

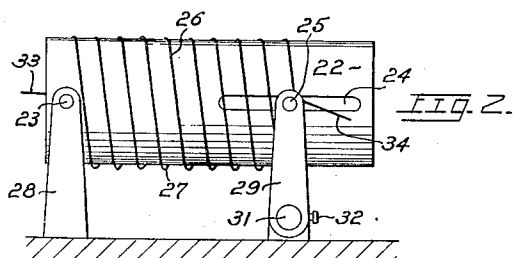
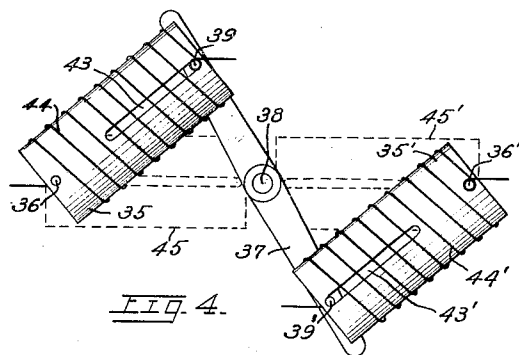
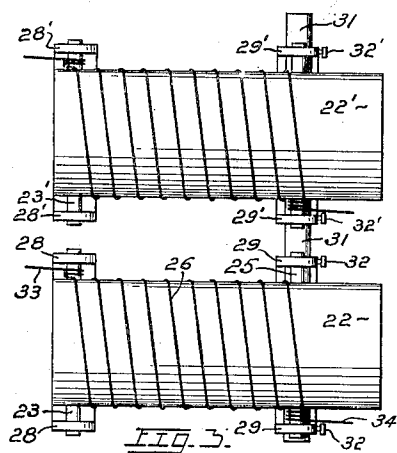
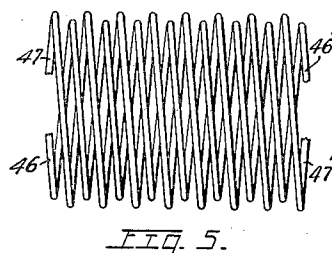
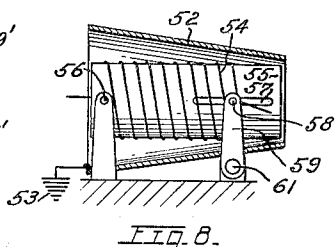
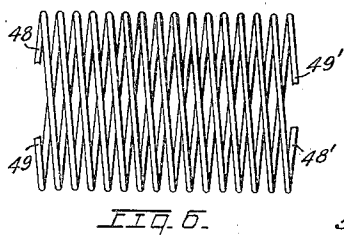
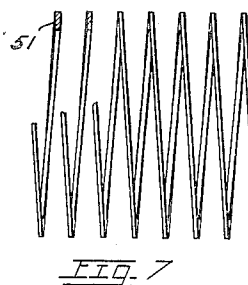
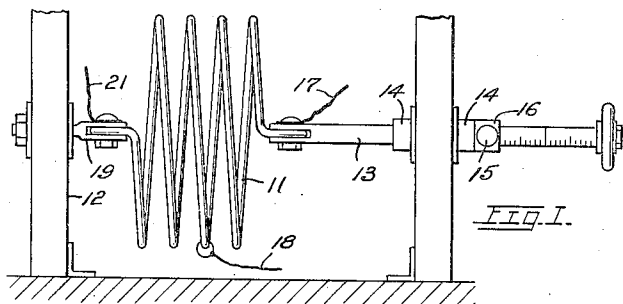
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H. R. LUBCKE

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BAND-PASS FILTER

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Inventor;
Harry R. Lubcke,
per
Arthur J. Farnsworth
Attorney.

UNITED STATES PATENT OFFICE

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BAND-PASS FILTER

Harry R. Lubeke, Los Angeles, Calif., assignor to
Don Lee Broadcasting System, Los Angeles,
Calif., a corporation of California

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6 Claims. (Cl. 178—44)

This invention relates to means for tuning resonant circuits, and especially to means adapted for tuning the resonant circuits of very high frequency which are now used in the radio and television arts.

Hitherto it has been difficult to adjust resonance in such circuits satisfactorily, because of the very noticeable effects of non-adjustable capacitance and inductance which are nearly always present. Where the energy wavelengths are less than about 30 meters, even the stray capacitance and inductance of connecting wires are appreciable. The present invention is adapted for overcoming such difficulties to a marked degree.

