

May 2, 1944.

D. A. HEISNER

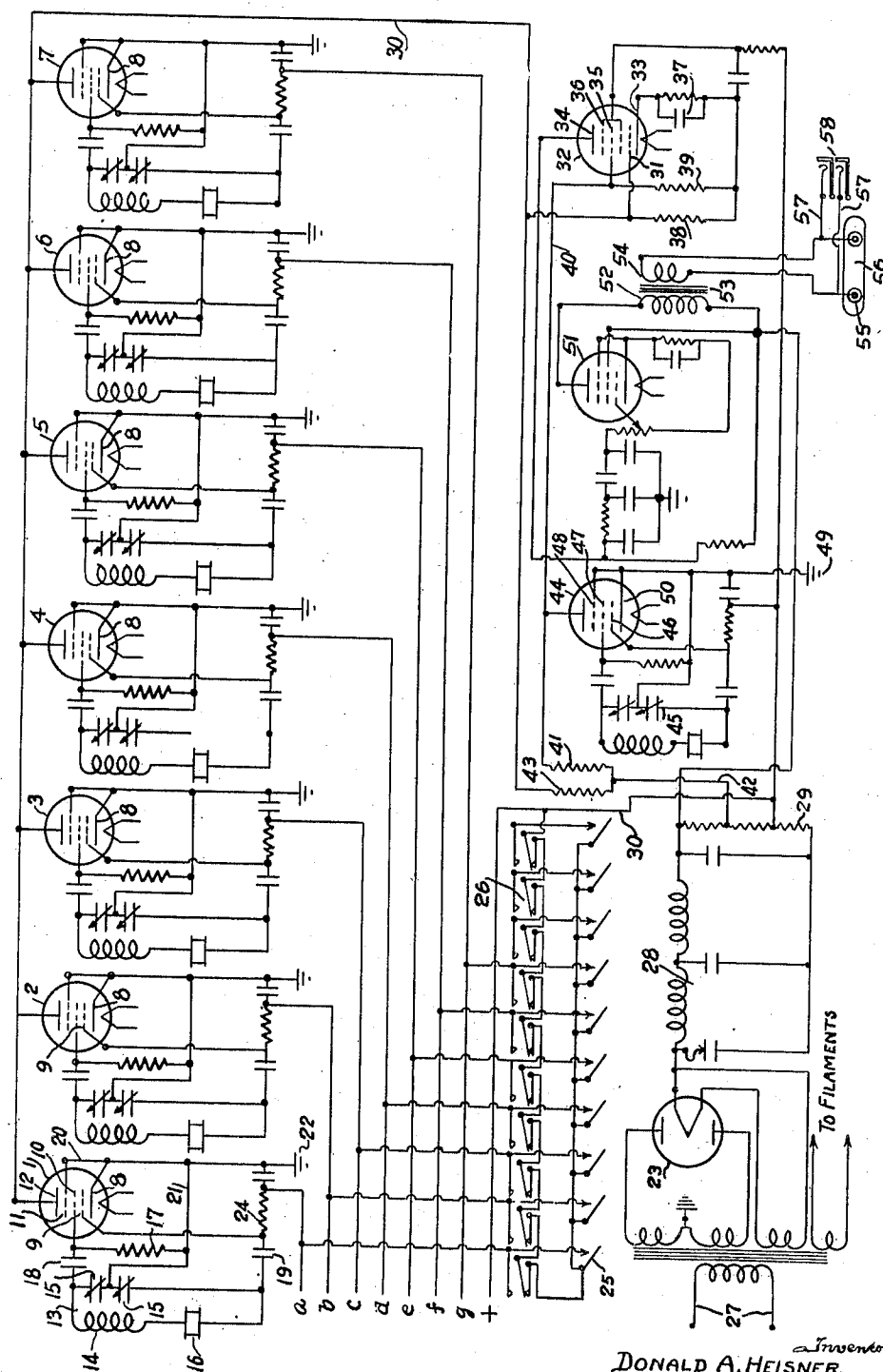
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HIGH FREQUENCY SWITCHING MEANS

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Fig. 1.



