

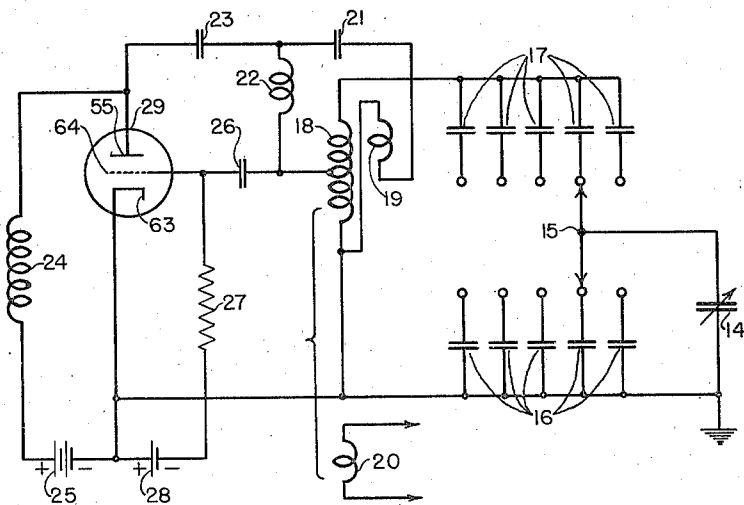
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MULTIBAND TUNABLE SYSTEM

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MULTIBAND TUNABLE SYSTEM

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10 Claims. (Cl. 250—40)

This invention relates to multi-band tunable systems and to methods of operating the same.

This application is a division of application Serial No. 540,581, filed May 28, 1931 which issued November 26, 1935, as Patent 2,022,067.

It is an object of this invention to provide a multi-band tunable system in which the scale divisions on a tuning dial associated with the tuning element of the system are relatively large and easy to read accurately for each of two or more of the bands over which the system is tunable.

The invention contemplates a multi-band tunable system having a single variable tuning element for selectively tuning the system over any of the several bands, together with provisions for so varying the effectiveness of the tuning element in accordance with the band selected that the several bands are of approximately equal frequency coverage or width and equal changes in the resonant frequency of the system are effected in two or more of the bands by displacements of the tuning element having magnitudes in a ratio, from band to band in the order of decreasing frequency, which is substantially greater than the inverse ratio of the mean frequencies of the bands. This arrangement is to be distinguished from the conventional multiband tunable system wherein the effectiveness of the tuning element remains constant so that equal changes in the resonant frequency of the system are effected in the several bands by displacements of the tuning element having magnitudes in a ratio, from band to band in the order of decreasing frequency, which is equal to, or only slightly greater than, the inverse ratio of the mean frequencies of the bands. In the particular embodiment of the invention hereinafter described in detail, the effectiveness of the tuning element is varied in accordance with the band selected so that for all of the bands substantially equal changes in the resonant frequency of the system are effected by displacements of the tuning element that are of the same order of magnitude.

More specifically, the invention contemplates a variable tuning condenser and an arrangement by which one or more auxiliary normally fixed condensers are selectively connected in circuit with the variable condenser in accordance with the band selected, the proportion and manner of connection of the auxiliary condensers being such that the effective capacity of the combination is adjusted for the several bands to cause the system to be tuned by the variable condenser

over bands of approximately equal frequency coverage or width.

The single figure of the drawing is a circuit diagram illustrating an embodiment of the invention as incorporated in the oscillator system which is particularly applicable to radio testing equipment.

Referring now to the drawing, the oscillator system there shown includes an arrangement to obtain a uniform voltage output when tuned over a large range of frequencies. To enable the invention to be readily practiced, there are given numerical values for the elements, which have been found satisfactory. These values are not intended to constitute limitations upon the invention.

The system comprises a three-electrode oscillator tube 29 which may be of the 171-A type, and a resonant frequency-determining circuit including a fixed inductance coil 18, a variable tuning condenser 14 and a number of fixed condensers 16 and 17. The condensers 16 are adapted to be connected in parallel with condenser 14 and the condensers 17 in series with condenser 14 by switch 15, as required. One end of coil 18 is connected to the cathode 63 of tube 29, and an intermediate point of the coil is coupled to the grid 64 of the tube through a fixed grid condenser 26 (250 micro-microfarads). The series combination of condenser 14 and one of condensers 17 (one of condensers 16 being in parallel with condenser 14), is connected across the entire inductance 18.

