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APPARATUS FOR THE HIGH TEMPERATURE TESTING OF DIELECTRIC MATERIALS

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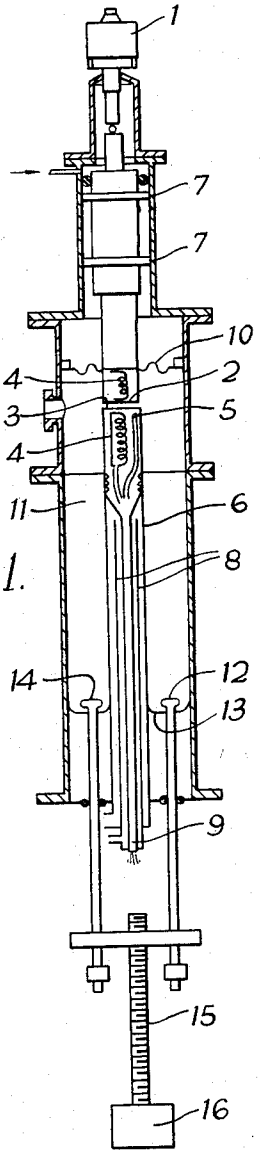


Fig. 1.

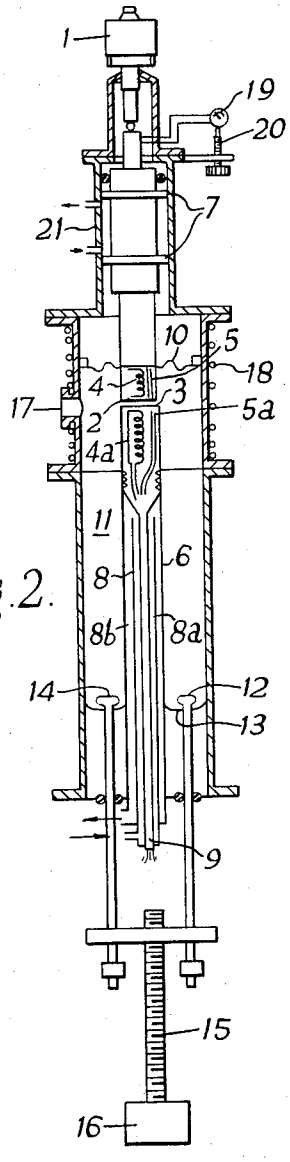


Fig. 2.

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APPARATUS FOR THE HIGH TEMPERATURE TESTING OF DIELECTRIC MATERIALS

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In my co-pending patent application Serial No. 855,239 (Patent No. 3,046,478) I have described apparatus for the testing of dielectric materials at ultra-high frequencies in which a disc-shaped specimen of the material to be examined is used as the dielectric of a capacitor formed between a fixed electrode face constituted by the end surface of the inner conductor of a coaxial-line element of adjustable effective length and a second electrode face, parallel to this end surface, which is provided on an electrode movable in the axial direction of the line element by an axial micrometer or equivalent device, the movable electrode being electrically connected to the outer conductor of the coaxial line element by a flexible metal diaphragm, thereby avoiding the need for the provision of any sliding contacts, the apparatus being further equipped with suitable U.H.F. input and output coupling elements. Testing apparatus incorporating these features will hereinafter be referred-to as of the kind specified.

The input and output coupling means described in the said Patent No. 3,046,478 comprise a capacity-probe input near the sample and an output loop extending into the air line near its short-circuited end. In order to permit the measurement of dielectric qualities at controlled temperatures the apparatus described in the said co-pending application has an air inlet through which hot or cold air may be blown into the space between the inner and outer conductors of the coaxial line in the vicinity of the electrode-forming surfaces, the diaphragm being imperforate or near-imperforate so that access of hot air to the sensitive micrometer portion is substantially avoided, although radial slots may be provided in the diaphragm to reduce inductance, and an exhaust slot being provided which preferably is so arranged as to serve also as opening for the insertion or removal of the discs of dielectric material to be tested.

The present invention has for an object to provide improved testing apparatus of the kind specified which can be used at substantially higher temperatures than the apparatus described in the said Patent No. 3,046,478, for example at temperatures of incandescence.