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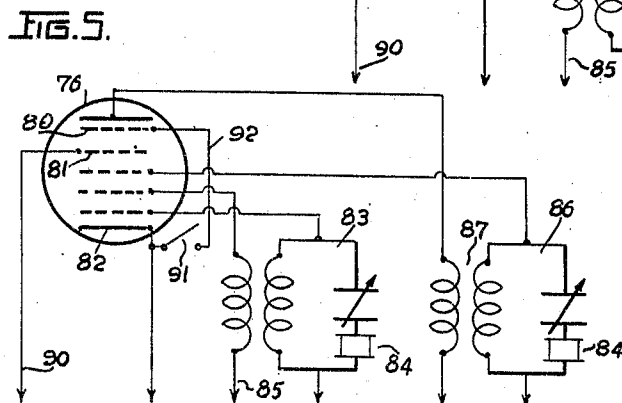
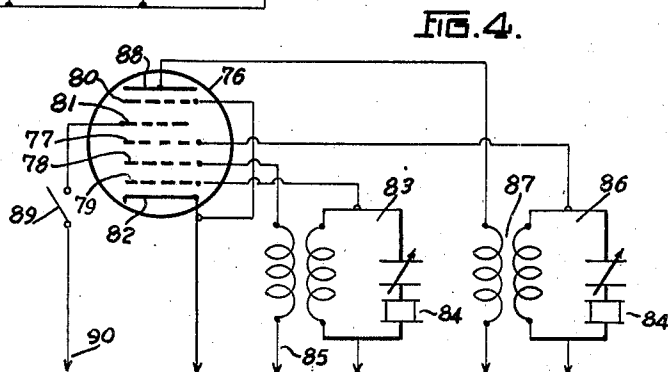
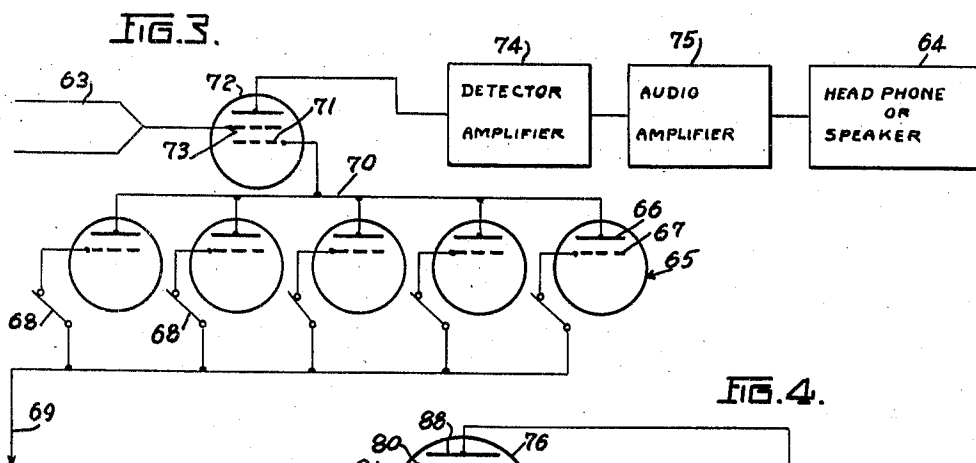
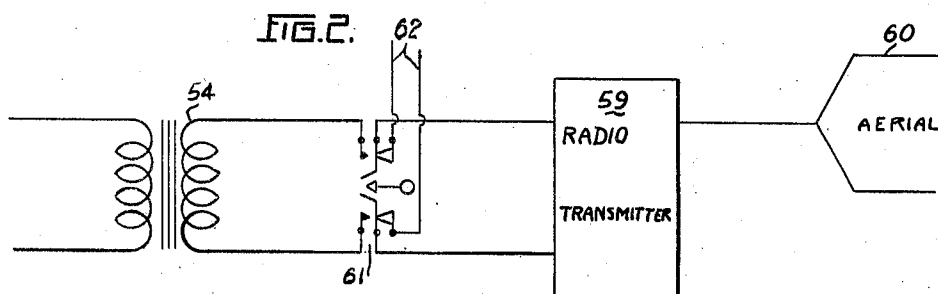
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HIGH FREQUENCY SWITCHING MEANS

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3 Claims. (Cl. 250—36)

The present invention relates to high frequency circuits, and more particularly to signalling systems which require the production of high frequency oscillations of strictly constant frequency, and in which the oscillations are instantaneously applied to or withdrawn from the line.

