

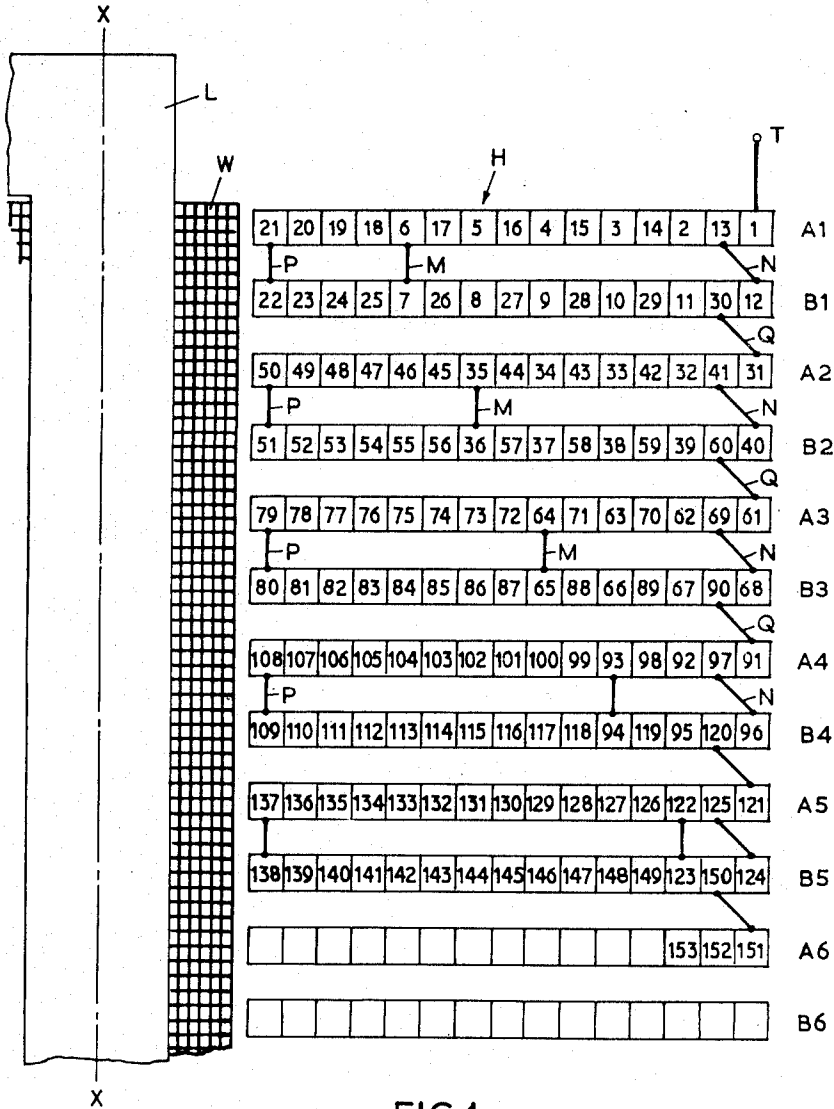
Nov. 30, 1965

A. E. BRIERLEY ET AL
INDUCTIVE WINDINGS HAVING DECREASED INTERLEAVING
IN PANCAKE SECTIONS

3,221,282

