June 8, 1965 F. R. HUBER ETAL 3,188,587

DIELECTRIC SUPPORT FOR THE INNER CONDUCTOR OF COAXIAL SYSTEMS

Filed Dec. 17, 1962 2 Sheets-Sheet 1

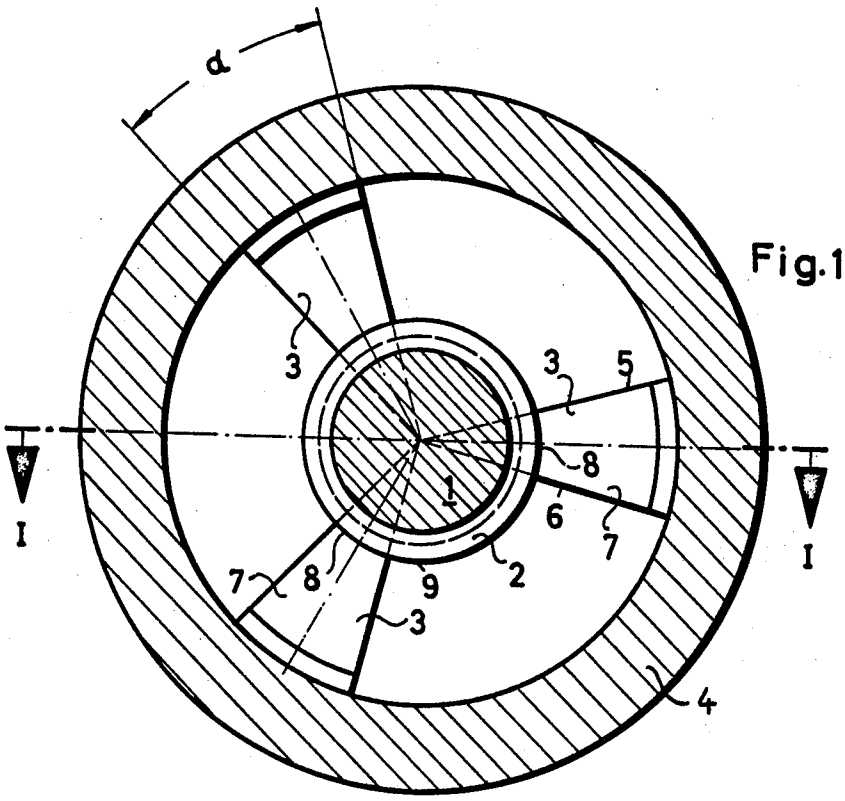


Fig.1

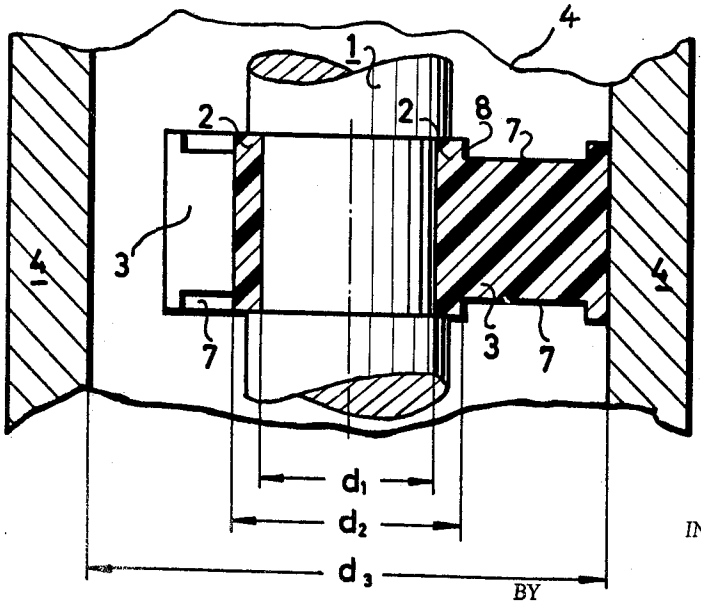


Fig.2

INVENTOR.S

BY

FRANZ REINHOLD HUBER and
HEINRICH NEUBAUER BY

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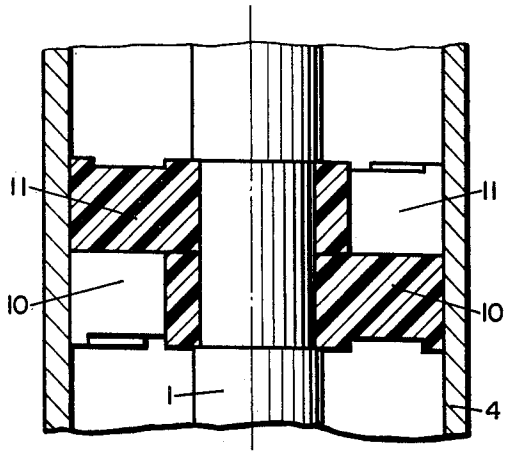


