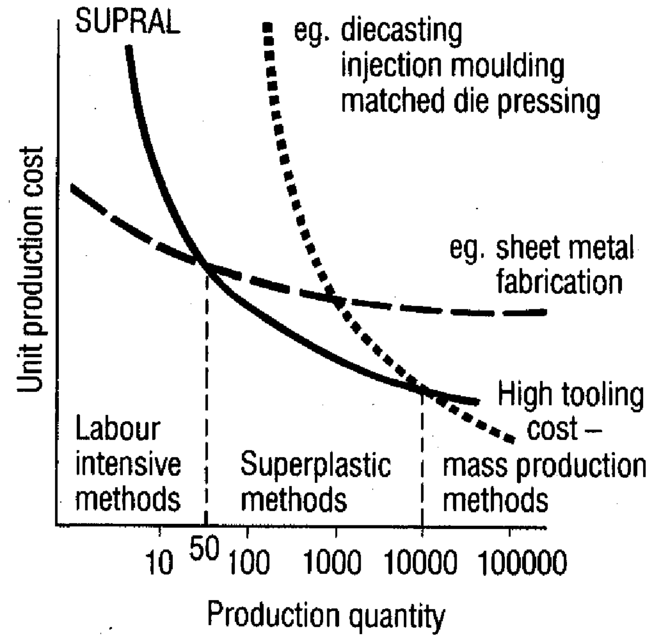
-Better material utilisation

-Low assembly cost

-Reduced part number

-Lower die cost

Low Cost Tools – Moderate Production Rates.
Cycle times for forming in SUPRAL sheet range from 5 to 40 minutes according to sheet thickness, depth of component and detailed design. Tool costs are modest, particularly for complex designs in comparison with die casting and matched die pressing of metal parts or injection moulding of plastics. Coupling the moderate production rates with low cost tools gives optimum production levels of around 50 to 10,000 parts.



[redacted]