Aug. 6, 1968 R. E. WHIPPLE 3,396,356

CROSS-WOUND OPEN MESH COIL

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Fig. 1.

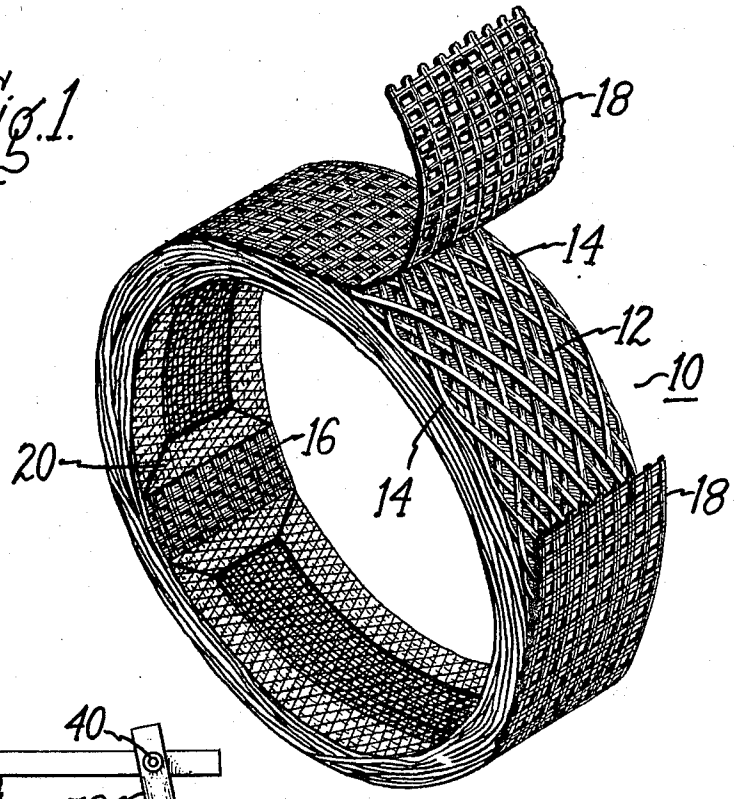
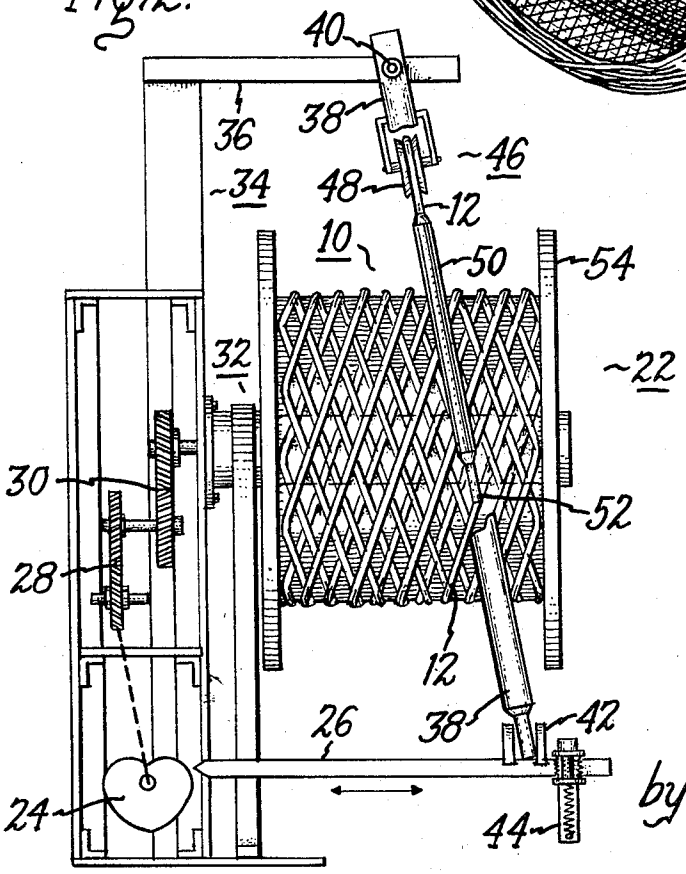


Fig. 2.

