

[54] **CAP-REACTOR POWER GROOVE
BALLAST CIRCUIT**

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[73] Assignee: **General Electric Company**, Hudson Falls, N.Y.

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[21] Appl. No.: **238,361**

Related U.S. Application Data

[62] Division of Ser. No. 91,674, Nov. 23, 1970, Pat. No. 3,691,435.

[52] U.S. Cl. **336/69, 336/223**

[51] Int. Cl. **H01f 27/28**

[58] Field of Search..... **336/69, 223, 70, 336/165; 317/260, 256**

[56] **References Cited**

UNITED STATES PATENTS

3,191,103	6/1965	Segall.....	336/69 X
3,106,671	10/1963	Coleman et al.....	317/260
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1,795,411	3/1931	Sprague	317/260
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Primary Examiner—Thomas J. Kozma

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[57] **ABSTRACT**

A cap-reactor power groove ballast circuit of the type including first and second, spaced-apart, elongated tape-like conductive foils having intervening layers of electrical insulation rolled together to form a compact cylindrical roll having combined capacitor-inductor-reactor characteristics. One of the spaced-apart conductive foils has its width separated into multiple, electrically isolated, strip-like separate foil areas contacting with the common remaining conductive foil to function in the manner of multiple capacitor-inductor components electrically interconnected in circuit relationship. By appropriate connection of terminal tap points to the structure, the device can be made to operate in the manner of a power groove ballast circuit having improved wave shaping characteristics.

3 Claims, 8 Drawing Figures

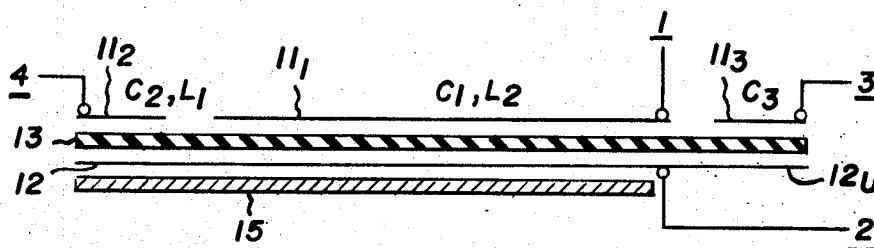
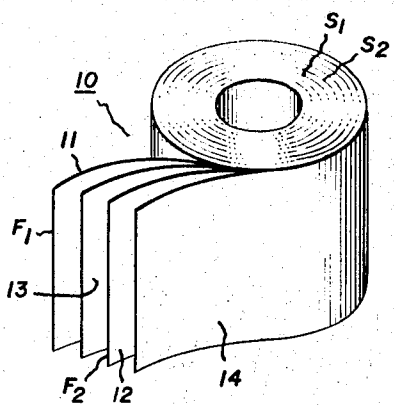


FIG.1. PRIOR ART



PRIOR ART

FIG.2.

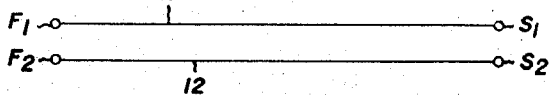


FIG.3.

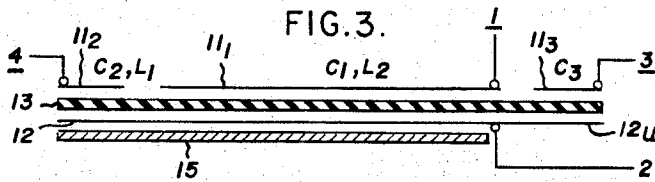


FIG.6.

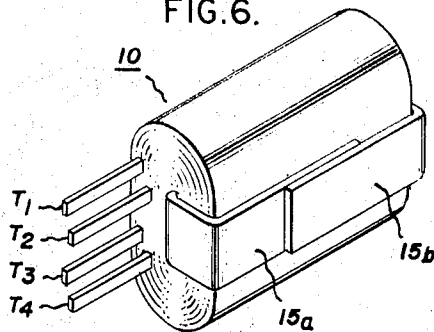


FIG.7a.

