May 31, 1938. K. E. ROLLEFSON 2,119,292

ELECTRICAL RESISTANCE UNIT AND METHOD OF MANUFACTURE

Filed March 30, 1936

FIG. 1

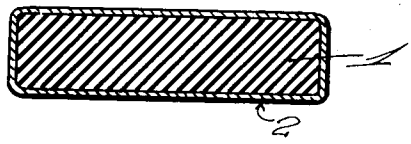


FIG. 2

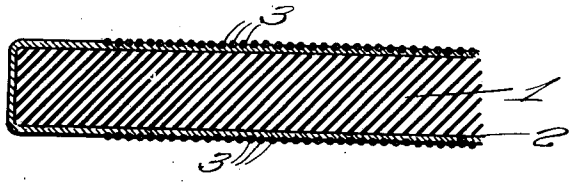


FIG. 3

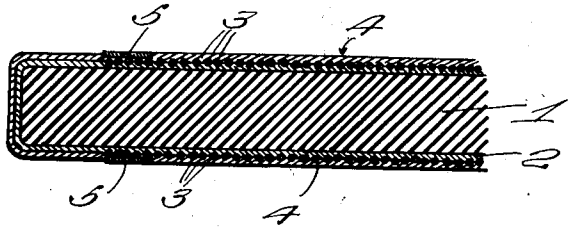


FIG. 4

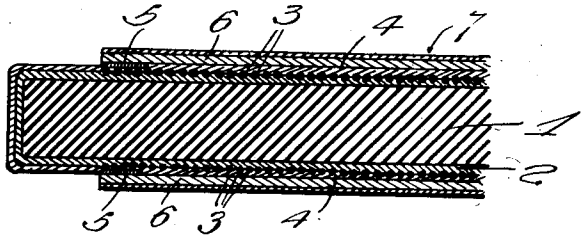
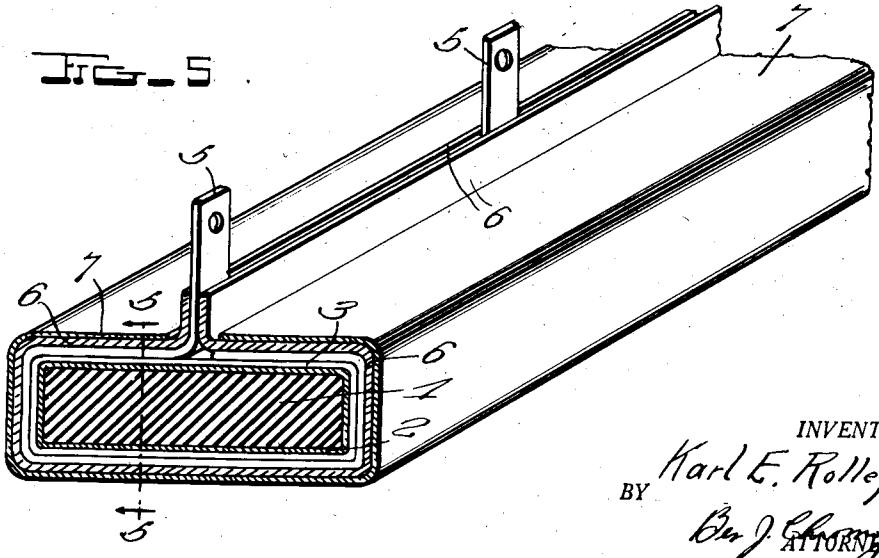


FIG. 5



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2,119,292

ELECTRICAL RESISTANCE UNIT AND METHOD OF MANUFACTURE

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12 Claims. (Cl. 201—67)

This invention relates to electrical apparatus and the manufacture thereof, generally. More particularly, this invention relates to electrical resistance units of the wire wound type and a method for making and testting same.

An object of this invention is to provide a resistance unit of the wire wound type in which the unit is treated during the manufacture thereof to remove and prevent minute deformations in the wire which produce anodic and cathodic areas therein.

Another object of this invention is to provide a resistance unit of the wire wound type in which the core upon which the resistance wire is to be wound is coated with a liquid material adapted to form a layer which is dried for a time long enough to make the varnish surface dry to the touch yet leave it soft and plastic enough to enable the resistance wire winding to sink in.

A further object of this invention is to provide a wire wound resistance unit employing wire of very fine diameter readily weakened and broken by stresses to which the wire is normally subjected, the wire of said unit being wound on a core of insulation material treated with a varnish having considerable body or solid content adapted to form a plastic bed for the wire and eliminate damaging strains from the wire.

