

**4º CURSO DE TECNOLOGIA DO VÁCUO  
PARA INDÚSTRIA E LABORATÓRIOS**

# **MATERIAIS E COMPONENTES**

**26 - setembro - 2016**

**UNIVERSIDADE DE SÃO PAULO - INSTITUTO DE FÍSICA**

# **MATERIAIS MAIS UTILIZADOS**

## **1 - METAIS**

### **PRÉ-VÁCUO:**

**COBRE**

**LATÃO**

**AÇO**

**FERRO**

**BRONZE**

**ALUMÍNIO LAMINADO**

**AÇO INOXIDÁVEL**

# 1 - METAIS

## ALTO-VÁCUO

**AÇO INOXIDÁVEL**  
**COBRE**  
**ALUMÍNIO LAMINADO**  
**DURALUMÍNIO**

**LIGAS ESPECIAIS (KOVAR)**  
**TITÂNIO (SUBLIMADORES)**  
**TUNGSTÊNIO (FILAMENTOS)**  
**MOLIBDÊNIO (FILAMENTOS)**  
**ÍNDIO (CRIOGENIA)**  
**NIÓBIO**  
**TÂNTALO**

## **2 - ISOLANTES**

**VIDRO (PYREX)**

**CERÂMICAS (ESTEATITA, ALUMINA)**

**EPÓXI (PASSADORES)**

**TEFLON**

**KEL-F**

**KAPTON**

**NYLON**

**ACRÍLICO (LUCITE)**

**TYGON**

**ELASTÔMEROS (O'RINGS)**

**BUNA-N (BORRACHA NITRÍLICA)**

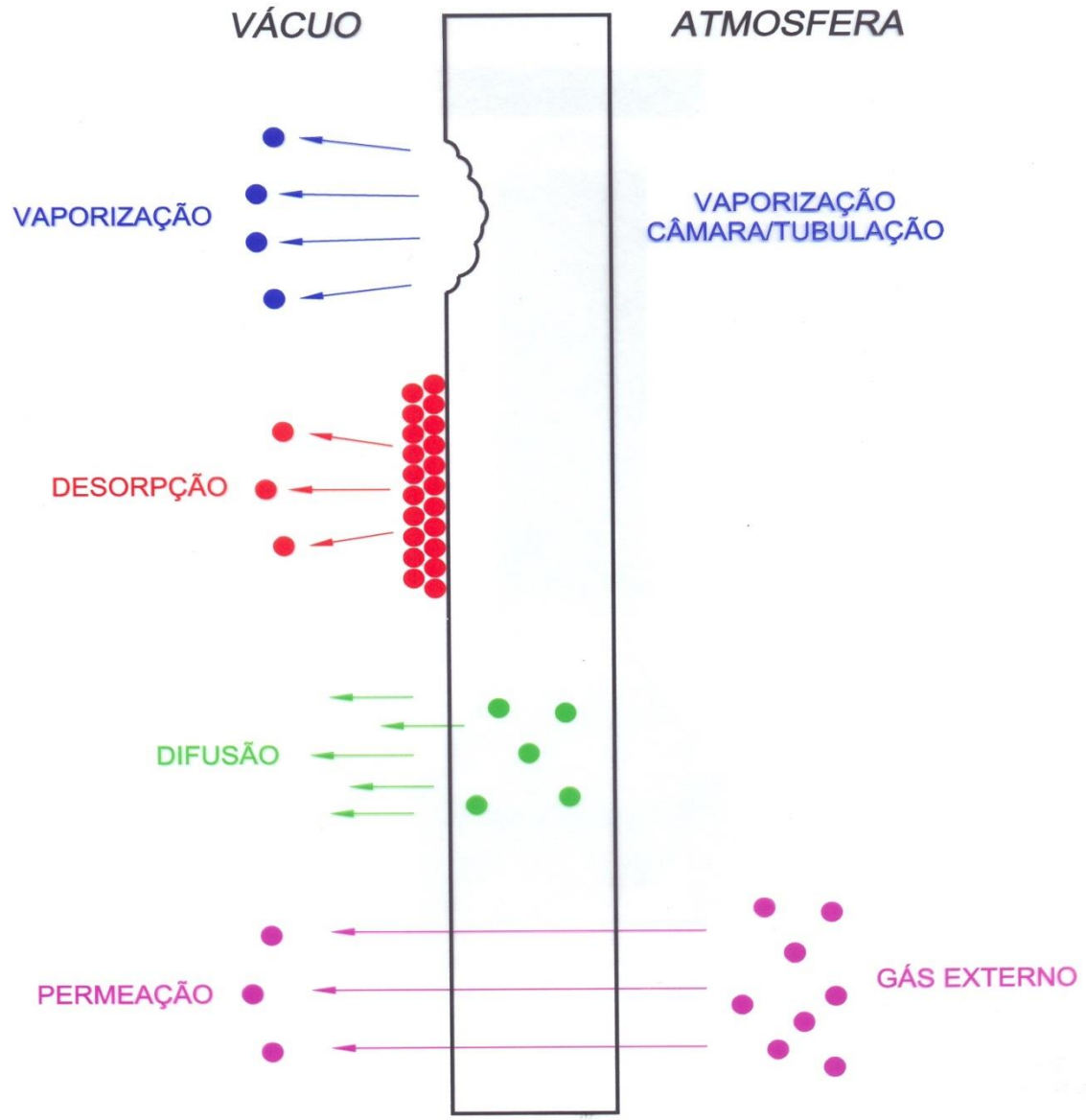
**NEOPRENE**

**ISOPRENE (BORRACHA NATURAL)**

**VITON**

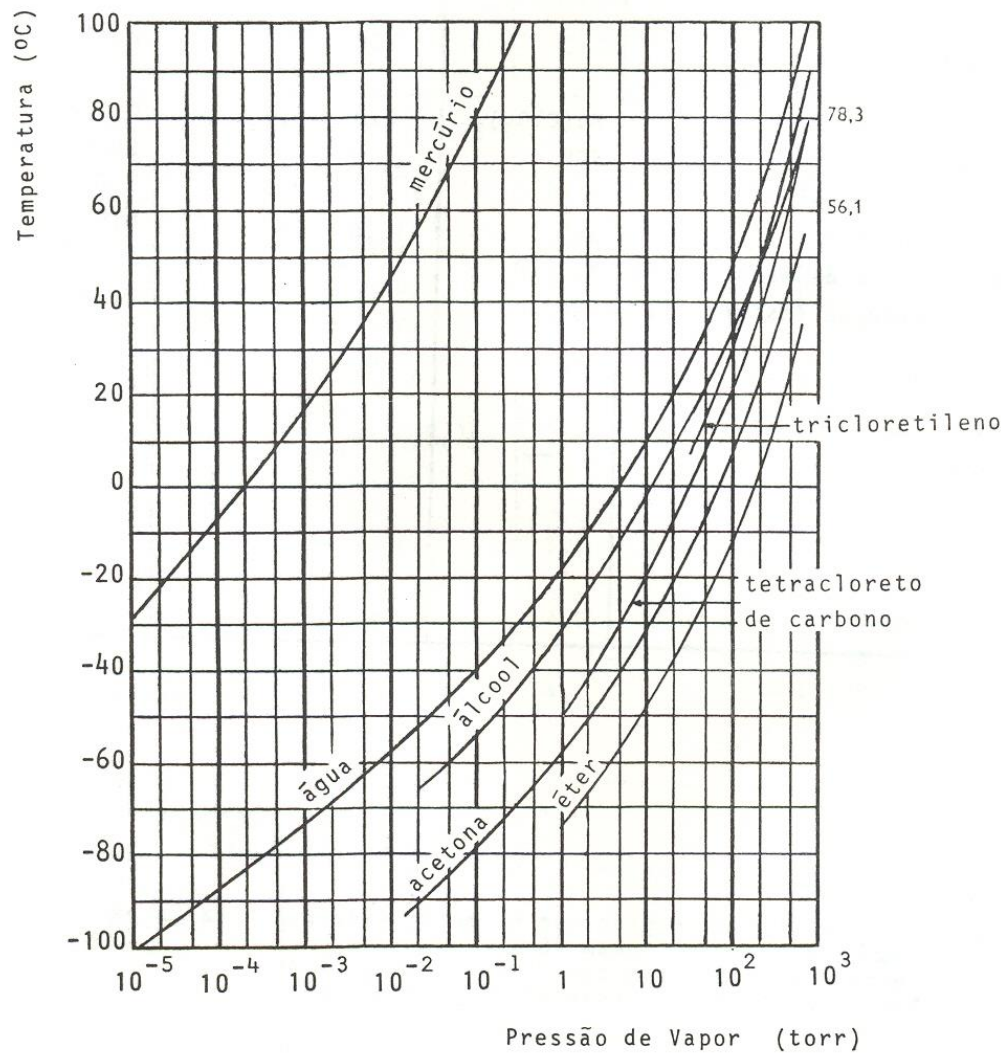


# DEGASIFICAÇÃO



ALGUNS DADOS DO AR À TEMPERATURA AMBIENTE

	PRESSÃO (TORR)						
	760	$10^{-3}$	$10^{-8}$	$10^{-10}$	$10^{-12}$	$10^{-14}$	$10^{-16}$
Caminho livre médio	$10^{-5}$ cm	7 cm	7 km	700 km	$7 \times 10^5$ km	$7 \times 10^6$ km	$7 \times 10^8$ km
Número de moléculas por cm	$2,5 \times 10^{19}$	$3,3 \times 10^{13}$	$3,3 \times 10^8$	$3,3 \times 10^6$	$3,3 \times 10^4$	$3,3 \times 10^2$	3,3
Número de moléculas batendo em $1 \text{ cm}^2/\text{s}$ .	$3 \times 10^{23}$	$3,5 \times 10^{17}$	$3,5 \times 10^{12}$	$3,5 \times 10^{10}$	$3,5 \times 10^8$	$3,5 \times 10^6$	$3,5 \times 10^4$
Taxa média de colisões entre moléculas	$5 \times 10^9/\text{s}$	$6,5 \times 10^3/\text{s}$	$6,5 \times 10^{-2}/\text{s}$ 1 a cada 15,4 s.	$6,5 \times 10^{-4}/\text{s}$ 1 a cada 25,5 min.	$6,5 \times 10^{-6}/\text{s}$ 1 a cada 45 h.	$6,5 \times 10^{-8}/\text{s}$ 1 a cada 188 dias	$6,5 \times 10^{-10}/\text{s}$ 1 a cada 51,5 anos



PRESSÃO DE VAPOR DE ALGUNS MATERIAIS

	Pressão de vapor a 20 °C (torr)	Ponto de fusão (°C)
Graxa Apiezon L	$< 10^{-10}$	47
Graxa Apiezon M	$< 10^{-8}$	44
Graxa Apiezon N	$< 10^{-9}$	43
Graxa Apiezon T	$10^{-8}$	125
Graxa Apiezon AP100	$< 10^{-10}$	47
Graxa Apiezon AP101	$< 10^{-5}$	(*)
Celvacene "light"	$10^{-6}$	90
Celvacene "medium"	$< 10^{-6}$	120
Celvacene "heavy"	$< 10^{-6}$	130
Vacuseal "light"	$10^{-5}$	50
Vacuseal "heavy"	$10^{-5}$	60
Graxa de Silicone	$< 10^{-6}$	215
Graxa Lubriseal	$< 10^{-5}$	40
Araldite	$< 10^{-6}$ (+)	60
Glyptal	$2 \times 10^{-4}$ (+)	100

(\*) Em temperaturas elevadas não chega a fundir

(+) A 25 °C



PROPRIEDADES DE SOLVENTES MAIS COMUNS

	Fórmula	Pressão de vapor à temperatura ambiente (torr)	Ponto de ebulição (°C)	Toxidez: máxima concentração permitida (ppm)
Tricloretileno	$C_2HCl_3$	60	87	100
Tetracloreto de carbono	$CCl_4$	88	77	10
Clorofórmio	$CHCl_3$	180	61	50
Benzeno	$C_6H_6$	80	80	25
Tolueno	$C_7H_8$	23	110	200
Xilol	$C_8H_{10}$	5	140	200
Éter etílico	$C_4H_{10}O$	440	35	400
Acetona	$C_3H_6O$	180	56	1000
Metil-etil-cetona	$C_4H_8O$	71	80	250
Alcool metílico (metanol)	$CH_4O$	98	65	200
Alcool etílico	$C_2H_6O$	46	78	1000
Alcool isopropílico	$C_3H_8O$	38	82	400
Freon MF	$CCl_3F$	700	24	1000
Freon TF	$CCl_2FCClF_2$	284	48	1000
Freon BF	$CCl_2FCCl_2F$	57	93	1000
Água	$H_2O$	17,535	100	-
Mercúrio	Hg	$1,2 \times 10^{-3}$	356,6	0,05mg/m <sup>3</sup>

# ÓLEOS PARA BOMBAS DE DIFUSÃO

ÓLEO	COMPOSIÇÃO QUÍMICA	PONTO DE EBUL. (°C)	PESO MOLECULAR	PRESSÃO FINAL (Torr)	VISCOSIDADE A (cSt)	
					20°C	150°C
APIEZON C	Hidrocarboneto de petróleo	255	479	1.0 E 10-7	283	4,0
SILICONE DC-702	Metil polisiloxano	185	530	4.9 E 10-6	55	2,4
SILICONE DC-704	Tetrafenil tetrametil trisiloxano	223	484	4.9 E 10-8	47	2,2
SILICONE DC-705	Pentafenil trimetil trisiloxano	254	546	1.0 E 10-9	240	3,3
SANTOVAC 5	Éter polifenílico	295	446	1.0 E 10-9	2400	4,5
FOMBLIN	Poliéter perfluorado	240	2650	2.0 E 10-8	190	9 a
NEOVAC SY	Éter mono-N-alquildifenílico	220	406	1.0 E 10-8	25 b	17 c
ALCATEL 214	Tetrafenil tetrametil trisiloxano	185	484	8.0 E 10-8	45	-
ALCATEL 220	Elcosil naftaleno	250	408	2.3 E 10-10	50	-
CONVOIL 20	Hidrocarboneto de petróleo	190	400	8.0 E 10-6	80	23 d
MERCÚRIO	(elemento químico)	127	201	-	1,15	-

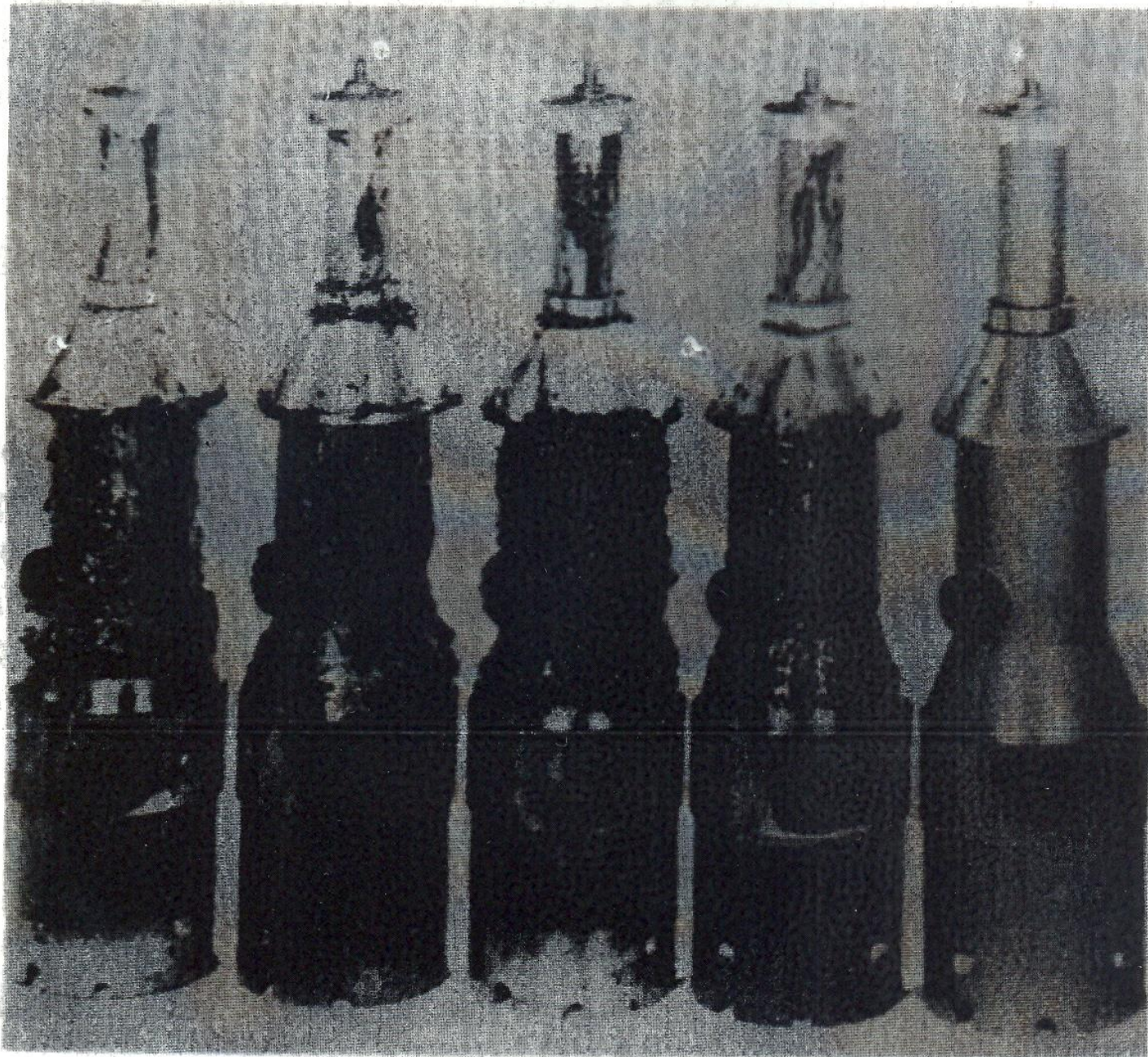
(a) 100°C

(b) 40°C

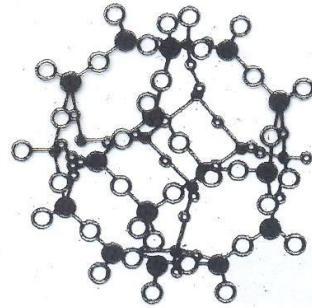
(c) 50°C

(d) 54°C

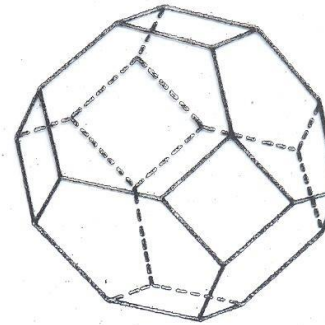




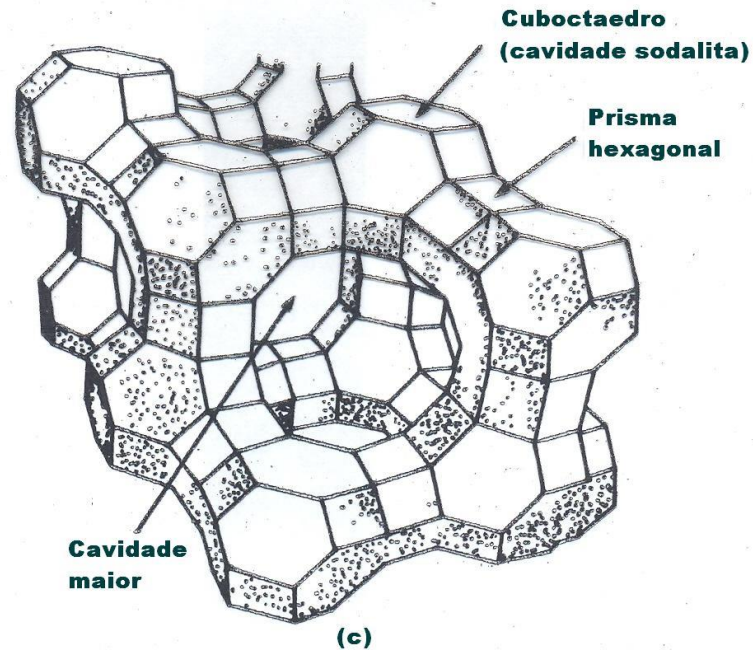
# ZEÓLITA



(a)



(b)

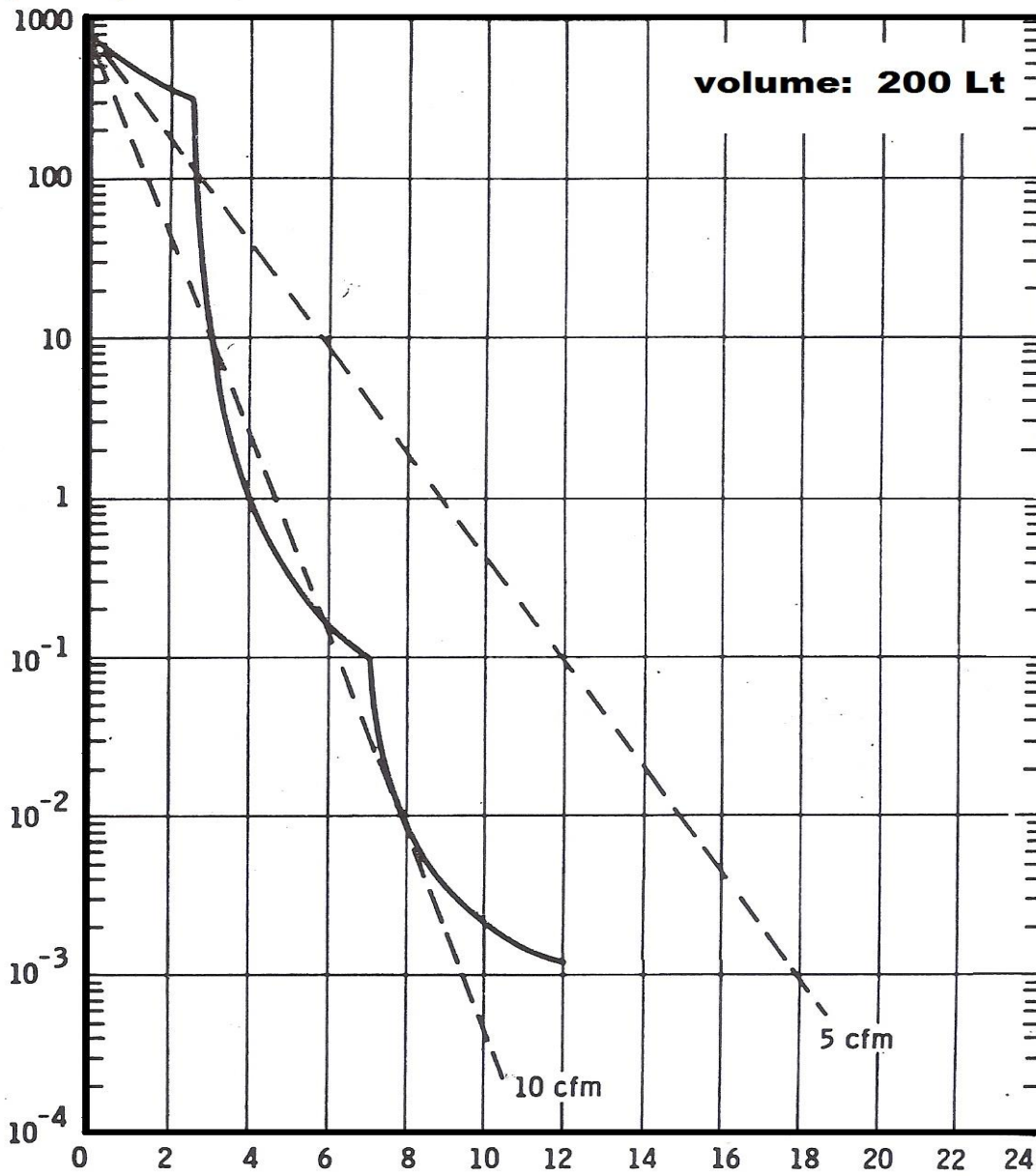


(c)

**Estrutura de uma zeólita. (b) Representação simplificada do cuboctaedro (a), onde aparecem os átomos de oxigênio [o] e os de alumínio ou silício [●]. Estes cuboctaedros unidos formam a zeólita (c).**














**P (Torr)**



**t (min)**

## AGENTES DE SORPÇÃO

PROPRIEDADE	ZEOLITAS	CARVÃO ATIVADO
CAPACIDADE DE SORPÇÃO		
CONDUTIVIDADE TÉRMICA		
PRODUÇÃO DE PÓ		
FACILIDADE DE REGENERAÇÃO		
PERIGO DE EXPLOSÃO COM O <sub>2</sub>		
CUSTO		

# PROPRIEDADES DE ELASTÔMEROS

<b>ELASTÔMERO</b>	<b>BUNA-N</b>	<b>NEOPRENE</b>	<b>VITON</b>	<b>ISOPRENO</b>	<b>SILICONE</b>
TIPO DE ELASTÔMERO	<b>NBR</b>	<b>CR</b>	<b>FPM</b>	<b>IR</b>	<b>SI</b>
MÁXIMA TEMPERATURA DE TRABALHO CONTÍNUO (°C)	<b>121</b>	<b>93</b>	<b>260</b>	<b>107</b>	<b>260</b>
RESILIÊNCIA (VOLTA AO NORMAL)	<b>R-B</b>	<b>MB</b>	<b>MB</b>	<b>B</b>	<b>B</b>
RESISTÊNCIA À ABRASÃO	<b>MB</b>	<b>MB</b>	<b>B</b>	<b>E</b>	<b>M</b>
RESISTÊNCIA A SOLVENTES	<b>M</b>	<b>M</b>	<b>R-B</b>	<b>M</b>	<b>M</b>
RESISTÊNCIA A ÓLEO	<b>R-B</b>	<b>R-B</b>	<b>MB</b>	<b>M</b>	<b>M</b>
RESISTÊNCIA A ÁGUA	<b>R-B</b>	<b>R</b>	<b>R-B</b>	<b>R-B</b>	<b>R-B</b>

