Ceramics in Electronics

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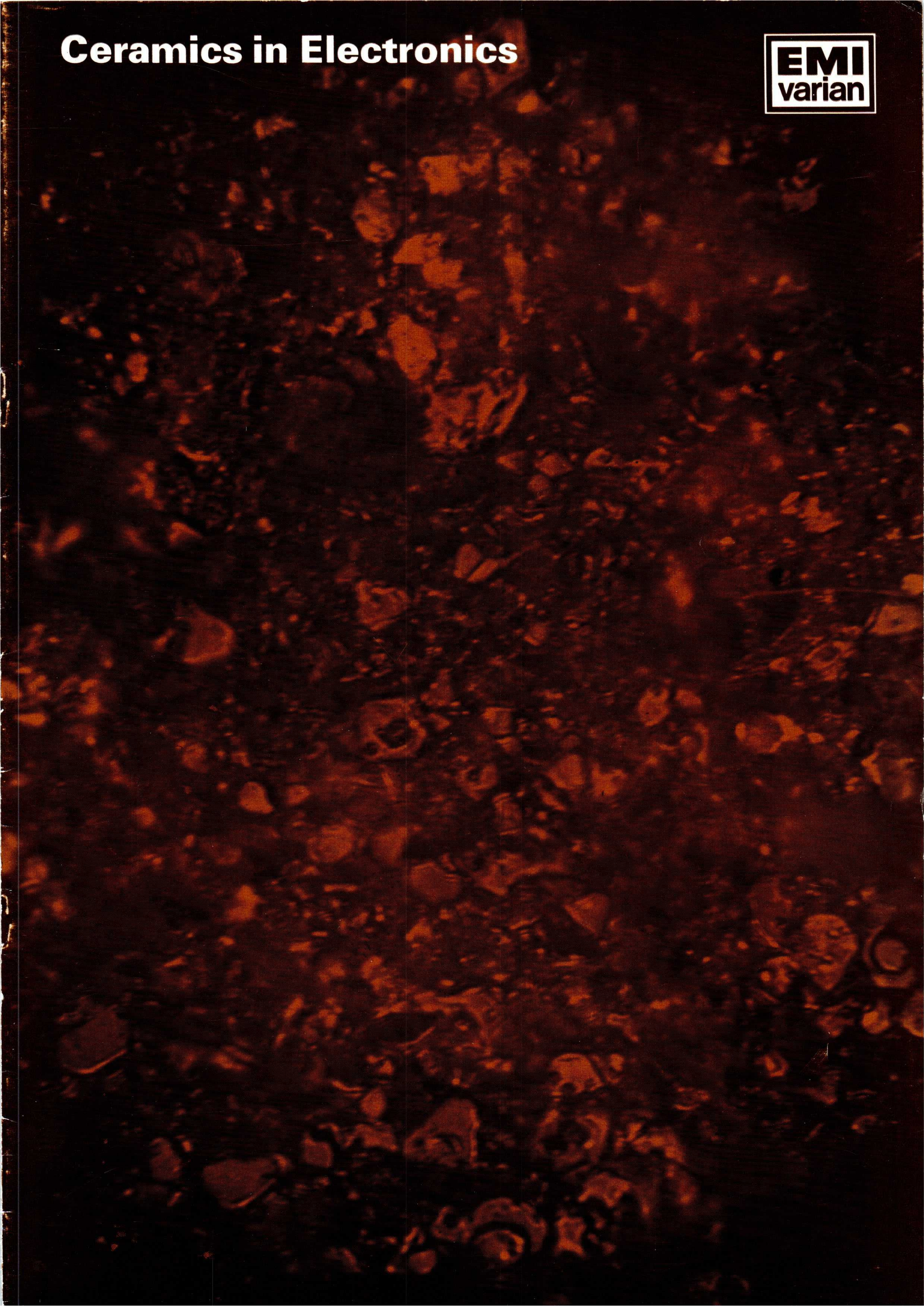

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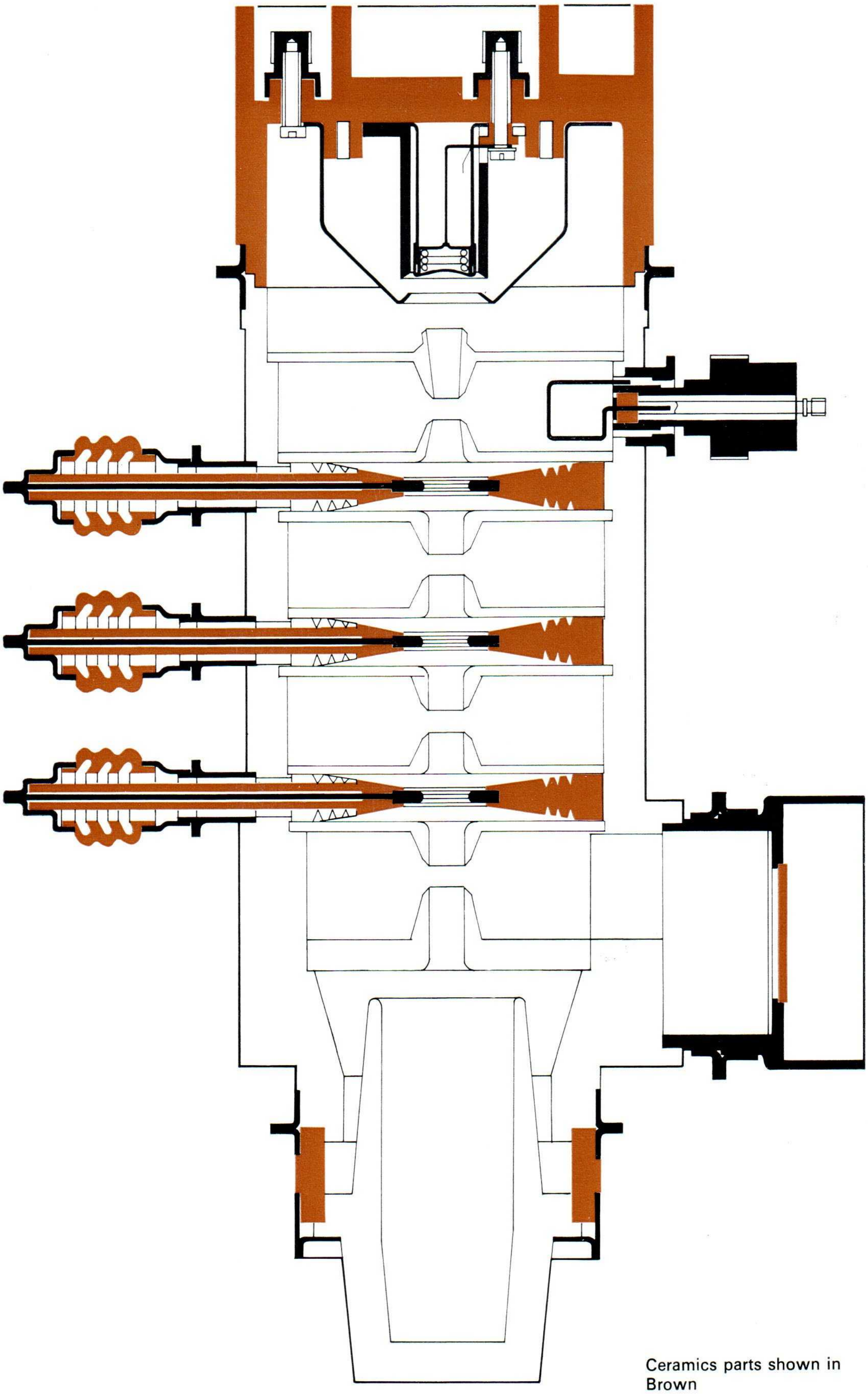


Ceramics parts shown in Brown

Ceramic Components in a modern E.S.F. Klystron

Ceramics in Electronics

Where leak-tight, high-vacuum components are required to withstand high temperatures, the glass parts of vacuum enclosures are the first to fail and the temperature must be kept below 470°C, the softening point of the most commonly used sealing glasses. For many modern tubes higher temperature baking is desirable, so this has led to the use of ceramic components.

