United States Patent [19]

Snedkerud

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[54] **SIMULATED ANTENNA**

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[30] **Foreign Application Priority Data**

May 28, 1971 Switzerland 7823/71

[52] **U.S. Cl.** .... **333/22 R,** 333/23

[51] **Int. Cl.** **H01p 1/26**

[58] **Field of Search** .... 333/22 R, 22 F, 23

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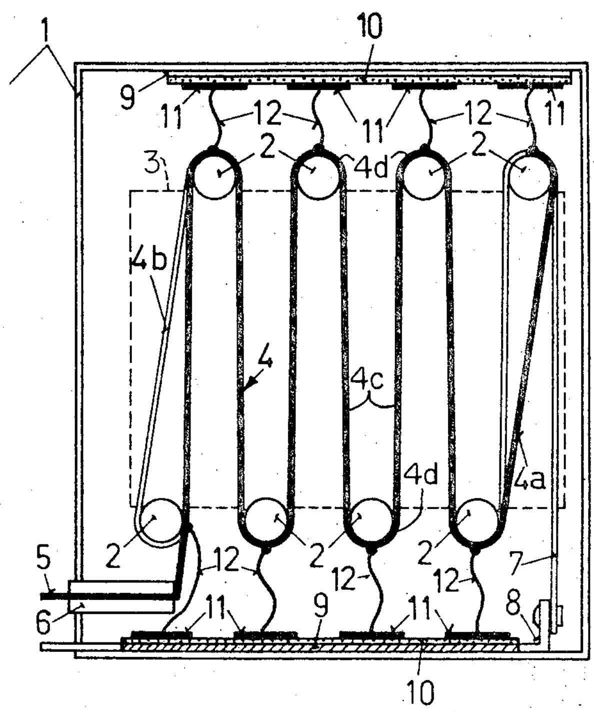
Attorney, Agent, or Firm—Pierce, Scheffler & Parker

[57] **ABSTRACT**

A simulated antenna structure for use in conjunction with trial or experimental operation of a radiant energy transmitter includes a metallic tape extending in a meandering fashion in one or more parallel planes over supporting insulators located within a housing through which a current of cooling air is passed in heat transfer relation with the tape. One end of the tape is connectible to the output terminal of the transmitter and the other end is grounded. Capacities are connected respectively between the grounded end of the tape and substantially equally spaced points along the tape. These capacities can be established by means including metallic linings within the supporting insulators when made in tubular form and also by metallic plates projecting into the spaces formed between adjacent loops of the tape, the metallic linings and metallic plates being electrically connected to the grounded end of the tape.

