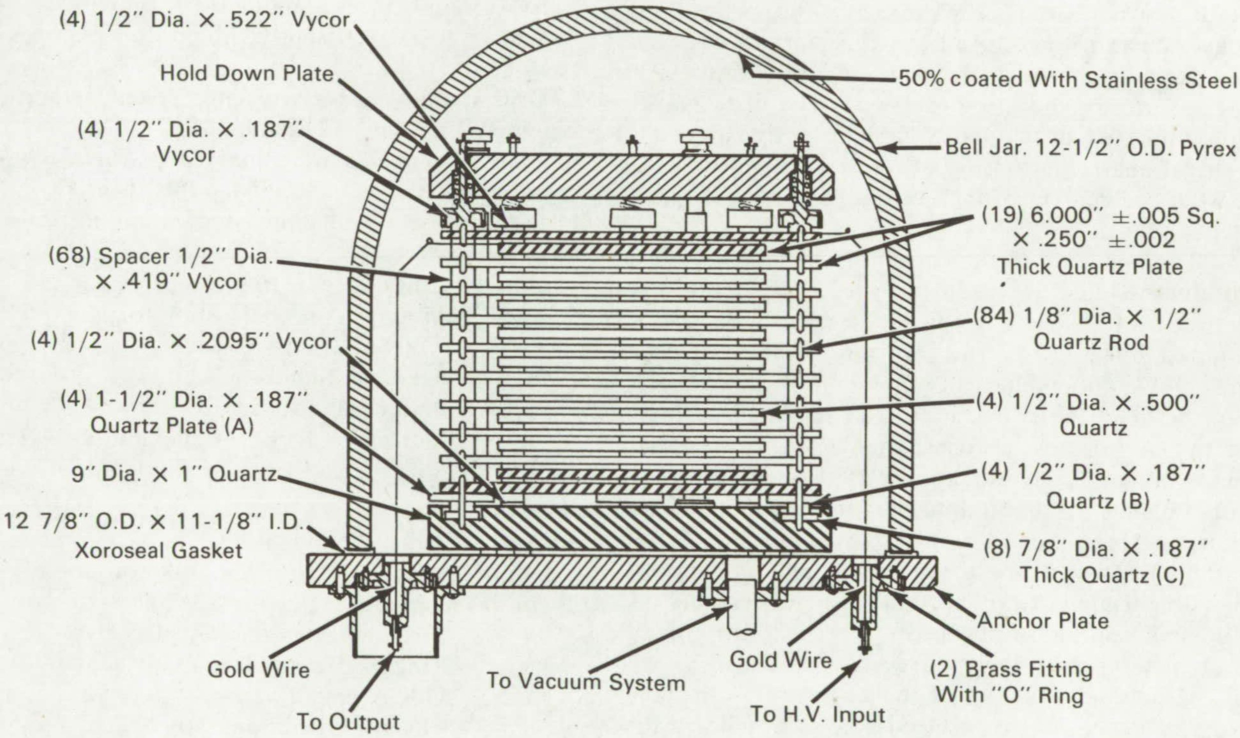
AEC-NASA TECH BRIEF

Precision Capacitor Has Improved Temperature and Operational Stability



The problem:

To fabricate a precision capacitor in the 1000–2000 picofarad range which will (1) have a near-zero temperature coefficient of capacitance, (2) eliminate ion chamber action caused by air ionization in the dielectric, and (3) minimize undesirable electromagnetic field charging effects on the surfaces of structural components of the capacitor.

Present air dielectric precision capacitors exhibit ion chamber action and charging effects of structural material. Temperature coefficients of capacitance in precision capacitors with dry nitrogen gas dielectrics are typically of the order of 16–22 ppm/°C.

The solution:

A vacuum dielectric capacitor which is fabricated from materials having very low temperature coefficients of expansion to achieve a temperature coefficient of capacitance of less than 0.57 ppm/°C. By using a vacuum dielectric design, ion chamber action is absent. The surfaces of structural components are plated with a conductive coating to ensure electrical

(continued overleaf)

continuity between the elements in the same plate stack.

How it's done:

The capacitor consists of interleaved input and output plate stacks of metallic-plated quartz, plate spacers of plated Vycor, and hold-down plates, assembled in a bell jar. The capacitor is contained in a vacuum, which eliminates ion chamber action. The use of materials with different temperature coefficients of expansion provides temperature compensation such that plate spacing expands more rapidly than the plate area, thus capacitance is kept constant.

Both plate stacks are fabricated from equal-sized plates of quartz. The input plates are rotated 45° with respect to the output plates, with the corners of the plates in both stacks lying outside the interleaved area. Each plate in the same stack is then supported at the corners by Vycor spacers. The plates and spacers are anchored together with quartz rods, each rod extending through the plate and into the Vycor spacer directly above and below it. The plate stacks are supported on a quartz base plate by three cylindrical quartz buttons, A, B, and C, aligned vertically at each corner of the bottom plate in each plate stack.

All components of the capacitor are plated with a conductive coating to ensure electrical continuity between all elements of the same stack. Plating is omitted, however, on one contacting surface of each group of support buttons to maintain electrical isolation between the two stacks. The unplated surfaces of the buttons are also insulated from any electric fields arising from the application of potential to either plate stack to minimize the influence of surface charge currents. Such currents decay slowly because of the high resistivity of the medium, and are almost indistinguishable from normal leakage currents. A similar insulation arrangement is used at the top of both plate stacks at the Vycor insulators.

The internal structure of the capacitor is shielded from influence of external electric fields by coating the interior surface of the bell jar with a semitransparent conductive layer of stainless steel. This coating is grounded to the metal base plate with finger contacts not shown in the figure. The dimensional stability of the capacitor over a varying range of temperatures is less than the coefficients of expansion of either structural material used, and the capacitor exhibits a short term temperature coefficient of capacitance of approximately 0.4 ppm/°C.

Notes:

1. The capacitor has been developed for use with a sensitive instrument capable of detecting and measuring the output voltage stability, in parts-per-million, of a dc voltage source of up to 10 Kv. The capacitor replaces both the reference voltage and resistive divider used as the input to a vibrating-reed electrometer. The guarded vacuum dielectric design of this capacitor is such that the effective leakage current is comparable to the electrometer background current, about 10^{-16} ampere, at voltages up to 1 Kv, rising to about 10^{-14} ampere at 10 Kv.
2. Drift stability of the capacitor system is approximately 1 ppm per 12 hours.
3. Additional details are contained in *Nuclear Instruments and Methods 29*, 1964, p. 141–148.
4. Inquiries concerning this innovation may be directed to:

   Office of Industrial Cooperation
   Argonne National Laboratory
   9700 South Cass Avenue
   Argonne, Illinois 60439
   Reference: B67-10313

   Source: W. K. Brookshier and R. N. Lewis
   Electronics Division
   (ARG-189)

Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

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