

Dec. 18, 1962

J. H. COLEMAN

3,069,283

POLYMERIZING METHOD AND APPARATUS FOR CARRYING OUT THE SAME

Filed Feb. 2, 1959

4 Sheets-Sheet 1

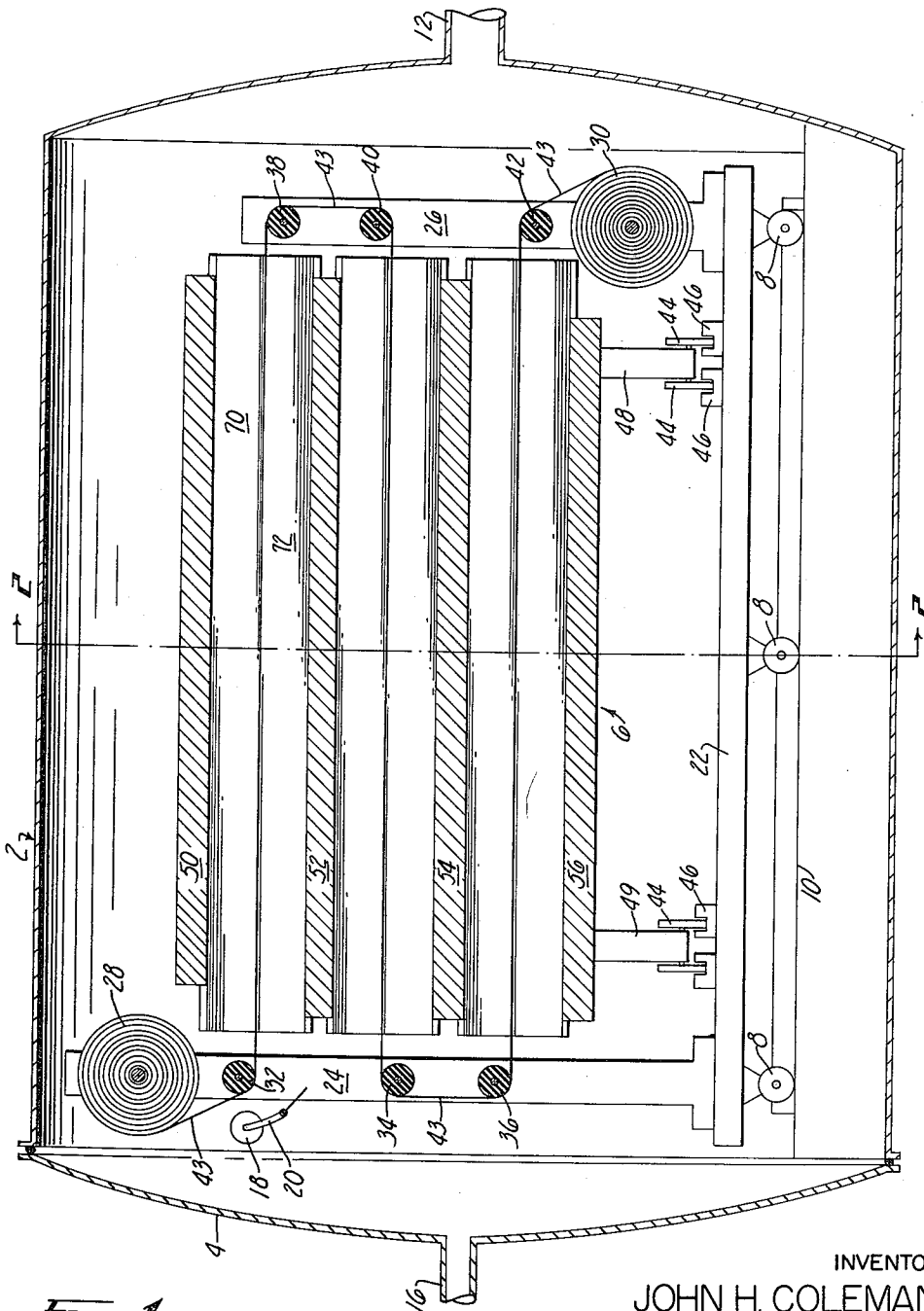


Fig. 1

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4 Sheets-Sheet 2