Still another object of this invention is to provide a bed of rubber-like material to the core support of fine resistance wire windings which will be plastic enough after being baked for a relatively short interval of time, to receive the fine wire winding and eliminate any damaging strains from the wire.

Still a further object of this invention is to provide a wire wound resistance unit by winding resistance wire upon a core of insulation treated to have a layer or layers of rubber-like, gummy substance, adapted to become soft and plastic, thereon, wrapping said core and winding in a varnished sheet of insulation material and enclosing the whole unit in an armor casing of metal.

Still another object of this invention is to provide a method of testing wire wound resistance units to determine the presence and location of any strains or deformations in the wire which will produce anodic and cathodic areas upon the wire.

Other and further objects of this invention will be apparent from the following specification and the claims.

The resistance units of my invention find their greatest field of application in the manufacture of radio receiving sets, particularly as voltage dividers and voltage reducers. They, of course, are adapted for use wherever a high grade, well-made unit is desirable and where long time service is an asset. These units are constructed to withstand effects of very damp and humid atmospheres which normally cause corrosion in the wire winding, particularly wires made of special alloys. Strains or deformations which are very small and may even be of the order of molecular dimensions, are produced in the wire as a result of winding it over the flat core. Anodic and cathodic areas are set up in the wire in places where these strains are present and corrosion sets in resulting often in the actual breaking of the wire. This corrosion is produced, in most instances, by electrolytic action and requires the presence of a certain amount of water or water vapor around the wire surface. Inasmuch as this action is electrolytic, small voltages and currents are set up thereby which, if the resistance unit is employed in a radio receiver having a sensitive amplifier, may cause objectionable and serious interference with reception.

In accordance with this invention I provide a method of manufacturing resistance units which is economical and readily adapted for use in production where units are to be produced rapidly and in substantial quantities. The resistance unit produced by my process is adapted to stand abuses to which such units are subjected in commercial and everyday use.

Briefly, my process consists of forming a core for supporting the resistance wire winding of insulation material, such as fiber, "Bakelite", or the like, adapted to stand temperatures up to 400 degrees Fahrenheit, without charring, and treating this core with a varnish adapted to form a coat of sufficient thickness to permit the wire wound thereon to sink into said coat and remove strains from the wire. The liquid material or varnish with which the core is treated before the winding is laid in place upon it is an insulating varnish having considerable body or solid content. The first stage in the drying of this varnish, whether it be in the open air or in an oven at elevated temperatures, is the evaporation of the solvents used in the preparation of this varnish. After the evaporation of the solvents has been completed the varnish proceeds to set which may be a process of oxidization or polymerization. When the solvents are present the varnish is in a fluid condition but may be and usually is quite viscous. As the drying or setting progresses, the film of varnish becomes

harder and harder. This will occur even though the varnish is dried in the open air, in which case the time required may be several days or even weeks before it reaches the ultimate hardness. In an oven at elevated temperatures this condition is reached in a much shorter period of time.

It is the purpose of this process to stop this setting or hardening before it has progressed to such an extent that the wires cannot sink into the bed of varnish provided for them. Therefore, in handling this film, going from a state of extreme fluidity or plasticity to one of lower plasticity, the drying process must not be allowed to progress too far. Should the drying and hardening proceed too far, most of the benefit to be obtained from this film is lost. The rate at which the wires sink into this film is slow.

The purpose of this bed, or first coat, of varnish may be considered as three-fold. First, it removes strains introduced into the wire by the winding operation. Second, it permits the formation of grooves by the wire which will securely hold the wire in place. Third, it assures a protective coat of insulating varnish underneath the winding. After the varnish coating applied to the core is air dried and/or baked until the varnish coating is soft and plastic to the touch, the fine wire is wound thereon. The wound core is then dipped into the varnish solution and given an additional coating of varnish whereupon it is air dried for a short time and then baked until dry for one hour at a temperature of 225 degrees Fahrenheit.

After the wound cores are baked, terminal strips are attached thereto to contact the wire winding and the units are placed into suitable metal jackets, suitably spaced therefrom by varnished paper, fiber, and the like. This varnished paper prior to treating with varnish may be a good grade of fish paper. After treatment, the electrical resistance of this paper becomes very high even when the resistance units employing it are exposed to a humid atmosphere of 95% or better relative humidity.

