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APPARATUS FOR PRODUCING INTERRUPTED ALTERNATING CURRENT

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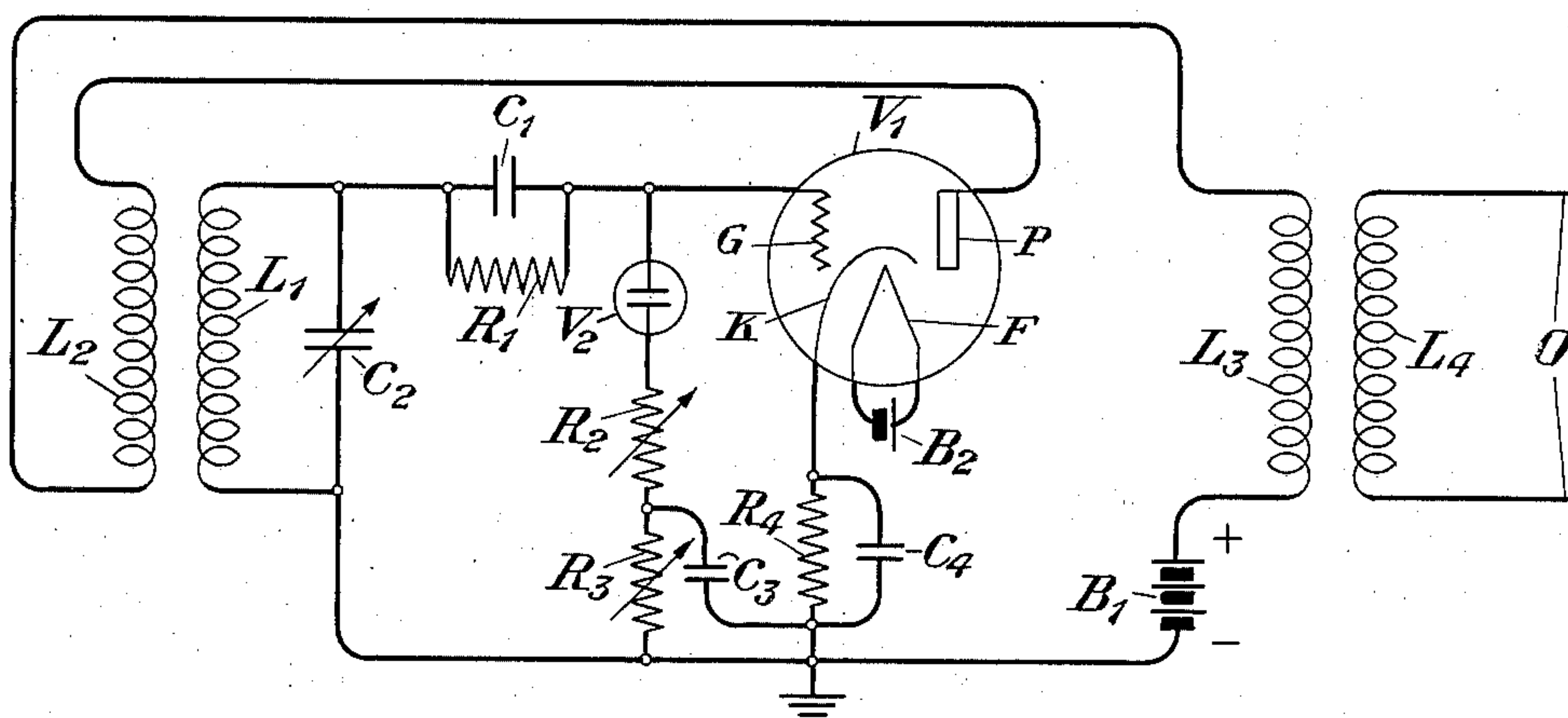