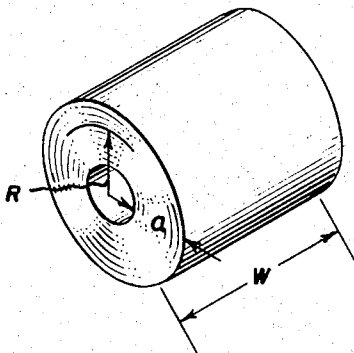
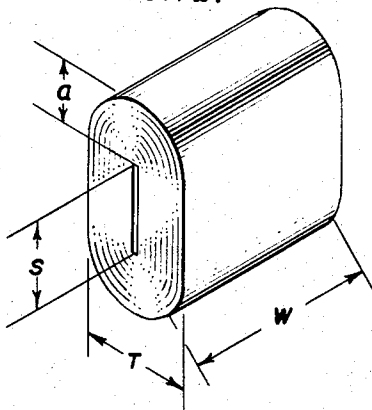


FIG.7b.



SHEET 2 OF 2

FIG. 4.

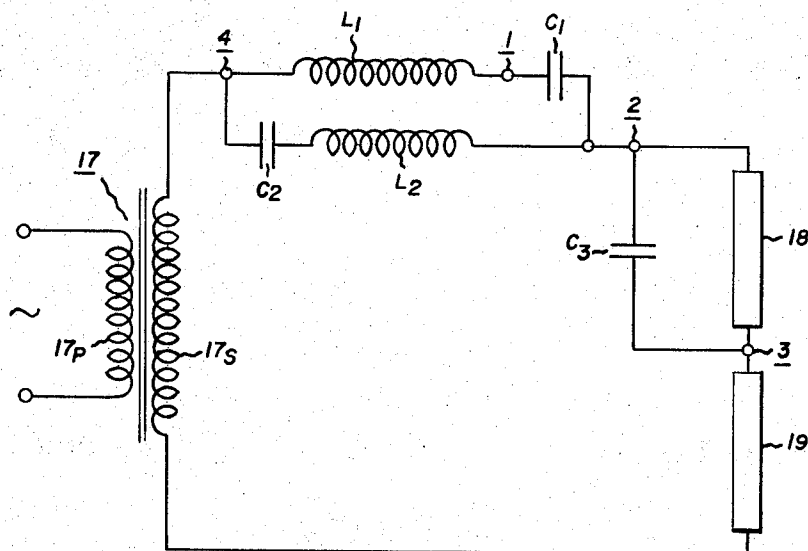
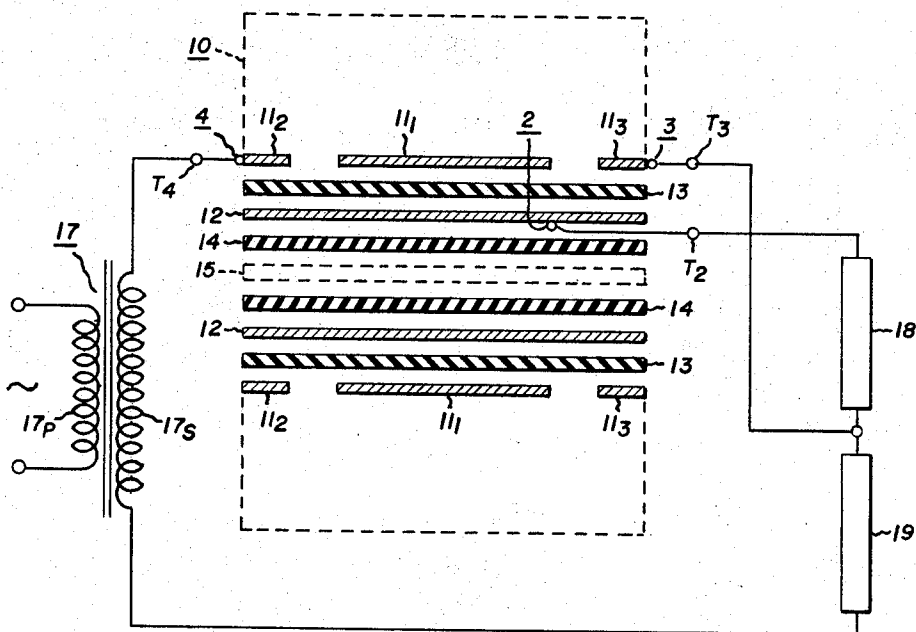


FIG. 5.



