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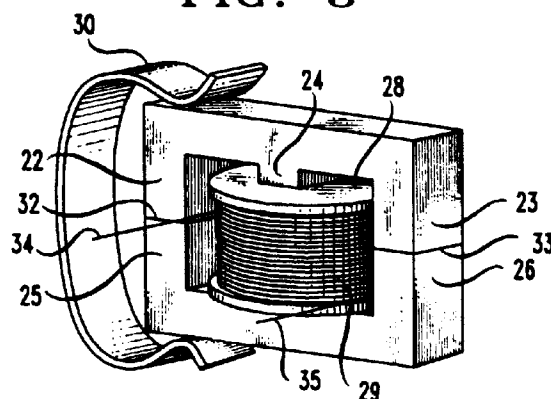
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(54) **Apparatus entailing adhesive bonding.**

(57) Cost and performance advantage are realized in a class of magnetic core transformers and inductors in which fabrication entails joining of core portions partially enclosed within windings. Bonding is accomplished by use of thermo-setting adhesive which is introduced in the uncured state by capillarity between prepositioned already-mated surfaces to be bonded, followed by curing.

FIG. 3



Background of the Invention

Technical Field

The invention is concerned with apparatus and fabrication dependent upon high-strength adhesive bonding to produce and maintain a continuous magnetic path. A particularly significant category is that of wire wound transformers and inductors dependent upon in situ bonding of magnetically soft ferrite surfaces to complete core structure.

Description of the Prior Art

The prior art discussion, in common with that of the detailed description, is primarily in terms of the commercial problem which provoked the effort and led to the solution of the inventive approach. Manufacture of a category of wire-wound devices - including transformers and inductors - commonly entails first winding a bobbin or other supporting structure, and subsequently forming magnetic core loop/s in part within the winding by joinder of preformed core portions. A particularly significant category is that class of devices which depends upon magnetically soft ferrite-core members. See, for example, E. C. Snelling and C. Eng, "Soft Ferrites, Properties and Applications", Second Edition, Butterworths (1988).

A prevalent manufacturing approach depends upon permanent mechanical clamping to keep mating surfaces in intimate contact (and thereby to maintain magnetic reluctance in the functioning device at the desired level). This approach continues in use despite high expense in terms of cost, weight and space relative to adhesive bonding. See, for example, pages 160-162 of "Soft Ferrites, Properties and Applications", as cited above.

A category of ferrite-core devices depends on adhesive "bridge bonding" in lieu of clamping. In accordance with this approach, temporarily clamped surfaces are joined by coating the outside of the joint with an epoxy or other thermo-setting resin which cures to leave an adherent encircling strength member, after which the clamp is removed. Strength requirement gives rise to a need for a fairly thick encircling adhesive layer. The expense of a mold is avoided by use of high viscosity/thixotropic material to minimize flow prior to and during cure. The approach is usefully applied to fabrication of devices in which strength requirement is small - likely to joinder of core sections of relatively large cross-section - of devices not likely to encounter severe environmental conditions in use.

The bridging adhesive method is costly - maximum strength afforded requires careful application of adhesive to the entirety of the peripheral surface to be wetted.

Under demanding space/strength needs where still further increased application costs can be justifi-

fied, adhesive bonding has taken the form of interfacial bonding - of coating individual surfaces to be mated, followed by mating and rubbing to assure wetting and to drive out excess adhesive before clamping.

Despite extensive effort to compensate for the various deficiencies of adhesive bonding, the approach continues to be limited in many terms - performance/reliability under demanding circumstances is generally considered to require mechanical fixturing (e.g. clamping). For interfacial adhesive bonding an added complication arises in that removal of excess adhesive material by compressing the joint after mating and prior to curing, imposes a limit on permitted viscosity. Further under many conditions, e.g. due to dissolved air and/or moisture, voids may form during elevated temperature curing, thus impairing initial strength and aggravating environmentally-induced strength loss. Added constraints restrict adhesive composition and may impact performance needs.

