

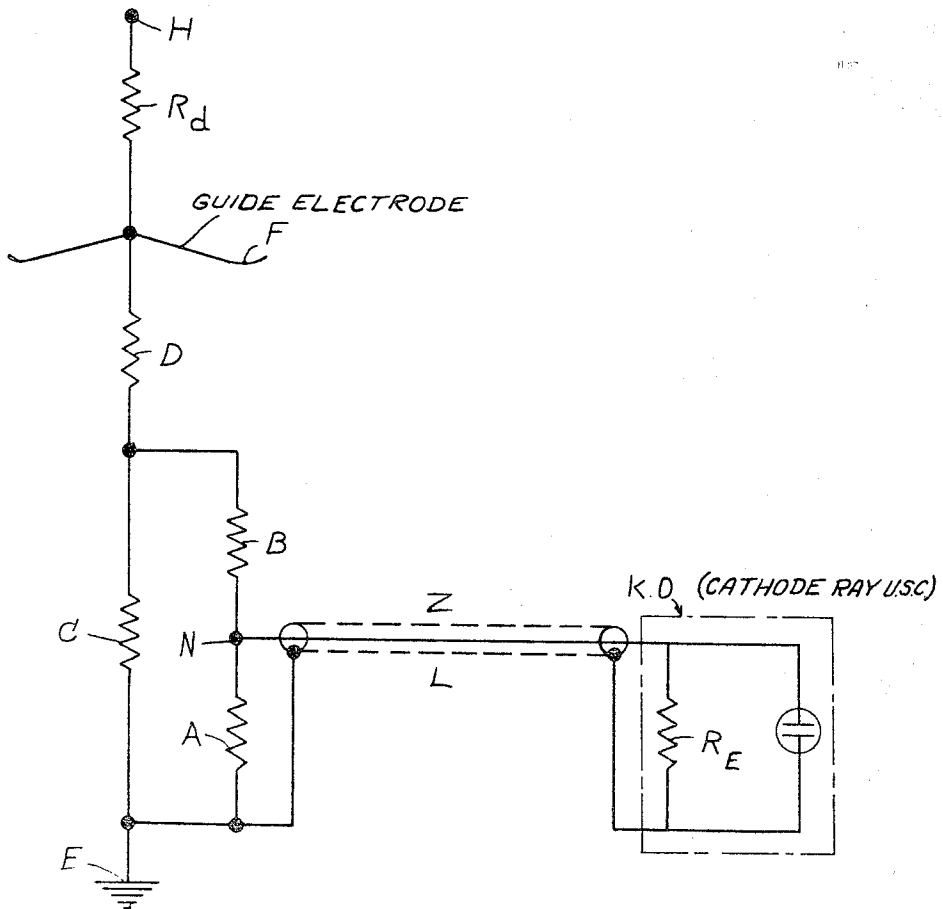
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W. KNOTH ET AL

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REFLECTION-FREE VOLTAGE DIVIDER FOR HIGH SURGE VOLTAGES

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INVENTORS
Walter Knoth
Werner Lüscher
BY
Pierre, Schiffler & Parker
Attorneys

1

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REFLECTION-FREE VOLTAGE DIVIDER FOR HIGH SURGE VOLTAGES

Walter Knoth, Oberengstringen, and Werner Lüscher, Zurich, Switzerland, assignors to Micafil A.G., Zurich, Switzerland, a joint-stock company

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1 Claim

ABSTRACT OF THE DISCLOSURE

A two-stage reflection-free voltage divider of the ohmic type is provided for use in the measurement of high impulse voltage by means of a cathode ray oscillograph. The voltage divider includes a first string of resistances arranged in series and connected between the high voltage source and ground, a guide electrode on this resistance string, and a second string of resistances likewise arranged in series and connected between a medium voltage point on the first string of resistances and ground. A co-axial line leads to the oscillograph from the voltage divider, the inner conductor of the line being connected to a tap between resistances in the second resistance group and the outer conductor of the line being grounded.

This invention relates to an improvement in the construction of voltage dividers, and has for its purpose the attainment of a two step voltage divider which is practically reflection-free, for use in the measurement of high surge voltages.

For oscillographic registration of fast varying, i.e., surge voltages with peak values from about one thousand volts up to maximum voltages of several million volts, one can advantageously utilize a voltage divider which is constituted entirely by a string of series connected resistances, or by a string of resistances in combination with condensers. The first type of divider is thus essentially ohmic while the second type is ohmic-capacitive in character. The voltage divider is connected to a surge registering oscillograph by way of a coaxial cable. As a rule, the input impedance to the surge oscillograph amounts to less than 100Ω. Consequently, one must take into consideration the whole circuit combination of the actual voltage divider, coaxial cable and input impedance of the oscillograph for the voltage division. The following concerns an ohmic type of voltage divider, the outer potential field of which is incapacitively controlled by a guide electrode.

As is known, an ohmic voltage divider generally consists of a high-tension proof resistance of some kΩ on the earth-sided end of which a fractional part of the total voltage across the divider is tapped and conveyed to the surge oscillograph by means of a coaxial cable which may be assumed to have a characteristic impedance amounting to Z.

