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MEANS FOR IMPREGNATING ELECTRIC COILS

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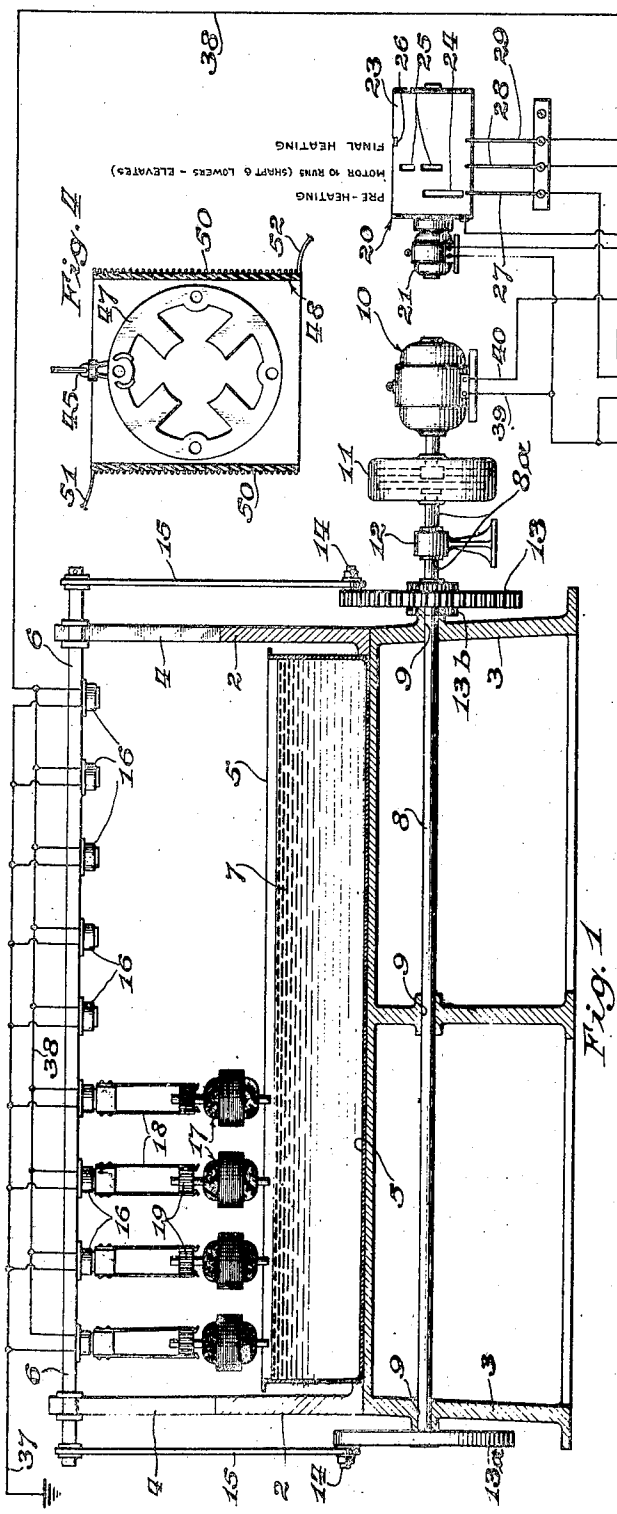


Fig. 1

Fig. 4

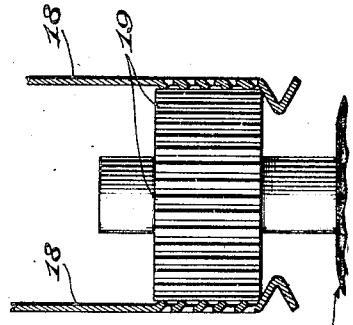


Fig. 3

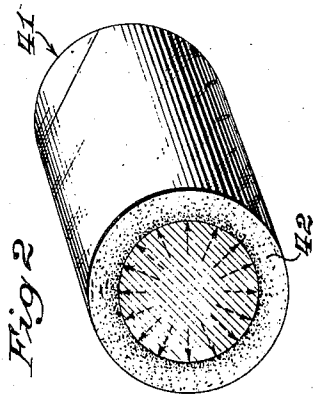


Fig. 2

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MEANS FOR IMPREGNATING ELECTRIC COILS

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2 Claims. (Cl. 91—46)

1

This invention relates generally to improvements in means for applying and solidifying varnish, and more particularly to improved means for varnish impregnating electric coils.