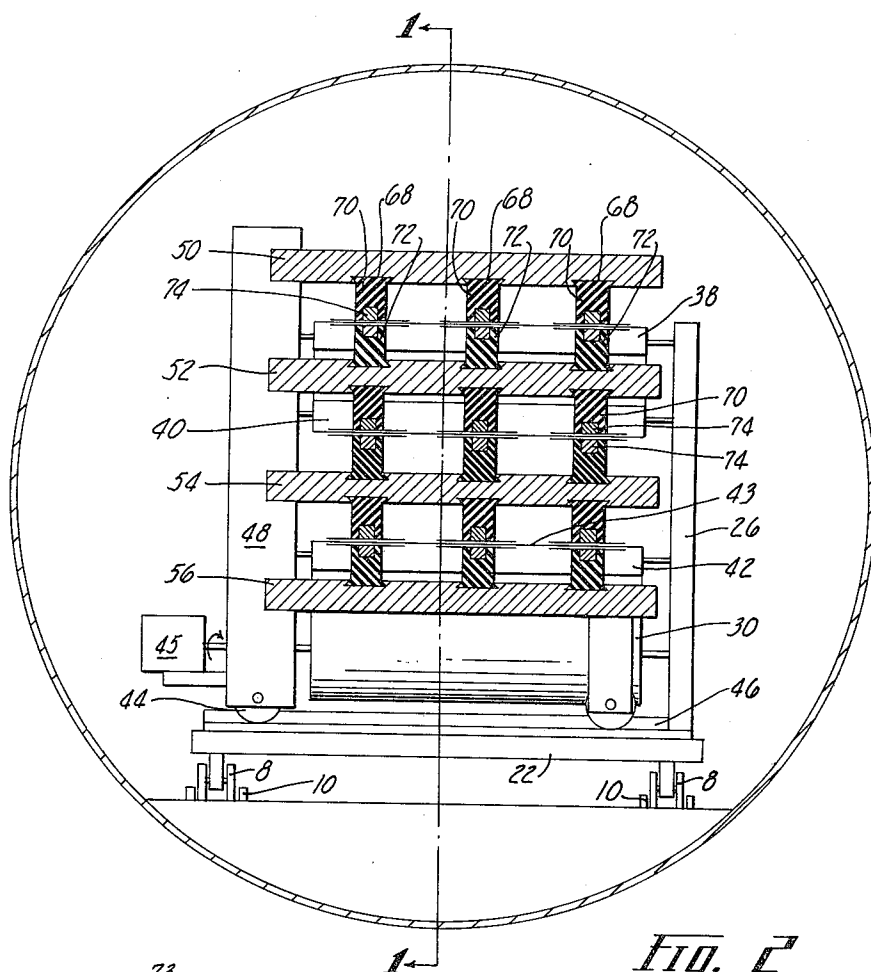


Fig. 2

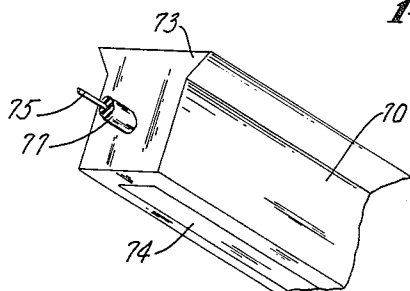


Fig. 3A

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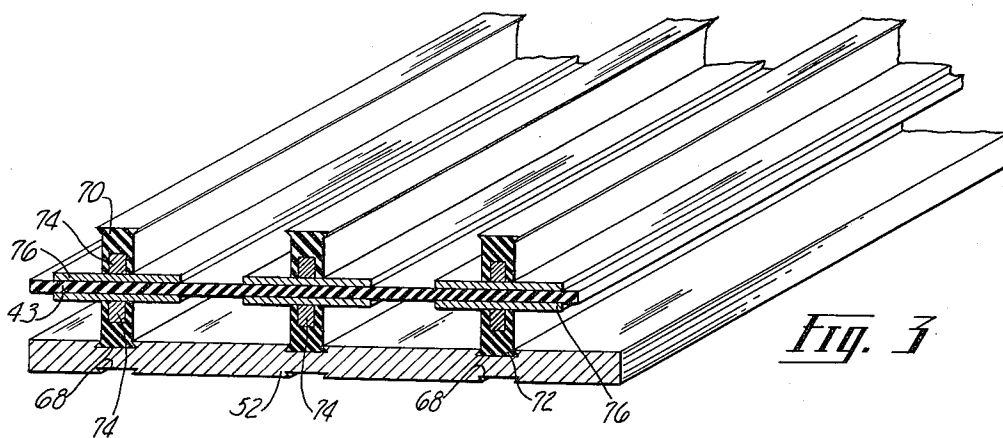


