

Feb. 18, 1941.

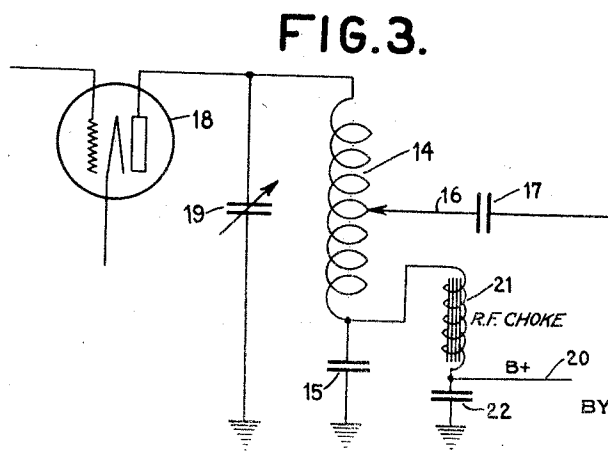
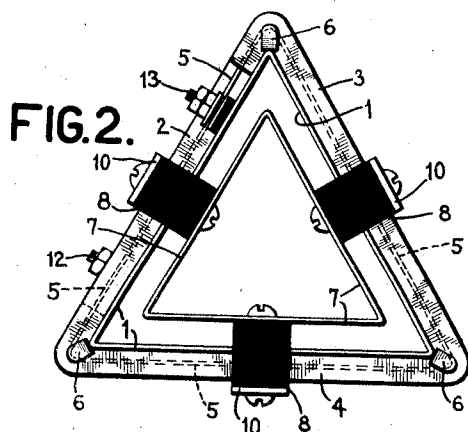
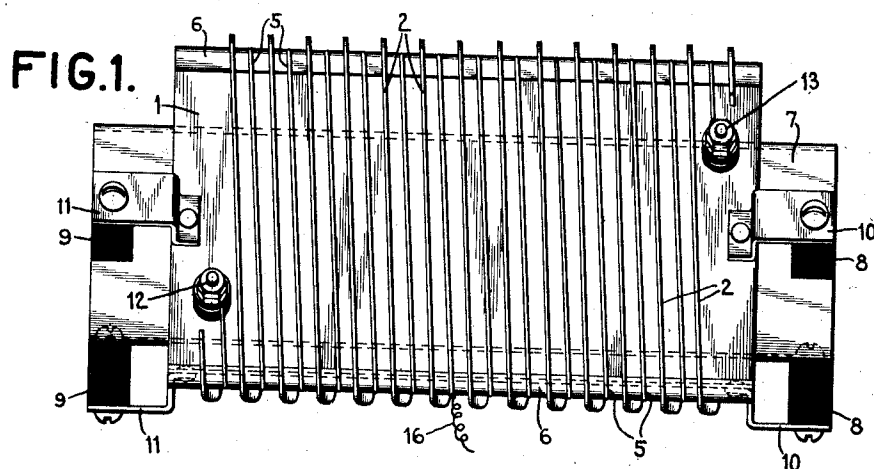
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2,232,042