According to the present invention each electrode is equipped with internal heating means, preferably with an electric heating element, thus rendering the heating of the probe independent of the presence of air temperature-sensing means being also provided permitting the electrode temperature to be ascertained, and means are provided for cooling the stem of each electrode and for limiting the transfer of heat from the heated electrode portions to the electrode-supporting means.

The stem of the fixed electrode is preferably equipped with internal cooling passages through which liquid cooling medium is conducted, and the part of the outer conductor containing the heated electrode portions and the specimen is evacuated, being sealed by a vacuum-tight diaphragm isolating it from the part of the conductor cavity containing the bearing means for the movable electrode. These bearing means may comprise two axially spaced annular bearing portions confining between them an annular chamber through which cooling medium is arranged to be conducted.

It is advisable to equip each electrode with a separate temperature-sensing element and individual heating control means, thus permitting both electrodes to be maintained at the same temperature irrespective of difference in the heat losses, and the micrometer device may be supplemented by a dial gauge permitting even more accurate reading of small electrode displacements.

FIGURE 1 of the accompanying drawing is an elevation in axial section, of one embodiment which has been designed to measure permittivity and power factor of solid insulating materials at frequencies in the range of 100 to 1,000 mcs. and temperature up to 1,000° C.

FIGURE 2 is an alternate embodiment of the present invention having cooling means and gauge means.

Referring now to the drawing, the apparatus is basically a capacitatively loaded coaxial cavity of a characteristic impedance to give maximum Q-factor. The cavity-loading capacitor is variable by means of a micrometer device **1**, which, for even greater accuracy, is supplemented by a dial gauge **19** movable with the movable electrode **2** and co-operating with a stop constituted by a set screw **20** adjustable in the fixed part of the apparatus and in order to test a specimen, the same is inserted between the capacitor electrodes **2** and **3**, which are moved to contact both surfaces of the sample, which thus forms the capacitor dielectric.

For tests at increased temperature the electrodes can be heated by heater elements **4**, **4***a* which are provided inside each electrode, and in order to permit the temperature to be recorded, and to be made equal in the two electrodes, a thermocouple or other heat-sensing element **5**, **5***a* is inserted in each of the electrodes **2** and **3**. To reduce heat loss and protect the outer structure from excessive heat, the cavity **11** in which the electrodes are arranged, is evacuated, an air lock **17** being provided to permit insertion and removal of specimens. In addition a cooling coil **18** through which water or other cooling medium is passed, is provided to cool the outer cavity wall near the heated part of the electrodes **2** and **3**.

The fixed centre conductor or stem **6** in the cavity **11** and the bearings **7** of the movable capacitor electrode **2** are cooled by a flow of a cooling medium, for example, or an air-and-water aerosol. To cool the bearing, cooling medium is conducted through the annular chamber **21** between the bearings **7**, and to cool the stem, a tube **8** forming two coaxial passages **8***a* and **8***b* for the conduction of the cooling medium in a U-type flow surrounds the wires **9** leading the heating current to elements **4** in the hollow centre conductor **6**. The movable capacitor electrode **2** is shorted to the outer conductor **18** of the cavity **11** by a flexible diaphragm **10** made of metal of approximately .003" thickness.

R.F. power is fed to the cavity via an input loop **12** connected to a movable short circuit **13**, and the output is obtained by a similar loop **14** diametrically opposite to the input loop **12**. The loops **12** and **14** are adjustable from outside the cavity **11**, thus permitting the coupling to be varied.

The movable short circuit **13** is moved along the cavity **11** by a screw thread **15** which is motorised as indicated at **16**, and the position of the short circuit **13** inside the cavity **11** may be indicated on a scale (not shown).

In order to test a sample disc, resonance is first established at a given frequency by moving the diaphragm **13** to vary the effective length of the air line, and the output level is read from the output loop. The sample is then removed and resonance restored by adjusting the micrometer, and the Q factor of the cavity is determined in the absence of the sample, whereupon the power factor and the dielectric constant of the sample can be determined from the output level reading, the Q factor, and the micrometer readings.

