Nov. 29, 1938. S. W. SEELEY ET AL 2,138,209

SELECTIVE TUNING SYSTEM

Filed Oct. 5, 1929 2 Sheets-Sheet 1

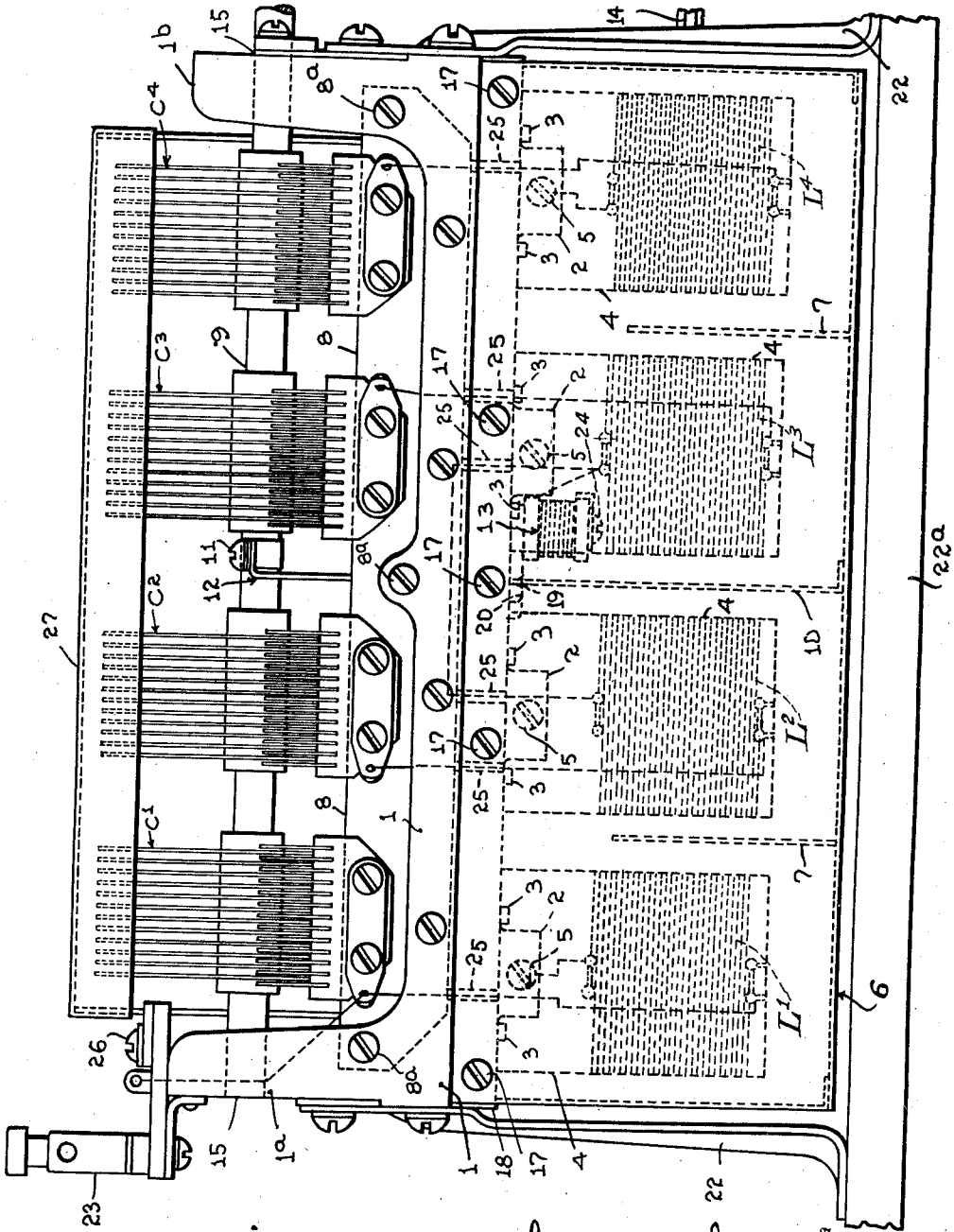

Fig. 1.