My principal object in the invention has been, to provide tuning means whereby the useful upper range of radio frequencies may be considerably extended. A second object was to develop improved ways for adjusting oscillatory frequencies in a plurality of circuits simultaneously, no matter what the combination of such circuits may be. A third object was to accomplish such plural tuning while keeping the involved circuits at the same resonant frequency. A fourth object was to discover a satisfactory method for concurrently adjusting capacitance and inductance in such circuits, in desired proportional degrees. A fifth object was to provide such a method without recourse to taps, or to rolling or scraping electrical contacts. A sixth object was to supply a better type of band-pass filter having adjustable resonance; wherein the width of the passed band will either remain constant, or vary with the frequency, according to variable physical characteristics of the filter. My seventh object was to secure each of the sought for results by means of simple and relatively inexpensive apparatus.

All of my stated objects have been attained, by the use of devices which include suitable types of helical coils having adjustable axial dimensions. It is known from the universally accepted fundamental definitions; that the inductance of a helical coil or solenoid varies substantially in inverse proportion to variations in the axial length thereof; and that the capacitance between the fixed number of convolutions of such coils also varies substantially in inverse proportion to variations in the axial length. Thus both capacitance and inductance may be varied by adjusting the axial length of the coil involved, and I make use of this principle in all embodiments of the present invention. I adjust the relation between the respective variations of capacitance

and inductance resulting from variation of the axial length, by varying the extent of the opposed projected areas between the coil convolutions.

Such coils, and methods whereby they may be utilized, are shown in the accompanying drawing. All of the figures are to be considered as being wholly diagrammatic, although some of them clearly suggest actual forms of construction. In the drawing—

Figure 1 is a conventional side elevation of apparatus which is adapted for utilizing my invention in radio or television broadcasting;

Figure 2 is a similar elevation of an embodiment of my invention adapted for use in radio or television receiving;

Figure 3 is a conventional plan view of two mechanically coupled units of the kind shown in Fig. 2, the combination being adapted for regulating resonance in two circuits simultaneously;

Figure 4 is a conventional side elevation of a band-pass filter, employing two coil-units of the type illustrated in Figs. 2 and 3;

Figure 5 shows two co-axial and nested helical coils, which may be utilized for a second type of band-pass filter embodying the principles of my invention;

Figure 6 represents two co-axial coils which are wound as a double helix, and which are adapted to constitute a third type of band-pass filter utilizing this invention;

Figure 7 is a diagram illustrating a manner in which capacitance may be greatly increased in a helical coil, without affecting its inductance; and

Figure 8 is a diagram showing, in side elevation and central section, how a helical coil, having an adjustable axial dimension, may be provided with a conducting envelope; for regulating the capacitance of the coil with respect to ground.

Similar reference numerals refer to similar things, throughout the several figures of the drawing.

As indicated above, the apparatus of Fig. 1 is especially adapted for transmitter technique. A short coil having a few turns of relatively heavy conductor, is shown at 11. Such coils may be wound with contiguous convolutions, of hard-drawn wire or even ductile tubing. When moderately extended horizontally, they may be quite strong enough to withstand gravitational sagging. Their resiliency may be depended upon for axial contraction, or to assist therein. Consequently one end of such a coil may be affixed to

an insulating support, as the slate panel shown at 12. The other end of the coil may be attached to an insulating rod 13, which is longitudinally slidable through guides 14. Thus the axial dimension of the coil may be adjusted against its resilient tendency to contract. A set-screw 15, in a collar 16, serves to maintain such adjustment. Connection to the movable end of the coil may comprise a very flexible conducting strip or braid at 17; and a similar flexible center-tap connection 18, for impressing special voltages upon the coil, may be employed. The fixed support 19 may be made of insulating material, and that end of the coil be connected by means of a conductor 21.

In Fig. 2 I have shown how the relatively fine-wire coils which are used in receiver technique, may be supported horizontally without gravitational sagging, even when they are fully extended. For this purpose, I find it convenient to employ a tubular insulating cylinder 22, conveniently made of such material as Bakelite. The cylinder has a pair of diametrically opposed round holes at one end, through which a stationary pivot pin 23 is passed. At the other end, the cylinder has a pair of diametrically opposed longitudinal slots 24, in which a bar 25 is engaged and laterally slidable. The coil 26 loosely surrounds cylinder 22; so that the upper portions of its convolutions are supported, and the lower portions hang spaced, in the manner indicated at 27. This construction permits free extension of the coil horizontally, while maintaining axial alignment of its convolutions. Insulated wire is used, so that the turns will not become short-circuited when the coil is fully compressed. Pivot pin 23 is held in fixed position by a pair of posts 28. The respective ends of slidable bar 25 are pivotally engaged by the upper ends of a pair of levers 29, and the lower ends of these levers are adjustably positioned upon a rotatable shaft 31 by means of set-screws 32. One end of coil 26 may be held in a convenient manner (as by taking a few turns about pin 23 and then short-circuiting these turns by soldering them together), before being extended at 33 for connection; and the other end of the coil is held by bar 25 (as by taking a few turns thereabout and soldering the turns together), before being extended at 34 for connection. Obviously the axial length of coil 26 may be varied very greatly in this construction, by imparting a rocking rotation to shaft 31. Any skilled person can supply suitable holding means for the shaft after adjustment; such as a set screw, or even a frictional grip.