When insulated copper wire has been wound into coils, to afford a plurality of separated turns of conducting metal for the passage of electric current, as for motor field coils, armature windings, transformer windings, magnet or solenoid coils and the like, these are generally dipped in insulating varnish, and then baked in ovens to form a non-hygroscopic covering of the whole coil. This anchors all of the wires into a solid unit to prevent rubbing of turns against their adjacent turns, which would otherwise cause mechanical wearing away of the insulation of the wire itself. This is particularly true when dust of any kind works into an unimpregnated winding. Vibrations set up by external forces, and vibrations due to magnetic changes about the wire, must not be permitted to set up movements in the coils, to cause turns to vibrate against each other, to wear off insulating material. An outer covering must also be provided to prevent the entrance of moisture into the coils to lower insulation resistance and promote corrosion. These purposes are both accomplished by the varnish impregnation and baking.

In the process now in use for treating the aforesaid coils with varnish, the coils are generally first subjected to high vacuum to remove moisture, or are subjected to elevated temperatures, or both, depending on the degree of moisture elimination required prior to impregnation. High voltage applications generally require greater elimination of moisture than do the lower voltage requirements, and quality jobs, or those where reliability and uniformity are essential, require moisture elimination comparable to the high voltage applications. The process is often very slow and expensive, as equipment to handle coils in quantity is expensive, and length of baking time required makes productivity of the equipment low.

After the vacuum treatment, or baking for this moisture elimination, the coils go immediately into the varnish, where they soak until all openings are filled. This is sometimes done, also under partial vacuum, to eliminate trapped air, which also makes the operation slow and expensive. The coils must remain in this treatment until all air is eliminated and all openings are filled. This is particularly difficult where fine wire is wound closely.

After the impregnation, coils are drained until

2

surplus varnish has run off the outside. Unless the vicosity of the varnish has been well controlled, it may drain from the inside also, which is generally undesirable. Coils are then usually placed in trays, which then go into ovens, for the baking operation, at temperatures which may be changed during the process. Beside the slow difficult methods of the moisture elimination, the following difficulties arise, in the baking operations, which are needlessly slow, troublesome and often serious.

It is characteristic of solutions of gums, or plastics, in solvents, that the rate of solubility of the gums, or plastics, in these solvents, decreases as the solvent proportion lessens, and conversely, that the rate of ability of solvents to pass through such solutions is dependent upon the amount of solvent present in the solution. For this reason, an undesirable solvent trapping effect occurs during the baking, when this is accomplished by external heat. This has been recognized in the application of radiant lamps to the drying of lacquer films, as on automobile bodies. In this case the temperature of the metal sheet is elevated above the temperature of the lacquer film, by the use of radiant lamps. This elevated temperature of the metal sheet causes the drying to start at the inner surface next to the metal, the solvent being driven to the outside before a solid film forms at the surface.

In the oven-baking method, the temperature of the outer film of varnish is elevated first, and the solvent thus dries from the outer surface more rapidly than from the mass of varnish within. Because of this condition, only very slow drying is possible, if bubbles or ruptures are to be avoided in the insulation, due to the formation first of the solid film, on the outside, while considerable solvent must still be removed from within.

Since these ovens are expensive, with their close temperature control equipment, and ventilation provisions for safety, the low production rates make the operation costly. This needlessly ties up usually expensive equipment and product in process, beside the other difficulties aforesaid, and the slowness of the process causes other difficulties to be explained later.

With reference to the radiant lamp method previously explained, it is evident that this method cannot be employed, as only the outer layer of wire would be heated, which would dry the outer film of varnish before the mass of varnish within the coil has been dried.

The enamels used to insulate, or cover the wires, are soluble in many of the solvents used in the

varnishes. Some of the enamels used, are soluble in naptha, benzene, kerosene and similar hydrocarbon solvents. Some are soluble in acetone, ethyl-acetate, amyl-acetate, and similar solvents, and some are dangerously soluble in mixtures of these and other solvents.

It is evident that when coils of wire insulated with these enamels are dipped into varnishes containing some or several of these or similar solvents, that it is desirable to drive the solvent away from the enamel as rapidly as possible. I accomplish this, as an important improvement, in my process, as I will show, whereas in the present baking processes, the formation of the solid film on the outside of the coil prevents rapid elimination of the solvents. This also traps the solvents, at elevated temperatures, about the wires, to soften the enamel and thus at times, permit the turns to make metallic contact with each other. This causes "shorts," or the softening may weaken insulation to later permit voltage breakdowns across these weakened spots, or to cause "hot spots" to ruin adjacent insulation.