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Filed Oct. 5, 1929 2 Sheets-Sheet 2

Fig. 2.

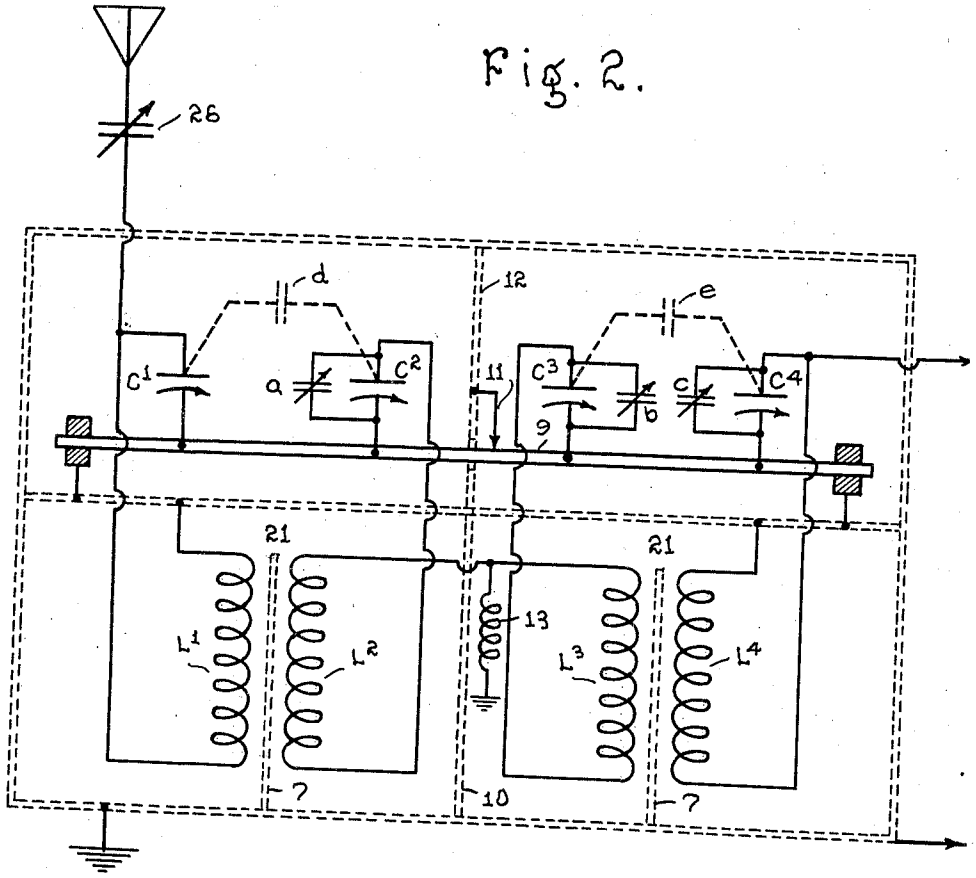
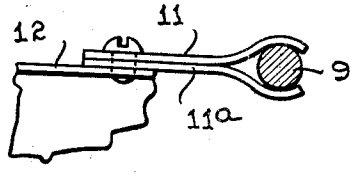


Fig. 1b.



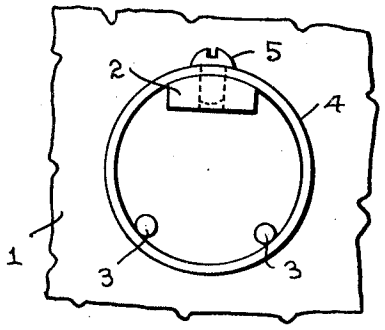


Fig. 1a.

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Patented Nov. 29, 1938

2,138,209

UNITED STATES PATENT OFFICE

2,138,209

SELECTIVE TUNING SYSTEM

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Application October 5, 1929, Serial No. 397,491

16 Claims. (Cl. 178—44)

This invention relates to a selective tuning system, and more particularly to a device for selecting the signal through a succession of coupled resonant circuits unassociated with vacuum tubes.