Considerable difficulty has been heretofore experienced in controlling the generation and transmission of high frequency oscillations, due to the fact that the switching means may introduce uncontrollable variables into the high frequency circuits. In order to switch on or off a high frequency circuit or generator, it is customary to open the feed-back, or other high frequency-containing circuit. However, under these conditions the opening and closing of these circuits may, in the case of high voltages, give rise to arcing across the switch contacts, and in any case cause a change in the capacitative or inductive reactance of the circuits which introduce variations in the generated or transmitted frequencies. Frequencies of an invariable magnitude are particularly harmful in the case of high frequency signalling systems which not only require speedy interruption of the circuits, as when a code is being transmitted or received, but also necessitate extreme accuracy of the frequency at the receiving end so as to operate the frequency-responsive devices, such as a ringer.

In the case of complex receiving systems, and particularly where the selection of the called station must be made from a large number of stations and the permissible wave length band over which all of the communication must be conducted is fairly narrow, the frequency-responsive devices are necessarily of a highly sensitive and selective character. Consequently, the frequency generating means at the transmitter and the frequency translating means at the receiver must both operate on a strictly constant frequency basis if false indications at the ringer, or other signal-responsive device, are to be avoided.

The primary object of the present invention is to provide improved apparatus and methods for controlling the generation, transmission and reception of high frequency currents.

Another object is to provide improved apparatus and methods for controlling the generation or translation of high frequency oscillations in an electron discharge device.

Still another object is to provide a highly effective switching device for use at the transmitting or receiving end of a high frequency signalling system which requires fast connection and disconnection of the high frequency circuits

without altering the reactive constants of the system.

A more specific object is to provide a high frequency signalling system, including the transmitting and receiving portion in which the highest degree of discrimination between frequencies is obtained and yet the system, or any part of it, can be readily controlled by an on-and-off operation without affecting in the slightest the frequency-determining characteristics of the system.

The above objects are attained, in brief, by introducing the circuit-controlling devices in only those circuits carrying direct current and leaving intact the circuits which carry the high frequency currents.

This invention will be better understood when the following specification is read in connection with accompanying drawings.

In the drawings:

Figure 1 is a high frequency generating and transmitting circuit which embodies the principles of the invention.

Figure 2 is a diagrammatic view of a modification of the system illustrated in Figure 1, but showing only the modified portion of that system.

Figure 3 illustrates the application of the invention to a high frequency receiving circuit.

Figure 4 shows an electron discharge tube of the pentagrid converter type and which includes some of the features of the invention.

Figure 5 is a modified form of the improved converter tube.

The invention is exemplified in Figure 1 in connection with a combined selective ringer and voice-modulated system, in which the called party is notified by a code signal formed of different frequencies sent in a predetermined order. A system of this type usually employs a plurality of oscillation generators of different frequencies, and any one of these generators is selected in a suitable manner to combine its generated frequency with that of a master oscillator in a frequency mixer tube. The sum frequencies may be taken from the mixer tube and transmitted over a radio antenna, or if desired the mixer tube may be employed to give a heterodyning effect, in which case the difference frequency may be transmitted over wires to a signal-responsive device, or may be employed to modulate externally produced radio frequency oscillations for radio transmission.

It is apparent that the advantage of obtaining relatively low frequency oscillations by hetero-

dyning two ultra-high frequency generators resides in the fact that frequency-determining crystals which operate only at relatively high frequencies may be employed to set and stabilize the frequencies generated by the oscillator. The disadvantage of such a system is, of course, the difficulty of controlling the tube circuits which carry the ultra-high frequency currents because these circuits are of a highly sensitive character and any interruption of the same will result inevitably in a change in the generated frequency and thus produce undesired changes in the sum or difference frequencies.