CAP-REACTOR POWER GROOVE BALLAST CIRCUIT

This is a division of application Ser. No. 91,674, filed Nov. 23, 1970, now U.S. Pat. No. 3,691,435.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a new and improved lamp ballast circuit.

More particularly, the invention relates to a power groove ballast circuit fabricated in the form of a unitary (integral) combined capacitor-inductor-reactor (hereinafter referred to as a cap-reactor) having improved operating characteristics.

2. Description of the Prior Art

A number of different cap-reactor devices which exhibit combined capacitor-inductor-reactor characteristics designed to operate in a number of different ways, are disclosed in U.S. Pat. No. 2,521,513 — Gray — "Stationary Induction Apparatus" — issued Sept. 5, 1950. These known cap-reactor devices are suitable for a number of different circuit applications but can not be employed directly in a number of different equipment without requiring considerable modification. The present invention makes available a new and improved cap-reactor power groove ballast circuit for use as a starting and ballast circuit for fluorescent lamps and having improved operating characteristics.

SUMMARY OF THE INVENTION

It is therefore a primary object of the invention to provide a new and improved cap-reactor power groove ballast circuit.

Another object of the invention is to provide such a cap-reactor ballast circuit having improved operating characteristics.

In practicing the invention, a combined capacitor-reactor device is provided which is of the type including at least first and second, spaced apart, elongated tape-like conductive foils having intervening layers of electrical insulation rolled together to form a combined capacitor-inductor-reactor. In the present invention the first conductive foil has its width separated into multiple, electrically isolated, strip-like separate foil areas coacting with the remaining common second conductive foil to function in the manner of multiple capacitor-inductor components electrically interconnected in circuit relationship.

The first conductive foil preferably is formed into at least first and second electrically isolated, separate foil areas of a size proportioned to provide two different desired values of capacitance. First terminals means are connected to the first separate foil area and second terminal means are connected to the remaining common first conductive foil on a side thereof opposite the point of connection of the first terminal means to the first foil area both with respect to the width and the length of the strip-like foil area. As a result, the capacitor-reactor device functions as a parallel connected network of two series circuit branches each comprised by a series inductor and capacitor.

The second terminal means is connected to the common second conductive foil at some point intermediate its width to thereby form an unconnected strip on the common second conductive foil which does not contribute to the inductance of the device. The first conductive foil only preferably has its width separated into

at least first, second and third electrically isolated, strip-like, separate foil areas with the third foil area being positioned opposite the unconnected strip of the common second conductive foil. Third terminal means are connected to the third separate foil area in a manner such that the cap-reactor device operates as though a third capacitor were connected in series circuit relationship with the parallel connected series circuit branches, and functions in the manner of a power-groove ballast circuit having improved wave shaping characteristics.

The device may be operated either as an air core device, or a magnetically permeable core member having a magnetic permeability greater than air may be positioned in the center of the roll of conductive foils and intervening layers of electrical insulation for increasing the value of inductance of the cap-reactor device.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features and many of the attendant advantages of this invention will be appreciated more readily as the same becomes better understood by reference to the following detailed description, when considered in connection with the accompanying drawings wherein like parts in each of the several figures are identified by the same reference character, and wherein:

FIG. 1 is a perspective view of a partially disassembled coil or roll of tape-like, conductive foil having intervening layers of electrical insulation and rolled to form a cap-reactor device;

FIG. 2 is a schematic illustration of the structure shown in FIG. 1 if it were unrolled into a straight line structure, and depicts the manner in which the structure derives its capacitive characteristics;

FIG. 3 is a partial, cross sectional view of a cap-reactor power groove ballast circuit constructed in accordance with the invention, and illustrates the relative proportions of the width of the conductive foils and conductive foil areas together with the point of connection of tap points or terminals to the conductive foils;

FIG. 4 is an equivalent circuit diagram illustrating the details of circuit construction and manner of operation of the cap-reactor power groove ballast circuit shown in FIGS. 3 and 4;

