March 4, 1947. T. R. FINCH ET AL 2,416,683

WAVE TRANSMISSION NETWORK

Filed Oct. 26, 1944

FIG. 1.

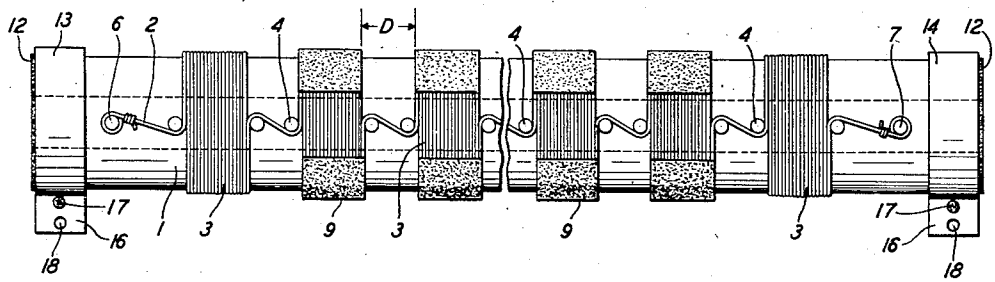


FIG. 2.

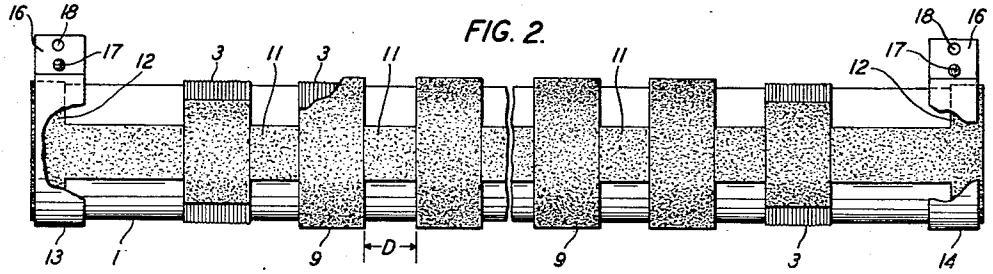


FIG. 3.

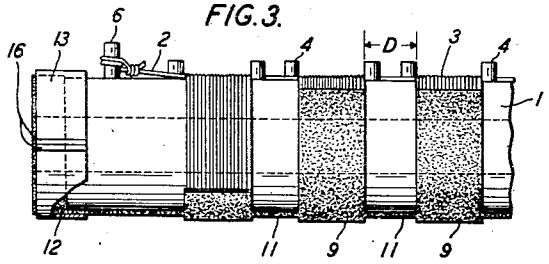


FIG. 4.

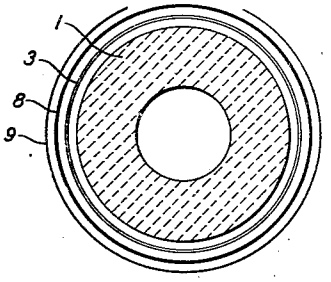


FIG. 5.

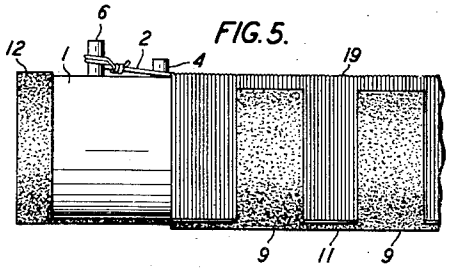


FIG. 6.

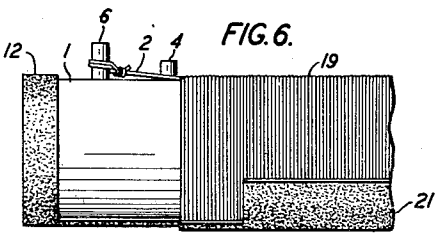
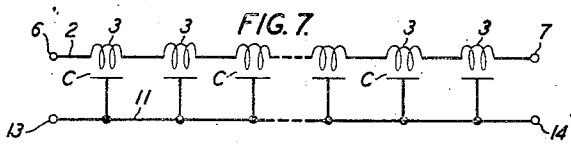


FIG. 7.



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WAVE TRANSMISSION NETWORK

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20 Claims. (Cl. 178—44)

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This invention relates to wave transmission networks and more particularly to those of the type comprising series inductance and shunt capacitance.

Objects of the invention are to reduce the size, weight and cost of such networks, to simplify their construction and assembly, and to improve their stability.