Summary of the Invention

The inventive teaching overcomes the obstacles to adhesive bonding as outlined in the previous section. The thrust depends on capillary flow of uncured thermosetting adhesive as applied to properly-dimensioned, prepositioned mating surfaces, thereafter followed by curing to secure the wetted surfaces of magnetic members to result in a continuous magnetic flux path including such surfaces. The usual objective is minimization or near-minimization of reluctance associated with the joint so as to approach performance of a continuous (unjointed) member. Accommodation of a wide variety of epoxy and other adhesive materials is broadened by variation in temperature to satisfy flow and curing needs. Consequent freedom in adhesive and processing permits economies in terms of ease of application and high yield. Both are consistent with desired performance properties - initial and as retained under adverse conditions likely to be encountered in use. With regard to the latter, maintenance of protective atmosphere, perhaps by device encapsulation as well as other practiced precautions, may often be avoided by the inventive approach.

The many limitations associated with bridge bonding are avoided. Disadvantages of prior art interfacial bonding are also overcome. In important part such disadvantages are due to need for fastidious coating of the entirety of surfaces to be mated. In general, in the practice of the invention, application of uncured adhesive at but a single position per joint may suffice for adequate wetting of the prepositioned surfaces, although for larger joints there may be some time advantage gain in multiple spot or stripe application - however, still depending on the thorough wetting implicit in capillarity flow-distribution.

Bond strength realized by the inventive method contributes further to design freedom. An example is

that of device fabrication entailing mating E-core sections (FIGS. 2 and 3) in which reliable joinder has been accomplished by adhesive bonding of but two of the three mating surfaces. Reference is here made to the E-core soft ferrite structure, in which the already-wound bobbin conceals the center joint. This functionally desirable design is described, for example, in "Soft Ferrites, Properties and Applications" cited above, at p. 281.

Inventive processing invariably depends upon capillarity to bring about wetting of already-positioned mating surfaces which are essentially in contact with each other. It is this aspect which assuredly brings about many of the advantages associated with the invention - regarding both ease of application and effective performance. The "Energetic Considerations" section in the Detailed Description considers the various factors concerned with effective application - factors including: spacing between mating surfaces; viscosity of the adhesive as affecting capillarity and particularly viscous drag; contact angle; and temperature as affecting any of the foregoing. A major objective of the invention - that of magnetic continuity consistent with desirable physical properties (strength, resistance to adverse conditions in use, etc.) depends upon inherent wetting as provided by the capillarity mechanism. Forces inducing capillary flow for otherwise suitable materials - for a broad category of uncured thermosetting resins in conjunction with contemplated surfaces to be joined - are considerable. Desired level of continuity in a preferred aspect of the invention is assured by maintaining surfaces to be joined in intimate contact as by clamping dig fabrication. The magnetically soft ferrites as used in devices fabricated in accordance with experimental work, including that of the Examples, present surfaces suitable to such capillary flow. Experimentally, surfaces produced by simple abrasion, as by grinding, as well as those entailing polishing to near-mirror surface, have all been joined by the inventive techniques. Clamping pressures to maintain minimal spacing between mating surfaces - to maintain intimate contact before capillary introduction - have been found insufficient to prevent the capillary flow-wetting of the invention.

Various means for initial introduction of the uncured resin are appropriate. Examples which have served experimentally include (1) application of adhesive at the peripheral outer surface of joints of an already-heated mating pair, and (2) heating of a mating pair after room temperature adhesive application. Heating may serve a variety of purposes including either or both of - reducing viscosity of the uncured adhesive to assure timely wetting of mated surfaces, and to accelerate subsequent curing. These differing objectives may be addressed sufficiently by maintenance at constant temperature, or, alternatively, temperature may be ramped to most effectively satisfy the

two. Alternatively, a variety of considerations may dictate flow-wetting and/or curing without heating.

Brief Description of the Drawing

FIG.1 is a diagrammatic view of surfaces to be mated to which reference is made in the general process description.

FIG. 2 is a schematic view of an, as yet unassembled, inductor with a magnetic E-core structure.

FIG. 3 is a view of the same E-core inductor as assembled.