Fig. 3

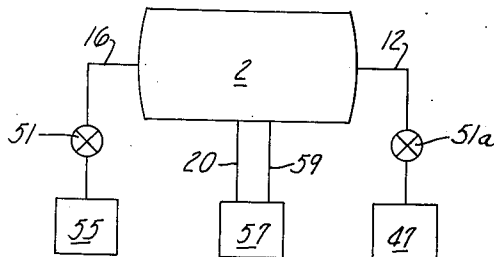


Fig. 4

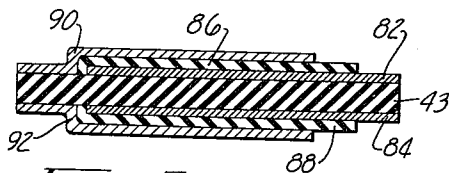


Fig. 5

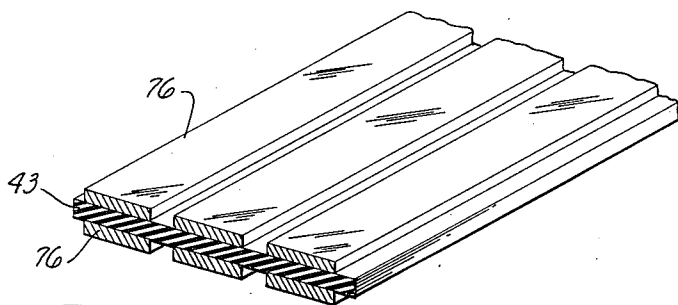


Fig. 6

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4 Sheets-Sheet 4

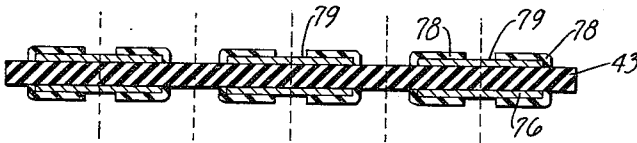


Fig. 6

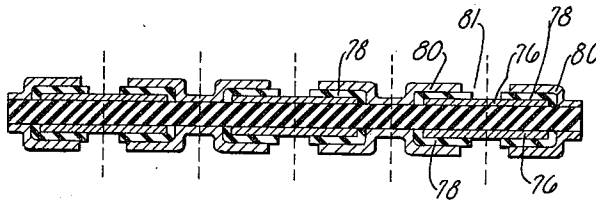


Fig. 7

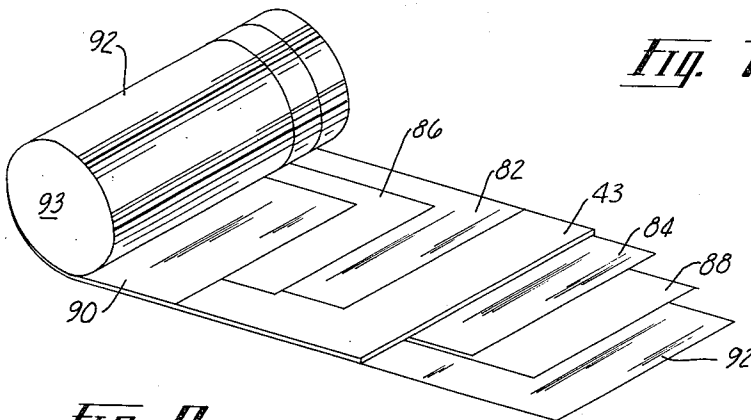


Fig. 9

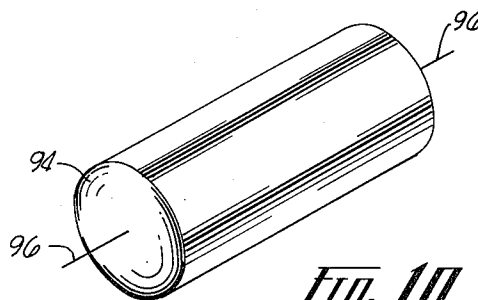


Fig. 10

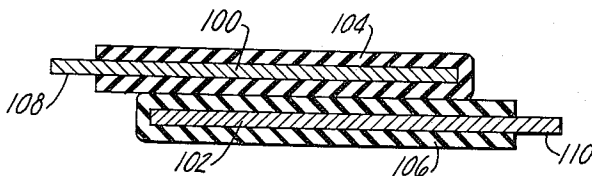


Fig. 11

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POLYMERIZING METHOD AND APPARATUS FOR CARRYING OUT THE SAME

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12 Claims. (Cl. 117—4)

This invention relates to new and improved electrical subcomponents and to new and improved methods and apparatus for their production. More specifically, the invention relates to capacitive subcomponents employing gas discharge polymerized dielectrics and having utility as elements in capacitors, transmission lines, and the like.

U.S. patent application Serial No. 593,907, filed in the name of Jerome Goodman on June 26, 1956, now Patent No. 2,932,591, and entitled "Dielectric Coated Electrodes," describes a new, highly compact, capacitive subcomponent and a process for its manufacture in which one of the subcomponent electrodes was provided with a gas discharge polymerized layer of dielectric material having a thickness on the order of 1.0 micron and a second electrode was then located on the dielectric. The aforesaid thin dielectric film was the product of polymerization of one or more vaporous or gaseous monomers on an electrode brought about by the action of a gas discharge which ionized the vaporous monomer or fractions thereof and transported the ionized material to the electrode surface where polymerization into thin films took place. Following deposition of the thin film on the electrode surface, the dielectric coated electrode was removed from the polymerization apparatus and, in one form of capacitive component, provided with a superimposed, conductive layer by metallizing.

Capacitive subcomponents produced according to the above method have particular advantage over other units of similar configuration because of the high capacitance to volume ratios they afford while maintaining high electrical quality. However, they are expensive because of the labor costs involved in unit or batch processing.

It is an object of this invention to provide an economical method and an apparatus for producing capacitive subcomponents utilizing gas discharge polymerized dielectric films.

It is still another object of the invention to provide an apparatus for use in plasma-phase polymerizing large areas of thin dielectric material on suitable conductive surfaces.

Still another object of the invention is the provision of a method and an apparatus for carrying out the method in which selected portions of conductive surfaces are covered with dielectric in a plasma-phase polymerization process while leaving other portions uncoated.