I have found that the presence and location of these anodic and cathodic areas may be readily and accurately determined in a test, such as the following, designated as the Feroxyl test. A solution consisting of 15 grams of agar agar, 10 grams of potassium ferricyanide and 10 grams of sodium chloride in 1000 cubic centimeters of water, is prepared for use in this process. The ingredients of this solution are thoroughly mixed together and the solution boiled until it is clear, after which it is poured over the resistance windings under test in a shallow glass tray. The mixture is allowed to jell and stand—awaiting the corrosive action of the salt upon the wire winding, after which the units can be examined under the microscope. The potassium ferricyanide acts as an indicator to show corrosive action. The jelly serves to keep these indications localized to the portions of the wire where corrosion takes place which appears in spots or balls growing on the wire.

A large number of units wound with Nichrome and other resistance wires were made and tested to determine anodic and cathodic areas developed by strains or deformations in the wire. Some of these units are identified as follows:

The following windings were subjected to the Feroxyl test:

1. Strips wound with Nichrome wire, 0.001 inch diameter.

2. Strips wound with Nichrome V wire, 0.001 inch diameter.

3. Strips 3" long with terminals attached at the ends and wound with Nichrome wire, 0.001 inch diameter.

4. Strips 3" long with terminals attached at the ends and wound with Nichrome V wire, 0.001 inch diameter.

5. Strips wound with Nichrome wire 0.001 inch diameter and then lacquered.

6. Strips wound with Nichrome wire 0.001 inch diameter and then varnished and baked.

7. Round rods of bakelite, rubber and glass $\frac{3}{8}$", $\frac{1}{16}$", and $\frac{1}{4}$" in diameter wound with Nichrome wire.

8. Strips wound with Nichrome wire of .00125, .00135, .00175 and .002 inch diameter.

9. Winding of Nichrome wire, 0.001 inch diameter removed from strip.

10. Nichrome wire, 0.001 inch diameter wound on strip which had first been varnished and baked.

11. Nichrome wire, 0.001 inch diameter wound on strip which had just been varnished and baked, then the complete winding varnished and baked.

After standing in the jell for a few hours the strips (1 and 2) of Nichrome and Nichrome V showed a great many corrosion spots with breaks in the wire occurring at some of the spots. As time went on, the breaks became more numerous. The Nichrome V showed a greater number of corrosion spots and breaks than the Nichrome. The most interesting fact about these spots and breaks was that practically all of them occurred at the edge of the winding, indicating that the physical strain produced in the wire at this place made possible the corrosive action.

The strips (3 and 4) with terminals on the ends showed the terminals to be very strong anodes but the density of spots was very much less than on the strips without terminals and it was further observed that the spots that did occur were in the middle of the strip, removed at least one inch from either terminal.

Strips (5) which had been lacquered over the winding showed a great number of corrosion spots which grew very large as time went on. Breaks in the winding occurred at many of these spots.

Strips (6) which were varnished and baked after winding went through the corrosion test with very few spots developing. This is probably due in part to the better protection offered by the varnish and in part to the fact that in baking the "Bakelite" strip suffered some shrinkage relieving the strain at the edges.

The round rods (test 7) wound with Nichrome showed relatively few spots. Of course there could be no localized strain set up in these windings and the results seemed to prove this.

The strips (8) wound with various sizes of Nichrome up to .002 all showed corrosion spots and it was noted that the larger sizes showed the greater number of spots. The smaller sizes of wire also showed breaks whereas no breaks were observed with the largest (.002) wire which showed the greatest number of spots.

This probably indicates that with the finer wires the least little corrosion weakens them sufficiently for the strain existing to part the wire.

According to the wire manufacturers, .001 Nichrome wire can stand the least elongation—one-half of 1% being probably the maximum with this wire, whereas the larger sizes will stand up to 10% elongation without failure.

The winding (9) removed from a strip showed

very few spots and there was no noticeable localization of the spots at the portions of the wire which had been over the edge of the strip. Removing the wire would, of course, remove the strain from it.

The winding (10) made over a strip which had first been varnished and baked showed a much smaller number of corrosion spots and breaks than the winding (1) made over the plain strip. In this case the varnish offered a plastic bed for the wire to sink slowly into, thus relieving the strain. This furnishes additional evidence that the strains produced in the wire are definitely associated with the faults.

The strips (11) wound on a varnished and baked strip, then varnished and baked again, stood up remarkably well, spots being very rare and no breaks have ever been noted in these strips. In this case a bed of plastic material was provided for the wire to rest upon and relieve the strains. In addition, an excellent protective coating was applied to the winding.