Detailed Description

General

Considerations set forth in this section are useful in identification of the various parameters - composition, processing conditions - suited to the needs at hand. In more general terms, operation of the invention is assured by inherency of suitable parameters for a broad range of choices with only broad common sense restriction. For example, choice of adhesive on the basis of adhesion and bond strength necessarily entails wetting of magnitude sufficient for assuring capillary flow. The additional requirement for application concerns viscosity - a requirement generally satisfied by use of unfilled thermosetting resins prior to curing. The functional mechanism of capillary flow, required for all aspects of the invention, is well-known as are the various considerations yielding timely flow (viscosity, in turn as affected by temperature, molecular weight, etc.).

While section 5, in setting forth equations determinative of application, is usefully employed in optimization, the artisan is well-equipped to identify both materials and process conditions to reliably practice the invention. Specification of differential pressures as well as values of surface tension, etc. concerns parameters to be optimized in usual terms. Operability of the invention does not depend upon such considerations. For example, while spacing between surfaces and surface smoothness are of consequence for performance optimization, experiment establishes suitability of a spacing as large as 10 mils for capillary flow wetting over the indicated viscosity range of up to 500 centipoise and higher. This value of nominal spacing certainly represents a maximum likely value from the performance standpoint - it is unlikely that desired values of inductance will suggest larger spacing between bonded mating surfaces. In fact since surfaces involved in this experiment were produced by simple grinding, the 10 mil spacers used assured only this maximum value with variations likely resulting in regions within which spacing was increased by up to 2 mils in regions between protrusions engaged by the spacers. All such experiments, as supplement-

ed by those involving joints clamped (unspaced) under 50 psi pressure, support assurance of operability of the inventive mechanism for joints to be encountered in device design.

A number of magnetic devices require a non-magnetic gap ("air gap") in the magnetic flux path. This is typically accomplished by grinding down the central leg(s) of three-leg core parts. Required tolerances on the length of the gap (and, therefore, on the total reluctance of the magnetic path) may be maintained in the mated structure by ensuring a minimal spacing between the mating surfaces of the outer legs, by clamping during bonding. Considerations pertaining to spacing between, and magnetic path continuity at, bonded mating surfaces are, therefore, generally equivalent for such "ungapped" and "gapped" core structures.

Relevant considerations with regard to choice of composition of the adhesive as well as processing depend upon a variety of factors including: time needed for application; demands resulting from configuration and size of surfaces to be bonded; demands resulting from performance requirements; design life with attention to conditions to be provided for, and overall cost considerations which may result in compromise of one or more of the foregoing. Such considerations are discussed, largely in exemplary terms.

Inventive Outline

It is convenient to introduce relevant factors, in terms of an outline. The outline presented considers various factors - adhesive character, application procedure, overall performance. While the outline is primarily in terms of necessary factors, variations including both optional procedures and permitted variation in order may be useful. While some variations are discussed, others are inappropriate to this disclosure and are left to the practitioner. In common with the remainder of the description, specific discussion is at least initially in terms of usual core construction entailing joining of core portions to yield a completed loop. Certain considerations, e.g. with regard to provision of deliberately reduced inductance, may translate into specified small spacing in the loop.

1. Surface Characteristics

Wetting - again, considerations are fundamental and entail e.g. surface energetics on the basis of which adhesive composition is chosen.

Physical - whether flat or other conforming geometry, surface roughness is of concern. From the device-functioning standpoint, some minimal smoothness is likely desirable to assure requisite continuity of the magnetic path. From the adhesive flow standpoint, surface topography of otherwise suitable surfaces is not critical. Timely wetting of an adequate por-

tion of the joint has been attained for all surfaces otherwise acceptable from the functioning standpoint.

Size - for purposes of particular consequence to the invention - for "linear" devices such as inductors and transformers in a communications circuit - mating surfaces are likely to be small e.g. fractions of a square inch. For so-called "power" devices, mating surfaces are often larger - may range to a square inch or more.