The network in accordance with the invention comprises a form, made of insulating material, upon which is wound insulated wire to provide an inductor. The winding may be continuous or it may consist of a number of series-connected sections longitudinally spaced along the form. Over the winding is applied one or more coats of organic insulating enamel. Over this insulating layer is applied an adherent, conducting coating which extends only part way around the form. If the inductor is a continuous winding the conducting coating may be of uniform width for the entire length of the winding, or it may be divided into a number of longitudinally spaced sections, connected by a narrow strip of conducting coating. If the inductor is wound in sections the conducting coating may be applied only over the inductor sections. There is thus formed one or more capacitors the inner electrode of which is the coil winding, the dielectric of which is the insulation on the wire and the layer of organic insulating enamel, and the outer electrode of which is the conducting coating. The enamel performs a threefold function: it serves to hold the winding in place, increases the voltage rating of the capacitor, and firmly binds the outer electrode to the dielectric.

The electrical circuit of the network is of the ladder type, comprising series inductances and shunt capacitances. By properly evaluating these inductances and capacitances the network may, for example, be designed to provide a phase characteristic which is substantially linear with frequency.

Since the network is simple to construct and assemble, its cost is comparatively low. It is also small in size, light in weight, and very stable with respect to changes in temperature or humidity, or with exposure to vibration. These latter qualities are of special importance in air-borne equipment.

The nature of the invention will be more fully understood from the following detailed description and by reference to the accompanying drawings, in which like reference characters refer to similar or corresponding parts and in which:

Figs. 1, 2, and 3 are, respectively, a top, bottom

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and side view of a network in accordance with the invention having lumped inductance and lumped capacitance;

Fig. 4 is a diagrammatic cross-section through an inductor section;

Fig. 5 is a side view of a modified form of the network, with continuous inductance and lumped capacitance;

Fig. 6 is a side view of another modification having continuous inductance and continuous capacitance; and

Fig. 7 gives the schematic circuit of the network.

As shown in Figs. 1, 2, 3 and 4 one embodiment of the network in accordance with the invention comprises a form 1 upon which is wound a wire 2 to provide an inductor. The form 1 is tubular and is made of suitable insulating material such, for example, as phenol fiber. The wire 2 has an insulating covering such, for example, as enamel, and is so wound as to provide a number of inductor sections 3 spaced apart along the length of the form 1 by the distance D. The spacing pins 4 serve to locate the inductor sections 3 in their proper positions. The wire 2 is anchored at its ends to the terminal pins 6 and 7, respectively. The form 1, with the inductor sections 3 in place, may now be baked for several hours at a temperature of, say, 140 degrees centigrade and allowed to cool to room temperature in a desiccator.

The entire structure is now given one or more coats of enamel 8 such, for example, as a suitable resinous or polymeric material or thermosetting organic material dissolved in a volatile solvent. The coats may conveniently be applied by dipping. After each coat the structure is held in a vertical position and subjected to a curing cycle, to drive off the volatile solvent. Further curing above room temperature is then required to complete the cure of the film, the exact treatment depending upon the nature of the insulating material being applied and the volatility of the solvent. For each consecutive coat the form 1 is inverted for dipping and curing as an aid in obtaining a uniform coat. The number of coats to be applied depends primarily upon the capacitance and the dielectric strength required.

Over each inductor section 3 and the layer of enamel 8 is applied an adherent, conducting coating 9. This extends only part way around the form 1 in order to avoid forming a short-circuited turn which would affect the value of the inductance and introduce considerable undesired dissipation. The coating 9 may con-

veniently be applied as a metallic spray or paint comprising, for example, finely divided silver powder, a synthetic resin, and an organic solvent for the resin. After application the coating is air dried or mildly heated to drive off the solvent, leaving an adherent, conducting coating of silver and solidified resin. If the coating 9 is applied as a spray, the portions of the form 1 not to be coated may be covered with adhesive tape, which is later removed.

The diagrammatic cross-section of Fig. 4 through an inductor section 3 shows the relationship between the various component parts. The conducting coating 9 forms one electrode of a capacitor the other electrode of which is constituted by the winding of the inductor section 3. The insulation on the wire 2 and the layer of organic insulating enamel 8 constitute the dielectric. The layer 8, in addition to serving as a dielectric, holds the winding 3 in place and forms a firm bond with the plating 9, thus contributing materially to the stability of the network when exposed to vibration or to changes in temperature or humidity.

It is preferable at first to make the electrodes 9 somewhat smaller than required to provide the desired capacitance C. Each capacitance C may then be measured and the electrodes 9 individually enlarged in area sufficiently to give the proper value of C. The electrodes 9 may conveniently be extended by painting on silver paste with a small brush. After each electrode 9 has been built out to the required area they are all electrically connected together by a strip of conducting coating 11 which terminates in the rings of conducting coating 12 around the ends of the form 1. In order to facilitate the making of soldered connections, the rings 12 are, in turn, encircled by bands of metal 13, 14 having at their ends a pair of flanges 16 which may be spot welded as shown at 17. The holes 18 through the flanges 16 are provided to accommodate the connecting wires.