Filed Feb. 28, 1963

5 Sheets-Sheet 1



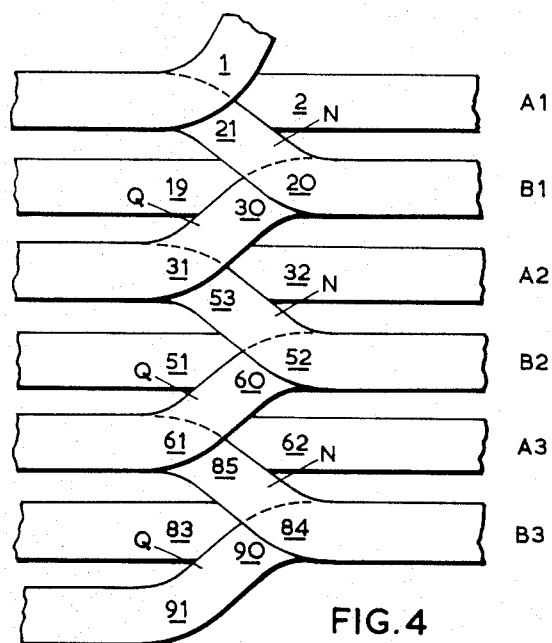
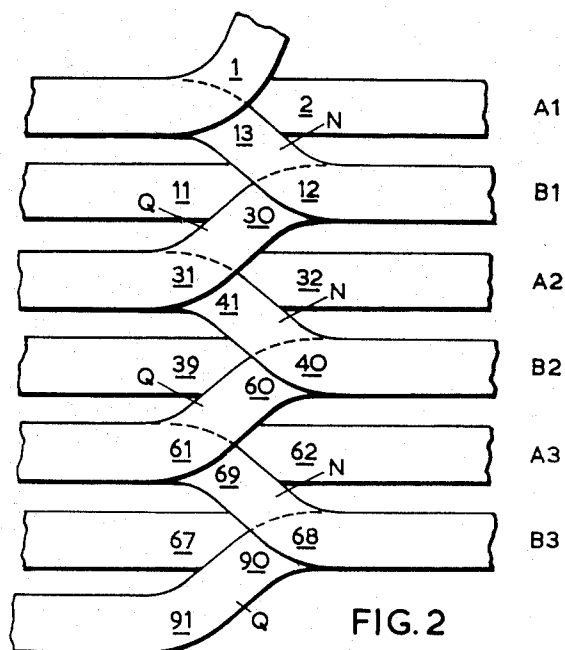
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