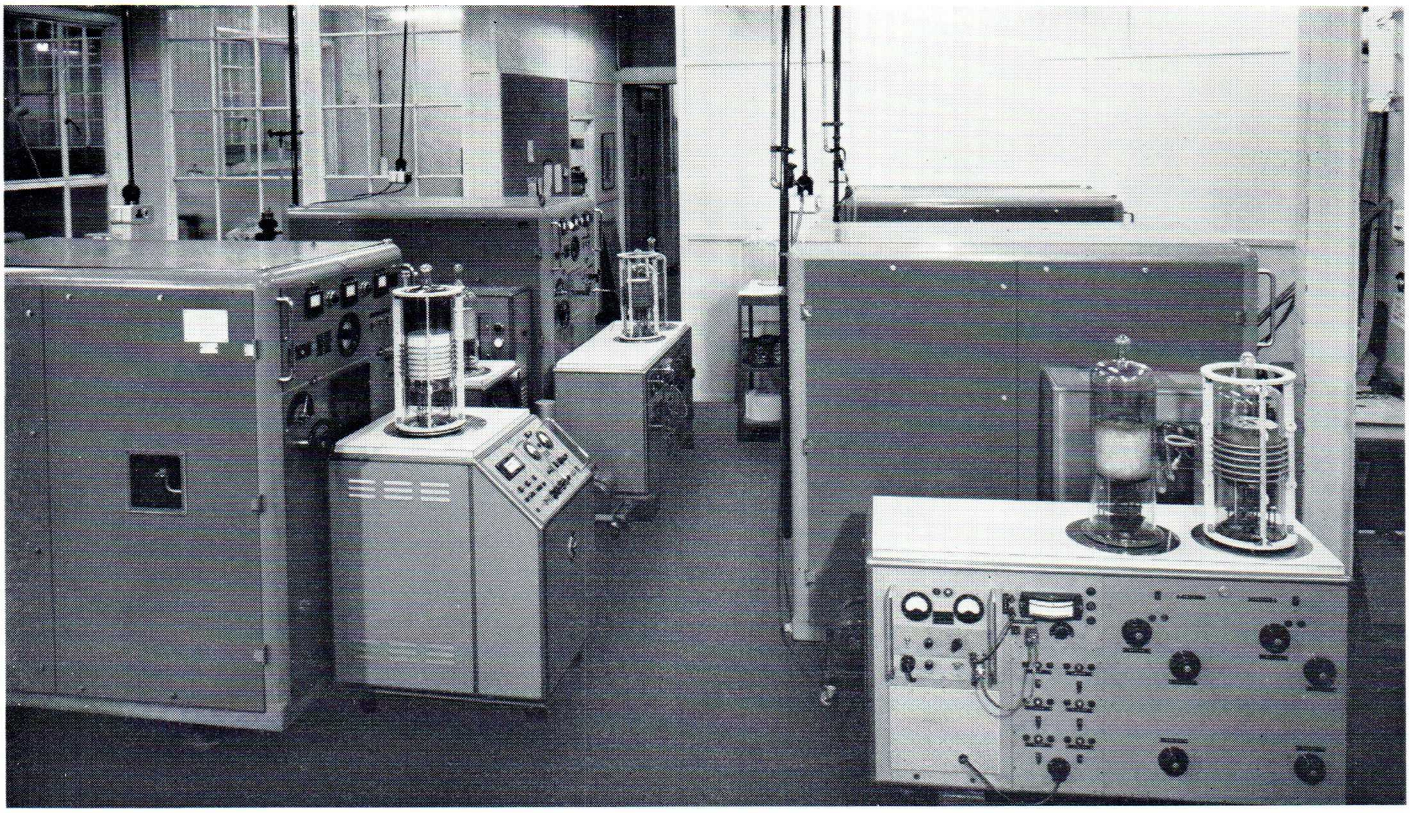
The use of ceramics in place of the conventional glass assemblies allows more accurate construction, better mechanical strength, higher power densities, improved compactness, better thermal and mechanical shock properties apart from improved assembly techniques.

A variety of metallising techniques have been developed, and a suitable method can be found to produce a satisfactory bond to the required metal for almost any type of ceramic. It is, of course, necessary to match the thermal expansion of the materials in order to avoid residual strains. Another important factor is the need for consistency of composition in the ceramic and components to ensure reliable seals.

The principal use of metal ceramic seals has been in insulators for various parts of microwave valves, such as target seals, coaxial input loops, gun terminals and getter ion pump terminal insulators. These metal ceramic components can be readily jointed to other parts of the valve by argon arc welding or brazing.

High power output windows have also been successfully produced in various shapes and sizes including cones and flat discs. For these one generally uses alumina ceramic but beryllia can also be used particularly where special power handling conditions require a material with higher thermal conduction.

Part of the Ceramic R.F. Sintering facility.



Alumina Ceramics

There are now several ceramic materials available including Forsterite, Steatite, Alumina and Beryllia. The first two have very limited applications due to a high flux material content restricting their use at high temperature because of weaknesses and the risk of deformation. Consequently today's requirements call for an Alumina or Beryllia ceramic that has only a small percentage of flux.

Typical of the Alumina Ceramics is Deranox 975, a closely controlled fine grain material which meets CVD/WPC (Ministry of Technology) specifications and is approved by the United Kingdom Atomic Energy Authority for use in radioactive and high pressure steam conditions.

Applications for this material include: Thermionic valve envelopes, cathode supports and heater insulators; waveguide windows; mechanical seal faces; valve seats; instrumentation insulators in nuclear reactors; special thread guides.

Deranox 975 can be readily metallised and maintains its colour in reducing atmospheres. A special glaze is available to remain stable up to 1450°C. under the same conditions.