Fig.4

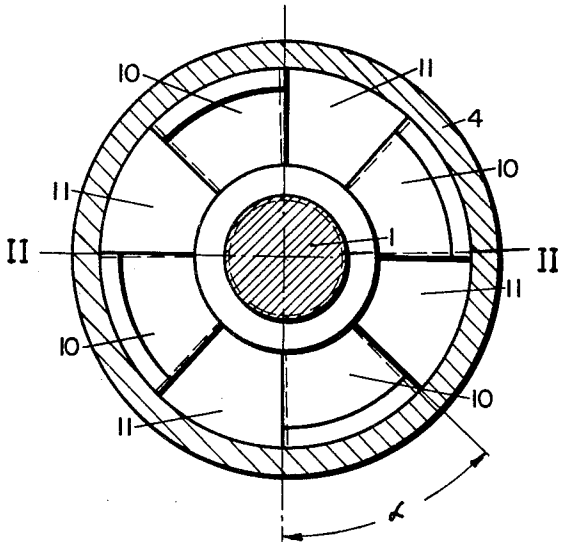


Fig.3

INVENTOR. S
FRANZ REINHOLD HUBER and
HEINRICH NEUBAUER
BY

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DIELECTRIC SUPPORT FOR THE INNER CONDUCTOR OF COAXIAL SYSTEMS

Franz R. Huber and Heinrich Neubauer, Munich, Germany, assignors to Rohde & Schwarz, Munich, Germany, a partnership

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In microwave technique the inner conductor of coaxial cables is mostly supported on dielectric discs. Such supporting discs, however, produce in the region of the discs, a disturbing change of the impedance of the coaxial system, and thereby disturbing reflections. These reflections occur especially in the transition zone between the air and the dielectric of the disc, and they are the greater the greater the dielectric constant is with respect to air. Even at very low values of the dielectric constant, the error is still inadmissibly high. Attempts have been made to provide reflection-free support by means of a spike-like suspension of the inner conductor on filaments of insulating material. These supporting arrangements did not find practical use because they were not reproducible and especially of rather low mechanical stability.

It is also known to fix the inner conductors of coaxial lines by means of supporting rods of ceramic material either in a unilateral arrangement or in a disc-type arrangement, or to employ disc-type supports having circular recesses or portions removed therefrom. The latter support arrangements having the disadvantage of resulting in oblique overlaps between the division lines: dielectric-air, and the field lines extending between inner and outer conductors. Here it is not possible to calculate such supports and it is necessary to provide experimental investigations which are extraordinarily difficult and incomplete because of the impossibility of separating the field distortions caused by the removed disc portion from those caused by the transition zone between the undisturbed line section and that filled with dielectric.

In order to match the impedance of a section having a supporting disc with the impedance of a support-less line section, it is also known to appropriately reduce the diameter of the inner conductor in the region of the supporting disc, and/or appropriately increase the diameter of the outer conductor. However, even in such coaxial systems, reflections occur on the transition zones between air and dielectric, and here again reflections are the greater the greater the dielectric constant of the dielectric is with respect to air.

It is therefore an object of the invention to provide a reflection-poor support for the inner conductor of coaxial systems, which affects the dielectric field at a minimum, even in the case of a relatively high dielectric constant, which is generally unavoidable; shape and dimensions of such reflection-poor support, at given dielectric constants and given dimensions of the coaxial line, are calculable and producible in a simple manner.

Starting with the dielectric support for inner conductors of coaxial systems having removed portions in the region between inner and outer conductors for reflection reduction, and especially coaxial systems having an impedance which is matched in the region of the support with the adjoining support-less coaxial section by an appropriate change of the diameters of the inner and/or outer conductors, the invention proposes that the edges of these removed portions are arranged only parallelly or perpendicularly to the electric field lines extending between inner and outer conductors. With an inner conductor of circular cross-section, preferably these edges extended concentrically or radially with respect to the periphery of the inner conductor. The support in accordance with the

invention can consist of a ring shaped portion surrounding the inner conductor and two or more, preferably three, radially outwardly extending support arms of circular-sector shaped outline, having longitudinal edges coinciding with the radii of the ring shaped portion and arranged equally distributed along the periphery of the ring shaped portion.