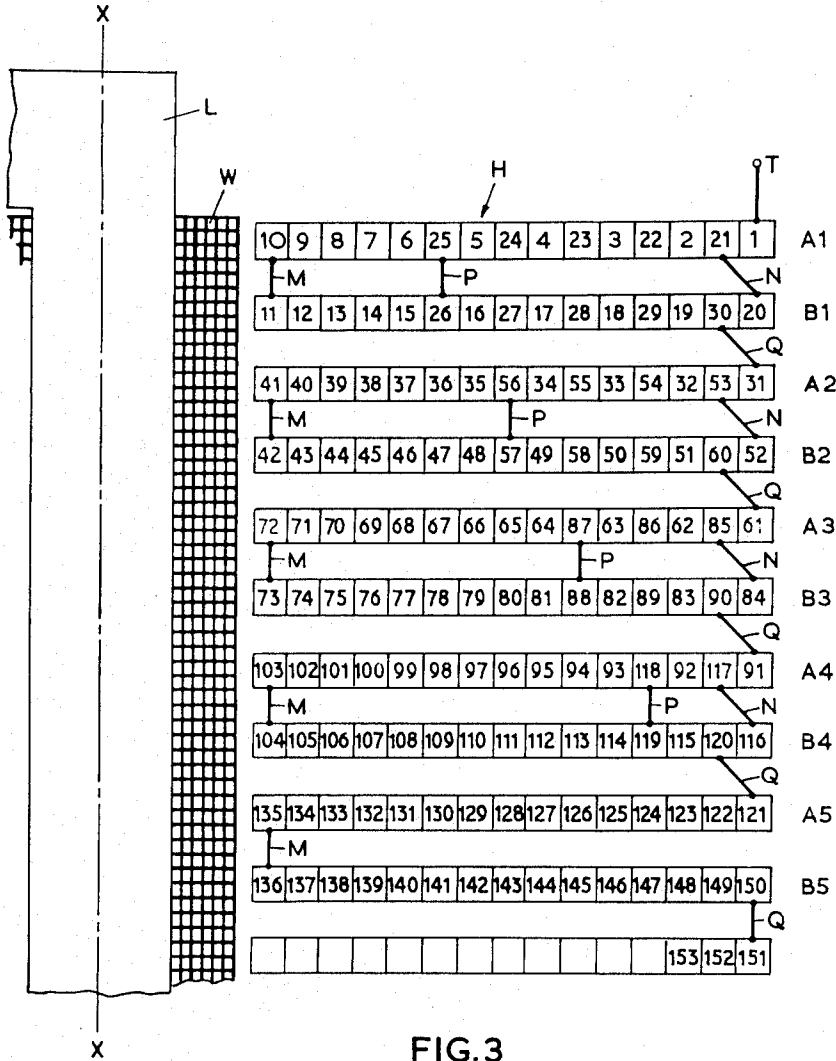
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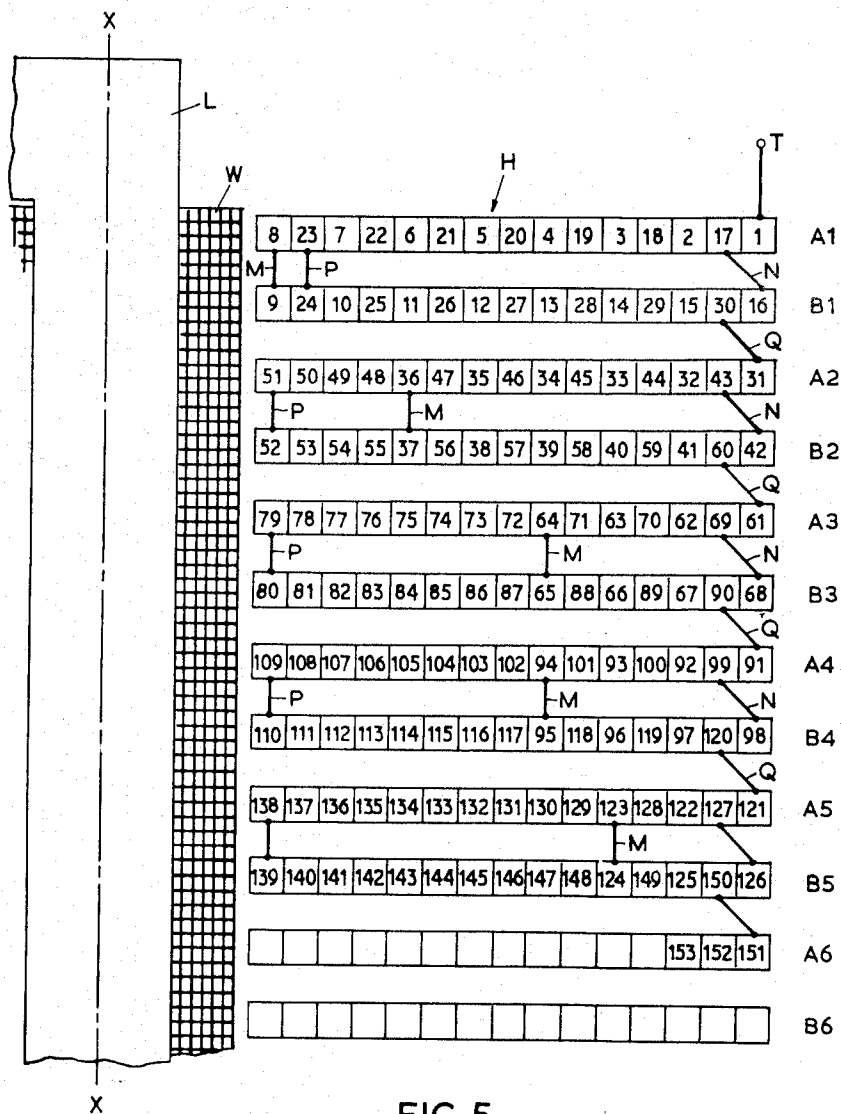