Property	975
Colour	White
Density g/cm^3	3·79
Chemical stability	Excellent
Maximum "no load" operating temperature °C	1700
Coefficient Linear Thermal Expansion	
20–600°C	$7{\cdot}66 \times 10^{-6}$
20–1000°C	$8{\cdot}11 \times 10^{-6}$

Property	975
Cross Breaking Strength	
Kg/cm^2	3,650
lb/in^2	52,000
Tensile Strength	
Kg/cm^2	2,100
lb/in^2	30,000
Young's Modulus	
Kg/cm^2	$3{\cdot}51 \times 10^{6}$
lb/in^2	50×10^{6}
Power Factor	
1 Mc/s	$1{\cdot}9 \times 10^{-4}$
9368 Mc/s at 25°C	$4{\cdot}3 \times 10^{-4}$
9368 Mc/s at 200°C	$4{\cdot}4 \times 10^{-4}$
9368 Mc/s at 400°C	$6{\cdot}3 \times 10^{-4}$
Permittivity	
1 Mc/s	9·55
9368 Mc/s at 25°C	9·49
9368 Mc/s at 200°C	9·68
9368 Mc/s at 400°C	9·98
Temperature Coefficient of Permittivity (p.p.m./°C)	115
Log Volume Resistivity Ohm cm.	
at 20°C	>14
200°C	13
400°C	10
600°C	8

Note: the values quoted are typical of results obtained from test pieces.

Ceramic Metallising

For good electrical insulation, ceramic to metal seals are preferred to glass, the main advantage being the greater out-gassing temperatures that become possible, higher than the melting point of the toughest glass.

For bonding to metal, the ceramic is coated with a composition of Moly-Manganese on to the desired surface and sintered. By conventional processes, this is at a temperature of ideally around 1400–1500°C for a strong bonding action.

Several Alumina brands, however, particularly where larger sizes are involved, will not retain their original shape when subjected to a metallising process which requires sintering temperatures in excess of 1400°C. In intricate and precision ground bodies, for example Alumina insulators of gun mounts for electrostatically focused klystrons, no change in dimensions can be allowed. It has become necessary therefore to apply new metallising techniques that will provide reliable seals at sinter temperatures below 1200°C. These techniques are now so successful that they are replacing the conventional processes which use higher temperatures; additional advantages are savings in furnace equipment and lower running costs.

Pure Alumina and pure Beryllia are single-phase ceramic bodies but ceramics used in practice are multi-phase because they contain flux material to a variable extent and composition. The flux melts during the sintering period of the manufacturing process, into a glassy phase, and, depending on its composition, influences the density grain size, electrical and mechanical properties and the deformation temperature of the body. To retain good electrical and mechanical properties only a small percentage of flux material can be allowed. It is believed that the glassy phase is also important for the formation of a metal layer which wets and adheres to the ceramic; it is also important for the metallising paint to be fine grained. For this reason, particularly when very pure Alumina has to be used, it is practice to improve wetting by adding titanium to the metallising paint, so that the properties of the bulk material are not affected in depth. The Moly/Manganese metal coating is fired at a high temperature in a dew point controlled protective atmosphere. The conductive metal surface is then either nickel or copper plated.

Terminals

Apart from special types, terminals fall into 4 main categories, i.e. to withstand potentials of:—

a 0 to 2KV
b 2 to 20KV
c 20 to 50KV
d 50 to 100KV

The terminal parts are in most cases interchangeable as indicated on the following pages, various sizes and types of caps and support flanges, etc., being readily available. From these charts a specific terminal may be selected and supplied for specialised applications with the minimum of delay.

It is important to note that due to the widely differing coefficients of expansion of Alumina Ceramic and stainless steel at high brazing temperatures, stainless steel is not brazed directly to Alumina; a buffer material of Nickel-Iron such as Vacon, which has a similar coefficient of expansion to Alumina, is therefore used. Stainless steel parts are then brazed or welded to the Vacon if required.

Small Ceramics 0 to 2KV

PTC 1040 Series

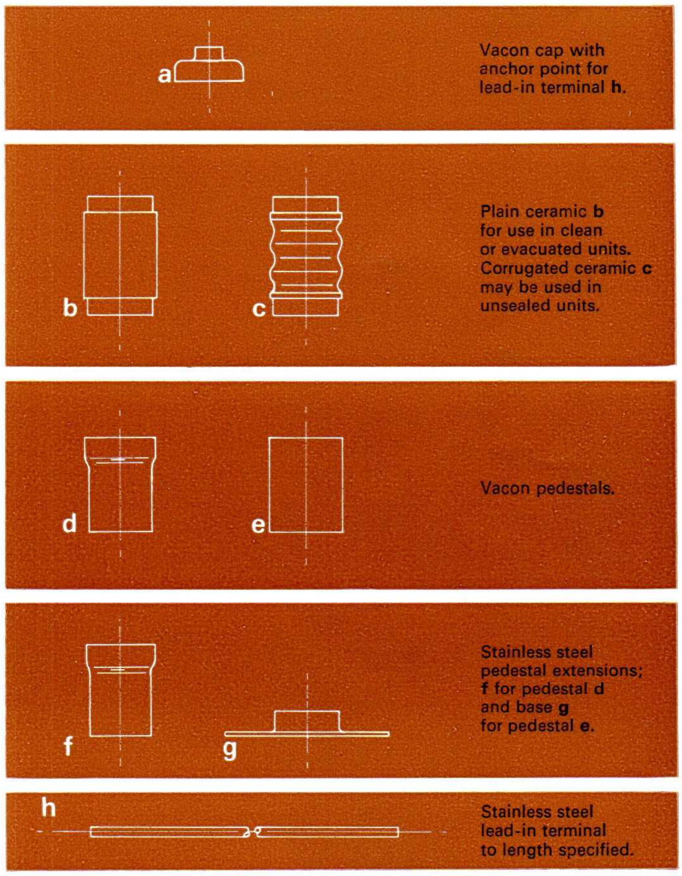
Plain ceramics, lead-in terminals brazed to Vacon Cap

Catalogue Number	Comprising	KV	Maximum overall Height cm.	in.
PTC 1040	**abdf**	2	4·1	1·60
PTC 1041	**abdfh**	2	4·1	1·60
PTC 1042	**abdh**	2	3·1	1·20
PTC 1043	**abeg**	2	3·2	1·25
PTC 1044	**abegh**	2	3·2	1·25