I have found that if the temperature of each wire is elevated above the temperature of the impregnating varnish, by internal heating of the wire, that the drying will start at this point. This immediately drives the solvent away from the enamel cover of the wire, thus protecting the wire cover, and setting up an internal drying first, which is highly desirable. This is one of the objects of my invention, i. e., to insure a better average quality of product, by lessening hazards to enamel wire coverings.

Another object is to eliminate handling from vacuum moisture removal ovens, to dipping tanks, to baking ovens, and to accomplish this all in one automatic machine.

Another object is to reduce the amount of heat lost from the multiplicity of large ovens, and to confine the heat employed to a useful purpose in the machine.

Other objects of the invention will be evident as I proceed with the disclosures.

Fig. 1 is a side elevation partly in section for automatically accomplishing my novel methods of drying, impregnating and setting of the varnish.

Fig. 2 is a cross-section of the wire surrounded by a coating of impregnating varnish.

Fig. 3 shows one type of contact clip which may be used to make electrical contact with commutator bars, when armatures are impregnated, and also support the whole assembly mechanically.

Fig. 4 shows a modification wherein a laminated stator stack is suspended in a high frequency magnetic field.

In Fig. 1, the frame of the machine is designated 2, which rests upon the bed 3. A tank 5, containing impregnating varnish 7, is shown supported by the bed 3. The upright portions of frame 2 are provided with vertical slots 4, within which the cross-shaft 6 is moved by connecting rods 15. Shaft 8, revolving in bearings 9, is driven at times during the process by motor 10, through gear reduction unit 11, off-set counter shaft 8a and pinion 13b. The shaft 8a is journaled in bearing 12, and pinion 13b is in meshing engagement with the external teeth of plate 13. As shown in Fig. 1, the plates 13 and 13a are fixed for rotation with shaft 8, and accordingly shaft 6 is elevated and lowered in the slots 4 by reason of the connecting rods 15, which connect the eccentric studs 14 with said shaft 6. Mounted on the shaft 6 are a plurality of fixtures 16 which accommodate attachments 18, for holding

any special coils, or armatures such as 17 shown in Figs. 1 and 3. These attachments not only support the armature or coil but make electrical contact, as on the commutator bars 19 or the clipping of the bare wire ends of the coils. The fixtures 16 are similarly constructed, in principle, to electric light sockets to permit separated electrical leads to be connected to them to pass electric current through to the fixtures 18, with their separated contacts, to the coil terminals in the commutators 19.

The control unit is shown as 20, Fig. 1. A synchronous or constant speed motor 21, with built-in speed-reducer, turns the drum 23 at the desired speed for a maximum cycle of time for one full operation. The metal drum 23 is excited, by one side of the line, over the same switch 22 which starts the synchronous motor 21. The metal drum is covered with an insulating sheet with slots 24, 25 and 26 which permit the brushes 27, 28 and 29 to make contact with the metallic drum in the proper sequence. These brushes 27, 28 and 29, when excited by contact with the metallic drum 23, actuate relays 30, 31 and 32 over the circuits shown. A greater number of these brushes and circuits may be used where more current changes are needed. Resistance coils 34 and 35 are used in the circuits to control current demands, but transformers or autoformers could be used with alternating current, which might be used with the armatures shown, to heat their iron stacks by induction. The line 37 leads to ground, and 38 leads from the control unit to the holding fixtures 16 to supply current for the processing of the windings and stack. Lines 39 and 40 lead from the control unit to the motor 10.

Fig. 2 shows a copper wire 41 surrounded by a film of varnish 42. The arrows show the direction of heat loss and temperature drop, and the region of heavy dots in the varnish film shows where the fast drying starts.

In Fig. 3, commutator bars of an armature are shown as 19, and 18 shows the metallic clips, which support the commutator as the armature hangs, and which supply electric current to the armature through these commutator bars.

In Fig. 4, a hook 45 is shown as a means of suspending a laminated stack, such as the one shown as 47. An insulating tube of ceramic material is shown as 48 supporting the insulated copper wire coil 50. Leads to the copper wire coil are shown as 51 and 52.

