Aug. 23, 1966 W. A. FOLL ETAL 3,267,968

LAMINATED GLASSINE PAPER COIL FOAM

Filed March 19, 1963

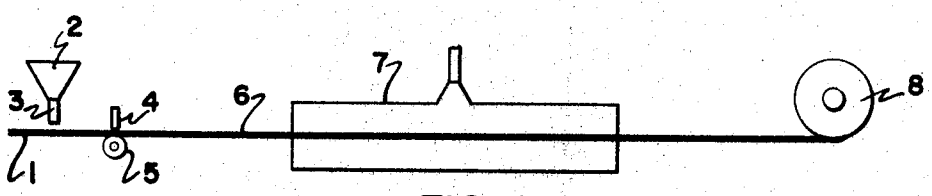
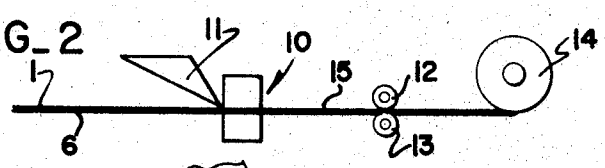


FIG_1

FIG_2



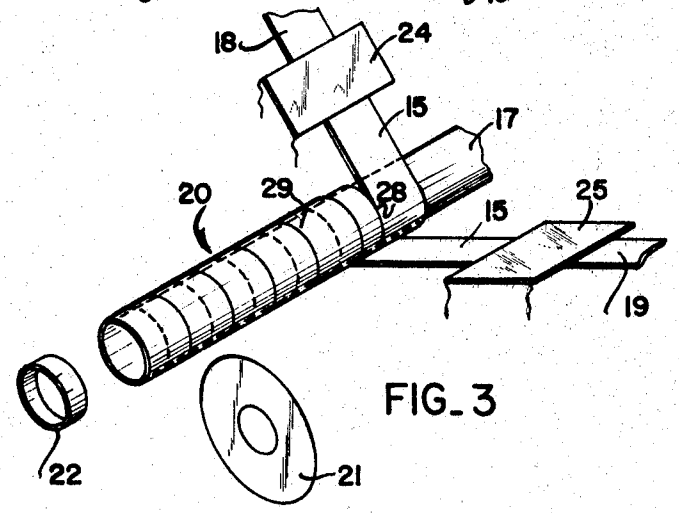


FIG_3

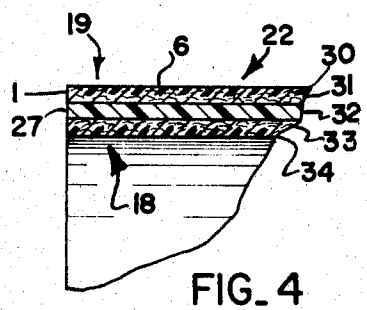


FIG_4

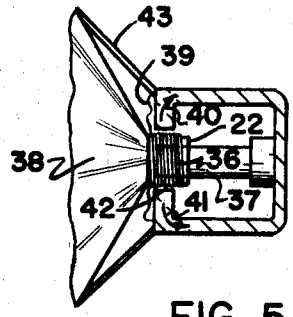


FIG_5

INVENTORS
WILLIAM A. FOLL
ALBIN M. HANCIK

BY

Oberlin, Maky & Donnelly

ATTORNEYS

United States Patent Office 3,267,968 Patented August 23, 1966

3,267,968

LAMINATED GLASSINE PAPER COIL FORM

William A. Foll, 3475 Doris Road, Cleveland 9, Ohio, and Albin M. Hancik, 2021 Clarence Ave., Lakewood, Ohio

Filed Mar. 19, 1963, Ser. No. 266,345
4 Claims. (Cl. 138—141)

This invention relates generally as indicated to a speaker coil form and more particularly to the manufacture of a small, dimensionally stable, highly water resistant cylindrical form on which speaker coils may readily be wound.

Most high quality speakers today use aluminum or other metal foil approximately on the order of .0005–.001 inch thick as the form upon which the wires of the speaker coil are wound. However, due to the form's conductive nature, it must be longitudinally slit. Moreover, the foil requires precise dies to make and special adhesives are required to secure the wires to the form and the form to the diaphragm cone. Although aluminum foil is chosen for its lightness of weight, it is still much heavier than desirable and, of course, requires stronger currents than a lighter coil form.

Since the air gap tolerances in a speaker must be very closely maintained to assure proper performance both in timber and tonal quality, it is necessary to maintain the diameter tolerance of the coil form to .001 inch. Due to the necessary longitudinal slit in the aluminum foil coil form, the speaker coil cannot be wound with the coil form on an expansible mandrel. Instead, the coil must be hand wound and this, of course, greatly increases the cost of speakers.