INDUCTANCE ELEMENT

Filed Nov. 21, 1936

2 Sheets-Sheet 1



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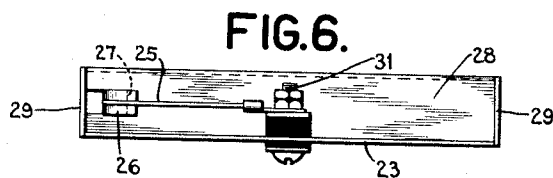
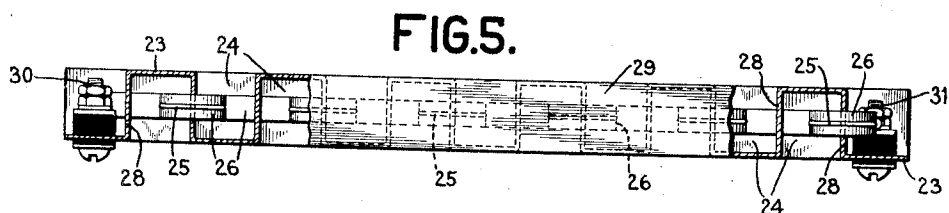
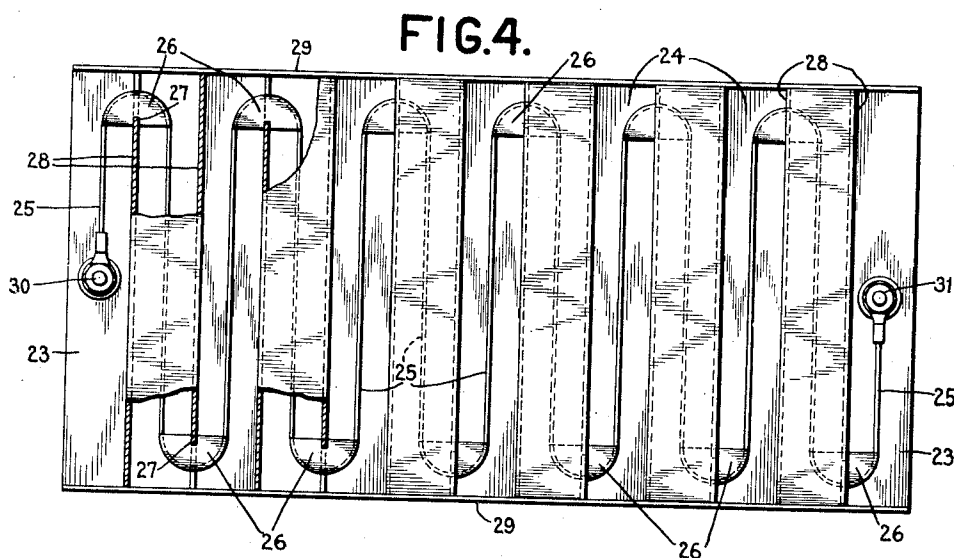
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,232,042

INDUCTANCE ELEMENT

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12 Claims. (Cl. 250—16)

This invention relates to inductance elements and pertains more particularly to improvements in inductance elements adapted for use at relatively high frequencies.

5 It is well known that most of the losses in high frequency circuits occur in the inductance elements. The condensers, connecting wires and associated parts are reasonably free from losses while the inductance elements are not ordinarily so. While in the region of lower frequencies, that is, below about 2 megacycles, the losses in inductance elements may be reduced to a considerable degree by the use of litzendraht as taught by the prior art and while in the region of ultra high frequencies, that is, in the region above about 20 megacycles the losses in the inductance elements have been reduced by the use of $\frac{1}{4}$ wave lines, tank circuits of the type disclosed in the copending application of Frederick A. Kolster, Serial No. 637,564, filed October 12, 1932, which matured into Patent No. 2,085,223, June 29, 1937, and the like; in one of the most important regions of high frequencies, i. e. from 4 to 20 megacycles, relatively high inductance losses have not heretofore been overcome. For these frequencies so far as I am aware ordinary coils made of $\frac{1}{4}$ " copper tubing are still substantially universally used in transmitters and plain enamel covered wire wound on "Bakelite" or "Isolantite" forms is being employed in receiving circuits.

The losses in the inductances used in transmitting circuits provided with copper tubing inductance elements are often so high that water must be passed through the tubing in order to prevent overheating of these coils. On the other hand, in the receiving circuits utilizing known inductances the losses in the coils are usually so high that the selectivity of the receivers or at least of the radio frequency stages thereof is limited to the selectivity obtainable with a Q of 125 or thereabouts, per stage, where Q represents the ratio of the reactive impedance to the resistive impedance of the coil.

45 In view of the fact that the $\frac{1}{4}$ wave at 20 megacycles is about 12 feet long and at the lower frequencies is even longer, the $\frac{1}{4}$ wave lines are impractical in this frequency region.

50 It is an object of my invention to overcome many of the difficulties already mentioned by providing an improved form of inductance element wherein the losses are very low indeed so that in many cases no water cooling will be necessary with such inductances when they are used in transmitting circuits and so that when such inductances are used in receiving circuits the selec-

tivity is greatly increased and is, in fact, no longer limited by losses in the oscillating circuit but instead by the losses in the grids of the associated vacuum tubes.