Fig. 1

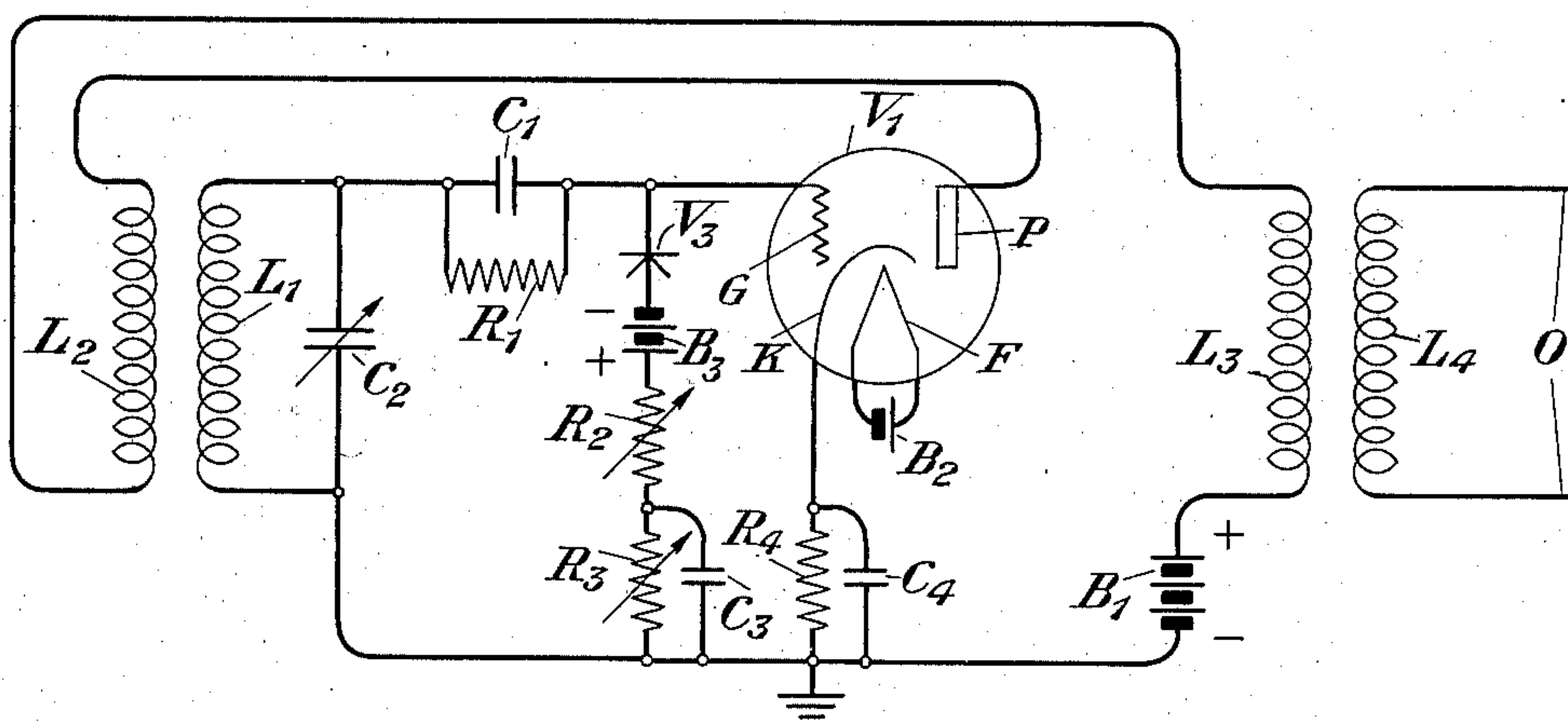


Fig. 2

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APPARATUS FOR PRODUCING INTERRUPTED ALTERNATING CURRENT

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9 Claims. (Cl. 250—36)

This invention relates to oscillation generators. This invention also relates to arrangements for interrupting the oscillations produced by oscillation generators at regular intervals. This invention further relates to gas tube circuits as well as to arrangements for utilizing the features of gas tube circuits for interrupting or controlling the flow of current of oscillation generators or other devices.

This invention will be better understood from the detailed description hereinafter following when read in connection with the accompanying drawing in which Figure 1 shows one embodiment of the invention employing a gas tube circuit to control the generation and interruption of oscillations of a vacuum tube oscillation generator and Fig. 2 illustrates a modification of the arrangement of Fig. 1 in which a rectifier circuit has been used in place of the gas tube circuit.

