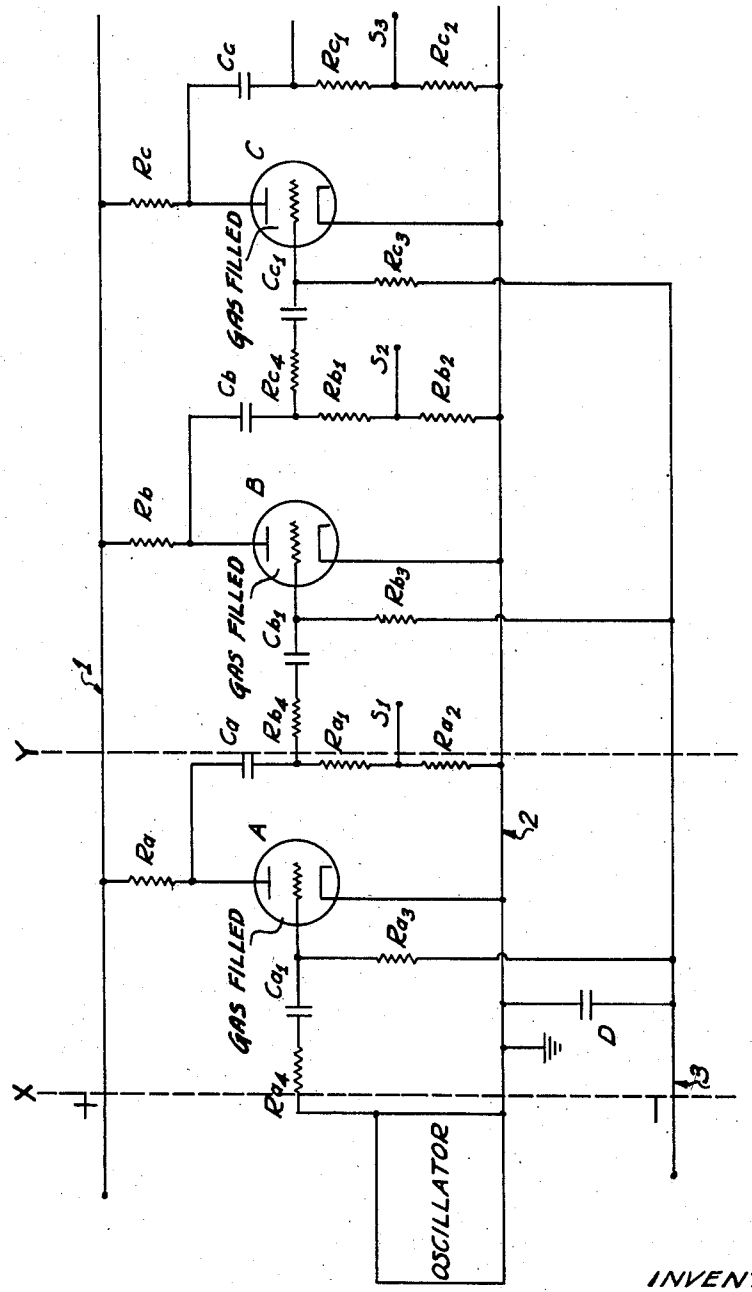
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FREQUENCY DIVIDER

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FREQUENCY DIVIDER

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Our invention relates to a means for providing a series of frequency dividers which, when supplied with a given input frequency, will in turn produce a series of frequencies separated by octave relation. Our invention is of particular importance in electrical musical instruments though its utility is not confined thereto.

In a copending application #53,955 filed December 11, 1935 by Winston E. Kock, Patent #2,128,367, granted August 30, 1938, it was shown that a series of cascaded gaseous discharge relaxation oscillators could be made to operate in synchronism at octave separation. Each oscillator had a definite frequency of its own and would oscillate at this frequency should the coupling circuit be opened. It was necessary that this self-excited frequency be somewhat less than the frequency at which it was desired to synchronize the oscillator in order that synchronization octave coupling would occur. If the relaxation oscillator tended to have a materially greater frequency than the synchronized frequency, the relationship between the frequency of the relaxation oscillator and its synchronizing signal would immediately change from a relationship of one to two to a relationship of perhaps the order of three to four, to secure a ratio of whole numbers. This effect was due to the fact that the synchronizing signal could control only the initiation, of the discharge.

The device to be described herein was developed to increase the range of control over which octave separation would occur and at the same time increase manufacturing tolerances as far as electrical constants were concerned. It was also developed to prevent lower notes in the octave series from becoming off-key if a higher frequency member of the series was rendered inoperative.