The sender or transmitter circuit shown in Figure 1 is designed to generate seven audio frequencies, for example 300, 270, 240, 210, 180, 150 and 120 cycles under the control of push buttons. Essentially, it consists of a crystal-controlled beat frequency oscillator. Conventional oscillators of this type use one oscillator tube for each of the two beating frequencies, and change the frequency of one of these oscillators by switching the associated tube from one crystal and tank circuit to another. Inasmuch as the oscillator frequencies are relatively high (from 10,000 to 100,000 cycles) and as the switching contacts are in the high frequency circuits, it is difficult to provide sufficiently reliable switching means which will not introduce uncontrollable variables into the high frequency circuits. In Figure 1 the seven primary oscillation generators are designated 1, 2, 3, 4, 5, 6 and 7, respectively, each of the tubes containing an indirectly heated cathode 8, a screen grid 9, an electrostatic control grid 10, a secondary emission suppression grid or "suppressor" 11 and an anode 12.

The tank circuit is generally designated 13, and consists of an inductance 14, a pair of variable condensers 15 for regulating the generated frequency, and a piezo-electric crystal 16 for stabilizing the generated frequency. A grid biasing resistor 17 and a grid condenser 18 are also employed. A direct current blocking condenser 19 is connected between the tank circuit 13 and the screen grid 9. The secondary emission suppression grid 11 is directly connected through a conductor 20 to the cathode 8, and the latter is connected to the grid resistor 17 through a conductor 21, this last-mentioned conductor being grounded as indicated at 22.

Positive potential is applied from a source indicated at 23 to the screen grid 9, through a resistor 24 and a bank of locking switches, generally indicated at 25, and also through a bank of non-locking switches (usually a push button), generally indicated at 26. This source of potential may comprise a full wave rectifier which derives its energy from the alternating current mains 27, and is provided with a filter generally indicated at 28 in the output circuit, the filter terminating in a multi-tap resistor 29. This type of rectifier is well known in the art and serves to convert the alternating current obtained from the mains 27 into direct current potential across the resistor 29 of substantially constant magnitude. A conductor 30 conveys the potential into the switch banks 25, 26. It will be noted that each of the tube generators 1 to 7 is connected respectively to its individual pair of non-locking and locking switches, the switches of each pair being superposed with respect to one another and connected in series. In order to identify each pair of switches with its respective tubes 1 to 7, inclusive, the designations *a* to *g* have been placed opposite the conductors which lead to the respec-

tive switch pairs, these letters following the same sequence as the respective tubes. For example, the first pair of switches, which is the superposed pair to the extreme left of the switch banks, is designated *a*, and this switch pair controls the first tube 1 of the series; likewise the pair *b*, which is the next pair to the extreme left pair, controls the tube 2, and so on throughout the switch banks.

In order to start the tube 1 oscillating, assuming that proper adjustments have been made at the condensers 15 and the inductance 14 and crystal 16 are of predetermined size and character, the left-hand switch of the locking bank 25 is first closed and thereafter the non-locking or push button switch to the extreme left of the non-locking bank 26 is momentarily depressed. Thus a complete circuit can be traced through both portions of the switch pair *a* from the resistor 29 to the screen grid 9. The constants of the tube 1, together with its tank circuit 13, has been so calculated that the tube will oscillate when direct current potential of a predetermined magnitude is applied to the screen grid 9, but the tube will stop oscillating when this potential is withdrawn from the screen grid. Consequently, when the push button or non-locking portion of the switch pair *a* is released the tube 1 will stop oscillating.

In case it is desired to start the second tube oscillating, the locking portion of the second switch pair *b* is first closed, the arrangement being such that upon closure of this switch the locking portion of the first switch pair *a* is automatically opened. The operator then momentarily presses the push button switch of the second pair *b* which applies direct current potential of the proper amount to the screen grid 9 of the tube 2 in order to cause the tube to oscillate. This substitutes audio frequency No. 2 for No. 1 without any appreciable intervening pause. The various other pairs of locking and non-locking switches can be depressed in any desired sequence to control the generation of oscillations at the remaining tubes, and it is apparent that any suitable form of lever system may be provided between the various pairs of the switches 25, 26 to close and open the screen grid circuits of the tubes 1 to 7 in any desired sequence.