It has for some time been understood that two resonant circuits independently tuned to the same frequency, when coupled together will show points of maximum response at two different frequencies. In other words, the system will exhibit the so-called "double hump" response. So long as the exterior limits of this dual frequency response lie within one broadcast channel, this effect is of considerable advantage, for the attenuation of the carrier components representing the higher audible frequencies is minimized. However, if the limits of frequency response lie more widely apart, the effect is a severe detriment in a broadcast receiver, for both selectivity and quality are sacrificed.

At the frequencies of the broadcast spectrum, the natural electromagnetic and electrostatic relations of the component parts as ordinarily placed in a broadcast receiver, give rise to such a degree of coupling that the tuning response broadens beyond one broadcast channel and adjacent frequencies are transmitted with too little attenuation. Practically, therefore, special precautions in the design of such a tuning system must be taken to prevent the natural couplings in the set from producing the faults mentioned above. Particular design is also demanded to prevent the energy at unwanted frequencies in the antenna circuits from coupling over directly into the work circuit systems. Compactness in design is also essential to minimize losses; as an example, in the development of this present invention, the effective ohmic loss of one inch of lead wire was found to be approximately 1 ohm.

The present invention is directed toward the solution of the difficulties presented above.

An object of the invention is to devise a tuning system which will pass a frequency band having a constant width throughout the entire tuning range.

A further object is to provide a cascade tuning system wherein means is provided whereby the energy in the input side of the system at frequencies other than that desired will be prevented from coupling into circuits associated with the selector output.

Another object is to provide a cascade system of coupled tuned circuits in which means is provided to prevent the direct transfer of energy from one tuned circuit to another removed therefrom, and whereby energy transfer from the first to the second circuit is accomplished only by transmission through the intermediate circuit or circuits.

Another of the objects of this invention is to provide means for the introduction of the small amount of coupling necessary between the circuits and yet prove accurate, simple and easy of manufacture.

It is also an object of this invention to overcome coupling by parasitic currents in the mechanical parts of the selector system.

It is an object of this invention to minimize the effective ohmic losses in leads and the circuit of the selector system.

It is a further object of this invention to place the several resonant circuits in an exceedingly compact space, with the consequent avoidance of lead losses, but at the same time to avoid difficulties caused by the increased inherent natural couplings between the tuning elements.

This invention will be clearly understood by reference to the annexed drawings in which; Figures 1, 1*a* and 1*b* illustrate the apparatus employed and; Figure 2 is a diagrammatic representation of the sircuit and shielding means.

Referring to Figure 1, a base plate 1, of cast or stamped metal is provided with upstanding ends 1*a* and 1*b* having trunnion bearings 15—15, wherein a condenser shaft 9 is freely revolvable. The shaft 9 carries the rotary plates of four variable condensers C1, C2, C3 and C4, and the stator elements of the condensers are supported by two strips of insulating material 8 secured to the two sides of the base plate by screws 8 *a*. The rotor plates of the variable condensers are protected from mechanical injury by a metallic cover 27 supported above the condensers from base plate 1. This cover also serves to electrically shield the condensers against external influences. While the cover 27 only partially encloses the condenser elements, it will be understood that it may be extended to the base plate 1 and entirely inclose the condensers. The base part 1 is provided with lugs at 2, 2, 2, 2, from which depend the coil support tubes 4—4 etc. These lugs, with locating bosses 3, 3, fix the position of the coil support tubes 4 directly below the associated condenser. The screws 5 serve both to hold the coil tubes 4 in place and provide a convenient ground with the shortest possible lead for the inductances L1 and L4 wound thereon. The arrangement of the locating bosses 3 with respect to the coil tubes and the lugs 2 is shown in Figure 1*a*. A box coil-shield 6 of such thickness and efficacy that substantial coupling is prevented therethrough,

fits snugly against the ground side surfaces 13 of the base plate 1 and is held in place by the screws 17. A pair of supporting brackets 22 are secured to the ends of base plate 1 and serve to support the entire structure, with the box-shield suspended from the base plate and out of contact with the supporting surface 22a.