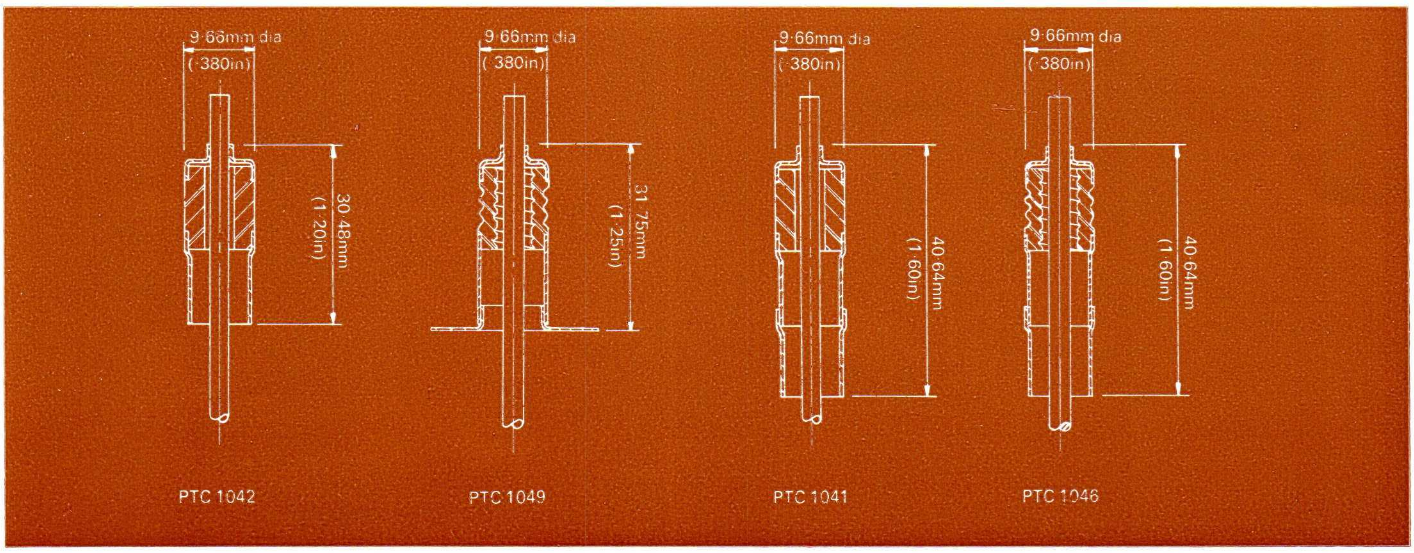
Corrugated ceramics, do not require clean operating conditions

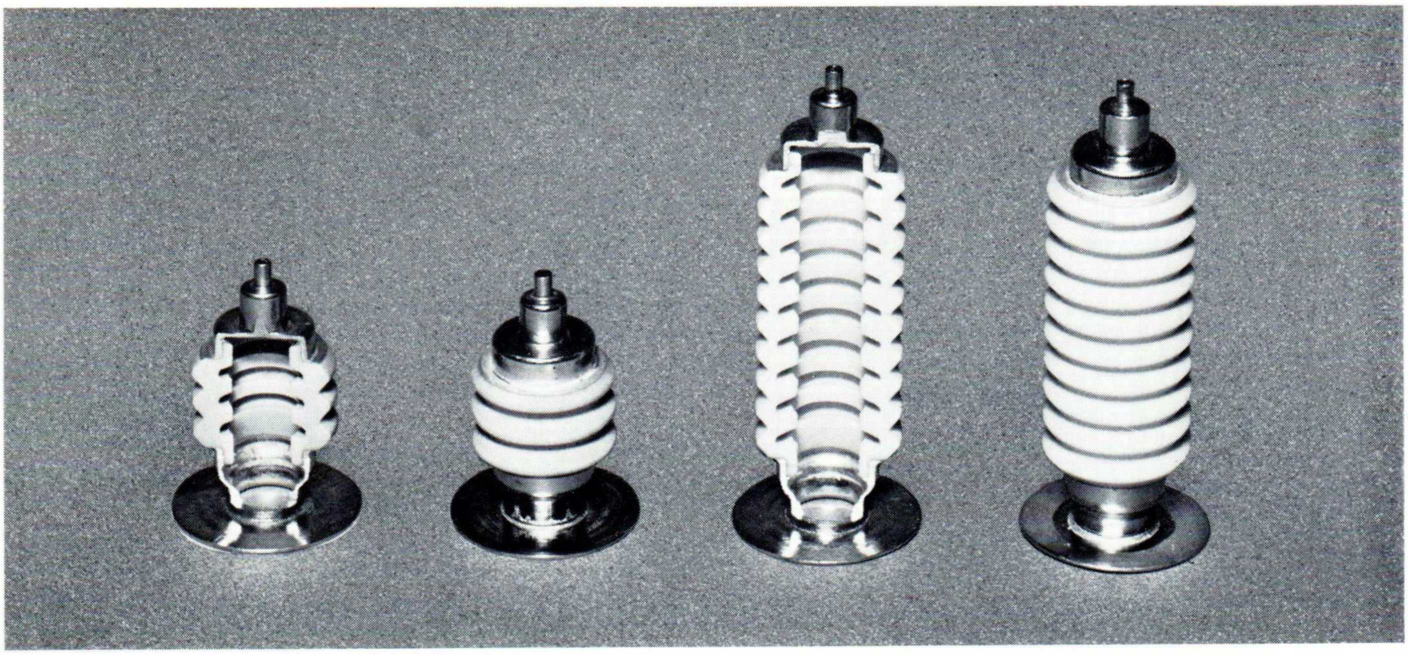
Catalogue Number	Comprising	KV	Maximum overall Height cm.	in.
PTC 1045	**acdf**	2	4·1	1·60
PTC 1046	**acdfh**	2	4·1	1·60
PTC 1047	**acdh**	2	3·1	1·20
PTC 1048	**aceg**	2	3·2	1·25
PTC 1049	**acegh**	2	3·2	1·25

N.B.: Overall height does not include lead-in terminal.