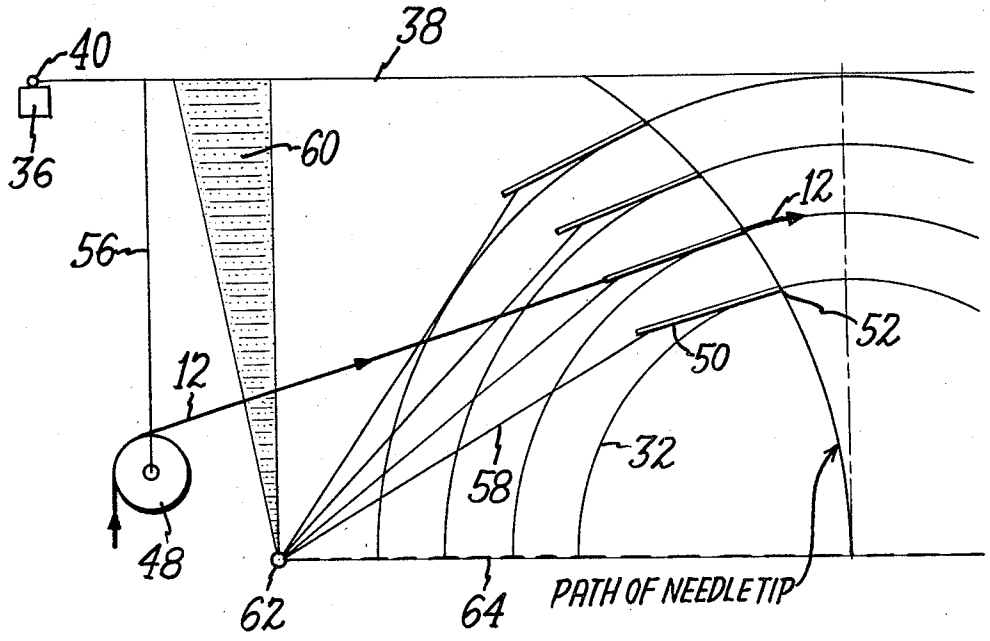


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Fig. 3.



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CROSS-WOUND OPEN MESH COIL

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3 Claims. (Cl. 336—189)

ABSTRACT OF THE DISCLOSURE

A novel cross-wound, open mesh coil and method of winding such coil. The open mesh coil is cross-wound on a flanged arbor using a thin-wall, hollow needle which presses the wire against the flange with a slight overthrow to help position the wire before the next traverse of the wire across the arbor. The cross-over points within the coil are bonded together by an adhesive overcoat on the wire, which is cured. An open mesh resin material is applied to the inner and outer surfaces of the coil and bonded thereto by curing. A specific machine for winding the coil is also disclosed.

This invention relates to high voltage coils and more particularly to cross-wound open mesh coils and to the method of making such coils.

As is well known to those skilled in the electrical art, electrical apparatus is becoming smaller and more compact while at the same time being subjected to greater amounts of electrical current and voltage. Also, greater use is being made of encapsulated components in such electrical apparatus. By "encapsulated" it is generally understood to mean to completely encase a component in an insulating resinous material, with such material completely filling, as far as possible, all voids in the structure of the component, As is well understood, voids in an electrical component subjected to high voltage leads to the development of corona in such voids. The corona generally leads to deterioration of the insulation and subsequent breakdown of the electrical component.

In electrical coil manufacture most coils are wound on an arbor with each layer of the coil wound directly over the preceding layer. The coils are wound as tightly as possible and depend on the insulation of the wire to provide necessary insulation between the various wire turns. For high voltage coils, layer insulation is sometimes placed between each layer of the coil to provide additional insulation between the layers. These types of coils cannot be adequately encapsulated because the encapsulating resin cannot penetrate the interstices of the coil and thus is not able to fill all of the voids between the various turns and layers within the coil. When encapsulated coils of this construction are subjected to high impulse voltages there is a tendency for corona to develop in these unfilled voids. As above noted, this corona will eventually lead to the breakdown of the coil. To overcome these problems a precision wound coil using open mesh insulation between the various layers of the coil has been considered. However, it has been found that such coils cannot be adequately encapsulated without leaving a number of voids within the coil structure.

