

PATENT SPECIFICATION

(11) 1281326

DRAWINGS ATTACHED

- (21) Application No. 1818/70 (22) Filed 14 Jan. 1970
 (45) Complete Specification published 12 July 1972
 (51) International Classification H01B 7/18//3/42, 3/18
 (52) Index at acceptance
 H1A 2E3D2 4B
 B2E 179 192 19Y 20Y 339 443 444 446 44Y 452 453
 454 455 456 457 467 479 498 510 51X 598 653
 656 657 65Y 662 663 664 665 666 677 689 708
 720 72X 74Y 768
 (72) Inventors RALPH W. HALL, ERNEST C. KOERNER and
 ROBERT T. TRICE



(54) A BONDABLE MAGNET WIRE AND BONDABLE PRODUCT

(71) We, PHELPS DODGE MAGNET WIRE CORPORATION, a corporation of the State of Delaware, United States of America, of 1302 East Creighton Avenue, Box 600, Fort Wayne, Indiana, United States of America, do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

Bondable magnet wires have long been used. Such wires may be arranged in all kinds of shapes and configurations, thick or thin, and bonded together by applying either solvent or heat to the magnet wire to soften the outer portion thereof and thereby to bond adjacent wire portions together.

Such magnet wires are conventionally referred to as "self-bonding magnet wire". The resultant product made in accordance with this technique in many instances is superior to that formed of conventional magnet wire and bonded together by varnish impregnation techniques, where the penetration of the varnish depends upon the thickness of the coil and the tightness of the winding.

The earliest use of bonding compositions on magnet wire was the use of magnet wire insulated with conventional black enamel "oleoresinous" insulation and having an outer coating of cellulose-acetate lacquer in the manufacture of self-supporting bonded electric coils, for example, voice coils for radios. Such coils were formed into a coil and treated with a solvent, such as acetone, to soften the resin and to bond adjacent portions of the wire together. However, the application of either acetone or heat to soften the cellulose-acetate lacquer was found to soften also the black enamel used underneath, causing shorts.

These deficiencies in black enamel lacquered magnet wire led to the wide-spread adoption of other bonding compositions. The most

frequently used bonding composition is a polyvinyl butyral resin, such as that sold under the Trademark "BUTVAR", by Monsanto Company. High molecular weight phenoxy formulations, such as the "Eponol" phenoxy resins sold by Shell Chemical Company are also used by some manufacturers.

One commercially available bondable magnet wire comprises a coating of polyvinyl butyral bonding composition over a base insulation of phenolic modified polyvinyl formal resin material, such as that sold under the Trademark "FORMVAR" by Monsanto Company. This bondable magnet wire is sold under the Trademark "FORMVAR BONDEZE" by Phelps Dodge Magnet Wire Corporation. Because of the thermosetting nature of the phenolic modified polyvinyl formal base insulation, as contrasted to the instant softening of the thermoplastic polyvinyl butyral, adjacent portions of such magnet wire can be bonded together by either the solvent or heat tacking techniques above-described without causing shorts.

"FORMVAR BONDEZE" magnet wire is manufactured highly advantageously since the coating of phenolic modified polyvinyl formal base insulation and the polyvinyl butyral can be applied to the wire in one continuous operation by conventional methods. This can be accomplished by cross-stringing the oven of a conventional wire coating machine since the baking and cure conditions of the base insulation and the adhesive coating are essentially the same.

Another commercially available bondable magnet wire is sold under the Trademark "SY BONDEZE" by Phelps Dodge Magnet Wire Corporation. This magnet wire differs from "FORMVAR BONDEZE" magnet wire in that "SY BONDEZE" magnet wire is solderable as a result of using a base insulation consisting of a low molecular weight poly-

ester resin material modified with isocyanates and polyvinyl formal resins (see U.S. Patents Nos. 3,067,063 and 3,077,462) and a cost of Nylon material (type 66 aliphatic Nylon material) instead of the phenolic modified polyvinyl formal base insulation of "FORMVAR BONDEZE" magnet wire. The two coatings of the base insulation of "SY BONDEZE" magnet wire and the outer adhesive coating of polyvinyl butyral resin thereof can also be cured under the same cure conditions; and thus, "SY BONDEZE" magnet wire also can be manufactured in one operation as above-described.