Typical 0 to 2KV Terminals



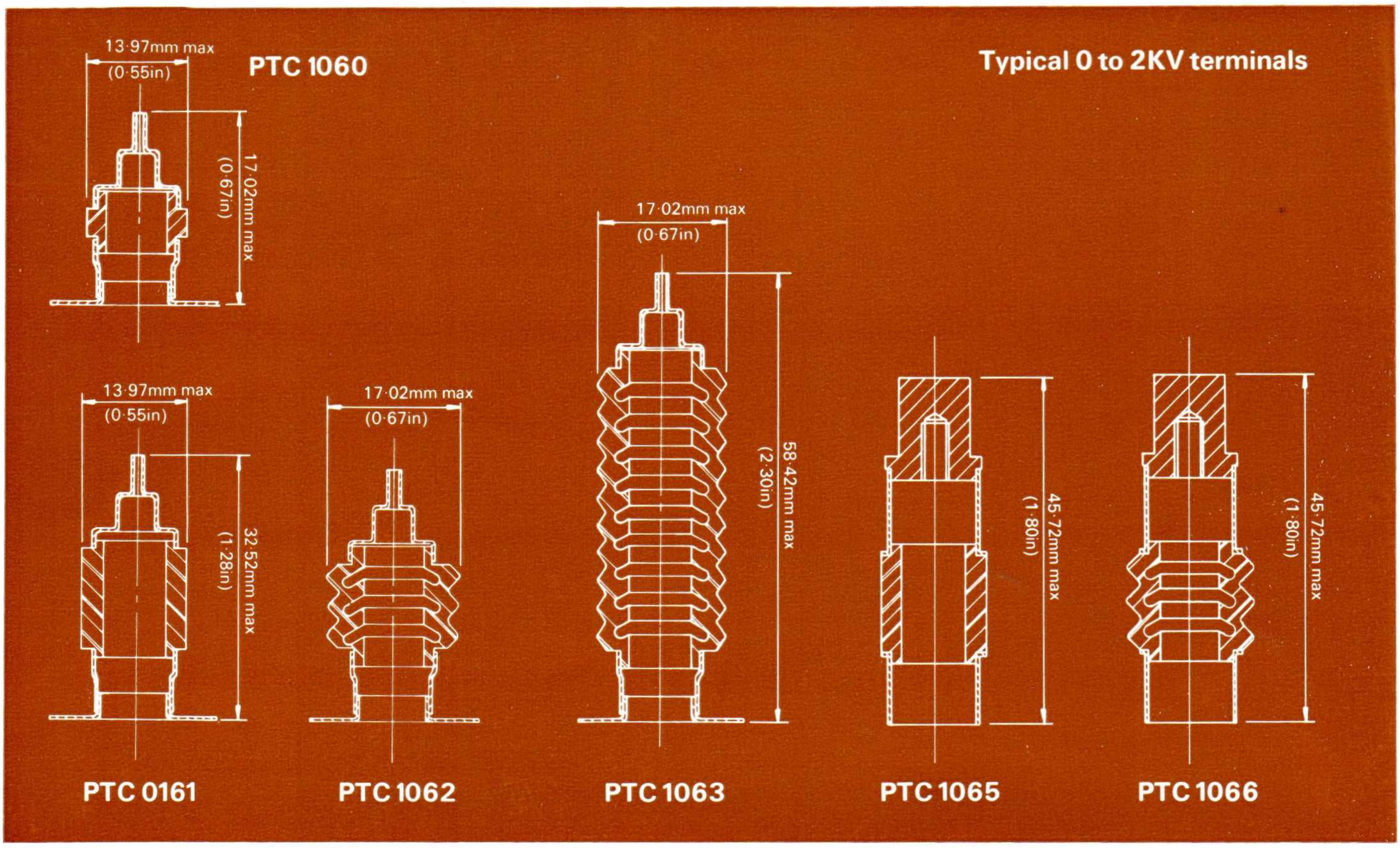


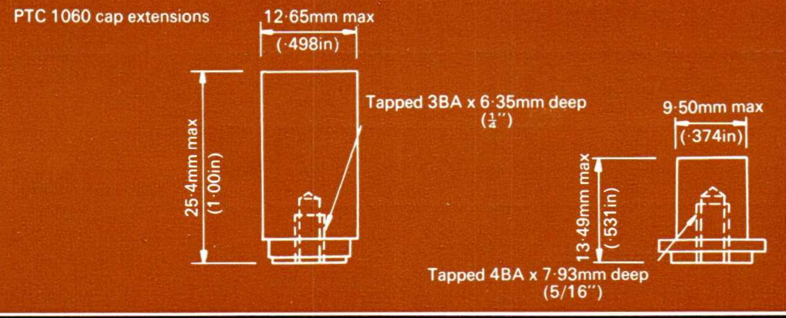
Medium Ceramics 2 to 20KV

PTC 1060 Series

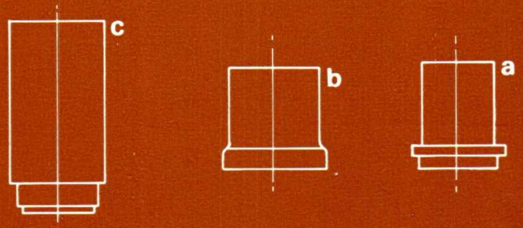
Catalogue Number	Comprising	KV	Max. Overall Height cm.	in.	Notes
PTC 1060	**dhoq**	2	2·54	1·00	For use in evacuated units.
PTC 1061	**djoq**	5	3·25	1·28	
PTC 1062	**dkoq**	5	3·25	1·28	For sealed or unsealed units.
PTC 1063	**dmoq**	20	5·85	2·30	
PTC 1064	**afhn**	2	3·86	1·52	For use in evacuated units.
PTC 1065	**afjn**	5	4·57	1·80	
PTC 1066	**afkn**	5	4·57	1·80	For sealed or unsealed units.
PTC 1067	**afmn**	20	7·15	2·81	

NB: Base plate q is ·875 in. dia. and base plate r is 1·25 in. dia.
The above list is of standard types, other combinations may be assembled as desired.

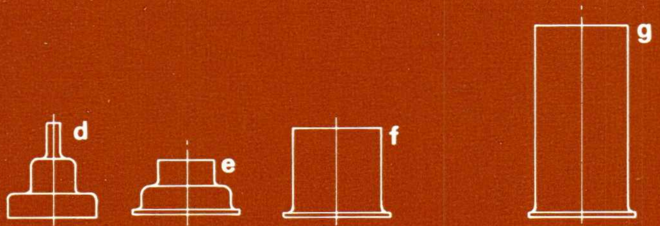




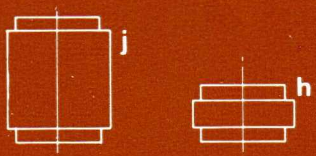
N.B. for cap extensions **c** and **a** the lead-in terminal support holes are standard as shown; but may be drilled and tapped to customer's specification.



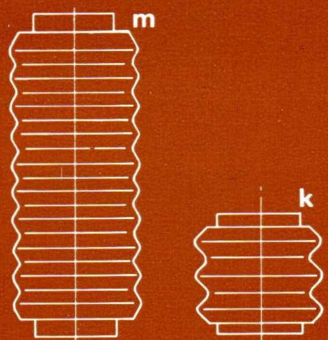
Cap extensions for Vacon terminal caps **f** & **g**
a & **c** are Vacon,
b is stainless steel.



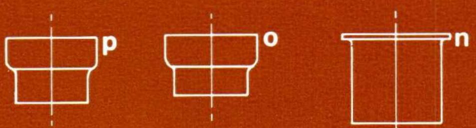
Vacon terminal caps.



Plain ceramics for use in clean or evacuated conditions.

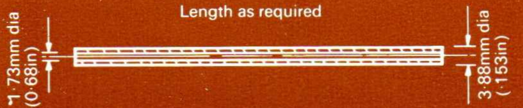


Corrugated ceramics for increased dielectric paths, allowing use in unsealed units.



Vacon pedestals to fit all above ceramics.

Base plates, **q** to fit pedestal **o**, and **r** to fit pedestal **p**.



Standard ceramic insulating tube.

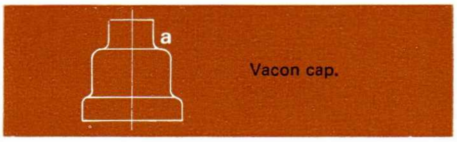
Medium Ceramics 20 to 50KV

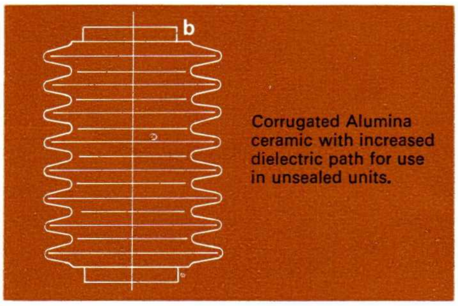
PTC 1070 Series

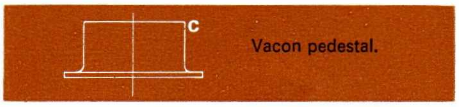
Catalogue Number	Comprising	KV	Max. Overall Height cm.	in.	Notes
PTC 1070	**abc**	50	6·4	2·5	
PTC 1071	**abcd**	50	7·4	2·9	With stainless steel pedestal brazed to Vacon.