As shown by the schematic circuit of Fig. 7 the network is of the ladder type, comprising a number of series-connected inductor sections 3 and shunt capacitances C connected between a pair of input terminals 6, 13 and a pair of output terminals 7, 14. By proper choices of the inductances of the sections 3, the spacing D between sections, and the capacitances C the network may be designed as a delay network having a substantially linear phase-frequency characteristic. The over-all phase shift will depend upon the number of sections. In Figs. 1 and 2 the central portion of the network has been removed and in Fig. 3 only the end portion is shown, in order to save drawing space. In Fig. 7 the missing portion is indicated by the dashed lines. Of course, any required number of sections may be provided in a single network. Also, the network may be designed to have other types of transmission characteristics, if desired.

Fig. 5 shows a side view of the end portion of a modified form of the network which is similar to that shown in Figs. 1, 2, 3 and 4 except that the spacing D between the sections 3 has been eliminated so that the inductance 19 is a continuous, closely spaced winding extending substantially from one end of the form 1 to the other. This form is easier to construct, and therefore cheaper, because the spacing pins 4 between sections have been eliminated and the inductor 19 is easier to wind.

Fig. 6 is a similar view of a further modification, similar to the network of Fig. 5 except that the electrodes 9 have been shortened and the connecting strip 11 widened to provide a single continuous electrode 21 of uniform width extending substantially from one end of the inductor 19 to the other. This form is even cheaper to construct, since the separate electrodes 9 have been eliminated. The modified structures of Figs. 5 and 6 may be designed to have substantially the same transmission characteristics as the network shown in Figs. 1, 2, 3 and 4.

What is claimed is:

1. A wave transmission network comprising a form made of insulating material, an inductor wound on said form, a layer of organic insulating enamel over said inductor, and an adherent, conducting coating applied over said enamel and firmly bonded thereto, said inductor being a continuous, closely spaced winding extending substantially from one end of said form to the other and said conducting coating extending in uniform width substantially from one end of said inductor to the other and part way only around said inductor.

2. A network in accordance with claim 1 in which said enamel comprises a suitable resinous material and a volatile solvent.

3. A network in accordance with claim 1 in which said enamel comprises a suitable polymeric material and a volatile solvent.

4. A network in accordance with claim 1 in which the area of said conducting coating is proportioned with respect to the inductance of said inductor to provide a phase shift which is substantially linear with frequency.

5. A network in accordance with claim 1 in which said conducting coating comprises silver.

6. A network in accordance with claim 1 in which said conducting coating comprises a mixture of silver powder, a synthetic resin, and an organic solvent for the resin.

7. A network in accordance with claim 1 in which said enamel comprises a suitable resinous material and a volatile solvent and said conducting coating comprises a mixture of silver powder, a synthetic resin, and an organic solvent for the resin.

8. A network in accordance with claim 1 in which said enamel comprises a suitable polymeric material and a volatile solvent and said conducting coating comprises a mixture of silver powder, a synthetic resin, and an organic solvent for the resin.

9. A network in accordance with claim 1 in which said inductor comprises wire having an insulating covering.

10. A network in accordance with claim 1 in which said inductor comprises wire having an enamel coating.

11. A wave transmission network comprising a form made of insulating material, an inductor wound on said form, a layer of organic insulating enamel over said inductor, and an adherent, conducting coating applied over said enamel and firmly bonded thereto, said inductor being a continuous, closely spaced winding extending substantially from one end of said form to the other and said conducting coating comprising a plurality of longitudinally spaced sections extending part way only around said inductor.

12. A network in accordance with claim 11 in which the area of said conducting coating is proportioned with respect to the inductance of said inductor to provide a phase shift which is substantially linear with frequency.

13. A network in accordance with claim 11 in which said enamel comprises a suitable resinous material and a volatile solvent.

14. A network in accordance with claim 11 in which said enamel comprises a suitable polymeric material and a volatile solvent.

15. A network in accordance with claim 11 in which said conducting coating comprises silver.

16. A network in accordance with claim 11 in which said conducting coating comprises a mixture of silver powder, a synthetic resin, and an organic solvent for the resin.

17. A network in accordance with claim 11 in which said enamel comprises a suitable resinous material and a volatile solvent and said conducting coating comprises a mixture of silver powder, a synthetic resin, and an organic solvent for the resin.

18. A network in accordance with claim 11 in which said enamel comprises a suitable polymeric material and a volatile solvent and said conducting coating comprises a mixture of silver powder, a synthetic resin, and an organic solvent for the resin.

19. A network in accordance with claim 11 in which said inductor comprises wire having an insulating covering.

20. A network in accordance with claim 11 in which said inductor comprises wire having an enamel coating.

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