The partitions 7, 7 of this shield 6 extend but part way up to the condenser base 1. A gap 21, 21 is left between the shielding partitions 7, 7 and the base part 1. Shield 10, however, is complete and is forced into a saw slot 19, cut through the raised portion 20 on the under side of base 1. A shield 12 supported from base 1 and in electrical contact therewith is inserted between the stators of condensers C2 and C3, and a grounding spring contact 11 supported by said shield 12, bears on the rotor shaft 9. The details of the grounding contact are shown in Figure 1b, where it will be seen that spring contact elements 11 and 11a are supported on shield 12 and maintain clamping engagement with shaft 9.

Coupling between circuits L2, C2 and L3, C3 (Fig. 2) is secured by the small coupling coil 13 supported on the under side of base 1, one end of the coil being grounded thru the screw support 24.

Input connections are made to binding posts, of which the ground post 23 is shown; the antenna terminal is immediately behind the ground terminal and is not shown. The antenna terminal is connected to a small adjustable condenser 26 mounted on end extension 1a.

Output connections are made by means of a grid pin-connector 14 connected to the stator of condenser C4 and by the foot bracket 22 at ground potential.

Slots 25, cut thru the finished face 18 of base plate 1 allow space for the connector wires. The lower terminal of coil L1 is connected to the stator of condenser C1 and to a terminal of the antenna condenser 26. The lower terminals of coils L2, L3 and L4 are likewise connected to the stators of condensers C2, C3 and C4 respectively. The upper terminals of coils L1 and L4 are connected to base plate 1 through supporting screws 5, and the upper terminals of coils L3 and L4 are connected together and to one terminal of coupling coil 13, the other terminal of which is connected to base plate 1 by screw 24. The rotors of the variable condensers are electrically connected with base plate 1 through shaft 9 by way of the bearings at each end and by way of contact 11 at the center.

Referring to Figure 2, coil L1 and variable condenser C1 constitute a loop resonant circuit connected in series with the antenna and the antenna condenser 26. A second tuned circuit includes coil L2, coupling coil 13 and variable condenser C2. This tuned circuit is coupled to the first tuned circuit by magnetic coupling between coils L1 and L2 through gap 21 above partition 7. A third tuned circuit includes coupling coil 13, coil L3 and condenser C3, the coil 13 serving to couple this tuned circuit with the second tuning circuit referred to above. A fourth tuned circuit includes coil L4 and variable condenser C4, which is coupled to the third tuned circuit by magnetic coupling between coils L3 and L4 through gaps 21 above shield 7. Condensers C2, C3 and C4 are provided with small trimmer condensers *a*, *b* and *c*, respectively (not shown in Fig. 1). The condensers *d* and *e* indicated in dotted lines represent the natural capacity existing between the stator plates of condensers C1—C2 and C3—C4, respectively.

Operation of the system is as follows:

By adjustment of the antenna condenser 26 and trimmer condensers *a*, *b* and *c*, each of the circuits is tuned to the same frequency. Current supplied to the first tuned circuit from the antenna circuit induces current into the second tuned circuit by the magnetic coupling between coils L1 and L2 through the gap 21, and also by electrostatic coupling between the stator elements of condensers C1 and C2, which coupling is represented in Figure 2 by the dotted condenser *d*. Current flowing in the second tuning circuit induces current in the third tuned circuit by means of the coupling coil 13. The third tuned circuit induces current into the fourth tuned circuit by magnetic coupling between coils L3 and L4 through gap 21, and by means of the capacity coupling between the stator elements of condensers C3 and C4. The degree of coupling between coils L1 and L2 and also between coils L3 and L4 is dependent upon the effective width of gaps 21. By this means the desired amount of electromagnetic coupling can be accurately introduced. In this particular instance, the size of the opening is such that the coupling, circuit to circuit, is about one and one-half per cent.

In order to obtain a more even response with frequency it is desirable to introduce a capacity coupling between tuned circuits L1, C1 and L2, C2 (also L3, C3 and L4, C4) in addition to the magnetic coupling between the tuning coils. This capacity coupling is introduced by arranging condensers C1 and C2 (also C3 and C4) so that the natural capacity existing between the ungrounded plates (usually the stator) affords the desired coupling between the circuits. However, if the required capacity can not be found in the natural circuit arrangements, physical condensers may be inserted at *d* and *e*, Fig. 2, which as shown, represent the actual capacity between the condenser stators.

