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HARMONIC GENERATOR

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Fig. 1.

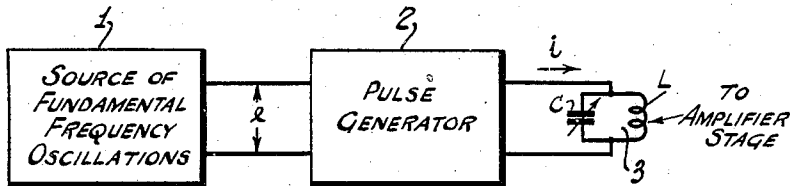


Fig. 2.

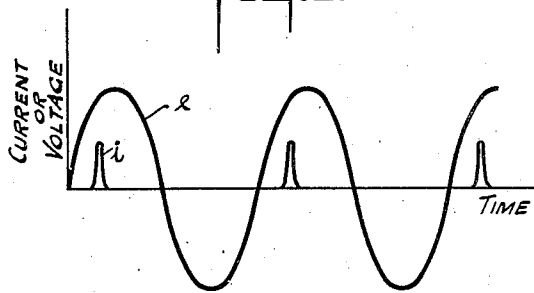
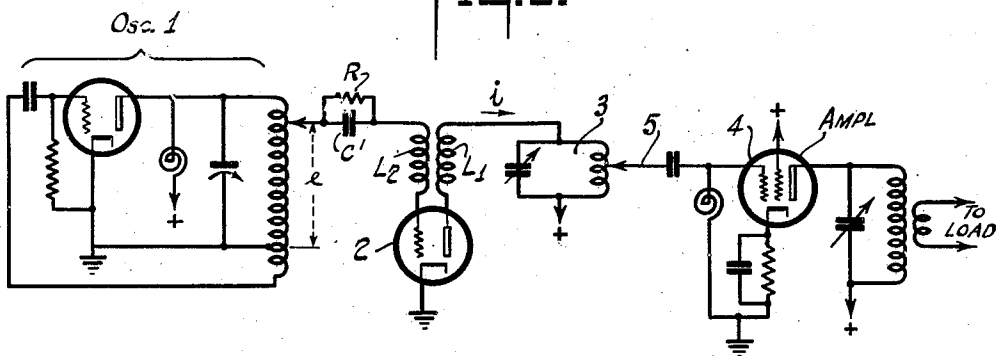


Fig. 3.



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HARMONIC GENERATOR

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1 Claim. (Cl. 250—36)

In amateur transmitters wherein the lowest frequency band is about two megacycles and the fifth band is about thirty megacycles, as is known, operation in five harmonically related bands is customary. When a variable oscillator is used, it is advantageous to operate the oscillator in the lowest frequency band, and multiply the frequency of the oscillator for exciting the final stage when output in higher frequency bands is desired. For example, the oscillator may be followed by a succession of frequency doublers having their tank circuits tuned to the successive bands, and excitation for the final stage in any desired band may be obtained by connecting the input of the final stage to the appropriate doubler tank circuit. This system, however, has the disadvantage of requiring a large number of tubes and associated circuits and also requires retuning a considerable number of tank circuits whenever the oscillator frequency is varied.

An object of the present invention is to provide an oscillation generation system having an oscillator and a final amplifier stage, and which does not require any adjustable circuit elements between the oscillator and the tuned input circuit of the final stage in any desired band of frequencies.

A more detailed description of the invention follows in conjunction with a drawing, wherein Fig. 1 illustrates diagrammatically, in block form, the essential circuit elements of one embodiment of the invention; Fig. 2 is a graphic illustration of the system of Fig. 1 given to explain the principles of operation; and Fig. 3 illustrates the circuits constituting a complete oscillation generator system of the type shown in Fig. 1.

The block diagram (Fig. 1) shows the essential elements of the system functionally. The voltage e derived from a source of oscillations 1 of fundamental frequency is impressed upon a pulse generating device 2, which generates a single pulse of current of great amplitude but extremely short duration for each cycle of the fundamental frequency. The output of the pulse generator 2 is passed through a tuned circuit 3 which is tuned to either the fundamental frequency or any harmonic thereof. To explain the operation of Fig. 1, it is convenient to assume that oscillations are taking place in the harmonic tank circuit 3 and that at the instant when the charge on the condenser C is a maximum, a pulse of current i from the pulse generator 2 suddenly flows into the tuned circuit, thus adding to the potential energy of the tuned circuit at the instant when its kinetic energy is substantially zero. This addition of

energy just takes care of the dissipation of energy in the circuit during the intervals between successive pulses, because the amplitude of oscillation automatically adjusts itself until this condition of equilibrium obtains. It will now be shown that so long as the duration of the pulse is short compared to a half cycle of the harmonic frequency in 3, substantially the same voltage will be developed in the harmonic tank, regardless of the order of the harmonic to which it is tuned. Let it be assumed that the voltage across the tank circuit 3 is the same for each harmonic frequency under the condition stated above. Then, since each pulse of current from pulse generator 2 flowing against the assumed voltage represents a certain energy increment, and since the number of pulses per second is always that of the fundamental frequency oscillator 1, the power input to the harmonic tank is the same regardless of the harmonic it is tuned to. If it is assumed that in the case of each harmonic under the foregoing condition the reactance of the tank coil L is the same, then a constant assumed voltage across the coil L will be accompanied by the same power dissipation, if the resistance of the coil is the same in each case. But this is the same as saying that the "Q" of the coil is the same for each harmonic, and it is known from experience that the "Q" of a tank coil is approximately the same for each frequency band. Therefore, the assumption of constant voltage developed across the tank 3 at each harmonic frequency is justified. This result is important in that it makes it possible to switch coils in the tank 3 which is used as the input circuit of the final stage, and obtain substantially uniform excitation in any one of several bands.

