

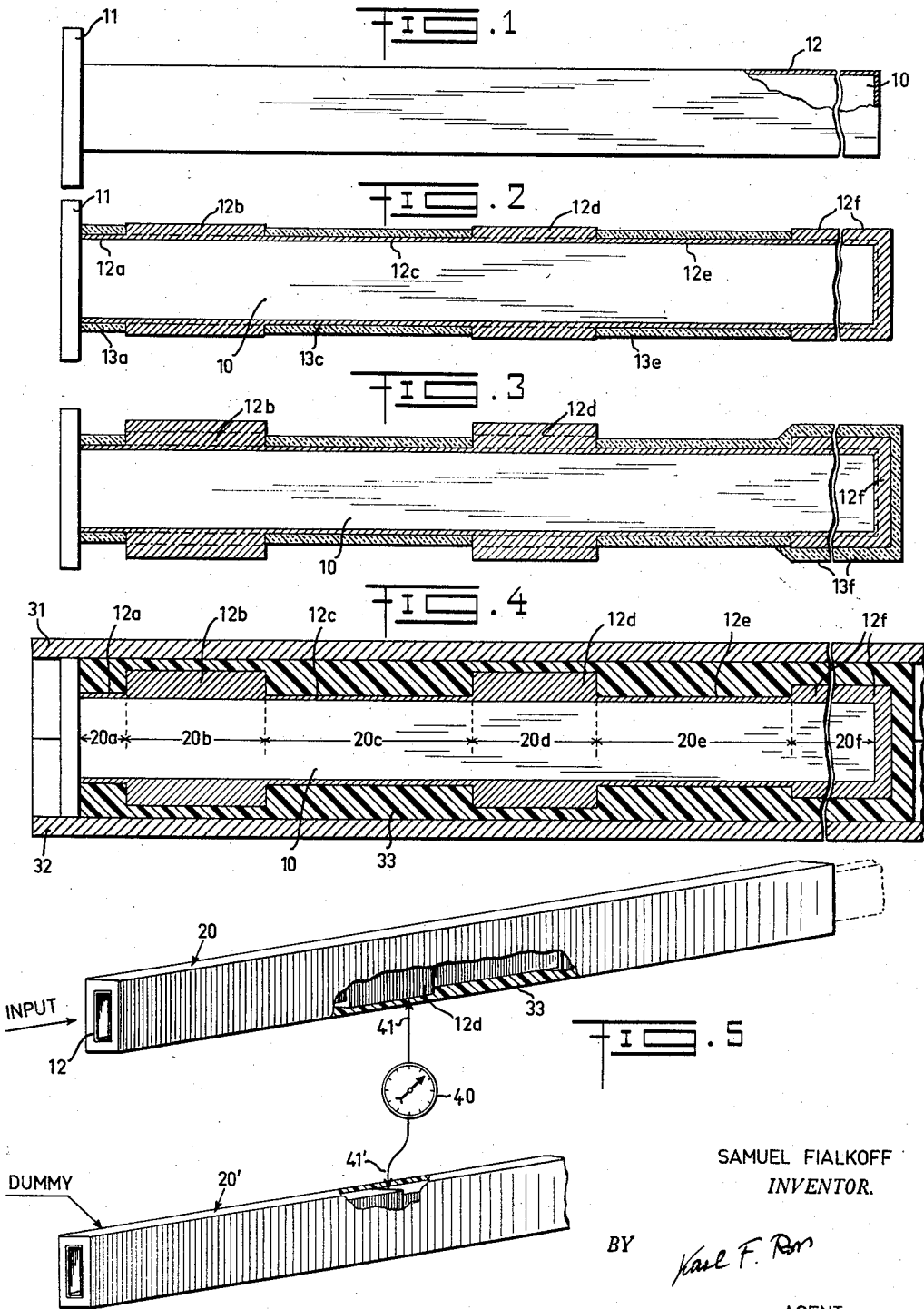
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S. FIALKOFF

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METHOD OF MAKING HOLLOW BODY OF NON-UNIFORM WALL THICKNESS

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SAMUEL FIALKOFF
INVENTOR.

BY

Karl F. Rom

AGENT

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METHOD OF MAKING HOLLOW BODY OF NON-UNIFORM WALL THICKNESS

Samuel Fialkoff, Roslyn, N.Y., assignor to Camin Laboratories, Inc., Brooklyn, N.Y., a corporation of New York

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4 Claims. (Cl. 204—9)

My present invention relates to the production of hollow metallic bodies, such as wave guides, by an electroforming process, e.g. as described in my co-pending application Ser. No. 467,607, filed November 9, 1954.