With the advent of more complex coils, such as colour television yoke coils, and the increased use of resistance heating to bond adjacent wires in such coils, higher bonding temperatures have now become commonplace, and in some coil forming and bonding processes, forming of the coils into particular shapes causes greater wire movement than heretofore experienced. The forming of such coils under these conditions requires a base insulation which undergoes far less plastic flow and has greater form stability during coil forming than the base insulations of either "FORMVAR BONDEZE" or "SY BONDEZE". Normally suitable plastic flow and form stability is possessed by a base insulation having a cut through of at least 300°C. as determined by NEMA Test Procedure (NEMA Stds. Publication, MW-1000 USA Std. C9-100-1968, Part 3, Par. 2.2.6). The formation of other coils, for example, solenoid coils, certain bobbinless coils and motor windings such as field coils, whether the coils are bonded by resistance heating or other high temperature (in excess of 200°C.) bonding techniques, may also require the base insulation of a bondable magnet wire to have a higher temperature heat shock resistance, i.e. at least 220°C., as determined by NEMA Test Procedure (NEMA Stds. Publication, MW-1000 USA Std. C9-100-1968, Part 3, Par. 2.2.3), than that possessed by the base insulation of "SY BONDEZE" bondable magnet wire.

With the advent of high temperature polyester resin materials (for example, polyamide ester, polyimide ester, polyamide-imide ester resin materials, terephthalic acid-glycol-glycerine polyester resin materials modified with isocyanates, isocyanurates, and the like, amidized and/or imidized polyester resin materials, and polyaromatic polycarboxylic polyimides including polyimide, polyamide-imide and amidized polyimide resin materials), base insulations possessing greater form stability and adequate heat shock resistance and the other properties required in a base insulation to withstand the afore-mentioned high temperature and high pressure bonding conditions, become available. However, because of

the high curing temperatures required for these materials, conventional bonding compositions, for example, polyvinyl butyral resin materials and phenoxy resin materials, cannot be used to manufacture a bondable magnet wire in the manner above-described. These bonding composition resins, upon being coated over base insulation materials such as those above-described and exposed to their high curing temperatures, suffer degradation. Such degradation is evidenced by excessive crazing of the bonding composition and the possible flaking and removal of the bonding composition from the magnet wire during winding. Some crazing of the bonding composition may extend through to the base insulation and initiate the same condition throughout the insulation of the magnet wire. Such crazing may result not only in unsatisfactory bonding of adjacent portions of the wire in a coil, but may result also in shorts. For this reason, it is highly desirable to develop an improved bonding composition which can be used to manufacture a bondable magnet wire having a base insulation comprising one of the high temperature resin materials afore-mentioned or combinations thereof in one continuous operation.

The term "polyester resin" is herein used to refer to that group of resin materials which contain a plurality of ester groups. This group includes polyamide-imide ester resins, polyamide-ester resins, and polyimide-ester resin materials, polyester resin materials modified with isocyanates, isocyanurates, and the like, amidized and/or imidized polyester resin materials, and other modified polyester resin materials.

It is therefore an object of this invention to provide an improved bondable magnet wire.

According to this invention there is provided an improved bondable magnet wire comprising an electrical conductor, an inner coating of base insulation material on the conductor, and an outer adhesive coating of thermoplastic polyester resin, the base insulation material comprising a continuous layer of a thermosetting polyester resin and a continuous layer of a polyaromatic, polycarboxylic aromatic imide, the inner and outer coatings being applied to the conductor under the same baking or curing conditions without the outer coating being subject to thermal degradation for example as evidenced by severe crazing and slight flaking, the outer coating being capable of being softened sufficiently to bond together portions of the wire which are in contact by procedures including treating the portions of wire with a solvent of the thermoplastic polyester resin and heating the portions of wire to a temperature above 100°C. without causing the inner coating to soften and flow, and the materials of both coatings being thermally stable under the said baking or curing conditions. Both the base insulation

material and the thermoplastic polyester resin adhesive material can be any one of a number of materials.

As afore-mentioned, the high temperature polyester resin materials overcoated with polyaromatic polycarboxylic aromatic imides have adequate heat shock, thermal stability and form stability and the other properties required in a base insulation of a bondable magnet wire to withstand the high temperature and high pressure bonding conditions mentioned above. As will become apparent hereinbelow, these materials, when properly applied to a conductor, are superior base insulation materials when compared with the base insulation materials of prior art bondable magnet wires, for example, "FORMVAR BONDEZE" and "SY BONDEZE" magnet wire, especially when the wire must withstand the more severe bonding conditions aforementioned.

The preferred base insulation material comprises an inner layer of thermosetting modified terephthalate polyester resin material cured on the conductor and a layer of linear polyaromatic, polycarboxylic, aromatic imide resin material, for example, the AI-10 resin material or AI-537 wire enamel, sold by Amoco Chemical Company, or the Pyre ML resin material, sold by E.I. DuPont de Nemours Company, the latter being a reaction product of oxydianiline and pyromellitic dianhydride, cured over the inner layer.

