May 28, 1946. G. S. WACHTMAN 2,400,896

TUNING SYSTEM

Original Filed Oct. 5, 1943

FIG. 1

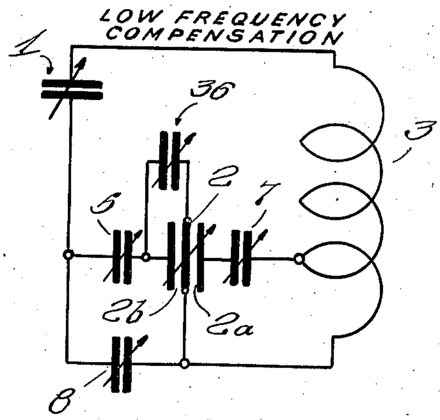


FIG. 3

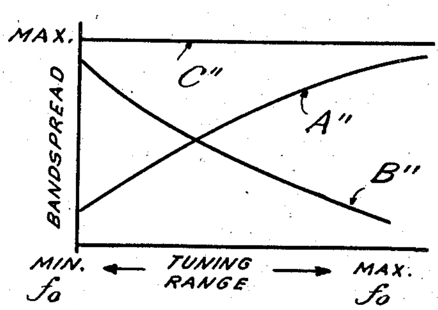


FIG. 2

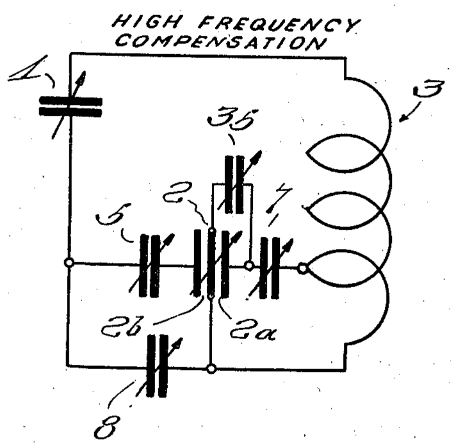


FIG. 4

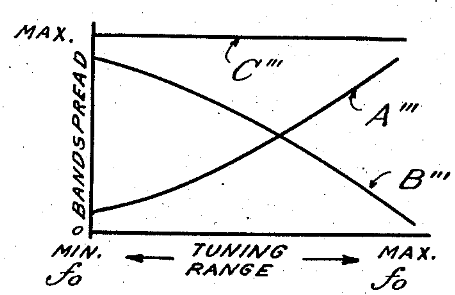


FIG. 5

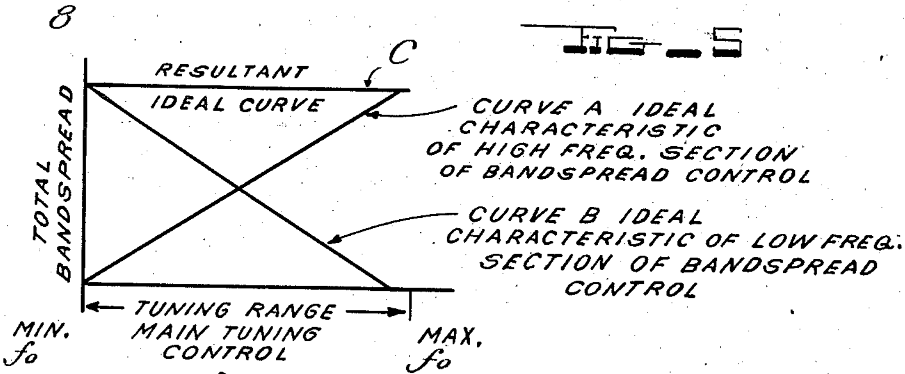
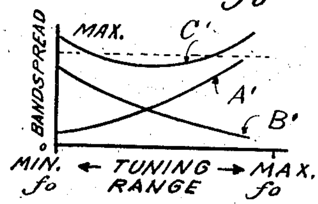


FIG. 6



INVENTOR.

George S. Wachtman,

BY

John B. Brady

ATTORNEY

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2,400,896

TUNING SYSTEM

George S. Wachtman, Harrisburg, Pa.

Original application October 5, 1943, Serial No. 505,048. Divided and this application November 14, 1944, Serial No. 563,383

3 Claims. (Cl. 250—40)

My invention relates broadly to circuit arrangements for high frequency oscillators and more particularly to a circuit for controlling the resonant frequency of tunable circuits over a variable frequency range with a high degree of precision.

This application is a division of my application Serial Number 505,048 for Electron tube apparatus, filed October 5, 1943.

One of the objects of my invention is to provide an improved circuit arrangement for controlling the resonant frequency of electrically tunable circuits with a high degree of precision.

Another object of my invention is to provide a dual condenser arrangement for oscillator systems wherein a pair of fixed stator condenser sections are associated with a central rotor section forming capacities which vary simultaneously in the same direction electrically connected with an impedance device in the oscillator system with means for compensating for changes which may be introduced into the circuit by operation of either of the dual condenser sections.