I claim:

1. In an apparatus for the high-frequency dielectric testing of specimen discs, the combination comprising an electrically conductive cylindrical casing, a fixed stem electrode coaxial with the casing having a plane end face, extending into the casing from one end thereof to form therewith a constant-impedance coaxial-line portion, a second stem electrode also coaxial with the casing and also having a plane end face, extending into the casing from the other end thereof to form therewith a further coaxial-line portion, means for so supporting the second electrode as to permit axial movement thereof towards and away from the fixed stem electrode, means for accurately setting and measuring the position of the second electrode relative to the fixed stem electrode, an electrically conductive diaphragm interconnecting the second electrode and casing in an airtight manner, said diaphragm constituting a short-circuit element determining the effective end of the further coaxial-line portion and forming with the casing a substantially airtight chamber enclosing the mutually opposed plane end faces of the two electrodes, said chamber having a sealable access opening adjacent to the said end faces for the insertion and removal of specimen discs, means for evacuating said airtight chamber, and electrical means for heating at least one of said stem electrodes closely adjacent to such end face thereof, a further short-circuit element electrically interconnecting the casing and fixed stem electrode and movable axially of the latter to vary the compound effective length of the coaxial-line portions, an input element and an output element for electrical oscillations, each extending into the airtight chamber, means for conducting cooling fluid through the interior of the fixed stem electrode to a point a predetermined distance from the plane end thereof, cooling means for cooling the wall of the casing, at least in the vicinity of the plane ends of the electrodes, cooling means for the stem of the movable electrode, means for ascertaining the temperature at a point near the end face of at least one of the stem electrodes, and means operable from outside the airtight chamber to adjust the position of the movable short-circuit member.

2. Apparatus as claimed in claim 1, wherein the casing includes a cylindrical guide sleeve and the second electrode has a pair of axially spaced flanges sealingly slidable in the guide sleeve, the guide sleeve being provided with a liquid-inlet aperture and a liquid outlet aperture, said apertures being axially spaced from each other and being both so arranged as to be located between the two guide flanges throughout a predetermined length of movement of the second electrode from the position in which its end face is in contact with that of the fixed stem electrode.

3. Apparatus as claimed in claim 2, wherein a dial guage is interposed between a point of the casing of the apparatus and a portion secured to the movable electrode separated by the guide flanges from the plane end of the second electrode.

4. In apparatus for the high-frequency dielectric testing of specimen discs, the combination comprising an electrically conductive cylindrical casing, a fixed stem electrode coaxial with the casing, having a plane end face, extending into the casing from one end thereof to form therewith a constant-impedance coaxial-line portion, a second stem electrode also coaxial with the casing and also having a plane end face, extending into the casing from the other end thereof to form therewith a further coaxial-line portion, means for so supporting the second electrode as to permit axial movement thereof towards and away from the fixed stem electrode, means for accurately setting and measuring the position of the second electrode relative to the fixed stem electrode, an electrically conductive diaphragm interconnecting the second electrode and casing in an airtight manner, said diaphragm constituting a short-circuit element determining the effective end of the further coaxial-line portion, and forming with the casing a substantially airtight chamber enclosing the mutually opposed plane end faces of the two electrodes, said chamber having a sealable access opening adjacent to the said end faces for the insertion and removal of specimen discs, means for evacuating said airtight chamber, electrical heating means in at least one of said stem electrodes closely adjacent to such end face thereof, and electrical conductor means accommodated in such stem and electrically insulated therefrom, said conductor means extending to said heating means from a point outside the said coaxial-line portions, a further short-circuit element electrically interconnecting the casing and fixed stem electrode and movable axially of the latter to vary the compound effective length of the coaxial-line portions, an input-loop element and an output-loop element, each extending into the airtight chamber, means for conducting cooling fluid through the interior of the fixed stem electrode to a point a predetermined distance from the plate end of said electrode, cooling means for cooling the wall of the casing, at least in the vicinity of the plane ends of the electrodes, cooling means for the stem of the movable electrode, means for ascertaining the temperature at a point near the end face of at least one of the stem electrodes, and means operable from outside the airtight chamber to adjust the position of the movable short-circuit member.

5. Apparatus as claimed in claim 4, wherein each stem electrode is equipped with separate temperature-sensing means and with separate heater-control means.

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