Examples of the inner layer of thermosetting modified terephthalate polyester resin material are disclosed, for example, in U.S. Patents Nos. 2,686,739; 2,686,740; 2,889,304; 2,936,296 and 3,342,780. The preferred base insulation material for the improved bondable magnet wire of this invention is disclosed in U.S. Patent No. 3,022,200. Magnet wire having such an insulation is sold by Phelps Dodge Magnet Wire Corporation under the Trademark "ARMORED POLY-THERMALEZE 200".

Other base insulation materials were proven to be less satisfactory than those above described. One such base insulation material comprises a layer of thermosetting terephthalate polyester material modified by the addition of tris (2-hydroxyl ethyl) isocyanurate in place of at least a portion of the glycerine in the material and cured on the conductor and a layer of the thermoplastic polyimide-ester or imidized polyester resin material which is the reaction product of trimellitic anhydride, methylene dianiline, glycol and tris (2-hydroxyl ethyl) isocyanurate (see U.S. Patent No. 3,390,118). Magnet wire having this insulation material cured on a conductor is sold by Phelps Dodge Magnet Wire Corporation under the Trademark "POLY-THERMALEZE 200". Another such base insulation material is a terephthalic polyimide-ester or imidized terephthalic polyester resin material such as that sold under the Trademark

"ISOMID" by Schenectady Chemicals Corporation. It has been shown that such insulation materials are not as satisfactory as the preferred insulation material abovementioned due to either lower resistance to heat shock and/or less form stability and/or greater thermoplastic flow than the aforementioned preferred base insulation material during the formation of shaped coils under the aforementioned more severe bonding conditions.

Referring now to Table I, there are shown comparative test results on the two prior art bondable magnet wires above-mentioned, a bondable magnet wire identical to "FORMVAR BONDEZE" magnet wire except for the modification of the polyvinyl formal base insulation material by the addition of isocyanate and melamine resins thereto, and bondable magnet wires comprising the above-mentioned three base insulation materials, each having a coating of a thermoplastic phenoxy adhesive material thereon, namely "Eponol B-53" resin material, as sold by Shell Chemical Company.

Test coils, similar to a T.V. yoke coil, (see Fig. 1) were formed of each of the abovementioned magnet wires and tested under the same conditions at different temperature/time conditions. Each coil was wound on a T.V. yoke coil winding machine having an arbor designed for a horizontal, 110°, 25" black and white coil of 192 turns of the size of wire tested and a packing gland or ram adjusted to form the coil to the desired size and shape. The particular T.V. yoke coil winding machine used was estimated to have a packing gland or ram capable of forming the coil into the desired size and shape at about 90 lbs. pressure.

Each of the coils tested was wound on the above-described winding machine after the arbor segments were suitably lubricated. An appropriate bonding solvent was applied to the coil form at the start of the winding to bond the first few turns. Ethyl alcohol, methyl ethyl ketone, and acetone were used successfully depending on the bonding resin used. The winding was terminated at 192 turns (using a conventional turn counter). The coil was resistance heated to a specified time (temperature) and then formed by pushing the ram into the forming saddle for about 1 second. The finished coil having the desired shape and size (see Fig. 2) was then taken out of the forming saddle of the machine and allowed to cool. Each coil was then tested with a "Rubicon" (Registered Trade Mark) short-circuit tester, Type B, Catalog No. 1091. This tester was found to detect instantly copper to copper shorts in coils such as those above-described and also to detect what is termed "leakage shorts".

A total of 50 coils identically wound and formed in accordance with the method above-described at identical time and temperature

conditions were tested with the "Rubicon" short-circuit tester. If all 50 coils indicated no shorts, 50 additional coils were wound and formed at the next most severe conditions and so on.

All of the coils wound and formed in accordance with the method above-described were formed of bondable magnet wire consisting of a copper conductor having an outside diameter from about 0.0158 to about 0.0159 inches and coatings of base insulation and adhesive material resulting in the coated wire having an outside diameter of from about 0.0188 to about 0.0190 inches. The elongation of the copper conductor used was 30%, or greater, thereby eliminating winding pressure and tension variables. The test above-described is identified as Phelps Dodge Test Procedure No. 58.

Test results for each of the above-mentioned bondable magnet wires are shown in Table I for a variety of temperature and time conditions. The temperatures from about 162°C. to about 313°C. were measured by thermocouples buried in the coils tested. The higher and lower temperatures were extrapolated from the measured temperatures and the measured time that the coils were resistance heated.