It was found, however, that with the extremely sensitive amplifier used in conjunction with this selector, but which forms no part of this invention, that the direct coupling of inductance L1, to inductance L4, though small in magnitude, was sufficient to cause considerable disturbance of the signal if the partition 10 was not complete, but was partial as are partitions 7, 7. The partition 10, therefore, isolates practically completely the fields of these two inductances. Electrostatic shielding between the stator systems of condensers C2 and C3 is necessary for the same reason. The shield 12 is, therefore, inserted to prevent the electrostatic transfer of extraneous signals.

If, however, the field of circuit L1, C1, is not isolated practically completely from the fields of circuits L4, C4, especially and L3, C3, preferably, a device will be produced which will tune broadly only. Were, therefore, the partition 10, of the same construction as are partitions 7, 7, a direct coupling path thru the succession of orifices would exist allowing sufficient direct "jump-over" coupling to limit the performance of the selector. Partition 10 is, therefore, inserted in such a manner to be as effective a shield as possible.

Similarly, the capacity path afforded by the end-on effect of condenser C2 to that of condenser C3, allows extraneous antenna energy to step across the gap, again producing a broadly tuning device. Such transfer has been avoided by placing a shield 12 between the stators of condenser C2 and C3.

In a similar manner, the shaft 9 offers a common parallel path between the said circuits, L2, C2—L3, C3, coupling thru which is of such a high value that broad tuning results. A grounding brush 11 (or a supernumerary bearing), grounding the condensers on the shaft between the rotor members of C2 and C3, prevents such coupling.

While the gaps 21 in partitions 7 have been shown located at the top of the partition, it is to be understood that these gaps may be of any desired shape and be located in other positions than the one shown. For example, the gap may be divided, part at the top and part at the bottom of the partition; or it may be made by forming holes of various shapes in a partition member 7 which extends entirely across the shield-box 6. It will be understood by those skilled in the art that the purpose of the gap or orifice in the partitions is to permit the desired amount of magnetic coupling between the coils on opposite sides of the partitions, and the effective size of the gaps or orifices is determined by the degree of coupling desired.

While the main purpose of the shields 7 is to reduce the natural magnetic coupling between adjacent coils to the desired value, these shields also serve to substantially eliminate the natural capacity coupling between the coils. Accordingly, any form of shield may be employed so long as it reduces the magnetic coupling to the desired value and substantially eliminates the electrostatic coupling between the coils. Where extremely small values of magnetic coupling are required the shields may extend entirely across the inside of the box and the amount of coupling will then be determined by suitable choice of the thickness of the sheet forming the shield.

It will thus be seen, that we have produced a compact selector and have provided simple means for the introduction and control of the small values of coupling required in a non-amplifying selector system.

What we claim is:

1. In combination, a plurality of tuned circuits each including an inductance coil and a condenser, said coils and condensers being arranged in inductive and capacitive relation respectively, shielding means for effectively isolating said coils in pairs, shielding means for isolating said condensers in pairs, shielding means between the coils of each pair for substantially eliminating capacity coupling between said coils but affording a desired amount of magnetic coupling, and an inductance coil common to one circuit of two adjacent pairs of circuits.

2. In combination, two spaced coils arranged in inductive relation to each other, a common shield surrounding said coils, and a conducting partition in said common shield arranged between said coils, said partition being provided with an aperture of predetermined effective size to reduce the magnetic coupling between said coils and substantially eliminate capacity coupling therebetween the major part of the energy in one circuit being produced by the electromagnetic coupling with the other circuit through said aperture.

3. As a tuning system in combination, a conducting base member, a series of insulated stator assemblies mounted thereon, a conducting shaft, a series of condenser rotor assemblies mounted thereon, grounding connections provided at certain positions along said shaft to said base member, a shield interposed between pairs of condenser stators to prevent end-on capacity coupling, a plurality of pairs of inductance coils supported beneath the base member and a shield provided with compartments for the complete isolation of pairs of said inductance coils and the partial isolation of the coils of said pairs.