5 In accordance with my invention I construct an inductance element by providing a metallic form having a plurality of spaced channels in which the wire conductor is positioned and held against movement by insulating elements, the sides of the metal channels serving effectively to shield the different sections of the wire, one from another so that the total inductance derived is in effect that of a single straight wire. The metal form or channeled member may be fabricated of sheet metal, preferably of high conductivity, such as copper, or it may be formed by diecasting. In the latter case where ordinary diecasting metals are used it will in most instances be found desirable to plate the finished article with copper or some other good conductor. The channeled member might also be made of an insulating material such as "Bakelite," "Isolantite" or the like plated with conducting material. The exact shape of the channeled member is immaterial; it may be a drum of triangular, square or cylindrical cross-section, the channels being placed side by side around the periphery of the drum or instead a flat element may be used, the channels all being in one side or alternately disposed first in one side and then in the other.

30 In accordance with a preferred embodiment of my invention the inductance element consists of a drum made of sheet copper and shaped into the form of a cylinder of triangular, square or cylindrical cross-section. Around this drum there is wound edgewise a copper strip in the form of a helix and in such a fashion that a helical channel is obtained. In this channel there are placed a series of insulators, e. g. at each corner when the drum is of triangular or square cross-section, so that a length of wire may be wound in a helical manner around the drum in such a way that it lies along the axis of the helical channel. If one end of this wire is connected to the drum and the total length of wire is shorter than $\frac{1}{4}$ wave length at the frequency to which the inductance is tuned, the impedance between the free end of the wire and drum is inductive.

55 The losses in such an inductor are less than the losses in an ordinary coil because each turn is shielded from all others by the edgewise wound copper strip forming the channel so that the magnetic field around any portion of the wire is merely the field produced by this portion of the wire uninfluenced by mutual inductance with

other turns. For this reason the skin effect which controls the distribution of current in the helical coil of wire is approximately the same as the skin effect in a straight wire, rather than that in a wire wound into a coil. The inductance obtainable with a given length of wire in this type of inductor is therefore naturally much less than the inductance obtainable with the same length of wire wound into an ordinary coil but the ratio of the inductive impedance to the resistance of the coil, or the Q, is very much greater than in an ordinary inductor so that a given inductive impedance may be secured by merely winding more wire and without, at the same time, increasing the resistance to the same value as that which would be obtained with an ordinary coil which has the same inductive impedance.

The above described inductor may be used in a tank circuit very much like an ordinary coil. For example, if the upper end of the helical wire is connected to the plate of a tube while the lower end of the wire is connected to the drum and this drum is by-passed by means of a large condenser to ground so that the source of plate voltage may be connected to the drum through a choke coil, one side of an ordinary variable air condenser may be connected between the plate of the tube and the ground to tune the whole circuit in very much the same manner as it would be tuned if the inductor of the new type were replaced by an ordinary coil. The power delivered by an associated vacuum tube to this tank circuit may be conveyed to an output circuit or to the next stage in the amplifier by means of a connection tapped onto the helical wire around the drum at some point between the two ends of this wire in the same way as with ordinary coils now in use.

The inductance element of this invention has a great advantage over the usual type of ordinary coil since the magnetic field around the element of the present invention is very small so that it may be placed in the neighborhood of other inductance elements without undue interference. When it is desired to reduce the electro-static field around the drum, which is not entirely zero when the drum is grounded through a by-pass capacity across which there is always some voltage drop, it is of course, possible to surround the whole inductor by another grounded drum which will not only provide the electro-static shielding desired but will also increase in effect the by-pass capacity used to by-pass high frequencies from the drum to ground. The by-pass capacity just referred to may be obtained simply by placing a grounded drum inside and in proper spaced relation to the drum on which the coil is wound.

When it is desired to obtain only a relatively small inductive impedance a flat inductance element constructed in accordance with the invention may be utilized. This type of element may consist of a metal plate to which there are soldered or welded a number of equally spaced parallel metal strips, each of these strips being equipped at both ends with an insulator so that the wire may be wound in zigzag fashion between the strips. This inductance element may be used in the same manner as that described heretofore. It has the advantage that it can be mounted near the wall of a radio cabinet so as to occupy comparatively little space. Alternatively a flat type of inductance element may be made by corrugating or bending into zigzag shape a piece of sheet copper thereby forming channels alter-

nately on the opposite sides thereof in which the wire may be wound.