The results shown in Table I clearly indicate that each of the experimental bondable magnet wires incorporating base insulations of the group of materials above-mentioned and an phenoxy adhesive material is superior to the prior art bondable magnet wires. Further, the results in Table I clearly indicate that the preferred bondable magnet wire tested is that incorporating the preferred base insulation material above-mentioned.

Referring now to Table II, there are shown comparative test results of various bondable magnet wires, each having the preferred base insulation. Each of the bondable magnet wires tested has outer coatings of different thermoplastic adhesive materials. Each of the bondable magnet wires tested comprise a base insulation consisting of three consecutive coats of a thermosetting modified terephthalate polyester resin material (PDG413 resin, as sold by P.D. George Company) and two consecutive coats of a poly-amide-imide resin (AI-537 wire enamel, as sold by Amoco Chemical Company) (see U.S. Patent No. 3,347,828), and an outer coating of thermoplastic adhesive material consisting of two consecutive coats of adhesive material.

The following examples describe the adhesive material applied to the preferred base insulation to form the self-bonding magnet wires tested and serve further to illustrate the invention:

EXAMPLE I

A solution is formed by dissolving 627.2 grams of phenoxy resin (Eponol 53-L-32, as sold by Shell Chemical Company) in 47.2 grams of cresylic acid (Pitt-Consol #9 sol-

vent, as sold by Pitt-Consol Company) and 125.6 grams of an aromatic solvent (NJ-100 solvent, as sold by Hoosier Solvents and Chemicals Corporation) by stirring the same at room temperature. After a clear and homogeneous solution is obtained, the solution is filtered if necessary and then applied in the manner herein-described.

EXAMPLE II

A solution is formed by dissolving 627.2 grams of phenoxy resin (Eponol 55-L-32, as sold by Shell Chemical Company) in 57.2 grams of cresylic acid (Pitt-Consol #9 solvent, as sold by Pitt-Consol Company) and 150.6 grams of an aromatic solvent (NJ-100 solvent, as sold by Hoosier Solvents and Chemicals Corporation) by stirring the same at room temperature. After a clear and homogeneous solution is obtained, the solution is filtered if necessary and then applied in the manner herein-described.

EXAMPLE III

A solution is formed by dissolving 627.0 grams of phenoxy resin (Eponol 55-L-32, as sold by Shell Chemical Company) in 70.8 grams of cresylic acid (Pitt-Consol #9 solvent, as sold by Pitt-Consol Company) and 182.0 grams of an aromatic solvent (NJ-100 solvent, as sold by Hoosier Solvents and Chemicals Corporation) by stirring the same at room temperature. After a clear and homogeneous solution is obtained, the solution is filtered if necessary and then applied in the manner herein-described.

EXAMPLE IV

A solution is formed by dissolving 150.0 grams of an ethylene terephthalate-neopentyl terephthalate copolyester in which the ethylene terephthalate units comprise from about 65 to about 75 percent of the sum of the ethylene terephthalate and neopentyl terephthalate units in the copolyester and the neopentyl terephthalate units comprise from about 25 to about 35 percent of the sum of the ethylene terephthalate and neopentyl terephthalate units in the copolyester (see Patent No. 1,029,136) in 450.0 grams of cresylic acid (Pitt-Consol #9 solvent, as sold by Pitt-Consol Company) and 150.0 grams of an aromatic solvent (NJ-100 solvent, as sold by Hoosier Solvents and Chemicals Corporation) by stirring the same at room temperature. The Softening point of the copolyester, as determined by the ring and ball method, ASTM Test Method E-28, is about 335°F. After a clear and homogeneous solution is obtained, the solution is filtered if necessary and then applied in the manner herein-described.

EXAMPLE V

A solution is formed by dissolving 375.0 grams of an ethylene terephthalate-ethylene

isophthalate copolyester in which the ethylene terephthalate units comprise from about 75 to about 30 percent of the sum of the ethylene terephthalate and ethylene isophthalate units in the copolyester and the ethylene isophthalate units comprise from about 25 to about 70 percent of the sum of the ethylene terephthalate and ethylene isophthalate units in the copolyester in 450.0 grams of cresylic acid (Pitt-Consol #9 solvent, as sold by Pitt-Consol Company) and 750.0 grams of an aromatic solvent (NJ-100 solvent, as sold by Hoosier Solvents and Chemicals Corporation) by stirring the same at room temperature. The softening point of the copolyester, as determined by the ring and ball method, ASTM Test Method E-28, is about 310°F. After a clear and homogeneous solution is obtained, the solution is filtered if necessary and then applied in the manner herein-described.