9 Claims, 5 Drawing Figures



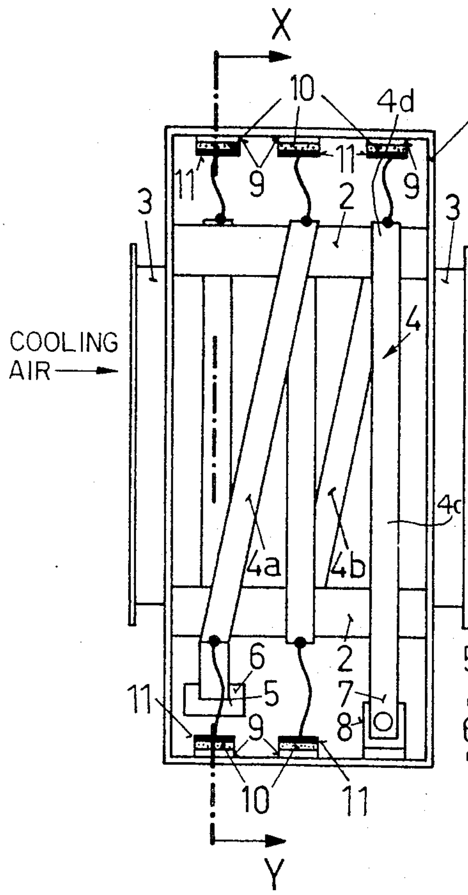

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Fig.1

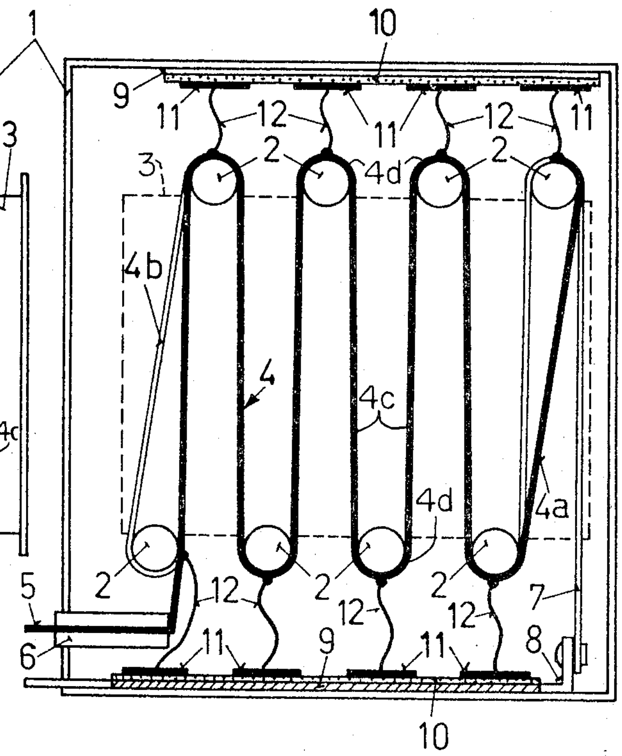
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Fig.2

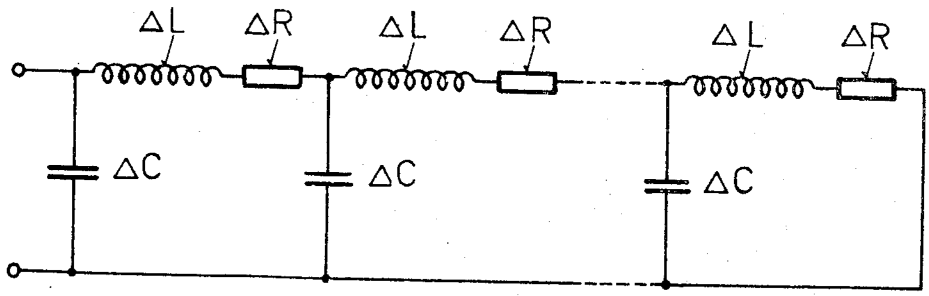

Fig. 3

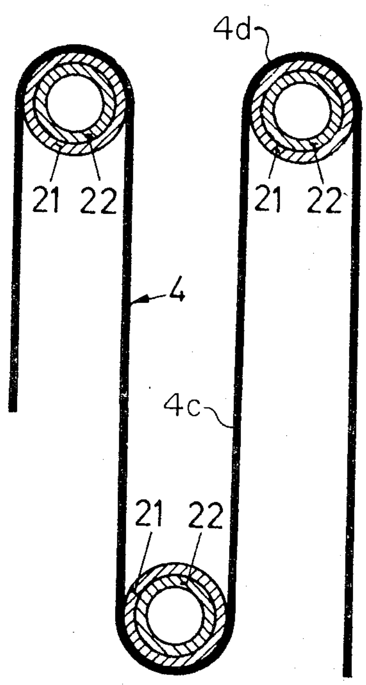

Fig. 4

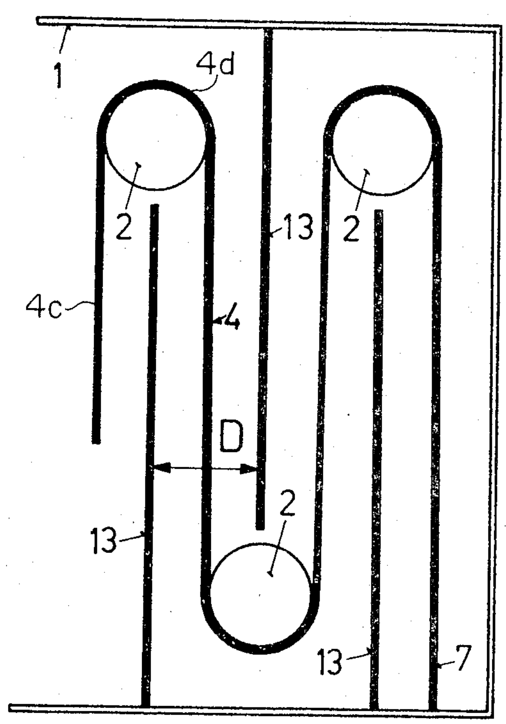

Fig. 5

SIMULATED ANTENNA

This invention relates to an improved construction for a simulated antenna for use in conjunction with trial or experimental operations of radiant energy transmitters.