FIG. 5

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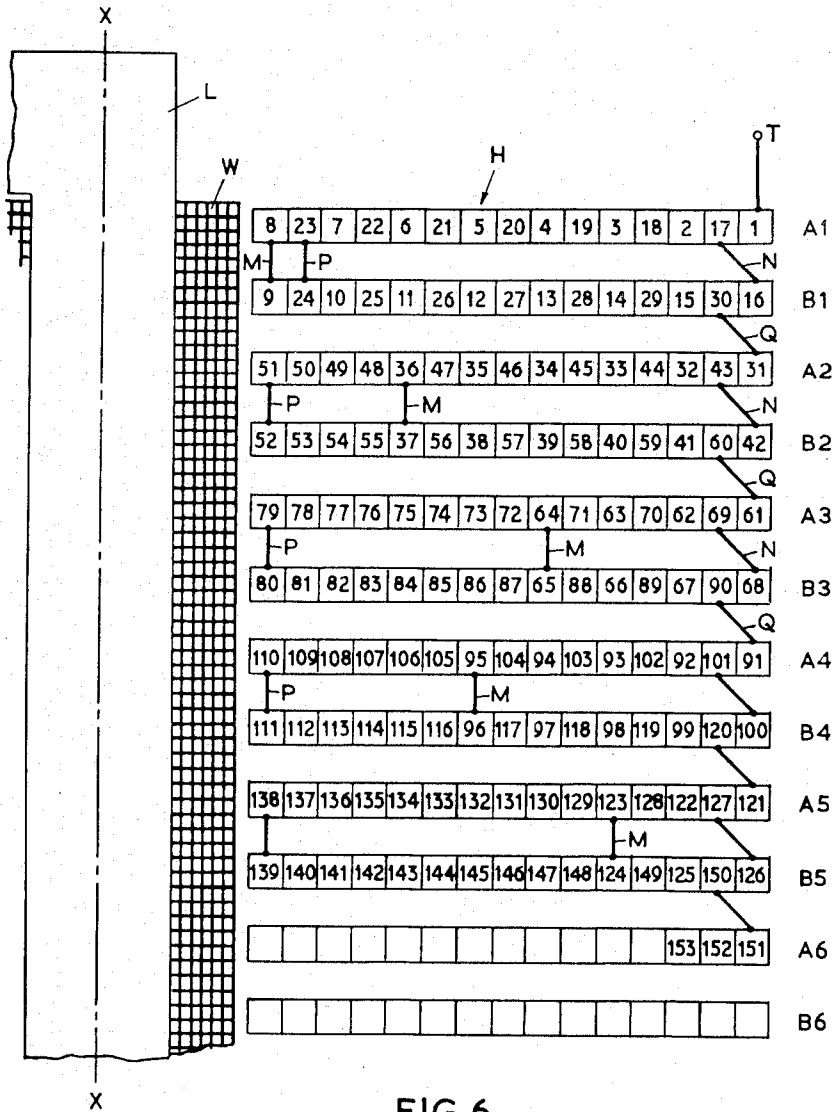


FIG. 6

1

2

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INDUCTIVE WINDINGS HAVING DECREASED INTERLEAVING IN PANCAKE SECTIONS

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4 Claims. (Cl. 336—69)

This invention relates to inductive windings, such as the windings of electric transformers and chokes.

According to the invention, there is provided an inductive winding wherein a portion of the conductor of the winding is arranged in a pair of sections spaced apart along a common axis, a first set of turns of the conductor of both sections of the pair is wound in interleaved fashion with a second set of turns of the respective section, the interleaved turns extend over part only of the radial width of the sections so that each section also includes adjacent turns of the same set of turns, and the sections are interconnected so that there is a noninductive capacitive bypath from the starting turn to the finishing turn of the pair of sections.

According to a feature of the invention, there is provided an inductive winding wherein a portion of the conductor of the winding is arranged in a plurality of pairs of sections spaced apart along a common axis, a first set of turns of the conductor of each of said sections is wound in interleaved fashion with a second set of turns of the respective section, the interleaved turns extend over part only of the radial width of each of the sections so that each section also includes adjacent turns of the same set of turns, the sections of each said pair have at least three cross-connections between them, and the sections are interconnected so that there is a noninductive capacitive bypath from the starting turn of the first of said plurality of pairs of sections to the finishing turn of the last of said plurality of pairs of sections, said capacitive bypath comprising in each pair of sections the capacitive coupling between the set of turns incorporating the starting turn of said pair of sections and the second set of turns of the first section of said pair, the capacitive coupling between the set of turns incorporating the finishing turn of said pair and the other set of turns of the second section of said pair, and a cross-connection between a turn of the second set of turns of the first section adjacent the starting turn and a turn of said other set of turns of the second section adjacent the finishing turn of said pair of sections.