FIG. 5 is a detailed sectional view of a cap-reactor power groove ballast circuit built according to the invention and illustrates the manner in which it is connected in circuit relationship with a lamp load and an input power supply transformer;

FIG. 6 is a perspective view of a completed cap-reactor power groove ballast circuit according to one form of the invention; and

FIG. 7a and 7b are a pair of sketches illustrating critical dimensions of a cap-reactor device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a perspective, partially disassembled view of a known cap-reactor device 10. The cap-reactor 10 is formed by rolling together two tape-like sheets of conductive foil 11 and 12 which are separated by intervening sheets of electrical insulating material 13 and 14. The conductive foils 11 and 12 may comprise aluminum foil or some other similar conductive sheet material and the sheets of dielectric material 13 and 14 may comprise any known electrical insulating dielectric ma-

terial which is capable of fabrication in tape-like rolls. For example, the dielectric materials 13 and 14 may comprise paper of a suitable thickness and dielectric strength such as kraft paper, linen paper or the like, sheets of a low loss dielectric resin including the polyolefins such as polypropylene, and other resins such as mylar (polyethylene-terephthalate), or any other known, suitable dielectric material. The sandwiched layers of tape-like conductive foils 11 and 12 and the intervening layers of electrical insulating dielectric material 13 and 14 are rolled together to form a unitary or integral coil structure 10 as shown in FIG. 1. While only one turn with two conductive foils 11 and 12 and suitable intervening insulating layers 13 and 14, are shown in FIG. 3, it is believed obvious that additional turns of foils and layers of insulation must be provided in order to obtain desired operating characteristics in the manner best shown in FIG. 5.

If the cap-reactor 10 of FIG. 1 were unrolled and laid out flat, it would appear schematically as shown in FIG. 2 where S_1 and S_2 represent the start of the tape-like conductive foils 11 and 12, and F_1 and F_2 represent the finish of each of the respective foils. When thus visualized, the manner in which the structure obtains its capacitive reactance characteristics can be more easily appreciated. Also, it is believed obvious from a consideration of the wound, interleaved, turns of the conductive foils 11 and 12 shown in FIG. 1 wherein the structure acquires its inductive reactance characteristics to thereby provide a combined capacitance-inductance reactance when employed in an electrical circuit.

In order for any given cap-reactor to be connected in electrical circuit relationship with the load, it must be specifically tailored or designed to serve that load. The particular cap-reactor described herein is specifically designed to serve as a power groove ballast circuit for a fluorescent lamp. For this purpose the device must serve to supply a high voltage surge across the lamp terminals for starting purposes as well as limit circuit current thereby ballasting the lamp since a fluorescent lamp while operating exhibits negative resistance characteristics. Preferably, the ballast circuit should also exhibit high power factor characteristics for improved performance, and should not introduce undesired transients into the power supply lines with which it is used. The power groove ballast circuit herein described is particularly designed to satisfy each of these requirements, in that it is intended for use with a single phase supply of alternating current, such as, a conventional, household, 60 cycle, 110-120 volt-15 amp residential power supply used to energize other electrical appliances such as television sets, etc. For this reason, it is desirable that the loading effect of the ballast circuit not unduly distort the wave shape of the incoming alternating current supply.

FIG. 3 is a partial cross sectional view of a cap-reactor device constructed in accordance with the invention and intended to operate as a cap-reactor power groove ballast circuit. It should be expressly noted that FIG. 3 is a cross sectional view that is transverse to the elongated or long dimension of the strip-like conductive foils (and hence transverse to the view shown in FIG. 2), and illustrates the manner in which the width of the conductive strips is proportioned (as well as the manner of connection thereto) to provide the desirable characteristics enumerated above in a single (integral) cap-reactor device. In FIG. 3, one of the conductive