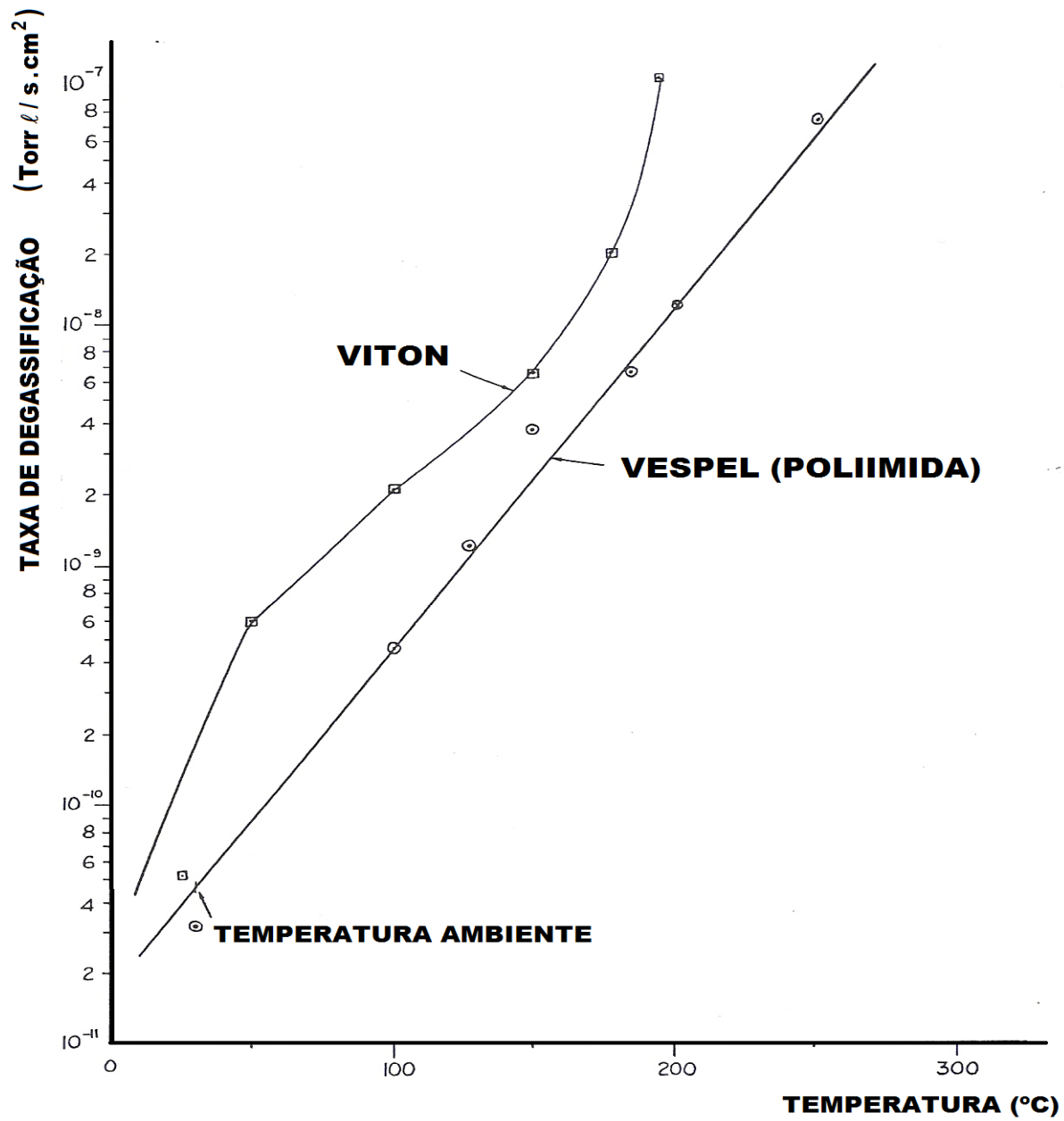
M = Mau

R = Regular

B = Bom

MB = Muito Bom

E = Excelente





# VÁLVULAS

- **COM “BELLOWS” (90°, 180°)**
- **AREJAMENTO**
- **DIAFRAGMA**
- **ESFERA**
- **AGULHA (AJUSTE FINO)**
- **BORBOLETA**
- **DISCO**
- **GAVETA**
- **VEDAÇÃO METÁLICA (FACA, DISCO CÔNICO)**



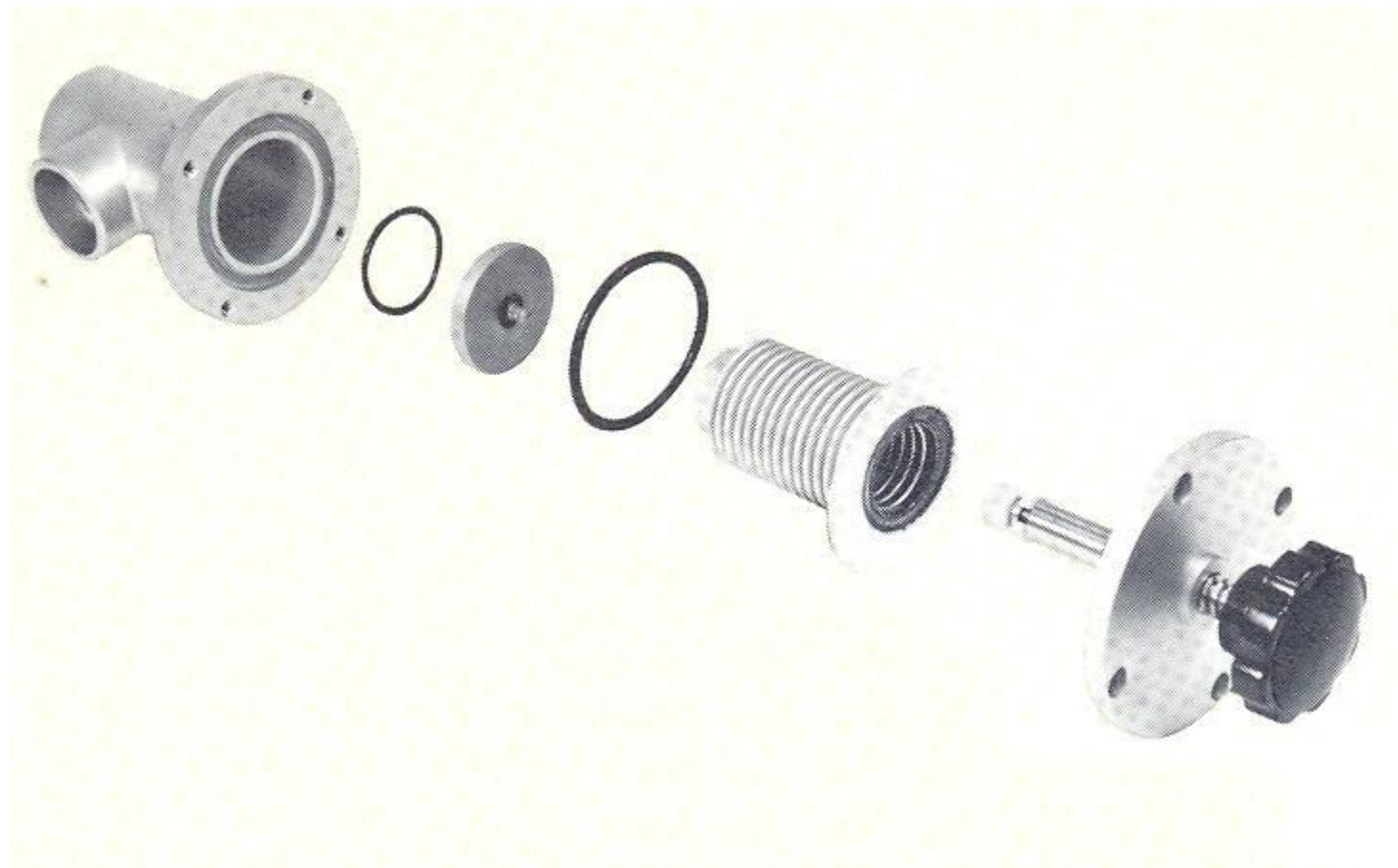




**Brass  
Vacuum Valves**



# VÁLVULA ANGULAR COM FOLE METÁLICO



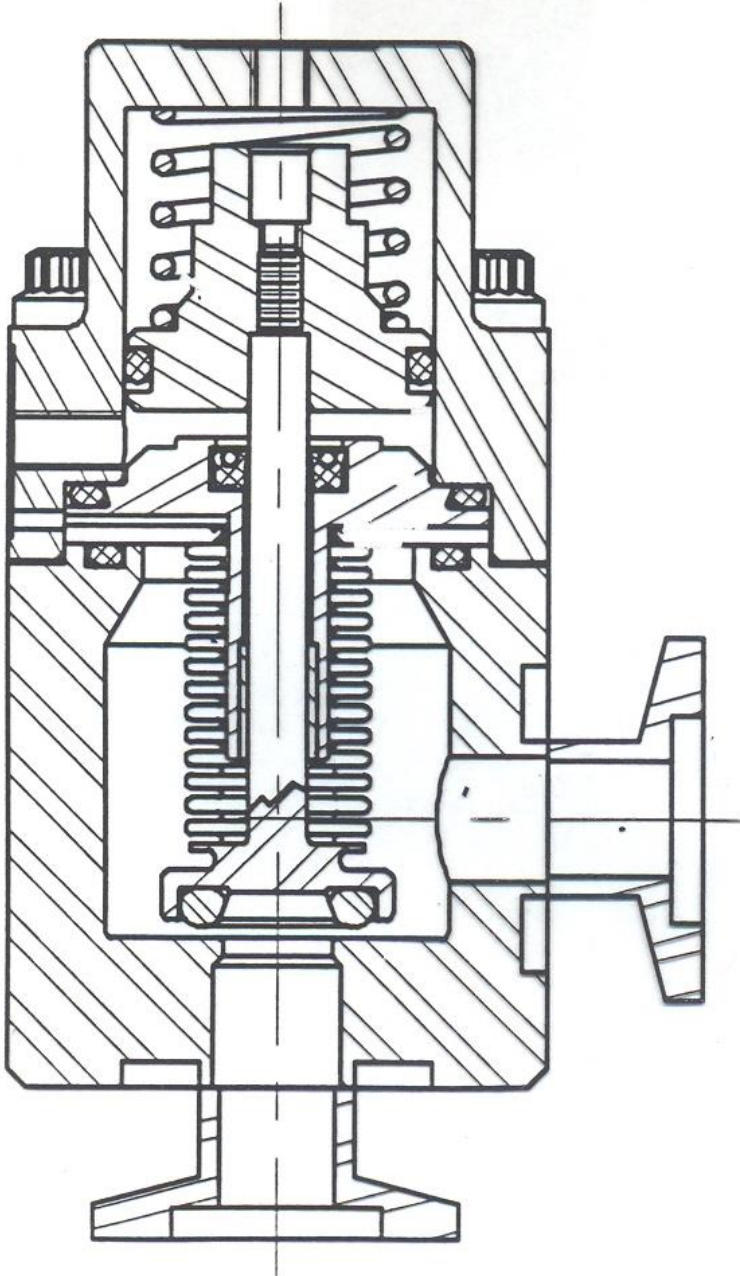






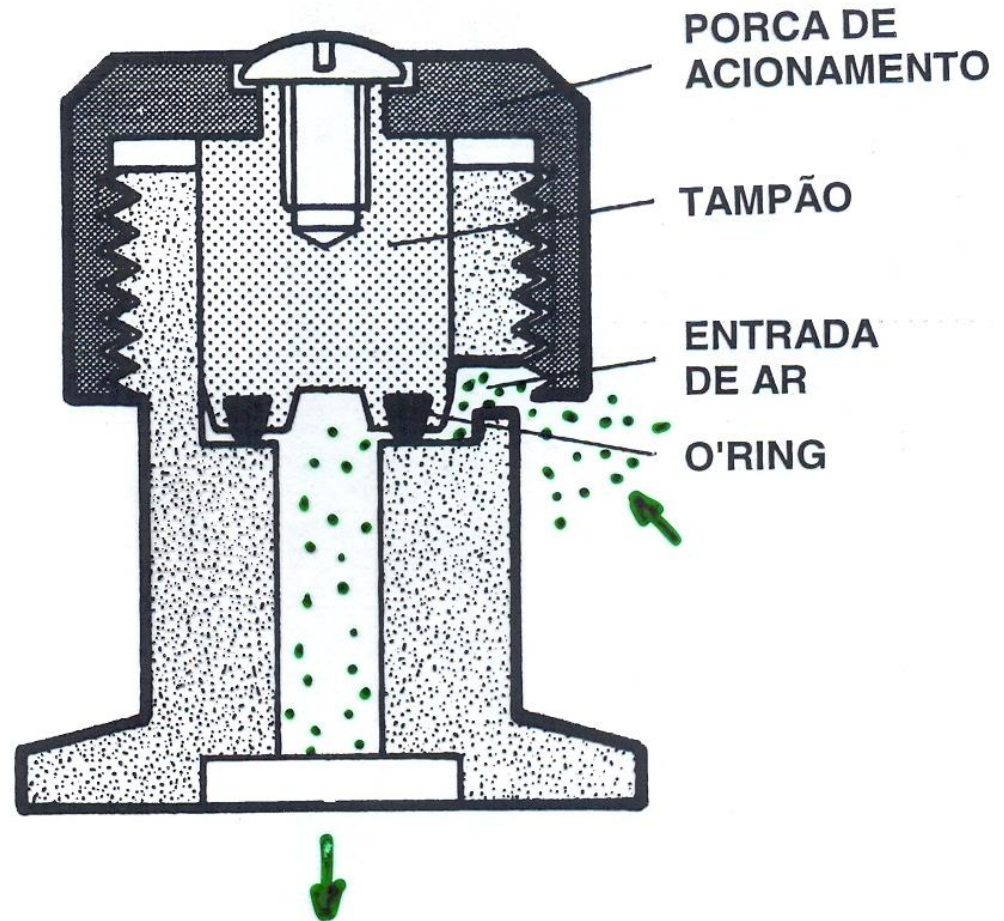
# VÁLVULA PNEUMÁTICA

**AR COMPRIMIDO**





# VÁLVULA DE ENTRADA DE AR

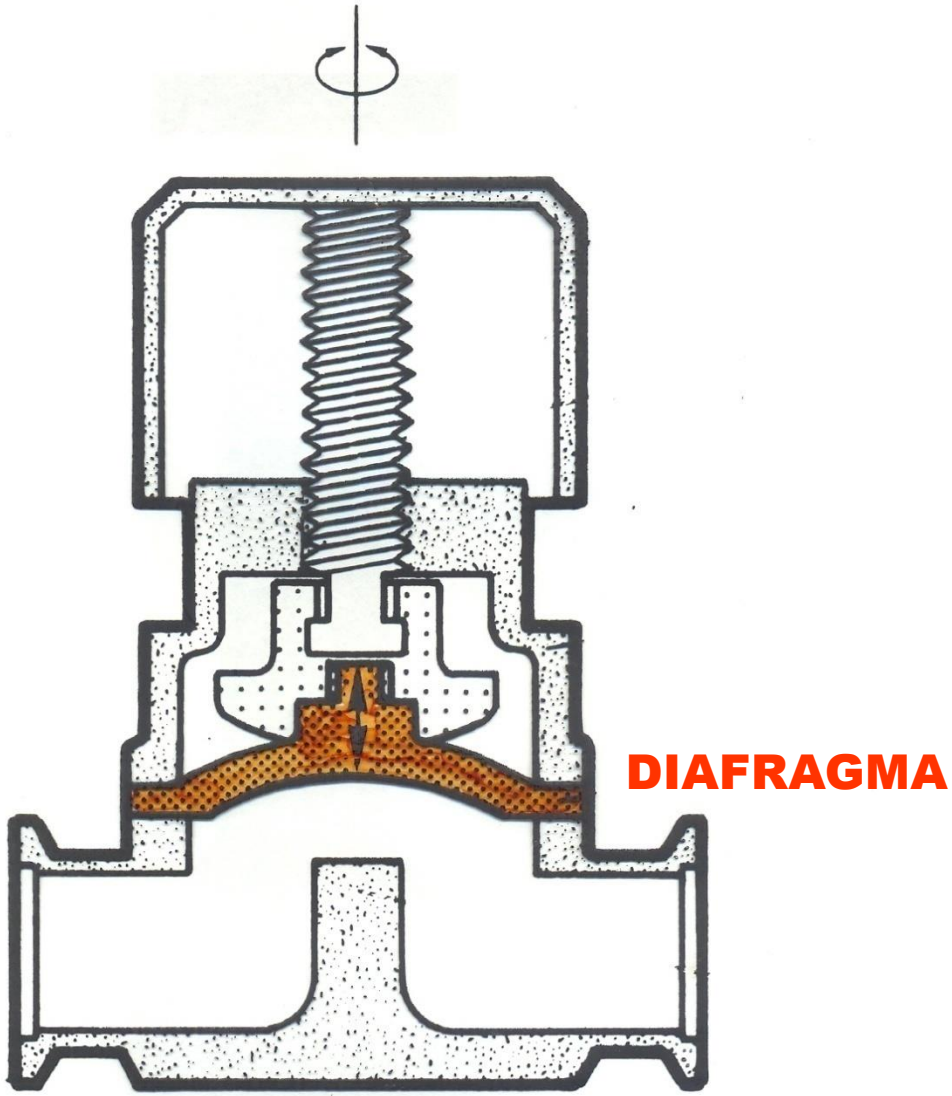




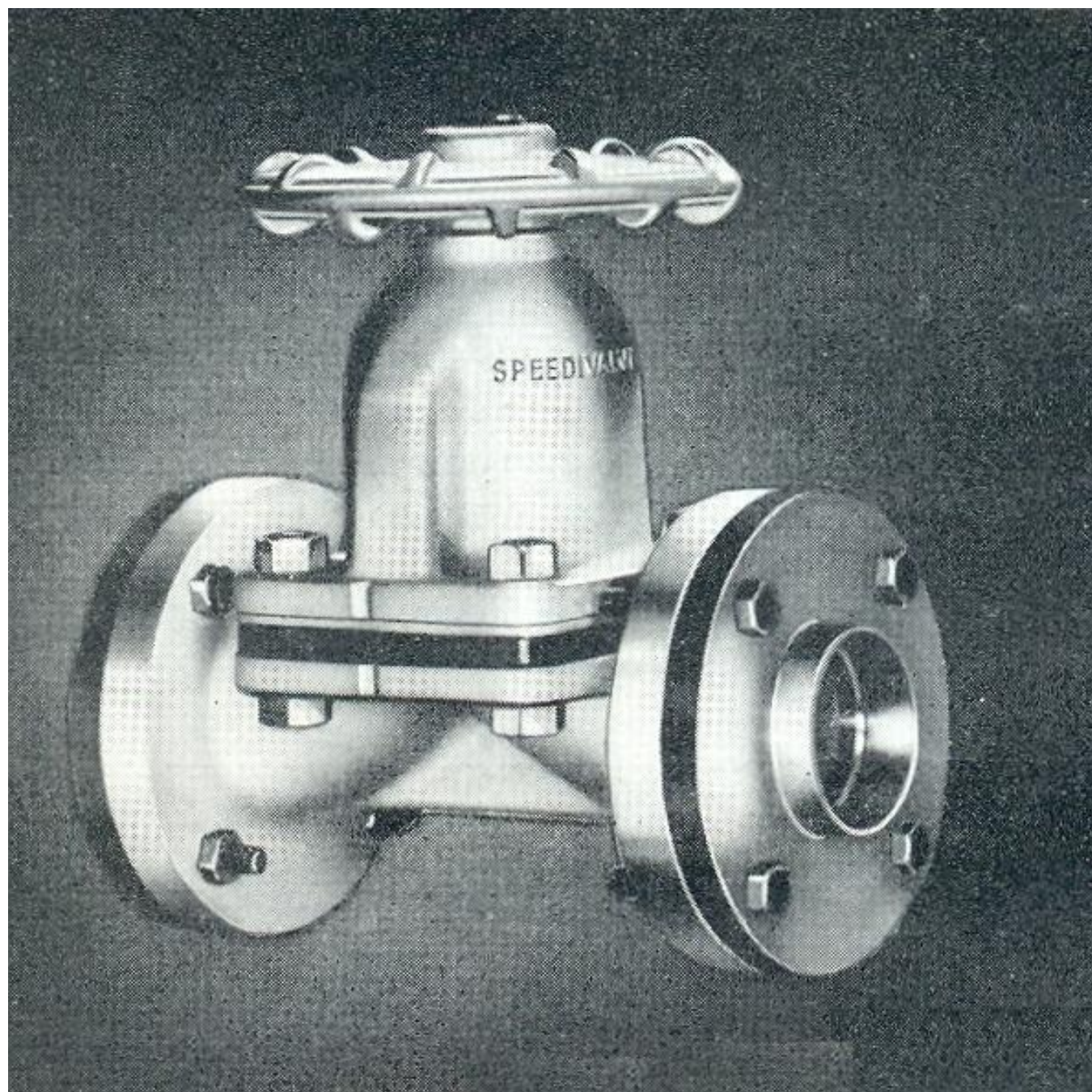




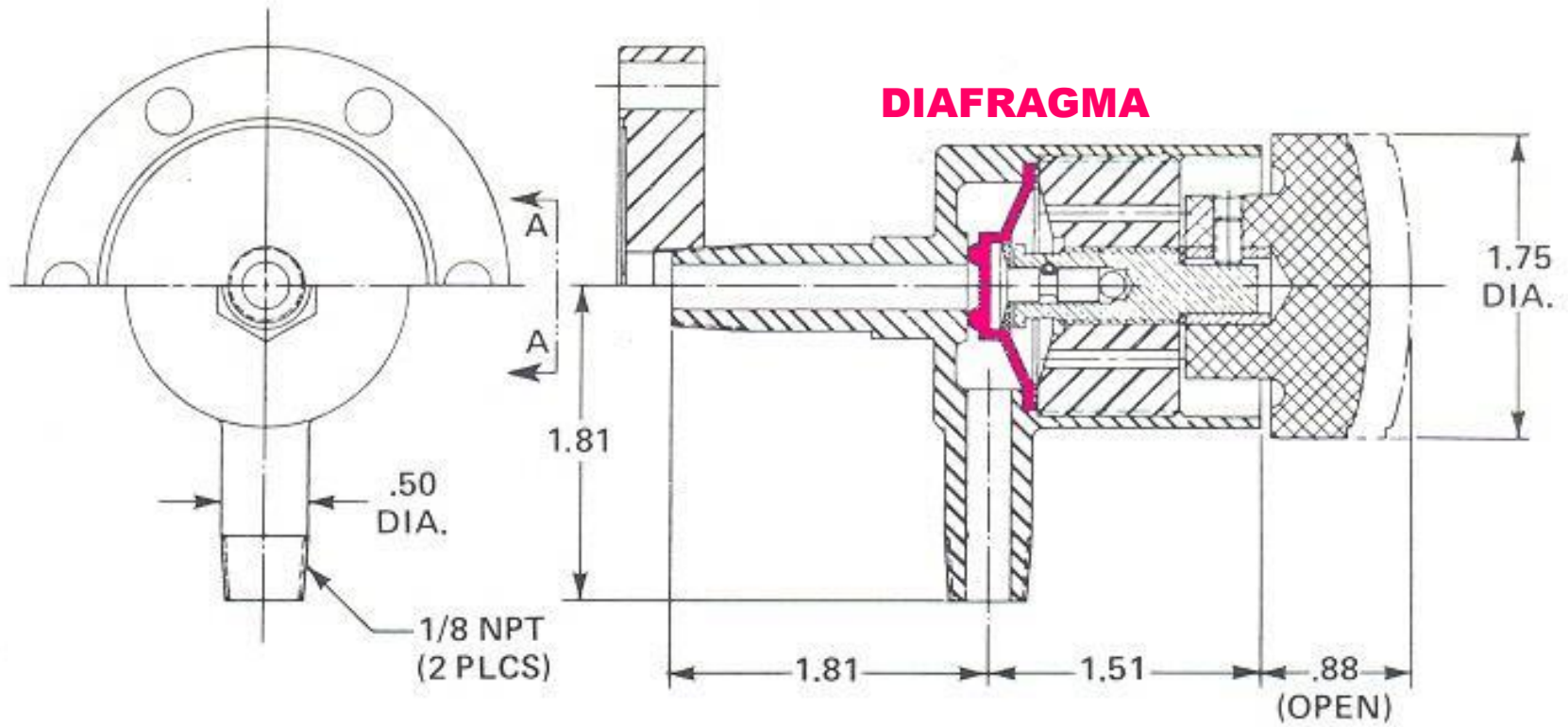
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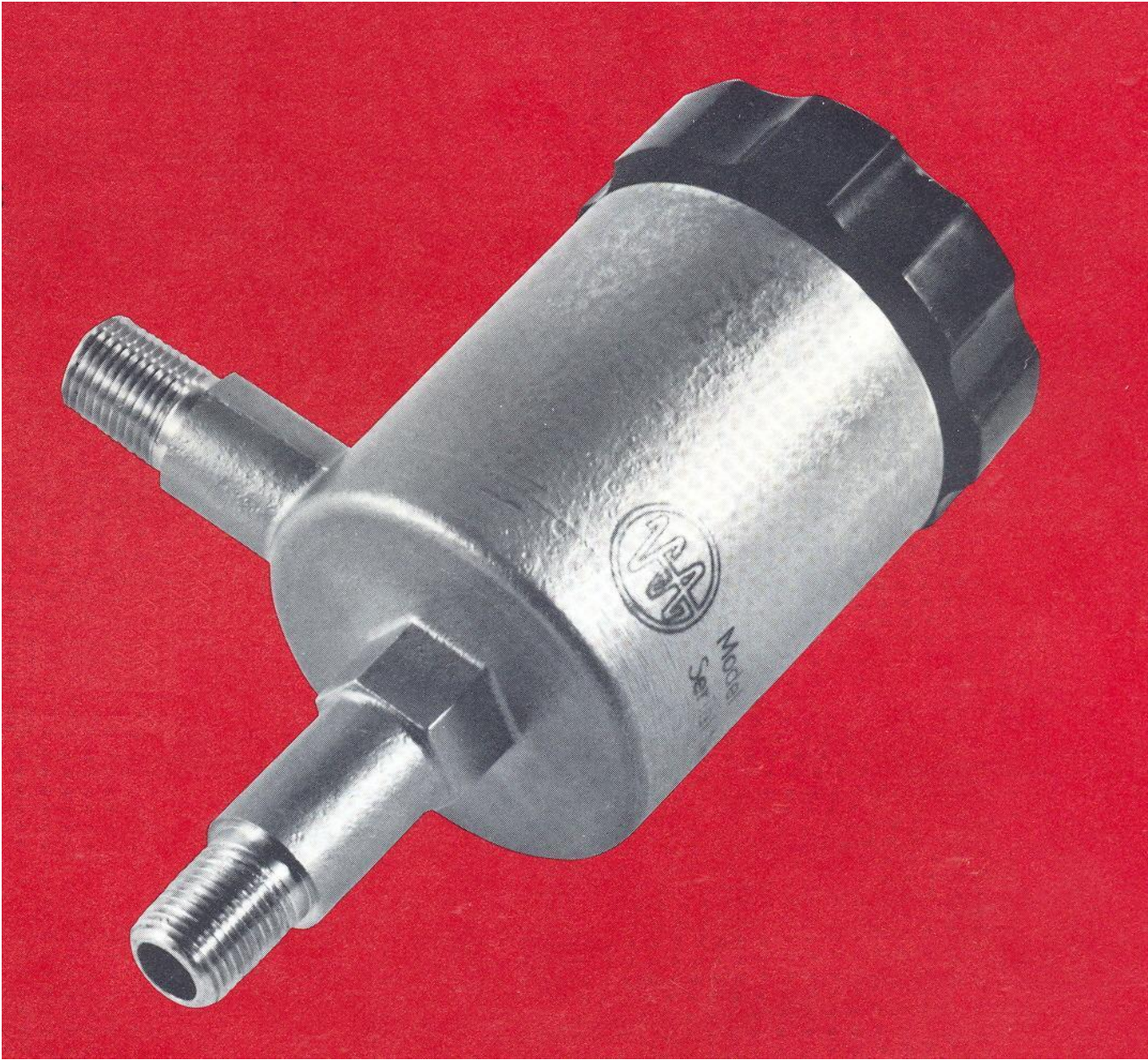