Positioning - mating surfaces are likely to be similar in size and shape. Minimal spacing, of consequence for most contemplated purposes, is generally achieved by pressure as by clamping or by other forms of mechanical fixturing. Examples of the latter may depend upon: magnetic attraction, which may conveniently make use of the inherent soft magnetic properties of commonly used cores, by application of an inhomogeneous magnetic field; or simply gravity, perhaps as aided by additional weights.

Core structures, fabricated in feasibility studies consistently showed maximum attainable inductance for the various surface topographics used at pressures within the 50 to 200 psi range.

2. Other

Curing, whether with or without increased temperature; heating means, whether for use before, dig, or after application; testing, whether of all or selective product, are among the many considerations familiar to those responsible for manufacturing specifications. (See "Handbook of Adhesives", ed. Irving Skeist, (1977) New York). They are of concern to the invention only insofar as they affect criteria set forth above.

Adverse Conditions - reliability, largely in terms of aging, is assured by appropriate choice of the noted parameters. Introduction of adhesive by capillarity in accordance with the invention permits maximization of properties inherent to both the adhesive and the surfaces to be bonded. Available materials and processes are sufficient to accommodate: temperature cycling both in fabrication and use; humidity aging; and mechanical conditions to be encountered - e.g. shock vibration.

3. The Adhesive

The central thrust of the inventive teaching depends upon flow of the adhesive as induced by capillarity. Timely, flow of adhesive is, in turn, dependent upon spacing, surface regularity, needed path length and surface energetics. Such considerations translate into needed adhesive characteristics for meeting such requirements. Adhesive characteristics of concern from this standpoint are viscosity and surface tension under temperature and other conditions during flow.

All such needs with regard to application are sat-

ified for a wide range of epoxy and other adhesives so that choice is not significantly limited due to such considerations.

Viscosity - a significant physical characteristic concerns this property. Always in terms of temperature during flow, timely flow for likely flow path length (e.g. centimeters per second) for most demanding use is realized for viscosities of less than about 500 centipoise (about 500 cps). Greater viscosities, not generally preferred from standpoint of flow, may be tolerated in the interest of accommodating adhesive materials of otherwise desired characteristics and/or cost. Relevant viscosity may be as measured during application, or at the temperature to which the mated surfaces are heated after lower temperature application (e.g. after room temperature application). For most magnetic core assemblies, choice of temperature is simply to assure flow before the onset of significant flow-impairing curing. For others, heat susceptibility may impose a maximum. For many otherwise suitable adhesives, e.g. for epoxy adhesives as used in examples herein, suitable flow is realized for temperatures below about 200°C. On occasion, heat susceptibility may suggest choice of adhesive from a somewhat more restricted class. Alternatively, this consideration may suggest redesign of the assembly being fabricated.

Composition - detailed description of suitable adhesive compositions is not appropriate. It is fundamental that the invention critically depends upon availability of adhesives of appropriate adhesion as well as strength properties. Beyond such considerations, suitability depends upon inherent demands as imposed by the invention. Contemplated compositions are thermosetting (as desired to yield both the initial low viscosity required for flow as well as adhesive and strength properties yielded upon curing). Flow properties in the uncured state, as discussed in detail under "Application - theory", entail such physical properties as viscosity, surface tension, contact angle, and dependence of such properties on temperature. there is a broad category of adhesive compositions (containing curing agent, any modifier, and the adhesive polymer itself) from which materials may be chosen to satisfy the requirements of the invention. Variants concern both choice of ingredients in the generic terms set forth and characteristics of particular consequence to the invention - e.g. choice of uncured polymer of molecular weight suitable to desired viscosity.