The process disclosed in that earlier application involves the electro-deposition of a metallic coating on a suitable mandrel finished to the internal dimensions of the hollow body to be formed, followed by the molding of a resinous shell around this coating and finally by a withdrawal of the mandrel from the hardened shell, the coating remaining in position as an inner metallic lining of the latter. In this manner a thin zone of the mainly dielectric, resinous wall can be made of highly conductive metal, such as silver, held to close tolerance in order to provide the necessary conductance with a minimum use of metal to save weight and cost.

It is sometimes desirable to have a hollow article of the character set forth in which the thickness of the metallic lining is not uniform but differs at various locations throughout its length. An example of such article would be a wave guide designed to be used for thermo-electric measurements in order to determine the amount of wave energy dissipated within or absorbed by the guide; for accurate measurements the test site should be thermally insulated from its surrounding as far as possible, it being thus necessary to reduce the thickness of the metal layer on both sides of this site to the bare minimum required for conduction while providing a section of considerably greater thickness at the measuring point in order to obtain the necessary thermal capacity at such point. In some instances parallel measurements are to be carried out at different points along the length of the guide, necessitating the formation of a plurality of identical discontinuities in the thickness of the metallic portion of the guide wall.

The general object of my present invention is to provide a method of accurately forming a wave guide or other hollow article comprising a metallic lining of varying thickness and continuous inner surface.

A more specific object of this invention is to provide a method of forming an article of this description wherein a plurality of sections of a given wall thickness are separated by sections of greatly reduced thickness.

In accordance with this invention I proceed initially as in my above-identified earlier application by depositing on a mandrel a metallic coating. After this coating has reached a thickness corresponding to that of the thinnest wall section of the article to be formed, I mask that part of the mandrel which is to correspond to such thin-walled section and continue to build up the conductive layer on the remainder of the mandrel. In case there are more than two different wall thicknesses to be observed, I mask another portion of the mandrel after a build-up corresponding to the second step and then continue as before. In this manner any desired number of thickness steps may be obtained with a maximum of uniformity between sections of like thickness.

In the production of an electrical circuit element, such

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as a wave guide, I prefer to use silver for the metallic coating, although copper could also be used.

The invention will be further described with reference to the accompanying drawing in which:

Fig. 1 is a side view of a mandrel after completion of the first electro-deposition step, with part of the deposited coating shown in section;

Figs. 2 and 3 are views similar to Fig. 1, illustrating further stages of operation and showing, in section, the progressively built-up metallic coating;

Fig. 4 illustrates the molding of a resinous shell around the coated mandrel; and

Fig. 5 is a perspective view schematically illustrating the use of the article made according to Figs. 1-4 in a thermo-electric measuring system.

The mandrel 10, shown in Figs. 1-4, is of rectangular cross section, corresponding to the interior cross section of a wave guide 20 (Fig. 5) to be formed therearound, and terminates at one end in a radially projecting flange 11. By cathodically connecting this mandrel in a suitable plating bath I deposit thereon a silver layer 12 of a very small thickness, e.g. of the order of 0.01 mm. It will be assumed that the finished wave guide 20 is composed of several longitudinally adjoining sections 20a-20f (see Fig. 4) of which the sections 20a, 20c and 20e are to have the minimum thickness represented by layer 12. Consequently, in accordance with the present invention, I mask the corresponding portions 12a, 12c, 12e of layer 12 with wax coatings 13a, 13c and 13e, whereupon the portions 12b, 12d and 12f of layer 12 are further built up as illustrated in Fig. 2. When the second level is reached, assumed to correspond to the desired thickness (say, of the order of 0.25 mm.) of the terminal section 20f of the guide, treatment is again interrupted and a wax coating 13f applied to the right-hand extremity of the coated mandrel, leaving only the layer portions 12a and 12c exposed. Finally, additional deposits are made upon these exposed portions to bring their thickness to the ultimate value required, e.g. of the order of 1.5 mm.

By this process there is thus formed on mandrel 10 a conductive layer composed of a first, thin section 12a, a second, heavy section 12b, another thin section 12c, a further heavy section 12d, a third thin section 12e, and a terminal section 12f of intermediate thickness, all as shown in Fig. 4. Next, I remove the wax coatings 13a, 13c, 13e, 13f and encase the coated mandrel in a mold consisting of two halves 31, 32 within which a resinous shell 33 is formed around the metal layer 12 to complete the wave guide 20. After the molded shell 33 has hardened, the mandrel 10 is withdrawn.