There is provided a feed-back arrangement which includes in a series circuit from the anode to the cathode of the oscillator tube, the following elements in the order named: fixed condensers 23 (0.1 microfarad) and 21 (250 micro-microfarads), and an inductance 19 which is inductively coupled to coil 18. An inductance is connected between the intermediate point of coil 18 and the point between condensers 21 and 23. The anode potential is furnished by a battery 25 (90 volts) connected between the cathode and the anode through a choke coil 24 (7 millihenries). The grid of the tube is negatively biased by a biasing battery 28 (about 20 volts) which is connected between the cathode and the grid of the tube through a high grid-leak resistance 27 (0.25 megohm).

The output of the oscillator is taken from across an output coil 20 which is coupled to inductance 18.

The switch 15 operates to connect condensers 16 and 17 in circuit, in pairs. Each pair of

series and parallel condensers enables the same tuning condenser 14 to cover a different frequency range. The variable condenser preferably has a capacity range of 42 to 900 micro-microfarads. The following table gives the combinations of series and parallel condensers required to cover the given frequency ranges:—

Frequency range	Parallel condenser	Series condenser
<i>Kilocycles</i>	<i>Micro-microfarads</i>	<i>Micro-microfarads</i>
500-700	586	1599
700-900	430	646
900-1100	330	355
1100-1300	214	215
1300-1600	108	

It is to be observed from the above table that, for the lowest frequency band, the series condenser 17 has an infinite capacitance or, in other words, consists of a direct conductive connection. Effectively, therefore, there is no series condenser 17 for that band. Thus, with the combination of capacities described above the operation of the switch 15 from the position corresponding to the lowest frequency band to the position corresponding to any of the other bands modifies the circuit relationship of tuning condenser 14 and inductance 18 by inserting one of the series condensers 17 in circuit therewith, for, in such lowest frequency band, no series condenser is utilized.

It is also to be observed that the effectiveness of the tuning condenser is modified by the values of the series and parallel condensers connected in circuit therewith by the switch 15. The term "effectiveness" of a tuning element, as used herein, may be defined as the ratio of the maximum effective value of the circuit reactance of the same type as that of the tuning element to the minimum value thereof, as the tuning element is varied between its maximum and minimum values.

It is further apparent from the above table that the effectiveness of the tuning element is decreased in successive steps as the system is adjusted to tune over successively higher frequency bands without increasing the magnitude of the effective capacitance in shunt with the inductance element 18. Thus, as the system is adjusted from the 500-700 kc. band to the 700-900 kc. band, the effective capacitance, with the tuning condenser 14 adjusted to its minimum value, is decreased from 626 micro-microfarads to 363 micro-microfarads; and, when the system is adjusted from the 700-900 kc. band to the 900-1100 kc. band, the effective minimum capacitance is decreased from 363 micro-microfarads to 236 micro-microfarads. Similar reductions occur with the condenser 14 adjusted to its maximum value. This, of course, means that the L/C ratio of the circuit for the higher frequency bands is not less than, but, in fact, is greater than, the L/C ratio for the lowest frequency band. This is a desirable feature by virtue of which the resonance gain of the system is not decreased in the higher frequency bands.

In order to secure a practically linear frequency calibration for the scale of condenser 14 over these various ranges in frequency, the condenser plates are made semi-circular but the axis of rotation is located eccentrically so that the radius of the entering edge of the rotor plates is one half the radius of the trailing edge.

This shape gives very nearly linear calibration over the intermediate-frequency range (900 to 1100 kilocycles) and only slight curvature in the frequency calibration of the other ranges.

The invention is described above as comprising an arrangement in which the effectiveness of the tuning element, or tuning reactance means, is modified so that for all of the bands equal changes in the resonant frequency of the system are effected by displacements of the tuning element that are of the same order of magnitude. It will be understood, however, that in certain applications it may be satisfactory to modify the effectiveness of this element to a lesser extent. Thus, in certain instances, a sufficient spread on the tuning indicator dial of the resonant frequencies in a higher frequency band may be obtained if the effectiveness of the tuning element in this band is considerably less than its effectiveness in the lowest frequency band. It will, therefore, be understood that the invention in its broadest aspects contemplates an arrangement, as described above, in which the effectiveness of the tuning element is varied in accordance with the band selected to effect, for two or more bands, equal changes in the resonant frequency of the system by displacements of the tuning elements having magnitudes in a ratio, from band to band in the order of decreasing frequency, which is substantially greater than the inverse ratio of the mean frequencies of the bands.