These objects and others which will become apparent from the following specification and claims are achieved in the invention by continuously moving a flexible dielectric substrate having a conductive band upon its surface through an atmosphere of monomer vapor which is subjected to the action of a gas discharge while a potential is applied to the band to cause polymerization of the ionized vapor on the surface thereof. According to one aspect of the invention, the conductive band is continuously contacted by means of suitably disposed contact surfaces along its path of travel during the polymerization process and a portion of the band is shielded from the action of the polymerizing discharge so as to prevent the formation of a dielectric film thereon. In a preferred embodiment of the invention, contacting and shielding functions are performed simultaneously by a contacting electrode having a dielectric covering which both prevents the striking of a discharge to the contacting electrode and shields portions of the conductive band on

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which thin film deposition is not desired. According to another feature of the invention, the production rate of the process is enhanced by employing a plurality of conductive bands disposed parallel to the length of the substrate, each band being individually contacted and shielded by means of its own contacting structure. The assembly of parallel conductive bands, each provided with a coating of thin dielectric film is then provided, as by metallizing, with individual conductive bands. The plural, parallel capacitive subcomponents so formed are then separated from one another to produce individual, capacitive units suitable for fabrication into capacitors, transmission lines, or other, like, electrical components.

Reference is now made to the drawings in which:

FIG. 1 is a side view in cross-section of an apparatus for polymerizing parallel layers of dielectric film on a moving, flexible dielectric substrate;

FIG. 2 is an end view in cross-section of the apparatus of FIG. 1;

FIG. 3 is a perspective view in partial cross-section of a portion of the apparatus of FIGS. 1 and 2 and showing greater detail;

FIG. 3a is a perspective view of an end portion of a shielded contacting electrode useful in the apparatus of FIGS. 1, 2 and 3;

FIG. 4 is a schematic representation of the processing equipment assembly;

FIG. 5 is a view in cross-section of a dielectric substrate of exaggerated thickness provided with conductive bands and ready for use in the apparatus of FIGS. 1 and 2;

FIG. 6 is a view in cross-section of the dielectric substrate of FIG. 5 after vapor phase polymerization in the apparatus of FIG. 1;

FIG. 7 is a view in cross-section of the substrate of FIG. 5 after polymerization and metallizing;

FIG. 8 is a view in cross-section of a single capacitive subcomponent configuration produced according to the teachings of the invention;

FIG. 9 is a view of a partially rolled capacitor employing the subcomponent of FIG. 7;

FIG. 10 is a perspective view of a completed capacitor according to the teachings of the invention; and

FIG. 11 illustrates an alternative form of capacitive subcomponent produced according to the teachings of the invention.

Referring now to FIGS 1 and 2, an apparatus useful for producing capacitive subcomponents according to the teachings of the invention is provided with vacuum chamber 2 having a removable vacuum tight door 4 at one end through which polymerizer assembly 6 may be carried on wheels 8 travelling on tracks 10. Chamber 2 is provided at its closed end with exhaust pipe 12 for connection as shown in FIG. 4 to evacuation equipment capable of producing a vacuum within the chamber of 10^{-4} millimeters of mercury or better. Access is also provided to the space within vacuum chamber 2 by means of monomer supply pipe 16 through which the vaporous or gaseous monomer to be polymerized may be supplied. Provision is also made by means of an electrically insulated compression seal 18 in the wall of chamber 2 for introducing electrical conductor 20 to supply electrical energy for the polymerizing discharge.

As previously indicated, continuous polymerizing apparatus 6 is adapted for insertion and removal from vacuum chamber 2 by means of movable base plate 22 which carries polymerization apparatus 6. Base plate 22 is provided at either end with uprights 24 and 26 which carry substrate supply and take-up reels 28 and 30, respectively. Also journaled in uprights 24 and 26 are idler rollers 32, 34, 36, 38, 40 and 42 which serve as

guides for reversing the direction of travel of substrate 43 in its passage between successive discharge electrodes. Centrally disposed between uprights 24 and 26 and carried on rollers 44 in transverse tracks 46 on bed plate 22 are vertical electrode supports 48 and 49 which receive horizontal electrodes 50, 52, 54 and 56. As will best be seen in FIG. 2, the vertical portions of supports 48 and 49 are positioned to one side of the path taken by the dielectric substrate in its course back and forth between the idler rollers. Electrodes 50, 52, 54 and 56 are centered into the spaces between the paths taken by the substrate during its passes between idler rollers 32-42 and serve both to provide discharge sustaining surfaces and, by means of longitudinal mortised grooves 68, as means for positioning dielectric contact electrode supports 70 and 72. The relationship of these elements and the manner in which they cooperate during operation of the apparatus may be understood by reference to FIGS. 3 and 3a.

Electrode holders 70 and 72 are conveniently made of the dielectric material known as "Teflon" (polytetrafluorethylene) and are of an elongated, rectangular configuration, having tenon-like projecting portions 73 (FIG. 3a) keyed to fit into the mortise-like indentations 68 of the opposing surfaces of electrodes 50, 52, 54 and 56. Paired electrode holders 70 and 72 project inwardly from opposing adjacent surfaces of electrodes 50, 52, 54 or 56, as the case may be, to embrace dielectric substrate 43 from opposite sides. Elongated contact bars 74 are recessed in each electrode holder, each bar 74 having a surface flush with the substrate embracing surface of its holder. FIG. 3a shows the manner in which all but one surface of the individual contact bar is surrounded by the dielectric material of its support holder so that, when contact is made with the substrate, the contact bar is effectively shielded from the action of the monomer.