The "Handbook of Adhesives" (cited above) identifies and characterizes several categories from which suitable adhesives may be selected. These include epoxies, anaerobics (e.g. acrylates and diacrylates - either containing dispersed curing agent), acrylics, urethanes, polyesters, as well as other materials of requisite properties as now available or to become available in the future. Curing agents, too, are chosen

with regard to effect on invention requirements - e.g. effect on flow rate, time to initiation of curing to permit distribution prior to significant flow-impeding curing. Required curing temperature is a factor in such choice as well. Useful adhesive compositions may desirably include one or more modifiers, for example, to reduce viscosity. Other ingredients may serve: to promote adhesion (e.g. organofunctional silanes as may be incorporated in some epoxies); to vary surface tension ("surfactants"); as well as to serve a variety of ancillary purposes, as colorant, etc. In general, particulate filler materials, thixotropes, and other non-essential ingredients tending to increase viscosity are not usefully included. Even here, special circumstances may dictate such inclusions. While undesirable in the usual situation, where the objective includes surface-to-surface continuity or near-continuity (in terms of magnetic reluctance), they may serve to restrict flow-loss, e.g. for vertically deposited, larger spacings between surfaces as desired to tailor inductance to some value below the maximum attainable.

Adhesives used in the examples were epoxies. Compositionally, they were based on diglycidyl ethers of bisphenol-A (epoxy equivalent weight ≈ 180) and included a heterocyclic amine curing agent.

4. Processing

Application - the uncured adhesive may be applied in any convenient manner - by syringe, eye dropper, nozzle, toothpick, etc. Quantity applied is sufficient to wet at least a major part of the mated surfaces - preferably to wet their entirety. Unlike prior art interfacial bonding, excess adhesive, in the preferred instance of clamping, is kept from entering the joint in the first place and, accordingly, cannot result in unwanted surface-to-surface spacing. Depending upon size criticality and other considerations, excess material may be permitted to remain outside the joint.

5. Application - Theory

This section deals with factors relevant to introduction of the uncured thermosetting adhesive.

Consistent with common usage, flow, assuring wetting of mated surfaces is referred to as "wicking". The term is used as alternative to, and synonymous with "capillary flow".

Capillary forces are responsible for adhesive flow between mated surfaces, and are resisted by viscous drag. The time, t , required to wick between surfaces over a flow path distance L is given by the equation:

$$t = \frac{3\mu L^2}{g\delta \cos \theta} \quad (1)$$

where

g = gap spacing between mated surfaces

μ = viscosity

δ = surface tension

θ = dynamic (advancing) contact angle of adhesive to surface, all in compatible units.

It is seen that: increasing viscosity and flow path increase time required, while increasing spacing size, surface tension and cosine of the contact angle decrease time required.

While it is common to measure contact angle θ statically, wicking rate is, in actuality, dependent upon wetting kinetics (upon the instantaneous value of θ). As expected, wicking is slowed by kinetic effects.

Reference is made to FIG. 1 in further consideration of the flow mechanism. The figure schematically depicts bodies 10 and 11 presenting prepositioned mating surfaces 12 and 13 defining gap, g . Overall path length, L , is to be filled by advancing meniscus surface 15 as originating from adhesive composition as initially applied at 14. The designation, $1(t)$ represents the instantaneous length of the path defined by the advancing meniscus 15 at time t .

The positive force causing flow ("wicking") is due to the pressure differential, Δp , across meniscus 15 in the direction of movement, Δp . This differential e.g. $p_{\text{liquid}} - p_{\text{air}}$ is of the value:

$$\Delta p = \frac{2\delta \cos \theta}{g} \quad (2)$$

in which parameters are as defined above.

The instantaneous velocity, V , within a region near the entrance position at 14 (remote from meniscus 15 at the position shown) is calculated as a balance between this positive force and viscous drag:

$$V = \frac{2\delta \cos \theta ((g/2)^2 - y^2)}{2\mu g L} \quad (3)$$

in which

y = distance measured from the center of the gap spacing

The velocity of flow at the advancing meniscus 15 (the velocity of the advancing front as represented by meniscus 15 itself) is:

$$\bar{V} = \frac{g\delta \cos \theta}{6\mu L} \quad (4)$$

Approximations made in development of the above equation are

$$g < L$$

and

$$g < \left(\frac{\delta}{\rho g_2} \right)^{1/2} \quad (5)$$

in which

g_2 = gravitational acceleration

Both assumptions are justified for usually contemplated geometries.