The generated oscillations are passed through a conductor 30 to the control grid 31 of a mixer or detector tube 32, which in addition to an indirectly heated cathode 33 and an anode 34, may include a second control grid 35 which is surrounded by a screen grid 36. A grid biasing network 37 and grid resistors 38, 39 may be employed to apply proper potential bias to the various control grids. This bias is obtained through a conductor 40, through a resistor 41 and conductor 42, which is connected to a tap on the rectifier resistor 29. Directly opposite the resistor 41 there is a resistor 43 which is also connected to the conductor 42, and terminates in the conductor 30 for supplying plate potential to the oscillators 1 to 7, inclusive.

In addition to the oscillators 1 to 7, there is provided a master oscillator 44, which is similar to the individual oscillators 1, 2, etc. in that it involves a crystal controlled tank circuit 45 and employs a screen grid 46, a control grid 47 and a suppressor 48. The suppressor grid is grounded at 49 and is connected to the indirectly heated cathode 50. The control grid 47 is connected to the tank circuit 45, and the output circuit of the oscillator is connected through the conductor 40 to the control grid 35 of the mixer or detector

tube 32. The output of the mixer tube is received by an amplifier 51, this amplifier being of the standard triple-grid type, the output circuit of which includes the primary coil 52 of a transformer 53. The secondary winding 54 of the transformer 53 is taken to a pair of terminals 55 positioned on a terminal block 56, and if desired conductors 57 may be taken from the terminals 55 to a microphone or telephone jack 58.

From the foregoing it is evident that I have disclosed a selective signal-sending apparatus, in which any one of the oscillators 1 to 7 may be made operative by manipulating its individual pair of switches at the switch banks 25, 26, and that these oscillations are carried through the conductor 30 into the mixing tube 32, where they are combined with the oscillations generated at the master oscillator 44. Either the sum or difference frequency may be taken from the mixer tube and amplified at the tube 51, the output of which is brought to the terminal block 56 of a jack 58. Thus the combination of the master oscillator 44 and the mixer tube 32 may serve as a superheterodyne circuit, in which the beating frequency obtained from the oscillators 1 to 7 may be brought out to the transformer 53. It is evident that in the event the sum frequencies are applied to the transformer 53, the latter is provided with an air core, although as shown, the circuit arrangement is set up as a superheterodyne system in which the difference frequency is brought out to the terminal block.

When a circuit, as described hereinbefore, had been employed in the prior art it was customary to use only one oscillator tube for each two frequencies generated, and this was accomplished by providing a pair of tank circuits of different characteristics for the oscillator tube. When one tank circuit was switched in and the other tank circuit switched out, the tube would generate oscillations of one predetermined frequency, and when the second tank circuit was substituted for the first tank circuit the tube would oscillate at a different frequency. However, under these conditions the switching of the tank circuits introduced a number of uncontrollable variables into the high frequency circuits, tending to prevent the generation of extremely constant predetermined frequencies at the oscillators.

In accordance with the present invention, each oscillator is provided with only a single tank circuit, and this circuit is permanently connected to its oscillator so that it can be adjusted once and for all to the proper frequency limits. The control of the beating oscillator 1 to 7, i. e. as to whether it will oscillate or remain quiescent, is vested entirely in the feature of applying the proper direct current potential to the screen grid without which the tube will not oscillate. This application of the direct current potential is, of course, controlled by the switches 25, 26, and inasmuch as the potential is of a direct current character no uncontrollable variables are introduced into the high frequency circuits. Each oscillator tube is thus caused to remain exactly on its prescribed frequency so that the difference or sum frequencies obtainable at the terminals 55 or 58 are of an accurately predetermined magnitude.

Figure 2 shows a system in which the audio frequency obtainable at the secondary coil 54 of the system shown in Figure 1 is applied to a radio transmitter 59, and thence is impressed on an aerial 60. The transmitter 59 may comprise a high frequency oscillation generator on which

the audio frequencies are superimposed by a modulating process, as is well known in the art. Reference numeral 61 designates a key switch, connected to a telephone circuit 62, over which speech undulations to be transmitted by the transmitter 59 may be received. Thus the transmitter may serve alternately to propagate at the antenna 60 carrier frequency which is modulated either by signal frequencies at the winding 54 or speech undulations conducted through the wires 62.