At the present time, simulated antennas consisting of systems of ohmic resistances are being used for this purpose, these being as radiation-free as possible, and which are usually utilized at the same time to measure calorimetrically the transmitter output being supplied. Most simple in design, and thus relatively inexpensive, are aircooled resistances which are suitable for maximum outputs in the medium and long-wave ranges. Preferably there are being utilized fabrics made from resistance wire (weft) and asbestos cord (warp) which due to their bifilar characteristic are of low inductance similar to cross-wound resistances.

These "mats" have a size of approximately 400 × 600 mm and are arranged in greater numbers, mechanically as well as electrically in parallel, behind a fan. By tapping the centers and by connecting them by way of a condenser to ground, thus obtaining a lowpass-T-filter section, it becomes possible to balance the residual inductance. In this manner it will be feasible to attain within the medium wave range and above up to approximately 5 MHz (at 60 ohm) mismatches below 1.1 Simulated antennas of this type, which represent the present state of art, will permit outputs in the magnitude of 100 kw without any difficulties.

The above described state of art is quoted from the "Taschenbuch der Hochfrequenz-technik," second edition, Meinke/Gundlach, Springer-Verlag 1962 (see page 1538). Reference will be made later on repeatedly to this publication which will be identified below for reasons of simplification by "Lit.A." A substantial disadvantage of the known air-cooled, simulated antennas (mats) is caused by their low stability. The greater the transmitter output, the greater will be the air-cooling required. However, it became impossible to increase the air velocity beyond a certain value because the resistance mats will then vibrate too vigrously within the flow of air. For this reason the asbestos cords, used originally, have been replaced by the thinner, but more firm, glass fibers. In this manner it became possible to reach the 1 megawatt range, but the air velocities, required at such magnitudes, caused breaks within the glass fiber texture, often after only a few hours of operations.

It is the primary objective of the present invention to create a simulated antenna which under air cooling can transform outputs of 1 megawatt and above into heat without suffering any damages. The mismatch should be held below 1.1 for frequencies in the long and medium wave ranges (up to approximately 5 MHz), and the manufacture of such antenna should be possible at low cost.

The invention solves this problem by providing a metal tape which runs in a meandering fashion within at least one plane, its beginning to be connected to a transmitter output and its end to the ground terminal of the transmitter, and by connecting capacities from this end to several points which are distributed along the metal tape at substantially equal distances.

The advantage offered by the invention is due primarily to the simple and sturdy method of construction which results, in comparison with the known simulated

or artificial antennas of the above described type, in a substantially greater durability. In addition thereto, the simulated antenna as proposed by the invention has a substantially greater band width, compared with the present state of art, a fact which will become readily apparent from the description given below.

The invention will now be described in detail and as illustrated in the accompanying drawing wherein:

FIG. 1 is a front elevational view of one embodiment of the improved simulated antenna structure;

FIG. 2 is a sectional view taken along line X–Y in the direction of the arrow;

FIG. 3 shows the equivalent electrical circuit for the anntenna structure illustrated in FIGS. 1 and 2;

FIG. 4 is a view of a modified arrangement for the meandering tape and capacitor components of FIGS. 1 and 2; and

FIG. 5 is a view of another modification for the meandering tape and capacitor components of the antenna.

In all of the various embodiments, identical parts are indicated by the same reference numerals.

