TEST ENG. FILE

1425-A

# Calibration Certificate
## and
## OPERATING INSTRUCTIONS

**STANDARD CAPACITOR**

| Type 1425-A | Serial No. |
|---|---|
| 100 μF, in 10-μF steps | ±0.25% at 1 kHz |
| NOMINAL CAPACITANCE | ADJUSTMENT ACCURACY |

**FREQUENCY:** 1 kHz **TEMPERATURE:** ±1°C

| Nominal Capacitance (μF) | Measured Capacitance (μF) | Typical Values | |
|---|---|---|---|
| | | Resonant Frequency $f_r$ (kHz) | Series L (μH) |
| 10 | | 154 | 0.107 |
| 20 | | 119 | 0.089 |
| 30 | | 104 | 0.079 |
| 40 | | 95 | 0.071 |
| 50 | | 89 | 0.064 |
| 60 | | 86 | 0.057 |
| 70 | | 82 | 0.054 |
| 80 | | 78 | 0.052 |
| 90 | | 74 | 0.051 |
| 100 | | 70 | 0.052 |
| 0 | 0.00012 μF | | |

Terminal capacitance is approximately 38 pF to 165 pF from H to G and 350 pF to 225 pF from L to G, depending upon capacitance setting used.

**MEASURED CAPACITANCE:** The measured values given above were obtained by comparison, at a frequency of 1 kHz, with working standards whose absolute values are known to an accuracy of ±0.05%. Each comparison was made to a precision better than ±0.01%. The values of the working standards are determined and maintained in terms of reference standards periodically calibrated by the National Bureau of Standards.

These are two-terminal capacitances measured at the terminals of the capacitor, with the low terminal connected to the case and enough 10-μF decade sections plugged in, starting at the lower end of the instrument, to yield the nominal capacitance for each measurement.

**DATE** **BY**

**STANDARDIZING LABORATORY**

**GENERAL RADIO COMPANY** WEST CONCORD, MASSACHUSETTS

# Type 1425-A DECADE CAPACITOR

## SPECIFICATIONS

**Total Capacitance:** 100 μF.
**Capacitance per Step:** 10 μF.
**Dielectric:** Polystyrene.
**Adjustment Accuracy at 1 kHz:** ±0.25%.
**Stability:** ±0.05%/year.
**Dissipation Factor at 1 kHz:** <0.0004.
**Insulation Resistance:** $>10^6$ ΩF.
**Voltage Recovery*:** <0.1%.
**Temperature Coefficient of Capacitance (typical) ppm/°C:** −140.
**Max Operating Temperature °C:** 65.
**Max Safe Voltage:** 25 V, peak, below 10 kHz.
**Dimensions:** Width 9 3/8, height 19 1/8, depth 8 1/8 inches (240 by 195 by 205 mm), over-all.
**Net Weight:** 46 1/2 lb (21.5 kg).
**Shipping Weight:** 67 lb (31 kg).

