Dec. 25, 1945. W. E. BRADLEY 2,391,386

HARMONIC GENERATOR

Filed July 2, 1943

Fig. 1.

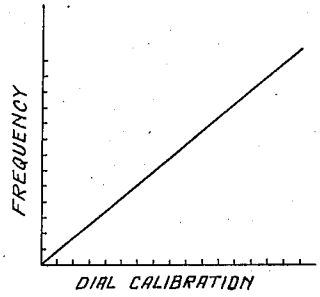


Fig. 2.

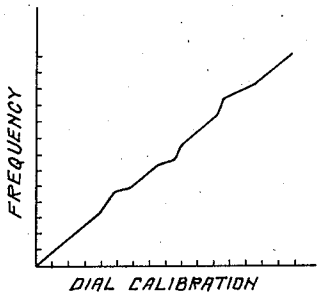


Fig. 3.

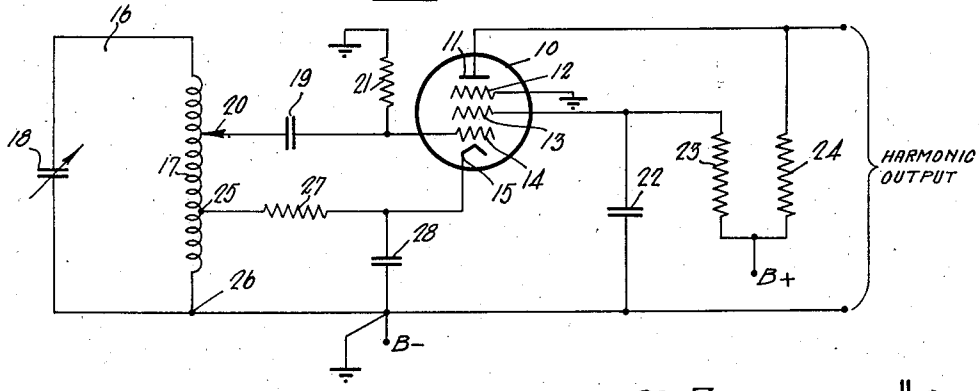


Fig. 4.

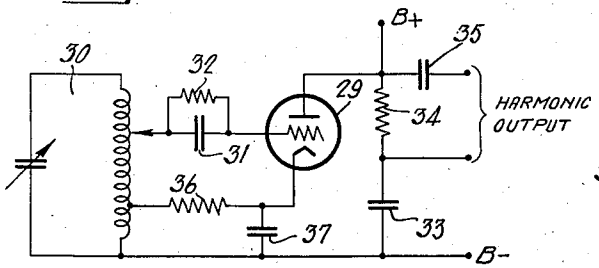
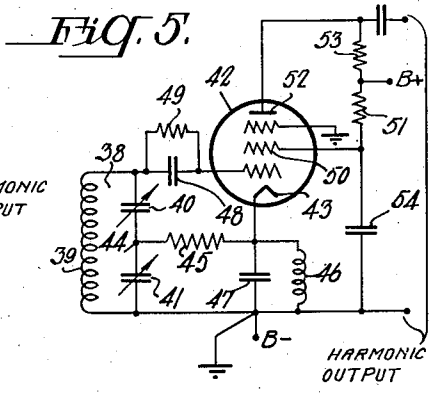


Fig. 5.



Inventor:-
William E. Bradley
by his Attorneys
Howson & Howson

Patented Dec. 25, 1945 2,391,386

UNITED STATES PATENT OFFICE

2,391,386

HARMONIC GENERATOR

William E. Bradley, Northampton, Pa., assignor to Philco Radio and Television Corporation, Philadelphia, Pa., a corporation of Delaware

Application July 2, 1943, Serial No. 493,265

5 Claims. (Cl. 250—36)

This invention relates to oscillators and, more especially, to variable frequency harmonic generators.

The primary objects are: (1) to eradicate certain objectionable output frequency aberrations and (2) to overcome certain abnormalities in operational efficiency which were found to obtain more or less concurrently with the aforementioned frequency aberrations.