Another object of my invention is to provide a dual condenser arrangement for a high frequency oscillation circuit in which the dual condenser includes a pair of fixed stator sections and a central rotor section constituting variable condensers having capacities which vary simultaneously in the same direction for adjusting the oscillator system with means associated with one of the condenser sections for compensating for mal-adjustment which may occur in the other condenser section in the adjustment of the circuit to a resonant frequency.

A still further object of my invention is to provide a high frequency oscillator system which includes an impedance device associated with a tuned circuit containing a dual condenser constituted by a pair of sections having capacities which vary simultaneously in the same direction with means associated with one of the sections for applying low frequency compensation to the circuit for the precision control of the oscillator system.

A still further object of my invention is to provide a high frequency oscillator system which includes an impedance device associated with a tuned circuit containing a dual condenser constituted by a pair of sections having capacities which vary simultaneously in the same direction and means for applying high frequency compensation to one of said condenser sections for effecting precision operation of the circuit.

Other and further objects of my invention reside in a dual condenser frequency control circuit arrangement with frequency compensation means associated therewith as set forth more fully in the specification hereinafter following by reference to the accompanying drawing in which:

Figure 1 diagrammatically illustrates the oscillator system of my invention showing the application of low frequency compensation means thereto; Fig. 2 diagrammatically shows the circuit arrangement of my invention illustrating the application of high frequency compensation means thereto; Fig. 3 shows the characteristic curves obtainable upon adjustment of the high frequency compensation means illustrated in the circuit arrangement of Fig. 1; Fig. 4 shows the characteristic curves obtainable when the low frequency compensation means of Fig. 2 are employed as set forth in the circuit arrangement of Fig. 2; Fig. 5 shows the characteristic curves constituting the ideal characteristic to which the compensation means of Figs. 1 and 2 approach; and Fig. 6 shows the characteristic curves obtainable without the use of the compensation control provided by the circuit arrangement of my invention.

Referring to the drawing in detail the oscillator system includes a broad tuning condenser 1 and a fine tuning dual condenser 2 electrically connected with impedance 3 as shown. The dual condenser 2 comprises a pair of fixed stator sections 2*a* and 2*b* and a central rotor 2*c* and constitutes a split stator or dual section variable condenser having capacities which vary simultaneously in the same direction. Reference characters 5 and 7 designate the trimmer condensers, whereby the control action of the fine tuning dual condenser 2 may be adjusted, and reference character 8 designates a condenser whereby the minimum or lowest tunable frequency of the combination may be adjusted.

A variable condenser 36 is connected between the central rotor of the dual condenser 2 and the stator 2*b* of the dual condenser at a point intermediate the stator 2*b* and the variable condenser 5 for providing low frequency compensation control for the circuit.

In Fig. 2 I have shown an arrangement whereby high frequency compensation control is obtained by employing a condenser 35 connected between the central rotor section of the dual condenser 2 and the stator section 2*a* of the dual condenser.

In Fig. 3 I have shown the characteristic curves obtainable by operation of the tuning system of

Fig. 1 wherein it will be seen that the curves plotted between bandspread frequency as ordinates and tuning range as abscissor produce a curve A'' representing the control action of the high frequency control section **2a** of the bandspread control **2** while curve B'' represents the control action of the low frequency control section **2b** of the bandspread control. Since the effects of the two sections **2a** and **2b** are additive, curve C'' is secure which represents the resonant action of curves A'' and B'' respectively. Thus it will be seen that the resonant curve C'' is secure upon applying low frequency compensation by means of condenser **36** for a frequency variation over the tuning range of the oscillator system which is substantially constant.

In the arrangement of Fig. 2, which provides for high frequency compensation, the curves of Fig. 4 are obtained wherein curve A''' represents the control action of the high frequency control section **2a** whereas curve B''' represents the control action of the low frequency control section **2b** of the bandspread control. The effects of the two sections **2a** and **2b** being additive produce the resonant curve C''' representing the resonant action of curves A''' and B'''. Thus it will be seen that with high frequency compensation applied by condenser **35**, a constant precision adjustment may be obtained throughout the tuning range of the bandspread control of the oscillator system.

In Fig. 5 I have shown the ideal characteristic curves for the circuit arrangement of my invention from which it will be seen that the two sections **2a** and **2b** of the dual condenser **2** are assumed to always exert some control over the resonant frequency of the oscillator circuit regardless of the setting of the main tuning control **1** for securing the ideal frequency characteristic curves shown at A and B for the high and low frequency sections **2a** and **2b** of the bandspread control dual condenser **2** respectively. Actually, however, these ideal characteristic curves A and B for producing the resonant curve C are never realized.

Ordinarily without the added low frequency or high frequency compensation secured by means of condensers **36** or **35** of Figs. 1 and 2, the characteristic curves obtainable would be as illustrated in Fig. 6 wherein curve A' represents the control action of the high frequency control section **2a** of the bandspread control **2** while curve B' represents the control action of the low frequency control section **2b** of the bandspread control **2**. These characteristic curves A' and B' are each distorted and when they are integrated to secure the characteristic for the oscillator system, it will be seen that the resonant curve C' is substantially distorted. Consequently, the importance of the high and low frequency compensation means for compensating for the non-linearity of curve C' of Fig. 6 will be appreciated. Accuracy of the order illustrated by curve C'' and C''' of Figs. 3 and 4 must be secured if precision work is to be accomplished with the circuit. The dual section or split stator variable condenser **2**, having capacities which vary simultaneously in the same direction, accomplish a great deal in the securing of precision operation, but to obtain the required accuracy in frequency control the low frequency compensation of Fig. 1 or the high frequency compensation of Fig. 2 must be added.