In operation, when the armatures or coils have been suspended in clips, as shown in Fig. 1, the switch 22 is thrown. This excites the drum 23, as previously stated, and starts the motor 21. When the drum 23 has turned a short distance it picks up contact with brush 27 through slot 24. This pulls in relay 30, which causes the current regulated by resistor 34 to pass through the armature windings, to dry the moisture from same. The length of time, before slot 25 makes contact with brush 28, controls the time of drying. At this point, and while the armature is still warm, the exciting of brush 28, by making drum contact through slot 25, pulls in relay 31, which causes the motor 10 to lower the armatures 17 into the varnish 7. It will be noted that the current continues to flow through the coils after they have been immersed. This is for the purpose of thinning the varnish, as it flows into the windings, to insure good penetration because of its lowered viscosity. When this has been accomplished, the current is cut off at the limit of slot 24. The current remains off, to allow thickening of the var-

nish in the windings, until the second slot 25 is reached, when the motor 10 is again excited, thus lifting the shaft 6 and coils 17 out of the varnish. At this point, contact is made at 26 with brush 29 to actuate relay 32, to pass the proper amount of current through impedance or resistance 35 to drive out the solvents from the windings and hold the temperatures of the windings at that desired to set the varnish. With gloves, the armatures or coils may then be removed from the clips 18 and laid in trays to cool. Removal of the solid varnish from the commutators and armature poles would be accomplished in the manner previously used.

I have now described the operation of the machine suited to my process or method. I have accomplished my objectives by passing the proper amount of electric current through the coils to first dry out all moisture, from the inside toward the outside. I have heated the heavier varnish close to the turns during impregnation, to lower its viscosity, and thus permit it to rapidly enter all openings after it has driven out any air by outward expansion, due to internal heating. I then cut off the current to let the varnish cool within the windings, to become heavy and viscous, before removing coils from varnish, to lessen internal drainage. I then accomplish the final drying and baking by passage of electric current of the proper intensity, or change of intensity through the windings. Change of current intensity may be accomplished by using several brushes, with different resistances, instead of the one brush 24, Fig. 1. By picking up and dropping these in the proper sequence, maximum rapidity of drying, outwardly from around each wire, is accomplished, because maximum tolerable internal heat conditions prevail, with the surface of the varnish still soft, with no crust or solid film to retard drying, as previously stated.

Alternating current, of the proper frequency, may be employed in the coils, when they surround a laminated stack of iron, to set up heat in each lamination to dry and set the separating varnish, in this manner, by liberating the heat from within. Frequencies and current intensities are adjusted to accomplish the required balance for the double purpose, with an automatic process, for heavy production, generally similar to that shown in Fig. 1, to permit the sequence of operations to be controlled automatically, as well as to control the frequencies and current intensities automatically.

It is sometimes desirable to impregnate a laminated core before winding, such as an armature stack assembly 47 (Fig. 4), or a stator stack assembly, to fill all of the openings between the laminations, to lessen eddy currents and to eliminate humming in the finished product. It may be desirable to use a heavier varnish, for this purpose, or a different varnish from that desired in the windings.

These may be treated in the following manner: The cores are hung in a fixture suspended on the machine in a manner similar to that shown in Fig. 4. The stack is hung on a hook within a coil of wire. The proper high frequency current is passed through the coil to elevate the temperature above the temperature of the varnish, to first accomplish drying at the inner surface, as I do

in my coil drying. The sequence of operations, in this case, is similar to those previously described.

Individual laminations could be passed through special machines to accomplish the same sequence to rapidly coat them with dried varnish also.

While I have shown one means for accomplishing my objects, it could be altered to accomplish good results. It is possible that varnishes might be used, in which the main solidifying of the impregnating fluid might be accomplished by polymerization due to heat. My machine would have many advantages in this case also. For this reason I do not propose to be limited to the exact disclosure, but to the broad principles of the invention.

Having disclosed my invention, what I claim is:

1. An apparatus for impregnating coils of electrically insulated wire comprising in combination a tank containing an impregnating varnish, a cross member adapted to support a plurality of coils to be impregnated, means to raise and lower said cross member to dip all of said coils in said varnish, means to pass current through said coils to eliminate moisture therefrom, and automatic means to sever the current flow through said coils during a period when they are submerged in said varnish to prevent internal drainage upon their removal from the varnish.

2. An apparatus for impregnating coils of electrically insulated wire comprising the combination of a tank containing an impregnating varnish, a cross member adapted to electrically support a plurality of coils to be impregnated, means to raise and lower said cross member to simultaneously dip all of said coils in said varnish, electrical means arranged to pass current through said coils before they are dipped in the varnish to drive moisture therefrom, and automatic means to sever the current flow through said coils during a period when they are submerged in the varnish to allow thickening of the varnish to prevent internal drainage upon their removal from the varnish, said last mentioned means adapted to re-establish said current flow through the coils upon their removal from the varnish to drive solvent out and solidify the varnish from the coils outwardly to prevent rupturing of said varnish during its drying period.

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