The recesses formed in the support define connecting passages between the spaces of the coaxial system on both sides of the support. This, in some cases, is undesirable, and in order to avoid air circulation and, as may happen, the entrance of foreign bodies in the interior of the coaxial line, in accordance with a further embodiment of the invention, the support is to consist of two support parts, and the support arms for each support part are to cover together at least an angular region of 180°; and these support parts, angularly displaced with respect to each other, are to form together a single support in such a manner that the support arms of one support part cover the recesses of the other support part. Preferably in this case, each support part is provided with four support arms, each covering an angular sector region of slightly more than 45°, preferably 47°.

The construction of the support in accordance with the invention results in a line section having zones of full dielectric distributed over the cross section, which alternate with regions of a sheeted dielectric which can be mathematically calculated. In this way, especially in connection with the method known per se, of matching the impedance of the section receiving the supporting disc with the support-less sections of a coaxial line by means of changing the coaxial dimensions, it is possible to build a practically reflection-free coaxial line in a simple and inexpensive manner.

By providing the support in accordance with the invention, the reduced diameter of the inner conductor can be made larger than in the known arrangements; this, on the one hand, causes a greater mechanical strength, and on the other hand, due to the larger inner conductor, it increases power carrying capacity and also reduces the dielectric loss.

In the following the invention will be more fully explained by means of schematic drawings on an example of realization.

FIG. 1 shows a top view of a support in accordance with the invention.

FIG. 2 shows a cross section through a support in accordance with FIG. 1 substantially along line I—I of FIG. 1.

FIG. 3 shows a further embodiment of a support in accordance with the invention in top view.

FIG. 4 shows a cross section through a support in accordance with FIG. 3 along line II—II.

The support of dielectric material in accordance with the invention consists of a ring portion 2 mountable on inner conductor 1 of a coaxial line, and of three supporting arms 3 made of one piece with ring portion 2 and arranged distributed equally along the circumference of ring portion 2. The ends of support arms 3, in the assembled state of the support, are arranged engaging the inner wall of the outer conductor 4 of the coaxial line. Each support arm 3 is shaped in the form of a circular sector in which the longitudinal edges 5, 6 which extend radially and form the angle of the sector, intersect at the center of inner conductor 1 as indicated in FIG. 1 by the prolongations of longitudinal edges 5, 6, drawn in dotted lines.

The arrangement and construction of ring portion 2 and support arms 3 attached thereto, results in that the electric field formed between inner conductor 1 and outer conductor 4 of the coaxial line intersects edge 9 of ring

portion 2 only perpendicularly, i.e. it extends in a direction parallel to the longitudinal edges 5, 6 of the support.

The impedance of the support in accordance with the invention, which is independent from the number of support arms, the width of these arms, and the distribution of the periphery of the ring portion, derives from the following formula

$$Z=60\cdot\sqrt{\frac{\left(\epsilon_r\cdot\frac{1}{\ln d_2/d_1}+\left[\frac{\sum\alpha}{2\pi}(\epsilon_r-1)+1\right]\frac{1}{\ln d_3/d_2}\right)\ln\frac{d_3}{d_1}}{\epsilon_r\cdot\frac{1}{\ln d_2/d_1}\cdot\left[\frac{\sum\alpha}{2\pi}(\epsilon_r-1)+1\right]\frac{1}{\ln d_3/d_2}}}$$

In this formula Z represents the desired impedance of the coaxial line, ϵ_r the relative dielectric constant of the support material used (dielectric constant of air $\epsilon_0=1$) and $\Sigma\alpha$ the sum of all angular regions covered by the individual supporting discs. Furthermore, d_1 represents the outer diameter of the inner conductor in the region of the support or the inner diameter of the support portion, d_2 represents the outer diameter of the support ring portion, and d_3 the inner diameter of the outer conductor of the coaxial line in the region of the support.

From the above formula, the remaining dimensions of the support can be calculated in a simple manner, for any desired impedance value of a line, depending on the dielectric constant of the support material to be used and on the existing or selected dimensions of the coaxial line. If, for example, as it frequently occurs in practice, the dielectric constant of the support material as well as diameters d_2 and d_3 are given, and the outer diameter d_1 of the inner conductor is to be found, the following relation results:

The support in accordance with the invention can either

$$d_1=\exp\left\{\frac{1}{2}\left(\ln d_2d_3+\frac{\epsilon_r\ln d_3/d_2}{\left[1+(\epsilon_r-1)\frac{\sum\alpha}{2\pi}\right]}\right)\pm\sqrt{\frac{1}{4}\left[\ln d_2d_3+\frac{\epsilon_r\ln d_3/d_2}{\left[1+(\epsilon_r-1)\frac{\sum\alpha}{2\pi}\right]}\right]^2+\left[\left(\frac{Z}{60}\right)^2\epsilon_r-\frac{\epsilon_r\cdot\ln d_3/d_2\cdot\ln d_3}{\left[1+(\epsilon_r-1)\frac{\sum\alpha}{2\pi}\right]}-\ln d_3\cdot\ln d_2\right]}\right\}$$

be simply mounted on the inner conductor, or it can be inserted with its ring portion 2 in an appropriately formed ring shaped groove of the inner conductor. The same also applies for the connection of supporting arms 3 with the inner surface of the outer conductor.

