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W. J. O'BRIEN
SIGNAL GENERATOR

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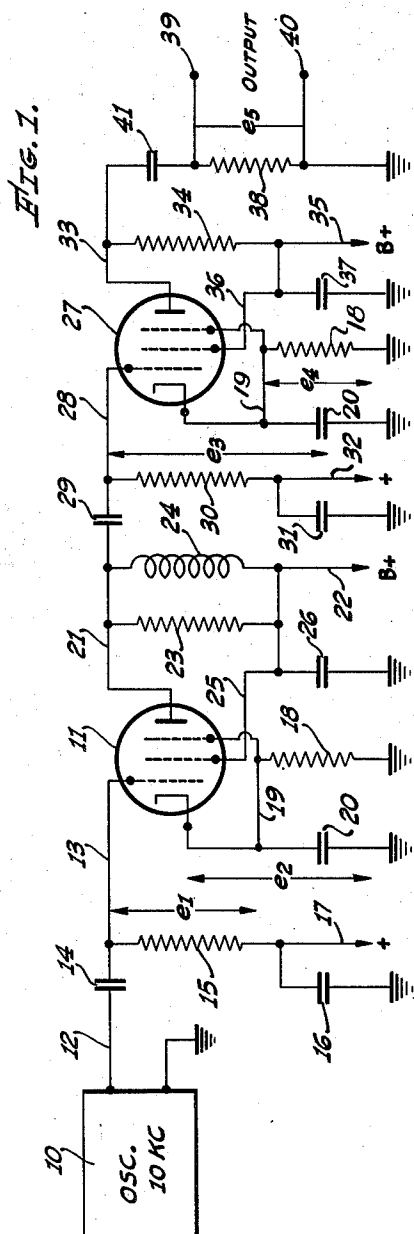


FIG. 3.

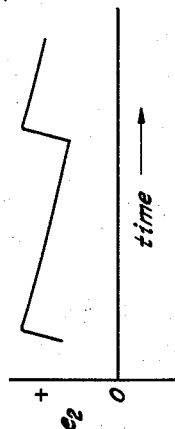


FIG. 6.

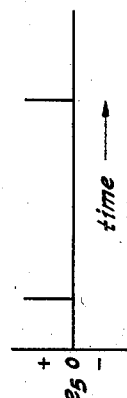


FIG. 4.

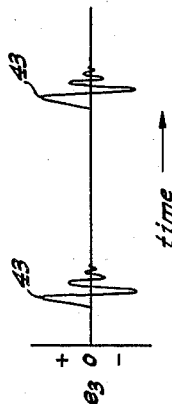


FIG. 5.

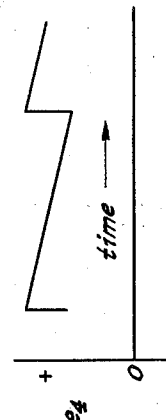
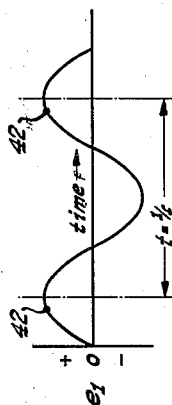


FIG. 2.



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SIGNAL GENERATOR

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4 Claims. (Cl. 250—36)

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My invention relates to a signal generator and has particular reference to a "pip" generator for generating an alternating potential signal rich in harmonics.

In the maintenance and adjustment of radio frequency apparatus and in certain types of radio frequency circuits, there is required an alternating potential of radio frequency which is rich in the higher harmonics. For example, in the alignment of radio frequency receivers, it is desirable to use a locally produced signal which has harmonics separated in frequency by the normal band separation of ten kilocycles and which has an amplitude which is substantially constant over the entire tuning range of the receiver. Also, in certain radio frequency circuits as, for example, multi-vibrator or frequency multiplying circuits, it is desirable to use such a signal for shock excitation of the resonant circuits used in these devices.

Prior to my invention there has not been available a signal generator capable of supplying a wide range of harmonics in which the harmonics are of substantially equal amplitude. Furthermore, where phase relationships is a matter of importance as, for example, in the testing and adjusting of equi-phase radio beacon systems such as is described in my copending application Serial No. 420,059, filed November 22, 1941 and since abandoned, the signal generators known prior to my invention did not provide the fixed multiple phase relation with uniform harmonic content and constant amplitude which is required for the proper checking and adjustment of the system.

It is, therefore, an object of my invention to provide a signal generator which supplies the above noted desiderata by generating an alternating electrical potential which contains a substantial number of harmonics and in which the harmonics are at a substantially constant amplitude.

It is also an object of my invention to provide a signal generator of the character referred to in the preceding paragraph in which the output signal comprises a series of "pips" or potential peaks of extremely short duration as compared with the frequency of production of said "pips."

It is an additional object of my invention to provide an apparatus of the character set forth in the preceding paragraphs in which a sinusoidal input signal is modified by a surge coil and thermionic vacuum tubes operating substantially at cut-off into a series of spaced pulses of extremely short duration as compared with the periodicity of the input signal.