Referring to Fig. 1 of the drawing, the reference character V_1 designates a vacuum tube comprising a grid G , a plate P , a cathode K and a filament or heater F . The grid G is connected to ground through a circuit comprising a grid condenser C_1 and leak resistor R_1 connected in parallel relationship and a coil L_1 which may be one of the windings of a transformer. The coil L_1 is shunted by a condenser C_2 the capacity of which may be varied for tuning purposes. The cathode K is connected to ground through a resistor R_4 and condenser C_4 which are arranged in parallel relationship. The circuit between the plate P and cathode K comprises the winding L_2 of the transformer already referred to, the primary winding L_3 of another transformer, a battery B_1 and the parallel-connected resistor R_4 and condenser C_4 . A battery B_2 may be used to supply current to heat the filament or heater F of the tube V_1 to incandescence. The grid G is also connected to ground through a circuit comprising a gas-filled tube V_2 of the two-electrode type and two resistors R_2 and R_3 which may be variable as shown. A condenser C_3 is connected between the terminal common to the resistors R_2 and R_3 and ground. The secondary winding L_4 may be connected to an output circuit O to which the current produced by the system may be transmitted.

It will be observed that without the gas tube V_2 , resistors R_2 and R_3 and the condenser C_3 , the circuit comprises an oscillation generator of well known type. In this circuit the coils L_1 and L_2 , which are respectively in the grid and plate circuits of the tube V_1 , are coupled to each other so as to feed current in the plate circuit back

to the grid circuit for the production of oscillations. These oscillations may be of any desired frequency, the frequency being determined by the adjustment of the condenser C_2 and by the proportions of the other elements of the circuit.

In the oscillation generator just referred to the grid condenser C_1 and resistor R_1 are employed to regulate the leakage of negative charge from the grid G of the tube V_1 to ground, the grid being biased to a negative potential with respect to the cathode K . It will be further noted that the flow of current from the battery B_1 over coils L_3 and L_2 and through the space between the plate P and cathode K of tube V_1 and through resistor R_4 causes a voltage to be produced across the terminals of the resistor R_4 (and of course across the condenser C_4) and this voltage furnishes part of the negative biasing potential for the grid electrode G of the tube V_1 .

In the grid leak type of oscillation generator just described the values of condenser C_1 and resistor R_1 may be so proportioned that interruptions of the oscillations may be obtained. However, changing these proportions in order to adjust the frequency of the interruptions changes the length of both the "on" and "off" periods. The addition of the gas tube V_2 , the resistors R_2 and R_3 and the condenser C_3 makes it possible to adjust the length of the "on" period so that control of the relative lengths of the "on" and "off" periods as well as control of the total period of the operating cycle is possible. The manner in which this circuit functions will be described hereinafter.

Two voltages are simultaneously impressed between the grid electrode G and the cathode K of the tube V_1 . One of these voltages is the alternating voltage fed from the plate circuit of the tube V_1 to its grid circuit through the coils L_2 and L_1 . The other of these voltages is a unidirectional voltage which is impressed across the grid condenser C_1 and the leak resistor R_1 , the latter voltage being always negative at the grid G when considered with respect to the cathode K . These two voltages may be treated independently of the voltage across resistor R_4 , which is relatively small as compared with the other two. The unidirectional voltage across condenser C_1 and the alternating voltage together form a wave which for only a small portion of each cycle—considerably less than half of the cycle—will apply a positive voltage to the grid G with respect to the cathode K , this voltage being of opposite polarity during the remainder of the cycle.