Aluminum foil is chosen as speaker coil forms because of its water resistant nature. High humidity will cause conventional paper completely cylindrical coil forms to pucker or expand and when dried, to shrink. Thus the required diameter tolerance cannot be maintained and the air gap tolerance will likewise not be maintained affecting the performance of the speaker. It is, of course, well known that the clearances between the voice coil assembly and the pole pieces of the magnet are purposely made quite small in the design of the speaker in that this provides a desirable concentration of magnetic flux in the separating gap wherein the voice coil is mounted. However, a slight variation in the diameter of the voice coil form will destroy this gap tolerance.

It is accordingly a principal object of the present invention to provide a speaker coil form ½ to ⅓ the weight of more conventional aluminum foil forms.

Another main object is the provision of such a voice coil form which will maintain a diameter tolerance of .001 inch.

Still another object is the provision of a speaker voice coil form which is highly water resistant.

A further object is the provision of a speaker voice coil form which can inexpensively be manufactured and, moreover, which can be employed with expansible mandrels for the automatic winding of the voice coil thereon.

A yet further object is the provision of an inexpensive voice coil form which will not have any of the inherent disadvantages of aluminum foil coil forms and yet which will produce a speaker having the proper high quality characteristics and a longer life.

Other objects and advantages of the present invention will become apparent as the following description proceeds.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawing setting forth in detail a certain illustrative embodiment of the invention, this being indicative, however, of

but one of the various ways in which the principle of the invention may be employed.

In said annexed drawing:

FIG. 1 is a schematic elevation illustrating a thermosetting coating material being applied to one side of a paper strip;

FIG. 2 is a similar schematic illustration showing the lamination of a polyethylene layer to the opposite side of the same paper strip;

FIG. 3 is a schematic illustration showing the employment of the thus produced material in conventional tube winding apparatus to form a spiral wound paper tube;

FIG. 4 is a greatly enlarged fragmentary transverse section of the paper tube thus formed; and

FIG. 5 is a fragmentary vertical section of a speaker illustrating the paper tube employed as a voice coil form.

Referring now more particularly to such drawing and especially to FIGS. 1 and 2, there is illustrated in FIG. 1 a strip of glassine paper **1**, which is a thin transparent or translucent paper made usually from digested pulp, such as sulphite pulp, by long continued beating and supercalendering. Such glassine paper can be held quite closely to thickness tolerances and in the illustrated embodiment, the thickness of the initial glassine strip is .001 inch. The top surface of the strip of glassine has applied thereto in liquid form a thermo-curing resin which will penetrate and seal the pores in the glassine paper strip. Such resin may be contained in a hopper **2** to pass through nozzles **3** onto the top surface of the glassine strip and a doctor blade **4** cooperating with a back up roll **5** may be employed to remove excess resin. As the glassine strip moves to the right as seen in FIG. 1 from beneath the doctor blade **4**, the top surface thereof will now be provided with a coating **61** of uncured thermo-setting resin which will penetrate the pores and which will not appreciably affect the .001 thickness of the glassine paper strip. The coated strip then moves into a tunnel evaporator and heater unit **7** which will raise the temperature of the glassine strip and the resin thereon to approximately 200° F. Although the tunnel evaporator and drier **7** will not completely cure the applied coating **6**, it will drive off solvents in the resin and remove the tackiness thereof so that the now coated strip of glassine may be wound in coil form as indicated at **8** for storage and transportation purposes.

The glassine paper strip **1** is thus treated on one side only with a sealant or penetrant of a thermo-curing nature which will enter the pores of the glassine and be thoroughly bonded thereto when set. The application of such sealant to the glassine renders one side thereof highly water resistant. As such thermocuring resin, it is preferred to use an epichlorohydrin-bisphenol condensate, commonly known as an epoxy resin. Although epoxy resins are preferred, other thermosetting resins may also be employed such as polyesters, phenol-formaldehydes, phenol-furfurals and urea formaldehydes. As a preferred epoxy sealant, Bostik 7008, manufactured by BB Chemical Company of Cambridge, Massachusetts, may be employed. Such thermosetting, synthetic resin contains a solvent which will be driven from the sealant in the tunnel evaporater **7** prior to the coated strip being wound in the coil **8**. The time required for the sealant properly to cure is, of course, dependent upon the temperature and such sealant will cure at room temperature over a relatively long period of time. In any event, before the next step in the described process, the sealant must be cured sufficiently to prevent the same from softening or becoming tacky upon a further application of heat.