With reference now to FIGS. 1 and 2, a housing for the simulated antenna components is indicated at 1. This housing is provided with cylindrical, or tubular insulators 2 installed between its side walls. At both side walls, flanged openings 3 are provided which serve for attachment of a fan and duct assembly, not illustrated, which serves to blow air through the simulated antenna structure in a direction parallel with the opposite faces of the metal tape 4. The extent of the lateral openings through which air is blown by the fan through the housing is indicated in FIG. 2 by an interrupted line 3. For the purpose of illustration, the front wall of housing 1 is to be considered transparent, so that the windings of the metal tape 4 become visible. In the case of this illustration the metal tape 4 runs within three planes. Within each plane the metal tape 4 is conducted with the aid of the insulators 2 in a meandering fashion, a fact which is more clearly shown by FIG. 2. More particularly, within each of the three meander planes, the tape 4 is seen to be constituted by a series of straight sections 4 *c* alternating with curved sections 4*d* such that the straight sections 4*c* of the tape are supported between upper and lower rows of parallel spaced insulators 2 around and in contact with which the curved tape sections 4*d* lie, and the plane of the meandering path is disposed at a right angle to the plane of the straight tape sections. The beginning 5 of the metal tape 4 is lead through the insulating bushing 6 to the outside of housing 1 and can thus be connected to a transmitter output. FIG. 2 shows the tape winding within the first plane, with the beginning 5, by depicting this portion of metal tape 4 in solid black. The metal tape 4 then enters the second plane, located further back, by way of another interconnecting slanting section 4*a*. The transition from the second to the third plane takes place by way of section 4*b* of another interconnecting slanting the metal tape 4. End 7 of the metal tape 4 is fastened to an L-shaped metal bracket 8. One leg of this metal bracket 8 extends to the outside of housing 1 so that end 7 of metal tape 4 can be connected to the ground terminal of a transmitter by way of this metal bracket 8.

In order to compensate for the inductivity of the metal tape 4, capacities are connected from its end to points which are distributed at equal distances along the metal tape **4**. Commerciallly available capacitors can be used for this purpose, or a special design, as shown diagrammatically in FIGS. **1** and **2**, can be employed. Inside the housing **1** there are arranged metal bars **9**. Two such metal bars **9** are required for each plane. They are electrically connected with the end **7** of the metal tape **4** and represent one plane of a condenser. A dielectric medium (for example mica) **10** is applied to each metal bar **9**. The construction of the condensers is completed by metal plates **11** which are connected by way of stranded wires **12** with the proper points of the metal tape **4**. Obviously, the extended leg of the metal L-shaped bracket **8** can also function as a metal bar **9**. If the housing **1** is made of metal with a sufficiently level surface, the metal bars **9** can be omitted by applying the dielectric medium **10** directly at the inner wall of the housing **1**. The metal tape **4** preferably has a thickness of approximately 0.2 mm and a width of 5 to 10 cm. It can consist, for example, of a copper alloy, but any other materials which are electrically conductive and are sufficiently stable under mechanical and thermal stresses can also be used. At a thickness of 0.2 mm, a skin effect will begin to appear only at approximately 10 MHz and will therefore not interefere. Important however is the maximum electrical carrying capacity per unit area (that is watt/cm^2) which is related to the material and can be computed from the allowable running temperature and the thermal dissipation at a specific cooling-air velocity and temperature.

An excessively strong flow of air is not desirable because there exists the danger of an interfering noise level. In order to avoid such excessive flow while still ensuring a sufficient cooling of the metal tape **4**, it becomes necessary to keep the sections of the metal tape **4**, which run parallel to each other, to a certain minimum distance. This minimum distance is influenced by main criteria (air temperature etc.) and can be determined most expediently by practical tests and will be in the order of approximately 2 to 10 cm. Due to this great distance, the bifilar character of the meandering metal tape **4** will be diminished greatly with the result that the parallel sections will represent inductances. In case of the known, previously discussed, "mats" the individual, parallel sections of the resistance wire are spaced at a distance of 5mm or less from each other, with the result that there exists still a substantial bifilar effect. It is obvious however, that in the case of a use of metal tape, the thermic and the high frequency data will lead to conflicting requirements concerning the distance between the parallel sections of the metal tape **4**. In order to reduce the inductance, the smallest possible distance would be desirable, while for the purpose of more efficient cooling, the distance should be so great as possible.

Thorough tests did disclose that the seeming disadvantage of a compensation for inductances will even be beneficial because there will occur a significant widening of the band width if, as proposed by the invention, the metal tape **4** is divided into a maximum number of sections, and if each section is compensated by use of one capacitance. The additional materials required for the compensation make it also feasible to adjust the simulated antenna system to a large extent to the thermic requirements, with the result that even more than 1 megawatt can be transformed into heat.