Before considering the manner in which the grid condenser and leak resistor and the gas tube circuit above referred to act to interrupt the generated alternating current, it may be well to keep in mind the inherent properties of a gas tube such as V_2 of the type here involved. The tube V_2 is of well known type and comprises two electrodes which are immersed in a gaseous medium of low pressure. When the voltage between the two electrodes of the tube V_2 exceeds a predetermined value, the gas within the tube will become ionized and an arc will be formed between these electrodes. The voltage at which the arc is formed is commonly referred to as the breakdown voltage. After the arc has formed, the arc will be maintained as long as the voltage between the electrodes of the gas tube remains higher than a lower predetermined value. The voltage at which the arc may be maintained after it has been initiated is commonly known as the sustaining voltage. As the voltage between the two electrodes is reduced below this latter voltage, namely the sustaining voltage, the arc will be extinguished and the gas within the tube will become deionized. The tube V_2 will operate substantially equally well regardless of the polarity of the applied voltage.

The composite alternating and direct voltage between the grid G and the cathode K of the tube V_1 , i. e., the alternating voltage fed back to the grid circuit of the tube and the one appearing across the condenser C_1 , may be divided, for the purpose of explaining the action of the system, into four parts. One part is that small portion of each cycle during which the grid G is charged to a positive potential with respect to the cathode K . The second part is the succeeding portion of each cycle when the grid voltage rises from a zero or negligible value to a substantially high negative voltage, the magnitude of which is equal to or greater than that required to ionize the gas within the tube V_2 and establish an arc between its electrodes. The third part of each cycle may be considered as that portion of the cycle after the gas within the gas tube V_2 has become ionized and an arc is established between the electrodes of the tube V_2 and including the interval when the arc is maintained between the electrodes of the tube. The fourth and last part of each cycle begins with a negative voltage applied to the grid which is substantially equal to or less than the sustaining voltage of the tube V_2 and extending to the beginning of that portion of the cycle at which a positive voltage is again applied between the grid electrode G and the cathode of tube V_1 .

During the first short interval, i. e., when a positive voltage is applied to the grid G , current will actually flow in the circuit including the tube V_1 (grid G to cathode K), the circuit including the resistor R_4 with its parallel connected condenser C_4 , the coil L_1 with its parallel connected condenser C_2 and the resistor R_1 with its parallel connected condenser C_1 . The flow of current through the resistor R_1 will be in such a direction as to charge the condenser C_1 , the direction of the charge being such that the right-hand terminal of the condenser will become negative with respect to its left-hand terminal.

During the second part of the cycle, i. e., when the voltage applied to the grid G becomes increasingly negative up to a point immediately before the gas tube V_2 becomes operated, the condenser C_1 will discharge the voltage impressed

upon its terminals. This discharge will occur through the resistor R_1 , the resistor R_1 being so large that the discharge rate of the condenser C_1 will be comparatively slow. While the condenser C_1 discharges, however, the negative voltage applied to the grid by the composite voltage will nevertheless increase and will thereafter reach a value sufficient to ionize the gas of tube V_2 . When this voltage is reached, an arc will be established between the electrodes of tube V_2 .

During the third part of the cycle, i. e., the interval during which the tube V_2 is in an ionized condition, the condenser C_1 will discharge through two parallel paths, one of which comprises the resistor R_1 , the other discharge path being formed by the coil L_1 with its parallel connected condenser C_2 , the resistor R_3 with its parallel connected condenser C_3 , the resistor R_2 and the tube V_2 . This portion of the cycle will terminate when the voltage across the electrodes of tube V_2 is reduced below the value required to maintain gaseous ionization within the tube V_2 and, therefore, the arc will become extinguished.

During the fourth and last part of the cycle the voltage applied to the grid G will become less and less negative with respect to the cathode K . During this last part of the cycle, the condenser C_1 will continue to discharge through the resistor R_1 . The cycle will be completed when the composite voltage applied between the grid G and the cathode K again renders the grid electrode G positive with respect to the cathode K .

The constants of the elements entering into the circuit are such that the voltage impressed upon the condenser C_1 at the end of each cycle is substantially greater than the voltage impressed upon the condenser at the beginning of the cycle. Thus during each cycle the voltage across the condenser C_1 will be raised, the right-hand terminal of condenser C_1 becoming more negative than its left-hand terminal. Hence the voltage applied to the grid G will become increasingly negative until this negative voltage has reached a value which is so large as to completely block the flow of current in the plate circuit of the tube V_1 . When this occurs no current will flow in the plate circuit of tube V_1 and no oscillations will be generated by the system. Therefore no current will be transmitted through the windings L_3 and L_4 to the output circuit O . During this period, moreover, the gas within the tube V_2 will remain deionized and there will be no arc between its electrodes.