6. Limits

The general nature of the inventive advance is clear. Implications are most meaningfully in terms of economy realized in the attainment of product excellence - largely as measured in terms of bond strength,

both initial and during needed life. For many purposes, excellence must take performance characteristics into account - for most purposes, e.g. in terms of magnetic reluctance, this requires prescribed spacing between bonded surfaces. This latter is generally optimized by minimal surface-to-surface spacing as assured by mechanical clamping.

The thrust of the invention concerns the thorough surface wetting which is inherent in the capillary flow mechanism. It is expected that commercial advantage will be in terms of optimization of this approach. Bridge bonding as practiced is premised upon sufficient viscosity prior to and during curing - generally assured by deliberate addition of thixotrope - as to inherently minimize any capillary flow as well as viscous flow. Practice change to follow disclosure of the inventive teaching will generally take the form of avoidance of thixotrope and of such other considerations - regarding composition and heating - as to assure the lessened viscosity which is both necessary for practice of the present invention and which is disadvantageous from the standpoint of bridge bonding.

The invention represents a distinct departure from prior art bridge bonding. Viscosity - for many purposes described as below about 500 centipoise (under temperature and other conditions during capillary flow-wetting) compares with values of many thousands, perhaps in the range of 50,000 centipoise or higher for bridge bonding.

7. The Drawing

Reference has been made to FIG. 1 in a discussion of the "wicking" mechanism which constitutes a major thrust of the invention. The remaining figures involve fabrication of an illustrative class of magnetic devices. It has been noted that devices of concern generally depend upon construction of mechanically reliable low magnetic reluctance paths. FIGS. 2 and 3 are consistent with the remainder of this description in which emphasis is on wire-wound devices in which function entails inductive coupling via a core loop, e.g. of a magnetically soft ferrite composition. The particular configuration depicted was used in examples included in section 8. This device is an inductor with a magnetic "E-core" structure, as commonly used in communications and power conversion devices. A variety of magnetic structures desirably fabricated by practice of the invention is well-known. See, for example, "Soft Ferrites", cited above e.g. at pp. 162, 281-284 and 288 describing suitable standard core structures including U, Pot, RM, PM, PQ, ETD, EC, EI, LP and others as well as the E-core.

FIG. 2 depicts an unassembled E-core structure including E-shaped core portions 20 and 21 each containing two outer legs and one center leg, 22, 23, 24, and 25, 26, 27, respectively. At the stage of fabrication shown, bobbin 28 has been wire wound so yield

inductor winding 29.

Structures of the type shown were among those fabricated in accordance with examples in the following section. In example 1 the structure is assembled and maintained in position by clamp 30 as shown in FIG. 3. As there depicted, the wound bobbin 28 encompasses the interface formed by center legs 24 and 27 (interface within and hidden by the bobbin 28 and not shown). (The particular structure shown is an inductor, and, so, has but two terminals 34, 35.) With clamp 30 in position, mating surfaces of leg pair 22 and 25 (forming interface 32) and of leg pair 23 and 26 (forming interface 33) are adhesively bonded in accordance with the inventive teaching (see, for example, discussion of FIG. 1). Clamp 30 is generally removed following curing of the thermosetting resin.

8. Examples

A considerable body of experimental work serves as basis for description as well as limits set forth. Devices constructed may serve a variety of magnetic functions. Construction of such devices entails inventive joining in the magnetic path, e.g. in the core loop in the instance of common inductors and transformers. In all structures, advantage is gained from reliability in the various terms: notably joint integrity both initially and under various conditions to be encountered in life. In some instances, appropriate adhesive composition consistent with other requirements was such as to resist attack by humidity and provide long-term resistance to vapor transmission as verified by accelerated life-testing - by immersion testing.

Applicability of the inventive process in the terms described is justified on the basis of the hundreds of experiments conducted to quality for manufacture. The examples were selected as likely representative of near-term fabrication - of inductors and transformers of characteristics typical for such devices presently in use in telephony as well as for similar devices used in power conversion.