In Figure 3 I have shown, in simplified form, the manner in which my improved method of controlling the generation of frequencies at a tube oscillator can be applied to a tube receiving circuit. In this figure reference numeral 63 designates an antenna which may, for example, receive radio signals from the antenna 60 in Figure 2, and which require a heterodyning effect to make the signals audible at the head 'phone or speaker 64. A number of oscillator tubes, generally designated 65, may be employed for the beating frequency, these tubes containing an anode 66 and a screen grid 67, together with the necessary control grid and cathode. The tubes are all connected to differently tuned tank circuits, preferably crystal-controlled, so that each tube is capable of oscillating at its predetermined frequency when positive potential of a predetermined magnitude is impressed on its screen grid. As shown, the screen grid circuits are all provided with individual switches 68 which are connected to a common source of direct current potential, indicated at 69. All of the electrodes except the anode and screen grid have been omitted for the sake of clarity.

The high frequency output of the tubes is taken through a common conductor 70 to one of the control grids 71 of a mixer or heterodyning tube 72. The other electrostatic control grid 73 of the tube 72 is connected in any suitable manner to the receiving antenna 63. The output of the mixer tube 72 is taken through a combined detector and amplifier 74, after which it is amplified at 75 and thereafter applied either to the head 'phone or speaker 64. The detector-amplifier unit 74 and the audio frequency amplifier 75, as also the head 'phone or speaker unit 64, may be of any suitable and well known type. It will be understood that the individual oscillator tubes forming the group 65 may be of the type shown in Figure 1, to each of which is connected a frequency-determining crystal-controlled tank circuit or other form of feed-back. These tank circuits are all tuned to different frequencies, as in the case of Figure 1, so that the various oscillation generators, when rendered operative, will produce oscillations of different frequencies in the common output circuit 70.

When either signal-modulated or speech-modulated carrier waves are received by the antenna 63, and assuming that all of the oscillators 65 are temporarily operative, the signal or speech is separated from the carrier by the beating or heterodyning action between the carrier frequency and one of the oscillators 65, depending on the magnitude of the carrier frequency. The audio frequency is detected at 74, and upon its reception at the head 'phone or speaker element the carrier frequency of the distant station can be identified, and from this information the operator will know as to which of the five oscillators 65 is heterodyning with the carrier frequency in the proper audio frequency range. All other oscillators except this one oscillator may then be rendered inoperative by simply with-

drawing the screen grid potential at the switches 68, leaving only the one oscillator to beat with the carrier frequency in the mixer tube 72. Thus, as in the case of the system shown in Figure 1, the operative condition of the oscillators is controlled solely by the application of a direct current potential to the screen grid of the oscillator so that no uncontrollable variables, such as changes in capacitive or inductive reactance, are introduced into the circuits which carry high frequency currents.

The circuit shown in Figure 3, which provides for the simultaneous operation of a plurality of oscillators 65 until the signal has been received, offers the advantage of responding to any one of five different carrier frequencies which, for example, may be transmitted by different transmitting stations. When the frequency of the carrier has been established at the head 'phone or speaker so that all other oscillators are rendered inoperative except the beating oscillator, the system provides a check as to the particular station which is temporarily transmitting the signals or speech. In other words, the oscillator arrangement 65 serves as a convenient "stand-by" system.

Figure 4 shows a pentagrid converter 76, provided with triple electrostatic control grids 77, 78, 79, a suppressor grid 80 and a screen grid 81. The cathode, which may be of an indirectly heated type, is indicated at 82. The grid 79 is connected to a reactive tank circuit indicated at 83, including a crystal 84 and a feed-back coupling 85. One coil of the coupling is connected to the grid 78. The remaining grid 77 is connected to a crystal-controlled tank circuit 86, which is coupled through the transformer 87 to the anode 88. The screen grid 81 is connected through the switch 89 to a source of direct current potential, indicated at 90. It is apparent that when the tank circuits 83 and 86 have been properly tuned to different frequencies, and the proper direct current potential is applied to the screen grid 81, the converter 76 will produce two sets of oscillations from which either the sum or difference frequencies may be obtained in the anode circuit. However, when the switch 89 is opened to withdraw potential from the screen grid, neither of the two frequencies will be generated by the tube. In other words, the switch 89 simultaneously controls the generation of both frequencies within the converter. The application of direct current potential to the screen grid to cause the converter to generate a plurality of frequencies, or the withdrawal of the potential from the screen grid to render the converter inoperative, does not affect the frequency-determining properties of the tube or of the tank circuits 83, 86. The latter are permanently connected to the tube circuits, so that the tube will always produce the same frequencies when the screen grid is energized.