In order to demonstrate the gain in band width being obtained, a brief discussion of the theory involved will be in order.

The maximum allowable operating temperature of the metal tape **4**, together with the cooling specifications, will give the maximum carrying capacity per unit area (watt/cm^2). On the basis of the width of the metal tape **4**, it is possible to compute the maximum allowable resistance per unit of length (ohm/cm). Since the d.c. resistance of the simulated antenna is determined by the transmitter (for example 60 ohm), the required total length of the metal tape **4** can thus be computed.

In accordance with the number of the capacitances, the metal tape **4** is divided into sections similar to a lattice network. FIG. 3 shows some of these sections in the form of an equivalent circuit. ΔL and ΔR denote the inductance and the ohmic resistance respectively of one section, and ΔC represents the capacitance assigned to the specific section.

The wave impedance Z of the simulated antenna (also called its characteristic impedance) is computed according to the formula:

$Z = \sqrt{(\Delta R + j\,\omega \Delta L / j\,\omega \Delta C)}$, where $j = \sqrt{-1}$, and $\omega = 2\pi f$.

(see Lit. A, page 247 "Wellenwiderstand einer verlustbehafteten Leitung" which translates into - wave impedance of an imperfect conductor-)

Since $\Delta R < \Delta L$, ΔR can be disregarded when computing the wave impedance, thus:

$Z = \sqrt{\Delta L / \Delta C} = \sqrt{L/C}$ where $L = \Sigma\,\Delta L$ and $C = \Sigma\,\Delta C$.

The wave impedance Z is to be equal to the d.c. resistance so that the required capacitances ΔC can be computed by use of the formula above (ΔL is known). However, each section also possesses a low-pass filter characteristic; therefore the wave impedance Z can be determined by the above formula only in the case of frequencies which are sufficiently below the resonant frequency.

The correct equation would be:

$$Z = \sqrt{(\Delta L / \Delta C) \quad (1 - \Omega^2)}$$

where Ω represents the standard angular frequency, with $\Omega = (\omega / \omega_o$;

ω = operating angular frequency and ω_o = resonant angular frequency.

This equation indicates that the wave impedance Z declines sharply in the vicinity of the low-pas resonant frequency, and reaches the zero value at the resonant frequency. Therefore, in order to obtain a wide band width for a simulated antenna, the resonant frequency must be set so high as possible. It is well known that the resonant frequency, or angular frequency ω_o respectively, is computed according to the equation

$$\omega_o = 1 / \sqrt{\Delta L \cdot \Delta C}$$

Therefore, the smaller ΔL and ΔC, the higher will be the resonant frequency.

Although the inducance L of the simulated antenna, designed in accordance with the invention, is greater than the inductance of a simulated antenna using resistance wire mats, such antennas representing the present state of art, the division into a multitude of sections will result in such small values ΔL and ΔC, that the resonant freqency will be much higher.

FIG. 4 shows, in a simplified manner, a second embodiment of the invention. The metal tape **4** is seen to run in a meandering fashion, in like manner as shown in FIGS. 1 and 2, but tubular insulators 21 are provided here which carry tubular metal linings 22 at their inner surfaces. These metal linings 22 are electrically connected with the end 7 of the metal tape 4, and function, in conjunction with the surfaces of the metal tape 4 in contact with the outer surfaces of the tubular insulators 21, as capacitances. Since such cylindrical or tubular insulators are needed in any event for the purpose of guiding the metal tape 4, and since the metal linings 22 can be attached without any difficulties, the second embodiment of the invention, shown diagrammatically in FIG. 4, does represent an advantageous and simplified development of a simulated antenna. In order to obtain the required capacity value ΔC, it is only necessary to design the tubular insulators 21 in such manner that their walls have the appropriate thickness.