# VÁLVULA DIAFRAGMA









# VÁLVULA ESFERA



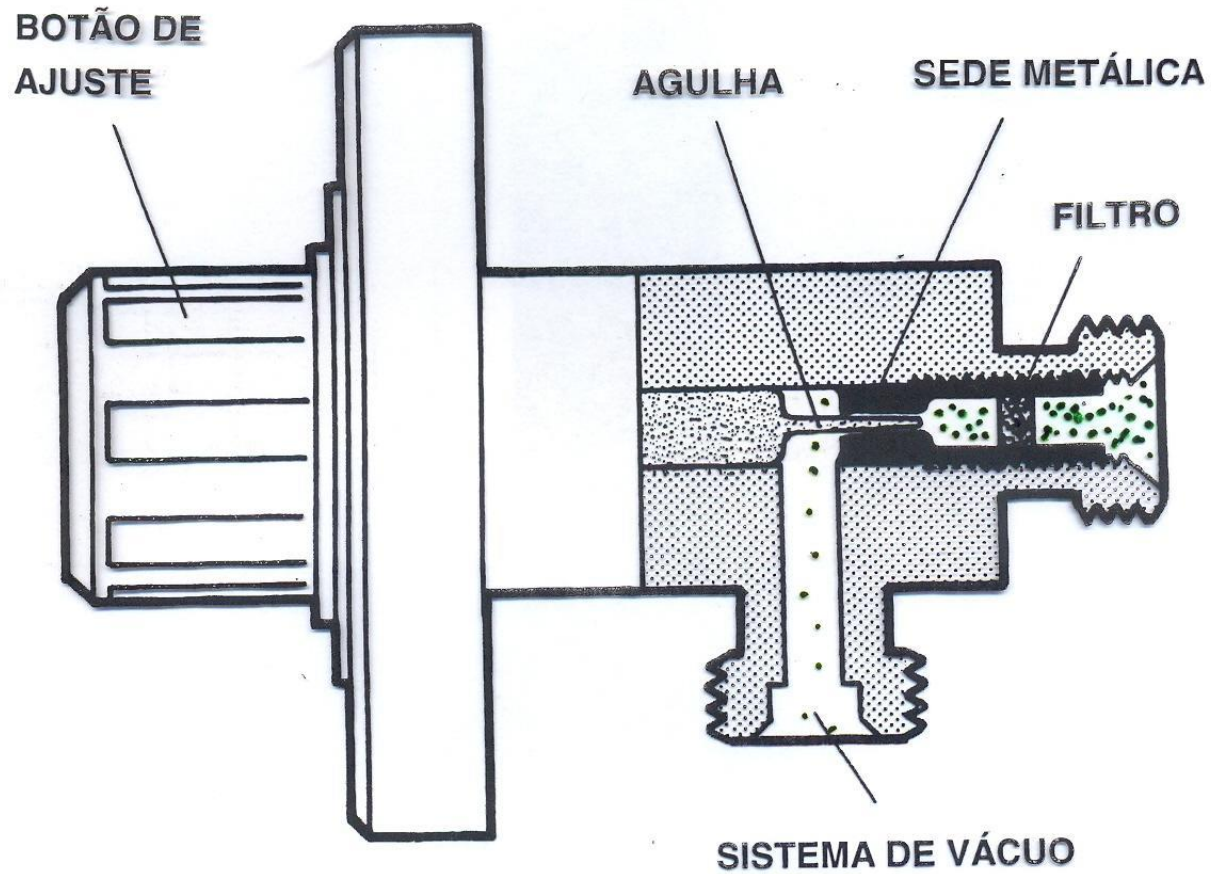
05/06/2007

# VÁLVULA ESFERA



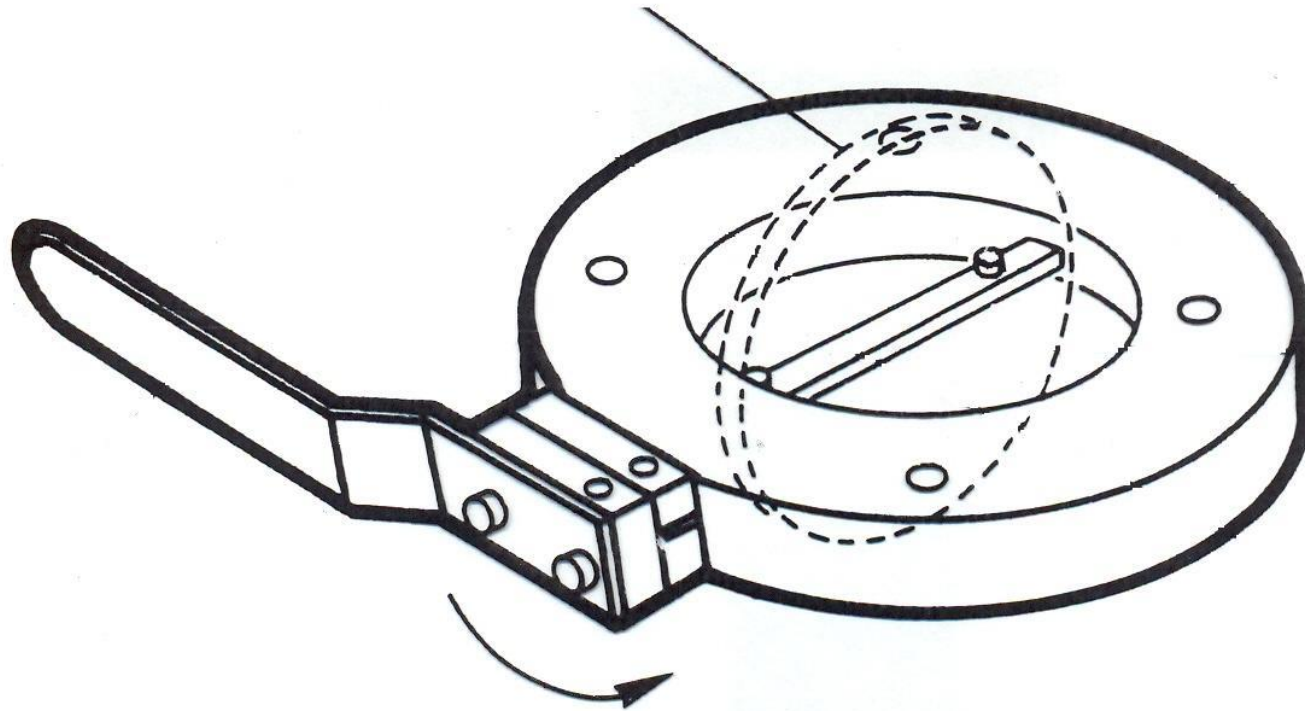
05/06/2007

# VÁLVULA AGULHA



# VÁLVULA BORBOLETA

DISCO COM O'RING

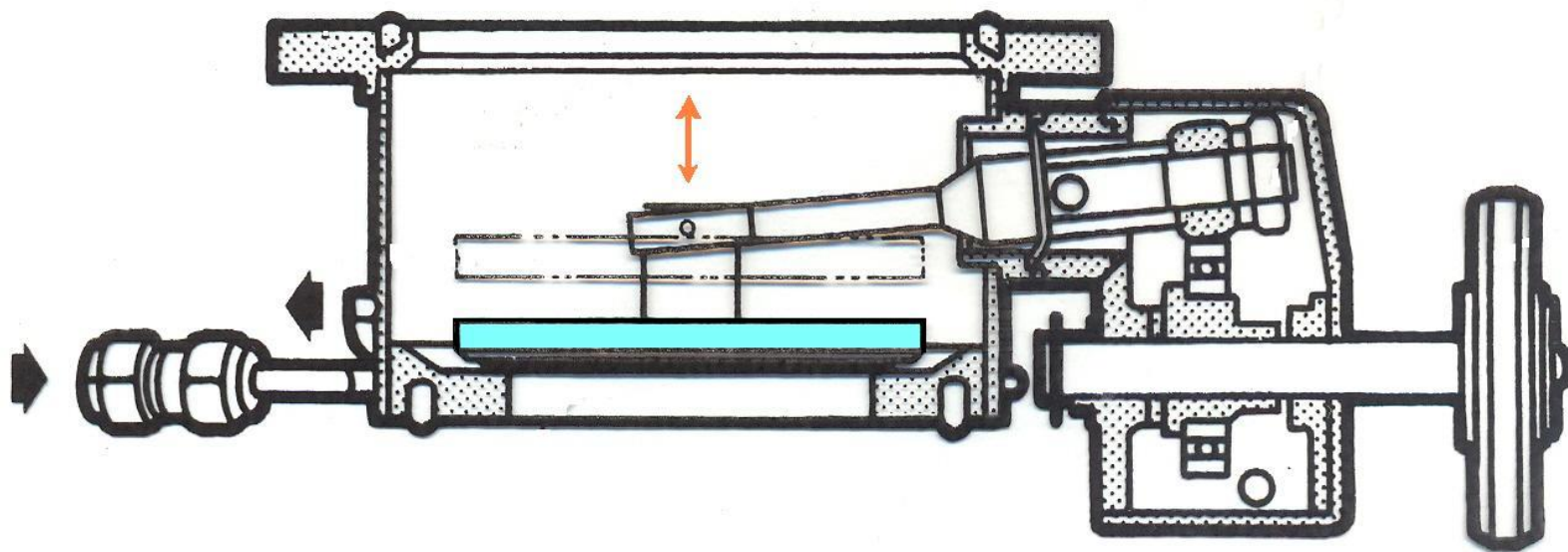




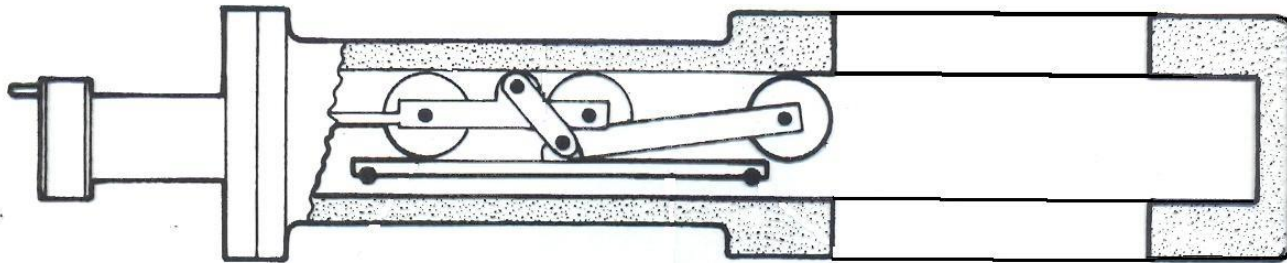
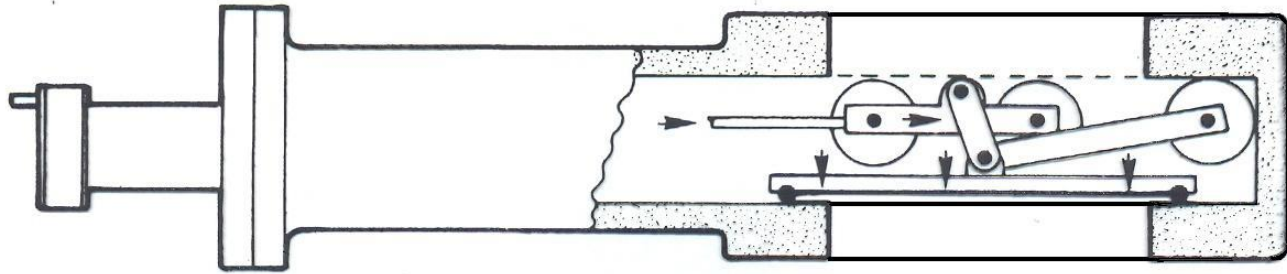




# VÁLVULA DISCO

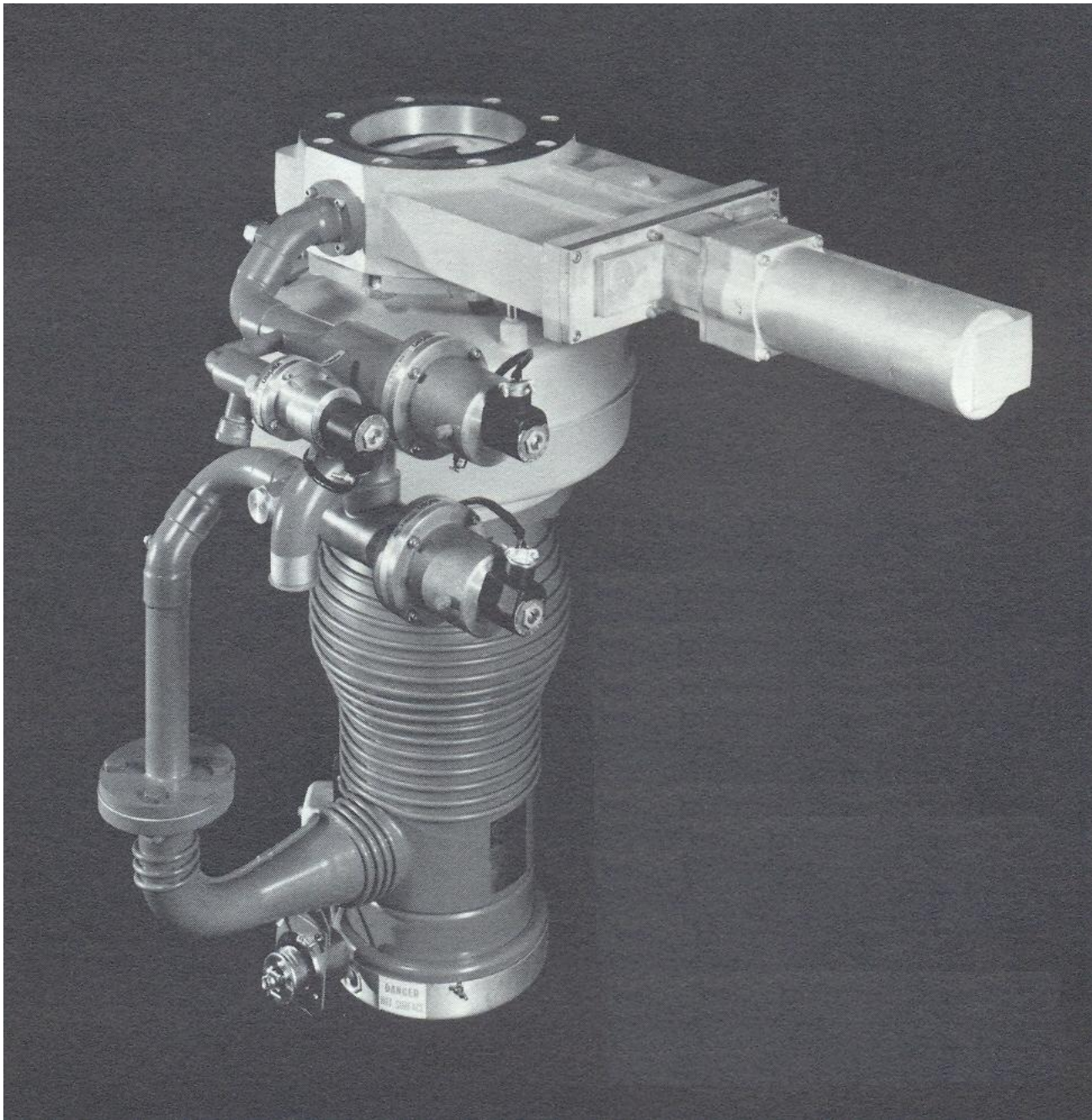


# VÁLVULA GAVETA



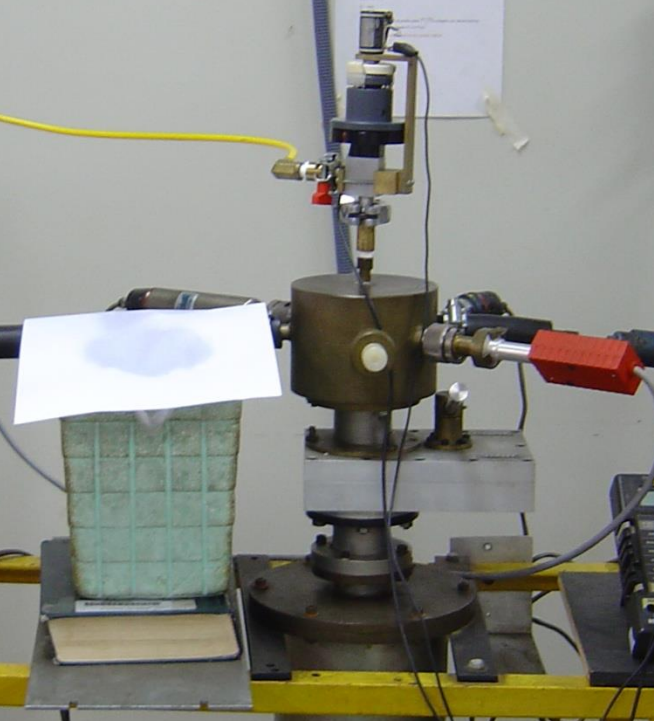
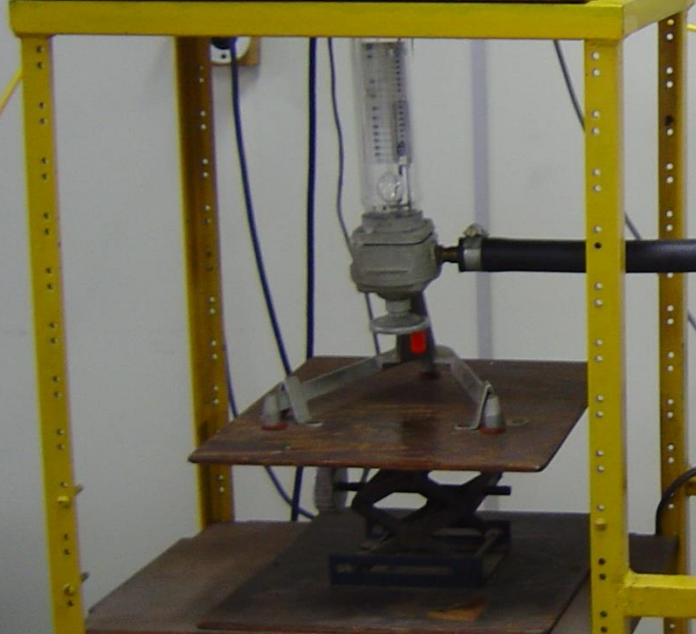




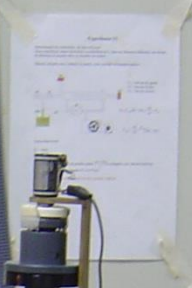




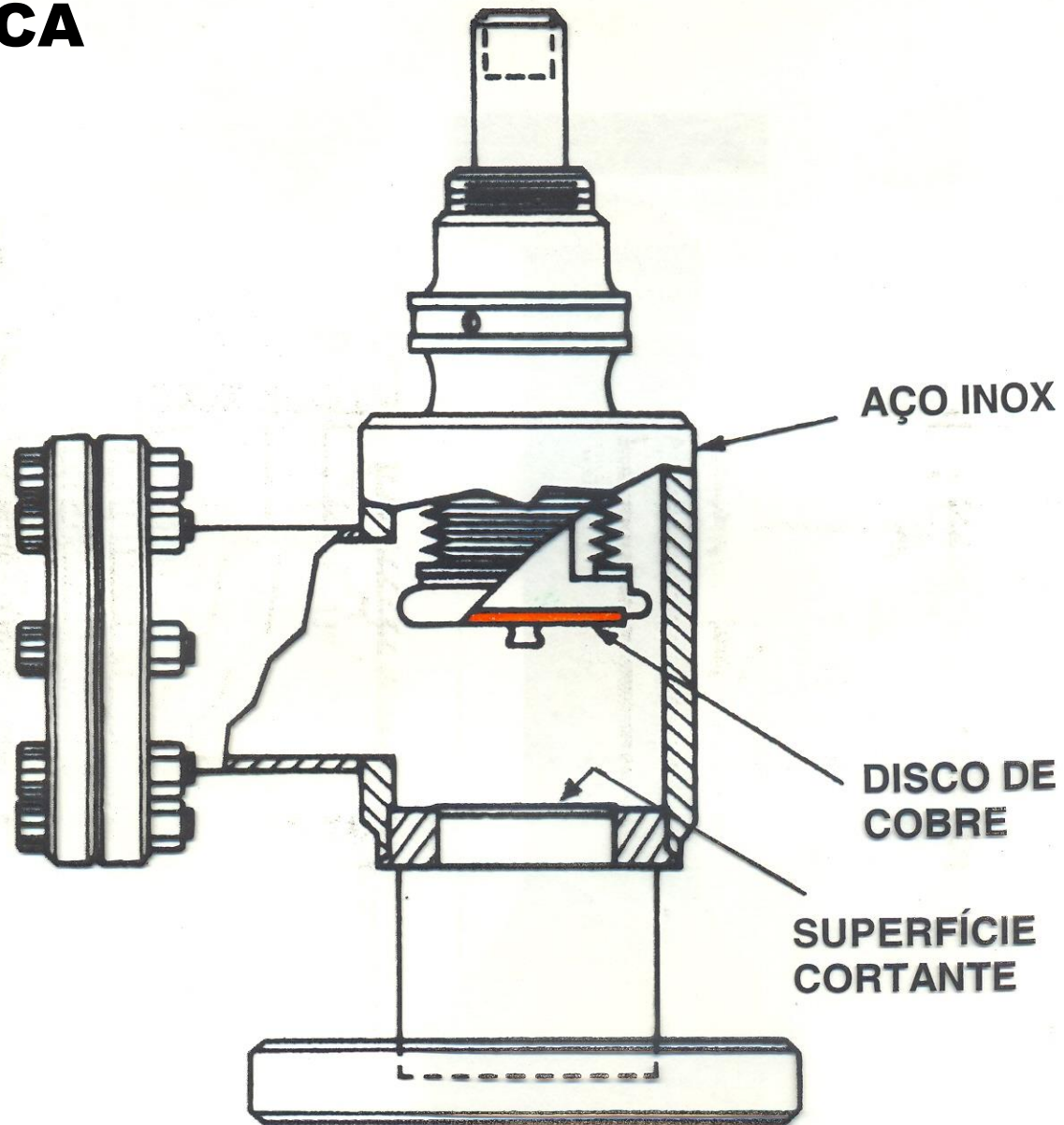
Escala Logarítmica



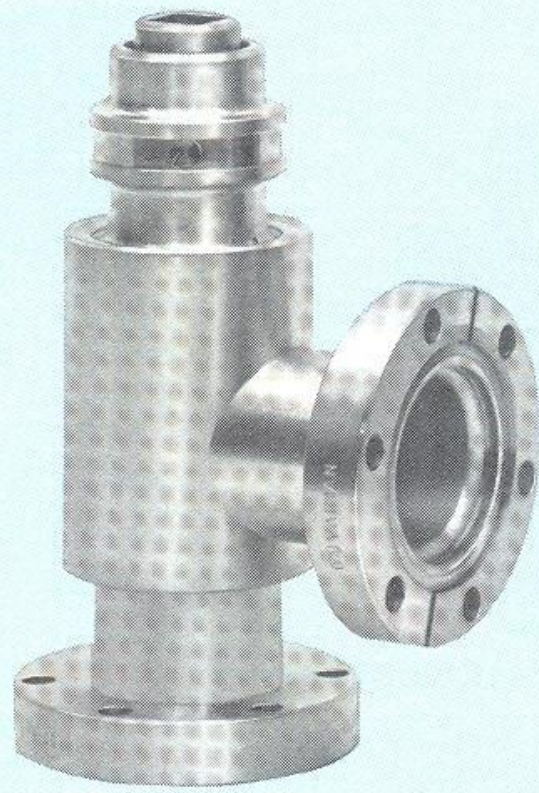
Diagrama



# VÁLVULA FACA

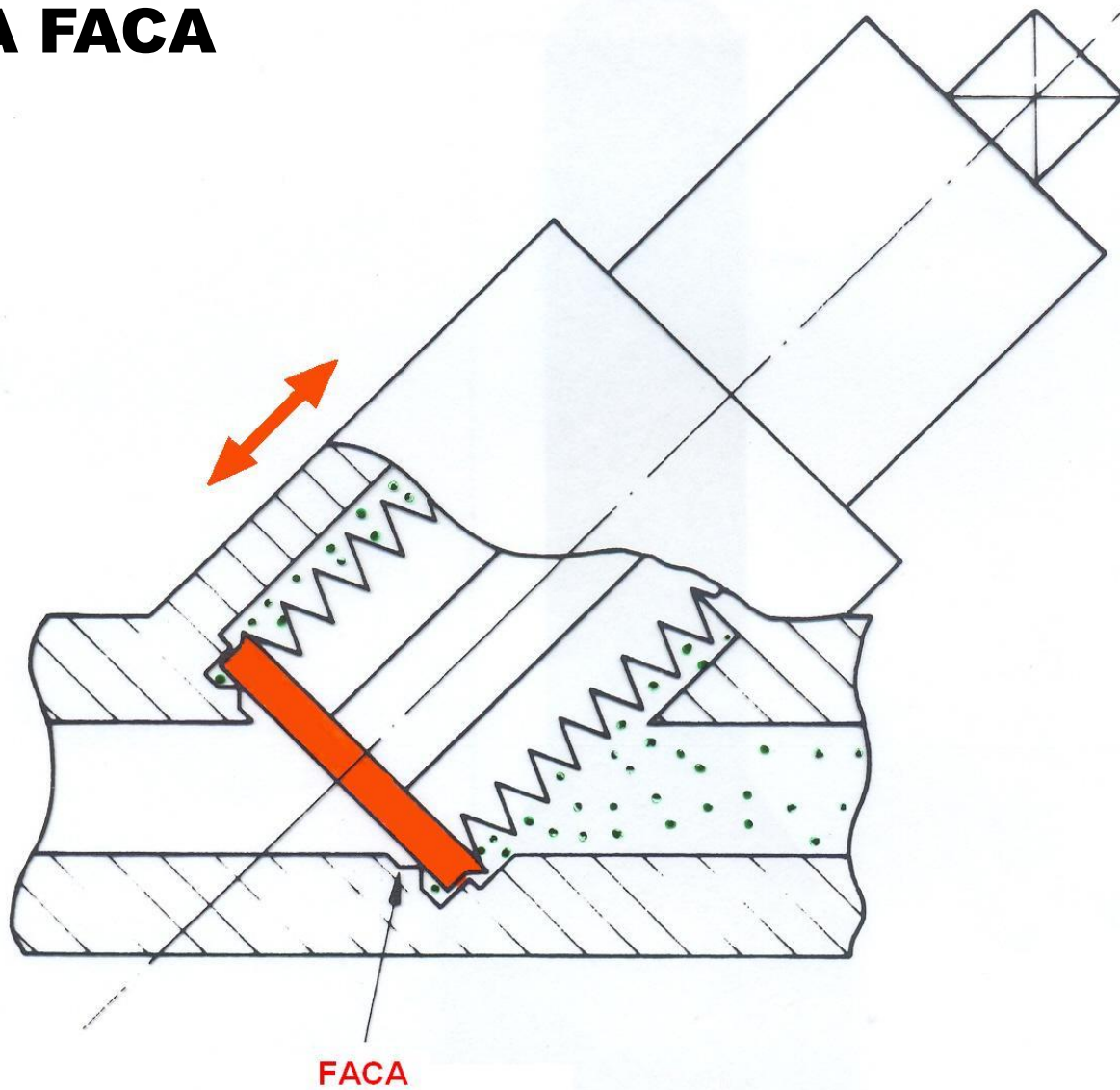




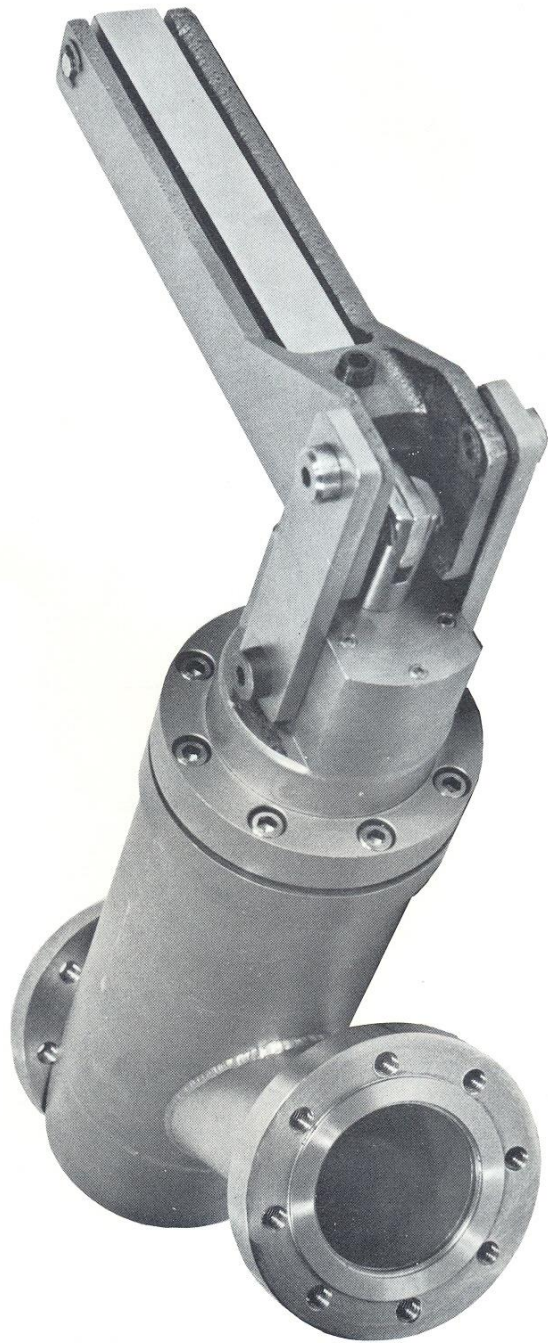


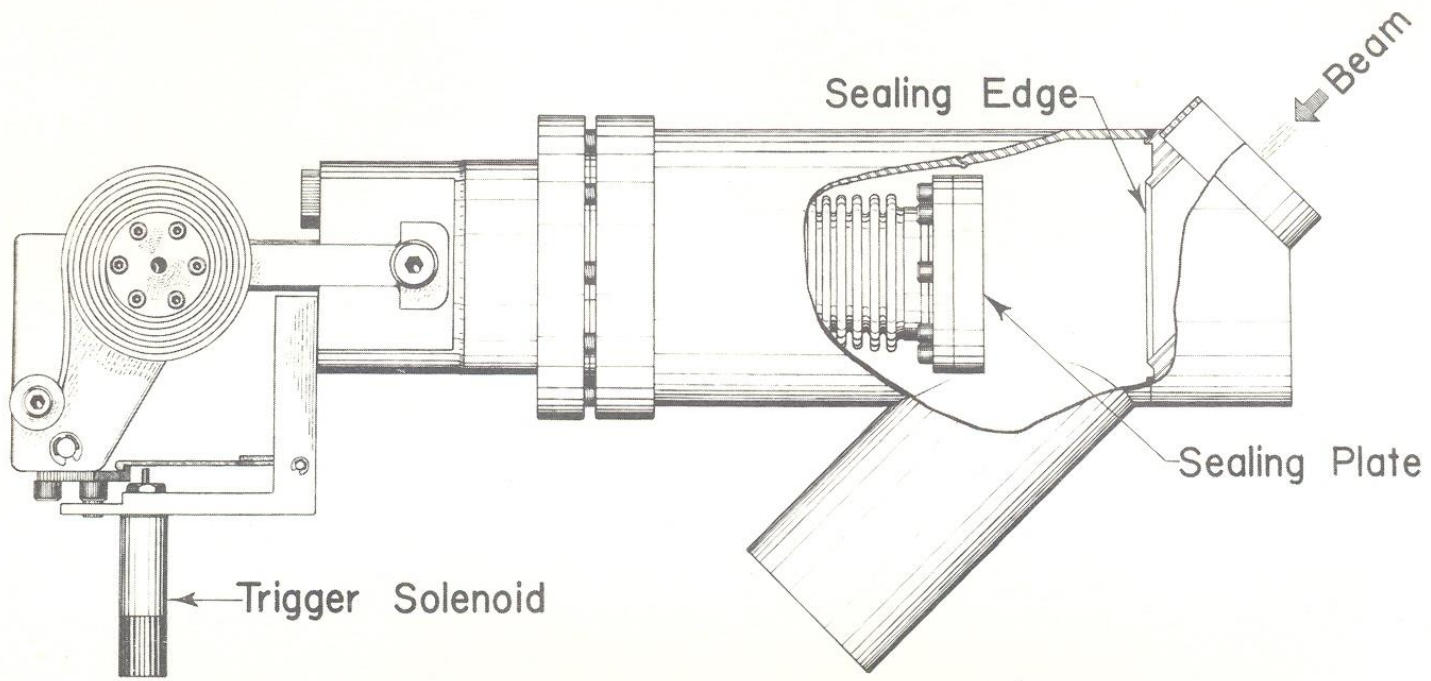


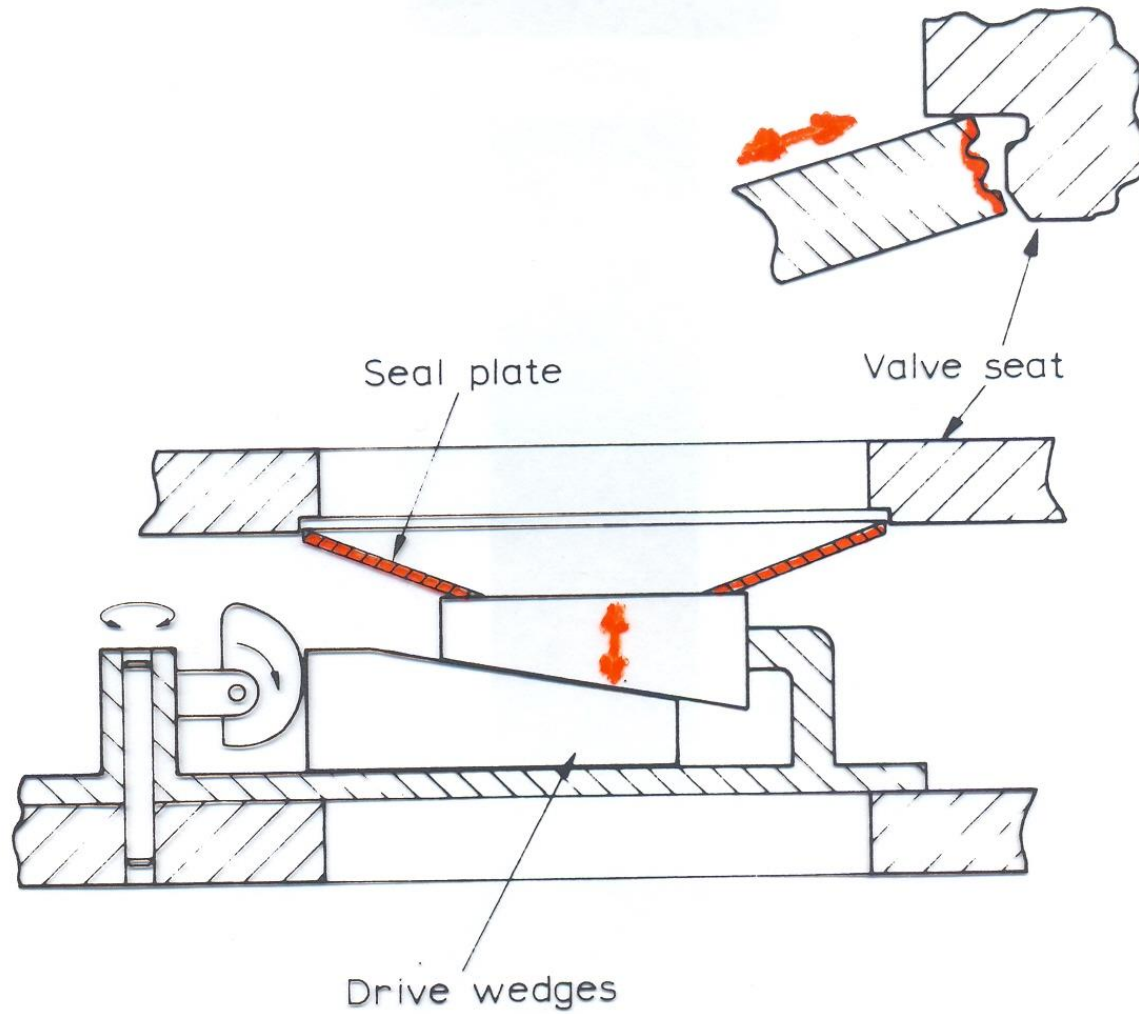
# VÁLVULA FACA





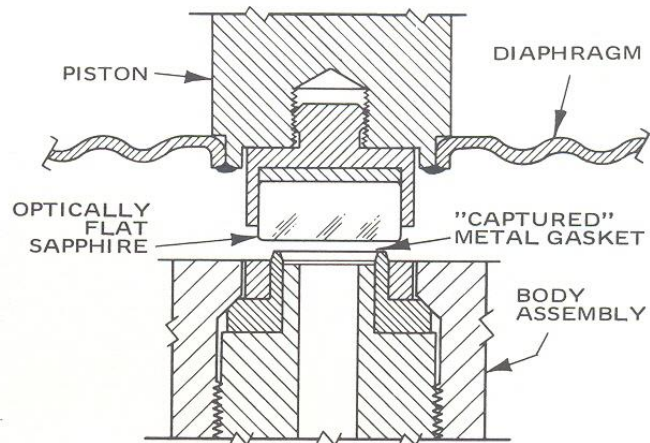
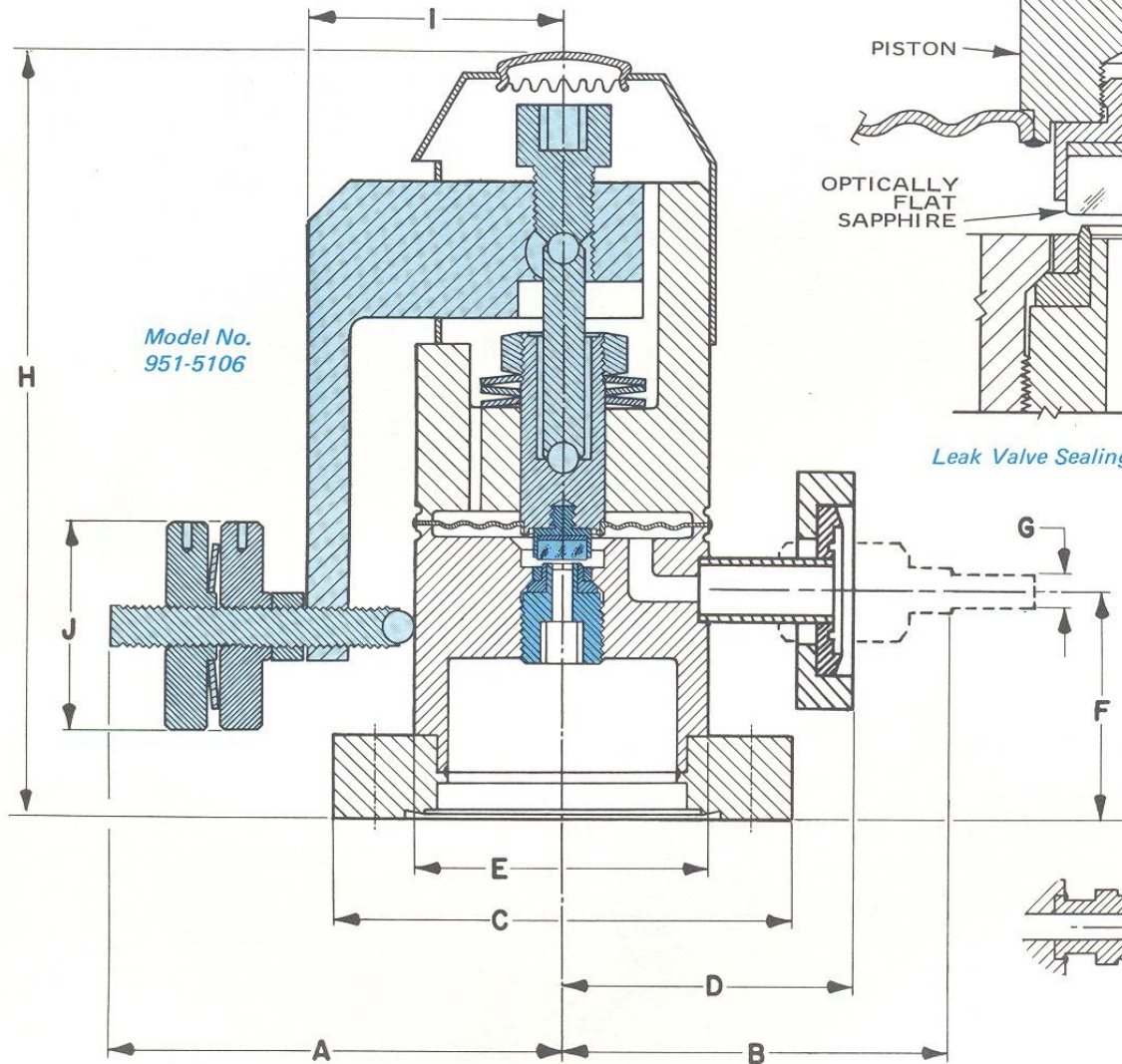






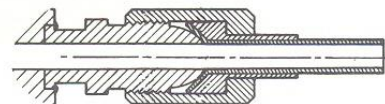
Gate valve design from Varian Associates





*Leak Valve Sealing Mechanism Detail*

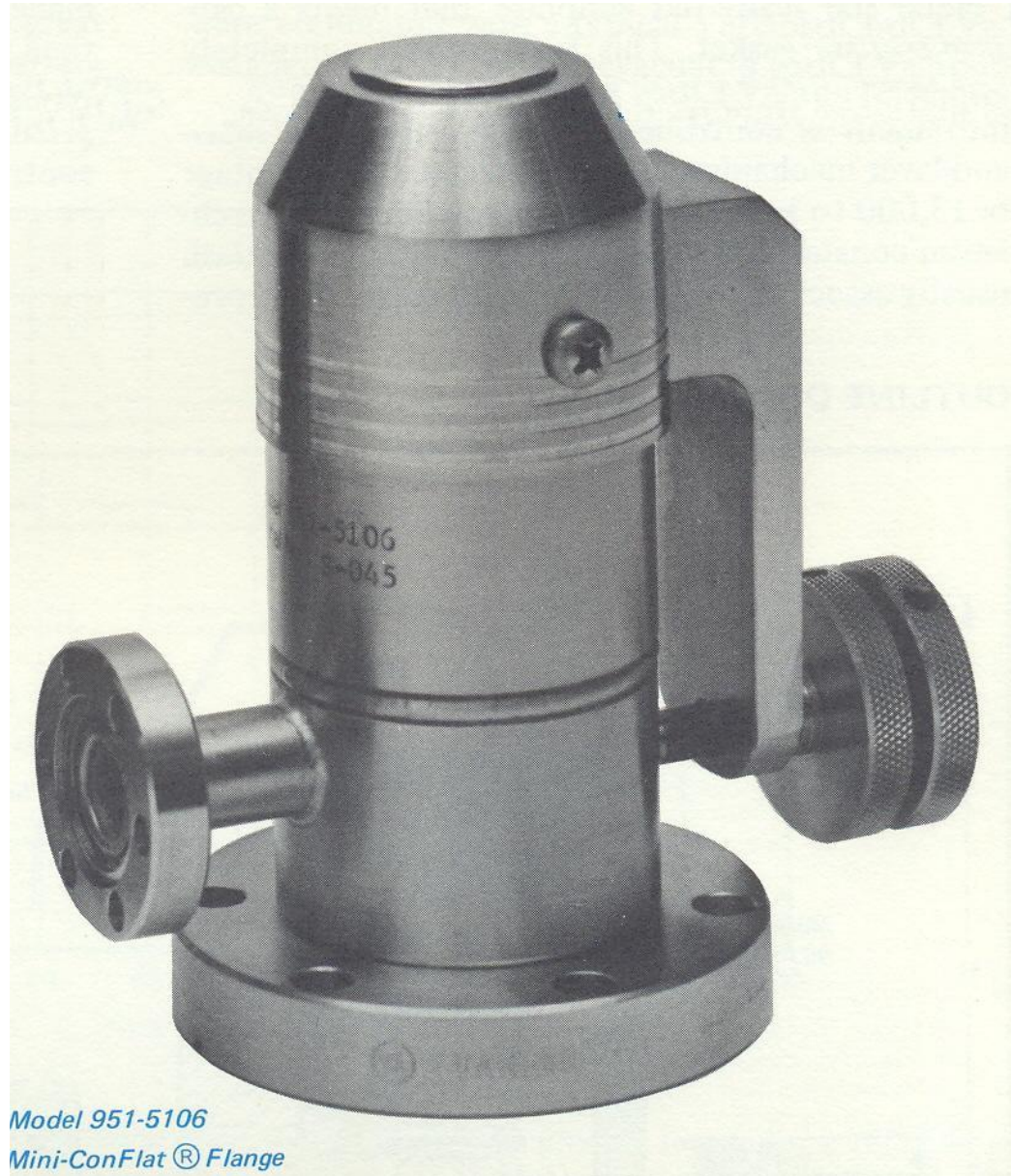
*1.33" O.D. Mini-ConFlat Flange or Flare Fitting For Gas Inlet Port*