foils (for example 11 hereinafter referred to as the first conductive foil) has its width separated into multiple (3), electrically isolated, strip-like separate foil areas 11₁, 11₂, and 11₃. During fabrication the respective separate foil areas 11₁, 11₂, etc. can be formed by securing an integral foil such as shown at 12 to one side of the dielectric layer 13, and thereafter etching away undesired portions of the foil through a suitable foil-resist and chemical etching steps to leave a composite structure comprised by the insulating layer 13 and the multiple electrically isolated strip-like separate foil areas 11₁, 11₂, etc. The composite structure thus obtained, may then be wound together with the remaining second conductive foil 12 (which is integral across its width and hence is common to all of the separate foil areas 11₁, 11₂, etc.) together with the required intervening insulating layers 13 and 14 (not shown in FIG. 3). As will be described more fully hereinafter, the width of the conductive foil 12 and separate foil areas 11₁, 11₂, etc.; the number of turns in the rolled cap-reactor device, the mean radius of the roll or other comparable dimensions, the radial thickness of the roll, the dielectric constant and the thickness of the intervening insulating layers 13 and 14, all are proportioned to provide a desired value of inductance and capacitance. In order to obtain increased values of inductance with the cap-reactor device it may prove desirable to include a magnetic permeable core member such as shown at 15 having a magnetic permeability greater than air. This core member is positioned in the center of the roll of conductive foils and intervening layers of electrical insulation as will be described hereinafter in connection with FIG. 4 and serves to increase the value of inductance of the cap-reactor device.

In addition to the width and length (area) of the respective conductive foils (and foil areas) an important parameter adjusting feature is obtained in the cap-reactor device by means of the point of connection of terminal tap points such as shown at one, two, three, and four in FIG. 3. If it is assumed that the point four constitutes an input terminal tap point to the cap-reactor device, and is connected on one end and on one side of the width of the conductive area 11₂, then the point of connection of terminal tap point two (assumed to be an output terminal point) would be on the side of the common second conductive foil 12 opposite the input terminal tap point four with respect to both the width as shown in FIG. 3 and the length of the foil as depicted by FIG. 2. For example, referring to FIG. 2, if the point F_1 is assumed to constitute the input terminal tap point four, then with respect to the length of the conductive foil, the point S_2 (or some intermediate point along the length depending upon the value of inductance desired) would be chosen as the output terminal tap point two.

It should also be noted that the second terminal tap point two is connected to the common second conductive foil 12 at a point intermediate its width to thereby form an unconnected strip indicated at 12_u, on the common second conductive foil 12. As will be explained more fully hereinafter this unconnected strip 12_u does not contribute to the inductance of the cap-reactor device, but acting in conjunction with the third conductive foil area 11₃ does form a third capacitor which is serially connected in circuit relationship in the manner shown in the equivalent circuit diagram illustrated in FIG. 4 of the drawings. FIG. 4 of the drawings

depicts the circuit construction of the cap-reactor power groove ballast circuit if the circuit were constructed of conventional components.

In FIG. 4, the terminal points one - four are identified and correspond to the terminal tap points indicated with the same reference numeral in FIG. 3. It will be appreciated that the power groove ballast circuit does not operate to step up the voltage in the manner of a transformer and hence is supplied from the secondary output winding of an input power supply step-up transformer 17 whose primary winding is supplied from a conventional 110 volt, 60 cycle alternating current residential source of electric energy. A pair of fluorescent lamps shown at 18 and 19 are connected in series circuit relationship across the output secondary winding 17, through the cap-resistor power groove ballast circuit by connecting one end of the series connected fluorescent lamps 18 and 19 to the terminal tap point number two. FIG. 5 of the drawings shows the nature of the physical connection to the tap two through the medium of output terminal T_2 . The remaining end of the series connected fluorescent lamps 18 and 19 is connected back to the lower end of the secondary winding 17. The upper end of the secondary winding 17, is connected through the input terminal T_4 to the terminal tap point four as shown in FIG. 5. The terminal tap point three is connected through terminal T_3 to the juncture of the fluorescent lamps 18 and 19 thereby serving to connect the capacitor C_3 formed by the conductive foil area 11₃ in conjunction with the unexcited strip 12_u to the juncture of the fluorescent lamps as best shown in the equivalent circuit diagram in FIG. 4.