Electrical connection of contact bars 74 to electrical input conductor 29 is made by individual contactor connecting leads 75 in a manner well known in the art. Each contactor connecting lead 75 is provided with insulating coating 77 and the joints (not shown) with conductor 20 are wrapped with insulating material so as to prevent the striking of gas discharges to exposed portions thereof. Insulated leads 75 are closely fitted through the wall of dielectric support body 70 so as to prevent the occurrence of discharge supporting paths.

FIG. 4 shows the manner in which vacuum chamber 2 is connected to the auxiliary equipment necessary for the continuous polymerization operation. Vacuum pump 47 is connected to exhaust line 12 on vacuum chamber 2 through valve 51a and monomer gas or vapor is supplied through valve 51 from container 53. When tetrafluorethylene is being used, for example, container 55 may contain the polymer and it may be heated to drive off vaporous monomer. Electrical energy for polymerization is supplied to the apparatus by conductors 29 and 59, energized by power supply 57. In the preferred embodiment of the invention, alternating current is used, the power supply being capable of outputs of as much as 450 volts and currents of at least 5 milliamperes per square inch of conductive substrate being acted upon. It will be understood that the operating voltage required is a function of monomer pressure within polymerization chamber 2 and that, by suitable choice of conditions, operation at lower voltages than that specified above may be achieved.

A portion of a dielectric substrate having plural conductive surface bands and suitable for use in the apparatus of FIGS. 1 and 2 is shown in FIG. 5. The dielectric substrate 43 proper may be any convenient flexible dielectric sheet material having thickness and strength characteristics adapted to meet the particular requirements of the end product. "Mylar" (polyethylene terephthalate) and "Teflon" (polytetrafluorethylene) are materials which are particularly suitable for use in the fabrication of

high quality components. Mylar may be used in thicknesses down to .00025 inch (the thinnest commercially available) and Teflon in thicknesses down to 0.0005 inch. Thinner Teflon films may be used, but are somewhat porous and have a tendency to stretch, a characteristic which is undesirable where the substrate is to be placed under tension. In the preferred embodiment of the invention, both of the surfaces of dielectric substrate 43 are provided with one or more bands 76 of conductive material running the length of the substrate, the width and spacing of the individual bands being chosen according to the requirements of the particular end product being fabricated, as will be apparent to those skilled in the art. In the illustrative embodiment of the invention, where the end use of the capacitive subcomponents will be rolled capacitors, conductive bands 76 may be made of aluminum applied by vapor deposition in thicknesses suitable to produce resistivities of the order of one ohm per square. This coating procedure is well known in the art.

A roll 23 of dielectric substrate thus provided with conductive bands is positioned in the polymerization apparatus and threaded between electrodes 52 to 56 with each conductive band 76 sliding between opposing, exposed surfaces of shielded contact electrodes 74 as shown in FIG. 3. During polymerization the substrate is moved from roll 23, between the stationary electrodes, to spool 30 and the coated substrate takes the form illustrated in FIG. 6. Motive power for drawing the substrate through the electrodes and winding it onto reel 30 is supplied by means of motor 45 (FIG. 2). The thickness of dielectric coating gas discharge polymerized on conductive bands 76 of dielectric substrate 43 depends, as will be understood, upon the rate of travel of substrate through the polymerizer and upon the rate of deposition of film. By varying the speed of motor 45 and the current supplied to the gas discharge by power supply 57, operation of the apparatus may be controlled to give the desired film thickness at the maximum rate. Films ranging in thickness up to 2 microns and greater can be produced with substrate residence times of about 5 minutes in the discharge when pyrolyzed tetrafluorethylene pressures of about 1 mm. Hg. are employed. When the apparatus is operated in this manner, the gas discharge which occurs may be characterized as a glow discharge, since large, diffuse regions of ionization exist in the spaces between the stationary electrodes and the conductive substrate surface.

Referring again to FIG. 6, it will be noted that central portions 79 of the surfaces of conductive bands 76 are left free of gas discharge polymerized dielectric 78 as a consequence of the shielding provided by the combined effect of dielectric electrode support 70, for example, and its associated electrode 74. It will be understood that widths of central gap portions 79 and their positions relative to the edges of conductive bands 76 may be varied at the will of the user by providing stationary electrodes having the desired contact electrode support spacings, so as to vary the product mix in a given run.

After completion of polymerization, reel 30 may be removed from chamber 2 and provided with additional bands 80 of conductive material as shown in FIG. 7. Where, as in the illustrative embodiment, the polymerized product is intended for use in capacitors, the added coating is preferably aluminum, produced by well understood vapor deposition processing and of a thickness having a resistance suitable for capacitor clearing. As shown in FIG. 7, gaps 81 are provided between conductive bands 80 at positions corresponding to gaps 79 previously provided in the gas discharge polymerized coatings. Gaps 81 are somewhat wider than gaps 79 and thus leave marginal surface portions of dielectric films 78 free of conductive material. In this way the creation of conductive paths to the exposed portions of conductive bands 76 is avoided.