*Gas Inlet Flare Fitting Detail For Model No. 951-5100*

 DRIVE MECHANISM

 SEALING COMPONENTS



*Model 951-5106  
Mini-ConFlat® Flange*



**VÁLVULA  
PNEUMÁTICA**

**TUBO FLEXÍVEL**

**PIRANI**

**MAGNETRON  
INVERTIDO**

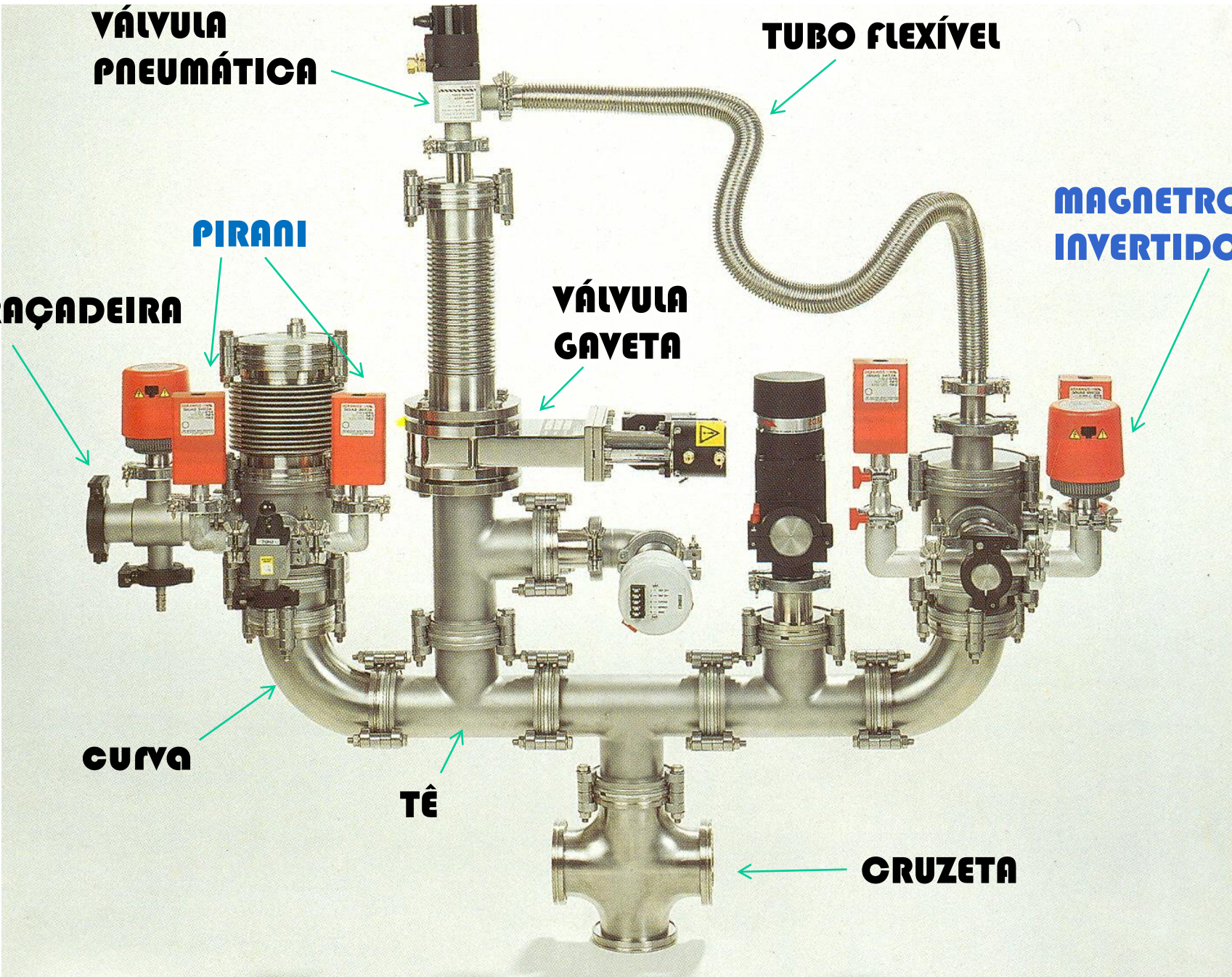
**ABRAÇADEIRA**

**VÁLVULA  
GAVETA**

**CURVA**

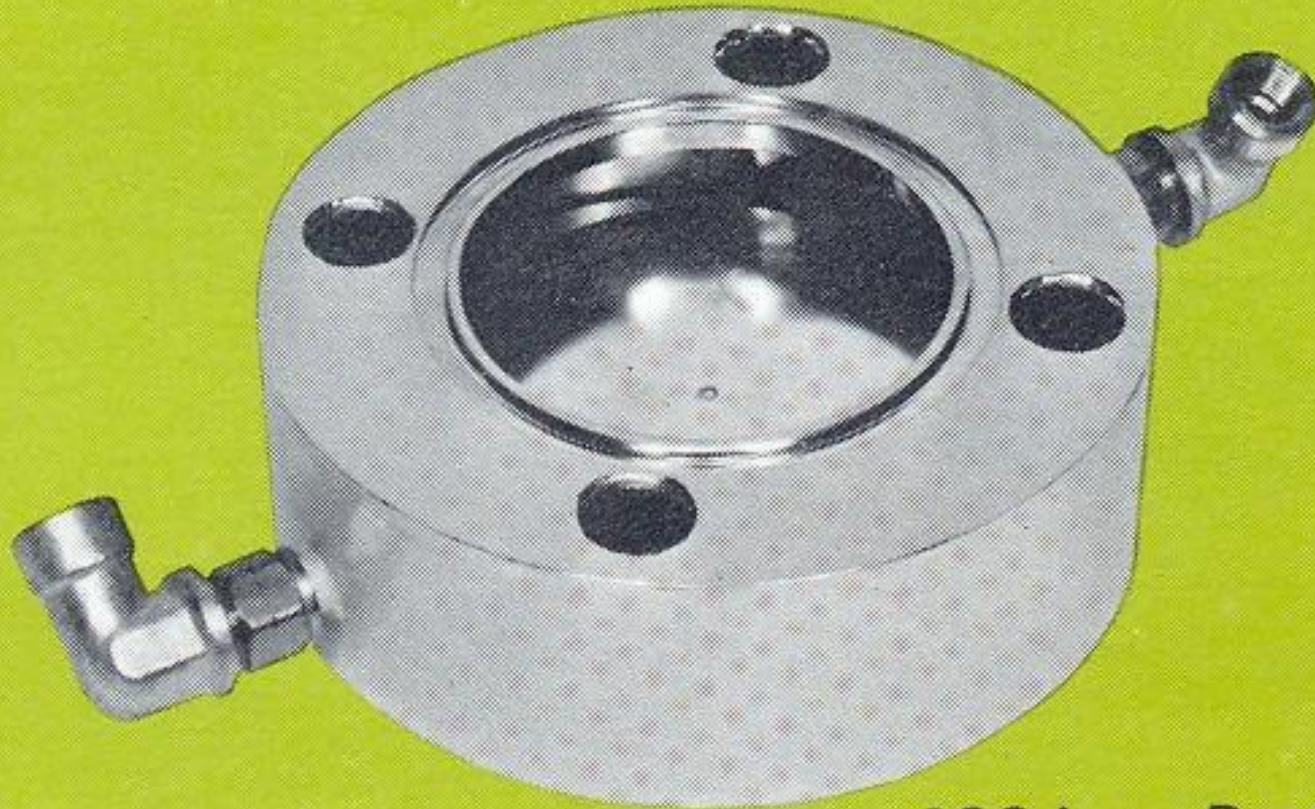
**TÊ**

**CRUZETA**





# CANAL DE O'RING

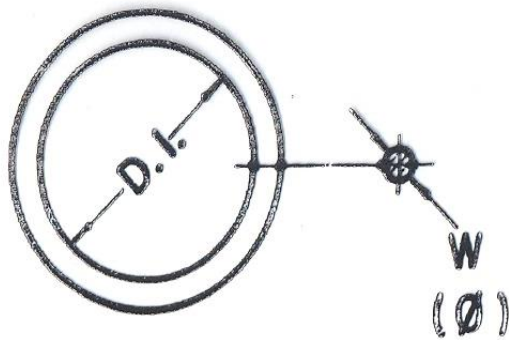
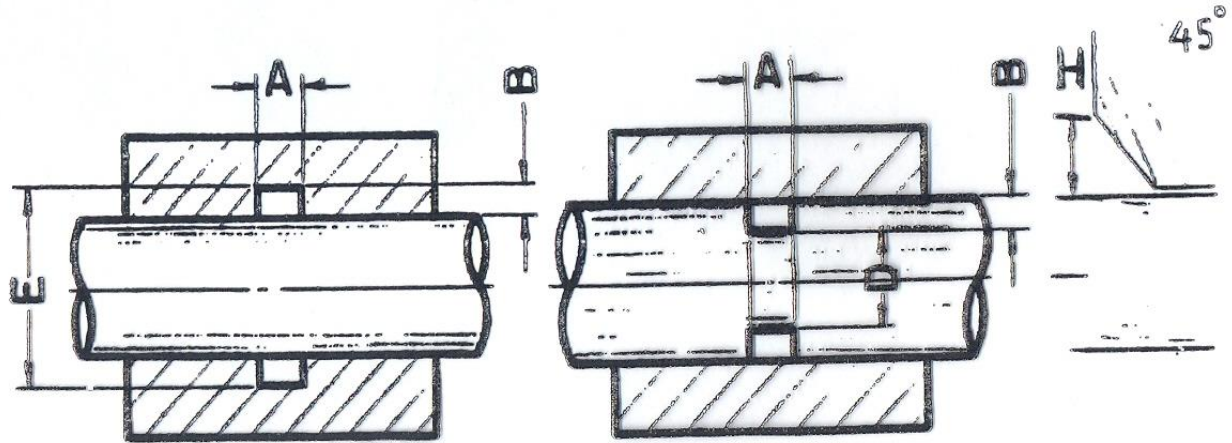
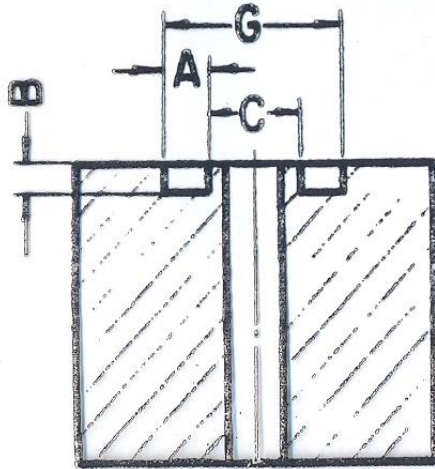


332 Low-Profile  
Water-Cooled Baffle  
300 ℓ/s Conductance

# O - RINGS

## APLICAÇÃO ESTÁTICA

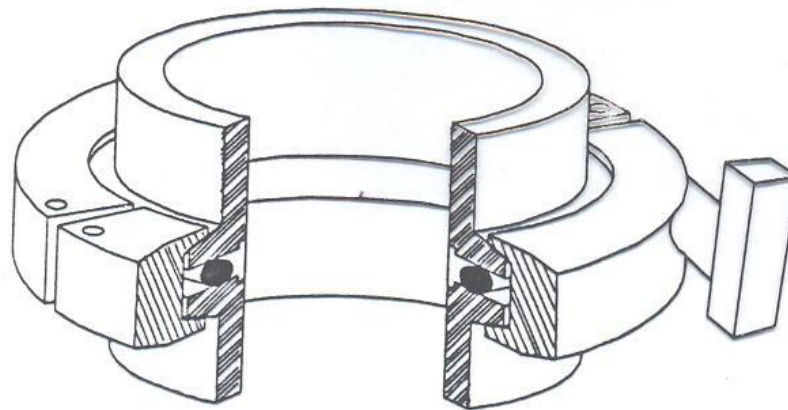
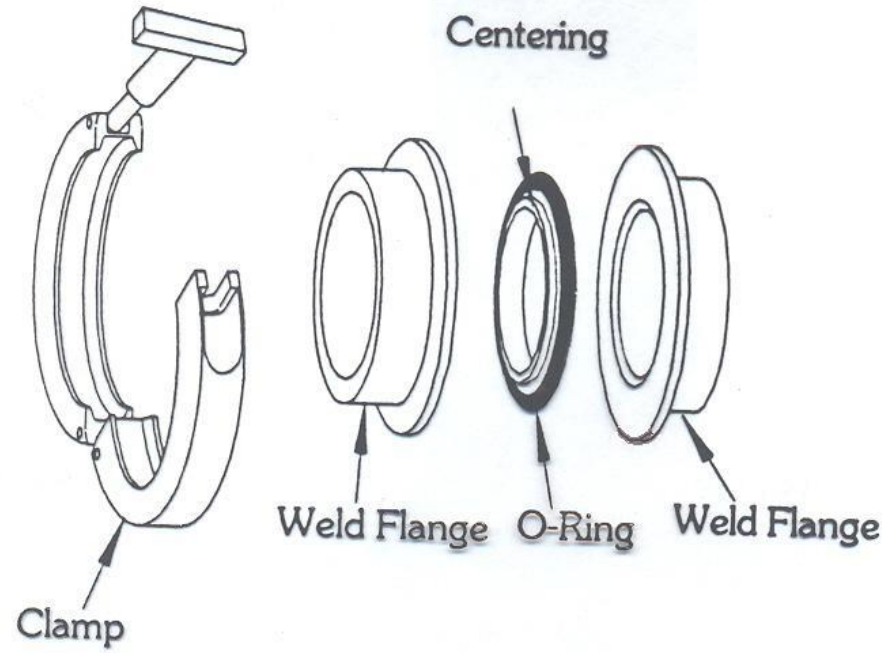
## APLICAÇÃO DINÂMICA



W	Ø	EST.		DIN.		H
		A	B	A	B	
1/16	1,78	2,4	1,4	2,3	1,3	2,3
3/32	2,62	3,6	2,3	3,2	2,1	3,4
1/8	3,53	4,8	3,1	4,2	2,9	4,6



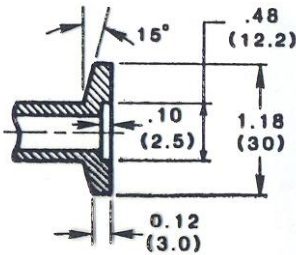
# FLANGE KF



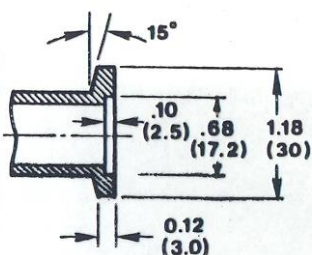




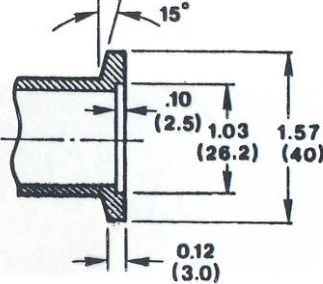
# THE ISO-KF SYSTEM



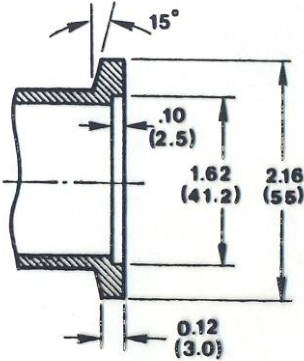
NW 10 ISO-KF



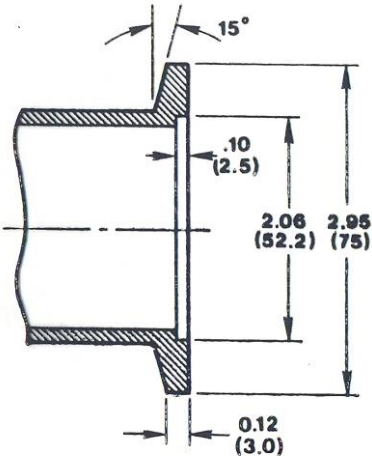
NW 16 ISO-KF



NW 25 ISO-KF



NW 40 ISO-KF



NW 50 ISO-KF

\* NW is from the German, *Nennweite* meaning nominal diameter. It is retained here by convention, not to specify flange type.

Figure 1  
Standard ISO-KF flange assembly

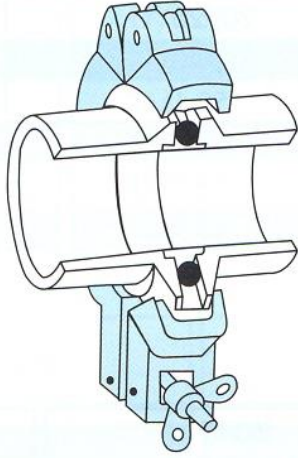


Figure 2  
Centering ring

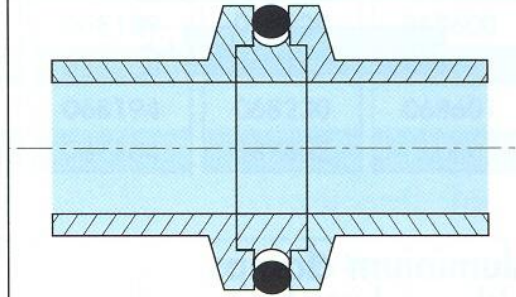


Figure 3  
Metal seal assembly

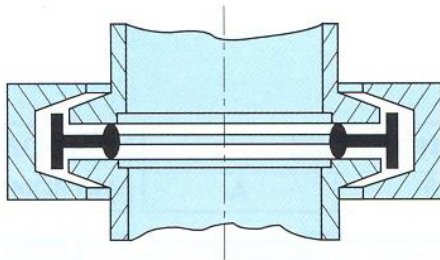


Figure 4  
Adapter centering ring

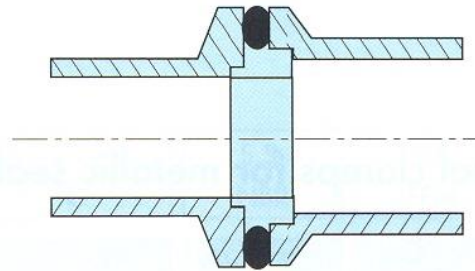




Figure 1  
Double claw clamp coupling

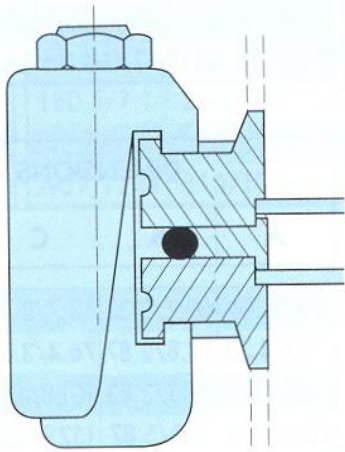


Figure 2  
Rotatable flange

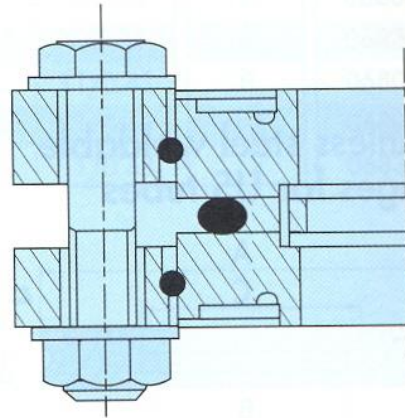


Figure 3  
ISO-F connection

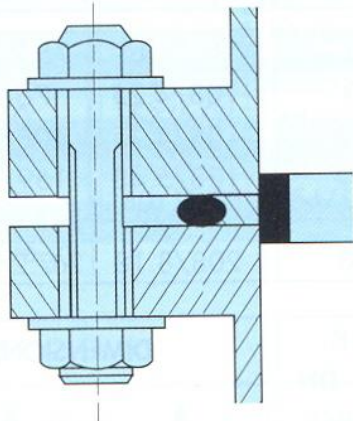
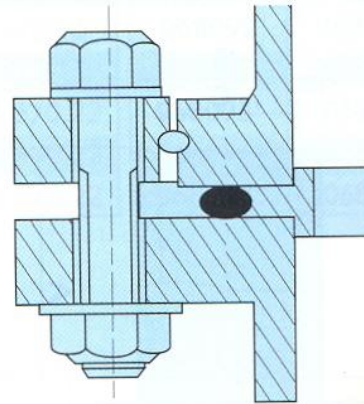