*Dielectric absorption

*General Radio Experimenter* Reference:
Vol. 39, No. 7, July 1965

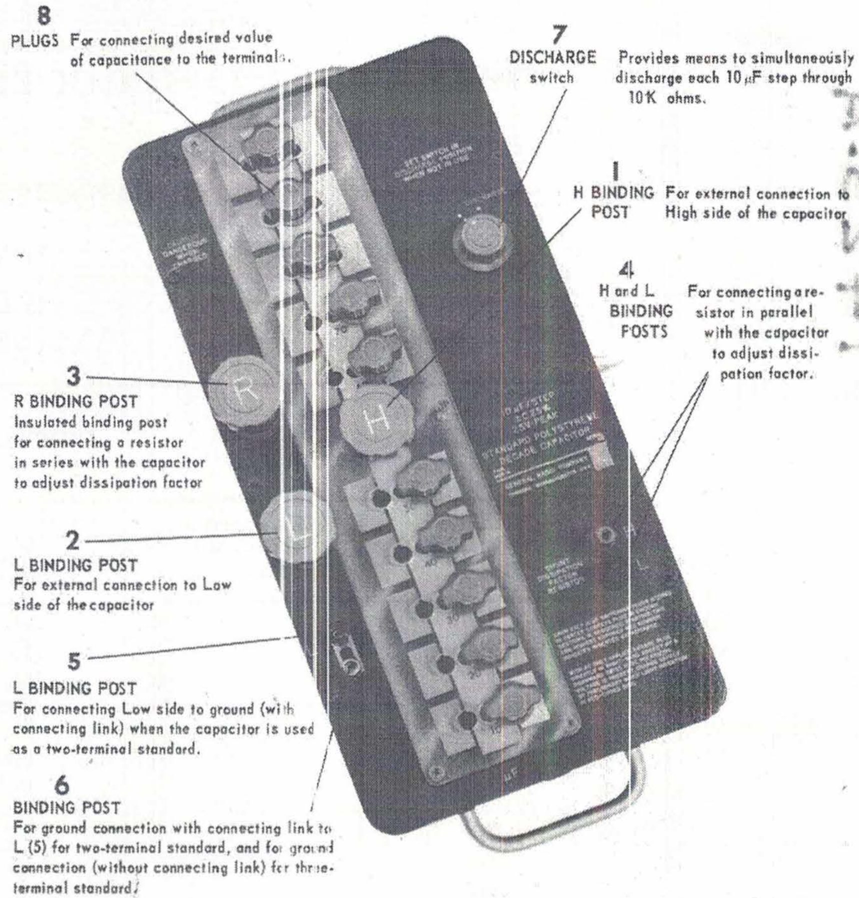


**Figure 1-1. Location and function of controls and connectors on the Type 1425-A Decade Capacitor.**

## 1 INTRODUCTION

### 1.1 PURPOSE.

The Type 1425 Decade Capacitor is a precision reference standard of high capacitance for bridge calibration, and for experimental applications in the laboratory. It may also be used with suitable resistors as a dissipation-factor standard.

### 1.2 DESCRIPTION.

This capacitor has a range of 100 μF, in ten 10-μF steps. Binding posts are available on the panel for connection of the unit as either a two- or three-terminal standard. Other binding posts are available for the adjustment of dissipation factor by connection of appropriate resistors in series, or in parallel, with the unit. Tapered plug connectors, rather than rotary switches, minimize switching resistance. A convenient switch is furnished for discharging the capacitor.

## 2 OPERATING PROCEDURE

### 2.1 CONNECTIONS.

See Figures 1-1 and 3-1 for identification of controls and connectors referred to in the following paragraphs.

Before connecting the capacitor to an external circuit, turn the discharge knob (7) to DISCHARGE, and insert all capacitance-connecting plugs (8) in their respective center-bar (middle) positions.

**CAUTION**

Excessive charge or discharge current may damage the capacitor. When operating on dc, always connect or disconnect the unit with the connecting plugs (8) in the zero (center bar) position, or when the circuit voltage is zero.

Connect the H binding post (1) and the L binding post (2) to corresponding high and low terminals on the bridge, or other external circuit used.

NOTE

Do not introduce unnecessary errors: connecting leads should be short, of low resistance, and arranged as close together as possible. For example, two 0.75 x 0.16-inch copper strips, approximately 7 inches long, will have an inductance of about 0.15 μH and a resistance of 0.001 Ω when connected between the capacitor and 3/4-inch spaced binding posts on a bridge. At a frequency of 1000 Hz, and with the capacitor set at 100 μF, an error of +0.06% in capacitance and +0.0006 added to the dissipation factor will result.

When using the capacitor as a two-terminal device, connect the L binding post (5) to the grounded binding post (6), using the connecting link supplied.

If a three-terminal connection is desired, disconnect the connecting link and connect binding post (6) to the external guard circuit.

## 2.2 OPERATION.

The capacitance markings are hidden from view when the capacitance-connecting plugs are inserted in the center-bar. When the plugs are in either the right-hand or the left-hand (red block) positions, the markings are exposed, thus indicating the effective value of capacitance.