Inductances constructed in accordance with my invention as described above may be utilized in receiving circuits as well as transmitting circuits and may be also employed in any type of electric oscillating circuit such as impedance matching circuits utilized at the output of transformers or in filter circuit for eliminating undesired harmonics or other undesired frequencies.

The above described and further objects and advantages of my invention will be more fully explained in the following description taken in conjunction with the accompanying drawings.

Fig. 1 shows in side elevation and partly in section, an inductance element of triangular cross-section constructed in accordance with my invention.

Fig. 2 is an end elevation view partly in section of the inductance element shown in Fig. 1.

Fig. 3 shows diagrammatically a portion of a vacuum tube circuit in which the inductance element of Fig. 1 may be used.

Figs. 4, 5 and 6 are, respectively, plan side elevation and end elevation views of a flat type of inductance constructed in accordance with my invention.

Referring more particularly to Figs. 1 and 2 of the drawings, reference numeral 1 indicates a drum of triangular cross-section formed of sheet copper, aluminum or other material having good conductive qualities. Around the periphery of this drum are soldered or welded or otherwise fastened a plurality of strips 2, 3 and 4, arranged at right angles to the faces of the drum and forming together with other similar strips a continuous strip helically disposed in a plurality of turns around the drum. As shown most clearly in Fig. 1 these strips form a continuous helically arranged channel or groove. In this groove is wound a wire 5, this wire being supported by insulating strips 6 arranged at the corners of the drum in openings provided in the strips 2, 3 and 4 already mentioned. These insulating members 6 may have small notches cut in them to receive the turns of the wire thereby holding them in proper spaced relation with respect to the sides of the channels.

Inside of the drum 1 is arranged a second drum 7 which is spaced from the first drum a suitable distance by insulating members 8 and 9 located at opposite ends of the drum and attached to brackets 10 and 11. By offsetting the brackets slightly as shown the length of the insulators 10 and 11 may be made greater than the space between the drums 1 and 7 so that danger of electrical break down of the insulators is reduced. The left hand end of the wire 5 may be grounded to the drum 1 at 12 while the right hand end may be connected to an insulated binding post 13.

An inductance element such as shown in Figs. 1 and 2 is especially adapted for use in a circuit such as shown in Fig. 3. In this figure the inductance element is indicated by reference numeral 14, the capacity 15 being that between the inner drum 7 and the outer drum 1. The inductance element is provided with a tap connection 16 leading through condenser 17 or other suitable means to a following vacuum tube or other piece of apparatus. In Fig. 3, 18 is a conventional vacuum tube, 19 a tuning condenser for the inductance 14. A potential for the plate of tube 18 is supplied through connection 20 which has in series therewith a radio frequency

choke coil 21. Numeral 22 indicates an ordinary by-pass condenser.

Figs. 4, 5 and 6 show a flat type of inductance which is formed by bending back and forth in zigzag fashion a strip 23 of copper, aluminum or other good conducting material thereby forming a series of channels 24 at opposite sides of the strip, in which the wire 25 is wound. This wire is supported by insulators 26 at opposite ends of the channels. These insulators are positioned in notches made in the walls 28 of the channels 24 and the insulators themselves have notches 27 serving to engage the wall 28 whereby the insulators are prevented from vertical or lateral displacement. The entire structure may be rendered rigid by plates 29 soldered or otherwise attached to the sides of the zigzag strip. These plates may be omitted if desired. One end of the wire 25 may be grounded directly to the strip 23 at 30 while the other end of the wire may be connected to an insulated binding post 31.

The dimensions of an inductance element constructed in accordance with my invention will naturally vary depending upon the frequency and voltage with which it is to be used. For example, referring to the structure shown in Fig. 1, at a frequency of 20 megacycles the drum 1 may be about 3" on each side and about 4" long. The strips 2, 3 and 4, may be about $\frac{3}{4}$ " wide and the width of the channel between the strips may be about $\frac{1}{2}$ ". The wire 5 is suitably of about No. 14 gage and is preferably located equi-distance from the sides of the channel and from the drum 1, that is in this case about $\frac{1}{4}$ " from each side of the channel and about $\frac{1}{4}$ " from the surface of the drum.