In pursuing the development of a variable frequency vacuum-tube signal generator wherein the purpose was to utilize as the output one or more harmonics of a band of fundamental frequencies, two related problems were encountered in that, firstly, there were produced erratic frequency deviations, often abrupt in character, as represented by more or less violent irregularities in the calibration curves; and, secondly, there took place, somewhat concurrently, abrupt changes in operating efficiency at various frequencies as manifested by correspondingly abrupt changes in output power.

The present invention is, in part, an outcome of my discovery that the aforementioned phenomena were due, probably, to intrusion of harmonic frequency currents into the frequency-determining resonant circuit which was tuned to the fundamental frequency, and to the resultant presence on the control grid of the oscillator of harmonic frequency potentials in excess of what could be tolerated. Having discovered the presence of strong harmonics on the oscillator-tube grid and having deduced that the total or partial suppression of such harmonics might lead to a cure, I proceeded to the further discovery that the desired isolation of harmonics could successfully be accomplished by the introduction of a suitable filter into the feed-back path of the oscillator and that this could be done without injuriously affecting the performance of the generator. This proved to be a complete solution of both difficulties.

It might reasonably be supposed that the effectuation of harmonic exclusion or suppression to a degree sufficient to accomplish the desired end, without interfering with proper operation of the generator, would at least require a filter having a sharp cut-off; but I found unexpectedly that all that was needed was a very simple and inexpensive single-section R-C filter consisting only of one series resistance and one shunt capacity—the properties of which are chosen with due regard to various factors which will be explained more at length in conjunction with the detailed description of the invention to follow.

While the problems leading up to this invention are thought to be more especially characteristic of variable frequency harmonic generators, it will become evident that the remedy which the invention provides is also applicable to fundamental frequency generators if similar difficulties should be encountered.

As previously indicated, it has been my experience that a single-section R-C filter is sufficient, but I am aware that in some special cases it may prove desirable and perhaps necessary to resort to a filter having more than one section, and that it may be expedient at times to resort to certain modifications of filter design.

In the drawing which accompanies this specification;

Fig. 1 is an ideal graph of output frequency plotted against dial calibrations;

Fig. 2 is a graph similar to Fig. 1 but exhibiting sporadic frequency aberrations at various dial settings—which aberrations it is one of the purposes of this invention to eradicate;

Fig. 3 is a diagrammatic showing of a Hartley type oscillator modified in accordance with this invention and designed to produce a harmonic output;

Fig. 4 depicts another harmonic generator based upon the fundamental Hartley-type oscillator circuit but modified in accordance with this invention and employing a three-electrode tube instead of the pentode tube of Fig. 3; and

Fig. 5 is an alternative design of harmonic generator embodying this invention and based upon the fundamental Colpitts-type oscillator.

Referring more particularly to the drawing, Fig. 3 depicts schematically what presently is considered to be the preferred embodiment of the invention. This is a variable frequency harmonic signal generator based upon the conventional Hartley-type oscillator and employing a pentode tube. It will be assumed that the fundamental frequency band covers the range from 125 k. c. to 250 k. c. and that harmonics of the fundamental frequency to which the generator happens to be tuned are available at the output terminals. Fig. 3 is fully representative of harmonic generators now in successful use.

Tube 10 may be of the 6SJ7 type, being a pentode tube comprising a plate 11, suppressor 12, screen grid 13, control grid 14 and cathode 15.

The tank circuit 16 comprises an inductance coil 17 and tuning condenser 18 and is tunable over the range of fundamental frequencies, e. g. 125–250 k. c.

Control grid 14 is connected to inductance coil

17 through a grid condenser 19 and movable contact 20. A grid-leak resistance 21 is connected between the control grid and ground.

Screen grid 13 here functions as the plate of the oscillator and is connected with the lower terminals of coil 17 and tuning condenser 18 through a blocking condenser 22.

The positive end of the B potential source is connected to the screen grid 13 through a suitable resistance 23 and to plate 11 through a resistance 24.

It will be observed that the feed-back path includes condenser 22 and that portion of coil 17 which lies between points 25 and 26. It was found that harmonics, as well as fundamental frequency currents, were injected into the tank circuit 16 via this feed-back path and that corresponding harmonic potentials were thus impressed upon the control grid to such extent as to cause the two aforementioned difficulties.

The filter, by means of which the feed-back of harmonics is successfully suppressed or attenuated, comprises a series resistance 27 and shunt condenser 28. For the particular range of fundamental frequencies under consideration, namely 125–250 k. c., the magnitude of resistance 27 may be 5000 ohms while the capacity of conconder 28 may be 250 mmf. At 125 k. c. the impedance of condenser 28 is approximately 5000 ohms. Hence, at the low end of the fundamental frequency scale the impedance of the shunt path comprising condenser 28 is substantially equal to that of the series path including the resistance 27, disregarding the impedance of that portion of coil 17 which is included in series with the resistance 27, and disregarding the skin effect of resistance 27. At the second harmonc and all higher harmonics the impedance of condenser 28 is much less than at the fundamental frequency, while that of resistance 27 remains constant except for skin effect which increases the apparent resistance at the harmonic frequencies. Also the impedance of the series path is increased at the harmonic frequencies due to increased inductive reactance. Manifestly, the filter operates selectively to permit feed-back of fundamental frequencies without excessive attenuation while effectively suppressing feedback of all the harmonics.

It will be observed that the I. R. drop across resistance 27 is impressed upon control grid 14 and biases the same negatively. It is important that the resistance value be such that the grid bias will be consistent with operation of the tube as a harmonic generator, unless some additional provision is made to correct the grid bias. The R-C values of the filter are not particularly critical. Of course, it is essential that these values be intelligently selected with a view to obtaining substantial suppression of the harmonics without at the same time over-attenuating the necessary feed-back of fundamental frequencies, and it is advisable that the value of resistance 27 be not so low that condenser 28 will in effect shunt a portion of coil 17 and thereby influence the tuning of the tank circuit.

Through the use of a pentode tube, electronic coupling is obtained between the oscillator anode grid 13 and the output anode 10, with the result that the generator operating frequency is not influenced by the load connected to the harmonic output terminals.

It will be self-evident that the filter which here consists of a single section network could comprise a plurality of sections, thus effecting a sharper cut-off of the harmonics, but I have not yet found it necessary to resort to a multi-section filter. It is possible that for operating on some other band or in employing different tubes a multi-section filter would be desirable. The design and proportioning of such multi-section filters is a subject so familiar to those skilled in the art and so widely known that it requires no specific treatment here.

The circuit of Fig. 3 was originally employed without the filter comprising resistor 27 and condenser 28 and it was found that the calibration curve instead of being uniformly linear as per Fig. 1 always contained a number of irregularities or aberrations somewhat as depicted in Fig. 2. The reason for this was discovered to be not merely the fact that harmonics were fed back into the tank circuit, but the further fact that inherent capacities across portions of coil 17—which capacities could not be eliminated—gave rise to a number of parasitic tank circuits which were resonant to various harmonic frequencies; and whenever in the course of tuning the generator a harmonic of a frequency equal to the resonant frequency of one of said parasitic tank circuits was impressed upon coil 17 via the feed-back path an irregularity would occur in the calibration curve. If the generator had been intended to operate at a single fixed frequency instead of being tunable over a considerable range it would have been possible to select a coil 17 which would not be resonant, as a consequence of its inherent distributed capacity, to any of the harmonics of that single frequency. But because of the fact that the tank circuit had to be tunable over a considerable range it was not practicable to so design coil 17 that it would not be self-resonant to some of the numerous harmonic frequencies produced in the course of tuning the generator from one end of its band to the other. It will be apparent from the foregoing explanation, that the present invention is especially advantageous only in connection with an oscillation generator which is tunable; that is to say, one which is designed to operate over a band of frequencies, as distinguished from a fixed frequency oscillation generator.

Fig. 4 illustrates a harmonic generator which is nearly identical with Fig. 3 except that it employs a three-electrode tube 29 instead of a pentode tube. Here the tunable tank circuit is identified by reference numeral 30, while 31 is the grid condenser, 32 the grid-leak resistance, 33 a blocking condenser in the feed-back path, 34 a coupling resistance and 35 a blocking condenser serving to isolate the D. C. plate current from the load. The R-C filter comprises a series resistance element 36 and a shunt condenser 37. The functioning of the filter is the same as in Fig. 3. The circuit of Fig. 4 is inferior to that of Fig. 3 because of the absence of the electronic coupling in the output, but otherwise it is fully equivalent to Fig. 3 and may successfully be employed where the load is not likely to reflect reactance into the oscillator circuit and thus influence the output frequency.

For the purpose of demonstrating that the invention is not limited to oscillation generators of the Hartley type, I have shown in Fig. 5 an application thereof to the well-known Colpitts-type oscillator. Here the tunable tank circuit 38 includes an inductance coil 39 and two variable condensers 40, 41. Tube 42 is a pentode whereof the cathode 43 is connected to the midpoint 44 through the filter resistance 45 and to the neg-

ative terminal of the B supply through a radio frequency choke coil **46** shunting the filter condenser **47**. The usual grid condenser **48** and grid-leak resistance **49** are inserted in the control grid lead. Shield grid **50** functions as the oscillator plate and is connected to the positive terminal of the B supply through a resistance **51** while the plate **52** is connected to the same terminal through a resistance **53**. A blocking condenser **54** is included in the feed-back path. The harmonic frequency output can be taken off as indicated or from the terminals of the series-combined resistances **51**, **53**.

It will be understood that the several embodiments illustrated and described are not intended to limit the invention, which may take other forms of physical expression within the scope of the appended claims.

I claim:

1. A variable frequency oscillation generator comprising an amplifying device having input and output terminals, a frequency-determining resonant tank circuit tunable through a range of oscillation frequencies, and a feed-back path connecting said output terminals with said resonant circuit, said input terminals being coupled to said resonant circuit, said feed-back path including a fixed-constant filter designed to pass efficiently the aforementioned range of oscillation frequencies and to substantially reject all harmonics of all said oscillation frequencies.

2. A variable frequency oscillation generator comprising an amplifying device having input and output terminals, a frequency-determining resonant circuit tunable through a range of oscillation frequencies, said input terminals being connected to said resonant circuit, and a feed-back path connecting said output terminals with said resonant circuit, said feed-back path including a fixed-constant filter designed to pass efficiently the aforementioned range of oscillation frequencies and to substantially reject all harmonics of all said oscillation frequencies, said filter including a series resistance and a shunt capacitance, said capacitance being isolated from said resonant circuit by said series resistance.

3. A variable frequency oscillation generator comprising a vacuum tube amplifier having input and output terminals, a frequency-determining resonant tank circuit tunable through a range of oscillation frequencies, a portion of said tank circuit being connected across said input terminals, a feed-back path including in series a second portion of said tank circuit and connecting said output terminals with said tank circuit, said feed-back path including a fixed-constant filter comprising series resistance and shunt capacity, said filter being designed to pass efficiently the oscillation frequencies within said range and to substantially reject all the harmonics of said oscillation frequencies.

4. A harmonic frequency generator comprising a vacuum tube amplifier having input and output terminals, a frequency-determining tank circuit tunable over a band of fundamental frequencies and having a portion connected across said input terminals, a feed-back path including in series a second portion of said tank circuit and connecting said output terminals with said tank circuit, said feed-back path including a fixed-constant filter for selectively suppressing the passage into said tank circuit of all harmonics of all said fundamental frequencies within said range without commensurately suppressing the passage of fundamental frequency currents into said tank circuit.

5. A harmonic frequency generator comprising a vacuum tube amplifier having input and output terminals, a tunable frequency-determining tank circuit including two condensers connected in series across the terminals of an inductance coil, said input terminals being connected across one of said condensers, said output terminals being connected across the other of said condensers through a feed-back path, and a fixed-constant filter in said feed-back path, said filter being characterized in that it passes efficiently all of the frequencies to which said tank circuit is tunable and further characterized in that it effectively suppresses all the harmonics of all said frequencies.

WILLIAM E. BRADLEY.