Sept. 16, 1930. C. D. WHITLOCK 1,775,880

RADIOFREQUENCY TRANSFORMER

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Fig. 6.

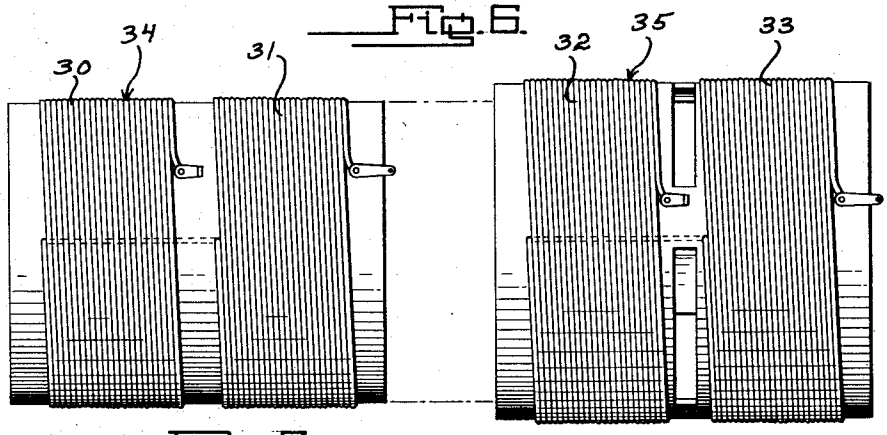


Fig. 7.

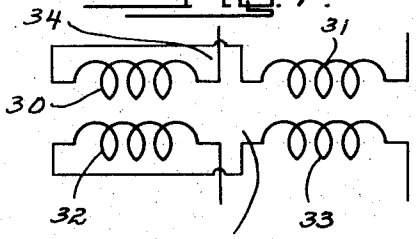


Fig. 3.

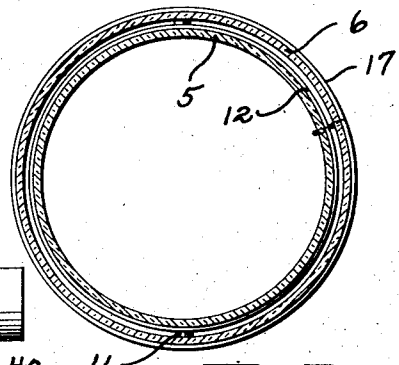


Fig. 1.

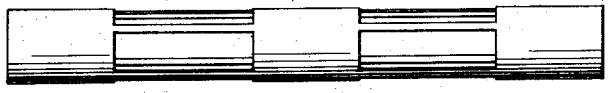


Fig. 8.

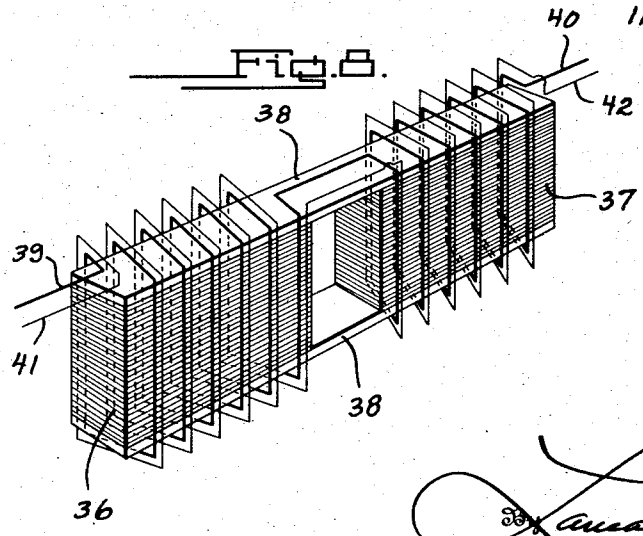
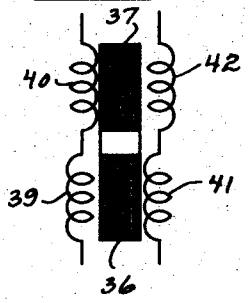


Fig. 9.



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RADIOFREQUENCY TRANSFORMER

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Fig. 2.

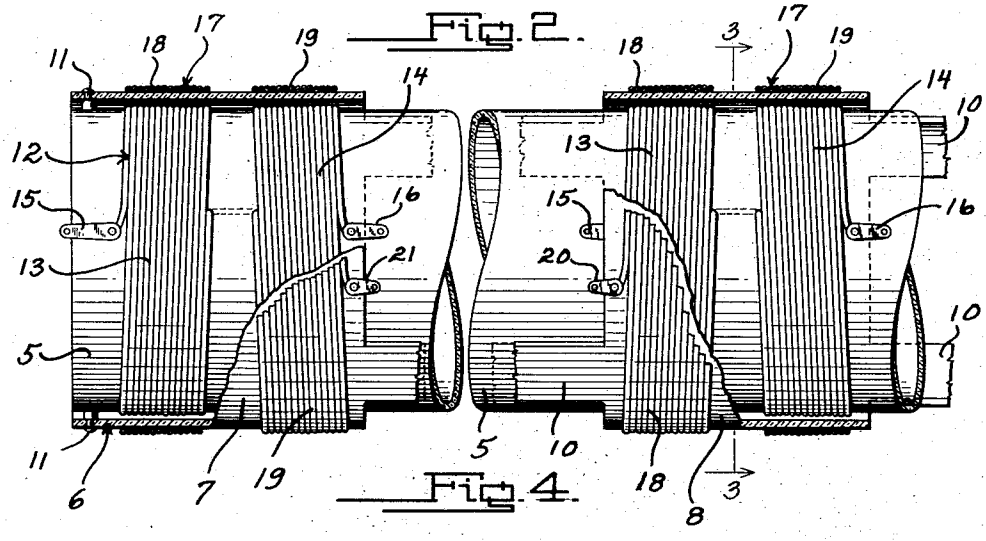


Fig. 4.

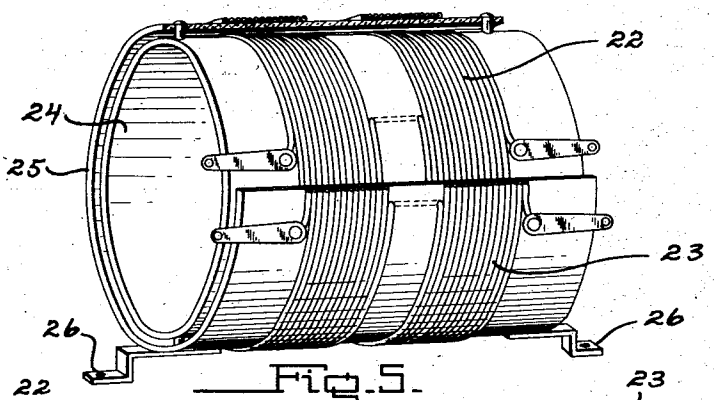
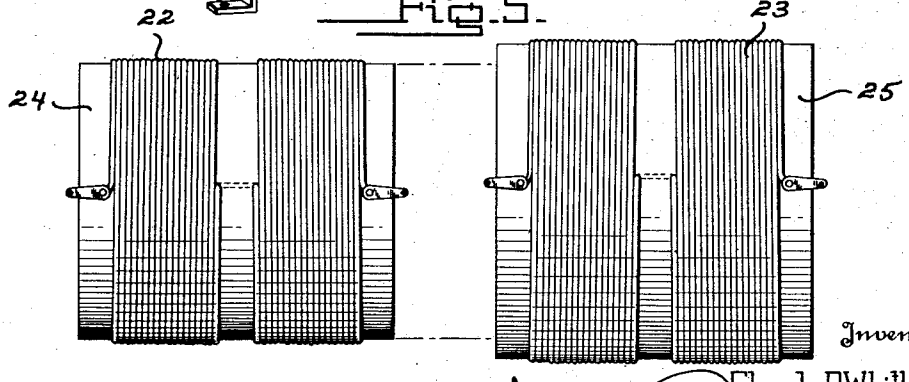


Fig. 5.



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UNITED STATES PATENT OFFICE

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RADIO FREQUENCY TRANSFORMER

Application filed October 5, 1927. Serial No. 224,229.

The present invention relates to improvements in radio receiving apparatus and primarily to a novel construction for radio frequency transformers and the relationship of a series of the transformers in a radio receiving set embodying multiple stages at radio frequency.

In the design and manufacture of radio frequency transformers of the capacity tuned type for use in connection with radio receiving apparatus, various types as at present employed includes those with closed fields such as torroid coils and figure 8 coils, and open field coils such as the plain solenoid type of coils. With all of such types of transformers, the coils could have no fixed relation to each other when a plurality of the transformers are employed in a receiving set used to receive signals or speech over a considerable wave band such as at present being used, without creating undesirable oscillations at some parts of the tuning scale or a loss of amplitude or signal strength, without resorting to the use of auxiliary controls, compensators, neutralizers, or phase shifting devices. This undesirable oscillation is caused by magnetic coupling between the transformers, and it has been proposed to eliminate such magnetic coupling by disposing the transformers at given angles which greatly nullifies the magnetic action of one transformer upon the other, but with this arrangement the use of neutralizing condensers or some similar means is provided for absorbing the undesirable current which is obviously generated by the magnetic coupling. In a radio frequency amplifier in which undesirable electric current is being generated due to magnetic coupling between the radio frequency transformers, the transformer having the greatest field density will act upon a transformer with a weaker field density, and since the earlier stages of the amplifier will be most effected, and owing to the action of the vacuum tubes to which they are coupled, a repeater action will be set up sustaining an audible beat note, commonly termed undesirable oscillations, providing no means is employed to alleviate the amplifier against such action. With the types of coils as now employed in radio frequency transformers, a rising amplitude or even a falling off of amplitude as met with in reception of different signal strengths, causes the magnetic field action to spread with a rise in amplitude beyond useful limits, and the reverse with a falling off of amplitude, thereby creating a disturbing effect on other transformers in the receiving circuit.

It is therefore a principal object of the present invention to provide a radio frequency transformer having a limited and definite field action regardless of natural amplitude when a series of the transformers are disposed in proper relation.

A further object of the invention is to provide a radio frequency transformer having a limited depolarized magnetic field action when a multiple of the transformers are used in a radio frequency amplifier circuit.

A further object of the invention is to provide a radio frequency transformer having a construction such as to permit and require straight alignment of magnetic pole ends between adjacent transformers when used in multiples in a radio frequency amplifier and thus permitting of a multiple of the transformers being mounted as a unit on a single form.

A further object of the invention resides in the provision of a radio frequency transformer having a limited and depolarized magnetic field, and which transformers are of such construction as to permit of the same being of the self supporting type as well as that type embodying a supporting form, and also permitting of the windings to be of any of the various types of interwoven coils.

A further object of the invention resides in the provision of a radio frequency transformer requiring means for varying the inductance value of its secondary winding, and permitting and requiring, when a multiple of the transformers are connected in an amplifier circuit, a multiple of variable condensers so connected as to be controlled as a unit.

A further object of the invention is to provide a radio frequency transformer having a field adjusting inter-action whereby no balancing or trimmer condensers are required for retaining the transformers of a like value

when a multiple of the transformers are used in a radio frequency amplifier.

A still further object of the invention resides in the provision of a coil system embodying a multiple of radio frequency transformers so constructed that when connected in a radio frequency amplifier system all magnetic fields will have a like magnetic polarity indication.

Other objects and advantages of the invention will be apparent during the course of the following detailed description, taken in connection with the accompanying drawings, forming a part of this specification and in which drawings,

Figure 1 is a side elevation of a supporting form for axial alignment of the transformers.

Figure 2 is a fragmentary detail view part in section and part in elevation illustrating one manner in which a multiple of the transformers may be constructed as a unit for insuring axial alignment of the transformers in fixed relations one to another.

Figure 3 is a transverse section on line 3—3 of Figure 2.

Figure 4 is a perspective view part in section and part in elevation and illustrating the manner in which each transformer may be constructed as a unit in itself.

Figure 5 is a view illustrating one manner in which the windings forming the primary and secondaries of the transformer may be wound upon cylindrical forms for positioning one within the other.

Figure 6 is a view illustrating a slightly modified form of the invention and showing an optional method of winding for producing a limited field action similar to that produced by the form of winding as illustrated in Figures 1 to 5 inclusive.

Figure 7 is a wiring diagram of the form of winding as illustrated in Figure 6.

Figure 8 is a perspective view illustrating the manner in which the principal may be applied to transformers having magnetic core material, the windings being arranged as in Figures 1 to 5 inclusive.

Figure 9 is a diagrammatic representation of the type of transformer illustrated in Figure 8.

In the drawings, similar reference characters designate corresponding parts throughout the several views.

Referring first to the form of invention as illustrated in Figures 1 to 3 inclusive, and wherein is illustrated a multiple of the transformers mounted upon a single form for installation as a unit in a multiple stage radio frequency amplifier, an arrangement has been shown whereby a series of radio frequency transformers may be so mounted as to be disposed in axial alignment and in fixed spaced relation one to the other. The coil windings of the transformers are of circular formation, and in the example illustrated a pair of concentrically arranged tubular supporting forms 5 and 6 have been shown for respectively supporting the primary and secondary coil windings of the individual transformers. The supporting forms 5 and 6 are of a suitable insulating material and of a length and diameter for proper construction and spacing of the individual transformers for given wave bands. The inner form 5 may be of plain tubular formation, while the outer supporting form preferably consists of a series of tubular sections 7, 8 and 9 connected in equally spaced apart relation as by a series of ribs 10 whereby an opening is provided between the tubular sections 7, 8 and 9 for a purpose to be subsequently explained. The inner tubular supporting form 5 is of a diameter less than the internal diameter of the outer supporting form 6 for permitting the inner form to be readily inserted into the outer form, and any suitable means such as illustrated at 11 in Figure 2, may be provided for supporting the form 5 concentrically within the form 6 and against longitudinal movement therein. The supporting form 5 is intended to support the primary inductance of each of the transformers, while the outer supporting form 6 serves as a support for the secondary inductance of each of the radio frequency transformers.

The primary coil windings 12 of each transformer comprises a pair of coil sections 13 and 14 each consisting of an equal number of turns of wire wound in opposite directions upon the circular supporting form 5 and connected together at their inner ends so as to form a primary inductance unit having the terminals 15 and 16 disposed at opposite ends of the winding. The inner ends of the coil sections 13 and 14 are spaced a predetermined distance apart, and are retained in co-axial alignment with each other by reason of the circular supporting form 5 upon which they are wound in opposed relation. These primary coil windings 12 are wound upon the circular supporting form 5 at equally spaced apart points along the form, and it will here be noted the supporting form serves as means for retaining the windings 12 in spaced relation end to end and in axial alignment one with another. It may here be well to state that the supporting forms may be of any desired length for mounting of more than three of the radio frequency transformers, as when the transformers are being employed in a radio frequency amplifier embodying more than three stages of radio frequency amplification.

The secondary coil winding 17 of each transformer comprises a pair of coil sections 18 and 19 each consisting of an equal number of turns of wire wound in opposite directions upon the tubular sections 7 of the supporting form 6 and connected together at their inner ends so as to form a secondary

inductance unit having the terminals 20 and 21 disposed at opposite ends of the winding. These secondary coil windings 17 are wound in a like manner as that of the primary coil winding 12, that is, the secondary coil section 18 is wound in a like direction as that of the primary coil section 13, and the secondary coil section 19 is wound in a like direction as that of the primary coil section 14. This reversed winding of the coil sections of the primary and secondary coil windings is clearly illustrated in Figure 2 and wherein the winding pitch of the wires has been somewhat exaggerated for the purpose of more clearly illustrating the opposed windings of the primary and secondary inductance units. The inner ends of the coil sections 18 and 19 are preferably spaced an equal distance as that of the spacing between the primary coil sections 13 and 14, and are retained in co-axial alignment with each other by reason of the tubular sections of the supporting form 6 upon which they are wound. Since the tubular sections 7 to 9 of the supporting form 6 are spaced equidistance apart as by the connecting ribs 10, the tubular sections will serve as means for equally spacing the secondary coil windings in fixed relation end to end and in axial alignment one with another.

The tubular supporting form 5 is intended to be inserted into the larger tubular supporting form 6 and secured in fixed relation as by the spacing elements 11 in a manner whereby the coil sections 13 of the primary coil windings will be disposed concentric with and directly under the coil sections 18 of the secondary coil windings 17, and the coil sections 14 disposed concentric with and directly under the coil sections 19. That is, when the primary coil winding is in fixed relation to the secondary coil winding, the windings of the coil sections 13 and 18 will be in a like direction and in opposed relation to the coil sections 14 and 19. Thus it will be seen that a radio frequency transformer will be provided having a primary and a secondary inductance, each embodying a right and a left hand winding, with the right hand windings of the inductances arranged concentrically, and with the left hand windings of the inductances arranged concentrically.

While the specific construction of the tubular supporting form 6 has been illustrated as consisting of the tubular sections 7, 8 and 9 upon which the secondary inductances are wound, and which sections are held in axial alignment and spaced relation to one another by the ribs 10, such construction has merely been shown for illustrating one manner of mounting a multiple of the transformers in fixed relation one to another and yet allow for making ready connections with the terminals 15 and 16 of the primary inductances when the tubular supporting form 5 is positioned within the outer supporting form 6. It will be seen that the open spaces provided by the ribs 10 will enable ready attachment of conductors to the terminals of the primary coil windings 12, and thus permit of a multiple of the radio frequency transformers being formed as a unit for ready connection in a radio frequency amplifier.

Referring now to the form of invention as illustrated in Figures 4 and 5, such illustrates an arrangement whereby the radio frequency transformers may be constructed as independent units for connection in multiples in a radio frequency amplifier. With this principle of construction, the primary and secondary coil windings 22 and 23 respectively, are wound about tubular supporting forms 24 and 25 respectively, the form 24 being of a diameter to freely fit within the tubular form 25 after the primary coil winding 22 has been wound on the form 24. The primary and secondary coil windings 22 and 23 are wound with spaced coil sections similar to those disclosed in Figure 2, with the sections of each winding wound in an opposite direction. The inner form 24 is held in fixed relation within the outer form 25 so that the coil sections of the primary and secondary coil windings are arranged concentrically, and suitable brackets 26 may be connected with the outer form for mounting of a series of the transformers in axial alignment in a radio frequency amplifier.

By so winding the primary and secondary inductances of the transformer in a manner as disclosed in Figures 1 to 5 inclusive and wherein the coil sections are wound in opposite directions end to end, it will be seen that opposed fields will be formed in each transformer and each field will have a reverse magnetic action to the other field within the transformer when the transformers are properly connected in a radio frequency amplifier.

Referring now to Figures 6 and 7 and wherein is illustrated an optional method of winding for the transformers for producing a limited field action as produced by the form of windings illustrated in Figures 1 to 5 inclusive, the coil sections 30 and 31, and 32 and 33, of the primary and secondary inductances 34 and 35 respectively, have been shown as each being wound in the same direction and so connected as to form opposing fields by reversing the connection to one of the coil sections. This is accomplished by connecting the outside lead of one section to the inside lead of the companion section thereby connecting the coil sections in opposition magnetically and producing a limited field action since the coil sections are placed end to end and in axial alignment. The primary and secondary inductances 34 and 35 may either be wound on the supporting forms as shown, or may be of the self supporting

type. This type of winding the coil sections will be found to be especially useful in connection with two concentrated inductances for long wave or low frequency signal reception. Likewise, with the type of winding as illustrated in Figure 6, the coil sections 30 and 31 of the primary inductance are intended to be disposed in concentric relation with the coil sections 32 and 33 of the secondary sections and permanently fixed in this relation.

Referring now to the form of transformer as illustrated in Figures 8 and 9, and which type of transformer will be found especially well adapted for use in radio frequency amplifiers employing the "super heterodyne" principle of reception, the transformer has been shown as being constructed with two sections of magnetic core material about which the coil sections of the primary and secondary inductances are wound. The transformer comprises a pair of independent cores 36 and 37 which are constructed of laminations of sheet iron, and which core sections may be held in spaced relation to one another by suitable strips of insulation 38 serving to retain the core sections in fixed relation and in longitudinal alignment. The primary inductance comprises a pair of concentrated windings 39 and 40 each consisting of an equal number of turns of wire wound in opposite directions about the magnetic core sections 36 and 37 respectively and connected together at their inner ends so as to form a primary inductance consisting of two opposing sections. The secondary inductance of the transformer comprises a pair of concentrated windings 41 and 42 each consisting of an equal number of turns and wound in a like direction as that of the windings 39 and 40 about the magnetic core sections 36 and 37 respectively in overlying relation with the respective primary windings. Thus it will be seen that the coil sections 39 and 40 extend in a like direction about the magnetic core section 36, while the coil sections 40 and 42 extend in a like direction about the magnetic core section 37 in opposition magnetically to the coil sections 39 and 41. As a method of constructing the transformer illustrated in Figure 10, the coil sections of the primary inductance may consist of many turns of fine wire wound back and forth in several layers on each of the core sections 36 and 37, with a layer of insulating material wrapped over the finished primary sections, and then the sections of the secondary inductance be wound back and forth in several layers over the insulating material. While the winding of the coil sections in opposite directions upon the magnetic core sections 36 and 37 has been shown for providing opposing magnetic fields within the transformer construction, it will be apparent that if so desired the coil sections may be wound in a like direction as in Figure 6 and connected so as to form opposing magnetic fields within the transformer.

As to the action of transformers so constructed that each of its primary and secondary coils embody opposed coil sections so related as to form opposing magnetic fields, a polarity test will show that if one end or head of the transformer is positive, the opposite end of the transformer will also be positive, or if one end of the transformer is negative the opposite end will also be negative. It will therefore be seen that if a series of such types of transformers be connected in a radio frequency amplifier circuit in a manner so that all primary windings and all secondary windings are carrying a direct current with which such an amplifier must be supplied, and in a direction to produce the same polarity between each and all of the transformers in the circuit, that is, each end of each transformer will be of a like polarity, that the positive magnetic field of one transformer cannot attract the negative magnetic field of another transformer and form field distortion between any two of the transformers, providing the transformers are mounted in straight alignment,—end to end.

Since each end of all of the transformers will be of a like polarity, and owing to the fact that the transformers are arranged in axial alignment end to end, no field rise will result between adjacent transformers when so connected, and it will be seen that a field drop will be prevented by the limiting factor in each transformer having two opposed fields within itself. Yet, by having the transformers placed a predetermined distance apart, a certain amount of inter-action will be manifest to maintain each transformer at an equal inductance value and thereby making it necessary in a receiving set that variable condensers be connected for simultaneous operation acting to tune the transformers as a unit.

The spacing of the transformers may be varied, and constructed in proper sizes for the desired wave bands for which the transformers are to be used, and the calculation of the spacing required will depend upon several factors, namely coil diameter, density of field windings, the peak value of amplifier plate voltage and the spacing between the two opposing sections within each transformer, since in the latter the limiting characteristic is secured for when the two sections are closely spaced, less outside field extension exists, and when the two sections are placed tight together, reception of signals becomes difficult but with proper spacing the signal reception is not hindered.

From the foregoing description it will be apparent that a novel and improved construction for radio frequency transformers has been provided embodying a construction for producing a limited and depolarized

field action, and a multiple of which transformers may be mounted in axial alignment, end to end, in a radio frequency amplifier circuit in a manner for preventing an audible beat note termed undesirable oscillations.

Changes in detail may made to the specific forms of the invention herein shown and described, together with mounting of a multiple of the transformers in a radio frequency amplifier in a manner other than that set forth, without departing from the spirit of the invention or the scope of the following claims.

I claim:

1. A radio frenquency transformer comprising a primary winding embodying a pair of spaced, connected coil sections arranged in axial alignment, and a secondary winding embodying a pair of spaced, connected coil sections arranged in axial alignment and concentrically of like coil sections of the primary winding, said coil sections being so wound as to produce magnetic fields of a like polarity at both ends of the transformer.

2. A radio frenquency transformer embodying an inner and an outer supporting form connected in fixed relation, coil sections wound in opposite directions on the inner form in slightly spaced apart relation, and connected at their inner ends, and a pair of oppositely wound coil sections wound about the outer form in slightly spaced apart relation and connected at their inner ends, with the windings on one form arranged concentrically with like wound coil sections of the companion supporting form.

3. A radio frequency transformer comprising a primary winding embodying a pair of coil sections arranged in spaced axial alignment and connected to form opposing fields, and a secondary winding embodying a pair of coil sections arranged in spaced axial alignment and connected to form opposing fields, said coil sections of the windings being similarly wound and with the coil sections of one winding arranged concentrically of the coil sections of the companion winding.

4. A radio frequency transformer comprising a primary winding embodying two equally formed coil sections arranged in spaced relation to end to end and forming opposing magnetic fields, and a secondary winding embodying two coil sections of similar constructions as that of the primary coil sections and arranged in spaced relation end to end and forming opposing magnetic fields, said primary and secondary winding being arranged in fixed relation with the coil sections of one winding arranged concentrically of the coil sections of the companion winding.

5. In apparatus of the character described, the combination of an inner and an outer supporting form, arranged in fixed relation one within the other, a series of windings supported in spaced relation on the inner form and each embodying spaced coil sections forming opposing magnetic fields, and a series of windings supported in spaced relation along the outer supporting form and each embodying a pair of spaced coil sections forming opposing magnetic fields, said coil sections of the outer form being arranged concentrically of the coil sections of the inner form.

6. In apparatus of the character described, an inner tubular supporting form, an outer tubular supporting form telescopically arranged over the inner form and embodying equally spaced apart tubular sections connected by a series of spacing ribs, means for fixedly retaining the supporting forms in fixed relation, a series of windings supported in spaced relation along the inner supporting form and each embodying a pair of coil sections arranged in magnetically opposed relation, and a series of windings supported one upon each of the tubular sections of the outer supporting form and each embodying a pair of connected coil sections arranged in magnetically opposed relation and concentrically of like coil sections of the windings on the inner supporting form.

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