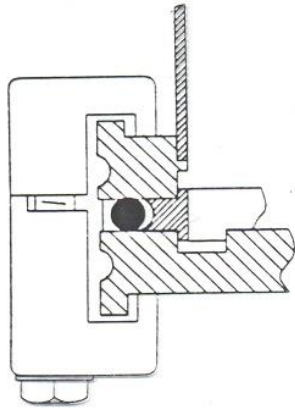
Figure 4  
ISO-K / ISO-F coupling



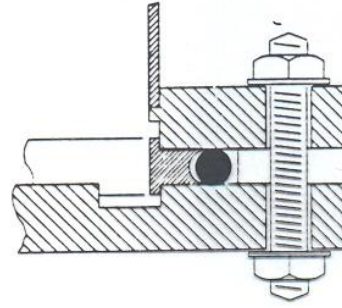
al  
s

l

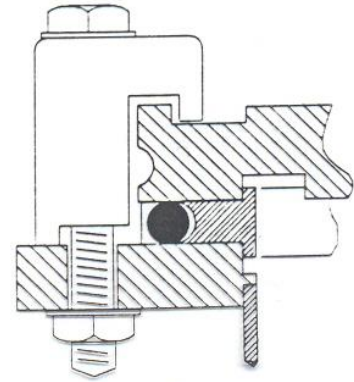
d  
ar



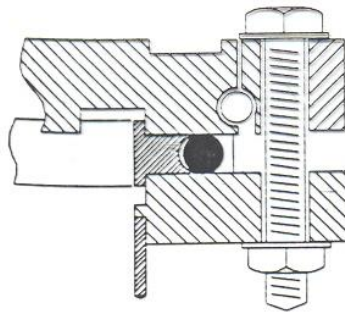
A



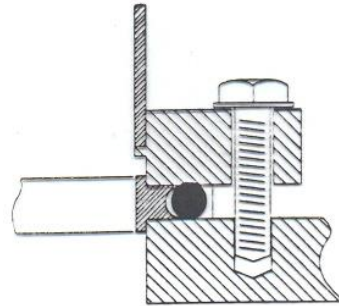
B



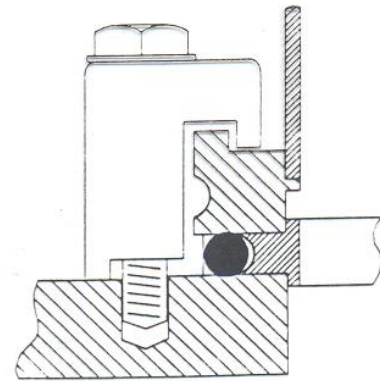
C



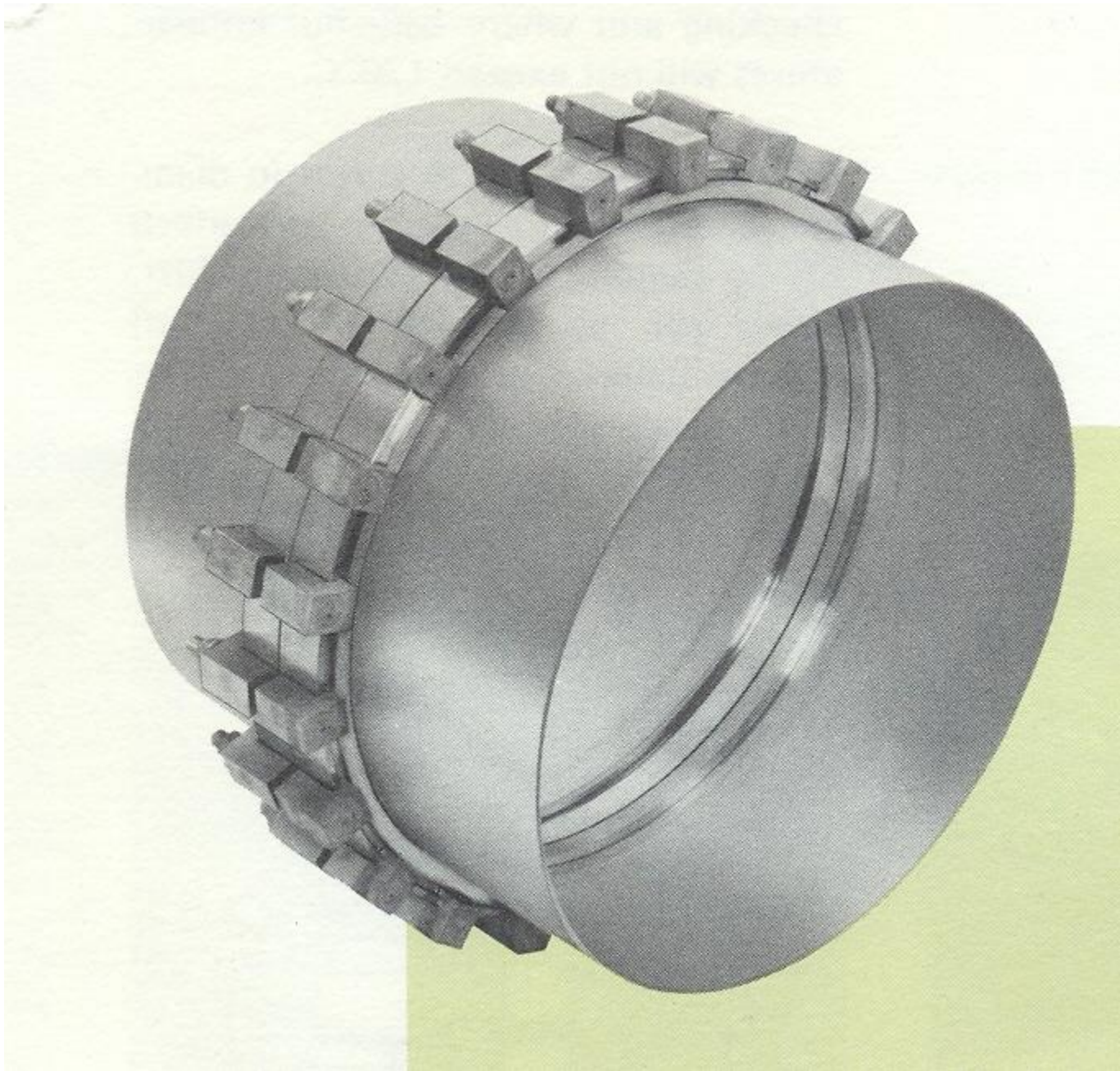
D



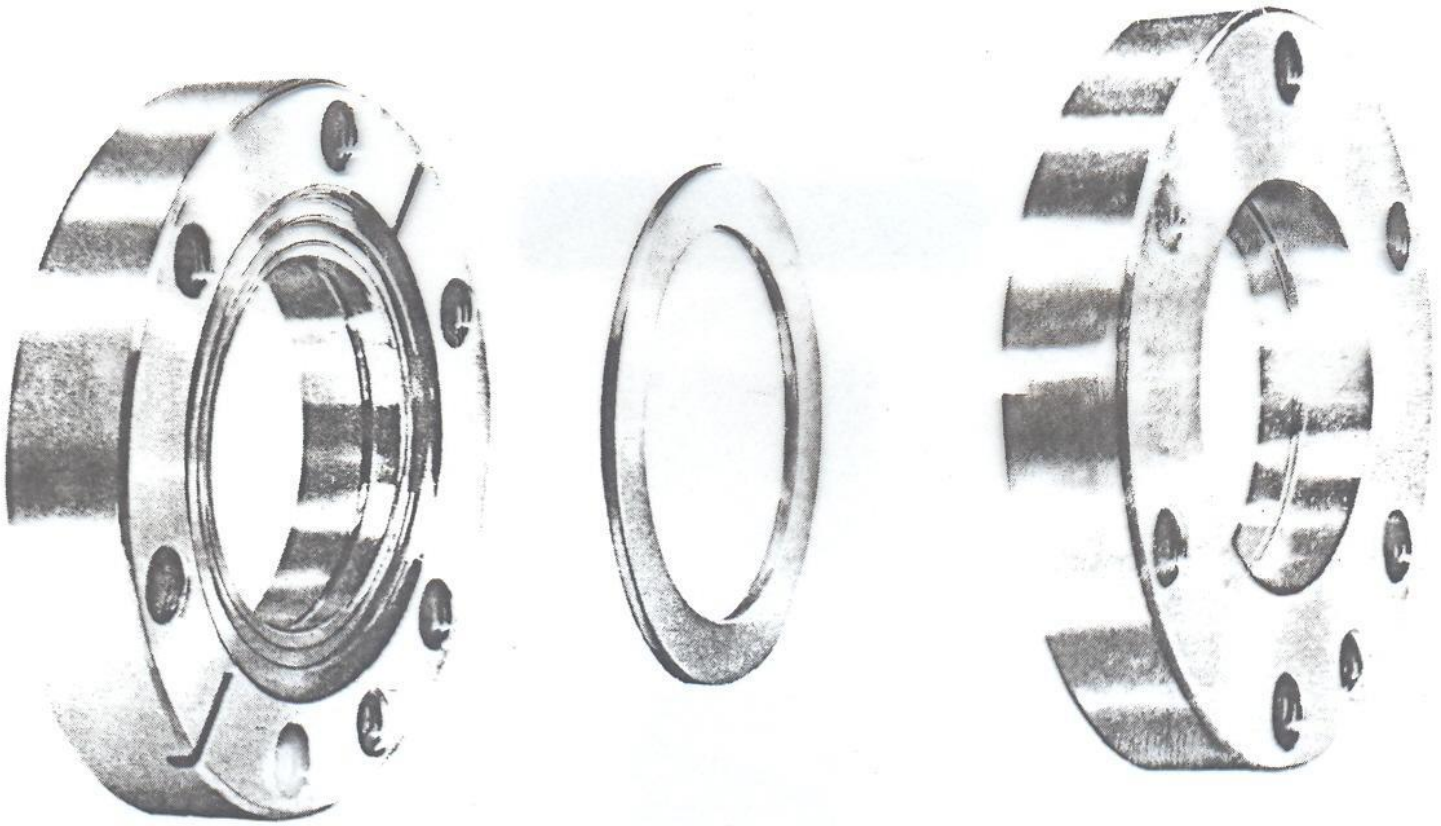
E



F

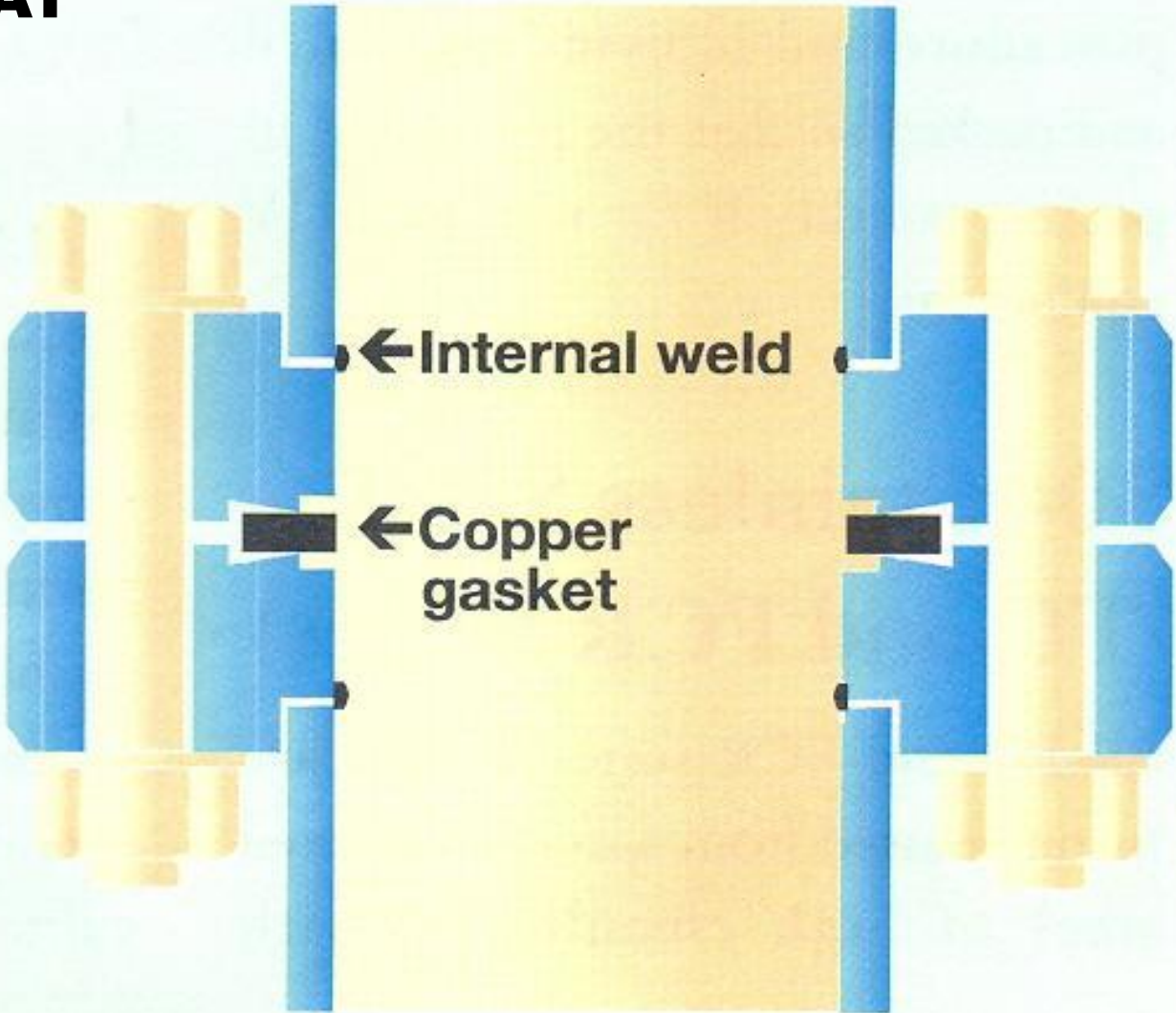




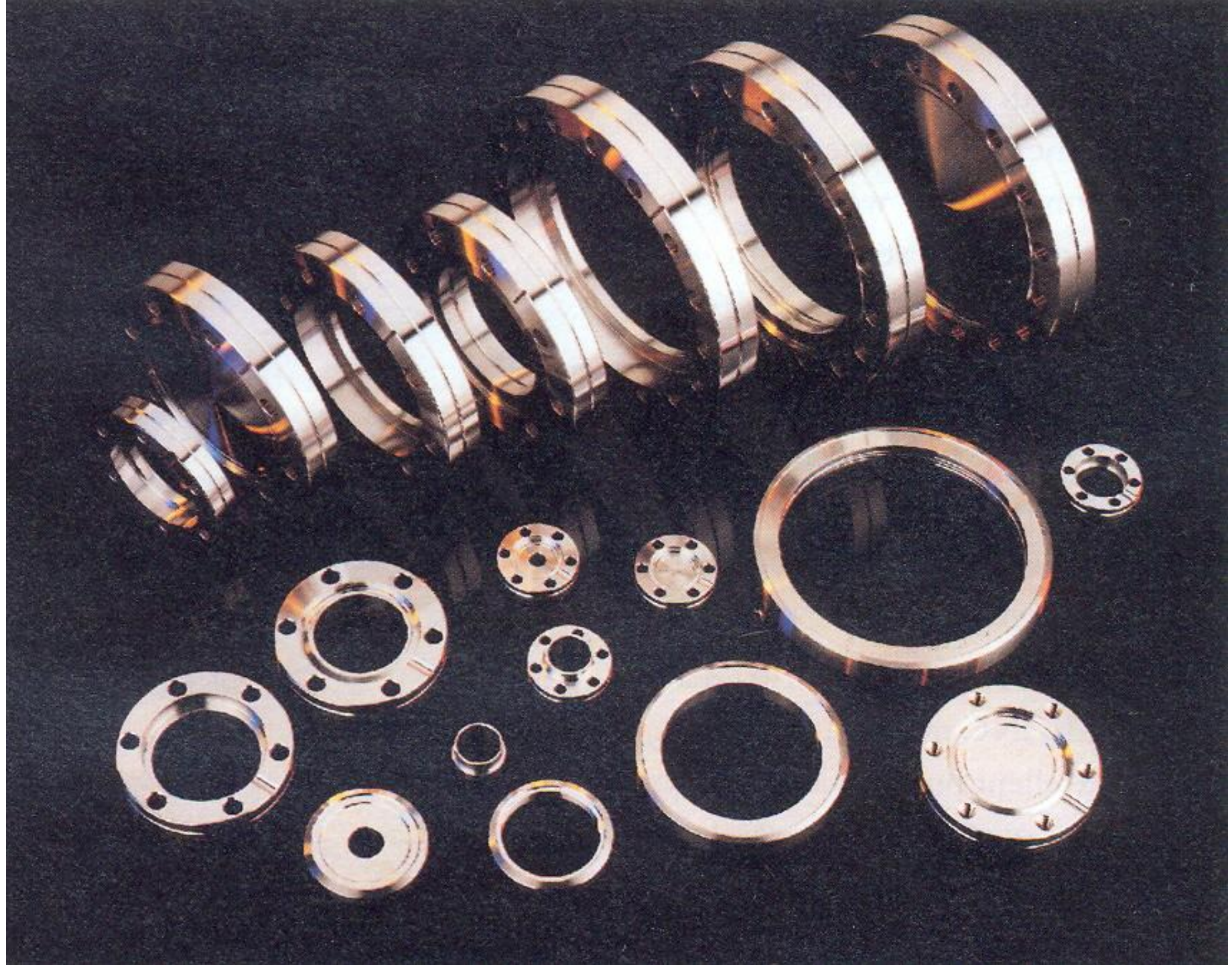


CF flange connection with copper gasket

# FLANGE CONFLAT

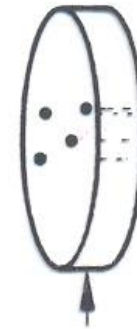
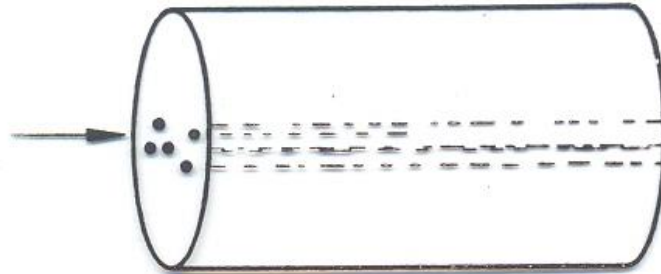




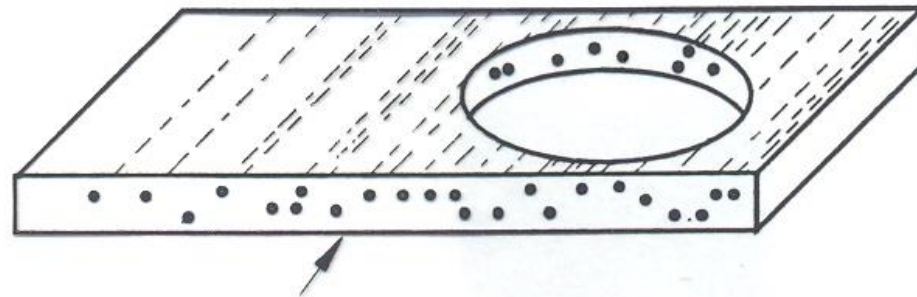




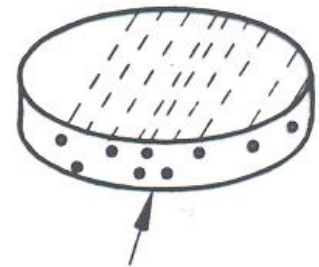
Axial voids in round bar stock



Porous flange

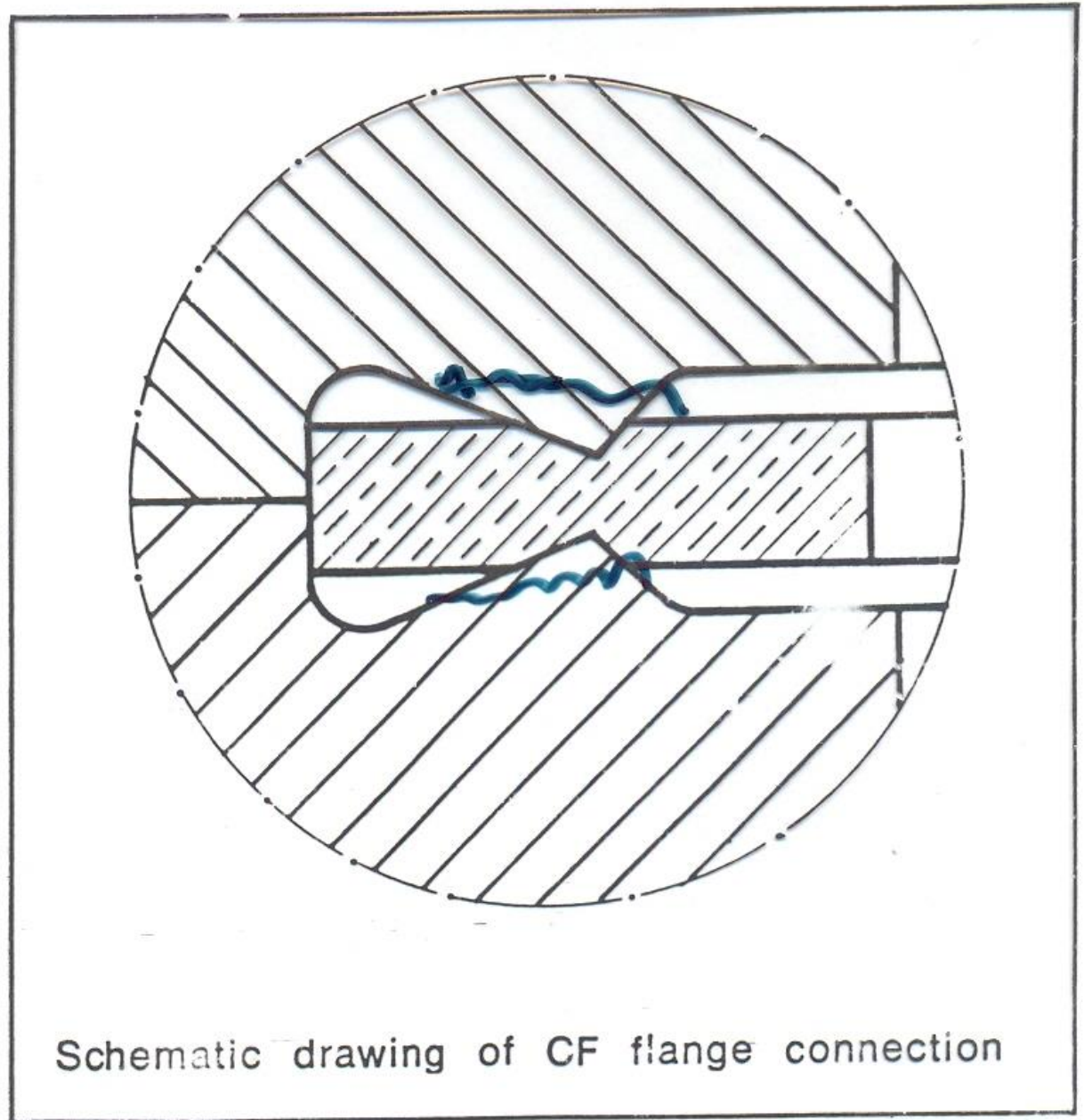


Longitudinal voids in rolled plate



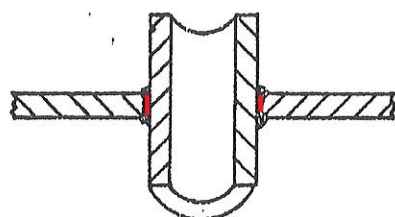
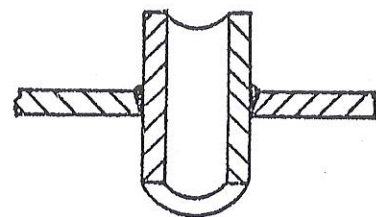
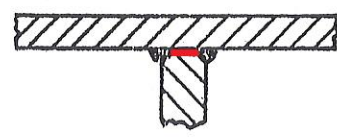
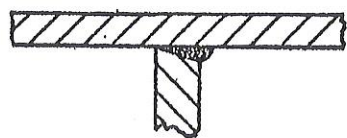
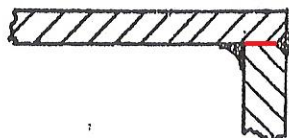
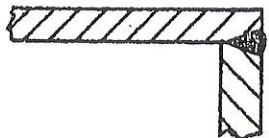
Non porous flange

# FLANGE CONFLAT

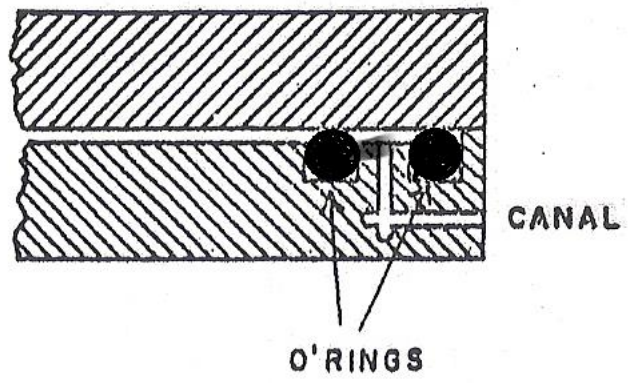
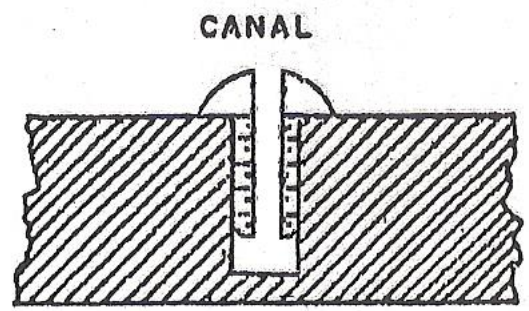
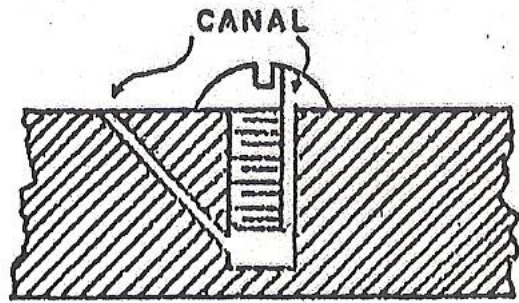