In Fig. 3 I have indicated how a plurality of coils may have their axial dimensions varied in the same way simultaneously, for correspondingly tuning plural resonant circuits. The lower portion of the figure is a plan view of the construction shown in Fig. 2. The upper portion of the figure is a plan view of another and identical construction. Both pairs of operating levers, designated 29 and 29' respectively, are mounted upon shaft 31, and swing in the same way when the shaft is rotated. Both of the pivot pins, designated 23 and 23' respectively, are affixed at the tops of their respective posts 28 and 28'; and cylinders 22 and 22' swivel respectively about the pivot pins. The two circuits of this composite arrangement may be brought into electrical "alignment;" by loosening the set-screws 32 of one unit at a time, adjusting the coil length of the unit by swinging its levers 29 until maximum resonance is obtained, tightening up said set-

screws while the levers are in the maximum resonance position, and repeating the process for the other unit. Shaft 31 may be supplied with a knob and dial for convenience of adjustment, and with holding means.

By extending the construction of Fig. 3, it is possible to tune any reasonable number of resonant circuits simultaneously; whether they include single extensible coils, extensible coils which are coupled to fixed coils, band-pass filters comprising two extensible coils, or any combination of such devices.

The use of two adjustable coil units of the kind described, to constitute a variable band-pass filter, is shown in elevation in Fig. 4. Therein the insulating cylinders 35 and 35', swivel about fixed pivot pins 36 and 36' respectively. An operating lever 37 is mounted at its center upon rotatable shaft 38, carries projecting pins 39 and 39' near its respective ends, and is adapted to be rocked by a suitable knob (not shown) which is attached to the shaft. Pins 39 and 39' engage and slide in the respective cylinder slots 43 and 43', and thus variably compress slots 44 and 44' respectively when lever 37 is moved counter clockwise. When the coils are fully compressed, they are in axial alignment, as is indicated by dotted outlines 45 and 45'. Shaft 38 may carry any desired number of such arrangements, spaced along its length, which will be operated simultaneously when the shaft is rotatively rocked.

Two co-axial coils of variable axial dimensions, may be used as a tunable band-pass filter. One arrangement of such coils is shown in Fig. 5; wherein the two coils have slightly different diameters, and the smaller coil 46-46' is wholly enclosed by the larger coil 47-47'. For securing a smaller coefficient of coupling and, consequently, a narrower passed band of frequencies, the difference between the diameters of the coils may be increased. Either coil may be the primary or secondary of the combination, and such a filter may be tuned by varying the axial length of the coils simultaneously. I have discovered that the two coils will tune concurrently to the same resonant frequency (at all frequencies to which the combination may be adjusted), if the inner coil is made proportionally shorter than the outer coil. The coils will then be geometrically similar. In practice such coils may be made to "track," by experimentally adjusting their relative lengths until maximum response is secured, using several representative frequencies within the tuning range.

In Fig. 6 I have shown another arrangement of two co-axial coils for the same purpose, and adjustable in the same way. Here the two coils, 48-48' and 49-49', are wound turn for turn as a double helix; the convolutions of the two coils alternating. All corresponding features of the two coils may be made exactly the same, and the coupling between primary and secondary will then be exceedingly close, since the coils will be geometrically congruent.

Fig. 7 illustrates the manner in which the relation between capacitance and inductance may be adjusted, in any type of open wound helical coil. This is done by flattening the sides of the coil convolutions; or by employing a ribbon conductor, and coiling it edgewise, in the manner indicated in section at 51. The capacitance of a coil may be greatly increased in this way, because the opposed surfaces of adjacent convolutions are thus made greater for a given cross-sectional

area of conductor, are parallel, and may be made to approach each other closely.