EXAMPLE VI

A solution is formed by dissolving 0.9441 pounds of polyvinyl butyral resin (Butvar B-73 resin, as sold by Monsanto Company) in 1.9425 pounds of cresylic acid (Pitt-Consol #9 solvent, as sold by Pitt-Consol Company) and 4.7785 pounds of an aromatic solvent (NJ-100 solvent, as sold by Hoosier Solvents and Chemicals Corporation) by stirring the same at room temperature. After a clear and homogeneous solution is obtained, the solution is filtered if necessary and then applied in the manner herein-described.

Each of the consecutive coats of insulation and adhesive material was applied by a conventional wire coating tower employing dies at speeds ranging from 27 feet per minute to 39 feet per minute, having bank temperatures of 850°F., 800°F., and 600°F. Each of the resultant bondable magnet wires was subjected to three tests: (1) Snap test to break, as determined by NEMA Test Procedure (NEMA Stds. Publication, MW-1000 USA Std. C9-100-1968, Part 3, Par. 2.2.1); (2) Flexibility, as determined by a 25% elongation followed by wrapping the same on a 1X mandrel; and (3) the "bottle test", hereinafter described.

With reference to the adhesive material of Example IV, the copolyester hot melt adhesive was found to have an intrinsic viscosity of 0.65 ± 0.1 . This intrinsic viscosity was measured by the method described in P. Flory *Principles of Polymer Chemistry*, Cornell University Press, 1953.

With reference to the "bottle test" mentioned hereinabove, this test was designed to indicate crazing, flaking or shattering of the insulation of bondable magnet wire under severe conditions. It was discovered that certain bondable magnet wires would exhibit no crazing, flaking or shattering upon being wound about mandrels having relatively small diameters, for example, 1X mandrels, but

that the same magnet wire would exhibit crazing, flaking and/or shattering upon being wound about larger diameter mandrels. Further, it was discovered that additional crazing, flaking and shattering occurred after aging, for example, after being held in stock for some time. Such "shelf aging" is particularly important since bondable magnet wire can be held in stock for several years before use.

The term "crazing" as used herein refers to hairline cracks in the coating of adhesive material and/or base insulation material of the bondable magnet wire. The term "flaking" as used herein refers to severe cracking and the loss of adhesion between the base insulation material and the adhesive material of the bondable magnet wire. "Severe flaking" is termed "shattering".

The "bottle test" consists of winding bondable magnet wire around a four ounce glass bottle having an outside diameter of about 1-3/4 inches, and inspecting the magnet wire either by the naked eye or by a microscope. This was done immediately after the manufacture thereof, seven days following the manufacture thereof, and on the first anniversary of the manufacture of the magnet wire.

The results of these tests performed on #18 AWG bondable magnet wires, each having the preferred base insulation, and the adhesive materials of Examples I through VI, except for the one wire having a base insulation of an imidized polyester (ISOMID polyester) and an adhesive material, cured or baked on the conductor at the same conditions, are shown in Table II. The speeds at which the resin materials were cured on the conductor were varied over a range to include the optimum speed and cure or bake conditions. As some light hairline cracks do not render the bondable magnet wire unusable, the terms "1 crack", "2 cracks", and "Craze O.K." are used to denote usable magnet wire which exhibits few, if any, light hairline cracks. The terms "slight craze", "minor craze", and "craze" denote a degree of cracking more severe than "craze OK". The terms "severe craze" and "slight shatter" are borderline but the terms "shatters", "brittle" or "bond coat unusable" denote entirely unsatisfactory conditions.

The results tabulated in Table II indicate the superiority of the bondable magnet wires of Examples IV and V. The bondable magnet wires of Examples I, II and III are not satisfactory due to the "shattering" experienced subsequent to the manufacture of the wire or upon "shelf aging". The magnet wire of Example VI is completely unusable. The unsatisfactory results of Examples I through III and VI are theorized to be the results of one of the following: (1) the cure range of the base insulation material and the bake range of the adhesive material are significantly different such that the curing and baking of the

materials under the same conditions results in one of the materials being overcured or overbaked or undercured or underbaked; or (2) the base insulation material and the adhesive material have sufficiently different coefficients of linear thermal expansion such that upon heating and subsequent cooling, stress between the conductor, the base insulation, and/or the adhesive material results causing crazing, flaking or shattering.

Reference is now made to Table III in which the results of tests, such as that above-described and tabulated in Table I, with reference to prior art and certain experimental bondable magnet wires, performed on the bondable magnet wire of Examples IV and V are shown and compared with the most favorable results tabulated in Table I. The comparison indicates that the results of the bondable magnet wires of Examples IV and V are equally favorable with the most favorable results tabulated in Table I.