The combination of capacities described above has the advantage that a single half turn of the tuning condenser covers a frequency range of only one-fifth the broadcast range, that all of the frequency ranges are equal or at least of the same order of magnitude and that the scale divisions are relatively large and easy to read accurately and are approximately equal or of the same order of magnitude for all of the frequency ranges. Each of the five frequency ranges has an individually engraved scale on the condenser dial. The dissipation in the condensers and switching system is negligible, and the feedback is not varied when switching condensers, so that the output suffers no abrupt change with frequency at the boundaries between adjacent frequency ranges.

The feed-back coil 19 has a relatively low inductance and with incidental capacities has a resonant frequency which is substantially higher than the tuning range. The inductance coil 22, on the other hand, has a relatively high inductance (.4 millihenry) and resonant with condenser 21 (250 micro-microfarads) at a frequency slightly below the tuning range. Coil 19 and the lower half of coil 18 are effectively included in this low-frequency resonant circuit but do not appreciably affect the resonant frequency because their combined inductance is much smaller than that of coil 22. At high frequencies the reactance of coil 22 is so large that almost the entire radio-frequency plate current flows through condenser 21 and coil 19.

By connecting the feed-back circuits so that coil 19 is coupled to coil 18 in a reverse direction, while coil 22 is connected to a tap on coil 18, the feed-back current through condenser 21 and coil 19 has an effect which is augmented by the feed-back current through coil 22 and the lower half of coil 18, the latter making a substantial contribution only at the lower frequencies. It is well known that an oscillator tuned by a variable condenser requires a greater amount of feedback at

the lower frequencies than at the higher frequencies if the output is to be maintained at a uniform level over a frequency range. This result is accomplished with the circuit arrangement described above.

This circuit is utilized with excellent results as one element of a standard signal generator for testing radio receivers. The special tuning arrangement contributes greatly to the ease of operation of this equipment.

The coil structure is preferably constructed as follows and located in a cylindrical copper can, 3.25" in diameter by 4.3" in length.

The coil 18 comprises 63 turns of No. 22 B. & S. gauge wire spaced 22 turns per inch on a cylindrical form 2" in diameter. The tap off is approximately at the center. Feed-back coil 19 comprises 12 turns of No. 30 B. & S. gauge wire spaced 16 turns per inch on a cylindrical form 2½" in diameter. Output coil 20 comprises 50 turns of wire on a cylindrical form 1½" in diameter. Coil 19 is wound over the upper half of coil 18 as indicated in the diagram, in order to prevent so-called "parasitic oscillations" which otherwise occur at frequencies much higher than the resonant frequency of the oscillator system.

While I have described what I at present consider the preferred embodiment of my invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from my invention, and I, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What is claimed is:

1. A multi-band tunable system comprising inductance means, capacitance means including a variable condenser connected in circuit with said inductance means to form a circuit tunable over a given frequency band, auxiliary capacitance means, and switching means for modifying the circuit relationship of said inductance and capacitance means and for including at least a portion of said auxiliary capacitance means in series with said capacitance means and at least a portion of said inductance means to form a circuit tunable over a second frequency band and to modify in a predetermined manner the effectiveness of said variable condenser in tuning the latter circuit, said auxiliary capacitance means being so proportioned, relative to the inductance means, the capacitance means and their circuit relation, that the ratio of maximum to minimum effective capacitance of the latter circuit is such that the system is tunable over a range of frequencies in the second band which is of the same order of magnitude as the range of frequencies in the first band.

2. A multi-band tunable system comprising; a single inductance element and a plurality of capacitance elements, at least one of said capacitance elements being variable; and switching means operable to one position to connect said inductance with a preselected group of said capacitance elements including a variable capacitance element to form a closed circuit tunable over a first frequency band and operable to a second position to connect said inductance element with another preselected group of said capacitance elements including a variable capacitance element to form a closed circuit tunable over a second band differing from said first band and having an L/C ratio not substantially less than that of said first-mentioned tunable circuit, said groups of capacitance elements being so pro-

portioned that, for both of said bands, equal changes in the resonant frequency of said system are effected by displacements of said variable capacitance elements of the respective circuits that are of the same order of magnitude.

3. A variable tuning arrangement comprising in combination, a variable tuning condenser, two groups of auxiliary condensers, the auxiliary condensers of each group progressively differing in value in the same sense, and means for selectively connecting said variable condenser in series with a condenser of one group and in parallel with a corresponding condenser of the other group progressively to vary the effective capacitance of the arrangement and the effectiveness of said variable condenser.

