



TYPE 722 PRECISION CAPACITOR

USES: The Type 722 Precision Capacitor is a stable and precise variable air capacitor intended for use as a standard of capacitance.

It is widely used in a-c bridges, both as a built-in standard and as an external standard for substitution measurements. It is also used as a tuning capacitor in oscillators and frequency meters, and as a standard in electronic gauges, calibrators and other instruments. Where highest accuracy and stability are important, it is the standard of the industry.

DESCRIPTION: The capacitor assembly is mounted in a cast frame, which gives the unit rigidity. The frame, spacers, stator rods, and rotor shaft are made of the best available alloys of aluminum, which combine the mechanical strength of brass with the weight of aluminum. The plates are also of aluminum, so that all parts have the same temperature coefficient of linear expansion.

A worm drive is used to obtain the desired high precision of setting. In order to avoid the slight eccentricity that may occur when a worm gear is mounted on a shaft, the shaft and the worm are one accurately machined piece. The dial end of this worm shaft runs in a self-aligning ball bearing, while the other end is supported by an adjustable spring mounting. Sealed, self-lubricating ball bearings, lightly stressed, are used at the ends of the rotor shaft. Electrical connection to the rotor is made by means of a silver alloy brush bearing on a silver overlay drum to assure a positive electrical contact.



The preliminary assembly of the frame, shaft, and gears is motor driven to grind in the gears before final assembly to improve smoothness and concentricity.

- FEATURES:**
- High stability.
 - High precision of setting — one part in 25,000 of full scale; scale length is 19.2 feet.
 - High accuracy.
 - Low backlash.
 - Low temperature coefficient of capacitance.
 - Low dielectric losses.
 - Direct reading in capacitance.

SPECIFICATIONS

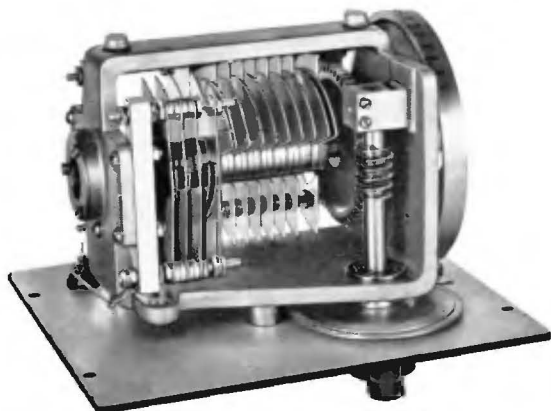
Capacitance Range: Three stock models are listed below. A fourth model for use at high frequencies is described on page 153.

TYPE 722-D, direct reading in total capacitance; and TYPE 722-MD and TYPE 722-ME, direct reading in capacitance removed from the capacitor and intended for use in capacitance measurement by the direct substitution method. Ranges and accuracies are tabulated below.

Type	Capacitance Range, $\mu\mu\text{f}$	Direct-Reading Accuracy	Approx. Cap. at Zero Scale Setting
722-D	100 to 1150	$\pm 1 \mu\mu\text{f}$ or $\pm 0.1\%$	—
	25 to 115	$\pm 0.2 \mu\mu\text{f}$ or $\pm 0.1\%$	—
722-MD	0 to 1050	$\pm 1 \mu\mu\text{f}$ or $\pm 0.1\%$	1110 $\mu\mu\text{f}$
	0 to 105	$\pm 0.2 \mu\mu\text{f}$ or $\pm 0.1\%$	135
722-ME	0 to 105	$\pm 0.2 \mu\mu\text{f}$ or $\pm 0.1\%$	145
	0 to 10.5	$\pm 0.05 \mu\mu\text{f}$ or $\pm 0.1\%$	35

Capacitance is indicated by the readings of the dial and drum, visible through a window in the panel.

Special models, including three-terminal designs, can be supplied to meet customers' specifications.



Interior view of the Type 722-ME Precision Capacitor.



Rotor Plate Shape: Semicircular for all models, to give a linear capacitance characteristic.

Correction Chart: A correction chart is supplied giving

corrections at multiples of 1, 10 or 100 μmf , depending on the total capacitance of the capacitor. Accuracies obtainable through the use of these charts are as follows:

Type	Range, μmf	Accuracy after correction is applied	
		Total Capacitance	Capacitance Differences
722-D	{ 100 to 1150 25 to 115	$\pm 0.1\%$ or $\pm 0.4 \mu\text{mf}^*$	$\pm 0.1\%$ or $\pm 0.8 \mu\text{mf}^*$
		$\pm 0.1\%$ or $\pm 0.08 \mu\text{mf}^*$	$\pm 0.1\%$ or $\pm 0.16 \mu\text{mf}^*$
722-MD	{ 0 to 1050 0 to 105	$\pm 0.1\%$ or $\pm 0.4 \mu\text{mf}^*$	$\pm 0.1\%$ or $\pm 0.8 \mu\text{mf}^*$
		$\pm 0.1\%$ or $\pm 0.08 \mu\text{mf}^*$	$\pm 0.1\%$ or $\pm 0.16 \mu\text{mf}^*$
722-ME	{ 0 to 105 0 to 10.5	$\pm 0.1\%$ or $\pm 0.08 \mu\text{mf}^*$	$\pm 0.1\%$ or $\pm 0.16 \mu\text{mf}^*$
		$\pm 0.1\%$ or $\pm 0.02 \mu\text{mf}^*$	$\pm 0.1\%$ or $\pm 0.04 \mu\text{mf}^*$

† When differences are taken from any zero worm-dial setting. * Whichever is greater.

Overall Usable Accuracy: The accuracies stated above can be attained in practice only if an acceptable standard technique is used by the operator to connect the capacitor into a measuring circuit. Otherwise, the usable accuracy at the capacitor terminals may be limited to approximately $\pm 1 \mu\text{mf}$. (See description on page 154 under TYPE 1401 or *General Radio Experimenter*, Vol.

XXI, No. 12, May 1947, for a complete discussion of connection errors.)

Worm Correction Calibration: Corrections for the slight residual eccentricity of the worm drive can be supplied for all models at an extra charge indicated in the price list. Mounted charts are supplied, which give the corrections to at least one more figure than the guaranteed accuracies, which are stated below.

Type	Range, μmf	Accuracy after worm correction is applied	
		Total Capacitance	Capacitance Differences
722-D	{ 100 to 1150 25 to 115	$\pm 0.1\%$ or $\pm 0.1 \mu\text{mf}^*$	$\pm 0.1\%$ or $\pm 0.2 \mu\text{mf}^*$
		$\pm 0.1\%$ or $\pm 0.02 \mu\text{mf}^*$	$\pm 0.1\%$ or $\pm 0.01 \mu\text{mf}^*$
722-MD	{ 0 to 1050 0 to 105	$\pm 0.1\%$ or $\pm 0.1 \mu\text{mf}^*$	$\pm 0.1\%$ or $\pm 0.2 \mu\text{mf}^*$
		$\pm 0.1\%$ or $\pm 0.02 \mu\text{mf}^*$	$\pm 0.1\%$ or $\pm 0.01 \mu\text{mf}^*$
722-ME	{ 0 to 105 0 to 10.5	$\pm 0.1\%$ or $\pm 0.02 \mu\text{mf}^*$	$\pm 0.1\%$ or $\pm 0.01 \mu\text{mf}^*$
		$\pm 0.1\%$ or $\pm 0.005 \mu\text{mf}^*$	$\pm 0.1\%$ or $\pm 0.01 \mu\text{mf}^*$

† When differences are taken from any zero worm-dial setting. * Whichever is greater.

Maximum Voltage: All models, 1000 volts, peak.

Dielectric Supports: Bars of low-loss steatite support the stator assemblies, and conical polystyrene bushings insulate the terminals from the panel. Quartz bars, coated with silicone to prevent formation of a water film, can be supplied on special order. (See price list.)

Dielectric Losses: The figure of merit, $D_s C_p$, (dissipation factor times capacitance), when measured at 1 kc, is approximately 0.03×10^{-12} for steatite insulation and 0.003×10^{-12} for quartz.

Insulation Resistance: Under standard conditions (23° C, 50% RH), greater than 10^{12} ohms.

Residual Parameters: Effective series inductance is approximately $0.06 \mu\text{h}$ for all high-capacitance sections and 0.10 for low-capacitance sections. Effective series resistance at 1 Mc is approximately 0.02Ω for high-capacitance sections and 0.03Ω for low-capacitance sections. The series resistance varies as the square root of the frequency. Its effect is negligible below 100 kc.

Frequency Characteristic: See Figure 2, page 149, for plot of variation of capacitance with frequency.

Temperature Coefficient of Capacitance: Approximately $\pm 0.002\%$ per degree Centigrade, for small temperature changes.

Backlash: Less than one-half division, corresponding to 0.01% of full scale value. If the desired setting is always approached in the direction of increasing scale reading, no error from this cause will result.

Terminals: Jack-top binding posts are provided. Standard $\frac{3}{4}$ -inch spacing is used. The rotor terminal is connected to the panel and shield.

Mounting: The capacitor is mounted on an aluminum panel finished in black crackle lacquer and enclosed in a shielded walnut cabinet. A wooden storage case with carrying handle is supplied.

Dimensions: Panel, $8 \times 9\frac{1}{8}$ inches; depth, $8\frac{1}{8}$ inches.