The improved bondable magnet wires of the invention, as exemplified by the magnet wires having the preferred base insulation and an outer coating of the adhesive of both Examples IV and V can be manufactured on conventional wire coating machinery. Both the base insulation and adhesive materials of the magnet wire can be cured or baked at the same

conditions, and are completely stable at these conditions. The improved bondable magnet wires of this invention have a base insulation which exhibits greater form stability and less plastic flow than base insulations of prior art bondable magnet wires, adequate heat shock resistance, and the other properties required in a base insulation to withstand the high temperature and high pressure bonding conditions mentioned hereinabove and can be manufactured in one continuous operation. The improved properties of the bondable magnet wires of this invention make possible the formation of better bonded products, for example, colour TV yoke coils, which can be manufactured by either the solvent or heat tacking techniques herein described.

A comparison of the improved bondable magnet wires of the invention and a bondable magnet wire having a base insulation of terephthalate imidized polyester (ISOMID polyester XWE-379, as sold by Schenectady Chemicals Corporation) and an outer coating of adhesive material (SM-7537 material, as sold by Stoner-Mudge Division of Mobil Chemical Company) is shown in Table II. The terephthalic imidized polyester base insulation material was compared with the preferred base insulation material of this invention in Table I.

TABLE I

Results of Comparative Tests on TV Yoke Coils Using Various Types of Prior Art and Experimental Insulations using Standardized Test Conditions. Values are % of Shorted Coils Following Various Resistance Heating Conditions.

Type of Bondable Wire	Base Coat	Top or Bond Coat	Bonding Cycle (Time/Temperature)				
			2 sec. 125—150°C	4 sec. 162—180°C	6 sec. 204—229°C	8 sec. 252—271°C	10 sec. 296—313°C
"Formvar Bondeze"	"Formvar" Poly-vinyl Formal (6 coats)	"Butvar B-73" Poly-vinyl Butyral (2 coats)	OK	OK	50%	100%	
"Formvar Bondeze" Modified	Poly-vinyl Formal modified with Iso-cyanates and Melamine resins (6 coats)	"Butvar B-76" Poly-vinyl Butyral (2 coats)	OK	OK	50%	100%	
"SY Bondeze"	Adipic polyester with Isocyanates and poly-vinyl Formal (3 coats) and Nylon 66 (2 coats) "Nyleze"	"Butvar B-73" Poly-vinyl Butyral (2 coats)	OK	OK	OK	100%	
Experimental	Terephthalic polyester (3 coats) and Poly-imide-ester (2 coats) "Polythermaleze 200"	Phenoxyl "Eponol 53-L-32" (2 coats)	OK	OK	OK	OK	OK
Experimental	Terephthalic imidized polyester "Isomid" (5 coats)	Phenoxyl "Eponol 53-L-32" (2 coats)	OK	OK	OK	OK	OK
Experimental	Terephthalic Polyester (3 coats) Poly-amide-imide (2 coats) "Armored Poly-thermaleze 2000"	Phenoxyl "Eponol 53-L-32" (2 coats)	OK	OK	OK	OK	OK

TABLE I (Continued)

Results of Comparative Tests on TV Yoke Coils Using Various Types of Prior Art and Experimental Insulations using Standardized Test Conditions. Values are % of Shorted Coils Following Various Resistance Heating Conditions

Type of Bondable Wire	Base Coat	Top or Bond Coat	Bonding Cycle (Time/Temperature)				
			12 sec.	14 sec.	16 sec.	18 sec.	22 sec.
			332-348°C	376-391°C	418-433°C	460-476°C	546-560°C
"Formvar Bondeze"	"Formvar" Poly-vinyl Formal (6 coats)	"Butvar B-73" Poly-vinyl Butyral (2 coats)					
"Formvar Bondeze" Modified	Poly-vinyl Formal modified with Isocyanates and Melamine resins (6 coats)	"Butvar B-76" Poly-vinyl Butyral (2 coats)					
"SY Bondeze"	Adipic polyester with Isocyanates and poly-vinyl Formal (3 coats) and Nylon 66 (2 coats) "Nyleze"	"Butvar B-73" Poly-vinyl Butyral (2 coats)					
Experimental	Terephthalic polyester (3 coats) and Poly-imide-ester (2 coats) "Polythermaleze 200"	Phenoxy "Eponol 53-L-32" (2 coats)	50%	100%			
Experimental	Terephthalic imidized polyester "Isomid" (5 coats)	Phenoxy "Eponol 53-L-32" (2 coats)	OK	100%			
Experimental	Terephthalic Polyester (3 coats) Poly-amide-imide (2 coats) "Armored Polythermaleze 2000"	Phenoxy "Eponol 53-L-32" (2 coats)	OK	OK	OK	OK	5% some carbonization