While the generation of alternating current by the oscillation generator remains interrupted, the condenser C_1 will discharge through the resistor R_1 . The discharge through resistor R_1 will continually reduce the negative voltage applied to the grid G . When this negative voltage has become sufficiently reduced, current will again flow through the plate circuit of the tube V_1 and an alternating voltage will be again generated and transmitted through the coils L_2 and L_1 and through the condenser C_1 to the grid G and cathode K of the tube V_1 as heretofore. Oscillations will be again supplied to the output circuit O . This cycle will be repeated and current of a predetermined frequency will be produced for a fixed interval, then interrupted for another fixed interval, and then reestablished for another interval, and so on.

In the circuit of Fig. 1, the average grid potential is driven beyond the cutoff point of the tube V_1 soon after oscillation starts. Oscillation

continues, however, even under these conditions due primarily to the extremely close feedback coupling between the plate and grid circuits of tube V₁. Eventually a grid bias of sufficiently high negative value is reached which causes the oscillations to cease. The oscillations cease and the system remains non-oscillatory because the gain of the amplifier is below the associated circuit losses.

It will be noted that the resistor R₂ primarily controls the maximum current which will be transmitted through the gas tube V₂. As the resistor R₂ is increased in magnitude the flow of current through the tube V₂ will become reduced.

The resistor R₃ primarily controls the minimum flow of current through the gas tube V₂. As the magnitude of the resistor R₃ is increased the minimum current flow through the tube V₂ will be decreased, and as resistor R₃ is made larger and larger the minimum current will approach a zero or negligible value. In most applications, the resistor R₃ will be substantially larger than resistor R₂.

It will be observed that the voltage impressed across the condenser C₁ is in turn applied between the grid G and cathode K. The voltage between grid G and cathode K will periodically rise above that required to ionize the gas of tube V₂ and then drop below that required to maintain the latter tube in an ionized condition. When the voltage between the grid G and cathode K exceeds the breakdown voltage value for the tube V₂, the ensuing flow of current through the tube V₂ will cause the condenser C₃ to be charged through the circuit of the resistors R₂ and R₁. Inasmuch as the grid G is always biased to a negative potential with respect to the cathode K, the left-hand terminal of the condenser C₃ will always be at a negative potential with respect to its right-hand terminal. The condenser C₃ will be continually charged to an increasing potential as long as the gas of tube V₂ remains ionized. After the tube V₂ becomes deionized, however, the voltage impressed upon condenser C₃ will be discharged through the resistor R₃ which is bridged across it. The condenser C₃ is charged by the voltage across condenser C₁ as well as that across the coil L₁, but condenser C₃ can become charged only when the gas within tube V₂ has become ionized.

The means for controlling the interval during which oscillations are produced by the vacuum tube system is in general substantially independent of the means to control the period during which oscillations cease. The resistor R₁ and its shunting condenser C₁ primarily control the period during which oscillations cease. As the resistor R₁, for example, is made larger and larger the interval during which no current will be produced will be made larger and larger. This is because the voltage impressed upon the condenser C₁ will then leak off more slowly. On the other hand, the interval during which oscillations are produced will be controlled primarily by the circuit comprising the tube V₂, the resistors R₂ and R₃ and the condenser C₃. As the magnitudes of the resistors R₂ and R₃, for example, are made smaller and smaller, alternating current will be generated for longer and longer intervals. This is because the voltage impressed upon the condenser C₁ will, with smaller resistors for R₂ and R₃, leak off at a faster rate and hence a longer interval will be required to raise the voltage applied to grid G

to a value sufficient to block the flow of plate current.