4. A variable capacity arrangement comprising in combination a variable condenser, a plurality of series condensers, a plurality of parallel condensers, and a multi-point switch which at each position connects said variable condenser in series with one of said series condensers and in parallel with one of said parallel condensers said series and parallel condensers for each of said positions progressively varying in capacitance in the same sense, whereby the effective capacity of the combination is variable over a different range for each different position of said switch.

5. A resonant circuit comprising a variable condenser, a group of series and parallel condensers, and a series-parallel switching arrangement connected with said condensers, said circuit being tunable over a set of contiguous frequency bands of approximately equal width, each different band being selected by switching in a different pair of said series and parallel condensers, and the frequency variation within each of said bands being effected by said variable condenser.

6. A variable tuning arrangement comprising in combination, a variable condenser, a plurality of first condensers having progressively decreasing values, a plurality of second condensers having progressively decreasing values, and switching means having a plurality of positions for selectively connecting, in successive positions thereof, said first condensers in parallel with said variable condenser and in their order of decreasing value, and for selectively connecting, in said successive positions thereof after its first position, said second condensers in series with said variable condenser and in their order of decreasing value, the several first and second condensers being so proportioned that the effectiveness of said variable condenser for the several positions of said switching means varies directly with the mean value of the effective capacitance of the arrangement.

7. A multi-band tunable system for operating over a plurality of different substantially mutually exclusive frequency bands comprising fixed inductance means, a variable tuning condenser, auxiliary capacitance means, and switch means operable to different positions, one for each of said bands, said switching means forming in each of said positions a closed circuit tunable over one of said bands and including said variable condenser, and at least selected portions of said inductance means and said auxiliary capacitance means, said selected portions of said auxiliary capacitance means being so proportioned, relative to said inductance means and said tuning condenser and their circuit relation, that for all of said bands equal changes in the resonant frequency of said system are effected by displacements of said variable condenser having magni-

tudes in a ratio, from band to band in the order of decreasing frequency, which is substantially greater than the inverse ratio of the mean frequencies of the bands.

8. A multi-band tunable system comprising fixed reactance means of a given type, variable reactance means of the opposite type connected in circuit with at least a portion of said first-named reactance means to form a circuit tunable over a given frequency range, auxiliary reactance means of said opposite type, and switching means for including said auxiliary reactance means in circuit with said tuning reactance means and at least a portion of said first-named reactance means to form a circuit tunable over a second band of higher mean frequency than said given band, said bands being substantially mutually exclusive, and to modify the effectiveness of said tuning means in tuning the circuit, said auxiliary reactance means being so proportioned relative to the first two reactance means and their circuit relation, that the L/C ratio of the circuit for said second band is not substantially less than the L/C ratio of the circuit for said given band.
9. A multi-band tunable system comprising fixed reactance means of a given type, variable reactance means of the opposite type connected in circuit with at least a portion of said first-named reactance means to form a circuit tunable over a given frequency range, auxiliary reactance means of said opposite type, and switching means for including said auxiliary reactance means in circuit with said tuning reactance means and at least a portion of said first-named reactance means to form a circuit tunable over a second band of higher mean frequency than said given band, said bands being substantially mutually exclusive, and to modify the effectiveness of said tuning means in tuning the circuit, said auxiliary reactance means being so proportioned, relative

to the other reactance means and their circuit relation, that the L/C ratio of the circuit for said second band is not substantially less than the L/C ratio of the circuit for said given band and a given change in the resonant frequency of said system when operating in said second band is effected by a displacement of said tuning element having a magnitude in a ratio to the magnitude of the displacement required to produce the same change in the resonant frequency of said system when operating in the lower frequency band, which is substantially greater than the ratio of the mean frequency of said given band to the resonant frequency of said second band.

10. A multi-band tunable system comprising, in combination, inductance means, variable capacitance tuning means connected in circuit with said inductance means to form a circuit tunable over a given frequency band, auxiliary capacitance means, and switching means for including at least a portion of said auxiliary capacitance means in series with said variable capacitance means and in circuit with at least a portion of said first means to form a circuit tunable over a frequency band higher than said given band and to modify the effectiveness of said variable capacitance means in tuning said latter circuit, said auxiliary capacitance means being so proportioned, relative to the first two means and their circuit relation, that a given change in the resonant frequency of said system when operating in said higher band is effected by a displacement of said tuning condenser having a magnitude in a ratio to the magnitude of the displacement required to produce the same change in the resonant frequency when operating in said given band, which is substantially greater than the ratio of the mean frequency of said given band to the mean frequency of said higher band.

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