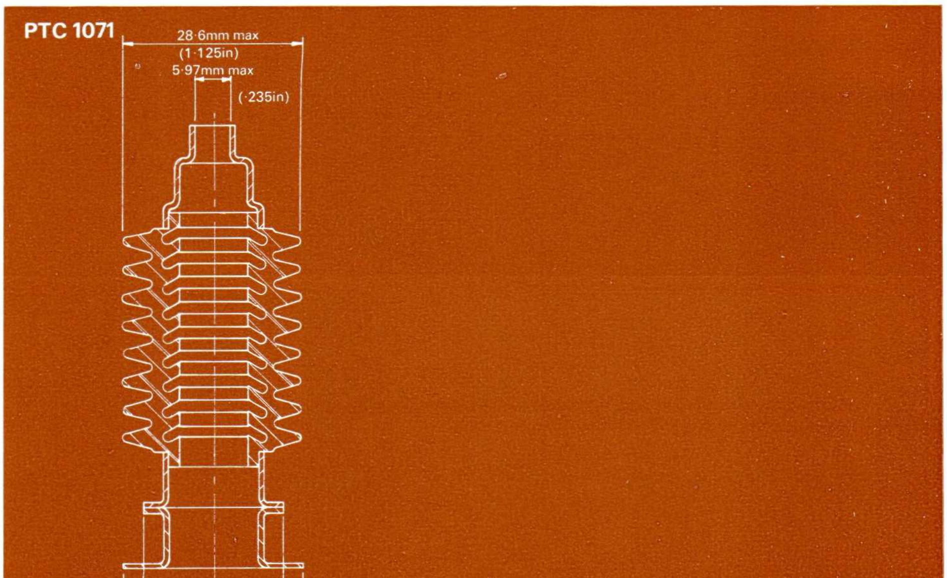
Note A: Pedestal c is of ·020 in. VACON 70.

Note B: Pedestal d is of 24 S.W.G. (·022 in.) stainless steel.







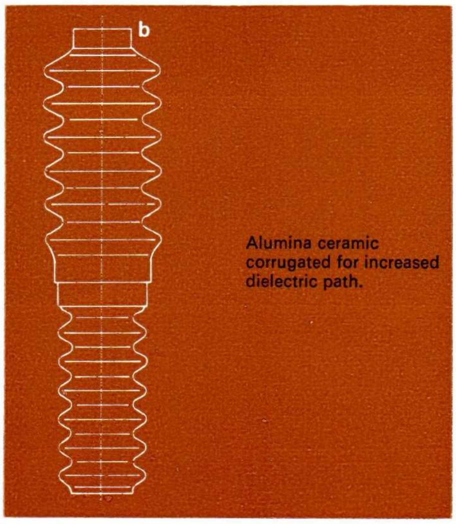


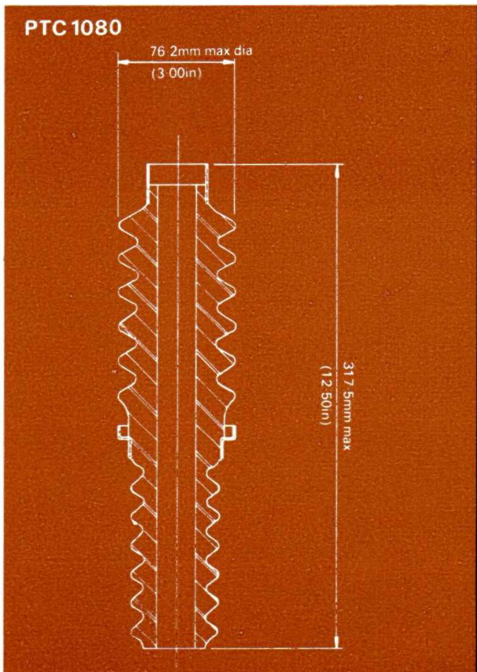
Typical 20 to 50KV terminal.

Large Ceramics 50 to 100KV

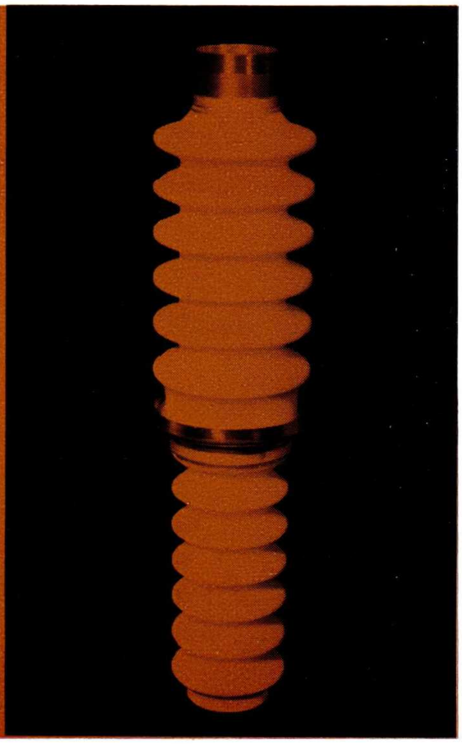
PTC 1080 Series

Catalogue Number	Comprising	KV	Max. Overall Height cm.	in.	Notes
PTC 1080	**abc**	100	31·75	12·5	Internal diameter is 1·00 inch (2·54 cm.).





Typical 50 to 100KV terminal.

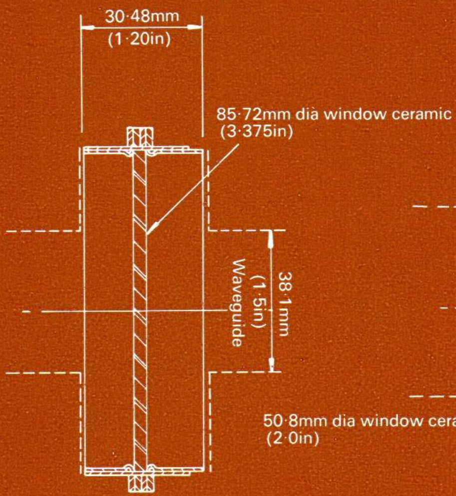


Microwave Windows

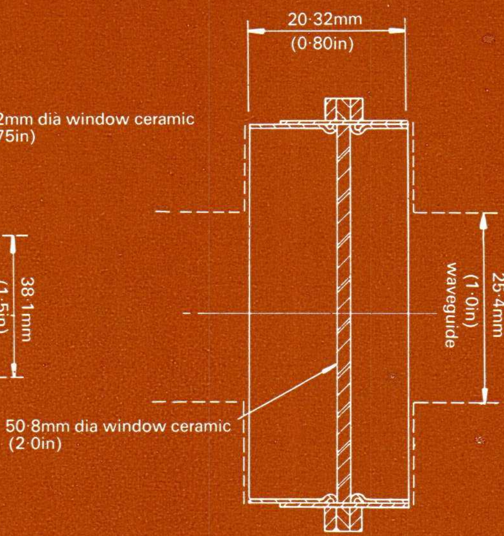
A particular application for ceramics is high-power microwave windows which allow power to pass from the vacuum of a tube to the external transmission line.