Another type of coil that has been considered for encapsulation is the cross-wound coil. This coil is sometimes referred to as a "universal" winding. Coils of this type are known in the prior art such, for example, as Patent No. 1,342,209. The cross-wound or universal coil has generally been used for inductance coils because of the lower distributed capacity of this type of winding. Many attempts to produce a cross-wound coil for high voltage application have been unsuccessful. When wire having adequate enamel insulation has been used in cross-wound coils the turns tend to fall off during winding. These turns provide

displaced wires which result in excessive stresses being placed on the insulation between such displaced wires and adjacent wires. When fabric covered wire is used to form such coil, the fabric tends to hold the coil turns in the desired position, but the fabric covering prevents the encapsulating material from filling the voids in the coil.

It has recently been discovered that a cross-wound coil can be made from wire having adequate enamel insulation by use of winding means which firmly position the end turns of the coil against the flanges of an arbor on which the coil is wound. It has also been discovered that after such cross-wound coils have been wound the coils may be dimensionally and physically stabilized by the use of inner and outer layers of epoxy material which may be cured to stabilize the coil prior to removal of the coil from the arbor. It has also been discovered that coating means may be provided over the enamel insulation which may be cured prior to removal of the coil from the winding arbor to stabilize the cross-wound coil.

Therefore it is one object of this invention to provide a novel, cross-wound, open mesh high voltage coil.

A further object of this invention is to provide a dimensionally stabilized cross-wound, open mesh coil which may be readily encapsulated in an insulating resinous material.

A still further object of this invention is to provide a novel method of winding a cross-wound, open mesh high voltage coil.

In carrying out this invention in one form, an open mesh, cross-wound high voltage coil is wound on a flanged arbor by means of a cross feed mechanism which causes the wire of the coil to be firmly positioned against the flanges of the arbor prior to the reverse traverse of the wire feed mechanism. The coil wound according to this invention in one form is an open mesh coil dimensionally and physically stabilized by means of a cured overcoat placed on the wire enamel. According to another form of the invention the cross-wound open mesh coil is dimensionally and physically stabilized by a layer of compatible insulating mesh material bonded to the inner and outer surfaces of the coil.

The invention which is sought to be protected will be particularly pointed out and distinctly claimed in the claims appended hereto. However, it is believed that this invention and the manner in which its various objects and advantages are obtained will be better understood by reference to the following detailed description of various embodiments thereof, particularly when considered in the light of the accompanying drawing, in which:

FIGURE 1 is a perspective view of a cross-wound open mesh coil according to one form of this invention;

FIGURE 2 is a plan view of one form of winding machine, with portions in phantom, which may be used to wind the coil of FIGURE 1; and

FIGURE 3 is a schematic view of one method of mounting the winding needle on the winding machine.

Reference will now be made to the drawing wherein like numerals are used to indicate like parts throughout the various views thereof. Reference ring first to FIG. 1 of the drawing, there is shown a cross-wound open mesh coil **10** which comprises a plurality of turns of wire **12**. As is clear from FIG. 1, the various turns of wire **12** are cross-wound over the width of the coil **10** forming the desired open mesh coil **10**. As will be apparent from FIG. 1, the wire **12** is wound angularly across the width of coil **10**, sharply turning at each edge of coil **10**, as indicated at **14**, and returning angularly across to the opposite edge of coil **10**. This, of course, produces an open mesh winding. According to this invention the open mesh coil **10** may be wound with greater than 50% open area within the coil, while providing a dimensionally and physically stabilized coil which may be readily encap-

sulated with an encapsulating resin which may fill all of the interstices of the coil structure.

In a preferred form of the invention a B stage epoxy glass mesh insulation **16** is placed on a winding arbor prior to winding of coil **10**. After the coil **10** is cross-wound on the arbor a second layer of B stage epoxy glass insulation **18** is tightly wound about the outside upper surface of coil **10**. In FIG. 1 the outer layer of epoxy insulation is shown as pulled back to better show the winding of coil **10**. However, it will be understood that the epoxy insulation **18** will be tightly wound about the outer surface of coil **10**. After the coil is wound and the B stage epoxy insulation is in place, the coil will be heated to cure the epoxy insulation. The cured epoxy insulation will dimensionally and physically stabilize the coil **10** securing the inner turns and preventing the coil from spreading.