CORRETO

INCORRETO





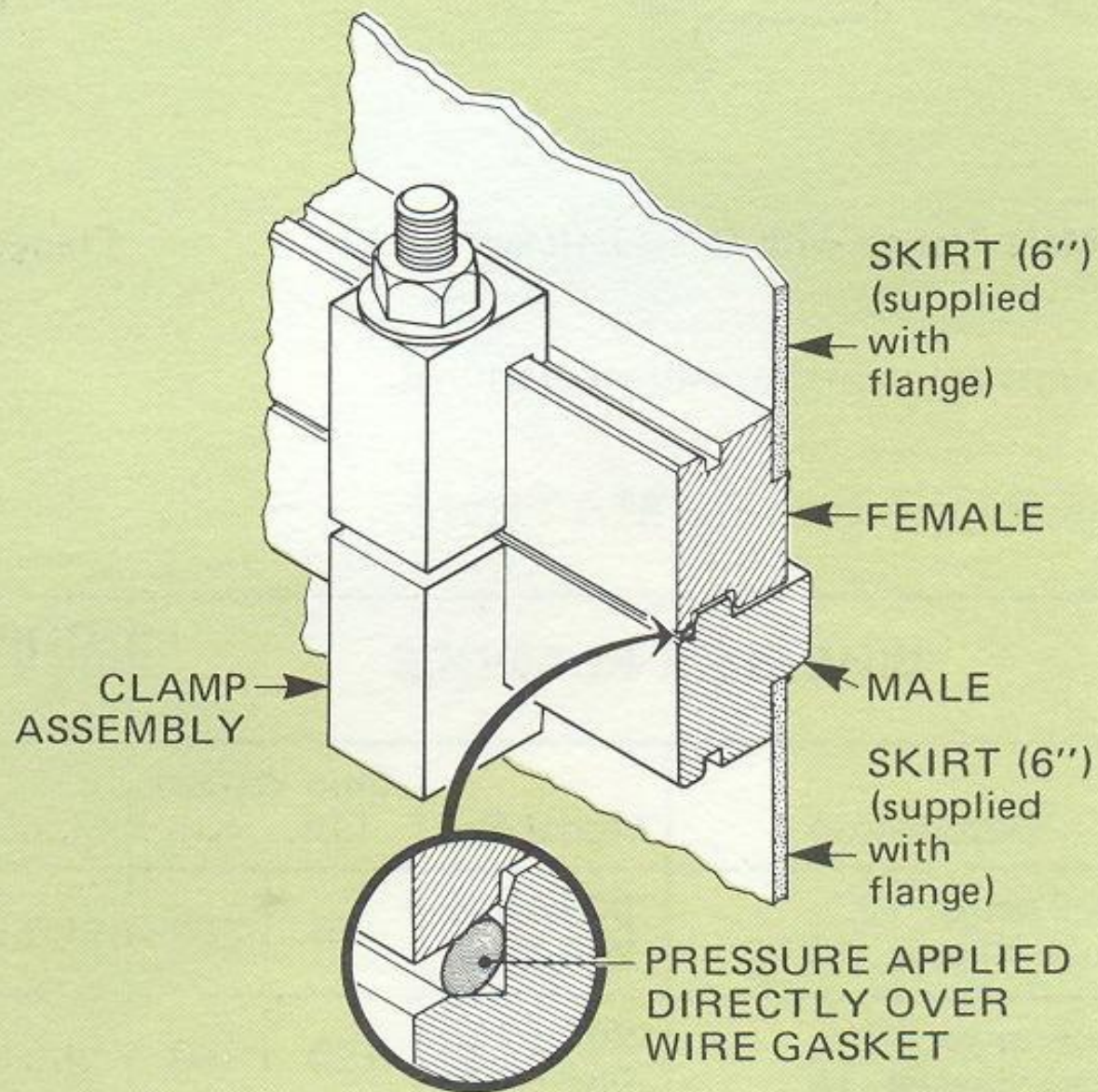












# **“BAFFLE” CHAPÉU MEXICANO**





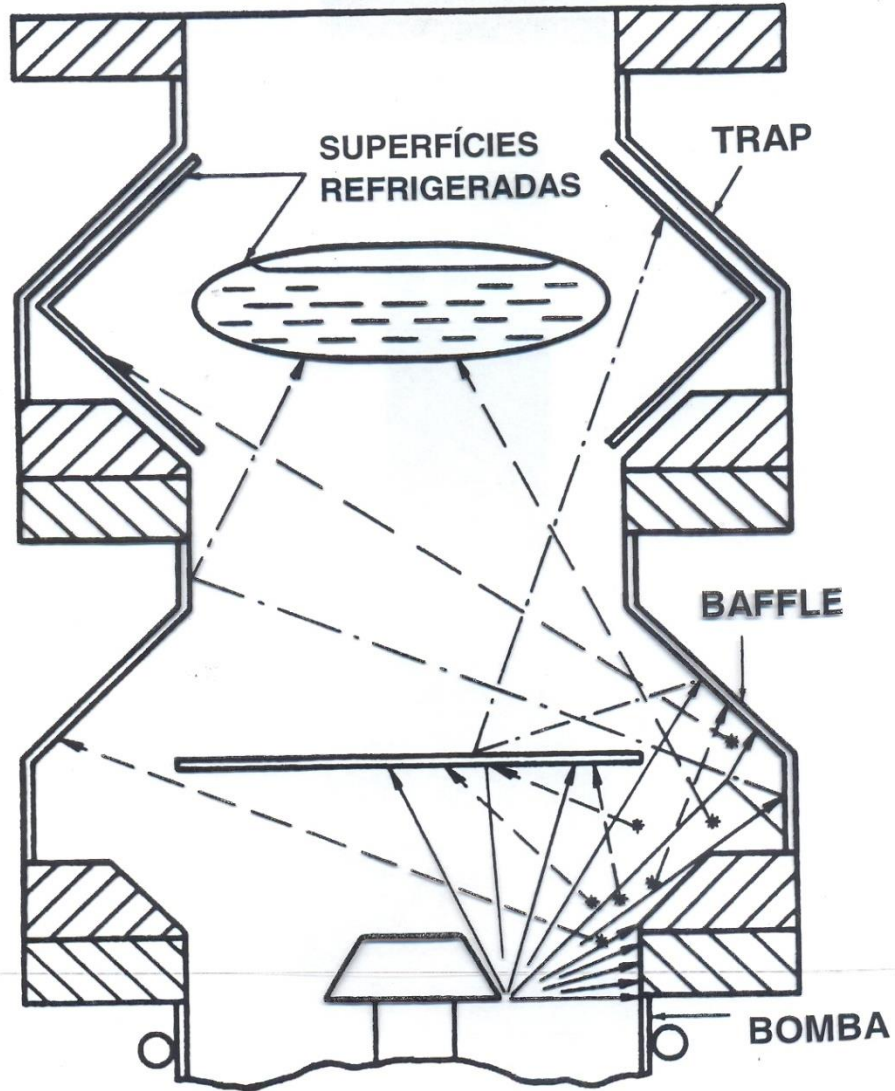


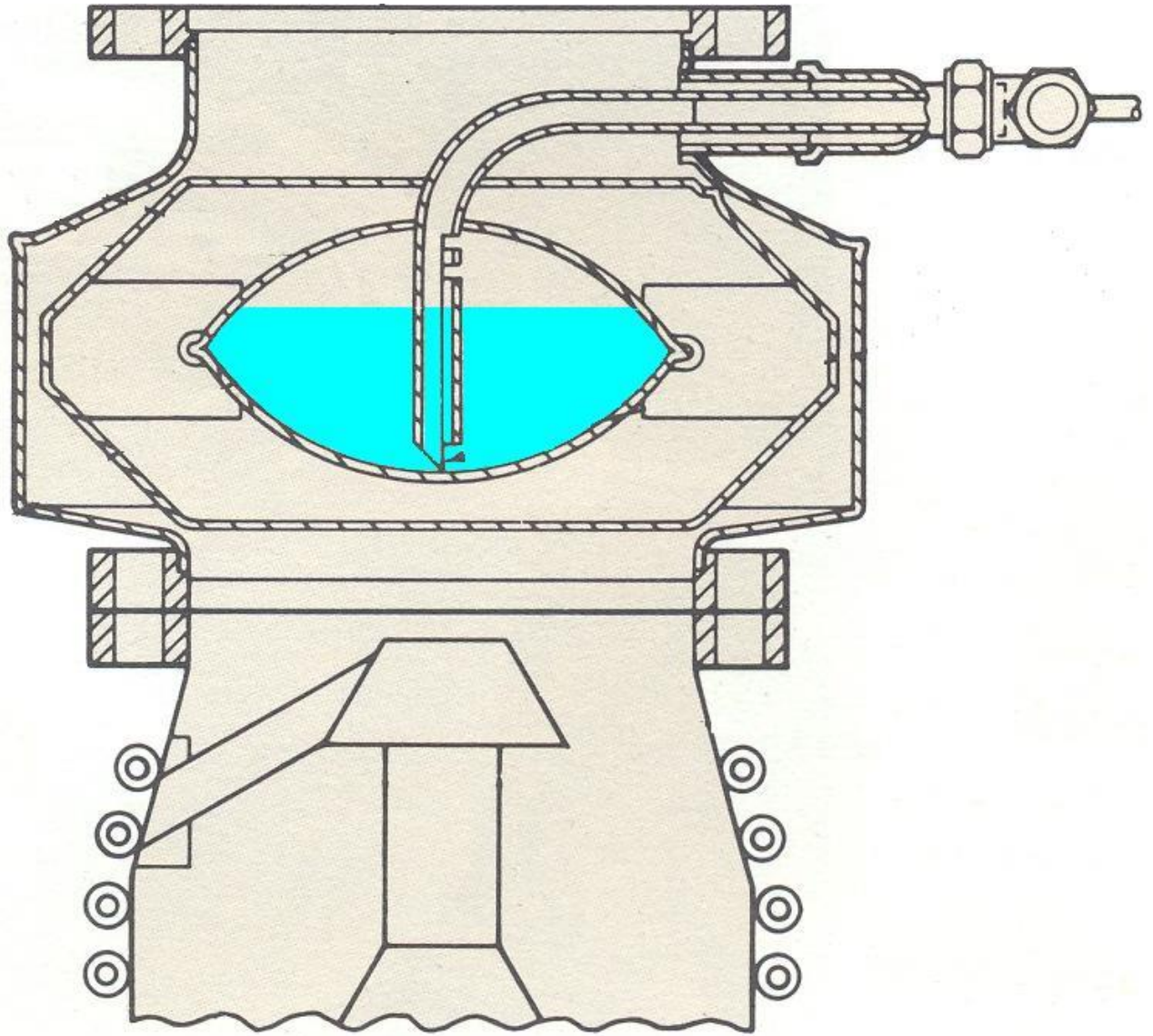
**332 Low-Profile  
Water-Cooled Baffle  
300 ℓ/s Conductance**



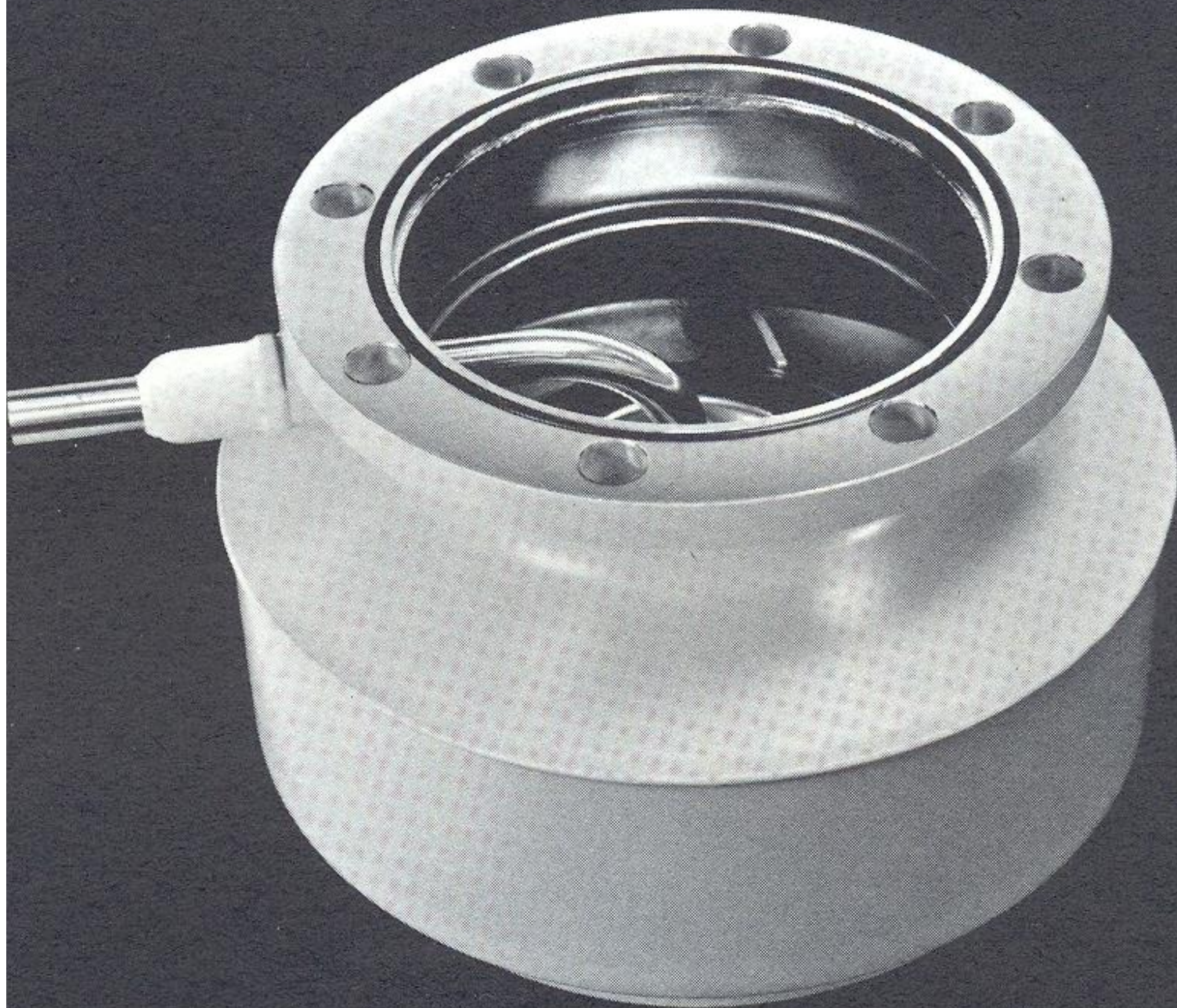


- Retrofluxo primário devido à expansão do jato
- - - - - Retrofluxo adicional devido a colisões
- · - · - Migração causada pela agitação térmica
- \* \* Colisões entre moléculas



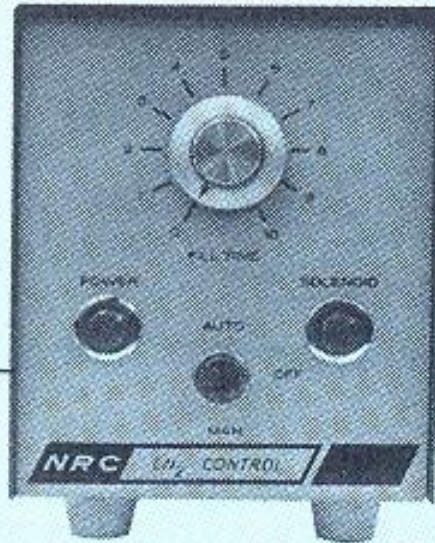






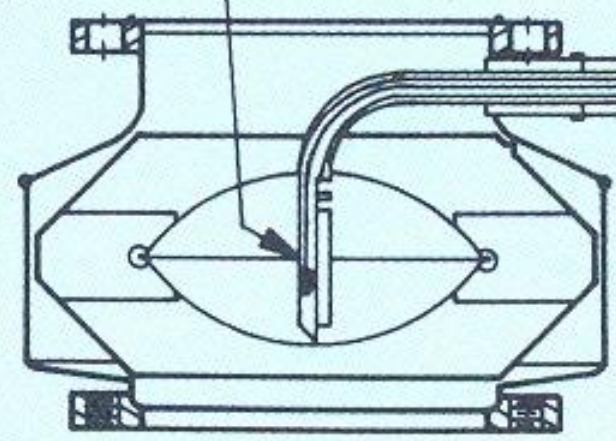


CONTROL



115 VAC

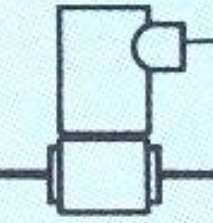
SENSOR



TYPICAL  
CRYOGENIC  
BAFFLE

TRANSFER  
LINE

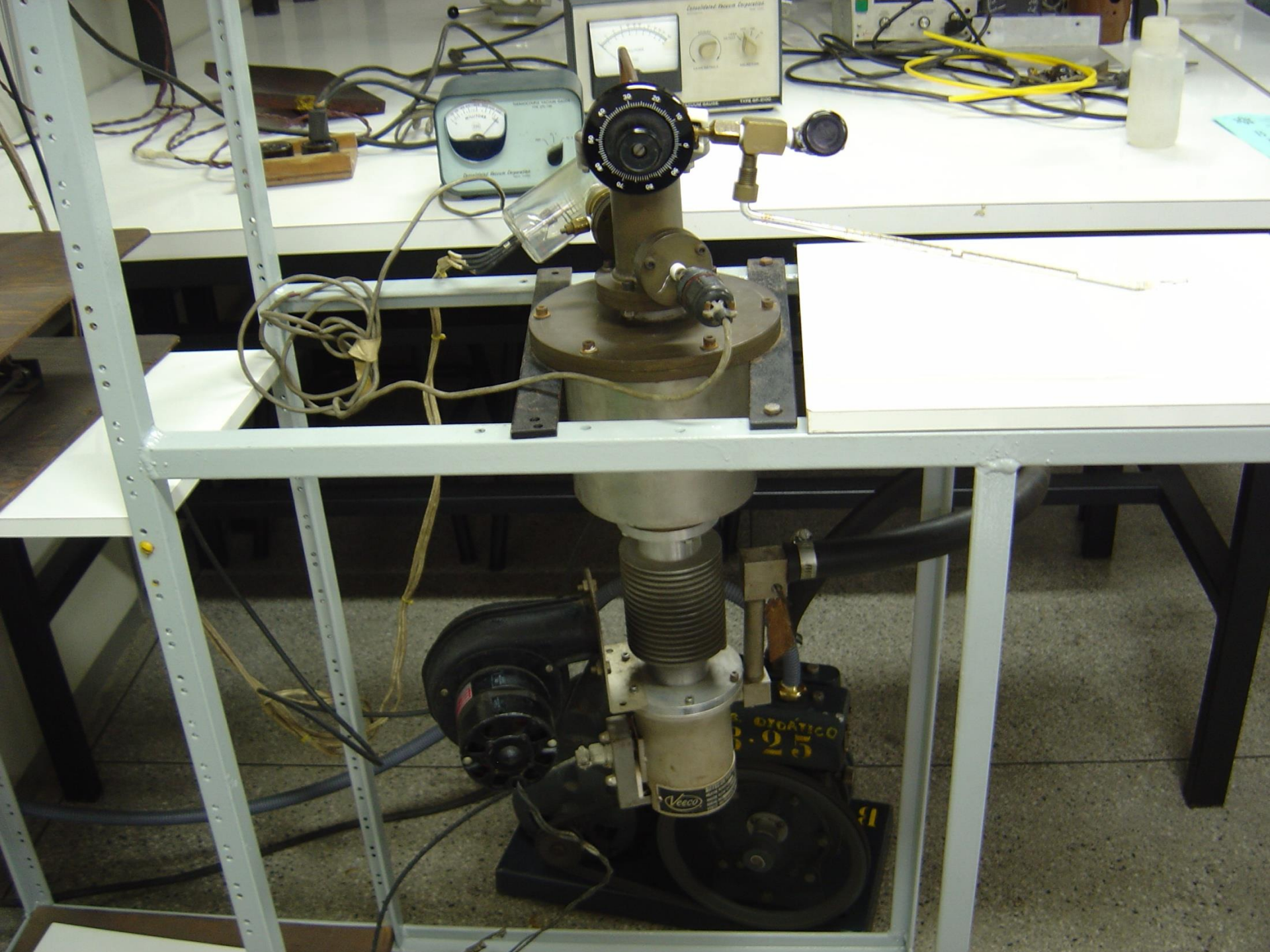
SOLENOID



LN<sub>2</sub> VALVE

TO PRESSURE OR  
NON-PRESSURIZED  
SUPPLY





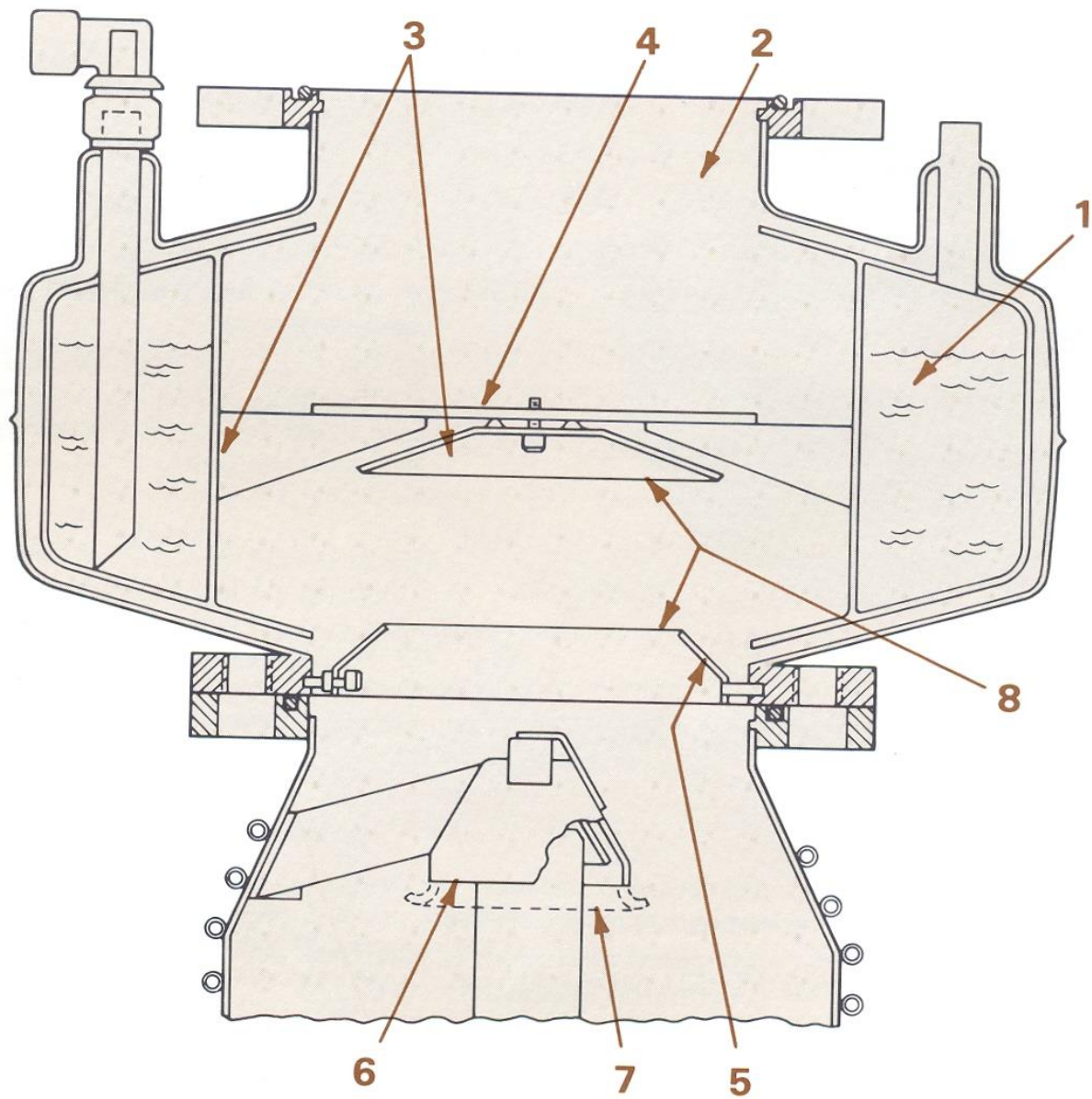
Dielectric Constant Dependent  
TYPE OF DIELECTRIC