These tests indicate that the finished resistance units tested in tests 11 made in accordance with this invention, as set forth in this specification, gave very little indication of corrosion. No breaks in the wire were noted in units used in these tests even though the tests were exacting.

Further details of my invention will be set forth in the following paragraphs of this specification and in the drawing forming a part thereof. In the drawing, briefly, Fig. 1 illustrates a section of the resistance winding core with a coating applied thereto; Fig. 2 shows a cross-section of the resistance unit core, coating, and winding partially embedded in the coating; Fig. 3 shows a unit with the second coating applied over the winding; and Figs. 4 and 5 illustrate cross-sections of the unit enclosed in a metal jacket.

Referring to the drawing in detail, reference numeral 1 designates the core of insulating material, such as fiber, bakelite, asbestos lumber, or the like. This core is covered with a coating 2 of varnish-like material, preferably of the type sold to the trade under the name of "Waterlox", reduced with approximately one part of naphtha or oleum spirits to four parts of "Waterlox", by volume which is thoroughly mixed. This varnish has good electrical insulating qualities, does not absorb or transmit water, will not support combustion or be ignited at temperatures of 350 to 400 degrees Fahrenheit and is sufficiently plastic at baking temperatures of 225 degrees Fahrenheit to permit the fine resistance wire to sink into the varnish coating and relieve the strain.

After the preliminary coating of varnish 2, adapted to act as a bed for the resistance wire, is applied to the core 1, by dipping, wiping, brushing, spraying, or other convenient method, the core and coating are permitted to dry in an atmosphere of ordinary air for a period of fifteen minutes to one-half hour. The varnish coating is then baked at a temperature of 225 degrees Fahrenheit for a period of approximately one hour, or until the varnish coating is soft and plastic to the touch. It is, of course, possible to air dry this coating until the desired hardness is obtained. However, the length of time required for this would be too long to be practical in a manufacturing operation. This winding 5 is applied to the baked varnish as soon as possible after baking so that the varnish will not harden too much. I prefer to use "Nichrome" resistance wire in winding the resistance units of my invention. However, other wires, such as, "Manganin", German silver, constantin, and the like, may be used where wires of different characteristics are desired. The soft plastic bed of varnish provided over the core receives the wire winding and grooves are formed therein to space the wire turns and prevent short circuit thereof. As the wire sinks into the soft plastic bed, the strains or deformations produced in it where it is bent over the edge of the core are removed. This eliminates anodic and cathodic areas where corrosion, due to the strains left in the wire after forming, is likely to occur.

A second coat of varnish is applied to the wire wound unit, as shown in Fig. 3, and allowed to air dry for a short period of approximately one-half hour and then baked for one hour at 225 degrees Fahrenheit. This second coat of varnish covers the wire winding, and the first varnish coating, protecting the winding from the atmosphere. The solvents present in the second coat of varnish before it is dry tend to soften the under coat of varnish, permitting the wire to sink further into the first coating to remove any strains therefrom.

The terminals 5, which are similar to those shown in Patent No. 1,789,150, are attached to the unit at predetermined intervals and pressed through the varnish coats into firm electrical contact with the wire winding.

The unit of my invention may be employed with the varnish coatings applied as described without any further covering, if desired. However, I prefer to enclose them in metal jackets of a type such as shown in the above Patent No. 1,789,150. Before placing the jacket over the wound unit a layer 6 of one or more thicknesses of fish paper of "Armite", treated with a solution of "Waterlox" varnish reduced in naphtha or oleum spirits as described above, is placed over the winding. An equivalent of two coats of this varnish is applied to the paper or "Armite" and each coat is permitted to dry for approximately fifteen minutes and baked for one-half hour at 225 degrees Fahrenheit. The jacket 7 is then pressed over the unit to enclose the winding and permit the terminals 5 to project outward through the longitudinal slot-like opening 8 in the jacket. This layer of treated paper or "Armite" greatly increases the electrical resistance of the leakage path between the resistance unit winding and the jacket. A comparison of treated and untreated "Armite" and cambric wrapped units is given below.