It is apparent that instead of applying oscillations from the tank circuit 83 to the grid 79, the tank circuit may be replaced by an antenna over which carrier waves corresponding in frequency to the tank circuit 83 are being received. In that case the frequencies generated by reason of the tank circuit 86 will beat with the carrier frequency to produce an audio frequency in the output of the tube. The switch 89 will likewise control the mixing or heterodyning function of the tube 76 when carrier frequency is applied to the grid 79 and oscillatory energy is applied to the grid 77 from the tank circuit 86.

While I have described my invention as con-

trolling the generation of high frequency oscillations by the application of direct current potential to the screen grid, thus leaving the tank circuit intact, it will be understood that the invention is not limited to this aspect but instead contemplates the application of direct current potential to any electrode of an oscillation generator which requires direct current potential for the operation of the generator. Thus instead of operating on the screen grid, in certain types of generators it may be feasible to apply the direct current potential to the secondary emission suppression grid or any of the control grids which are normally provided with direct current potential. In case the suppressor grid is connected directly to the cathode, it is generally sufficient merely to place a switch in the grid cathode circuit so that upon opening the switch the tube cannot oscillate, but when the switch is closed the tube will oscillate at the frequencies determined by the tank circuit connected to the control grid.

A modification of this type has been illustrated in Figure 5, in which the circuits are somewhat similar to those shown in Figure 4 and therefore bear the same reference numerals, except that the screen grid 81 is permanently connected to the source of direct current potential 90 and the suppressor grid 80 is connected back to the cathode 82 through the switch 91. It is well known that, due to the rectifying action of the tube, current in only one direction, i. e. direct current, flows through the conductor 92 connecting the suppressor grid to the cathode. Consequently, the opening and closing of the switch 91 positively cannot introduce any reactive effect or other uncontrolled variations in the tank circuits 83, 86 which determine the frequencies of the oscillations generated within the tube.

It is apparent that by reason of the improvements described hereinbefore, I have transferred the selective switching operation from the high frequency circuits, where difficulties are usually encountered, to direct current circuits which present no switching difficulties. This is accomplished by providing a complete or intact high frequency circuit, including a vacuum tube for each of the various high frequencies involved, and switching the direct current screen or suppressor grid circuits. My invention is not limited to audio frequency generators but may be used for a variety of other purposes, for example, multi-frequency radio receivers.

It will be understood that I desire to comprehend within my invention such modifications as come within the scope of the claims and the invention.

Having thus fully described my invention, what I claim as new and desire to secure by Letters Patent is:

1. An oscillation generator comprising a tube containing a plurality of electrodes including a cathode, anode, control grid and a secondary emission suppression grid, an equipotential conductor connected directly between the suppressor grid and cathode, feed-back circuits connected between the cathode, anode and control grid, and a circuit-opening means in the suppressor grid circuit for determining whether or not oscillations will be generated within the tube.

2. An oscillation generator adapted to generate a plurality of frequencies, said generator including a plurality of control grids each of which is connected respectively to frequency-determining tank circuits, a suppressor grid and a cath-

ode in said generator connected together through a switch and an equipotential conductor whereby when the switch is closed the generator will produce oscillations but when the switch is open the tube is rendered inoperative.

3. An oscillation generator adapted to generate a plurality of frequencies, a plurality of control grids in said generator connected respectively to a plurality of frequency-determining tank circuits, a suppressor grid and a cathode in said 10

generator connected together by an equipotential conductor through a switch, and a screen grid positioned between the suppressor grid and one of said control grids, said screen grid being 5 charged to a direct current potential and the operative condition of said tube being controlled by the manipulation of the switch in the suppressor grid-cathode circuit.

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