Before the guide 20 is placed in operation, its closed end 12f may be opened up and connected to a suitable load through an extension 21 indicated in dot-dash lines in Fig. 5. When wave energy is supplied to the input end of the guide, part of this energy is dissipated and converted into heat which raises the temperature of thermally insulated guide sections 12b and 12d. In Fig. 5 I have illustrated how, with the aid of an indicator 40, this heat may be measured for the purpose of ascertaining the amount of wave energy entering the guide. Indicator 40 may comprise a thermocouple whose hot terminal is in the form of a probe 41 engaging conductive section 12d of guide 20 and whose cold terminal is in the form of a similar probe 41' engaging a corresponding section of a dummy guide 20' to which no energy is supplied. Any number of other, similar devices may be arranged in parallel with instrument 40 at wave-guide section 12d or 12b to give an indication of the heat distribution along these sections whereby, for example, the presence of standing waves may be determined.

It will be understood that at least the leads from instrument 40 to probes 41, 41' and adjacent parts of

wave guides 20, 20' should be insulated thermally from each other and from their environment to insure correct readings.

Any of a number of thermoplastic or thermosetting compounds may be used for the resinous shell 33, the choice of material depending upon the dielectric, mechanical and thermal properties required. Mandrel 10 may consist of oil-hardened tool steel having a highly polished and chrome-plated or otherwise passivated surface. Molds 31, 32 may likewise consist of polished steel, chrome-plated and coated with a suitable mold-release agent, such as a silicon oil. The mandrel could also be made of a low-melting-point alloy of a readily soluble material for removal from the mold by thermal or chemical action, as described in my co-pending application referred to above.

It will be understood that the specific form of wave guide described and shown in the drawing is merely illustrative of a large class of structures in which the inner wall of a hollow body is lined with a metallic layer of varying thickness which must be held to close tolerances. The invention is, accordingly, not limited to the embodiment particularly disclosed but may be realized in various modifications without departing from the spirit and scope of the appended claims.

I claim:

1. The method of forming a hollow body having an inner wall lined with a metallic layer, said layer being of a smaller thickness in one annular section of the body and of a greater thickness in another annular section thereof, which comprises the steps of providing a mandrel dimensioned to conform to the interior of said body, electro-depositing on said mandrel a metallic coating to a depth equaling said smaller thickness, masking an annular portion of said coating corresponding to said one annular section of the body, electro-depositing on the unmasked part of said coating an additional amount of the same metal until said unmasked part has reached a depth equaling said greater thickness, subsequently molding a resinous shell around the coated mandrel, and removing said mandrel while leaving said shell intact.

2. The method according to claim 1, wherein said portion is masked by the application of a wax layer thereto.

3. The method of forming a hollow body having an inner wall lined with a metallic layer, said layer including spaced-apart annular portions of a first, smaller thickness separated by an intermediate annular portion of a second, larger thickness, which comprises the steps of providing a mandrel dimensioned to conform to the interior of said body, electro-depositing on said mandrel a metallic coat-

ing extending across the locations of both said spaced-apart annular portions and said intermediate annular portion, building up said coating to a depth equal to said first thickness, masking parts of said coating corresponding to said spaced-apart portions, electro-depositing an additional amount of the same metal on a part of said coating corresponding to said intermediate portion until the last-mentioned part of the coating has reached a depth equaling said second thickness, subsequently molding a resinous shell around the coated mandrel, and removing said mandrel while leaving said shell intact.

4. The method of forming a hollow body having an inner wall lined with a metallic layer, said layer being composed of contiguous annular portions having at least three different thicknesses, which comprises the steps of providing a mandrel dimensioned to conform to the interior of said body, electro-depositing on said mandrel a metallic coating coextensive with said layer to a depth equaling the smallest of said thicknesses, masking an annular portion of said coating, electro-depositing on the unmasked part of said coating an additional amount of the same metal until said unmasked part has reached a depth equaling the next-smallest of said thicknesses, masking an annular portion of the hitherto unmasked part, electro-depositing a further amount of said metal on the remaining part until the coating thereon has reached the third-smallest of said thicknesses, continuing in this manner until the coating conforms to said layer in all its thicknesses, molding a resinous shell around the coated mandrel, and removing said mandrel while leaving said shell intact.

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