The number of interleaved turns in each pair of sections may be varied in progressive steps, or in any desired fashion, along the length of the winding.

According to another feature of the invention, there is provided an inductive winding wherein a portion of the conductor of the winding is arranged in a plurality of pairs of sections spaced apart along a common axis, a first set of turns of the conductor of each of said sections is wound in interleaved fashion with a second set of turns of the respective section, the interleaved turns extend over part only of the radial width of each of said sections, the extent of interleaving decreases from one pair of sections to the next in the direction away from the high-potential terminal, the sections of each said pair have at least three cross-connections between them, and the sections are interconnected so that there is a noninductive capacitive bypath from the starting turn of the first of said plurality of pairs of sections to the finishing turn of the last of said plurality of pairs of sections, said capacitive bypath comprising in each pair of sections the capacitive coupling between the set of turns incorporating the starting

turn of said pair of sections and the second set of turns of the first section of said pair, the capacitive coupling between the set of turns incorporating the finishing turn of said pair and the other set of turns of the second section of said pair, and a cross-connection between a turn of the second set of turns of the first section adjacent the starting turn and a turn of said other set of turns of the second section adjacent the finishing turn of said pair of sections.

According to another feature of the invention, there is provided an inductive winding wherein a portion of the conductor of the winding is arranged in two pairs of sections spaced apart along a common axis, a first set of turns of the conductor of both said sections is wound in interleaved fashion with a second set of turns of the respective section, the interleaved turns extend over part only of the radial width of at least the pair of sections further from the high-potential terminal so that each of the sections of the last-mentioned pair also includes adjacent turns of the same set of turns, the number of interleaved turns of said last-mentioned pair of sections are less than the number of interleaved turns of the other said pair, and the sections are interconnected so that there is a noninductive capacitive bypath from the starting turn to the finishing turn of the pair of sections.

According to yet another feature of the invention, there is provided an inductive winding wherein a portion of the conductor of the winding is arranged in a plurality of pairs of sections spaced apart along a common axis, a first set of turns of the conductor of each of said sections being wound in interleaved fashion with a second set of turns of the respective section, the interleaved turns extending over the whole radial width of one or more but not all of the sections, and the interleaving in other sections extending over part only of the radial width of said other sections so that each of said other sections also includes adjacent turns of the same set of turns, the sections of each said pair having at least three cross-connections between them, and the sections being interconnected so that there is a noninductive capacitive bypath from the starting turn of the first of said plurality of pairs of sections to the finishing turn of the last of said plurality of pairs of sections, said capacitive bypath comprising in each pair of sections the capacitive coupling between the set of turns incorporating the starting turn of said pair of sections and the second set of turns of the first section of said pair, the capacitive coupling between the set of turns incorporating the finishing turn of said pair and the other set of turns of the second section of said pair, and a cross-connection between a turn of the second set of turns of the first section adjacent the starting turn and a turn of said other set of turns of the second section adjacent the finishing turn of said pair of sections.

A number of embodiments of the invention will now be described by way of example, with reference to the accompanying drawings, of which:

FIG. 1 is a diagram illustrating one arrangement of transformer winding in accordance with the present invention;

FIG. 2 is a detail of the arrangement of FIG. 1;

FIG. 3 is a diagram illustrating a second arrangement of winding;

FIG. 4 is a detail of the arrangement of FIG. 3;

FIG. 5 is a diagram illustrating a third arrangement; and

FIG. 6 is a diagram illustrating a fourth arrangement.