Before setting the desired capacitance, turn the discharge knob (7) to the left-hand (charge) position. Always plug in the decade steps sequentially, starting with the 10-μF step at the bottom and proceeding upward until the correct value of capacitance is indicated. For example, the capacitor shown in Figure 1-1 is set at 70 μF.

To set the capacitor, with ac applied, remove the plug from the center-bar socket (A) and insert it directly into the adjoining right-hand socket (C). When inserting the tapered plug, turn the plug knob slightly to wring the plug into its mating socket — a firm fit will ensure low connection resistance. If a d-c voltage is present, insert the plug into the adjoining left-hand socket (B) for a fraction of a second, and then plug it into the right-hand socket (C). This intermediate step limits the charging current to a safe value when dc is used (refer to paragraph 3.2).

The capacitor may be safely discharged after it is disconnected from the external circuit, or after the applied voltage is removed. Turn the discharge switch (7) to DISCHARGE. Keep the switch in this position when the capacitor is not in use.

## 2.3 DISSIPATION FACTOR.

To use the Type 1425 Capacitor as a dissipation-factor standard, connect the required value of series resistance between the large H and R binding posts (1 and 3), and then connect the High lead from the bridge or other device to the R binding post. The R binding post is completely insulated from other parts of the instrument. A pair of conventional binding posts (GR Type 938) H and L (4) is used to connect a resistor in parallel with the capacitor.

Electrolytic capacitors are usually specified in terms of their series components; therefore, if the bridge used to measure them is calibrated in series terms, it is desirable to check the bridge in the same terms. Ordinarily, the dissipation factor, or equivalent series resistance, is sufficiently high and little difficulty is encountered in selecting a convenient value of series resistance. However, when low values of dissipation factor are needed, a parallel resistor is more convenient to use.

The following relations are useful in determining the values to use:

$$R_s = \frac{D}{\omega C_s} \qquad R_p = \frac{1}{D\omega C_p} \qquad C_s = C_p\,(1 + D^2)$$

where:

- $D$ = dissipation factor
- $R_s$ = equivalent ac series resistance
- $R_p$ = equivalent ac parallel resistance
- $C_s$ = series capacitance
- $C_p$ = parallel capacitance
- $\omega$ = $2\pi f$

Example:

the series resistance required to produce a D of 0.5, at a frequency of 120 Hz, with a 50-μF capacitor is:

$$R_s = \frac{0.5}{6.28 \times 120 \times 50 \times 10^{-6}} = 13.2\,\Omega$$

Or for a D of 0.01, at 60 Hz, with 30-μF capacitor:

$$R_s = \frac{0.01}{6.28 \times 60 \times 30 \times 10^{-6}} = 0.88\,\Omega$$

If this value of resistance is not available with the desired accuracy, a parallel resistor may be used:

$$R_p = \frac{1}{0.01 \times 6.28 \times 60 \times 30 \times 10^{-6}} = 8800\,\Omega$$

And if the bridge reads series capacitance, a correction may be required when the parallel resistor is used:

$$C_s = 30\,(1 + 0.0001) = 30.003\,\mu F$$

This small difference of 0.0030 μF, or 0.01%, is negligible for most bridges.

# 3 PRINCIPLES OF OPERATION

## 3.1 GENERAL.

The following paragraphs briefly describe some of the principles of operation applicable to the Type 1425 Decade Capacitor. For a detailed discussion of the characteristics of standard capacitors, refer to the General Radio Catalog.

## 3.2 CIRCUIT DESCRIPTION.

An elementary schematic diagram of a single decade step is shown in Figure 3-1.