Weight: $10\frac{1}{2}$ pounds; $19\frac{3}{4}$ pounds with carrying case.

Type		Code Word	Price
722-D	Precision Capacitor.....	CRUEL	\$225.00
722-MD	Precision Capacitor.....	CYNIC	205.00
722-ME	Precision Capacitor.....	COUPE	210.00
Worm-Correction Calibration for any model*		WORMY	75.00

* When ordering, use compound code word, CRUELWORMY, etc.

QUARTZ INSULATION

Any TYPE 722 Precision Capacitor can be obtained with quartz insulation.

Type		Code Word	Price
722-DQ	Type 722-D with Quartz Insulators.....	CRUELQUATZ	\$320.00
722-MDQ	Type 722-MD with Quartz Insulators.....	CYNICQUATZ	300.00
722-MEQ	Type 722-ME with Quartz Insulators.....	COUPEQUATZ	305.00



TYPE 722-N

PRECISION CAPACITOR

(FOR USE AT
RADIO FREQUENCIES)



USES: This capacitor has been designed particularly for use as a standard at radio frequencies in series- or parallel-resonance methods of impedance measurement. It is also useful as a variable capacitor in radio-frequency bridges.

DESCRIPTION: The frame, bearing, and drive mechanism of this capacitor are identical with those used on the other TYPE 722 Precision Capacitors. The rotor and stator leads, however, are not brought out in the conventional manner. Connection is made at the center of both plate stacks to minimize residual inductance and resistance.

The rotor connection is made by spring-temper, silver-alloy brushes bearing on a silver-overlay disc.

FEATURES: The important features of this capacitor are its low metallic resistance and low inductance. Both of these quantities are about one-third the magnitude of those in the TYPE 722-D. The accuracy of calibration is as good and the dielectric losses nearly as low as in the other TYPE 722 Capacitors.

SPECIFICATIONS

Capacitance Range: 100 to 1150 $\mu\mu\text{f}$, direct reading.
Standard Calibration Accuracy: The capacitance, measured at 1 kc, is indicated directly in micromicrofarads by the dial and drum readings to $\pm 1 \mu\mu\text{f}$ or $\pm 0.1\%$.

A correction chart is supplied giving corrections to 0.1 $\mu\mu\text{f}$ at multiples of 100 $\mu\mu\text{f}$. By using these data the direct-reading accuracy is $\pm 0.1\%$ or $\pm 0.1 \mu\mu\text{f}$, whichever is the greater, and the accuracy for capacitance differences is $\pm 0.1\%$ or $\pm 0.8 \mu\mu\text{f}$, whichever is the greater.

Worm Correction Calibration: A worm correction can be supplied on special order. (See price list.) A mounted chart is supplied giving the corrections to at least one more figure than the guaranteed accuracy stated below.

When the worm correction is used, the capacitance can be determined within $\pm 0.1\%$ or $\pm 0.1 \mu\mu\text{f}$, whichever is the greater, and capacitance differences can be measured to an accuracy of $\pm 0.1\%$ or $\pm 0.2 \mu\mu\text{f}$, whichever is the greater.

Dielectric Supports: Two bars of steatite support the stator assembly, and a third bar insulates the high term-

inal from the panel. Quartz insulation can be supplied on a special order. See price list below.

Dielectric Losses: The figure of merit, $D_s C_p$ (dissipation factor times capacitance), when measured at 1 kc, is approximately 0.04×10^{-12} for steatite insulation.

Other Residual Parameters: The series metallic resistance is about 0.008 ohm at 1 megacycle and increases directly as the square root of the frequency. The dielectric and metallic losses are approximately equal at a setting of 1000 $\mu\mu\text{f}$ and a frequency of 1 Mc.

The series inductance is approximately 0.021 μh . The increase in capacitance caused by this inductance reaches 10% at a setting of 1000 $\mu\mu\text{f}$ and a frequency of 10 Mc.

At smaller capacitance settings the effects of residual parameters are less. The equal division of losses occurs at 20 Mc for a setting of 100 $\mu\mu\text{f}$ and the 10% capacitance rise occurs at 30 Mc for the same setting.

Frequency Characteristic: See Figure 2, page 149, for plot of variation of capacitance with frequency.

Dimensions: Panel, 8 x 9 $\frac{1}{8}$ inches; depth, 8 $\frac{1}{8}$ inches.

Net Weight: 11 $\frac{1}{4}$ pounds; 20 $\frac{1}{2}$ pounds with carrying case.

Other specifications are identical with those of TYPE 722-D, page 152.

Type	
722-N	100 to 1150 $\mu\mu\text{f}$, direct reading
722-NQ	Type 722-N with Quartz Insulation.....
Worm-Correction Calibration.....	

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