The relations between the fundamental frequency voltage e applied to the pulse generator 2, and the output current pulse i delivered to the harmonic tank 3 by the pulse generator 2 are shown in Fig. 2. It will be seen that the problem solved by the present invention is that of obtaining current pulses of short duration, not exceeding one-half of the period of the highest harmonic to which the harmonic tank 3 is intended to be tuned. In known types of frequency multipliers, as used at present, somewhat shortened pulses of plate current are obtained by operating the multiplier tube at several times cut-off bias, so that plate current in the multiplier tube flows only during a reduced portion of the positive half wave of excitation voltage. But, this method of shortening the pulses cannot be carried far enough to produce extremely short

pulses because of the broadness of the excitation wave near its peak. That is, in order to greatly shorten the current pulse, only the extreme top portion of the positive wave should cause the flow of plate current, and since the instantaneous potential on the grid of the multiplier tube must swing from cut-off value to a somewhat positive value, this requires that the excitation voltage be impracticably high. It is, therefore, necessary in accordance with the invention to employ a pulse generator which, either by reshaping the excitation wave or by creation of a series of short pulses under control of the excitation wave, will produce a sufficiently narrow pulse without requiring unduly large voltage at the input to the generator.

Fig. 3 shows one embodiment of the invention in accordance with the latter expedient, where tube 2 is a blocking oscillator arranged to generate a single pulse of plate current per cycle of control voltage impressed on its grid from the oscillator 1. Oscillator 1 is of conventional form and its mode of operation will be apparent to any one skilled in the art. Blocking oscillator 2 has a pair of coupled grid and plate coils L_2 and L_1 , respectively, and a grid leak and condenser combination R, C' . This blocking oscillator is of the type described in R. C. A. License Laboratory Bulletin LB-503, and its operation is as follows: Due to rectified grid current, the bias developed across C' is well beyond cut-off value for tube 2, but when the oscillator voltage e is positive, the total grid potential is reduced at some point of the positive half wave of the oscillator to such a value that plate current starts to flow through coil L_1 . This coil is regeneratively coupled to coil L_2 so that increasing plate current induces a still more positive voltage on the grid which, in turn, still further increases the plate current. This process is cumulative so that the plate current rapidly builds up to a saturation value, after which it starts falling again since there is no further rate of increase to maintain the positive grid voltage. Once it starts falling, the induced grid voltage is negative and the plate current is rapidly reduced to zero. This whole process takes place in a time comparable with a half cycle of the sustained oscillation which would be produced if coils L_1 and L_2 were loosely coupled to produce sustained oscillation. Hence, by choosing L_1 and L_2 sufficiently small to be suitable for producing oscillations of a frequency at least as high as that of the highest harmonic to be used, the duration of the plate pulse may be made as short as necessary. It will be appreciated that during the growth of plate current a negative charge is drawn to the grid and if grid resistor

R is not provided this negative charge will produce a bias (across C') which may be too large to permit the subsequent positive half cycle of the oscillator to bring the grid potential to a value which will permit another pulse to be initiated.

A second pulse will occur only after a sufficient number of oscillator cycles have taken place to give this excess bias time to leak off through resistor R . Thus, when R is sufficiently large, only one pulse will be generated every so many cycles of the oscillator voltage. For the purpose of the present invention, however, R is made sufficiently low so that the charge on condenser C' will leak off rapidly enough to permit a pulse being generated at each cycle of the oscillator. These pulses of current are arranged to traverse the harmonic tank 3 and maintain it in oscillation as explained above, and excitation for the input of the final amplifier stage 4 is obtained by connection 5 to the harmonic tank 3.

It should be understood that other types of pulse generators than that illustrated in Fig. 3 may be employed in the practice of the invention in order to obtain short, sharp pulses.

What is claimed is:

In a system for producing substantially uniform voltage at several harmonic frequencies by the mere change of an element of a single harmonic tank circuit, a source of fundamental oscillations of stabilized frequency of the order of two megacycles, said source comprising a Hartley type oscillator, a high vacuum blocking oscillator directly controlled thereby to produce narrow pulses of current through said harmonic tank at the fundamental frequency and independent of conditions in said harmonic tank circuit, the duration of the pulses produced by said blocking oscillator being less than the half period of the highest harmonic thereof to which said tank circuit is intended to be tuned, said blocking oscillator comprising a vacuum tube having grid and anode electrodes, a transformer having a primary winding one terminal of which is directly connected to said grid and the other terminal of which is connected to the coil of said stabilized oscillator, said transformer having a secondary winding one terminal of which is directly connected to said anode and the other of which is directly connected to one terminal of said harmonic tank circuit, said harmonic tank circuit comprising an inductance coil shunted by a condenser, and a vacuum tube amplifier having an input electrode coupled to a point on the said inductance coil of said tank, whereby harmonic voltages of substantially equal amplitude are generated up to about 30 megacycles.

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