The support in accordance with the invention can be provided, in a manner known per se, with a ring shaped recess by which the capacitive influence of the front surfaces of the support is compensated. In the example of realization shown in FIG. 1 such a ring shaped recess is indicated at 7 formed on the individual support arms 3 between ring portion 2 and outer conductor 4. Such an arrangement is particularly easy to manufacture if a ring portion 2 surrounding inner conductor 1 coincides with the inner edge section 8 of the ring shaped recess 7.

FIGS. 3 and 4 show a support in accordance with the invention, which corresponds in its dimensions to the support described above and consists of two support halves 10 and 11 which are arranged angularly displaced with respect to each other in such a manner that the support arms of one-half cover the recesses of the other half. In this way a separation between two adjoining spaces of the coaxial line is achieved. In this case, the support arms of one section, are so formed that they cover together an angular region of at least 180°.

In the example of realization shown, angle α is selected to be slightly larger than 45°, preferably 47°, so that the two support arms 10 and 11 will overlap.

The manufacture of this composite support occurs, preferably, in such a way that, at the outset, one support disc is produced with appropriately formed support arms, and thereafter this support disc is cut into two identical support halves by a cut extending in the middle, perpendicular to its axis. The resulting support halves, appropriately angularly displaced, are then again placed upon each other. In this case, if necessary, the two support disc sections can be connected in their overlap position, for example, by glue. The supports, however, can also be manufactured from a single piece by pressing, die casting, or machining from a single workpiece.

We claim:

1. A coaxial transmission line having an inner conductor and an outer conductor, dielectric means for supporting said inner conductor relative to said outer conductor, recesses in one of said conductors for matching the characteristic impedance of the supported portions of the coaxial transmission line to adjacent unsupported coaxial sections, said support means including cut-out portions for reducing reflections, the edges of said cut-out portions extending substantially parallel with and selectively perpendicular to the electric field lines within the coaxial transmission line, said support means further including two ring-shaped portions each having a set of support arms, each of said sets covering together an angular region of at least 180 degrees, said ring-shaped portions forming a single supporting unit, and being angularly displaced with respect to each other in such a manner that said support arms of one ring-shaped portion cover the recesses of the other ring-shaped portion.

2. A transmission line as defined in claim 1, wherein said inner conductor is of circular cross-section and said edges of the cut-out portions extend concentrically and selectively radially with respect to the periphery of said inner conductor.

3. A transmission line as defined in claim 1, wherein each ring-shaped portion has four support arms, each covering an angular section region of somewhat more than 45 degrees.

4. A transmission line as defined in claim 3, wherein said sector region is 47 degrees.

5. A transmission line as defined in claim 1, wherein at least one of said ring-shaped portions surrounds said inner conductor and at least three of said support arms, of circular, sector-shaped outline, extend radially outward from said one ring-shaped portion.

6. A transmission line as defined in claim 1, wherein at least one of said ring-shaped portions surrounds said inner conductor and at least two of said support arms, having a circular, sector-shaped outline, extend radially outward from said one ring-shaped portion.

7. A transmission line as defined in claim 6, wherein said two support arms are distributed equally along the periphery of said one ring-shaped portion.

8. A transmission line as defined in claim 7, wherein said one ring-shaped portion and said support arms are dimensioned in accordance with the following formula:

$$Z=60\cdot\sqrt{\frac{\left(\epsilon r\cdot\frac{1}{\ln d_2/d_1}+\left[\frac{\sum\alpha}{2\pi}(\epsilon r-1)+1\right]\frac{1}{\ln d_3/d_2}\right)\ln\frac{d_3}{d_1}}{\epsilon r\cdot\frac{1}{\ln d_2/d_1}\cdot\left[\frac{\sum\alpha}{2\pi}(\epsilon r-1)+1\right]\frac{1}{\ln d_3/d_2}}}$$

wherein Z represents the impedance of the support means, E_r the relative dielectric constant of the support means material, Σ_α the sum of the angular regions covered over by the individual sector-shaped support arms, d_1 the outer diameter of the inner conductor, d_2 the outer diameter of

the ring-shaped portions, and d_3 the inner diameter of the outer conductor.

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HERMAN KARL SAALBACH, *Primary Examiner.*