Because of the high r.f. voltages existing in the region of such a window, electron and occasionally ion bombardment of the window can occur, thus allowing a build-up of charge on the surface in addition to possible direct damage from the bombardment. Both the high dielectric strength and thermal shock resistance properties of ceramics are required in this application. The bombardment also releases gas from the ceramic surface. This effect has been studied extensively and has, with the aid of a mass spectrometer, helped in the understanding of the behaviour of ceramics under these conditions.

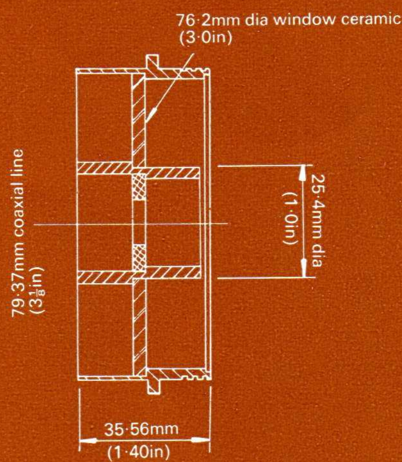
PTC 1105
S-Band window.



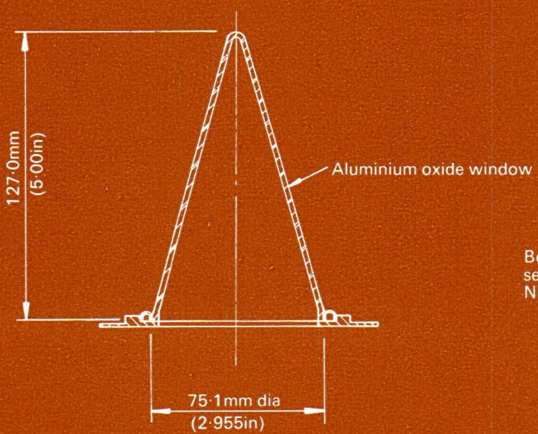
PTC 1103
C-Band window.



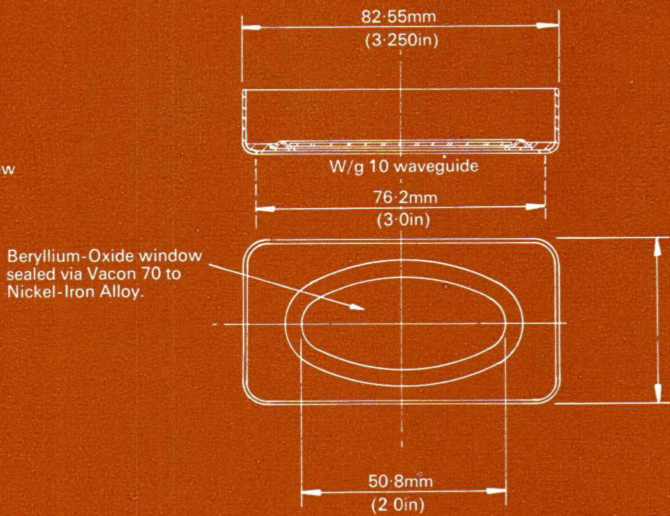
PTC 1104
L-Band window.

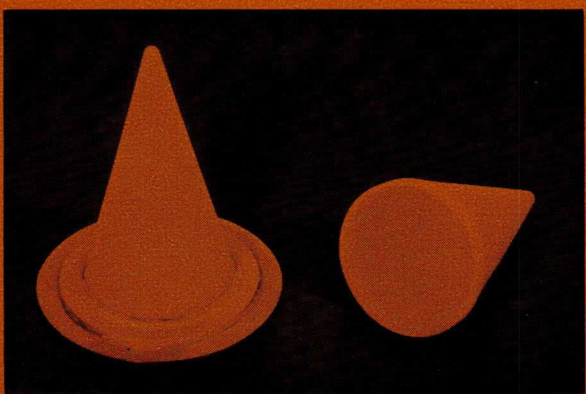


PTC 1100



PTC 1102





Material: A_2O_3 (98·5%)
Sealed via Vacon 70 to Nilo-k.

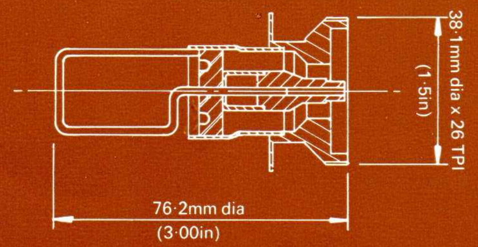
Co-axial Loops

A standard range of vacuum sealed coupling loops for microwave applications is available and are bakeable up to a temperature of 600°C.

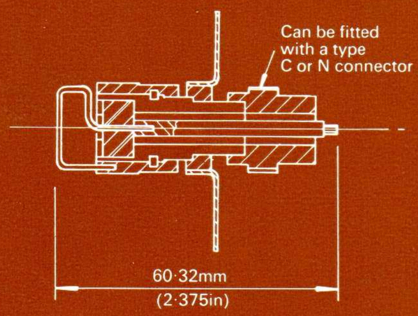
The insulator is Aluminium Oxide which is brazed to a stainless steel welding flange via Vacon 70 with a silver copper eutectic.

Although the following section lists standard sizes, the loop wire dimensions may be altered to suit particular applications.

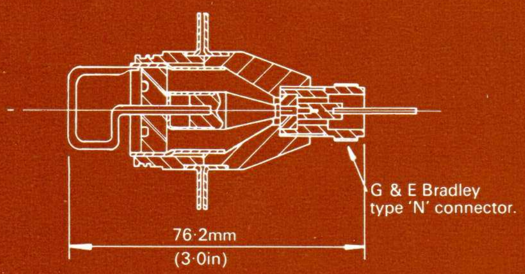
Material: A_2O_3 (98·5%) sealed via Vacon 70 to a stainless steel welding flange