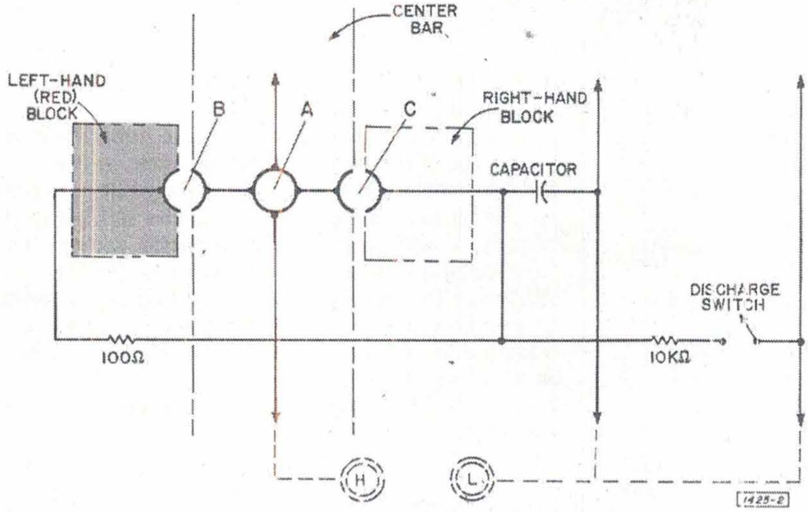


**Figure 3-1. Elementary diagram of a decade step in the Type 1425-A Decade Capacitor.**

With the connecting plug inserted in socket (A), an open circuit exists between terminals H and L. When inserted in socket (B), the 100-Ω resistor limits the charging current to a safe value. With the plug inserted in socket (C), the capacitor is charged with no current-limiting resistor in the circuit. When the discharge switch is closed, the capacitor will discharge through the 10-kΩ resistor Individual 100-Ω and 10-kΩ resistors are provided with each decade step.

The Type 1425 Decade Capacitor contains four large capacitance cans which are tapped for the various capacitance values needed for the ten decade steps. The decade steps add sequentially, starting with the 10-μF step at the bottom, to a total of 100 μF.

### 3.3 FREQUENCY CHARACTERISTICS.

Interfacial polarization increases the capacitance at low frequencies and series inductance increases the effective terminal capacitance at high frequencies. The combined effect is shown in Figure 3-2.

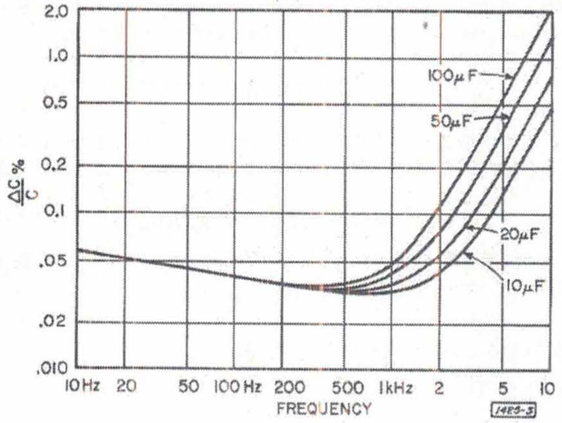


**Figure 3-2. Typical curves for change in capacitance with frequency for the Type 1425-A Decade Capacitor. These changes are referred to the values which the capacitor would have if there were neither interfacial polarization nor series inductance. The 1-kHz value on the plot should be used as a basis of reference in estimating frequency errors.**

The approximate effect of inductance alone, at frequencies well below the resonant frequency ($f_r$), is given by:

$$\frac{\Delta C}{C_o} \approx \omega^2 L C_o = \left(\frac{f}{f_r}\right)^2$$

where $\Delta C$ is the increase in effective capacitance, $C_o$ is the zero-frequency capacitance, and f is the operating frequency. Typical values of resonant frequency and series inductance are given on the Calibration Certificate.

## 4 SERVICE AND MAINTENANCE

### 4.1 WARRANTY.

We warrant that each new instrument manufactured and sold by us is free from defects in material and workmanship, and that properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, Sales Engineering Office, or authorized repair agency personnel will be repaired, or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

### 4.2 SERVICE.

The two-year warranty stated above attests the quality of materials and workmanship in our products. It is recommended that the instrument be returned to General Radio for service that requires replacement of major components or removal of the front panel. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated, please write or phone our Service Department giving full information of the trouble and steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument. Ask for a Returned Material Tag if the instrument must be returned for service. Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

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