The circuit shown in the drawing may be adjusted for the production of alternating current of any frequency as for example, current of low frequencies such as 20 cycles or 60 cycles, or current of higher frequencies of many kilocycles. Each such current will be interrupted periodically and the interruptions may be varied over as wide a range as desired. The interrupted current produced by the system may be utilized for the production of ringing currents and busy tones in connection with telephone apparatus.

When current is being generated by the vacuum tube oscillator, the tube V₂ will flash several times as the breakdown voltage of the tube is reached at different times. These flashes will be visible to the operator. In general, they may be used to measure the interval during which current is produced by the system. The absence of such flashes will correspond approximately with the interval when no current is being produced by the system.

In order to obtain a finite non-oscillatory period, the grid voltage at which oscillation ceases must be appreciably more negative than the grid voltage at which oscillation again begins. This requirement is met by the proper adjustment of the circuit elements of the system disclosed here. If this requirement were not met, the time required for the grid voltage to change from the "non-oscillating" condition to the "oscillating" condition would be infinitesimal and the non-oscillating condition would accordingly also be infinitesimally short.

Fig. 2 illustrates a modification of the arrangement of Fig. 1 in which a rectifier V₃ and a biasing battery B₃ have been substituted for the gas tube V₂ of Fig. 1. The rectifier V₃ may be of the copper oxide type or, if desired, of any vacuum tube type. The rectifier V₃ and biasing battery B₃ have been poled so that no current will normally flow from the battery B₃ through the rectifier V₃ to charge the condensers C₁ or C₃. The rectifier V₃ will, however, pass current when the composite voltage is of the proper polarity and of sufficient magnitude, as already described with respect to Fig. 1. The magnitudes of resistors R₂ and R₃ will, as in the case of Fig. 1, control the rate at which condenser C₁ will discharge. Moreover, this discharge will in general occur whenever the composite voltage wave exceeds the voltage of the biasing battery B₃.

The rectifier V₃, therefore, provides a discharge path for condenser C₁ whenever oscillations are being generated by the vacuum tube system. Nevertheless this discharge path will be ineffective during the idle period when no oscillations are being generated.

The condenser C₃ is not absolutely essential to the operation of the circuits of Figs. 1 and 2. If the resistors R₂ and R₃ are properly adjusted, this condenser may be eliminated.

The oscillation generator of Figs. 1 and 2 may also include any well-known means for controlling the frequency of the current generated thereby as, for example, a tuning fork. Such a fork may be positioned between the coils L₁ and L₂, the coil L₂ being used for driving the fork and the coil L₁ for picking up a voltage of a frequency corresponding to the period of the fork, or one of its harmonics, and applying that voltage between the grid G and cathode K of the tube V₁.

The oscillation generator has been shown as comprising the magnetically coupled coils L_1 and L_2 for the generation of oscillations merely for the purpose of illustration. It will be understood that vacuum tube oscillators of other types, such as the Hartley or Colpitts oscillators, may be substituted therefor.

While this invention has been shown in certain particular arrangements merely for the purpose of illustration, it will be understood that the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. The combination of a vacuum tube oscillator, the plate and cathode of the vacuum tube of said oscillator being in a circuit which is coupled to the circuit of the grid and cathode to feed voltages back to the latter circuit to generate oscillations, a condenser, a leak resistor connected in parallel with said condenser between the grid and cathode of the vacuum tube of said oscillator, means for charging said condenser, means for delaying the charge of said condenser, said delaying means comprising a gas tube circuit connected effectively in parallel with said condenser, the operation of said gas tube circuit being controlled by the magnitude of the charge on said condenser, and means responsive to a predetermined charge on said condenser for interrupting the generation of oscillations by said oscillator for a substantial time interval.

2. Apparatus for producing interrupted alternating current comprising a vacuum tube arrangement including plate, grid and cathode electrodes set up for feeding energy in the plate-cathode circuit back to the grid-cathode circuit to generate oscillations, a condenser and resistor connected in parallel with each other and connected between the grid and cathode electrodes of said tube, a gas tube circuit also connected between the grid and cathode electrodes of said tube for controlling the rate of charge of said condenser, said gas tube being operated when the charge on said condenser exceeds a first predetermined value, and means responsive to a charge on said condenser exceeding a second predetermined value for periodically interrupting the oscillations generated by said vacuum tube arrangement for a predetermined interval.