As best shown in FIG. 4, the plurality of conductive foil areas 11₁, 11₂, and 11₃ acting in conjunction with the common second conductive foil 12 forms three capacitors C_1 , C_2 , and C_3 . These capacitors in effect are connected in electrical circuit relationship with the inductances L_1 and L_2 exhibited by the cap-resistor device as a consequence of the flux linkage between the multiple turns of the device. The value of these capacitances and inductances is determined by the width of the foil areas acting in conjunction with the common second conducting foil, the number of turns in the roll, the mean radius of the roll or other comparable dimensions, the radial thickness of the roll, the dielectric constant and the thickness of the intervening layers of electrical insulation as set forth in the following equations. In these equations, it has been assumed that the rolled cap-reactor device is either round or flattened. If it is round, it will have a mean radius R measured from the center of the arbor hole in the device, and if flattened, it will have an elongated arbor hole or center slit of length S . Also, with a flattened roll, it will have a roll thickness T . With either type of construction, the roll will have a radial build as depicted in FIGS. 7a and 7b of the drawings. The value of capacitance and inductance is given by the following equations:

$$C_f = (5.4 \text{ kW/d}) \cdot 10^{-3}$$

Where:

C_f = Capacitance — farads

k = Dielectric Constant

W = Width — inches

d = Thickness of dielectric — inches

$$L = R^2 N^2 / [10 (R+W+a)]$$

(2)

Where:

L = Inductance — microhenries

N = Number of turns

W = Width of foil — inches

R = mean Radius — inches

a = Radial build — inches

$$L = [(s + a) T (N^2 + 3/4 N)] / 94 (W + 0 a)$$

(3)

Where

L = Inductance — microhenries

W = Width of foil — inches

T = Length of pad — inches

S = Length of center slit — inches

a = Radial build — inches

N = Number of turns

In operation, the circuit arrangements of FIGS. 4 and 5 operate in the known manner of a power groove ballast circuit to provide an igniting voltage surge across the fluorescent lamps 18 and 19 and thereafter to limit current flow through the lamps and ballast their negative resistance characteristics while lighted. In operation, the inductor L_1 and series capacitor C_1 operate in the normal manner of a choke and surge capacitor for providing the starting surge and current limiting functions. The parallel connected series circuit branch comprised by the inductor L_2 and series connected capacitors C_2 functions as a compensating coil and capacitor for improving the wave form characteristics of the overall circuit arrangement. The capacitor C_3 provides the desired power factor improvement.

Referring again to FIG. 5, it will be noted that the core member 15 is shown in dotted outline form. This has been done to indicate that the magnetically permeable core member 15 may be included if desired, or alternatively the device may be operated as an air core device. If the core member 15 is included, it will increase the value of the inductance L_2 so that the capacitance of the series connected capacitor C_2 should be correspondingly increased. In one known embodiment, the parameters of the cap-reactor were adjusted so that the value of the inductance L_2 were approximately 22 millihenries and the capacitor C_2 had a value on the order of 0.028 microfarads. In the event that the magnetically permeable core member 15 is employed, it may comprise a single steel lamination about 1 inch wide by 0.014 inches in thickness and having a length such that its ends protude beyond the ends of the roll capacitor 10 and can be bent together in overlapping closed magnetic circuit relationship in the manner shown by 15a and 15b in FIG. 6 of the drawings. Other types of core structures could of course be employed; however, the single lamination core fabricated in the above manner is desirable due to its low cost. The completed cap-reactor would appear as shown in FIG. 6 of the drawings wherein T_1 , T_2 , etc. constitute the input and output terminals to the device. Due to the fact that in many circuit applications an input terminal will not be required to the tap point one, it is of course obvious that the input terminal T_1 could be eliminated where the device is to be employed in the manner depicted in FIGS. 4 and 5. However, the input terminal T_1 has been

illustrated to show the general utility of the cap-reactor device for use in circuit applications where it is desired to connect to the tap point one.

It has been determined also that a cap-reactor ballast circuit according to the invention can be built using an air core. When thus employed, the inductance L_2 may have a low value on the order of 0.25 millihenries which is almost 100 times less than the inductance required if an iron core is employed. With such an arrangement, the value of the capacitance C_2 should be comparably lower on the order of 0.18 micro farads. It appears that this reduction in capacitance coupled with the lower value of inductance accomplishes the same wave forming characteristics as does the higher valued iron core structure. The amount of inductance required to accomplish the desired wave forming; however, is determined by a particular cap-reactor design used for a specific circuit application.