	Megohms
Untreated Armite after one week	.275
Unit dipped in Waterlox and baked, after one week	1.2
Armite Waterloxed and baked 1 coat after 72 hours	1.5
Armite Waterloxed and baked 2 coats after 72 hours	50–75
Armite Waterloxed and baked 3 coats after 72 hours	100
Varnished cambric instead of Armite after 1 week	75–100

This table refers to the insulation resistance between the winding and the jacket with various insulators employed and is the resistance measured after the units had been left in at atmosphere of 75% relative humidity for the time stated. For example, the first item:

	Megohm
Untreated Armite after one week	.275

means that the resistance between the winding and the case, where the insulator employed was untreated Armite, after the unit had been left in an atmosphere of 75% relative humidity for one week and then removed from the humidity chamber and measured, was .275 megohm.

When wire larger than 0.0031 inch diameter is employed to wind the resistance unit, the preliminary coating of varnish on the "Bakelite" core is not necessary, but it is highly desirable. As the wire increases in diameter, the effect of the small areas of corrosion upon the whole becomes of less importance than with fine wires which break very quickly as a result of corrosion. Subsequent treatment of resistance units wound with the larger wire is the same as that of the smaller wire units.

The resistance units produced by my process are uniform even though manufactured in quantity lots by mechanical production methods. Not only are the units uniform, but they remain so even when used at their rated capacity for long periods of time. This is because the wire windings do not break and short circuit sections of the wire or become loose and permit turns thereof to overlap and short circuit.

The accuracy of these units made according to this process has been greatly increased because the plastic varnish film over the core furnishes a soft bed for the wires to lie in which causes them to retain their position during further processing which will continue to retain these wires in their proper position when heat that is generated while the resistor is under load would cause expansion of the wire, loosening the turns and permitting them to slide along a smooth surface to the extent that they would come in contact with each other and short circuit out sections of the resistance wire, thus altering the value of the total resisance. It is obvious that this cannot take place after the aforesaid treatment.

The life of the units has been greatly increased by this processing because we have eliminated the anodic and cathodic areas where corrosion would set in and we have provided an insulating coating around the wires which will retard the penetration of moisture or other fumes necessary for corrosion.

While I have described the Feroxyl test as particularly applicable to Nichrome wire, it is to be understood that this test has been used by me on various kinds and sizes of wire commonly used in winding resistance units. I do not, therefore, desire to limit this invention to the Feroxyl test where determinations of strains or deformations in the wire are being made. The essential ingredients in a general type of test are:

1. A corroding material. This may be an acid, a base, or a salt.

2. An indicator. A chemical compound which will indicate the process of corrosion of electrolysis by change in color or some other visible means.

3. A jelly, to localize the action and maintain the change in the indicator in the immediate vicinity of the action.

The Feroxyl test is a special type of test, using salt (sodium chloride) as the corroding agent, potassium ferricyanide as the indicator, and agar-agar as the jelly, and the name Feroxyl should probably be limited to this particular test.

Another test of similar type might use dilute sulphuric acid as the corroding agent, phenolphthalein as the indicator and gelatin or agar-agar as the jelly.

Resistance units also may be made in accordance with this invention, using wire smaller than 0.001 of an inch in diameter. Wire 0.0007 of an inch in diameter may be used conveniently and, of course, where smaller wires are available, they may be used.

It will be observed that I have described my process and the resistance unit of my invention in detail. However, modifications thereof may be made without departing from the spirit and scope of this invention and therefore I do not desire to limit this invention to the exact details described except insofar as they may be defined by the claims.

What I claim and desire to secure by Letters Patent is as follows:

1. A method of manufacturing electrical resistance units wound with wire of fine diameters, comprising the steps of forming a core of insulating material, applying a coat of insulating varnish liquid consisting of one part of naphtha to four parts of Waterlox to said core, drying and baking said varnish until it is soft and plastic, winding wire of fine diameter into a helical coil upon said bed of insulating varnish while said varnish is sufficiently plastic to permit said wire to sink into said varnish a short distance to eliminate minute strains caused in said wire by bending said wire around said core, said varnish acting as a bed for said wire insulating the outer surface of said winding with a coat of varnish, drying said last coat of varnish, and attaching terminals to said core to contact said winding.

2. A method of manufacturing electrical resistance units wound with wire of fine diameters, comprising the steps of treating a core of insulating material with an insulating varnish, removing a sufficient quantity of solvent from said varnish coat to make said varnish plastic, winding wire upon said varnished core while said varnish is plastic, dipping said core and wire winding into liquid insulating varnish to make the surface of the first coat of varnish sufficiently plastic to take up residual strains in said wire, and drying said first and second coats of varnish.