After approximately no less than 24 hours, the now coated glassine strip is fed through a polyethylene extruder shown schematically at **10** in FIG. 2. The polyethylene which may be supplied from a hopper or screw

extruder **11** is heated to approximately 600° F. when it contacts the glassine strip **1** and the temperature of the polyethylene will further set the epoxy coating **6** which is now on the opposite side of the glassine strip **1**. When polyethylene is heated to such a temperature, it will immediately bond with the uncoated side of the glassine strip **1** and is in a tacky condition. The lamination of polyethylene and coated glassine paper is then passed through top and bottom chill rolls **12** and **13**, respectively, which will cool the layer of polyethylene thereon to eliminate tackiness so that the material can now be coiled in coil form as indicated at **14** for storage and shipment. It will, of course, be understood that the coating **6** on the bottom side of the glassine strip **1** in FIG. 2 must be sufficiently heat-cured so that it will not soften or otherwise be affected by the 600° F. temperature of the applied polyethylene on the opposite side of the strip. The thickness of the lamination of polyethylene on the glassine paper strip will be held to .0005 inch by application of approximately 7 pounds of polyethylene per ream of paper.

There is then produced in the coil **14** a material which comprises a strip of glassine paper **1** having a coating of thermo-cured epoxy resin **6** on one side and a lamination or layer of polyethylene **15** on the other side. Since the layer of polyethylene is .0005 inch thick, the total thickness of the material will be .0015 inch. The material is now slit into tapes approximately 1¼ to 1½ inches wide for tube winding.

Referring now to FIG. 3, there is illustrated a substantially conventional tube winding apparatus which comprises a smooth mandrel **17** about which two plies of the same thickness of such material **18** and **19** are spirally wrapped and lapped to form a two ply tube of such material. Such plies will be fed to the mandrel at a predetermined lead angle from spools of such tape. The plies will be drawn from the storage rolls by a winding belt (not shown) to form a spirally wound tube shown generally at **20**. Such tube will move longitudinally off the mandrel to be severed by a rotating flying knife **21** into short segment cylindrical forms shown at **22**. In conventional paper tube winding, adhesives are employed to hold the lapped plies together but in the present invention, the lamination of polyethylene on one side of the plies **18** and **19** will be employed to adhere the plies together to form an integrated two ply paper tube. The lead angle at which the plies are disposed with respect to the axis of the mandrel **17** may vary from 30° to 60° and such lead angle will be a factor in determining the speed at which the wound tube extends from the end of the mandrel **17**. The ply **18**, which is the first wound ply, will have the layer of polyethylene **15** on the exterior thereof as it is wound about the mandrel. Conversely, the ply **19** will have the layer of polyethylene **15** thereon interiorly as it is wound about the mandrel. The ply **19** thus overlaps the ply **18** and is the outer ply of the two ply paper tube thus formed.

In order to cause the respective layers of polyethylene **15** on the exterior and interior of the plies **18** and **19**, respectively, to bond or fuse together as the tube is wound, heating elements **24** and **25** which may be of the electrical type are positioned closely adjacent and yet spaced from the plies **18** and **19** on the side which carries the polyethylene. The distance between the heating elements and the plies will be closely controlled and to some degree, such spacing will be dependent upon the speed at which the tube is wound. The heating elements then soften the polyethylene to the point wherein the two layers of such polyethylene on the respective plies will then fuse into a single intermediate layer, shown at **27** in FIG. 4, not only firmly adhering the two plies together, but providing an intermediate layer in the tube thus formed of polyethylene which will make the tube water impervious. As the tube is wound, the tension on the winding belt and plies **18** and **19** will supply the required bonding pressure and when the polyethylene cools, the fusion has taken place firmly to secure the plies of the tube together. The tube is then severed into appropriate lengths for use as coil forms for speaker coils. It will be noted, that in order to maintain the inside and outside diameter tolerances of the tube, a butt joint providing a very minor gap between adjacent turns of the plies as indicated at **28** is utilized in order to avoid any lapping of the ply material. The inside ply will then be provided with a spiral gap seam which will be closed by the polyethylene. Similarly, the outside ply is provided with a spiral gap seam which will be axially offset from the seam in the inside ply as indicated at **29**.

There is now produced, as seen in FIG. 4, a short length cylindrical tube which may have a peripheral wall thickness of .003 inch. Reading from top to bottom or outside to inside as seen in FIG. 4, the tube wall is comprised of an external coating of epoxide resin **30** which has been heat-cured to provide a highly water resistant exterior coating. Such epoxide resin is penetrated into the pores of the glassine paper strip **31** which has interiorly bonded thereto a .0005 inch lamination of polyethylene which is now fused to the similar lamination of polyethylene on the ply **18** to form an intermediate lamination **32** within the tube which is now .001 inch thick. The intermediate lamination **32** is thus comprised of the .0005 inch thick laminate on both the exterior and interior plies. The interior glassine paper **33** has interiorly bonded thereto an epoxy coating **34** which may be identical in form to the coating **30**. Such epoxy coatings prevent humidity penetration and thus puckering of the glassine to maintain the proper dimensional thickness of the tube. The epoxy coatings may contain a dye since they are normally colorless. This then provides a visual indication that the coating has been applied and color coding is also then possible.