In addition to the above considerations, it should be noted in FIG. 5 that additional volume for the rolled cap-reactor 10 is indicated by the dotted outline structure. This dotted structure has not been shown in detail since it would be identical to the two turns of the rolled conductive foils and the intervening layers of insulation shown in FIG. 5. It is of course anticipated that any desired number of turns may be employed in fabricating the device depending upon the values of inductance and capacitance required. It should be noted also that if more turns than those shown are employed, the tap off points two and three would be moved to corresponding points on the outermost turn as will be obvious to one skilled in the art in view of the above teachings.

From the foregoing description, it will be appreciated that the invention provides a new and improved power groove ballast circuit fabricated in the form of a unitary (integral) combined capacitor-inductor-reactor having improved operating characteristics.

Having described several embodiments of a new and improved cap-reactor power groove ballast circuit constructed in accordance with the invention, it is believed obvious that other modifications and variations of the invention are possible in the light of the above teachings. It is therefore to be understood that changes may be made in the particular embodiments of the invention described which are within the full intended scope of the invention as defined by the appended claims.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. In a combined capacitor-reactor device of the type including at least first and second, spaced-apart, elongated tape-like conductive foils from intervening layers of electrical insulation rolled together to form a combined capacitor-inductor-reactor, the improvement comprising

- a. only the first conductive foil having its width separated into first, second and third electrically isolated, strip-like separate foil areas coacting with

the remaining common second conductive foil to provide different capacitances and to function in the manner of multiple capacitor-inductor components in electrically interconnected circuit relationship,

- b. first terminal means connected to the first separate foil area,
- c. second terminal means connected to the common second conductive foil on the side thereof opposite the point of connection of the first terminal means to the first foil area relative to both width and length, whereby the capacitor-reactor device functions as a parallel connected network of two series circuit branches each comprised by a series connected inductor and capacitor,
- d. the second terminal means being connected to the common second conductive foil at some point intermediate its width to thereby form an unconnected strip on the common second conductive foil which does not contribute to the inductance of the device,
- e. the third foil area being positioned opposite the unconnected strip of the common second conductive foil,
- f. third terminal means connected to said third separate foil area whereby a third capacitor is connected in series circuit relationship with the parallel connected series circuit branches,
- g. an input fourth terminal means on said second foil area of the first foil, and
- h. a magnetically permeable core means having a magnetic permeability greater than air positioned in the center of the roll of conductive foils and intervening layers of electrical insulation for increasing the value of inductance of the combined capacitor-reactor device.

2. A combined capacitor-reactor device according to claim 1 wherein the core member comprises a single steel lamination inserted in the arbor hole of the rolled foils and intervening insulating layers and having the ends thereof projecting beyond the width of the roll bent together in overlapping closed magnetic circuit relationship.

3. A combined capacitor-reactor device according to claim 1 wherein the single steel lamination is on the order of one inch wide by 0.014 inches thick, and the width of the common second conductive foil and separate foil areas, the number of turns in the roll, the means radius of the roll or other comparable dimension, the radial thickness of the roll, the dielectric constant and the thickness of the intervening layers of electrical insulation all are proportioned to provide a compensating inductance on the order of 22 millihenries, and a series connected compensating capacitance on the order of 0.28 microfarads whereby the power groove ballast circuit has improved wave shaping characteristics.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,775,720 Dated November 27, 1973

Inventor(s) Oliver H. Winn

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

- Column 2, line 9, change "braches" to - branches -
- Column 5, line 16, change "resistor" to - reactor -
- Column 5, line 39, change "resistor" to - reactor -
- Column 5, line 60, delete "(" before 5 and the ")" after d -
- Column 6, line 2, delete "[" before 1 and the "]" after a -
- Column 6, line 12, delete "0" before the - a -
- Column 6, line 18, change "Length" to - Thickness -
- Column 6, line 19, change "Lenght" to - Length -
- Column 6, line 47, change "were" to - was -
- Column 6, line 49, change "0.028" to - .28 -
- Column 8, line 49, change "means" to - mean -

Signed and sealed this 9th day of April 1974.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

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