The plurality of capacitive subassemblies of FIG. 7 are then divided, as by slitting, along the vertical dashed

lines shown in FIG. 7. The elongated subassemblies so produced may then be cut into shorter lengths to produce individual capacitive subassembly structures having cross-sections such as shown in FIG. 8. As shown in FIG. 8, a completed capacitive subassembly may comprise a tape-like structure having parallel, oppositely disposed conductive bands 82 and 84 bonded to opposite surfaces of dielectric substrate 43. Conductive bands 82 and 84 are of aluminum, having resistivities of the order of one ohm per square and substrate 43 is of .00025 inch sheet Mylar. Conductive bands 82 and 84 extend to one edge of dielectric substrate 43 and are spaced back from the opposite edge to leave uncoated, marginal portions adjacent to that edge. Thin Teflon films 86 and 88, gas discharge polymerized as described above, overlie a major portion of metallized electrodes 82 and 84 and extend marginally onto the adjacent, unmetallized portions of dielectric substrate 43. Marginal portions of conductive bands 82 and 84 are left free of thin film dielectric at the opposite edge of dielectric substrate 43 to provide exposed electrical contact surfaces in the rolled capacitor. Finally, the capacitive subassembly includes external conductive bands 90 and 92 which may also be of one ohm per square aluminum and which extend laterally from the otherwise unmetallized edge of dielectric substrate 43 onto thin films 86 and 88. The second edge of substrate 43 thus serves as a second connective base for making connection to the rolled capacitor. It will be noted that, since conductive layers 90 and 92 do not extend all of the way across dielectric layers 86 and 88 into contact with conductive layers 82 and 84, short circuiting of the capacitor is avoided.

FIGS. 9 and 10 illustrate how the capacitive subassembly of FIG. 8 may be rolled and formed into a capacitor. In FIG. 9 the various layers of a partially rolled capacitive subassembly are peeled back from one another to illustrate the manner in which the various subassembly layers meet one another and so cooperate in a finished capacitor. Since corresponding conductive bands and thin dielectric layers extend across the dielectric substrate in the same direction and for the same distances, corresponding members from opposite sides of the capacitive subassembly meet each other during the rolling process. Thus, outer conductive bands 92 and 90 come back to back with each other as do the exposed, projecting portions of dielectric films 86 and 88 and inner conducting bands 82 and 84 and the separate capacitors on opposite sides of the substrate are thus connected in parallel with each other by juxtaposition of corresponding electrodes. When the capacitive subassembly has been completely rolled, the flat end portions of the cylinders so formed may be conventionally sprayed with metal to form metallized end surfaces 94 (FIG. 10) for receiving soldered pigtail leads 96. The metal spray coating of terminal surfaces 94 thus serves as both a mechanical and an electrical bond. The completed capacitor assembly may then be encased in any manner well known in the art. Capacitors so produced have extremely high capacitance to volume ratios, are readily cleared of imperfections, and have high resistivities and low power factors.

The method and apparatus described above may readily be employed to provide thin dielectric coatings of thicknesses heretofore unknown in structures other than the one shown above, as will be clear to those skilled in the art. For example, the substrate need be coated on one side only, this being readily accomplished by providing conductive surfacing on one side of the substrate only. Alternatively, metal substrates may be dielectric coated on one or both sides. A section of a capacitor structure employing metal substrates is shown in FIG. 11.

The capacitor section of FIG. 11, as will readily be understood, represents a section of a capacitor having two dielectric coated conductive strips 100, 102. Strips 100 and 102 are coated on both sides and one edge, the

coating having been gas discharge polymerized on a single sheet of metal substrate. For this particular structure it is convenient to coat both sides of a double width of foil, leaving central strips uncoated, and then to slit the foil down the uncoated center portion. In order to assure the polymerization of an adequate insulating coating on the edges of the double width foil, it is desirable that the stationary electrodes of the polymerization apparatus be somewhat wider than the foil so as to encourage deposition on the foil edges. The foil need only be sufficiently thick to provide desired tensile strength and ease of handling in the processing apparatus. Stainless steel, .00025" in thickness and aluminum foil .001 inch in thickness, may be used, for example. As before, the dielectric coatings 104, 106 may be of gas discharge polymerized tetrafluorethylene of the desired thickness.

In assembling the capacitive subcomponent of FIG. 11, the coated strips 100, 102 are displaced laterally with respect to each other so as to project the uncoated, slitted edge portions 108 and 110 beyond the overlapping dielectric covered portions. Convenient surfaces are thus provided in the rolled unit for electrical connection by the metal spray bonding process described above. Rolled capacitors produced by using metal foils coated on both sides are preferable to those which use coatings on only one side since two thicknesses of dielectric are used between electrodes of unlike polarity and the likelihood of imperfections occurring at coincident locations is minimized.

While the invention has been described in particularity as applied to the production of specific types of capacitive subcomponents useful in rolled capacitors, it will be apparent to those skilled in the art that it may readily be used for the coated conductive foils of many descriptions having many other uses. It will similarly be apparent that many materials other than those specified may be employed. For example, the monomers of most dielectric polymers, if supplied to the apparatus in vapor or gaseous form at a pressure suitable for the maintenance of a gas discharge, may be substituted for tetrafluorethylene, many organic and inorganic materials, such as styrene, boron trifluoride, etc. may be used. Similarly other conductive materials may be substituted for those specified, and many materials are suitable for use as coating receiving substrates. Accordingly, it is intended that the below appended claims be interpreted in keeping with the spirit of the invention rather than limited to the specific embodiments described herein.

