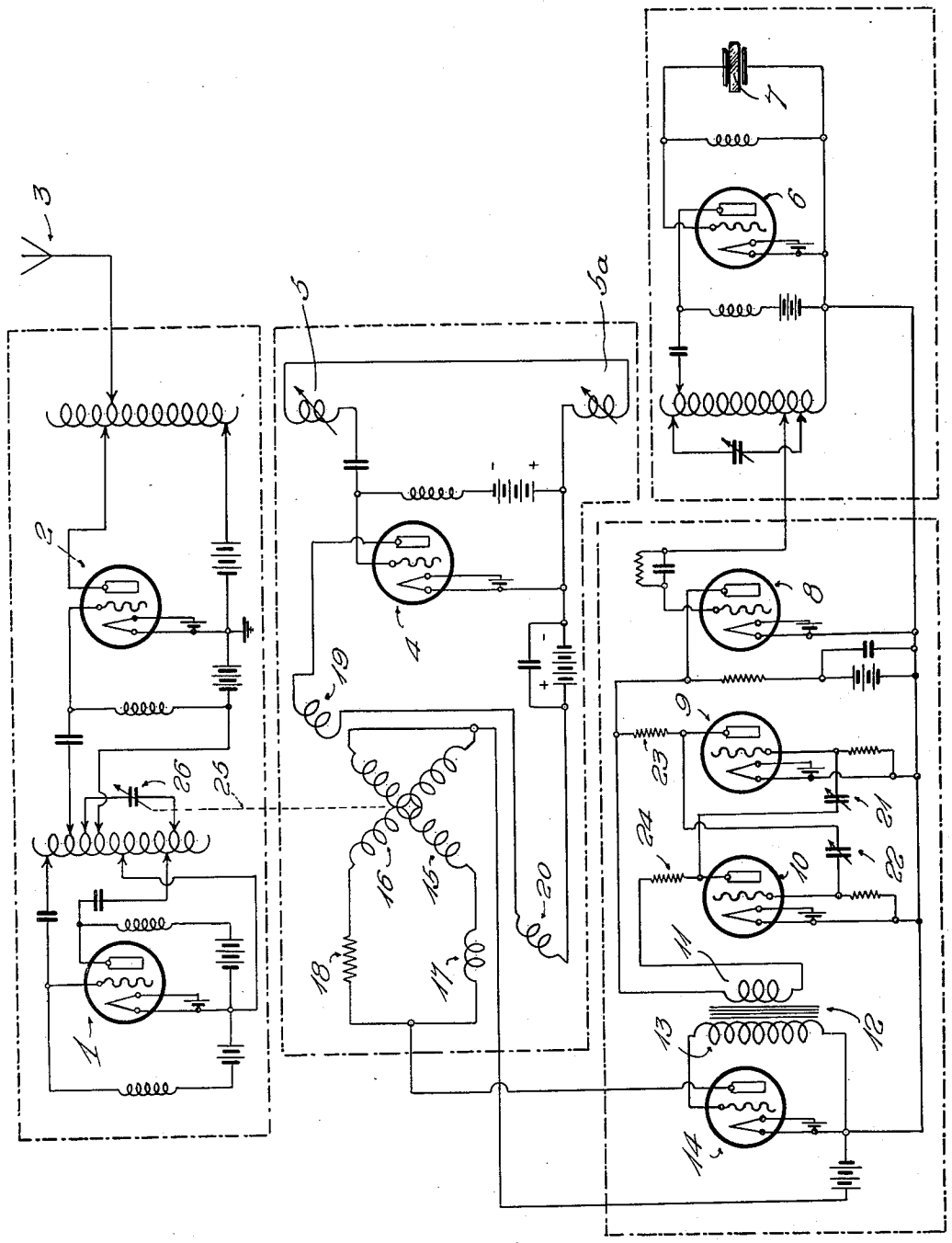
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HIGH FREQUENCY STABILIZER

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HIGH FREQUENCY STABILIZER

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My invention relates broadly to the frequency control of high frequency systems and circuit arrangements.

One of the objects of my invention is to provide a frequency control system for stabilizing the frequency of a radio transmitter.

Another object of my invention is to provide a frequency control system wherein the frequency characteristics of an oscillatory circuit are maintained substantially constant.

Still another object of my invention is to provide a frequency control system wherein the frequency of the energy emanating from a transmitting station is automatically controlled in accordance with the frequency from a low power constant frequency source.

A further object of my invention is to provide a frequency control system wherein a device responsive to difference in frequency has two coils one of whch is supplied with a frequency which is the difference between a standard frequency and a frequency to be controlled, and the other of which coils is supplied with a sub-multiple of the standard frequency.

Other and further objects of my invention are to provide certain circuit arrangements for obtaining the desired operating characteristics, a better understanding of which can be had from the specification following and the accompanying drawing, which is a schematic circuit diagram showing a high frequency transmitter the frequency characteristics of which are controlled in accordance with my invention.

In my system for frequency control of radio transmitters I employ a synchroscope adjusting arrangement somewhat similar to that shown and described in my copending application, Serial No. 350,053, filed March 26, 1929, entitled "High frequency stabilizers", now Patent No. 1,822,812, issued September 8, 1931.

A suitable mechanically vibratile element serves as a standard of frequency. The accompanying drawing shows element 7 as a piezo electric crystal, however any suitable means may be employed as an initial frequency standard. Element 7 is connected with the input circuit of thermionic tube oscillator 6. The output circuit of thermionic tube 6 is associated with the input circuit of thermionic tube rectifier 8. The output circuit of thermionic rectifier 8 is delivered to a multi-vibrator or subharmonic circuit comprising thermionic tubes 9 and 10. This circuit is adapted to produce subharmonics of the frequency of the exciting source as described by Lewis M. Hull and James K. Clapp in "Proceedings of the Institute of Radio Engineers", Volume 17, pages 252–271, February, 1929, in an article entitled "A Convenient Method for Referring Secondary Frequency Standards to a Standard Time Interval". Any suitable arrangement may be employed to produce the subharmonic frequencies other than the arrangement illustrated. In the arrangement shown it is possible to produce a sub-harmonic of a value one-tenth of the frequency of the exciting source. The arrangement shown depends for its operation upon a number of factors, primarily the asymmetry of thermionic tubes 9 and 10, or, in equivalent, the asymmetry of their circuits. Thermionic tubes having unlike characteristics may be employed or the effective characteristics of the tubes caused to vary by means of resistors 23, 24, connected with their respective anodes.

These resistors may be of values having ratios of substantially 50 to 1 or other ratio as determined from experiment. Condensers 21, 22, contribute to the operating characteristics and assist in establishing the desired condition for producing sub-multiples of the exciting energy. By exciting energy is meant the energy from the output circuit of thermionic tube rectifier 8. Thermionic tube 8 may be of any suitable type other than that shown, for instance, it may be of the screen anode type or screen control electrode type. This may be desirable to prevent interaction from the "multivibrator" as pointed out in the reference article by Hull and Clapp. Again, I desire it to be known that it is not essential to my invention that the "multivibrator" illustrated in the drawing be employed. Any suitable system for producing submultiple frequencies may be employed.

The transmitter proper comprises thermionic tube oscillator 1 having associated input and output circuits for producing oscillations of high frequency energy. The output of thermionic tube 1 is delivered to the input circuit of thermionic tube amplifier 2. The output of thermionic tube 2 is delivered to space radio radiating system 3, as shown, or may be delivered to any desired load circuit such as a wired radio system. Thermionic tube 4 is fundamentally a rectifier having a divided input circuit comprising coils 5 and 5a. Coil 5 is in inductive relation to the output circuit of thermionic tube 2 or in other manner connected or coupled with the energy in this circuit. Coil 5a is similarly coupled with constant frequency oscillator standard 6. Energy from oscillator 1 and energy from oscillator 6 is introduced into the input circuit of thermionic tube

rectifier 4. The output circuit of rectifier 4 comprises coils 19 and 20 wherein are present frequencies of the order of the sum of the frequencies of the energy from oscillators 1 and 6 or the difference (beat frequency) of these two frequencies. The output energy of subharmonic producer 9—10 is connected with winding 11 of transformer 12. Winding 13 of transformer 12 is connected with thermionic tube 14. The output circuit of thermionic tube 14 comprises coils 15 and 16 and phase-splitting circuit 17, 18. Coils 15 and 16 are mounted substantially at right angles to each other and suitably supported on a pivot which allows free movement of the coils. Coils 19 and 20 are mounted substantially as schematically illustrated, in inductive relation to coils 15—16 and may be fixed in position so that coils 15 and 16 move in relation to coils 19 and 20. The shaft carrying coils 15 and 16 cooperatively actuates the control member of condenser 26 by means of mechanical connection 25 or in any suitable manner. My copending application, Serial No. 350,053 now Patent No. 1,822,812, issued September 8, 1931, describes the adjustable frequency control in greater detail.

The operation may be summed up somewhat as follows: Suppose for example, it is desired to generate and transmit energy from oscillator 1 having a frequency of 405 kilocycles. The power rating of thermionic tube 1 may be of the order of 10 kilowatts. Mechanically vibratile element 7 may be chosen to have a fundamental frequency of 400 kilocycles. The energy from oscillator 6 transferred to the input circuit of thermionic tube 4 would have a frequency of 400 kilocycles. The frequency of the energy from oscillator 1 transferred to the input circuit of thermionic tube 4 would have a frequency of 405 kilocycles. In the output circuit of thermionic tube 4 comprising coils 19 and 20, a beat frequency of 5 kilocycles is present. The frequency of the energy transferred from oscillator 6 to thermionic tube 8 will be 400 kilocycles. Selecting the eightieth submultiple frequency of this value means that the input circuit of thermionic tube 14 will have a current having a frequency of 5 kilocycles. The current of 5 kilocycles frequency from thermionic tube 14 energizes movable coils 15—16 at this frequency. Since the excitation of coils 19—20 is by a current of like frequency value no torque is exerted upon coils 15—16. If however, the frequency of the energy from oscillator 1 should reduce to 404.5 kilocycles instead of the desired value of 405 kilocycles, the energization of coils 19—20 would be at a frequency of 4.5 kilocycles instead of 5 kilocycles. This difference would be sufficient to produce a torque which would be exerted upon coils 15—16 moving the same from their normal position. This motion is in turn transmitted by suitable means, represented at 25, to any suitable frequency controlling device herein represented as condenser 26. The motion transmitted to condenser 26 may be sufficient to correct the adjustment of frequency, as in the example above, increase the frequency characteristics of the oscillatory circuit to the amount of 500 cycles or 0.5 kilocycles to reestablish the generation of the 405 kilocycle energy. In like manner, should the frequency from oscillator 1 increase to 405.5 kilocycles instead of remaining at 405 kilocycles, the beat frequency would be 5.5 kilocycles.

Since the difference between the 5.5 kilocycles beat frequency in coils 19—20 and the 5 kilocycle frequency in coils 15—16 is 500 cycles, a torque would be exerted upon movable coils 15—16 causing a displacement of the movable coils. From first consideration it would seem that the 500 cycle increase of frequency or the 500 cycle decrease of frequency would effect a similar displacement of the movable coil and that no stability results. Here it must be remembered that the beat frequency in coils 19—20 which in the first instance was 4.5 kilocycles, in the latter instance is 5.5 kilocycles. The frequency of the energy in coils 15—16 remains constant at 5 kilocycles. Between the frequency of the energy in coils 15—16 and the frequency of the energy in coils 19—20, in the first instance, the difference was 0.5 kilocycle. In the latter instance the difference is also 0.5 kilocycle. The solution rests in the fact that in the former instance the frequency of the energy in coils 19—20 was 4.5 kilocycles while in the latter instance the frequency is 5.5 kilocycles.

It is evident the numerical value of the torque produced will be the same in either instance. It is also obvious that the angular displacement of the movable coils will be a like amount. However the displacement in the first instance will be in the opposite direction to the displacement in the latter instance. Movable coils 15—16 are not set at zero beat but are moved an appreciable displacement from such position which allows movement in either direction. When the frequency of the energy in coils 19—20 increases, coils 15—16 will be moved in a given direction. When the frequency decreases coils 15—16 will be moved in the opposite direction.

From a summary of the operation it is obvious that since the change of frequency of the energy causes a change in the frequency characteristics of the circuit where such change occurs, a very high degree of accuracy results. It is obvious that since the change of frequency is corrected almost simultaneously, it would be next to impossible to actually change the frequency. The change of frequency and the correction of frequency are absolutely interdependent.

I realize that many modilcations of my invention are possible and it is to be understood that my invention is not to be restricted by the foregoing specification or by the accompanying drawing but only 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. In a high frequency circuit arrangement, a high frequency oscillator, frequency controlling means in said oscillator, a movable coil member, a connection between said movable coil member and said frequency controlling means in said oscillator for adjusting said oscillator when said movable coil member is operated, an independent constant frequency source, means for producing submultiple frequencies of the energy of said independent constant frequency source, connections between said movable coil member and said last mentioned means whereby a submultiple frequency of the energy from said independent constant frequency source is impressed on said movable coil member, and a stationary coil member coupled with said movable coil member and connected with both the output of said independent source and said oscillator for controlling the adjustment of said movable coil member.

2. In a high frequency circuit arrangement, a high frequency oscillator, frequency control means in said oscillator, a movable coil member connected with said frequency control means in said oscillator for adjusting said frequency con-

trol means when said movable coil member is operated, an independent constant frequency source, means for producing a submultiple frequency from said independent constant frequency source, a stationary coil member in inductive relation to said movable coil member, connections between said movable coil and said last mentioned means, and means connecting said stationary coil member with both said high frequency oscillator and said independent constant frequency source whereby a beat frequency is produced by combining the outputs of said independent source and said oscillator for actuating said movable coil member.

3. In a high frequency circuit arrangement, frequency controlling means in a high frequency circuit, a movable coil member connected with said frequency controlling means in said circuit for adjusting said frequency controlling means when said coil member is actuated, a stationary coil member in inductive relation to said movable coil member, an independent constant frequency source, means including connections between said movable coil member and said constant frequency source for energizing said movable coil member by a submultiple frequency of the energy from said independent constant frequency source, and connections between said stationary coil member and both said high frequency circuit and said independent constant frequency source whereby energy which is a beat frequency between the energy in said circuit and the energy from said independent source energizes said stationary coil member.

4. In a device of the class described, an oscillator circuit having frequency adjusting means therein, means including a second oscillator circuit for producing substantially constant frequency energy, submultiple frequency producing means controlled by said energy, beat frequency producing means actuable in accordance with differences in frequency existent between the two said oscillator circuits, and electro-magnetic actuating means jointly controlled by said beat frequency producing means and said submultiple frequency producing means, said electromagnetic actuating means being mechanically coupled to said frequency adjusting means.

5. In a frequency control system, a source of power oscillations, a source of oscillations of standard frequency, means for producing subharmonics of said standard frequency, means for producing a beat frequency between said power oscillations and said oscillations of standard frequency, a two-circuit device responsive to differences in frequency in its two circuits, connections between one of the circuits of said two-circuit device and said means for producing subharmonics, connections between said source of beat frequency and the other circuit of said two-circuit device, a frequency control element connected for controlling the frequency of said power oscillations and cooperatively actuated by said two-circuit frequency responsive device, whereby variations in the frequency of said power oscillations cause compensating adjustment of said frequency control element and the frequency of said power oscillations is maintained constant.

6. In a radio transmitter, a source of power oscillations, an antenna, an antenna coil connected to said antenna and to said source of power oscillations, a source of oscillations of standard frequency, means for producing subharmonics of said standard frequency, a comparison circuit coupled to said antenna coil and to said source of oscillations of standard frequency, a frequency responsive device having two circuits and responsive to differences in frequency in its two circuits, means for impressing upon one of said two circuits the beat frequency in said comparison circuit between said standard frequency and the frequency of said power oscillations, means for impressing upon the other of said circuits energy from said means for producing subharmonics, a frequency control element connected for controlling the frequency of said power oscillations and cooperatively actuated by said frequency responsive device, whereby variations in the frequency of said power oscillations cause compensating adjustment of said frequency control element and the frequency of said power oscillations is maintained constant.

7. In a frequency control system, a source of power oscillations, a source of oscillations of standard frequency, means for producing subharmonics of said standard frequency, means for producing a beat frequency between said power oscillations and said oscillations of standard frequency, a two circuit device responsive to differences in frequency in its two circuits, comprising two sets of coils mounted for relative motion, connections between said means for producing subharmonics and one of said two circuits, connections between said means for producing a beat frequency and the other of said two circuits, a frequency control element connected for controlling the frequency of said power oscillations and cooperatively actuated by said two circuit frequency responsive device, whereby variations in the frequency of said power oscillations cause compensating adjustment of said frequency control element and the frequency of said power oscillations is maintained constant.

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