Fig. 8 is a side elevation, shown partly in central section, of an approved method for providing adjustable coils of the type shown in Fig. 2 with a conducting grounded envelope. In this figure the envelope 52 takes the form of a hollow truncated cone, grounded at 53, and its truncated apex is adjacent the extensible end of coil 54. The envelope, like coil cylinder 55, is adapted to swivel around a fixed pin 56 at its larger end; and it is provided with diametrically opposed slots, opposite cylinder slots 57. Bar 58 is engaged by, and laterally slidable in, slots 57. The respective ends of that bar are pivoted at the upper extremities of a pair of operating levers, of which one is shown at 59. The lower extremities of these levers engage a rockingly rotatable shaft 61. In such an arrangement, when coil 54 is fully compressed, it occupies but a small part of the space contained within envelope 52. At that time, also, the effective surface of the coil is at its minimum, and it is farthest away from the envelope. Therefore, in its compressed condition, the capacitance of the coil with respect to ground will be at its lowest value. As the coil is extended, its capacitance with respect to ground will be much increased, because the effective surface of the coil will be far greater, and it will be much closer to the envelope. The capacitance of this arrangement may be made to double from its minimum to maximum.

Other configurations of envelope 52, and various forms of adjacent shielding compartments, may be arranged. They afford convenient methods for variously relating capacitance to the axial length of the coil. The envelopes or shielding compartments also may be positioned by other forms of linkage connected to shaft 61. It will be obvious to persons skilled in the art, how various kinds and degrees of capacity and length relationships may be secured in such ways.

In all extensible helical coils, the frequency of resonance increases with the axial dimension, but there are mechanical reasons why such coils should not be pulled out too far. The limit of extension ordinarily should be set not to exceed about eight times the compressed length, and the latter dimension should be made to be about $\frac{1}{4}$ of the coil diameter. If these things are done, I have found that there is practically no danger of exceeding the elastic limit of such materials as are likely to be employed for the coil windings.

It is well known that, in order to secure uniform width of a frequency band by means of a band-pass filter, the coefficient of coupling between the primary and secondary circuits of the filter must vary inversely with the frequencies passed. The filter device shown in Fig. 4 is admirably adapted for securing this result. When the two coils thereof are fully compressed, they are co-axial. The coupling coefficient will then be at its maximum value, and the resonant frequency of the device will be at its lowest value. When the two coils are in their fully extended positions; their axes will be farthest apart, the coupling coefficient will be at its minimum value, and the resonant frequency will be at its maximum value. In order to secure still greater var-

iation of the coupling coefficient, cylinders 35 and 35' may be turned end for end, by placing fixed pins 36 and 36' on opposite sides of shaft 38 and close thereto. The two coils will then be very near together in their fully compressed positions, as well as being co-axial.

It will be appreciated that neither the transmitter or receiver aspect of my invention is limited to the use of coils having but few turns, or made of any special conducting material. It will also be understood that compressible and extensible helical coil devices, of the character herein disclosed, may be used merely as convenient variable inductances in non-resonant and low frequency circuits.

Obviously the actual designing and proportioning of the devices described, and the supplying of various mechanical expedients which are necessary or desirable for their adjustment and operation, are well within the ability of persons who are skilled in the art involved.

It will be seen that, by the use of homogeneous conducting material and conductors of uniform diameter, the convolution pitch of the coils described will be substantially uniform, at all values of the axial dimension.

I claim as my invention:

1. A band-pass filter comprising; two helical conducting coils having variable axial dimensions; means for adjusting said dimensions; and means for varying the positions of the coils with respect to each other, for adjusting their mutual inductance.

2. A band-pass filter comprising; a pair of like helical conducting coils having variable axial dimensions; means for adjusting said dimensions correspondingly and simultaneously; and means whereby the mutual inductance of the coils is varied simultaneously with, and in inverse proportion to, all variations of said dimensions.

3. A band-pass filter comprising; a shaft adapted for rocking rotation; a pair of oppositely extending arms on said shaft; and a pair of helical conducting coils of which each has a variable axial dimension; one extremity of each coil being fixed in position, and the other extremities of the coils being positioned by said arms respectively.

4. A band-pass filter comprising; a plurality of helical conducting coils having variable axial dimensions; and means for simultaneously adjusting said dimensions; each coil, at the frequency of the energy impressed thereon, and within the range of variation of its axial dimension, having substantial inductive reactance.

5. A band-pass filter comprising; two helical conducting coils having variable axial dimensions and different diameters; and means for adjusting the mutual inductance of the coils; said coils being co-axial, and one of them being completely enclosed laterally by the other.

6. A band-pass filter comprising; two conducting coils wound turn for turn as a double helix; said helix having a variable axial dimension, and a substantially uniform convolution pitch, at any value of said dimension; and the mutual inductance of the coils being relatively great at all values of said dimension.

HARRY R. LUBCKE,