4. In combination a plurality of tuned circuits each including a coil and a variable condenser, a common conducting base for supporting said condensers, means on said base for supporting said coils adjacent the respective tuning condensers, one side of certain of said coils being connected to said conducting base through said supporting means.

5. In combination a plurality of tuned circuits each including a coil and a variable condenser, a common conducting base for supporting the rotary elements of said condensers upon a common shaft, insulating means for supporting the stator elements of said condensers upon said conducting base, means for supporting said conducting base in an elevated position, and means for suspending said coils beneath said base adjacent the respective tuning condensers.

6. In combination a plurality of tuned circuits each including a coil and a variable condenser, a common conducting base for supporting said condensers, a common conducting shaft for said condensers journaled at its ends in said conducting base, means on said base for supporting said coils adjacent the respective tuning condensers, one side of certain of said coils being connected to said conducting base through said supporting means, and means for grounding said shaft to said conducting base at a point intermediate its ends.

7. A plurality of loosely coupled circuits, the coils of the circuits being placed in close physical juxtaposition and each being nearly completely magnetically shielded in order to obtain the desired loose coupling despite the close physical juxtaposition the major part of the energy in a succeeding circuit being produced by the coupling with a preceding circuit through the incomplete shielding.

8. A selector for energy of a desired frequency comprising tuned circuits coupled directly in cascade, the coils of the tuned circuits being placed in close juxtaposition in order to obtain a compact structural arrangement, each of said coils being nearly completely magnetically shielded in order to obtain a desired loose coupling between the circuits the major part of the energy in a succeeding circuit being produced by the magnetic coupling with a preceding circuit through the incomplete shielding, and the group of coils being additionally completely shielded with respect to external fields.

9. A selector for energy of a desired frequency comprising tuned circuits coupled directly in cascade, the coils of the tuned circuits being placed successively in close juxtaposition, and at least some of the coils being so nearly completely magnetically shielded by means serving to condense or localize the flux field of the said coils to the immediate vicinity thereof, that the major part of the energy in a succeeding one of the last mentioned coils is produced by magnetic coupling with a preceding coil through the incomplete shielding and the non-adjacent coils have no direct coupling therebetween.

10. A selector for energy of desired frequency comprising sharply tuned circuits coupled directly in cascade, the coupling coils of the tuned circuits being fixedly placed with their axes par-

allel and in close physical juxtaposition in order to obtain a simple compact structural arrangement, and magnetic shielding confining the flux of the coils, said shielding being so disposed that non-adjacent coils are not directly coupled at all, while adjacent coils are coupled by a relatively small component of the normal flux field, and consequently are only loosely coupled the major part of the energy in a succeeding one of the last mentioned coils being produced by the said component of the normal flux field of a preceding coil.

11. The combination of two coils spaced from each other and an electrical shielding surface interposed in said spacing, said surface having an aperture of controllable and predetermined dimensions for electrically coupling said coils the major part of the energy in one of said coils being produced by the said coupling.

12. The combination of a metallic casing, two electrical circuits within said casing, and a conductive partition spaced between said circuits, said conductive partition having an aperture of variable and controllable dimensions providing an air space for coupling said circuits the major part of the energy in one of said circuits being produced by the said coupling.

13. The combination of two circuits and a metallic device spaced from said circuits and interposed therebetween, said device having an aperture of variable and controllable dimensions providing an air space for coupling said circuits the major part of the energy in one of said circuits being produced by the said coupling.

14. The method of changing the flow of energy from a first circuit to a second circuit, the first circuit being surrounded by a conductive surface having an aperture, which consists in changing the size of the aperture and producing the major part of the energy in the second circuit by the coupling through said aperture.

15. The combination of a source of electrical energy, a circuit external to said source, and an electrical shielding surface surrounding said circuit and having an aperture providing an air space of adjustable dimensions for controlling the transfer of energy from said source to said circuit the major part of the energy in said circuit being produced from said source through said aperture.

16. The combination of two circuits and a conductive surface housing both circuits and providing a separating partition, the separating partition of said conductive surface having an aperture providing an air space for coupling both circuits the major part of the energy in one circuit being produced by the lines of force extending through said aperture.

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