Example 1

This example describes fabrication of an E-core inductor as depicted in FIGS. 2 and 3. Overall dimensions of the completed device were approximately one inch by one inch in the major plane of the core. Leg surfaces joined were approximately one quarter inch square. Fabrication entailed clamping with a total force of about ten pounds (≈ 50 psi). The clamped assembly was preheated in an oven to a temperature of approximately 150°C , and a drop of adhesive composition was applied to one side of each of the exposed joints by use of a syringe (the center leg joint was not accessible). The particular adhesive composition was based on an epoxy resin - diglycidyl ether of bisphenol-A ("DGEBA") having an epoxy equivalent of 180-

190. The composition contained ≈ 10 phr (parts per hundred resin by weight) curing agent - 2 ethyl-4 methyl imidazole (2,4-EMI). After permitting sufficient curing time (< 5 min.), the structure was removed from the oven, the clamp was removed, and the resulting structure was tested. Mechanically, both tension and torsion testing resulted in failure of core material prior to adhesive joint failure. Similar results were realized after accelerated life testing - including one hour immersion in boiling water. Performance, too, easily met usual specifications - inductance was equal to or superior to that of prior art structures which were bridge bonded or interfacially bonded, as well as to permanently clamped structures. Performance characteristics were essentially unchanged following life testing.

Example 2

An inductor of the size and characteristics of that of Example 1 was fabricated with the same adhesive composition by a procedure which varied in but one respect - initial application of adhesive was at room temperature, following which the clamped assembly was placed in the oven, and was removed within five minutes after attaining the temperature of 150°C . Test results were unchanged.

Claims

1. Fabrication yielding a device dependent for its operation on a magnetic path, such fabrication entailing completion of such path by adhesive bonding of mating surfaces of magnetic elements which as bonded contribute to such path, adhesive bonding being due to wetting of at least portions of such surfaces with substantially uncured thermosetting adhesive followed by curing, characterized in that such wetting results from capillary flow of said uncured adhesive between such surfaces as prepositioned so as to approximate the mating relationship.
2. Fabrication of claim 1 in which the said device comprises an electrically conductive coil and the said path is substantially defined within a magnetic core providing for inductive coupling in operation, and in which the said mating surfaces are those of core parts.
3. Fabrication of claim 2 in which the said coil is fabricated by wire winding a hollow member and in which the said path consists essentially of at least one loop partially contained within such member.
4. Fabrication of claim 3 in which the core parts consist essentially of magnetically soft material.

5. Fabrication of claim 4 in which the said core parts consist essentially of a ferrite material.
6. Fabrication of claim 5 in which any spacing between prepositioned surfaces is of minimum dimension having a maximum value of 10 mils. 5
7. Fabrication of claim 6 in which the said mating surfaces are prepositioned so as to be in physical contact so that the said minimum dimension is numerically 0. 10
8. Fabrication of claim 7 in which prepositioned mating surfaces are in clamped contact during capillary flow. 15
9. Fabrication of claim 8 in which the said uncured adhesive is maintained at elevated temperature for a period during which capillary flow is favored by decreased viscosity of the said adhesive. 20
10. Fabrication of claim 9 in which uncured adhesive is heated subsequent to introduction and prior to a substantial part of capillary flow. 25
11. Fabrication of claim 6 in which at least one of the said core parts has at least three legs, in which the said hollow member encompasses the joint formed between the center legs of the parts and in which the joints formed between the outer legs are bonded. 30
12. Product produced by any of claims 1 through 11. 35