3. Apparatus for producing interrupted alternating current without any moving parts whatever, comprising an oscillator including a vacuum tube having plate, grid and cathode electrodes, the plate-cathode circuit of said tube being coupled to its grid-cathode circuit for generating oscillations, a condenser and leak resistor in parallel relationship with each other and connected in said grid-cathode circuit, a gas tube circuit also connected in said grid-cathode circuit, said gas tube circuit being operated when the charge on said condenser exceeds a predetermined value, the constants of said condenser and leak resistor being proportioned to fix the interval during which the oscillations produced by said oscillator are interrupted, the constants of the gas tube circuit being proportioned to fix the interval during which oscillations are generated by said oscillator.

4. The method of producing interrupted alternating current with apparatus including a condenser and a gas tube circuit, which consists in generating alternating current, rectifying a pre-

determined portion of the current during each cycle, periodically discharging some of the rectified current through said gas tube circuit, building up a voltage on said condenser from the remainder of the rectified current step-by-step, and interrupting the alternating current as the built-up voltage exceeds a predetermined value.

5. The method of producing alternating current with an oscillation generator having a grid condenser and leak resistor and a gas tube circuit, which consists in operating said oscillation generator so as to obtain alternating current, rectifying a portion of said current during each cycle thereof, charging said condenser and elevating the voltage on said condenser by an increment of voltage during each succeeding cycle, delaying the charge of said condenser by discharging a portion of its voltage through the gas tube circuit, the charge upon the condenser being increased after each cycle, interrupting the production of alternating current in response to a predetermined voltage across said condenser, and discharging said condenser through said resistor.

6. The combination of a vacuum tube oscillation generator including a vacuum tube having grid, plate and cathode electrodes, the grid-cathode circuit being coupled to the plate-cathode circuit so that voltages may be fed back from the plate-cathode circuit to the grid-cathode circuit to generate oscillations, a grid condenser and leak resistor connected in parallel with each other in the grid-cathode circuit of said tube, the condenser being periodically charged by the voltages present in the grid-cathode circuit of said tube, and a gas tube circuit connected also in the grid-cathode circuit of the tube to delay the charge of said condenser, said gas tube circuit being operated when the charge on said condenser exceeds a predetermined value.

7. The combination of a vacuum tube including plate, grid and cathode electrodes, a condenser and a resistor connected in parallel relationship to each other and connected between the grid and cathode electrodes, a feedback circuit interconnecting the plate and grid electrodes of said tube in order that the tube may generate oscillations, the condenser and resistor being proportioned so as to periodically interrupt the generation of oscillations, and a gas tube circuit also connected between the grid and cathode electrodes to delay the charge of said condenser.

8. The combination of a vacuum tube oscillation generator having a condenser connected to the grid and filament electrodes of the vacuum tube thereof, the plate and filament electrodes of the tube forming a circuit which is coupled to the circuit of the grid and filament electrodes for the generation of oscillations, a gas-filled tube circuit connected effectively in parallel to said condenser, means for applying voltage to said condenser, means for varying the voltage applied to said condenser between values which exceed the voltage required to establish an arc between the electrodes of said gas tube and another voltage which is less than that required to sustain said arc, and means including a resistor for limiting the flow of current through said gas tube.

9. The combination of an oscillation generator including a vacuum tube having a circuit connected to its grid and filament electrodes and a circuit connected to its plate and filament electrodes which is coupled to the first-mentioned

circuit to feed voltages back to said first-mentioned circuit to generate oscillations, means for interrupting the generation of oscillations by said oscillation generator, said interrupting means including a condenser connected to the grid and filament electrodes of the vacuum tube of said oscillation generator, and means for fixing the interval during which oscillations are

produced by said oscillation generator, said latter means comprising a gas tube circuit connected effectively in parallel to said condenser, said gas tube circuit being operated when the charge on said condenser exceeds a predetermined value.

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