3. A method of manufacturing electrical resistance units wound with wire of fine diameters easily broken by ordinary handling, comprising the steps of cutting a core of substantially flat fibrous insulating material, applying to said core a bed of viscous insulating varnish of sufficient thickness to remove the strains from the wire winding, drying said varnish to remove the solvents therefrom until said varnish is soft and plastic to the touch, winding a wire coil on said varnish core while said varnish is plastic to permit the wire to sink sufficiently into said varnish, before the varnish setting has progressed too far, to remove the strains from said wire, said varnish acting as a bed for said wire.

4. A method of manufacturing electrical resistance units wound with wire of fine diameters, comprising the steps of forming a core of substantially flat insulating material, applying to said core a bed of viscous insulating varnish of sufficient thickness to remove strains from the wire winding, drying said core and varnish to remove the solvents from said varnish until the varnish is soft and plastic, winding wire of fine diameter into a helical coil upon said bed of insulating varnish while said varnish is plastic to permit the wire to sink into said varnish before the varnish setting has progressed too far to remove the strains from the wire, applying additional varnish over the surface of said winding to soften the aforesaid bed of varnish to insure

the removal of residual strains from said wire, and drying the varnish coats.

5. A method of manufacturing electrical resistance units wound with wire of fine diameters, comprising the steps of forming an elongated core of insulating material, applying a coat of viscous insulating varnish to said core of sufficient thickness to form a bed for the wire winding, drying said varnish until it is soft and plastic to the touch, winding wire of fine diameter into a helical coil upon said bed of insulating varnish while said varnish is sufficiently plastic to eliminate minute strains caused in said wire by bending said wire around said core, applying additional varnish over the outer surface of said winding to soften said varnish bed sufficiently to permit the removal of residual strains from said wire and drying said varnish.

6. A method of manufacturing electrical resistance units comprising the steps of shaping a core of flat insulation material, applying an insulating varnish having considerable body and solid content to said core element, drying said varnish until it is soft and plastic, winding fine wire over said varnish while said varnish is in this soft and plastic condition to permit said wire to sink into said varnish enough to remove strains from the wire, said varnish acting as a bed for said wire, and applying insulation over the outer surfaces of said wire.

7. A method of manufacturing electrical resistance units comprising the steps of applying an insulating varnish having considerable body and solid content to a core element, evaporating enough of the solvent from said varnish to make it viscous to permit fine wire wound thereon to sink into said varnish only sufficiently to remove strains from the wire, winding wire of fine diameter over said viscous varnish, and insulating the outer surfaces of said wire winding.

8. A method of manufacturing electrical resistance units comprising the steps of shaping a core of flat insulation material, applying an insulating varnish having considerable body and solid content to said core element, conditioning said varnish until it is soft and plastic, winding fine wire over said varnish while said varnish is in this soft and plastic condition to permit said wire to sink into said varnish enough to remove strains from the wire, said varnish acting as a support for said wire, and applying insulation over the outer surfaces of said wire.

9. A method of manufacturing electrical resistance units comprising the steps of dipping a core element into an insulating varnish liquid having considerable body and solid content, drying said varnish on the core element until it is soft and plastic enough to permit fine wire wound thereon to become at least partially embedded in said varnish only sufficiently to remove strains from the wire, winding wire of fine diameter over said soft and plastic varnish, and insulating the outer surfaces of said wire winding.

10. A method of manufacturing electrical resistance units comprising the steps of shaping a core of flat insulation material, applying an insulating varnish having considerable body and solid content to said core element, conditioning said varnish until it is soft and plastic, winding fine wire over said varnish while said varnish is in this soft and plastic condition to permit said wire to sink into said varnish enough to remove strains from the wire, said varnish underneath said wire acting as a bed for said wire.

11. A method of manufacturing electrical resistance units comprising the steps of dipping a core element into an insulating varnish liquid having considerable body and solid content, drying said varnish on the core element until the surface of the varnish is soft and plastic, winding fine wire on said varnish while the varnish is in this condition to permit the wire to sink into said varnish only sufficiently to remove strains from the wire.

12. A method of manufacturing electrical resistance units comprising the steps of shaping a core of flat insulation material, dipping the core into an insulating varnish liquid having considerable body and solid content adapted to form a bed for a wire winding, baking said varnish until the surface thereof is soft and plastic to the touch, and winding fine wire over said varnish while said varnish is soft and plastic to permit said wire to sink into said varnish bed enough to remove strains from the wire.

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