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Other objects and advantages of my invention will become apparent from a study of the following specifications, read in connection with the accompanying drawings, wherein:

Fig. 1 is a schematic wiring diagram illustrating the preferred embodiment of my invention;

Fig. 2 is a graph on Cartesian coordinates illustrating the character of the input signal;

Fig. 3 is a graph similar to Fig. 2 and illustrating the voltage developed across the cathode of the first thermionic vacuum tube used in the circuit;

Fig. 4 is a graph similar to Figs. 2 and 3 but illustrating the voltage developed in the plate circuit of the first tube;

Fig. 5 is a graph similar to Fig. 4 but illustrating the voltage developed on the cathode of the second tube in the circuit illustrated in Fig. 1; and

Fig. 6 is a graph similar to Figs. 2 through 5 and illustrating the character of the output signal.

Referring to the drawings, I have illustrated the preferred embodiment of my invention as including a suitable source of alternating potential. This source may comprise a vacuum tube oscillator 10 operating to produce a sinusoidal output voltage having any desired frequency. For use in the alignment of broadcast receivers and like devices, a frequency of ten kilocycles is preferred. The output of the oscillator 10 is coupled to a vacuum tube 11 by means of conductors 12 and 13 extended to the grid of the vacuum tube 11 and including a coupling condenser 14. The grid of the tube 11 is connected to ground through a grid resistance 15 and a by-pass condenser 16. The point in the input circuit common to resistance 15 and condenser 16 is connected to a suitable source of positive direct potential as by a conductor 17.

In Fig. 1 the sources of D. C. operating potential are not shown since any suitable source of supply as, for example, batteries may be used. Plate potential connections have been indicated by an arrow conventionally designated B+, whereas the supply of positive potential to the grids of the tubes has been similarly indicated by an arrow marked simply +. Likewise filament or heater circuits for the vacuum tubes have been omitted.

The cathode of the vacuum tube 11 is connected to ground through a resistance 18 by means of a conductor 19 and the resistance 18 is by-passed by a condenser 20. The plate circuit for the vacuum tube 11 includes a conductor 21 which is connected to the source of plate potential by a

conductor 22, there being connected in parallel between conductors 21 and 22 a plate load resistance 23 and a surge coil 24. The surge coil 24 should have a self-resonant frequency of from five to fifty times the frequency of the oscillator 10, and must be arranged in a highly damped circuit. The suppressor grid of the tube 11 is connected to the cathode in the conventional manner and the screen grid is connected to the plate potential supply by means of a conductor 25, the conductor 25 being also returned to ground through a condenser 26.

The voltage developed across the surge coil 24 is conveyed to a second vacuum tube 27, the coil of said tube being connected by means of a conductor 28 to the plate conductor 21 through a coupling condenser 29. The grid of the tube 27 is connected to ground through a resistance 30 and a by-pass condenser 31, the point of common connection between the resistance 30 and the condenser 31 being connected as by a conductor 32 to a source of positive direct potential. The cathode and suppressor grid circuits are duplicates of those previously described in connection with the vacuum tube 11.

The plate circuit for the tube 27 includes a plate conductor 33 which is connected through a plate load resistance 34 to a conductor 35 which is connected to the source of direct plate potential. The screen grid of the tube is likewise connected to the conductor 35 as by means of a conductor 36 and is by-passed to ground through a by-pass condenser 37.

The output signal is developed across a resistance 38, the ends of which are connected, respectively, to output terminals 39 and 40, the terminals 40 being by preference grounded. The ungrounded terminal 39 is coupled to the plate conductor 33 by a coupling condenser 41.

As stated, the oscillator 10 is by preference chosen to generate an alternating potential signal having a frequency of ten kilocycles. This voltage is applied to the grid of the tube 11 and has been designated e_1 . The character of this voltage is represented by the graph of Fig. 2. The application of a positive potential to the grid of the vacuum tubes 11 and 27 is not conventional, but it has been found that superior results are obtained if the cathode resistances 18 of the tubes 11 and 27 are both made very high to self bias the tubes 11 and 27 sufficiently to render them non-conductive except during a small part of each cycle. The use of a high value of cathode resistance is made possible by the application of a positive potential to the grids.

Since the tube 11 is, during operation, self-biased to cut-off, no substantial plate current is drawn until the positive signal voltage applied to the grid rises to a value equal to an operating bias voltage. This potential is indicated on Fig. 2 by the reference character 42. When that potential is reached, the tube draws plate current to develop across the cathode by-pass condenser 20 a voltage such as that illustrated in Fig. 3. It will be noted that this voltage rises abruptly to a maximum which is reached at the time the maximum input potential is reached. Thereafter the plate current falls to zero at a rate dependent upon the capacity of the condenser 20. The result is a cathode potential curve of the character shown in Fig. 3. Since the rising portion of this curve is representative also of the plate current drawn by the tube during the same period, it will be seen that there is periodically applied to the surge coil 24 a potential characterized by steeply rising wave

front. This produces a transient or a damped oscillation in the surge coil 24, resulting in a potential e_3 being passed on to the grid of the tube 27, the potential e_3 having a wave form such as that illustrated in Fig. 4.