A third embodiment of the invention is shown in FIG. 5, likewise in a simplified manner. The metal tape 4 is guided along a meandering path inside the housing 1 by the insulators 2 in the same manner as shown by FIGS. 1 and 2. Metal plates 13 project into the loops formed by the metal tape 4 and are electrically connected to the end 7 of the metal tape 4. If the housing 1 consists of metal, the electrical connection is ensured automatically. The areas of the metal plates 13 which are disposed opposite the metal tape 4 will function as capacities. In this manner there is produced a capacity cover, distributed nearly uniformly over the entire metal tape 4 (with the exception of the tape-bending areas if the housing 1 is non-metallic). This means that in case of the equivalent circuit diagram, as shown by FIG. 3, the values ΔL, ΔR and ΔC are replaced by incrementally small values dL, dR and dC, From these extremely small incremental values, there will result a still greater increase in the band width.

The wave impedance Z in case of this embodiment can be computed approximately by use of the equation

$$Z = 60 \cdot \log_e 2.55 \cdot D/b,$$

where D represents the distance between two metal plates 13 and b the width of the metal tape 4 (as to this equation, see Lit. A, page 257).

When selecting the distance D, it will be necessary to take the voltage ratio into consideration. Between a section at the beginning of the metal tape 4 and a metal plate 13, opposite this section, there could exist, for example, a voltage potential difference of 20 kv. Obviously, any arc-over has to be avoided.

It will be expedient, especially if the housing 1 is non-metallic, to use the embodiments shown in FIGS. 4 and 5 in combination. In this manner, there will be obtained a completely uniform capacity cover over the entire metal tape 4, resulting in an optimum band width of the simulated antenna.

I claim:

1. A simulated antenna structure for use in conjunction with trial or experimental operation of a radiant energy transmitter comprising a metallic tape extending in a meandering path comprising a series of straight sections alternating with curved sections, said meandering path being arranged within at least one plane which is located at a right angle to the plane of said straight section, one end of said tape being connectible to the output terminal of the transmitter and the other end thereof being grounded, and capacities connected respectively between the grounded end of said tape and substantially equally spaced points along said tape.

2. A simulated antenna structure as defined in claim 1 wherein the meandering path of said metallic tape is arranged within a plurality of parallel planes and wherein the portion of the tape located in one plane passes to the portion of the tape located in an adjacent plane by means of slanting straight section of the tape.

3. A simulated antenna structure as defined in claim 1 and which further includes a housing within which said metallic tape is supported, said housing including an inlet and outlet for conducting a current of cooling gas therethrough in a direction parallel with the opposite faces of said tape and in heat transfer relation with said tape.

4. A simulated antenna structure as defined in claim 1 including tubular insulators said curved sections of supporting said meandering tape at substantially equally spaced locations therealong and wherein said spaced capacities are established by metallic linings within said tubular insulators and which are electrically connected to the grounded end of said tape.

5. A simulated antenna structure as defined in claim 1 including insulators supporting said curved sections of said meandering tape at substantially equally spaced locations therealong and wherein said spaced capacities are established by metallic plates projecting into the spaces formed between adjacent straight sections of said tape and which are electrically connected to the grounded end of said tape.

6. A simulated antenna structure as defined in claim 1 including tubular insulators supporting said curved sections of said meandering tape at substantially equally spaced locations therealong, and wherein said spaced capacities are established in part by metallic linings within said tubular insulators and also in part by metallic plates projecting into the spaces formed between adjacent straight sections of said tape, said metallic linings and said metallic plates being electrically connected to the grounded end of said tape.

7. A simulated antenna structure as defined in claim 6 and which further includes a non-metallic housing within which the metallic tape, the metallic lined supporting insulators therefor and the metallic plates are located.

8. A simulated antenna structure as defined in claim 7 and wherein said housing is provided with an inlet and outlet for conducting a current of cooling gas therethrough in a direction parallel with the opposite faces of said tape and in heat transfer relation with said tape.

9. A simulated antenna structure as defined in claim 1 and which further includes a housing within which said curved sections of metallic tape are supported on insulators at substantially equally spaced locations along said tape and wherein said spaced capacities are established by plate-type condensers supported by a wall of said housing and each of which has one plate thereof electrically connected to a corresponding curved section of said tape.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,796,972 Dated March 12,1974

Inventor(s) OLE SNEDKERUD

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In Claim 4, the word "supporting" in line 3 should be transposed to appear following "insulators" in line 2

Signed and sealed this 18th day of June 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents