G. VON ARCO & R. H. RENDAHL.

SELF INDUCTIVE MEANS FOR ELECTRICAL OSCILLATORY CIRCUITS.

APPLICATION FILED JAN. 29, 1910.

1,175,489.

Patented Mar. 14, 1916.

2 SHEETS—SHEET 1.

Fig. 1.

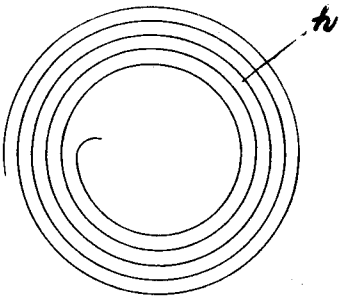


Fig. 2.

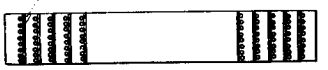


Fig. 3.



Fig. 3a.

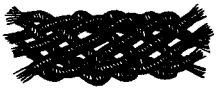


Fig. 4.

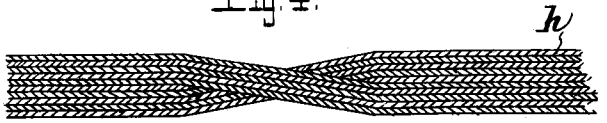


Fig. 5.

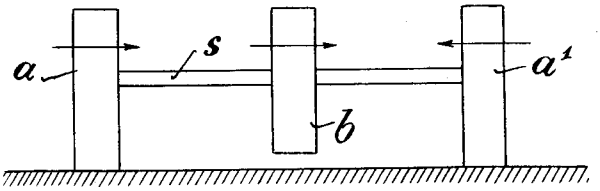


Fig. 6.

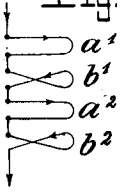
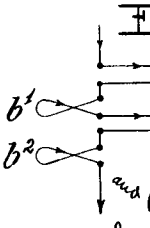


Fig. 7.



Witnesses

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2 SHEETS—SHEET 2.

Fig. 8.

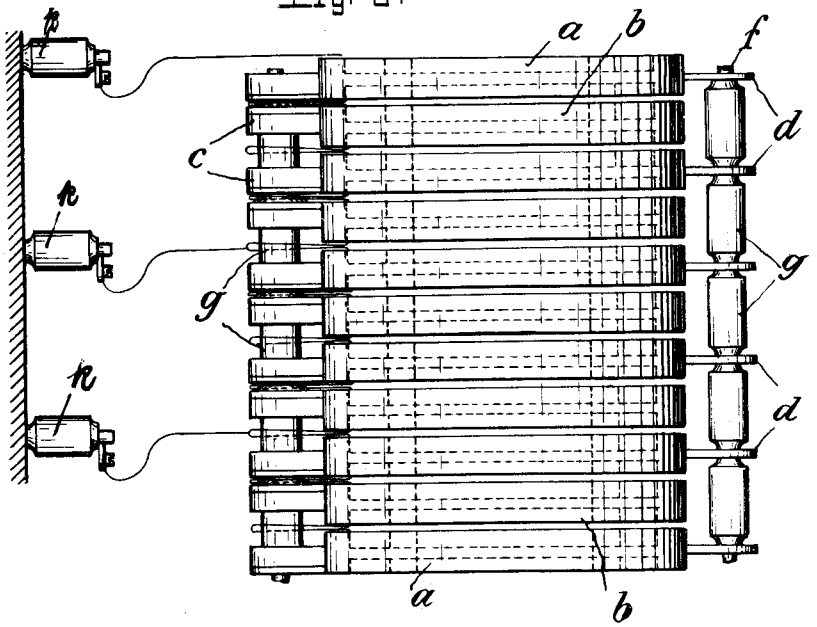
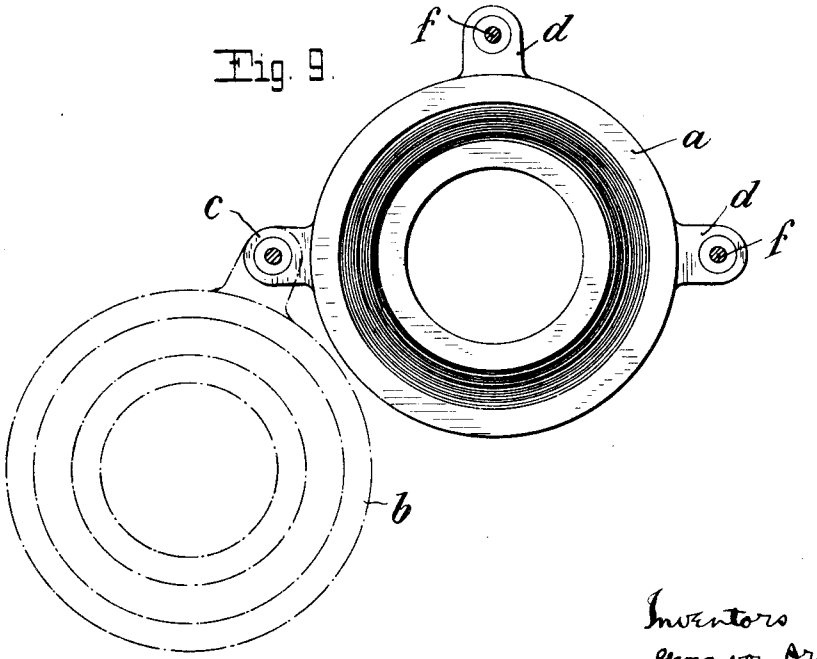


Fig. 9.



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UNITED STATES PATENT OFFICE.

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SELF-INDUCTIVE MEANS FOR ELECTRICAL OSCILLATORY CIRCUITS.

1,175,489. Specification of Letters Patent. Patented Mar. 14, 1916.

Application filed January 29, 1910. Serial No. 540,914.

To all whom it may concern:

Be it known that we, GEORG VON ARCO and RAGNAR HÅKAN RENDAHL, subjects of the German Emperor and the King of Sweden, respectively, and residing, respectively, at Berlin, Germany, and Lilienholm, near Stockholm, Sweden, have invented certain new and useful Improvements in Self-Inductive Means for Electrical Oscillatory Circuits, of which the following is a specification.

Our invention relates to self-inductive means for electrical oscillatory circuits, particularly for transmitting arrangements in wireless telegraphy.

Our invention substantially consists in forming the self-inductive coils as flat spirals and it also comprehends the special arrangement of such coils relatively to one another such that a fine variation of the self-induction is possible even in high-tension circuits.

Some illustrative embodiments of our invention are represented diagrammatically by way of example in the accompanying drawing wherein:—

Figures 1 and 2 are top plan view, and cross-section, respectively, showing diagrammatically a coil formed as an annular disk; Figs. 3 and 4 are perspective views showing two forms of the winding elements for such coils; Fig. 3ª shows a modified form of a winding element; Fig. 5 shows diagrammatically in elevation a special arrangement of the coils according to our invention for varying the self-induction within small limits; Figs. 6 and 7 are diagrams showing another arrangement of the coils for varying the self-induction within wider limits, whereas Figs. 8 and 9 show a system of coils according to Figs. 6 and 7 assembled to form a variometer, Fig. 8 being an elevation, and Fig. 9 a top plan view in which the position of the movable coils when swung out is represented by dotted lines.

As our experiments have shown, the damping of coils having the form of an annular disk is much less, when the winding is sufficiently subdivided; than that of the best cylindrical coils. Experiments have shown that the least damping action is obtained when the internal diameter is approximately half the external. The height of the coils must be small relatively to this diameter.

Winding elements are well-known consisting of a large number of individual conductors of at most 0.2 mm. diameter which are stranded together and sufficiently insulated from one another to prevent the passage of Foucault currents. If it is desired to make such an element for heavy loads, such as occur, for example, at the transmitting stations of wireless telegraphic systems, the cross section of the conductor becomes so great, that with a given length of conductor fewer turns can be made on account of the windings standing farther apart from each other, so that the self-induction of the coils decreases; or for a given self-induction the length of such heavy conductor and consequently its ohmic resistance and also the dimensions of the coil increase, by which increase the damping effect of the coil is materially increased.

One of the principal objects of the present invention is to obtain a self-induction coil for high frequency currents which will stand the heaviest possible load at minimum damping and maximum self-induction.

According to our invention, for winding coils for heavy loads we employ not one strand, but a plurality of strands connected in parallel, each of which strands is in turn stranded and consists of a large number of wires of at most 0.2 mm. diameter, insulated from one another to prevent the passage of Foucault currents, the principal feature rendering a maximum load at minimum damping and maximum self-induction possible being that the main strands all are so arranged that they form a flat ribbon *h*, as shown in Figs. 1 and 2. In such a flat ribbon not only is a self-induction obtained, which is a maximum for a given volume of coil and a given length of conductor, but an exceedingly convenient arrangement of the coils is also produced.

Provision must be made that the individual strands as well as the individual conductors in the strands vary their positions in the magnetic field, so that each conductor is subject to the same average strength of field. Moreover, we preferably insulate the individual strands one from another, this

insulation being, of course, considerably greater than that of the individual thin wires. Also the well-known tendency of high frequency currents to travel on the outermost surfaces of the conductor is counteracted by the alternation of the position of the individual strands relatively to the ribbon center, and by the fine subdivision of the strands into fine individual conductors, so that the current for instance in case of a flat ribbon conductor cannot travel on the outer edges of the conductor. We can fulfil these requirements in various ways. For example, we may place ten individual strands one beside another and connect them together with suitable texture of silk or the like in the manner in which for instance ribbon elastics are made. The texture may, if desired, simultaneously serve as insulation of the strands. In order to vary the position of the individual strands in the field, we wind the ribbon spirally around a flat, ribbon-like support of insulating material, for instance a strip of press-spahn. The winding element thus formed may now be used for any desired form of winding. Fig. 3 shows such an arrangement. In Figs. 1 to 3, *h* designates a ribbon composed of ten strands connected in parallel and wound spirally around a strip of press-spahn *i*. The ribbon may also be made by twisting or braiding the strands into each other in known manner like a hair braid. In this event the support shown at *i* Fig. 3 is superfluous since the ribbon can sustain its shape during the winding of the coil. This modification is shown in Fig. 3ª.

Fig. 4 shows a ribbon *h* made in a different manner. The strands are placed rectilinearly for a certain distance and then change their position from time to time in such manner that, for example, the outermost strands are located in the center and the central ones at the outside. The crossing may take place, about once in every convolution. In this form also the wires may be connected together by texture or be secured with varnish or shellac on a support of press-spahn.

As will be readily understood from the hereindescribed illustrative embodiment of our invention, to which a large number could be added, it is essential that the average distance of each of the individual strands from the center of the ribbon remains equal or approximately equal.

The coils just described are particularly suitable where small variation of the self-induction is required, even in transmitting arrangements in which insulation difficulties could not be overcome heretofore. Fig. 5 shows such an arragement diagrammatically for stations working with three different wave-lengths obtained by interpolating and cutting out coils, a case in which it is important to be able to make small corrections of tuning of the antennæ. In this figure, *a*, *a'* and *b* are coils interpolated in the antennæ, the two outer coils *a*, *a'* being fixed and the central coil *b* displaceable on a rod *s* in such manner that according to the position of the central coil in each instance relatively to the two others the resulting self-induction is different when the direction of field is selected correspondingly; the close proximity of *b* to *a* increases, and its close proximity to *a'* decreases the self-induction. For example, if the station is to work with three wave-lengths of 1,000, 1,500 and 2,000 meters, the conditions can be selected such that when employing all three coils a wave-length of 2,000 meters is obtained which can be varied between 1,800 and 2,200 meters by displacing the central coil. Likewise, by employing the coils *b* and *a'* a wave-length of 1,500 meters can be obtained and by employing coils *b* and *a* a wave-length of 1,000 meters, which lengths can be varied within the limits of 1,400 to 1,600 meters and 900 to 1,100 meters, respectively, by displacing coil *b*.

Obviously, by connecting the coils in series and in parallel a great variety of combinations may be produced.

The displaceable coil is preferably arranged between two coils having fields of different direction. This case is supposed in the illustrative embodiment, in which the arrows indicate the direction of field. Coils *a* and *b* have the same direction of field, so that when they approach one another the self-induction is increased, whereas coils *b* and *a'* have different directions of field so that when they are moved closer together the self-induction is diminished.

The subject matter just described with reference to Fig. 5 is not claimed in the present application, but forms the subject matter of a divisional application, Serial Number 792,681, filed September 30th, 1913, patented July 27, 1915, No. 1,148,279.

The last described arrangement admits of only a small variation of the self-induction. For stations which should emit waves of any desired length within wide limits the employment of variometers cannot be avoided.

Variometers known heretofore comprise individual coils which can be displaced relatively one to another in space. The variation of the self-induction obtained is larger, the nearer all the windings of the coils can be brought together. Their proximity is limited only for mechanical reasons. These variometers, however, do not come into consideration in practice for the transmitting circuit because it is impossible to bring the reciprocally movable parts, between which considerable differences of potential exits, so near one to another that a suitable variation can be obtained. For whereas, for ex-

ample, in a variometer for receiving circuits a variation of the self-induction of 1:17 can be conveniently obtained, it is practically impossible to construct a heavy current variometer capable of producing a variation of more than 1:2. For this reason, in spite of its undisputed advantages the heavy current variometer has not been introduced in practice in wireless telegraphy.

A further object of our invention is to overcome the above disadvantages.

According to our invention we subdivide the entire self-induction among a plurality of small variometers connected in series. In this manner the tensions between the reciprocally movable parts of the individual variometers are diminished so that these parts can be brought nearer together and a greater possibility of variation results. The range of variation of the arrangement is materially increased, in addition, by the individual variometers being formed as flat, superposed coils arranged in pairs, of which one coil of each pair is arranged fixed and the other able to swing out from the system of coils parallel to the plane thereof. These particular features are set forth and claimed in a divisional application, Serial Number 792,682, filed September 30th, 1913, patented Mar. 9, 1915, No. 1,131,187, but we shall describe hereinafter the arrangement embodying these features, so as to show the manner in which we propose to employ the specific coils claimed in the present application. We will now explain this with reference to the diagrams Figs. 6 and 7. In Fig. 6 four coils are shown superposed, of which two, *i. e.* a^1, a^2, are fixed and the two others b^1, b^2 movable. The coils a^1, and a^2 are wound in one sense and the coils b^1 and b^2 in the other, so that the resultant self-induction of the arrangement in this position is zero. The arrows indicate the direction of current. In Fig. 7 the movable coils b^1, b^2 are swung out in such manner that their opposing influence is removed from the coils a^1, a^2. The result is that the total self-inductance of the variometer in this position is greater than the sum of the inductances of the individual variometer a^1, b^2 and a^2, b^2 if they were separated from each other but each in the position shown in Fig. 7 with its movable coil swung out. The explanation of this feature is that each variometer a^1, b^1 and a^2, b^2 when in the position shown in Fig. 7 and when removed from the other variometer has a certain maximum self-inductance. Now if the two variometers in this maximum position are assembled as shown in Fig. 7, their coils are in such position that all coils wound in the same sense inductively react upon each other (a^1 and a^2, and b^1 and b^2 react upon each other), in other words the certain maximum self-inductance of each variometer is increased by the reaction of the other variometer, so that the total of inductance produced by this arrangement is greater than the sum of the inductances of the individual variometers on account of the mutual inductance. Obviously the arrangement may be carried into practice with any desired number of variometers. Likewise, we may use a plurality of groups of movable coils.

In Figs. 8 and 9 *a* designates fixed coils and *b* movable coils of the form according to Figs. 1 and 2 wound with ribbons according to Fig. 3 for example. All the coils have eyes *c* for receiving the pivotal axle on which the loose coils swing. The fixed coils *a* have, in addition, eyes *d*, through which pins *f* pass preventing the fixed coils from rotating on said axle. Insulators *g* are arranged between the pairs of eyes *c* and between the eyes *d*. If necessary, two or more movable coils may be connected mechanically together so that a larger number of coils can be swung simultaneously. The arrangement is such that the fixed coils *a* and movable coils *b* are arranged alternately in the system. As may be clearly seen from Fig. 8 any suitable number of variometers may be thrown into circuit by the connection with the desired binding post *k*.

What we claim is:

1. A self-inductance for electrical oscillatory circuits consisting of at least one coil in the form of a flat annular disk which is formed by the conductor wound as a flat spiral, the inner diameter of said disk being substantially equal to one half of the outer diameter thereof.

2. A self-inductance for electrical oscillatory circuits consisting of at least one coil in the form of a flat annular disk, and having its conductor consisting of a plurality of strands, conductively connected with each other at both ends and bound together throughout their whole length in the shape of a flat ribbon, the inner diameter of said disk being substantially equal to one half of the outer diameter thereof.

3. A self-inductance for electrical oscillatory circuits consisting of at least one coil in the form of a flat annular disk and having its conductor consisting of a plurality of strands, conductively connected with each other at both ends and bound together throughout their whole length in the shape of a flat ribbon, the average distance from the ribbon center of all of said ribbon strands during one convolution being approximately equal, the inner diameter of said disk being substantially equal to one half of the outer diameter thereof.

4. A self-inductance for electrical oscillatory circuits consisting of at least one coil in the form of a flat annular disk, and

having its conductor consisting of a plurality of strands conductively connected with each other at both ends and bound together throughout their whole length in the shape of a flat ribbon, each of said strands varying its position relatively to the ribbon center at suitable intervals, the inner diameter of said disk being substantially equal to one half of the outer diameter thereof.

5. A self-inductance for electrical oscillatory circuits consisting of at least one coil in the form of a flat annular disk and having its conductor consisting of a plurality of strands, conductively connected with each other at both ends and bound together throughout their whole length in the shape of a flat ribbon, said strands passing from one side of the ribbon to the other side in each convolution, the inner diameter of said disk being substantially equal to one half of the outer diameter thereof.

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