The transformer windings described herein may form part of either a single-phase or a three-phase transformer, and in the embodiments shown have a core, around a limb L of which is wound a layer-type low voltage winding W, which in turn is surrounded by a high-voltage

pancake winding generally indicated at H. Parts of the transformer which are not necessary to an understanding of the invention are omitted from the drawings for the sake of clarity.

The high voltage winding H has its conductor arranged in a considerable number of annular sections A1, B1, A2, B2, etc. which are spaced apart along a common axis X—X, which is the axis of the core limb L. The sections are supported in spaced relation in any known or convenient manner.

Each pair of sections, e.g. A1 and B1, is termed a coil in the art, and the winding spirals inwardly in the first section in each coil and outwardly in the second for a given sense of rotation. For example in section A1 the winding spirals inwardly and in section B1 its spirals outwardly in the clockwise sense when viewed from above. The turns of the conductor of the winding are indicated at 1, 2, 3, etc.

The portion of the winding to which the invention is applied, as shown in FIGS. 1 and 2, consists of the five pairs of sections nearest the high-potential end of the winding, and turn 1 may be considered the starting turn of these pairs of sections and turn 150 may be considered their finishing turn.

The high-potential terminal T is connected to the first turn 1 of the conductor, which lies at the outside of the first section A1 of the winding and form the starting turn of the pair of sections A1, B1. In the first section A1 two sets of turns of the conductor are wound together in interleaved fashion over part of the radial width of the section; the first set of turns 1, 2, 3, 4, 5, 6 of the conductor extends from the outside of section A1 only part way to the inside, whereas the second set of turns 13, 14, . . . 21 of the conductor extends over the full width from the outside to the inside of the section. Thus the turns 2, 3, . . . 6 each lie between a pair of turns 13, 14, . . . 18 of the second set, the turns 19, 20, 21 of the same set being each directly adjacent to the preceding turn outside it.

The inside turn 6 of the first set of turns of section A1 (though not at the inside of the winding) is connected through cross-connection M to the inside turn 7 of one of the sets of turns of the second section B1, this set of turns 7, 8, . . . 12 being interleaved with a set of turns 25, 26, . . . 30, including the finishing turn 30 of the pair of sections A1, B1, between turn 7 and the outside of the winding. Thus the turns 7, 8, 9, 10 and 11 each lie between a pair of turns 25, 26, . . . 30 of the second set of turns of section B1, but the inner turns 22, 23, 24 of the same set are each directly adjacent to the preceding turn.

The outside turn 12 of the first set of turns of section B1 is connected to the outside turn 13 of the second set of turns of section A1 through cross-connection N, and the inside turn 21 of the second set of turns of section A1 is connected to the inside turn 22 of the second set of turns of section B1, through cross-connection P. The finishing turn 30 of the pair of sections A1, B1, is connected through connection Q to the first turn 31 at the outside of the first section A2 of the second coil, which forms the starting turn of the second pair of sections A2, B2.

Sections A2 and B2 are identical with sections A1 and B1 respectively except that instead of there being five complete turns of the first set of turns of each section interleaved with the turns of the second set of turns, there are only four such complete turns 31, 32, . . . 35 and 36, 37, . . . 40.

The following sections A3, B3, A4, B4, A5 and B5 are also identical except that the number of turns of the first set of turns is progressively reduced, sections A3 and B3 having three such complete turns, sections A4 and B4 having two such turns and sections A5 and B5 having one such turn.

Sections A6 and B6, and succeeding coils, are wound in conventional fashion, without any interleaved turns.

The current-carrying path of the winding passes from the high-potential terminal T through the turns of the winding, in the order in which they are numbered, to the low-potential terminal; there is however also a capacitive by-path from the high-potential terminal T to the finishing turn 150 of this portion of the winding, which includes the capacitive coupling between turns 1, 2, . . . 6 and 13, 14, . . . 18 of section A1, cross-connection N and the capacitive coupling between turns 12, 11, . . . 7 and 30, 29, . . . 25 of section B1, connection Q and the corresponding elements of the following sections A2, B2, . . . B5; it will be noted that in this embodiment no capacitive coupling is provided in section A6 or sections nearer the low-potential terminal.