VACUUM GAUGE  
MANUFACTURED BY VEECO  
TYPE OF DIELECTRIC

Veeco

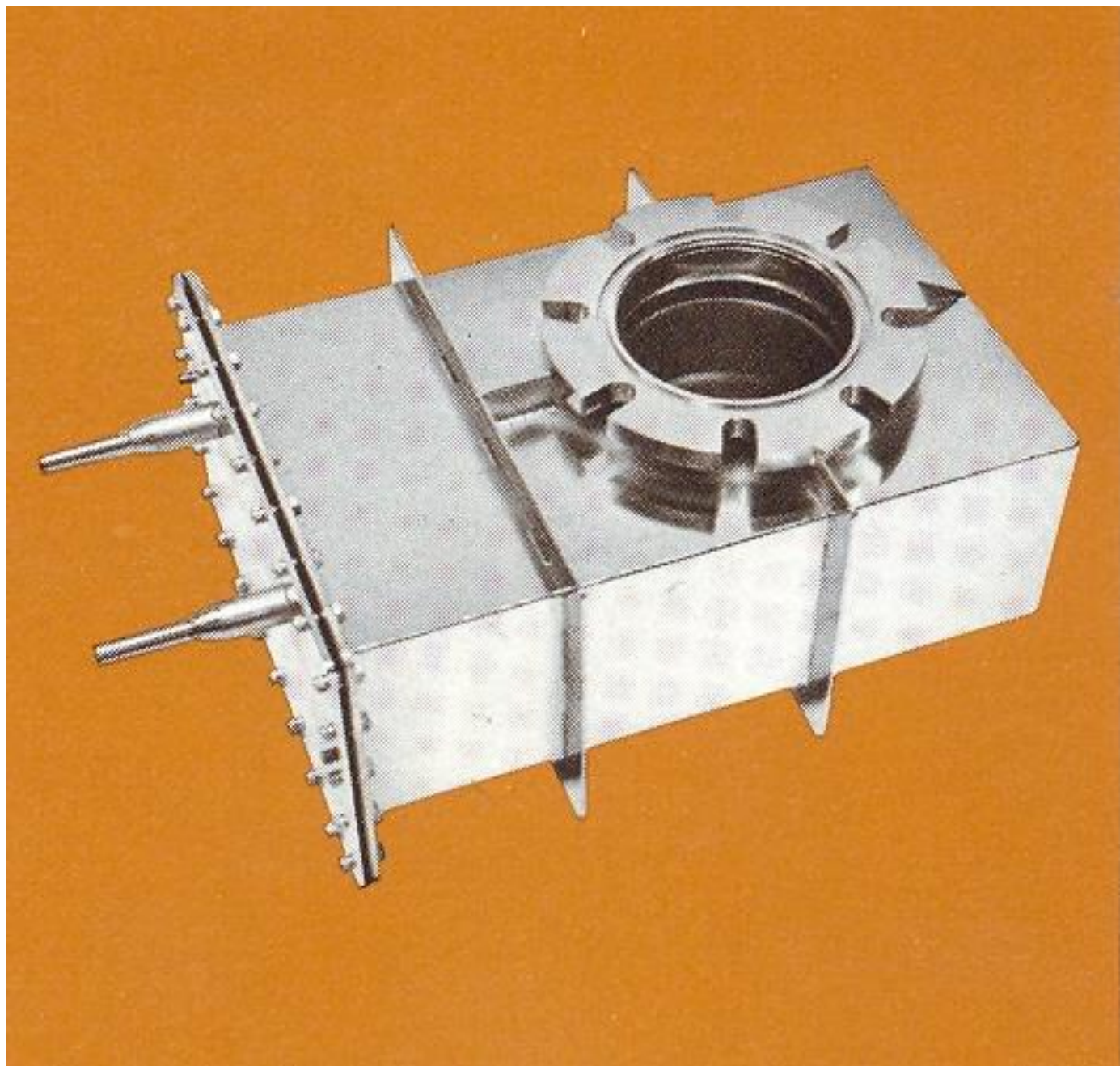
ORGANICO  
3.25













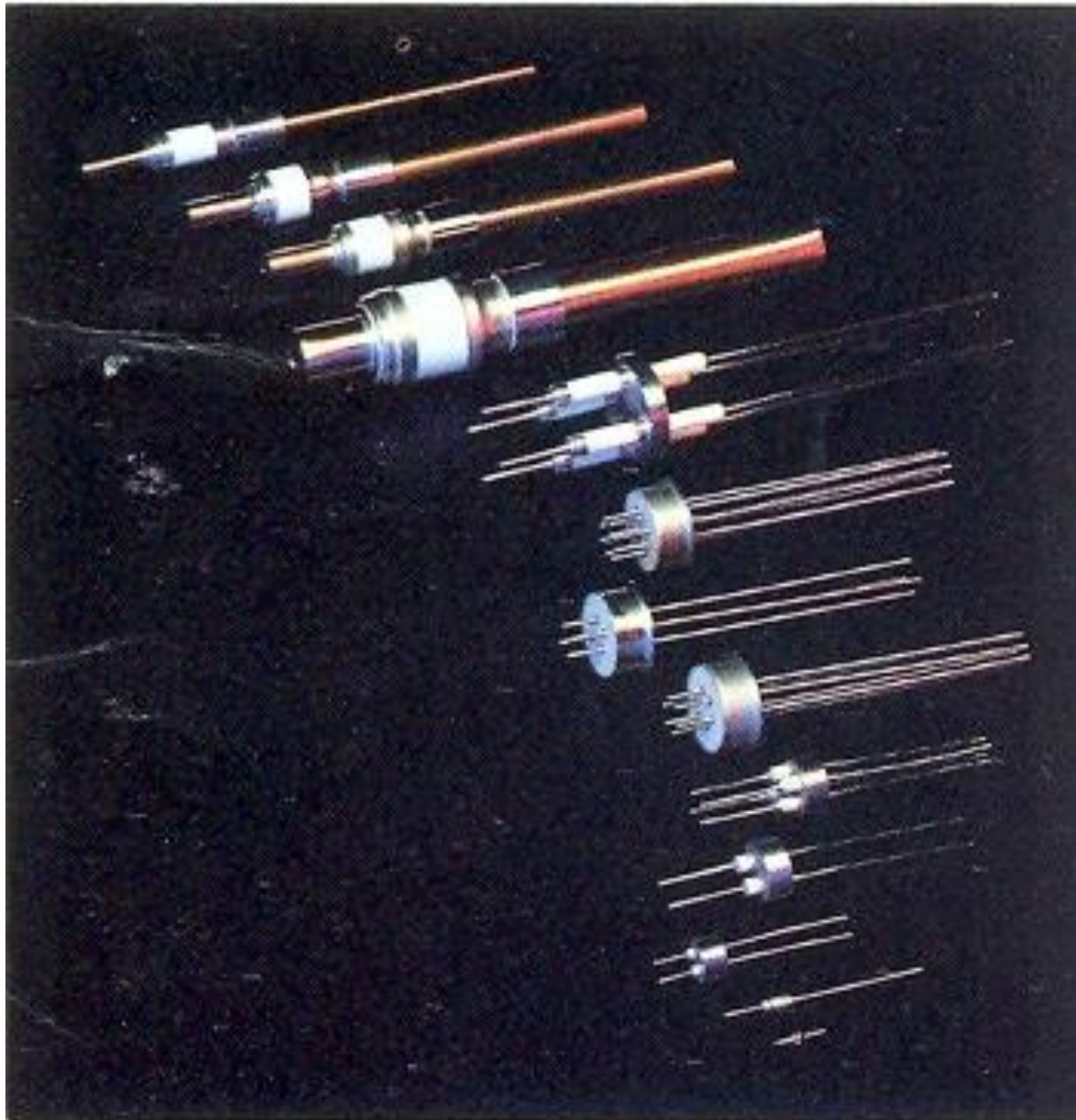


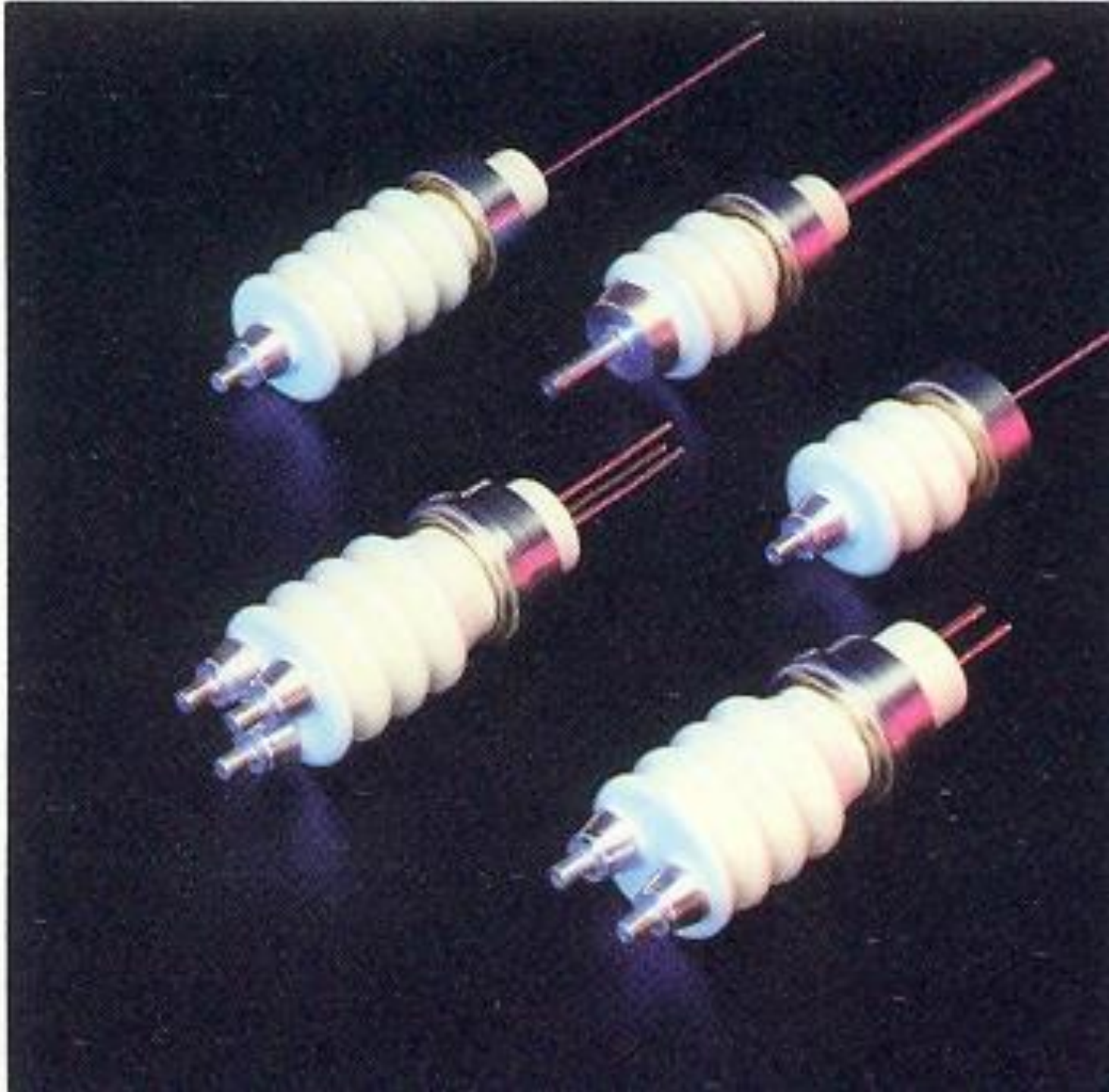




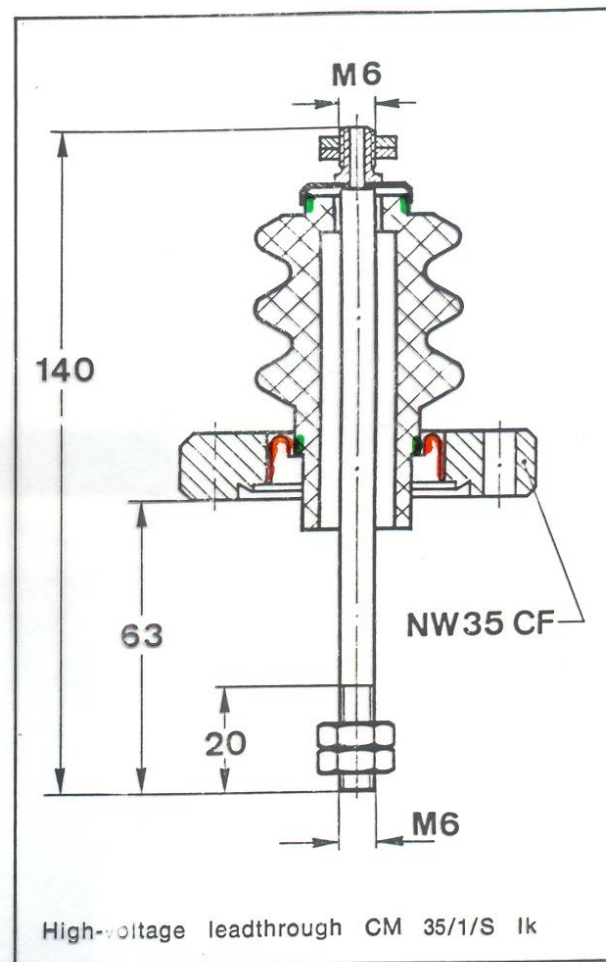
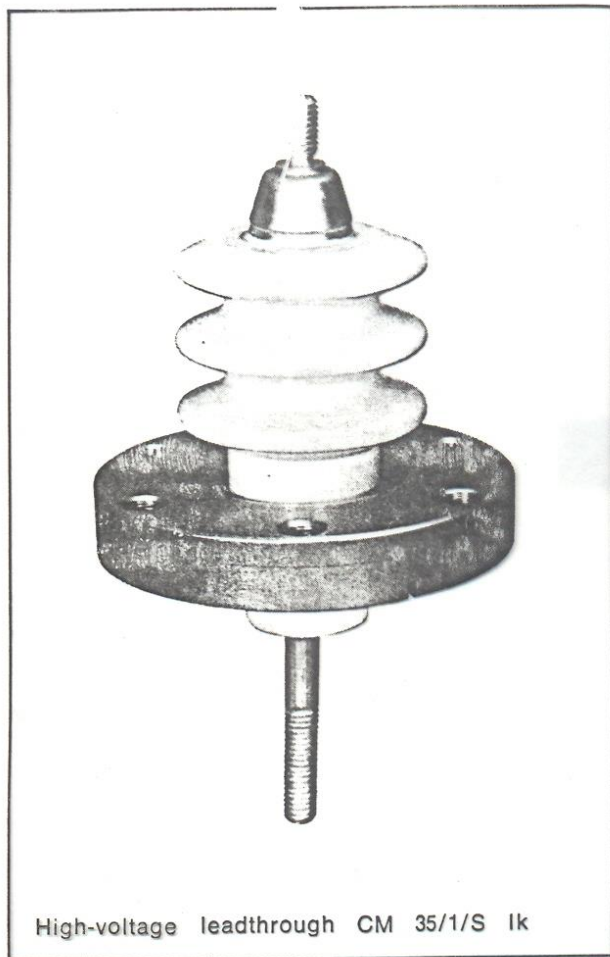




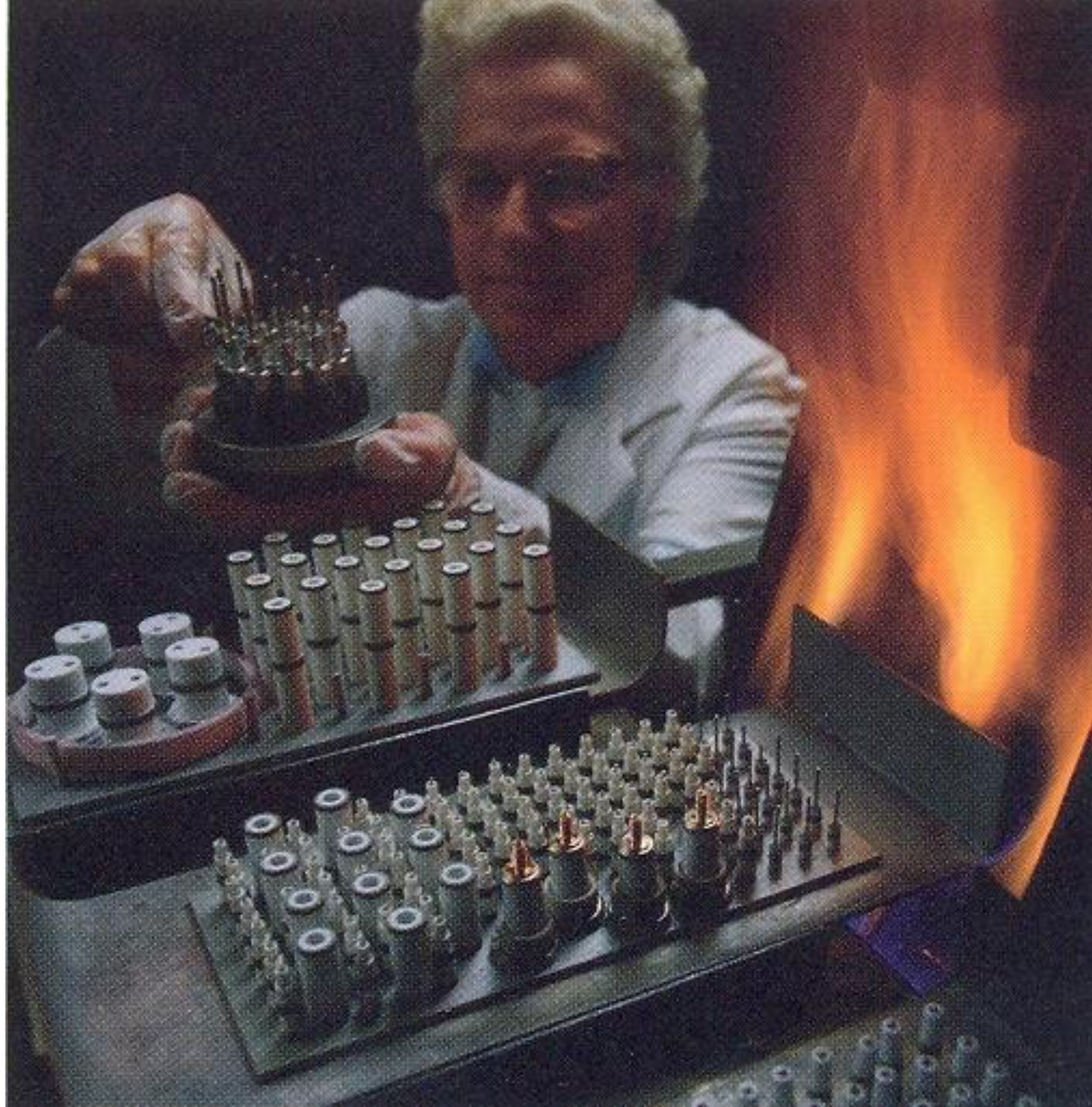




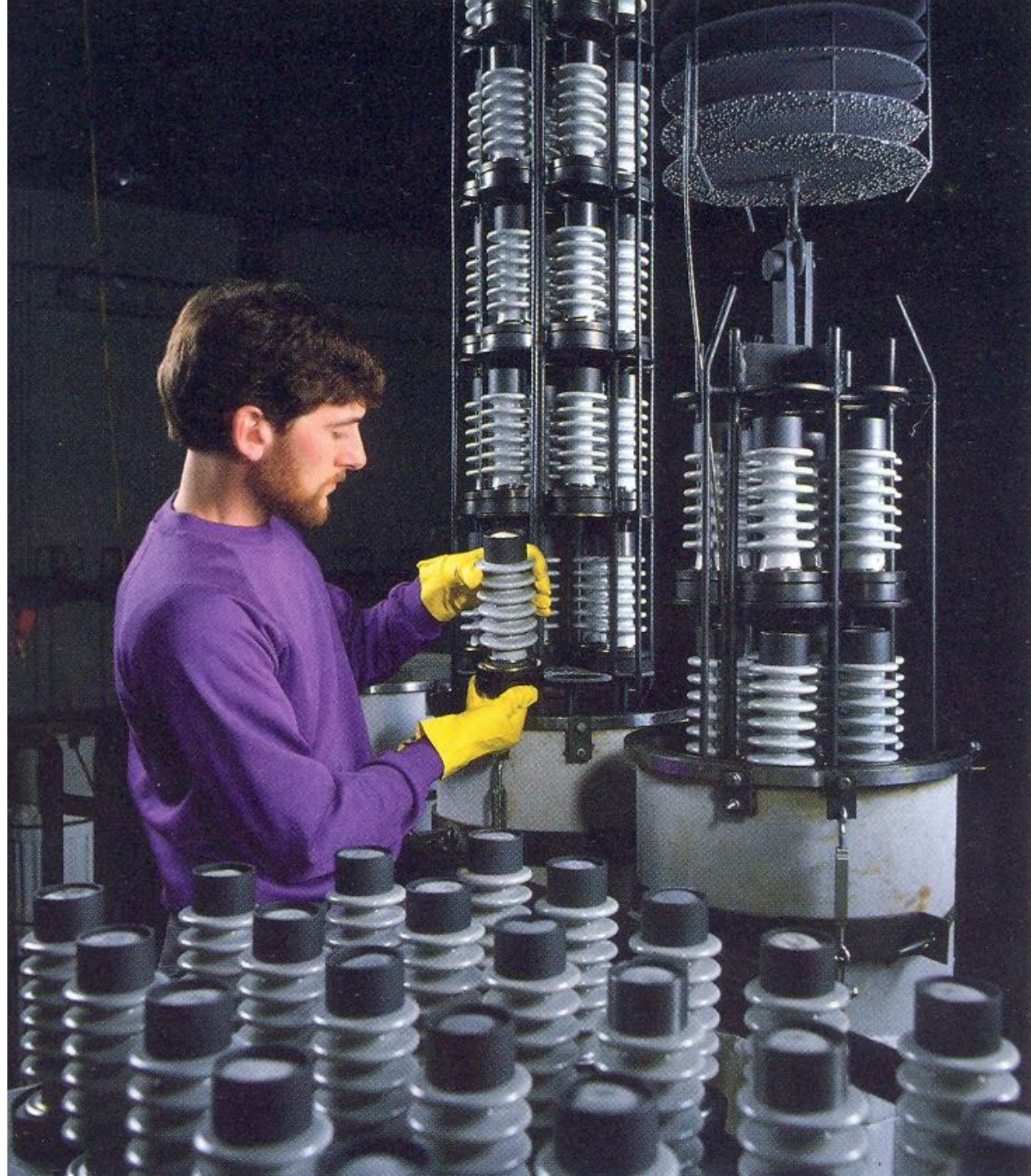
# PASSADOR DE ALTA TENSÃO



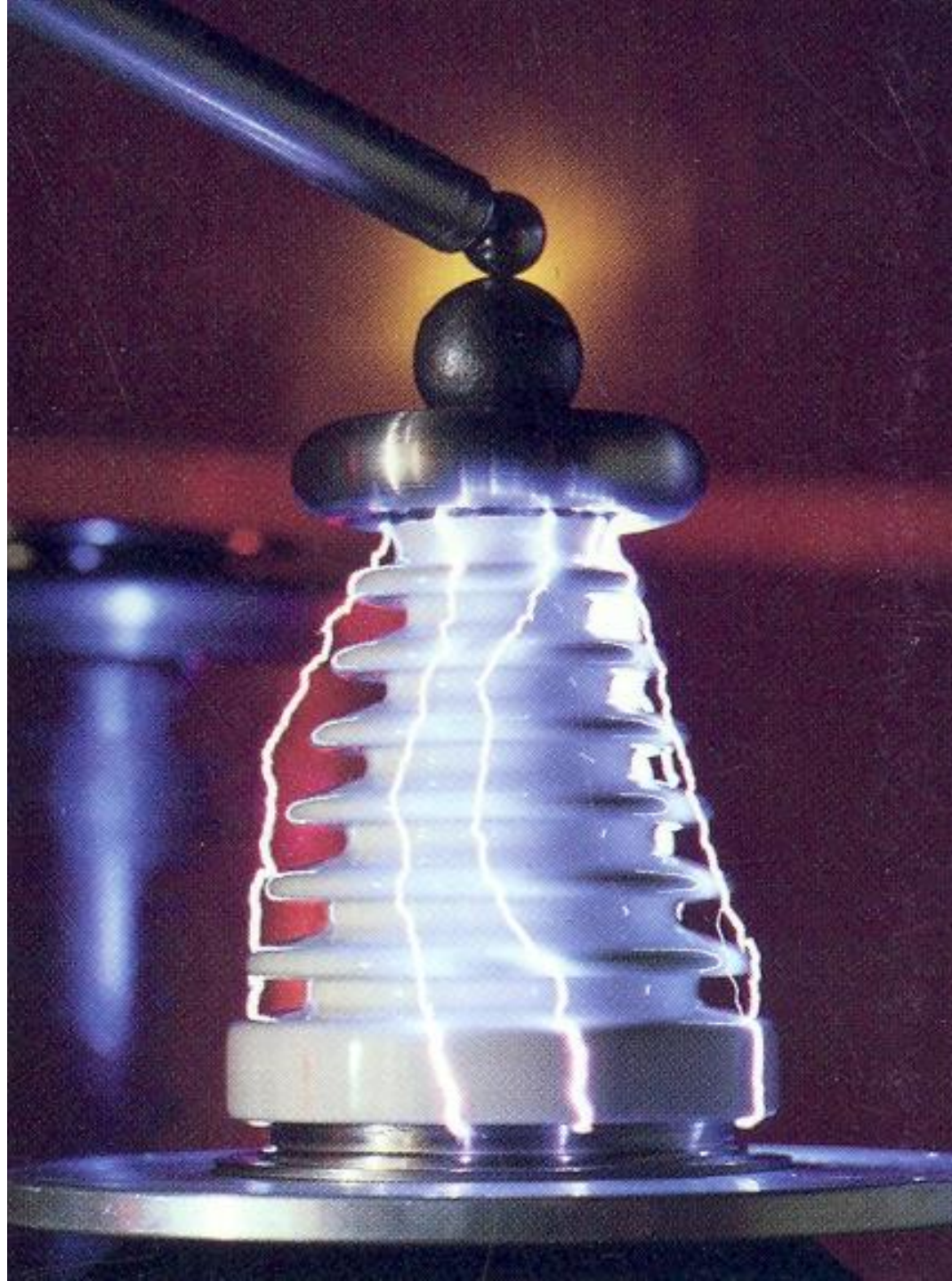
















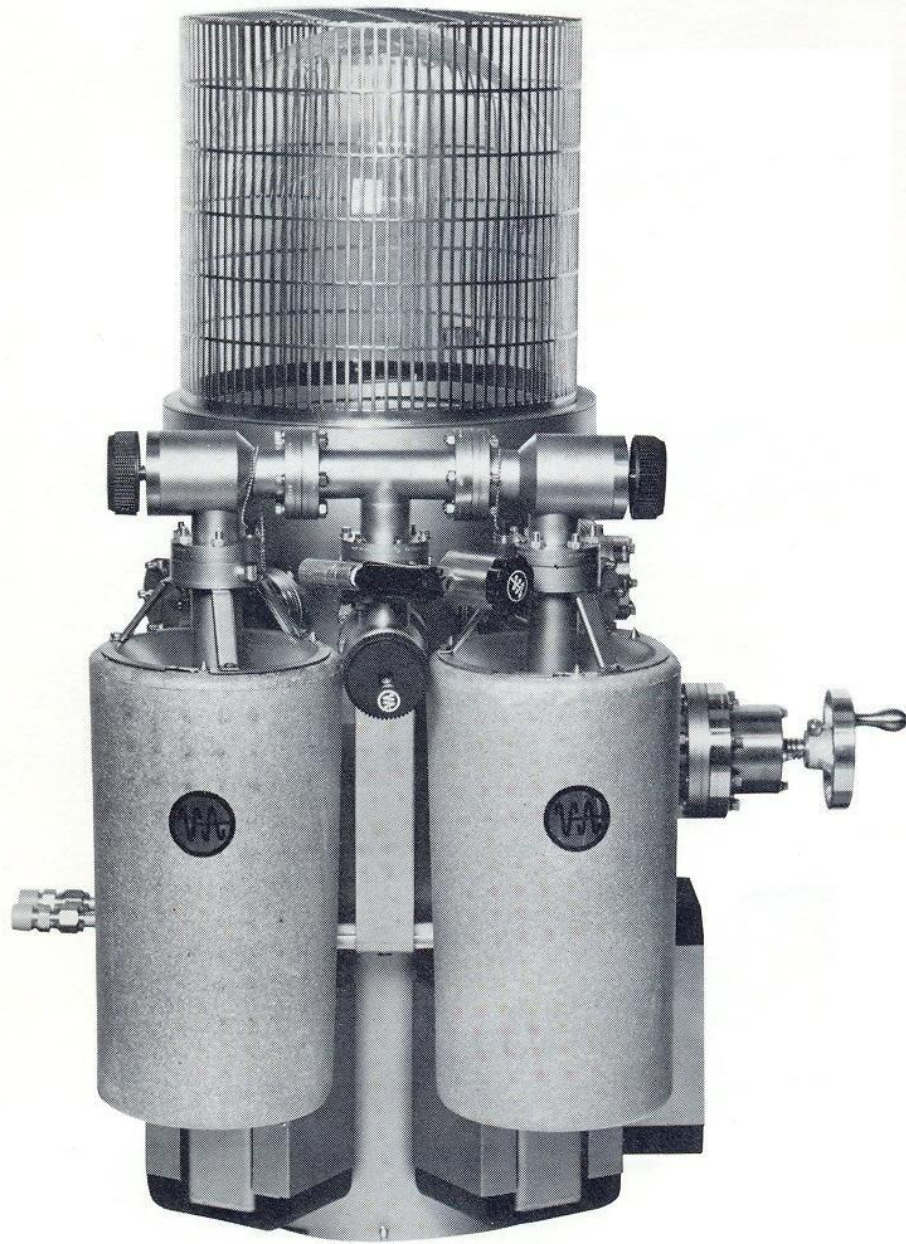
# **PASSADOR DE FLUIDO MAGNÉTICO**



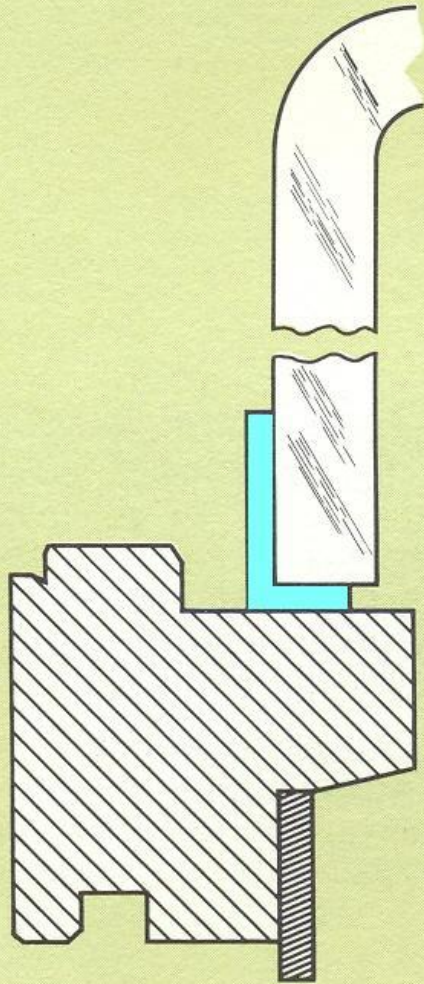


# VISORES (VIDRO RECOZIDO)

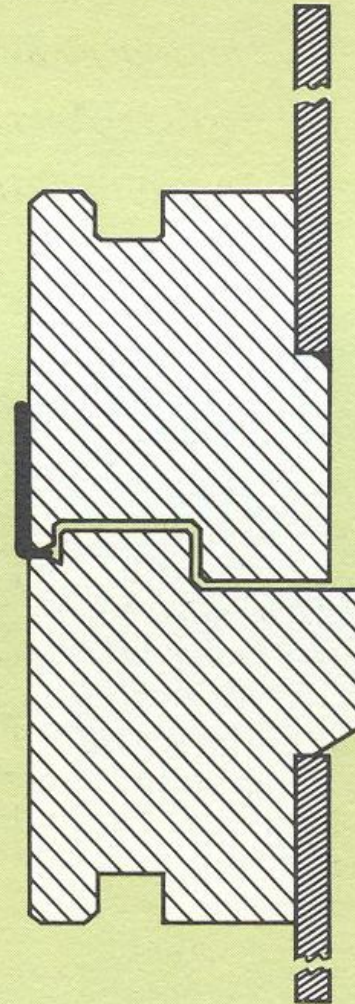








Male Flange with Glass Bell Jar



Flanges Sealed with Viton Gasket