I claim:

1. The method of forming a polymerized coating, comprising advancing successive portions of an elongated member in an interaction space along a path spaced from an electrode by a distance across which a gaseous glow discharge is maintainable in an atmosphere of a polymerizable gaseous medium, establishing an atmosphere of said polymerizable gaseous medium for sustaining a gaseous glow discharge in said interaction space, initiating a gaseous glow discharge in said medium in the region of said interaction space between a leading portion of said elongated member and said electrode, and continuing to advance successive portions of said elongated member through said region of said interaction space while maintaining said atmosphere and controlling the current of said gaseous glow discharge to continuously form a solid coating of polymerized particles of said medium along said successive portions of said elongated member.

2. The method of forming a polymerized dielectric coating, comprising establishing a low pressure atmosphere of an ionizable polymerizable material in an interaction space, advancing an elongated member along a path in said interaction space, initiating a gaseous glow discharge in said interaction space to form ionized particles of said material by means of a voltage applied across a portion of said interaction space in a direction to cause ionized particles of said material to move toward said advancing elongated member, and maintaining said atmosphere while

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controlling the current of said gaseous glow discharge and advancing said elongated member all at a rate to form a polymerized electrically highly resistive continuous dielectric coating of said material along said elongated member.

3. The method of forming a dielectric coating, comprising establishing and maintaining a low pressure atmosphere of an ionizable polymerizable material in an interaction space, moving an elongated sheet-like conductor so that successive longitudinally extending portions thereof advance along a path in said interaction space spaced from an electrode, applying a voltage between said electrode and said portions of said moving conductor to initiate and sustain a gaseous glow discharge in said interaction space between said electrode and said moving portions of said conductor and thereby form an ionized medium of particles of said material, and continuing to advance said conductor along said path while controlling the current of said gaseous glow discharge at a rate to provide deposition of a continuous dielectric coating on said conductor formed from polymerization of said material particles thereon.

4. The method of forming a dielectric coating of a polymer, comprising establishing a gaseous glow discharge sustaining atmosphere of an ionizable polymerizable material in an interaction space, moving an elongated sheet-like member having a conductive surface so that successive longitudinally extending portions of said conductive surface advance along a path spaced from an electrode, applying a voltage between said electrode and said conductive surface to initiate a gaseous glow discharge in said interaction space, continuing to advance said sheet-like member while controlling the current of and confining said gaseous glow discharge to preselected portions of said conductive surface so that a continuous dielectric coating of a polymer formed from said atmosphere is deposited on said preselected portions of said conductive surface.

5. The method of forming dielectric coatings of a polymer, comprising establishing a low pressure atmosphere of an ionizable polymerizable material in an interaction space, forming an elongated dielectric substrate with a plurality of spaced conductive bands extending longitudinally therealong, advancing said dielectric substrate along a path in said interaction space spaced from an electrode, applying a voltage between said electrode and each of said conductive bands and initiating a gaseous glow discharge for ionizing particles of said polymerizable material between said electrode and successively advancing portions of each of said conductive bands, and continuing to advance said substrate along said path while controlling the current of said gaseous glow discharge and maintaining said atmosphere to deposit a continuous dielectric coating along each of said conductive bands.

6. The method of forming capacitive subassemblies, comprising establishing a gaseous glow discharge sustaining atmosphere of an ionizable polymerizable material in an interaction space, advancing along a path in said interaction space an elongated sheet-like dielectric substrate having a plurality of elongated spaced conductive bands extending longitudinally therealong with successive portions of said conductive bands passing in spaced relation to an electrode, applying a voltage between said electrode and each of said conductive bands and initiating a gaseous glow discharge for ionizing particles of said polymerizable material between said electrode and the successively advancing portions of said conductive bands, continuing to advance said substrate along said path while controlling the current of said gaseous glow discharge and maintaining said atmosphere all at a rate to deposit a continuous dielectric coating along each of said conductive bands, shielding a longitudinally extending portion of each of said conductive bands from said gaseous glow discharge to prevent the formation of a coating thereon, and forming another conductive band on the dielectric coated portions of said first-mentioned conductive bands.

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7. The method of forming a capacitive subassembly, comprising establishing a gaseous glow discharge sustaining atmosphere of an ionizable polymerizable material in an interaction space, advancing along a path in said interaction space an elongated sheet-like dielectric substrate having a plurality of elongated spaced conductive bands extending longitudinally therealong with successive portions of said conductive bands passing in spaced relation to an electrode, applying a voltage between said electrode and each of said conductive bands and initiating a gaseous glow discharge for ionizing particles of said polymerizable material between said electrode and the successively advancing portions of said conductive bands, continuing to advance said substrate along said path while controlling the current of said gaseous glow discharge and maintaining said atmosphere all at a rate to deposit a continuous resistive dielectric coating along each of said conductive bands, shielding a central longitudinally extending portion of each of said conductive bands from said gaseous glow discharge to prevent the formation of a coating thereon, forming another conductive band on the dielectric coated portions of said first-mentioned conductive bands, and parting the thus treated substrate along lines extending along the uncoated portions of said first-mentioned conductive bands.