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FIG. 1

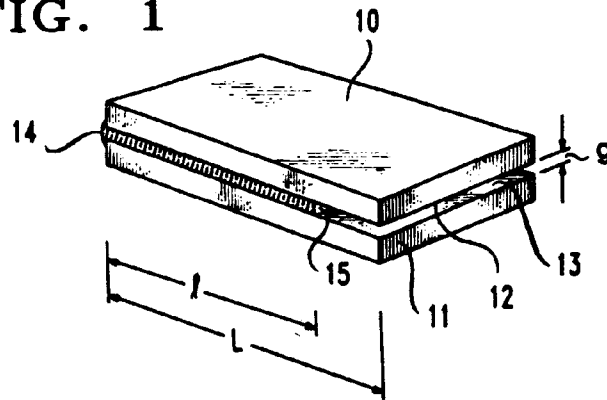


FIG. 2

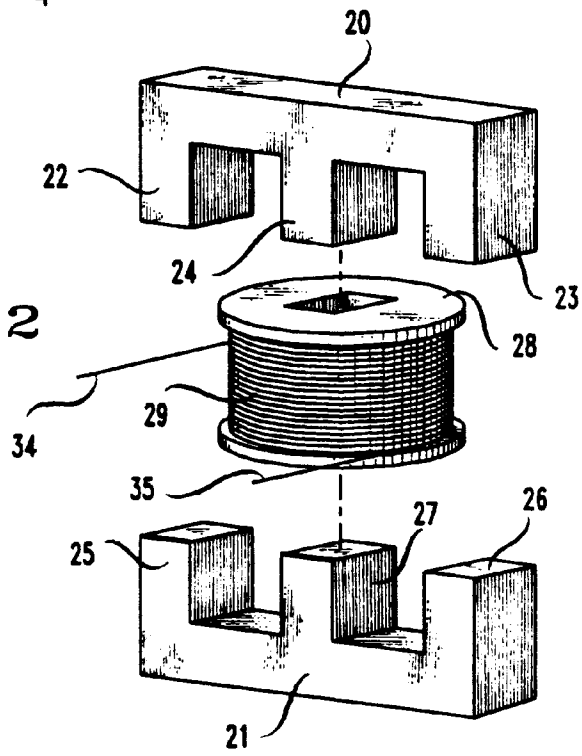
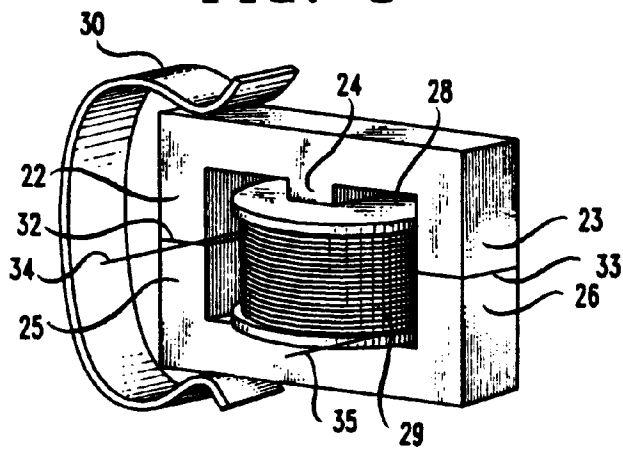


FIG. 3





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 30 4597

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-4 085 347 (WHITE-WESTINGHOUSE CORP.) * column 4, line 27 - line 54 *	1	H01F27/26
A	---	4,8	
A	PATENT ABSTRACTS OF JAPAN vol. 7, no. 174 (E-190)(1319) 2 August 1983 & JP-A-58 080 818 (NIHON FERRITE) * abstract *	1,2	
A	---	1,2	
A	US-A-3 222 626 (ADVANCE TRANSFORMER CO.) * column 6, line 31 - line 41 *	1,2	
A	---	1,4,8-10	
A	EP-A-0 010 654 (BROWN, BOVERI & CIE) * page 4, line 6 - line 12 *		
A	---		
A	GB-A-1 326 766 (GENERAL ELECTRIC COMPANY) ---		
A	DE-A-1 905 498 (WAASNER, BRUND) ---		
A	PATENT ABSTRACTS OF JAPAN vol. 13, no. 321 (E-790)(3669) 20 July 1989 & JP-A-1 089 415 (HITACHI LTD) * abstract *		TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	---		H01F C09J
A	PATENT ABSTRACTS OF JAPAN vol. 11, no. 222 (C-435)(2669) 18 July 1987 & JP-A-62 036 478 (TOHOKU METAL IND LTD) * abstract *		
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 28 AUGUST 1992	Examiner VANHULLE R.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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