Since the tube 27 also operates at cut-off, plate current will be drawn only during the input signal peaks represented in Fig. 4 by the points marked 43. As in the case of the tube 11, the cathode voltage e_4 of the tube 27 rises almost instantly to a maximum value and then declines slowly at a rate determined by the capacity of the cathode by-pass condenser.

The wave front of the transient e_3 is very steep, with the result that the cathode potential e_4 rises almost instantly to its maximum value. Since this maximum value is very close to the bias voltage, the tube 27 draws plate current for a time which is approximately equal to the length of time the potential e_4 is at its maximum. The plate current and voltage output curve have the form represented by the graph of Fig. 6.

I have found that using an oscillator frequency of ten kilocycles and a circuit of the character described, the output voltage consists of a series of "pips" such as that represented by Fig. 6 occurring at a frequency of ten thousand per second and each having a duration of approximately 0.3 micro second. These values were obtained using a surge coil circuit 23-24 having a self-resonance of about 350 kilocycles.

It can be shown that a signal of the character represented by Fig. 6 can be represented mathematically by a sine wave series comprising all of the even and odd harmonics of the fundamental of equal amplitude and of a fixed phase relation. An infinitely short "pip" signal may, therefore, be considered to comprise a series of sine waves having all frequencies from ten kilocycles to infinity and at the same amplitude. As a practical matter, I have found that the output signal frequency ranges from ten kilocycles to about five hundred kilocycles in ten kilocycle steps without a significant change in amplitude.

From the foregoing it will be observed that I have provided a signal generator which provides an output signal which is rich in harmonics and in which the harmonics occur at a substantially constant amplitude.

It will also be noted that the conversion of a sine wave input to a "pip" signal output is obtained by operating the vacuum tubes substantially at cut-off and through the use of the surge coil circuit which is interposed between the vacuum tubes 11 and 27.

Attention is directed particularly to the fact that the "pip" signal thus produced is characterized by a fixed multiple phase relationship, making the device particularly suitable for use in the testing and adjustment of those radio frequency circuits which require that the multiple phase relationship between two separate signals be maintained within close limits.

While I have shown and described the preferred embodiment of my invention, I do not desire to be limited to any of the details of construction shown or described herein, except as defined in the appended claims.

I claim:

1. In a signal generator for producing short duration signal impulses of a given periodicity, the combination of: a source of alternating potential having said given periodicity; a pulse shaping means connected to said source and including a sawtooth amplifier for producing a saw-

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tooth signal of said given periodicity having a rate of voltage rise many times greater than the rate of voltage decline, and means for applying said sawtooth signal to a surge coil having high damping and a resonant frequency many times greater than that corresponding to said given periodicity; and an electronic output circuit connected to said surge coil and including a vacuum tube amplifier having means biasing said tube beyond cut-off to such an extent that said tube is conductive only during the first positive half cycle of the highly damped oscillatory voltage produced across said surge coil.

2. In a signal generator for producing short duration signal impulses of a given periodicity, the combination of: a source of alternating potential having said given periodicity; a pulse shaping means connected to said source and including a sawtooth amplifier for producing a sawtooth signal of said given periodicity having a rate of voltage rise many times greater than the rate of voltage decline, and means for applying said sawtooth signal to a surge coil having high fixed damping and a resonant frequency many times greater than that corresponding to said given periodicity.

3. In a signal generator for producing short duration signal impulses of a given periodicity, the combination of: a source of alternating potential having said given periodicity; a pulse shaping means connected to said source and including a sawtooth amplifier for producing a sawtooth signal of said given periodicity having a rate of voltage rise many times greater than the rate of voltage decline, and means for applying said sawtooth signal to a surge coil having a fixed resistance connected in shunt therewith and a resonant frequency many times greater than that corresponding to said given periodicity; and an electronic output circuit connected to said surge coil and including a vacuum tube amplifier having means biasing said tube beyond cut-off to such an extent that said tube is conductive only

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during the first positive half cycle of the highly damped oscillatory voltage produced across said surge coil.

4. In a signal generator, the combination of: a source of alternating electrical potential; a pair of thermionic amplifier stages each including a multi-element vacuum tube having a grid, a cathode and a plate, each of said stages including an input circuit interconnecting said grid and said cathode and each including an output circuit interconnecting said cathode and said plate, the input circuit of one of said stages being connected to said source and the output circuit of said stage being connected to the input circuit of the other said stages; means for applying to the grids of the tubes of each said stages a positive direct potential; a resistance connected in series with each of said cathodes; a condenser connected in shunt with each of said resistances, said resistances and condensers being of such magnitude as to hold said cathodes at a positive potential relative to said grids and of such magnitude as to render said tubes non-conductive until the signal voltages at said grids approach a maximum value; and coupling means interposed between said stages and connected respectively to the output circuit of said one stage and the input circuit of said other stage, said coupling means comprising a surge coil having high fixed damping.

WILLIAM J. O'BRIEN.

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The following references are of record in the file of this patent:

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