In the embodiment shown in FIGS. 3 and 4, the winding is modified as compared with the arrangement of FIGS. 1 and 2 and in this embodiment a first set of turns 1, 2, . . . 10 of the first section A1 of the winding extends from the outside of the winding, where the starting turn 1 of the pair of sections A1, B1 is connected to the high-potential terminal T, over the full radial width to the inside. Here turn 10 is connected through cross-connection M to the inside turn 11 of one of the sets of turns 11, 12, . . . 20 of the second section B1, which extends from the inside to the outside of the winding.

Interleaved with the first set of turns of the first section A1 is a second set of turns 21, 22, . . . 25, each of which lies between a pair of turns 1, 2, . . . 6 of the first set. The outside turn 21 of the second set is connected by cross-connection N to the outside turn 20 of one set of turns of the second section, and it will be noted that the second set of turns 21, 22, . . . 25 extends only part way across the radial width of the winding so that turns 6, 7, . . . 10 of the same set are adjacent one another. The innermost turn 25 of the second set of turns of the first section A1 is connected by cross-connection P to the inner most turn 26 of a second set of turns 26, 27, . . . 30 of the second section B1. The latter are interleaved with the first set of turns 11, 12, . . . 20 between turn 26 and the outside of the winding, so that each turn 26, 27, . . . 30 lies between a pair of turns 15, 16, . . . 20 of the first set, but turns 11, 12, . . . 15 of the same set are adjacent one another.

Moreover this second set of turns includes the finishing turn 30 of the pair of sections A1, B1 which is connected to the starting turn 31 of the next pair of sections A2, B2 by connection Q.

As in the embodiment described with relation to FIGS. 1 and 2, the remaining sections of the portion of the winding to which the invention is applied are identical with sections A1 and B1 respectively except that the number of turns of the second set of turns is progressively reduced, the pairs of sections A2, B2, A3, B3 and A4, B4, having respectively three, two and one complete turns. Sections A5 and B5 and succeeding coils are wound in conventional fashion.

In this embodiment also the current-carrying path passes through the turns in order, the capacitive bypath including the capacitive coupling between the two sets of turns in the first section of each pair, cross-connection N, and the capacitive coupling between the two sets of turns in the second section of each pair of sections.

A number of variations are possible within the scope of the invention; for example, in one or more coils (though not all) the turns may be interleaved over the full width of the winding, from the outside to the inside. In another example, instead of the number of turns which are interleaved being varied progressively through the first, second and subsequent coils, the number may be varied in any desired manner, and may even in certain embodiments increase from one section to another section further from the high-potential terminal.

said eighth set being wound in a spiral alternately with part of said seventh set of turns and including first and second end turns, the number of turns of said sixth and eighth sets being less than the number of turns of said second and fourth sets respectively; a fourth cross-connection between said second end turn of the third set of turns and said second end turn of the sixth set of turns; a fifth cross-connection between said first end turn of the fifth set of turns and said first end turn of the seventh set of turns, said first end turn of the seventh set of turns being adjacent said first end turn of the fifth set of turns; a sixth cross-connection between said first end turn of the sixth set of turns and said first end turn of the eighth set of turns, said first end turn of the eighth set of turns being adjacent said first end turn of the sixth set of turns; a seventh cross-connection between said second end turn of the fifth set of turns and said second end turn of the eighth set of turns, a fifth of said sections having a ninth set of turns wound in a spiral and including first and second end turns, and a tenth set of turns wound in a spiral alternately with part of said ninth set of turns, said tenth set including first and second end turns; a sixth of said sections having an eleventh set of turns substantially equal in number to the number of turn of the ninth set, said eleventh set being wound in a spiral and including first and second end turns, and a twelfth set of turns substantially equal in number to the number of turns of the tenth set, said twelfth set being wound in a spiral alternately with part of said eleventh set of turns and including first and second end turns, the number of turns of said tenth and twelfth sets being less than the number of turns of said sixth and eighth sets respectively; an eighth cross-connection between said second end turn of the seventh set of turns and said second end turn of the tenth set of turns; a ninth cross-connection between said first end turn of the ninth set of turns and said first end turn of the eleventh set of turns, said first end turn of the eleventh set of turns being adjacent said first end turn of the ninth set of turns; a tenth cross-connection between said first end turn of the tenth set of turns and said first end turn of the twelfth set of turns; and an eleventh cross-connection between said second end turn of the ninth set of turns and said second end turn of the twelfth set of turns, whereby a capacitive, non-inductive current path is provided from the high-potential terminal to the second end turn of the eleventh set of turns, the extent of the capacitive coupling effect being decreased from the first of said sections to the sixth of said sections.