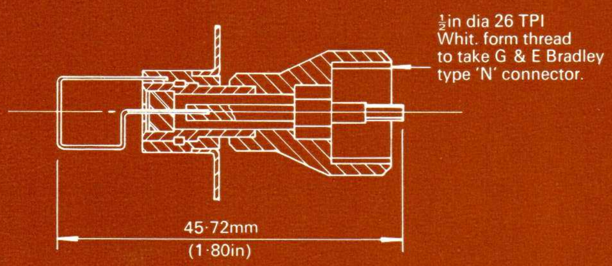
PTC 1090



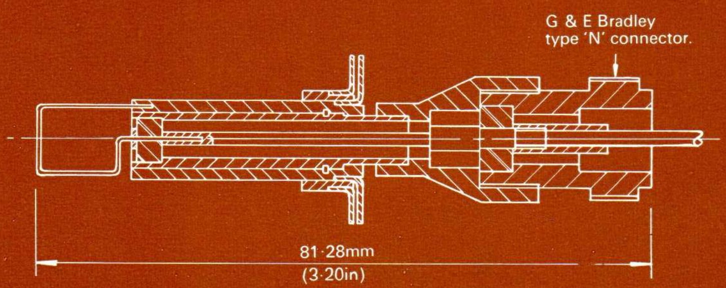
PTC 1091



PTC 1094



PTC 1092



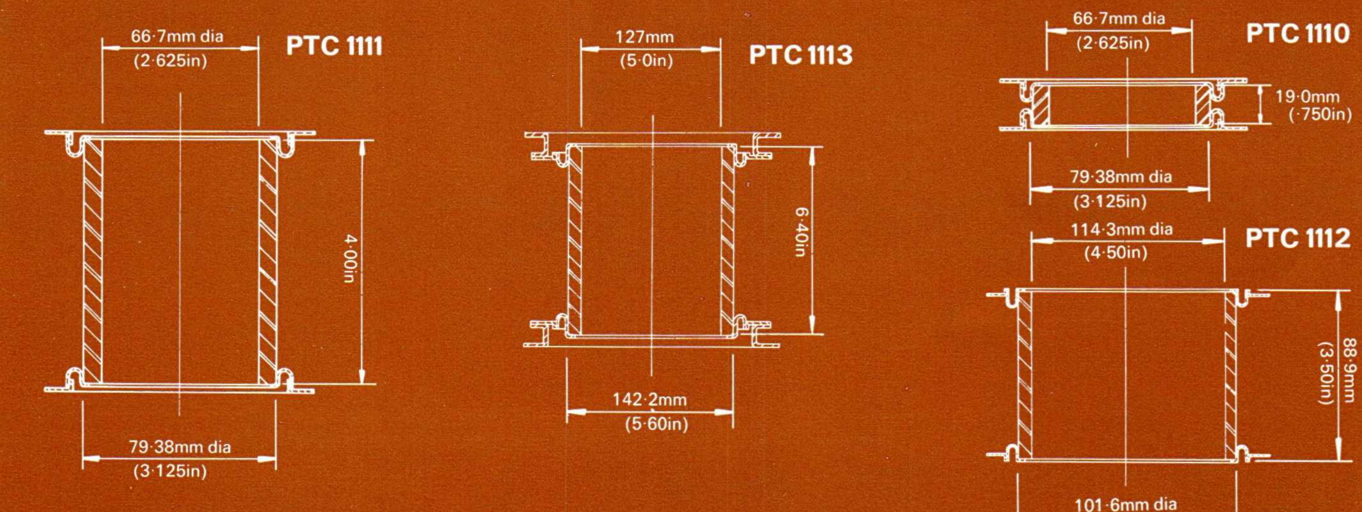
PTC 1093

Miscellaneous

Included in this section are various sizes of cylindrical ceramic insulators. Although primarily designed as klystron gun and collector insulators, these components are easily adaptable for other insulating purposes. Due to the special mounting techniques, baking temperatures of up to 550°C are possible.

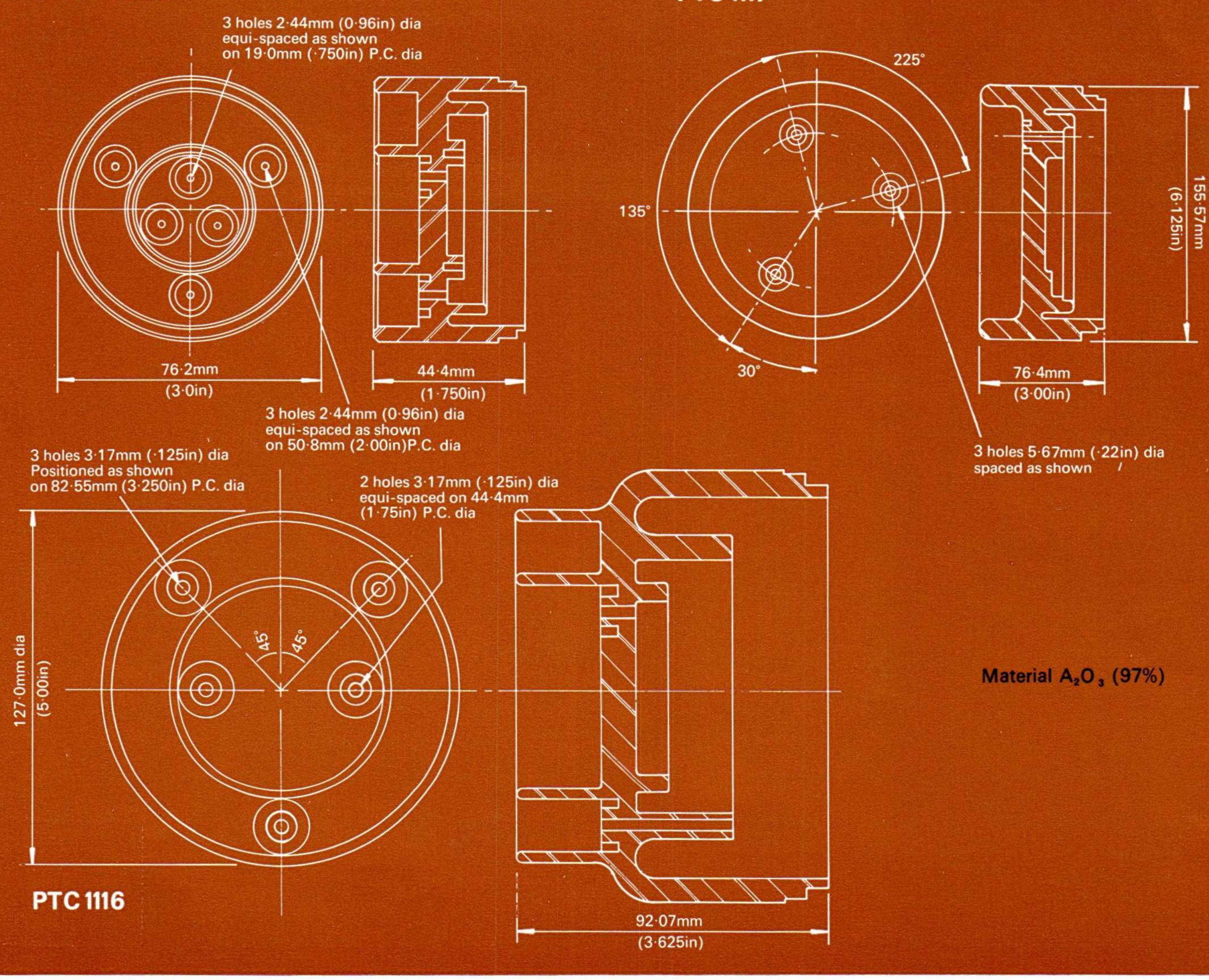
Also available are klystron gun ceramics, which, although designed for specific klystron applications, may well be adapted for other tubes.

Cylindrical Ceramic Insulators.



Material: A_2O_3 (96%) sealed via Vacon 70 to stainless steel or Nilo-k

Gun Ceramics



Material A_2O_3 (97%)

Ceramics in Electronics

Photomicrograph of an Alumina ceramic surface × 300

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