In another form of the invention the coil **10** is wound with wire **12** in which the wire **12** is provided with a coating over the enamel insulation. The overcoat on the enamel insulation is used to lock the adjacent turns of the wire together at their cross-over points. One type of overcoat that provides the desired adhesion of adjacent wires is a polyvinyl butyral resin. After winding of coil **10** it is heated while in place on the arbor. The heating first softens and then cures the overcoat. This curing effectively locks the adjacent turns of wire **12** at their cross-over points. Obviously, other material could be used as the overcoat as long as it is compatible with the wire enamel used.

Of course it will be understood that both the epoxy glass insulation and the overcoat material may be used together if desired. In coils utilizing wire of very small diameter, the overcoat material is particularly useful in providing additional insulation for the coil, as well as providing a more stable coil.

Also shown in FIG. 1 is an electrostatic shield member **20**, the shield member **20** is made of expanded metal and used in the manner particularly set forth in application Ser. No. 505,911 filed Nov. 1, 1965, now abandoned, for Electrostatic Shield for Encapsulated Electrical Apparatus, in the name of the present inventor and assigned to the same assignee as this invention. When the electrostatic shield **20** is used it is placed on the winding arbor prior to the inner epoxy mesh insulation **16**. Obviously, when the epoxy mesh insulation **16** is cured the shield **20** is firmly bonded to coil **10** in the desired position. Of course, it will be apparent to those skilled in this art that a second electrostatic shield could be placed over the outer epoxy resin insulation **18** and firmly bonded to coil **10** if desired.

The preferred method of making the cross-wound open mesh coil of this invention is best shown in FIG. 2 of the drawing. FIGURE 2 shows a coil winding machine **22** provided with a cross feed mechanism comprising a cam member **24** and pusher arm or cam follower **26**. Of course, it will be understood that cam **24** will be of a preferred shape, according to the form of open mesh winding desired. In the present instance, cam **24** is shown as a heart-shaped cam which produces a linear traverse motion with minimum reversal angle. Cam **24** is driven through gears **28** which are driven in synchronism with gears **30**. As is shown, gears **30** drive the winding arbor **32**. As will be understood gears **28** and **30** are driven from any desired source of power (not shown). The pusher arm **26** will traverse the width of the winding arbor **32** for each rotation of cam **24**. The ratio between gears **28** and gears **30** will determine the number of times that pusher arm **26** traverses winding arbor **32** for each rotation of the winding arbor **32**. This ratio will determine the amount of open area within the coil **10**.

Winding machine **22** is provided with a fixed frame **34** to which is rotatably and movably attached the various components of winding machine **22**. Winding frame **34** includes a cross-arm **36**, and a pivot arm **38** is provided at one end to the cross arm **36** as shown at **40**. The pivot arm **38** is connected at its opposite end to pusher arm **26** as indicated at **42**. Pusher arm **26** is spring mounted in mounting means **44** which is fixed to the frame **34**. The spring mounting **44** continuously forces pusher arm **26** against cam **34** while allowing the arm **26** to move across the width of winding arbor **32** when pushed by cam **24**. Of course, it will be understood that pusher arm **26** and mounting means **44** could be replaced by other types of cam followers, if desired.

The pivot arm **38** shown partially in phantom view, carries a wire feed device **46** which includes a pulley **48**, a hollowing guiding finger **50** and a thin-walled, flexible, hollow needle **52**. Wire **12** is fed from a feed roller (not shown) over pulley **48** through hollow guide **50** and hollow needle **52** to the winding arbor **32**. The stroke of pusher arm **26** is set for a traverse slightly greater than the width of arbor **32**. Flanges **54** are provided on the winding arbor **32**. Thus when needle **52** is moved by pivot arm **38** and pusher arm **26** to the end of the traverse stroke, the needle **52** will contact one of the flanges **54**. With the over travel of arms **26** and **38** the needle **52** flexes against the flange **54**, holding wire **12** against flange **54** for a short distance. This allows wire **12** to position itself firmly against flange **54** so that it will not be pulled away from flange **54** when the wire feed mechanism **46** reverses to traverse back across the winding arbor **32**. As will be apparent, by the winding method herein described, a flexible needle **52** is provided moving with a traverse stroke slightly greater than the width of winding arbor **32**. This provides a dwell of the wire **12** against the flange **54** sufficient to allow wire **12** to be firmly positioned against the flange **54** before the reversal forces of the traverse mechanism are applied to the wire **12**. The flanges **54** keep the turns of coil **10** in proper position during the winding preventing wire falling off during the winding operation. As will be apparent from FIGURE 2 of the drawing, pivot **40** is positioned along cross arm **36** such that wire guide **50** and needle **52** will swing equal arcs about its center position between flanges **54**.

