INVENTOR,
Steven R. Carlon,
by Gilbert R. Carlon
His Attorney.
This invention relates to stationary electrical induction apparatus, and more in particular to an improved spacing arrangement for axially spacing disc-shaped coils for transformers and the like.

In one form of transformer, the windings are comprised of a plurality of axially displaced disc-shaped coils, the coils generally although not necessarily being serially connected. Each of the disc-shaped coils comprises one or more conductor turns. The coils are surround a cylindrical winding member of insulating material, and elongated axially extending spacing members separate the coils from the winding cylinder to provide cooling ducts. The coils are axially displaced from one another in order to provide for proper cooling as well as to insure sufficient insulation therebetween, and in order to maintain the separation of the coils against mechanical displacement or displacement caused by electromagnetic forces within the transformer, it is customary to insert radially extending spacers between the coils.

In the past, various means have been employed for axially spacing the coils. In one conventional spacing arrangement, the axially extending spacing members, commonly known as tie strips, have a generally T-shaped cross section with the widest portion of the spacing member, i.e., the cross arm, being away from the winding cylinder and engaging the radially inner surfaces of the coils. Flat generally rectangular insulating spacers are provided with their radially inner edges having apertures that engage the T-shaped axially extending members to interlock the radially extending members against pivotal and radial movement. In other words, the flat radially extending spacers, commonly referred to as key spacers, are provided with apertures in the radially inner end that match the cross section of the axially extending members or tie strips.

In this arrangement, the key spacers are only held in position by the small projections engaging the tie strips, and these projections may become broken due to excessive "pounding" of the spacers that may arise, for example, from "arc-back" in rectifier transformers, or from short circuiting of the electrodes connected to arc furnace transformers. When the projections of the key spacers become broken, the key spacers may fall out of the windings, with consequent damage to the transformer due to possible axial contact between adjacent coils or fouling of the circulation pumps of the transformer by the broken spacer.

The breaking of the projections of the key spacers is believed to be due to pivotal movement of the key spacer about the tie strip, commonly known as "walking," resulting for example from unequal movement of the conductors of the coils engaging the key spacers when excessive current in the transformer produces radial forces within the transformer tend to radially expand the windings. That is, when a transformer winding is subjected to excessive current conditions, the windings tend to expand radially, and if the conductors are not wound with the same tension, slight circumferential movement may occur between adjacent conductors, and this movement may result in circumferential movement of the key spacers.

In order to prevent such movement of the key spacers, axially extending members having channel-shaped cross sections have been provided engaging the radially outer extremities of the key spacers. This arrangement has not, however, provided a satisfactory solution to the problem, since the channel-shaped members were relatively expensive, and it was necessary to manually tie the channel-shaped members to the windings. In addition, the channel-shaped members did not sufficiently hold the key spacers to entirely prevent the breaking and falling out of the key spacers.

It is therefore an object of this invention to provide an improved means for axially spacing disc-shaped coils of an electrical winding.

It is also an object to provide locking means for preventing breaking and falling out of key spacers in an electrical winding, the locking means being characterized in that it is economically provided, and does not require manual tying to the winding.

Briefly stated, in accordance with one aspect of my invention, I provide a winding for an electrical induction apparatus such as a transformer or reactor. The winding is comprised of a plurality of axially aligned disc-shaped coils disposed on a winding cylinder. A plurality of elongated axially extending spacing members space the coils from the cylinder to provide cooling ducts therebetween. Radially extending spacing means are provided for axially spacing the coils. Axially extending locking strip means are provided circumferentially aligned with the axially extending spacing members radially outwardly of the coils, and the radial ends of the radially extending spacers are circumferentially, radially and pivotally interlocked with the axially extending spacing members and the locking strip members.

While the specification concludes with claims particularly pointing out and distinctly claiming a subject matter which I regard as my invention, it is believed that the invention will be better understood from a following description taken in connection with the accompanying drawing.

In the drawing:

Fig. 1 is a perspective view of a portion of a winding embodying the coil spacing arrangement of one aspect of my invention.

Fig. 2 is a partially cross-sectional top view of the winding of Fig. 1 with the upper key spacers removed.

Fig. 3 is a top view of a key spacer of the windings of Figs. 1 and 2 and Figs. in 4 and 5 are top views of variations of the key spacer of Fig. 3.

Referring now to the drawing, and more in particular to Fig. 1, therein is illustrated an electrical winding comprising a plurality of disc-shaped coils 10, 11, and 12. The coils are axially aligned and surround an insulating cylinder 13. A plurality of axially extending elongated spacing members such as tie strips 14 are provided on the outer circumference of the winding cylinder 13 to space the coils from the cylinder and provide a cooling duct therebetween. The spacing members 14 are preferably equally spaced circumferentially about the cylinder 13. The winding cylinder 13 may surround a magnetic coil (not shown) according to the conventional practice.