It is also known that the frequency response of an ohmic type voltage divider is improved by use of capacitive control, in which case the partition of the entire resistance over the length of the voltage divider is made proportional to the static voltage distribution over that length. The static voltage distribution can be influenced and stabilized against stray external fields by using, for example, additional condensers arranged parallel to the

2

resistances, or by use of a head electrode with an enlarged girth. By this partition of resistance, the time constant of longitudinal resistance and stray capacity becomes independent as to height, i.e.

$$d\tau/dh=0,$$

wherein:

$$\tau=dr \cdot dC_s$$

h=height above ground, i.e., earth,

dC_s=differential of stray capacity against ground at the height h,

dr=differential of resistance at the height h.

Such a partition of the resistance can be approximately realized by dividing the overall height of the divider resistance into a string of from six to twelve resistance sections. To each section is allocated a resistance value which is proportional to the static voltage difference between the ends of the section.

Further it is known that with respect to a lead established at points at which the characteristic impedance changes by leaps, reflections of voltage waves appear. The magnitude of the reflections increases with the relative change of the characteristic impedance at the leap spot. If, however, the lead is concluded with an ohmic resistance equal to the characteristic impedance, no reflection can arise. Hence it results for the surge transmission coaxial cable that when it is concluded on both ends with its characteristic impedance, the cable transmits the voltage in a reflection-free manner.

On the side of the surge oscillograph, it is a relatively simple matter to fulfill the equation $Z=R_B$.

On the side of the voltage divider, the relationship $R_{T1}=Z$ (with R_{T1} =internal resistance of the divider at the tap, high tension electrode grounded) is attained for example in the following manner. One utilizes, as is known, the divider-total resistance resulting from the product of (1+the transformation ratio)·Z.

However, with transformation ratios beyond about 500, this possibility meets with difficulties as regards the technique of fabricating the resistances, and also brings about disadvantages as to measuring techniques because the behavior of the transmission of the divider reacts even more so to stray capacitances, and on changes of which due to the experimental structure, the higher the resistance of the divider. Consequently, it is not possible to attain a satisfactorily undistorted image of the course of the high voltage surge on the oscillograph instrument.

The disadvantages of the prior constructions for voltage dividers for measuring surge voltages are avoided in accordance with the present invention by use of a two-step divider which permits of a free choice of the total voltage divider resistance and also a free choice of the tap-sided internal resistance R_{t1} . For this purpose, a second string of resistances is connected between ground and a medium voltage tap point on the first string of series connected divider resistances connected between the high voltage source and ground, and the inner conductor of a coaxial cable leading from the voltage divider to a cathode ray oscillograph is connected to a tap on the second resistance string, the outer conductor of the coaxial cable being grounded.

In order to improve the frequency response of the voltage divider structure of the invention, the resulting resistance of the network below the medium voltage tap on the high voltage divider resistance obtains a value proportional to the field strength in the same manner as all sec-

tions of the high voltage divider resistance lying above the tap. With this the network also includes the connected to input resistance of the surge reading oscillograph.

One suitable embodiment of the invention is illustrated in the accompanying drawing in electrical schematic form.

With reference now to the network shown in the drawing, the high voltage divider resistance is seen to include the string of resistance sections C and D connected in series between the high voltage line H and ground E. Also included in this resistance string is a damping resistance R_d connected between the line H and the first resistance section D of the divider. A guide electrode in the form of a ring F is located on the resistance string between divider resistance section D and the damping resistance R_d . A second string of two series connected resistance units A and B is connected across the lowermost resistance section C of the high voltage divider resistance, i.e. between the ground and a medium voltage tap at the upper side of resistance section C. The coaxial line L extending between the oscillograph K.O. and the voltage divider has its inner conductor connected at a tap N between the two resistance sections A and B, and its outer, sheath conductor connected to ground E. The characteristic impedance of the coaxial transmission line L is assumed to have a value of Z and the input resistance of the oscillograph is assumed to have a value of R_E .

In order that the surge voltage appearing at the input to the coaxial line L, i.e., across points N and E be reflection-free, the following equation must be satisfied.

$$\frac{(M+B) \cdot A}{M+B+A} = Z \text{ (H-E short-circuited)}$$

In the above equation:

$$M = \frac{(R_d + D) \cdot C}{R_d + D + C}$$

For this purpose, for similar reasons $R_E = Z$.

Then the transformation ratio S of the second step is attained with:

$$P = \frac{Z \cdot A}{Z + A}; S = \left(\frac{B}{P} + 1 \right)$$

The transformation ratio W of the first step is attained with:

$$T = \frac{B + P \cdot C}{B + P + C}; W = \frac{R_d + D}{T} + 1$$

We claim:

1. A reflection-free two-stage voltage divider of the ohmic type for use in the measurement of high impulse voltages by means of a cathode ray oscillograph connected to the divider by a coaxial line comprising a first string of resistance connected in series between a high voltage source and ground, said resistance being distributed according to the electrostatic field between a guide electrode and ground, and a second string of resistances connected between ground and a tap on said first string of resistances having a voltage intermediate that of said high voltage source and ground, the inner and outer conductors of said coaxial line being connected to a tap on said second string of resistance sections and to ground respectively and the output terminal resistance of the divider being adapted to the characteristic impedance of said coaxial line.

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JOHN F. COUCH, *Primary Examiner*.

35 G. GOLDBERG, *Assistant Examiner*.

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40