In order to wind relatively thick coils, two or more inches thick, it is necessary that the point of needle **52** should be substantially tangent to the diameter of the coil **10**. FIGURE 3 shows, in diagrammatic and schematic form, a side view of one means of mounting needle **52** on pivot arm **38** to insure that the needle **52** will remain tangent to the diameter of coil **10** as it is wound on arbor **32**. As shown in FIGURE 3, arm **38** is pivoted at **40** on cross arm **36**. Pulley **48**, over which wire **12** is fed, is suspended below arm **38** by pulley support **56** which may be, for example, a U-shaped bracket depending from arm **38**. A support arm **58** is provided, to which is connected, at one end, wire guide **50** and needle **52**. The opposite end of support arm **58** is pivotally mounted on depending member **60**, as at **62**. As shown, member **50** is mounted on arm **38** and extends below arm **38** to substantially the center line **64** of winding arbor **32**. Of course, it will be understood that pivot point **62** is such that support arm **58** is pivotal only in a vertical direction. Obviously, member **60** and arm **58** must traverse the arbor **32**, in the manner indicated in FIGURE 2, to provide the desired cross-wound coil **10**. FIGURE 3 shows in phantom lines the plurality of positions taken by support arm **58**, wire guide **50** and needle **52** as the thickness of the winding increases on arbor **32**.

Of course it will be understood that in using the winding machine **22** either the epoxy glass mesh insulation, such as **16** and **18**, or an overcoat, or both such means, may be used to stabilize the finished coil. After the winding **10** is completed on arbor **32** the winding is heated to cure either the epoxy insulation or the overcoat or both to dimensionally and physically stabilize the coil **10**.

From the above it will be apparent that by means of this invention a cross wound open mesh coil is provided which may be readily encapsulated in any desired encap-

sulating resin. The open mesh of the coil will readily allow the encapsulating resin to completely fill all the voids in the winding structure.

While there has been shown and described the present preferred embodiments of this invention, it will be understood that such descriptions are for illustrative purposes only. Obviously, many changes may be made in the various constructional details without departing from the spirit or scope of the invention, particularly as it is defined in the appended claims.

What is claimed as new and which it is desired to secure by Letters Patent of the United States is:

I claim:

1. A cross-wound, open mesh coil comprising a plurality of turns of wire cross wound to form an open mesh coil having at least 50% open area within such coil and having a layer of epoxy glass mesh insulation firmly bonded to the inner and outer surfaces of said coil.

2. A cross-wound, open mesh coil as claimed in claim 1 in which a resin overcoat material on said wire firmly bonds the cross-over points within said coil, leaving said open area within said coil free of said resin material.

3. A cross-wound, open mesh coil comprising a plurality of turns of insulated wire cross-wound to form an open mesh coil having at least a 50% open area within said coil, the cross-over points within said coil being firmly bonded by a cured resin overcoat material on said insulated wire leaving said open area free of said resin material.

References Cited

UNITED STATES PATENTS

873,780	12/1907	Peterson	336—190 XR
1,398,372	11/1921	Gowen	336—190 XR
2,195,233	3/1940	Boyer	336—206 XR
2,282,759	5/1942	Gavitt	336—205 XR
2,295,958	9/1942	Lutz	336—206 XR
2,489,867	11/1949	D'Orio	336—205 XR
2,780,742	2/1957	Jennen et al.	336—205 XR
3,038,831	6/1962	Rosenberg	174—120 XR
3,237,136	2/1966	Ford	336—205

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