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ELECTRIC COIL MANUFACTURE

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This invention relates to the manufacture of electrical coils.

Copending applications Ser. No. 401,333, filed December 30, 1953, and Ser. No. 477,518, filed December 24, 1954, describe a novel type of electrical coil formed by winding together a sheet of metal foil and an interleaved sheet of insulating material to form a wound roll which is then thoroughly impregnated with a wax or resin and finally cut transversely of its axis into thin flat coil elements. The most satisfactory method of cutting the rolled assembly into coils is to rotate the roll while advancing a cutting edge into it. This technique frequently results in a burring of the cut edges of the foil with the result that adjacent turns become electrically connected and short circuited unless the burrs are removed.

The present invention is concerned primarily with the removal of these burred edges, and provides an improved method of etching the burrs from the edges of the conductor strips. Etching has been suggested in my prior applications but is often difficult to achieve unless care has been exercised in cutting to prevent the wax with which the coil has been impregnated from smearing over the burred edges. The presence of a wax or resin coating on the burrs protects them against the action of the acid and renders ordinary etching techniques unsatisfactory. The burrs may of course be cleaned to remove this coating prior to etching, but it has been found that carefully limited conditions of the etching process may be established by which the coating is removed during etching without a preliminary cleaning step and the burrs are then completely etched off.

This invention accordingly consists in a process of removing the burrs from the edges of the metal foil strips to eliminate short circuits they create while avoiding any damage to the conductor strips in the coil and without disrupting the established impregnation of wax or resin within the coil. In this connection, it is noteworthy that the process provides for the selective removal of metal and wax without substantial effect on the metal and wax within the coil—the etching process of this invention providing for the removal of wax from the burrs, but not from the body of the coil, and for the removal of the burrs from the edges of the strips without damage to the strips themselves.

In general, the process is carried out under conditions by which the reaction is localized so that the burrs and the wax on them react differently from the conductor strips and wax within the coil. This is achieved through the use of a hot etching bath, the temperature which assures a violent local reaction but without melting the wax within the body of the coil. Under conditions thus established, the use of concentrated aqueous acid solutions will strip the wax or resin from the burrs by the scouring actions of the escaping gaseous reaction products and will dissolve the burrs but without disrupting the wax within the coil and without seriously disintegrating the conductor strips. Where several coils are etched cleaned at once they are most advantageously arranged vertically and

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spaced apart during the etching step so that the action of the acid proceeds without entrapment of the escaping gas bubbles and with maximum scouring action.

The acid will of course, be selected with reference to the metal of the conductors, and should be as reactive as possible with the metal, that is it should be chemically able to attack the metal with the evolution of gas, and it should be strong enough to react rapidly. Its temperature has been found to be a matter requiring careful control, for it should be below or not substantially above the melting point of the wax, but it should be above 50° C. and preferably above 60° C. At lower temperatures the reaction is too slow to be effective. Generally, temperatures above 70° C. are unnecessary and frequently result in uncomfortable fumes being emitted.

As indicated, the temperatures may be above the melting point of the wax or resin in the coil, but if it is, other precautions should be exercised so that the wax or resin within the coil does not melt. For instance, the time of immersion may be limited so that melting does not occur, the treatment being repeated after interposed coolings if necessary, or the coil may be precooled so that its temperature does not rise above the melting point of the wax in the time required to strip the wax coated burrs.

Under the conditions of the process, elevated temperature and high concentration of the acid, the time of the reaction is extremely short, and should in any case be less than 30 second for the process to be optimally effective.

Under these conditions of treatment, the reaction occurs with violence but is largely localized at the burred edges. It appears that the burred edges are heated locally by the reaction so that wax coating them is readily stripped off and the reaction proceeds at a rate much faster than elsewhere. The conductors themselves within the coil, and the wax there surrounding them, are not significantly effected.

This invention is described below in detail as it is preferably practiced in forming coils of aluminum foil as described in copending application Ser. No. 477,518, filed December 24, 1954.

The coils are sliced from the roll consisting of aluminum foil wound upon itself with an interleaved insulating ply of an epoxy resin, such as "Mylar" on each side of which is a paper web, the whole assembly being thoroughly impregnated with a wax having a melting point of about 110° C. The coils as sliced from the roll have shiny side surface resulting from the wiping out of the edges of the foil forming burrs largely extending from one turn to the next.

The etching bath consists of concentrated commercial hydrochloric acid (35–37% HCl) heated to a temperature of 65° C. The coils are arranged vertically and spaced apart in a suitable acid-resistant basket, and immersed in the acid bath for 20 seconds after which they are immediately immersed in rinse water, and dried. The coils are now ready for further processing and assembly into electronic components, the burrs on the edges of the conductors having been completely removed.

The technique described above, used in conjunction with the formation of the coils as described in copending application Ser. No. 477,518 has been found to result in a greatly enhanced productivity with rejects occurring because of inadequate burr removal or because of acid damage to the coil itself reduced to an insignificant amount.

In treating coils of copper foil according to this invention, the same procedure is followed except that the etching bath is concentrated nitric acid, which is more reactive toward copper than other common acids.

The invention, although described in detail with reference to its preferred embodiment may of course be modified according to the particular use to which it is applied without departing from its scope. For instance, coils of

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other metals may similarly be treated and other acids may be used, all as generally described above.

Having thus disclosed our invention and described in detail its preferred embodiment, we claim and desire to secure by Letters Patent:

1. In the manufacture of impregnated coils formed of overlying turns of metal foil separated by interleaved turns of insulating material, in which the edges of the turns of foil are burred to bridge between adjacent turns, the method of removing the burrs and cleaning the impregnant from the edges of the turns comprising immersing the coils for from 10 to 30 seconds in a concentrated aqueous solution of an acid which is reactive with the metal, at a temperature between 50° C. and 70° C., the time and temperature conditions being such that the impregnant is not melted within the coil, then rinsing the acid from the coils and drying them.

2. The process defined by claim 1 wherein the foil is aluminum and the acid is hydrochloric.

3. In the manufacture of wax impregnated coils formed of overlying turns of metal foil separated by interleaved turns of insulating material, in which the edges of the turns of foil are burred to bridge between adjacent turns, the method of removing the burrs and cleaning the wax from the edges of the turns comprising immersing the coils in a concentrated aqueous solution of an acid which is reactive with the metal, at a temperature between 50° C. and 70° C. and below the melting point of the wax, then rinsing the acid from the coils and drying them.

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4. The process defined by claim 3 wherein the foil is aluminum and the acid hydrochloric.

5. The process defined by claim 4 wherein the temperature is above 60° C.

6. In the manufacture of impregnated coils formed of overlying turns of metal foil separated by interleaved turns of insulating material, in which the edges of the turns of foil are burred to bridge between adjacent turns, the method of removing the burrs and cleaning the impregnant from the edges of the turns comprising immersing the coils in a concentrated aqueous solution of an acid which is reactive with the metal, at a temperature between 50° C. and 70° C. the time of immersion and temperature conditions being such that the impregnant is not melted within the coil, then rinsing the acid from the coils and drying them.

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