8. Apparatus for forming a polymerized coating, comprising means forming a vacuum chamber, defining an interaction space, means for advancing an elongated member in said vacuum chamber so that longitudinally extending portions of said elongated member pass in succession along said path, means for introducing an atmosphere of polymerizable material into the interaction space of said vacuum chamber and for maintaining said atmosphere at subatmospheric pressure, and means including an electrode extending along and spaced across a portion of said interaction space from said path for applying a voltage and for controlling the current across said portion of said interaction space to cause ionization of particles of said polymerizable material and initiation of a gaseous glow discharge successively along the advancing portions of said elongated member.

9. Apparatus for forming a polymerized dielectric coating, comprising means forming a vacuum chamber defining an interaction space, means for introducing and maintaining a low pressure atmosphere of a polymerizable material in said interaction space, a supply of dielectric substrate having an elongated conductive surface extending longitudinally therealong and means for withdrawing and advancing said dielectric substrate along a path in said interaction space so that longitudinally extending portions of said conductive surface pass in succession along said path, and means including an electrode extending along and spaced from said path for applying a voltage across said electrode and said conductive surface and for initiating and controlling the current in a gaseous glow discharge in said interaction space between said electrode and successive portions of said conductive surface as they pass along said path, whereby ionized particles of said material are formed and deposited on said successive portions of said conductive surface and polymerize thereon to form a solid resistive dielectric coating.

10. Apparatus for forming a polymerized dielectric coating, comprising means forming a vacuum chamber defining an interaction space, means for introducing and maintaining a gaseous glow discharge sustaining atmosphere of a polymerizable material in said interaction space, a supply of a dielectric substrate having an elongated conductive surface extending longitudinally therealong and means for withdrawing and advancing said dielectric substrate along a path in said interaction space so that longitudinal portions of said conductive surface pass in succession along said path, an elongated first electrode extending along said path in position for sliding engagement with the surface of said

successive portions of said conductive surface, an elongated second electrode extending along said path in opposed spaced face-to-face relation with said successive portions of said conductive surface as the latter advance along said path, means for applying a voltage across said first and second electrodes and for initiating and controlling the current in a gaseous glow discharge in said interaction space between said successive portions of said conductive surface and said second electrode, means for isolating said first electrode from said discharge, and said first electrode serving to isolate and shield a portion of said conductive surface from said discharge and thereby prevent the formation of a coating thereon.

11. Apparatus for forming a polymerized dielectric coating, comprising means defining an interaction space, means for introducing and maintaining a gaseous glow discharge sustaining atmosphere of a polymerizable material in said interaction space, a supply of dielectric substrate having a plurality of laterally spaced elongated conductive surfaces extending longitudinally therealong and means for withdrawing and advancing said dielectric substrate along a path in said interaction space so that longitudinal portions of said conductive surfaces pass in succession along said path, a plurality of elongated first electrodes each extending along said path in position for sliding engagement with the surface of said successive portions of one of said conductive surfaces, an elongated second electrode extending along said path in opposed spaced face-to-face relation with said successive portions of said conductive surfaces as the latter advance along said path, means for applying a voltage across said first electrodes and said second electrode and for initiating and controlling the current in a gaseous glow discharge in said interaction space between said successive portions of said conductive surfaces and said second electrode, means for isolating said first electrodes from said discharge, and said first electrodes each serving to isolate and shield a portion of the conductive surface associated therewith from said discharge and thereby prevent the formation of a coating thereon.

12. Apparatus for forming a polymerized coating, comprising means defining an interaction space, means for advancing an elongated member along a path in said interaction space so that longitudinally extending portions of said elongated member pass in succession along said path, means for introducing a gaseous glow discharge supporting atmosphere of polymerizable material into said interaction space, a pair of electrically conducting elements supported in spaced relation in said interaction space, said elongated member advancing through said interaction space along said path adjacent one of said elements, means for controlling the current between and for applying a gaseous glow discharge sustaining potential difference to said elements for maintaining an ionizing gaseous glow discharge in said atmosphere to said advancing portions of said elongated member for ionizing particles of said polymerizable material whereby said ionized particles are deposited and polymerized on the successively advancing portions of said elongated member.

UNITED STATES PATENTS

References Cited in the file of this patent

1,784,611	Polanyi et al.	Dec. 9, 1930
2,258,218	Rochow	Oct. 7, 1941
2,425,652	Starkey	Aug. 12, 1947
2,551,035	Miller	May 1, 1951
2,650,565	Spooner	Sept. 1, 1953
2,728,693	Cado	Dec. 27, 1955
2,734,478	Reynolds et al.	Feb. 14, 1956
2,740,928	Ward	Apr. 3, 1956
2,754,230	McLean et al.	July 10, 1956
2,759,854	Kilby	Aug. 21, 1956
2,793,970	Jeppson	May 28, 1957
2,797,373	Peck	June 25, 1957
2,932,591	Goodman	June 10, 1958

FOREIGN PATENTS

746,179	Great Britain	Mar. 14, 1956
558,514	Canada	June 10, 1958