The exact distance from the wire to the adjacent walls of the metal channel should be great enough to prevent an electrical breakdown at the voltages applied. The size of the channel then may increase progressively from the low voltage end to the high voltage end of the wire while still satisfying this requirement. Referring to the inductor of Fig. 1 as used in the circuit of Fig. 3, the size of the channel or the spacing of the wire from the walls of the channel may be smallest at the bottom end and greatest at the top end where the inductor is connected to the plate of the vacuum tube. Such an arrangement has the advantage of saving space.

The channels may be of substantially the same height and width in which case the wire may be located at substantially the center of the channel cross-section. But it is preferable that the height of the channel away from the base member to which the strips are attached be somewhat greater than the width of the channel, the wire being located nearer the bottom of the channel than the top or open side thereof, as described in the specific example above given.

While I have described particular embodiments of my invention for the purpose of illustration, it should be understood that various modifications and adaptations thereof, occurring to one skilled in the art, may be made within the spirit of the invention as set forth in the appended claims.

What is claimed is:

1. An inductance element comprising a base member of conducting material having substantially parallel channels therein, said material providing a good conductive path along each of said channels and also transversely between adjacent channels, a wire passing continuously

through said channels and insulating means for holding said wire in spaced relation to the walls of said channels.

2. An inductance element comprising a triangular drum of conducting material, a strip of conducting material passing in a helical path around said drum and being connected thereto substantially at right angles to the surfaces of said drum thereby forming a helical channel, a wire positioned axially of said channel and insulating means for preventing displacement of said wire with respect to said channel.

3. An inductance device in accordance with claim 2 wherein a second triangular drum is positioned inside of said drum first mentioned and spaced therefrom by insulating means.

4. An inductance element in accordance with claim 1 wherein one end of said wire is conductively connected to said base member and the other end of said wire is insulated therefrom.

5. An inductance element comprising a metallic drum, metallic means forming a helical channel around the surface of said drum, a wire substantially centrally disposed within said channel and extending lengthwise thereof around said drum and insulating means for preventing movement of said wire with respect to said channel.

6. An inductance element comprising a base member of sheet metal having a zigzag shape thereby forming channels alternately at opposite sides thereof, insulating means at opposite ends of said channels and a wire passing from one channel to another around said insulating means.

7. An inductance element in accordance with claim 6 wherein said insulating means are set in slightly from the ends of said channel members and conducting plates are attached to the ends of said base member to close the ends of said channels and impart rigidity to the structure.

8. A high frequency inductance element for connection with a condenser to form a tuned circuit resonant at a working frequency above two megacycles which comprises a wire having a length of less than one-quarter wavelength of said working frequency and so bent that several portions thereof are mutually juxtaposed, and a substantially unipotential shield structure shaped and positioned to shield each of said portions from any mutual inductance influence of the others of said portions and only partially surrounding said wire along a substantial length thereof whereby the inductance of said wire is reduced but its resistance is reduced to a greater extent.

9. In a high frequency resonant circuit having a capacitive reactance and an inductive reactance connected together to resonate in a desired working frequency above two megacycles, a structure for constituting said inductive reactance which comprises a shielded line less than one-quarter wave length long at said working frequency, said line having a single inner conductor and an outer conductor at least partially surrounding the inner conductor, the said line being bent so that several portions of the outer conductor are mutually juxtaposed, and means connectively joining said several portions to maintain them at the same potential so as to form a continuous substantially unipotential shield structure, whereby different parts of the inner conductor are shielded electromagnetically and electrostatically from one another.

10. A circuit element according to claim 8, further comprising a direct conductive connection between the wire and the said shielding means.

- 5 11. A circuit element according to claim 8, wherein said shielding means has substantially the form of a cylinder with channel shaped recesses in which the wire is disposed.

12. A circuit element according to claim 8, wherein said shielding means has substantially the form of a plane with channel shaped recesses in which the wire is disposed.

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