It is, of course, necessary that the epoxy coatings **30** and **34** for the tube be previously cured so that they will not soften or otherwise change in stability as the tapes pass adjacent the heating elements **24** and **25** heating the polyethylene laminate thereon to fusing temperature.

The short length tube **22** is then placed upon an expansible mandrel and may automatically be wound with a very small diameter wire such as .001 to .0005 inch to form the voice coil. The wire normally passes through an alcohol bath to soften the varnish or other insulation on the wire so that it will stick to the coil form. The wires are necessarily wound quite tight and may even indent the exterior surface of the coil form. Here again is a further advantage of the present coil form over aluminum foil forms in that the indentation of the exterior surface of the present coil form will facilitate the securance of the wires to the form.

In FIG. 5 there is illustrated somewhat schematically a P-M dynamic loudspeaker showing the coil form of the present invention in place. The voice coil **36** wound thereon surrounds a center pole piece **37** of a permanent magnet. The outer end of the form **22** is adhesively secured to the apex of the speaker cone diaphragm **38** and a spider or voice coil support **39** is also secured thereto. The permanent magnet will induce a magnetic flux, the path of which is shown by the arrows **40** and **41**. The air gap **42** around the outside of the voice coil **36** is intentionally maintained as small as possible and it can readily be seen that any variation in the diameter or any puckering of the coil form my close such gap and cause a malfunction or poor performance of the speaker. The outer edge of the cone diaphragm **38** is supported on a spider **43** in conventional manner.

It can now be seen that there is provided a speaker voice coil form which will provide the dimensional stability under adverse temperature and humidity conditions heretofore thought available only with metal foils such as aluminum. Moreover, the present coil form is lighter in weight and does not require the longitudinal slit for insu-

lation purposes. Such slit in aluminum foil coil forms often collects dust and even the most minute dust particle in such slit can impair the operation of the speaker. Furthermore, aluminum foil coil forms require very special and expensive tools to produce and must be heated to drive off oils therein which would otherwise preclude the varnish on the wire or other adhesive from adhering thereto. Finally, and perhaps most importantly, the dimensional stability of the coil form of the present invention permits the coil to be machine wound on an expansible mandrel rather than hand wound as was heretofore the case in high quality speakers especially of the smaller variety such as tweeters. In any event, a more economical, higher quality and longer life speaker is thus afforded.

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features stated in any of the following claims or the equivalent of such be employed.

We, therefore, particularly point out and distinctly claim as our invention:

1. A speaker voice coil form comprising an outer ply of glassine paper, an external coating of thermosetting resin thereon, an internal ply of glassine paper, an inner layer of heat sealable polyethylene on said outer ply of glassine paper bonded to an outer layer of heat sealable polyethylene on said internal ply of glassine paper, and a coating of thermosetting resin on the interior of said coil form on the inner ply of glassine paper.

2. The method of making a speaker voice coil form and like tubular products comprising the steps of applying a thermosetting resin sealant to one side of a glassine paper strip, heat-curing said thermosetting resin, laminating a heat sealable polyethylene to the opposite side of such strip, spirally winding two plies of such strip material with the heat sealable polyethylene therebetween, heating such polyethylene to bond such plies together, and cutting

the thus formed spirally wound tube to form the speaker voice coil form.

3. The method of making a speaker voice coil comprising the steps of applying a thermosetting resin to one side of a glassine paper strip, heat-curing such resin, applying a layer of heat sealable polyethylene to the opposite side of such strip, spirally winding two plies of such strip on a mandrel with the heat sealable polyethylene therebetween to form a spirally wound glassine paper tube, heating such polyethylene to bond such plies together, and severing such tube to form a short length coil form.

4. The method set forth in claim 3 including the step of mounting said form on an expansible mandrel and winding a wire coil on said form.

References Cited by the Examiner

UNITED STATES PATENTS

2,029,525	2/1936	Ellis	117—155
2,180,420	11/1939	Larsen	336—198
2,181,160	11/1939	Shankweiler	117—153
2,354,574	7/1944	Carson	117—155
2,677,165	5/1954	Copenhaver et al.	138—44 X
2,789,075	4/1957	Stahl	156—191 X
2,803,560	8/1957	McIntyre et al.	117—153 X
2,858,248	10/1958	Hastings et al.	161—165
2,899,655	8/1959	Forte et al.	336—198
2,972,804	2/1961	Ellis	200—155.57
2,974,401	3/1961	Zwelling	29—155.57
3,003,903	10/1961	Vaughan	161—165
3,037,529	6/1962	Hancik	174—110.44

LEWIS H. MYERS, *Primary Examiner.*

JOHN F. BURNS, ROBERT K. SCHAEFER, *Examiners.*

T. J. KOZMA, *Assistant Examiner.*