The coils 10, 11 and 12 are axially spaced apart by substantially flat radially extending insulating spacing members such as key spacers 15. As more clearly illustrated in Fig. 2, the tie strips 14 may have T-shaped cross sections with the widest portion of the tie strips being away from the winding cylinder 13 and engaging the radially inner edges of the coils. An aperture 20 is pro-
vided in the inner radial extremity of each key spacer 15, the aperture 20 being shaped the same as and at least partially surrounding the tie strip 14 so that the key spacer 15 is interlocked with the tie strip to prevent circumferential and radial movement of the spacer 15 with respect to the winding, as well as pivotal movement about the tie strip.

Elongated locking strip members 21 are provided circumferentially aligned with the tie strips 14 radially outwardly of the coils. Apertures 22 are provided in the radially outer extremities of the spacers 15 that at least partially surround the locking strip member 21 to interlock the spacers 15 to the locking strips 21 and thereby provide circumferential, radial and pivotal interlocking of the spacers 15 and the locking strips 21. As illustrated in Figs. 1 and 2, the locking strip 21 may have a substantially rectangular cross section with the widest side tangential to the coils, and the aperture 22 in the spacer 15 may be shaped to engage the radially inner surface portion of the radially outer surface of the locking strip 21. The locking strips 21 preferably do not contact with the radially outer edges of the coils, in order to allow for radial expansion of the coils.

While the preferred shapes of the tie strips, key spacers, and locking strips, are substantially as illustrated in Figs. 1–3, it is obvious that other shapes may be provided for these components without departing from the spirit or scope of my invention. Thus, any non-circular shape may be provided for the apertures in the spacers 15, and the cross sections of the tie strips and locking strips may have any non-circular shape as long as the members co-act to prevent the pivotal, radial and circumferential movement of the spacers 15. Thus, as illustrated in Fig. 4, the aperture 22 in the member 15 may be similar to the aperture of the key spacer of Fig. 3 with the exception that it is completely enclosed. In this variation, the locking strip employed is preferably the same as the locking strip illustrated in Figs. 1 and 2. In another variation, as illustrated in Fig. 5, the aperture 22 in the member 15 may be trapezoidal in shape, with the larger base forming the radially inner edge of the aperture. In this latter case, it is of course preferable that the locking strip also be trapezoidal in cross section to conform to the shape of the aperture in the spacer 15.

Since, in the spacing arrangement of my invention, the radially extending spacing members are positively locked on both ends from movement in the circumferential and radial directions with respect to the transformer and pivotally about the locking strips and the tie strips, there is no danger that the projections of the radially extending spacing members will be broken as a result of internal forces due to excess current flowing through the transformer windings.

It will be understood, of course, that, while the forms of my invention herein shown and described constitute preferred embodiments of the invention, it is not intended herein to illustrate all of the possible equivalent forms or ramifications thereof. It will also be understood that the words used are words of description rather than of limitation, and that various changes may be made without departing from the spirit or scope of the invention herein disclosed, and it is aimed in the appended claims to cover all such changes as fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. Electrical induction apparatus of the type having a plurality of radially aligned disc-shaped winding coils that radially expand when excessive current passes therethrough, an insulating cylinder, said coils surrounding said insulating cylinder, a plurality of axially extending spacing members circumferentially disposed on said cylinder and radially spacing said coils from said cylinder, a plurality of radially extending spacing members disposed between said coils, said radially extending spacing members separating said coils axially along said cylinder, said radially extending spacing members being of substantially uniform thickness and having substantially flat smooth outer surfaces that permit radial movement of said coils therel abox, axially extending locking strips circumferentially aligned with said axially extending spacing members and disposed radially outwardly of said coils a distance sufficient to permit said coils to radially expand with excessive current, said radially extending spacing members having non-circular apertures in their inner and outer radial extremities at least partially surrounding said axially extending spacing members and locking strips, said apertures and the cross sections of said axially extending spacing members being shaped to prevent radial and circumferential movement of said radially extending spacing members with respect to said winding and pivotal movement of said radially extending spacing members with respect to the radial extremities thereof, whereby fracturing of said radially extending spacing members on expansion of said coils is prevented.

2. The winding of claim 1 in which said axially extending spacing members have substantially T-shaped cross sections with the widest dimension radially outwardly and engaging the radially inner edges of said coils, the apertures in said radially extending spacing members are substantially T-shaped with the widest dimension toward the centers of the members, and the locking strip means have substantially rectangular cross sections with the longest width substantially tangential to said coils.

3. The winding of claim 1 in which said axially extending spacing members have substantially T-shaped cross sections with the widest dimension radially outwardly and engaging the radially inner edges of said coils, said locking strip means have substantially rectangular cross sections with the longest width substantially tangential to said coils, and the apertures in said radially extending spacing members partially surround said axially extending spacing members and completely surround said locking strip means.

4. The winding of claim 1 in which said axially extending spacing members have substantially T-shaped cross sections with the widest dimension radially outwardly and engaging the radially inner edges of said coils, said locking strip means have substantially trapezoidal cross sections with the longest base toward said coils, and the apertures in said radially extending members at least partially surround and conform to the shape of said axially extending members and locking strip means.

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