3. An inductive winding as claimed in claim 2 comprising also a seventh and an eighth of said sections spaced apart along said common axis, said seventh section having a thirteenth set of turns wound in a spiral and including first and second end turns, and a fourteenth set of turns wound in a spiral with part of said thirteenth set of turns and including first and second end turns; said eighth section having a fifteenth set of turns substantially equal in number to the number of turns of the thirteenth set, said fifteenth set being wound in a spiral and including first and second end turns, and a sixteenth set of turns substantially equal in number to the number of turns of the fourteenth set, said sixteenth set being wound in a spiral alternately with part of said fifteenth set of turns and including first and second end turns, the number of turns of said

fourteenth and sixteenth sets being equal to the number of turns of said tenth and twelfth sets respectively; a twelfth cross-connection between said second end turn of the eleventh set of turns and said second end turn of the fourteenth set of turns; a thirteenth cross-connection between said first end turn of the thirteenth set of turns and said first end turn of the fifteenth set of turns, said first end turn of the fifteenth set of turns being adjacent said first end turn of the thirteenth set of turns; a fourteenth cross-connection between said first end turn of the fourteenth set of turns and said first end turn of the sixteenth set of turns, said first end turn of the sixteenth set of turns being adjacent said first end turn of the fourteenth set of turns; and a fifteenth cross-connection between said second end turn of the thirteenth set of turns and said second end turn of the sixteenth set of turns, whereby a capacitive, noninductive current path is provided from the high-potential terminal to the second end turn of the fifteenth set of turns.

4. An inductive winding as claimed in claim 2 comprising also a seventh and an eighth of said sections spaced apart along said common axis, said seventh section having a thirteenth set of turns wound in a spiral and including first and second end turns, and a fourteenth set of turns wound in a spiral with part of said thirteenth set of turns and including first and second end turns; said eighth section having a fifteenth set of turns substantially equal in number to the number of turns of the thirteenth set, said fifteenth set being wound in a spiral and including first and second end turns, and a sixteenth set of turns substantially equal in number to the number of turns of the fourteenth set, said sixteenth set being wound in a spiral alternately with part of said fifteenth set of turns and including first and second end turns, the number of turns of said fourteenth and sixteenth sets being greater than the number of turns of said tenth and twelfth sets respectively; a twelfth cross-connection between said second end turn of the eleventh set of turns and said second end turn of the fourteenth set of turns; a thirteenth cross-connection between said first end turn of the thirteenth set of turns and said first end turn of the fifteenth set of turns, said first end turn of the fifteenth set of turns being adjacent said first end turn of the thirteenth set of turns; a fourteenth cross-connection between said first end turn of the fourteenth set of turns and said first end turn of the sixteenth set of turns, said first end turn of the sixteenth set of turns being adjacent said first end turn of the fourteenth set of turns; and a fifteenth cross-section between said second end turn of the thirteenth set of turns and said second end turn of the sixteenth set of turns, whereby a capacitive, noninductive current path is provided from the high-potential terminal to the second end turn of the fifteenth set of turns.

References Cited by the Examiner

UNITED STATES PATENTS

2,287,170 6/1942 Ganz ----- 336—69

FOREIGN PATENTS

1,225,834 2/1960 France.
1,239,758 7/1960 France.

JOHN F. BURNS, *Primary Examiner*.