TABLE II

TABLE II
Magnet Wire

TABLE II

Tests on Various Self-Bonding Magnet Wires — Samples made on Laboratory Equipment
with Standardized Oven Temperatures of 850°F — Top, 800°F — Middle, 600°F — Bottom
— Using #18 AWG "Bondeze 2" Wire

Base Insulation	Top or Bond Coats	Speed of Wire "Cure"	Snap at Date of Mfg.	Film Flexibility 25% IX at Date of Mfg.	Bottle Test at Date of Mfg.	Bottle Test 7 Days	Bottle Test 1 Year
Terephthalic polyester (3 coats) Poly- amide-imide "Armored Poly- thermaleze 2000"	Example 1 Phenoxy "Eponol 53-L-32" (2 coats)	30 33 36	OK OK OK	OK OK OK	Sl. Shatter OK OK	Shatters Shatters Craze	Shatters Shatters Severe Craze
	Example 2 Phenoxy "Eponol 55-L-32" (2 coats)	30 33 36	OK OK OK	OK OK OK	OK OK OK	Shatters Shatters Craze	Shatters Shatters Craze
	Example 3 Phenoxy "Eponol 55-L-32" (2 coats)	27 30 33 36 39	Sl. craze OK OK OK OK	Sl. craze OK OK OK OK	Shatters Shatters OK OK OK	Shatters Shatters Craze Craze Craze	Shatters Shatters Shatters Craze Craze
	Example 4 Co-Polyester (2 coats)	27 30 33 36 39	OK OK OK OK OK	OK OK OK OK OK	OK OK OK OK OK	OK OK OK OK OK	OK OK OK OK OK
	Example 5 Co-Polyester "Vitel" (2 coats)	27 30 33 36 39	OK OK OK OK 2 cracks	Craze OK OK OK OK	Craze Sl. craze Sl. craze Sl. craze Minor craze	Craze—OK Craze—OK Craze—OK Craze—OK Craze—OK	Craze—OK Craze—OK Craze—OK Craze—OK Craze—OK
	Example 6 "Butvar B-73" Polyvinyl Butyral (2 coats)	30 33 36	— — —	OK Base Coat OK Base Coat OK Base Coat	Outer Coat Brittle—Crack off Wire Outer Coat Brittle—Crack off Wire Outer Coat Brittle—Crack off Wire	— — —	— — —
					Bond Coat Unusable	—	—

TABLE II (Continued)

Tests on Various Self-Bonding Magnet Wires — Samples made on Laboratory Equipment
with Standardized Oven Temperatures of 850°F — Top, 800°F — Middle, 600°F — Bottom
Using # 18 AWG "Bondeze 2" Wire

Base Insulation	Top or Bond Coats	Speed of Wire "Cure"	Snap at Date of Mfg.	Film Flexibility 25% IX at Date of Mfg.	Bottle Test at Date of Mfg.	Bottle Test 7 Days	Bottle Test 1 Year
Terephthalic imidized poly- ester "Isomid" (5 coats)	StonerMudge "SM-7537" (2 coats)	27	1 crack	1 crack	Craze	Shatters	Shatters
		30	OK	OK	Craze	Severe craze	Shatters
		33	OK	OK	Craze	Severe craze	Severe craze
		36	OK	OK	Sl. craze	Severe craze	Severe craze
		39	OK	OK	Craze	Severe craze	Severe craze

TABLE III
Results of Comparative Tests on TV Yoke Coils Using the Best of the Experimental Insulations shown in Table I and the Insulations of the Invention using Standardized Test Conditions. Values are % of shorted Coils Following Various Resistance Heating Conditions

Type of Bondable Wire	Base Coat	Top or Bond Coat	Bonding Cycle (Time/Temperature)				
			2 sec. 125—150°C	4 sec. 162—180°C	6 sec. 204—229°C	8 sec. 252—271°C	10 sec. 296—313°C
Experimental	Terephthalic polyester (3 coats) Poly-amide-imide (2 coats) "Armored Polythermaleze 2000"	Phenoxy "Eponol 53-L-32" (2 coats)	OK	OK	OK	OK	OK
Experimental	Terephthalic polyester (3 coats) Poly-amide-imide (2 coats) "Armored Polythermaleze 2000"	Example 4 Ethylene Terephthalate Neopentyl Terephthalic Co-polyester (2 coats)	OK	OK	OK	OK	OK
Experimental	Terephthalic polyester (3 coats) Poly-amide-imide (2 coats) "Armored Polythermaleze 2000"	Example 5 Ethylene Terephthalate Isophthalic Co-polyester (2 coats)	OK	OK	OK	OK	OK

TABLE III (Continued)
Results of Comparative Tests on TV Yoke Coils Using the Best of the Experimental Insulations shown in Table I and the Insulations of the Invention using Standardized Test Conditions. Values are % of Shorted Coils Following Various Resistance Heating Conditions.