As may be readily seen from the curves of Figs. 3 and 4, the resultant curves C'' and C''' are identical with curve C of Fig. 5, but the separate control curves A'' and A''' and B'' and B''' only approximate the curves A and B of Fig. 5. However, the action which is obtained is a very vast improvement over the conditions existing as illustrated in Fig. 6 and for practical purposes the compensation illustrated in Figs. 1 and 2 is very effective.

The uses to which the above described control circuits can be put are manifold. For example, it can be applied to various circuits to test lapped quartz blanks for activity and frequency to a close tolerance before they are hand-finished and put in holders. It can be used in receivers where it is desired to have a continuous bandspread of frequency; i. e., one that is constant at any setting of the main tuning control. In conjunction with a local piezo oscillator (frequency to be determined by type of use) and a receiver, and used in a stable variable frequency generator circuit by "standardizing" at time of use, the circuit can be used to determine the frequency of another signal within a few cycles. This is done by heterodyning the signal emitted by the generator against the unkown signal and detecting the heterodyne beat by audible or electrical or electro-mechanical means and then reading frequency by interpolation from a known standard signal (local piezo oscillator) and the calibration on the dial of the fine-tuning control. The circuit can also be used to control the frequency of the emitted radiation of a radio transmitter, allowing the frequency to be varied over a wide range, and yet, by means of the fine-tuning control and pre-standardization against a local piezo oscillator or other primary or secondary frequency standard, control the frequency within a few cycles of the desired frequency.

The applications of this invention, as can be seen from the foregoing, are almost limitless. The control circuit can be applied to any device wherein the resonant frequency is desired to be variable. It can be applied to capacity-inductance or capacity-resistance or other impedance-tuned generators or oscillators, to tuned circuits, such as radio frequency, intermediate frequency or audio frequency stages in amplifiers, receivers, filters, etc., or to other tuned circuits wherein any combination of capacity, inductance, resistance, or reactance is used.

Features of my invention disclosed but not claimed herein are set forth in the parent application Serial No. 505,048, filed October 5, 1943, for Electrical tube apparatus, and my co-pending divisional applications Serial No. 563,384, filed November 14, 1944, for Electrical tuning system, and Serial No. 563,385, filed November 14, 1944, for Selective tuning system.

While I have described my invention in certain of its preferred embodiments, I realize that modifications in the arrangement of the circuit may be made and I intend no limitations upon my invention other than may be imposed by the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. An electrical tuning system comprising in combination with an impedance device, a variable tuning condenser having one side thereof connected with a point on said impedance device, a dual condenser including a central rotor and a pair of variably related capacity areas constituting a pair of condenser sections whose capacities vary simultaneously in the same direction, said rotor being electrically connected with another point of said impedance device, one of the con-

denser sections of said pair being disposed in series with said variable tuning condenser and the other of the condenser sections of said pair being connected effectively in parallel with the said variable tuning condenser and effectively in parallel with said impedance device, independently adjustable variable capacity means connected in series with each of the condenser sections of said dual condenser, and an adjustable condenser connected in shunt with one of said sections of said dual condenser.

2. An electrical tuning system comprising in combination with an impedance device, a variable tuning condenser having one side thereof connected with a point on said impedance device, a dual condenser including a central rotor and a pair of variably related capacity areas constituting a pair of condenser sections whose capacities vary simultaneously in the same direction, said rotor being electrically connected with another point of said impedance device, one of the condenser sections of said pair being disposed in series with said variable tuning condenser and the other of the condenser sections of said pair being connected effectively in parallel with the said variable tuning condenser and effectively in parallel with said impedance device, independently adjustable variable capacity means connected in series with each of the condenser sections of said dual condenser, and means connected in shunt with one of the condenser sections of said dual condenser for compensating for the effectiveness of the last mentioned condenser section at the higher frequency end of the spectrum over which said system is tunable.

3. An electrical tuning system comprising in combination with an impedance device, a variable tuning condenser having one side thereof connected with a point on said impedance device, a dual condenser including a central rotor and a pair of variably related capacity areas constituting a pair of condenser sections whose capacities vary simultaneously in the same direction, said rotor being electrically connected with another point of said impedance device, one of the condenser sections of said pair being disposed in series with said variable tuning condenser and the other of the condenser sections of said pair being connected effectively in parallel with the said variable tuning condenser and effectively in parallel with said impedance device, independently adjustable variable capacity means connected in series with each of the condenser sections of said dual condenser, and means connected in shunt with one of the condenser sections of said dual condenser for compensating for the effectiveness of the last mentioned condenser section at the lower frequency end of the spectrum over which said system is tunable.

GEORGE S. WACHTMAN.