Type of Bondable Wire	Base Coat	Top or Bond Coat	Bonding Cycle (Time/Temperature)					
			12 sec. 332-348C	14 sec. 376-391C	16 sec. 418-433C	18 sec. 460-476C	20 sec. 493-517C	22 sec. 546-560C
Experimental	Terephthalic polyester (3 coats) Poly-amide-imide (2 coats) "Armored Poly-thermaleze 2000"	Phenoxy "Eponol 53-L-32" (2 coats)	OK	OK	OK	OK	OK	Approx. 15% some carbonization
Experimental	Terephthalic polyester (3 coats) Poly-amide-imide (2 coats) "Armored Polythermaleze 2000"	Example 4 Ethylene Terephthalate Neopentyl Terephthalic Co-Polyester (2 coats)	OK	OK	OK	OK	OK	Approx. 10% slight carbonization
Experimental	Terephthalic polyester (3 coats) Poly-amide-imide (2 coats) "Armored Polythermaleze 2000"	Example 5 Ethylene Terephthalate Isophthalic Co-Polyester (2 coats)	OK	OK	OK	OK	OK	Approx. 10% slight carbonization and brittleness



WHAT WE CLAIM IS:—

1. A bondable magnet wire comprising an electrical conductor, an inner coating of base insulation material on the conductor, and an outer adhesive coating of thermoplastic polyester resin, the base insulation material comprising a continuous layer of a thermosetting polyester resin and a continuous layer of a polyaromatic, polycarboxylic aromatic imide, the inner and outer coatings being applied to the conductor under the same baking or curing conditions without the outer coating being subject to thermal degradation for example as evidenced by severe crazing and slight flaking, the outer coating being capable of being softened sufficiently to bond together portions of the wire which are in contact by procedures including treating the portions of wire with a solvent of the thermoplastic polyester resin and heating the portions of wire to a temperature above 100°C. without causing the inner coating to soften and flow, and the materials of both coatings being thermally stable under the said baking or curing conditions.
2. The magnet wire of claim 1 wherein the thermoplastic polyester resin is a linear copolyester material comprising a mixture of a plurality of polyester materials, the mixture having a softening point lower than the individual softening points of the polyester materials.
3. The magnet wire of claim 2 wherein the copolyester material is a mixture of polyester components of the group consisting of terephthalic acid, isophthalic acid, ethylene glycol and neopentyl glycol components, and wherein the mixture has a softening point lower than the softening points of poly (ethylene terephthalate), poly (ethylene isophthalate) and poly (neopentyl terephthalate).
4. The magnet wire of claim 1 wherein the thermoplastic polyester resin is of the group consisting of (1) an ethylene terephthalate-

ethylene isophthalate copolyester in which the ethylene terephthalate units comprise from 75 to 30 percent of the sum of the ethylene terephthalate and ethylene isophthalate units in the copolyester and the ethylene isophthalate units comprise from 25 to 70 percent of the said sum of units and (2) an ethylene terephthalate-neopentyl terephthalate copolyester in which the ethylene terephthalate units comprise from 65 to 75 percent of the sum of the ethylene terephthalate and neopentyl terephthalate units in said copolyester and the neopentyl terephthalate units comprise from 25 to 35 percent of the said sum of units.

5. The magnet wire of claim 1 wherein the base insulation material has a heat shock resistance of at least 220°C. as determined by NEMA Test Procedure (NEMA Stds. Publication, MW-1000 USA Std. C9-100-1968, Part 3, Para. 2.2.3), and a cut-through of at least 300°C. as determined by NEMA Test Procedure (NEMA Stds. Publication, MW-1000 USA Std. C9-100-1968, Part 3, Para. 2.2.6).

6. The magnet wire of claim 4 wherein the thermoplastic polyester resin is an ethylene terephthalate-neopentyl terephthalate copolyester in which the ethylene terephthalate units comprise 70 percent of the said sum of units and the neopentyl terephthalate units comprise 30 percent of the said sum of units, and wherein the thermoplastic polyester resin has an intrinsic viscosity of 0.65 ± 0.1 , and a specific gravity as measured by ASTM Test Method D792-50 of 1.280 to 1.300 at 25°C.

7. A bondable product comprising the magnet wire of claim 1.

WITHERS & SPOONER,
Chartered Patent Agents,
148-150, Holborn,
London, E.C.1.
Agents for the Applicants.