Briefly, in the practice of our invention, we provide a series of glow discharge tubes of the three element type connected in a cascade in such a way that the oscillations generated in each tube are caused to act upon and vary the potential of a grid in a succeeding tube. There is for the series a master oscillator of some sort. This oscillator may be of any type, preferably stabilized, or may be any means for producing a stabilized audio frequency output. We prefer to use what we have termed an inductive glow discharge oscillator, which comprises a glow discharge tube having a feed circuit and a control circuit of tuned character for stabilizing the oscillations and containing both inductance and capacity. Or we may employ the modification of this oscillator set forth in the application referred to above and comprising a three element glow discharge tube, the grid of which is energized by pulsations inductively derived from pulsations in the plate circuit. Instead of using the grid excitation as employed in the aforesaid Patent #2,128,367 to trigger the discharge of a succeeding tube, in our present system we so arrange the constants in the several tube circuits that those tubes other than the master oscillator, tend normally to remain in a condition of continuous discharge, because they tend to remain continuously in the ionized or conducting state; and we employ the grid excitation voltage as a means for extinguishing the said continuous discharge, by swinging the grid far enough negative, as will be more fully explained hereinafter.

In the drawing, we have illustrated a portion sufficient for the understanding of our invention, of a system comprising a master oscillator, and a plurality of frequency dividers, as aforesaid. The lead 1 is a power lead for the application of a positive potential to the plates of the cascaded tubes A, B and C, and these plates are connected to the lead 1 through resistances R*a*, R*b*, R*c*, etc. The cathodes or filaments are, of course, grounded to a lead 2. A biasing potential for the grids of these tubes is supplied by a negative lead 3, connected to the grids of the several tubes as shown, through resistances Ra_3, Rb_3, Rc_3, as shown. Each tube has a controlling circuit comprising a capacity C*a*, C*b*, C*c*, etc., and resistances R*a*, Ra_1, Ra_2; R*b*, Rb_1, Rb_2; R*c*, Rc_1, Rc_2, etc. Terminals S_1, S_2, S_3, etc., provide means for tapping off the frequencies of the several tubes for use elsewhere. It will be noted that the output of each of these frequency divider circuits is connected to the grid of the succeeding frequency divider circuit, through a resistance and capacity, which is indicated as Ra_4, Ca_1; Rb_4, Cb_1, Rc_4, Cc_1, etc. The oscillator is so marked in the drawing.

In each of the frequency dividing circuits, in the drawing, no self-excited oscillation can occur. In the circuit including tube A shown between the two dotted lines X and Y drawn purely for explanation, constants of the resistance R*a* and Ra_1, Ra_2 and capacity C*a* are so chosen that the gaseous discharge tube tends to remain continuously in the ionized or conducting state so that no alternating or pulsating current is normally present when the grid of the tube is not excited by an alternating current. The grid of the tube is maintained at a negative d-c potential thru resistor Ra_3. An alternating

potential from an external source is developed across Ra_3, thru resistance Ra_4 and condenser Ca_1. The voltage across Ra_3 will then swing alternately more or less negative. On the more negative peaks the tube A will be deionized and the discharge will cease. The discharge cannot again continue until condenser Ca builds up to the ignition potential of tube A. If the constants Ra, Ra_1 and Ra_2 and Ca be properly chosen, the tube will be deionized in only alternate cycles of voltage from the external source shown, labeled oscillator in the drawing. The resistance Ra, Ra_1 Ra_2 and capacity Ca are chosen such that their values would tend approximately to make tube A operate at half the frequency of the synchronizing signal, were the resistance Ra_1 small enough to allow continuous self-excited oscillations. However, Ra_1 is made so large that the condition of self-excited oscillation cannot occur and the tube tends to be continually in the ionized state, except when deionized by the incoming signal. Ra_2 is a resistance small as compared with Ra_1 and is used to provide a low impedance source from which to draw current for signal purposes by means of the lead S_1. Condenser D is provided as a bypass to ground for the synchronizing frequency.

To deionize a three element glow discharge tube through the exercise of a voltage change on its grid requires, of course, the application of a heavy negative grid voltage. In a preferred practice of our invention however, we provide most of this voltage by applying to the grid a negative potential of such value that the tube, as ionized, is above its extinction point by a small departure. The balance of the negative voltage required we then provide in the negative pulsation from the incoming signal, and in this way we effect an economy of signal required for the purpose. It will be understood however, that within limits, we may reduce the amount of negative grid potential and increase the amount of signal.

The ignition potential of a three element glow discharge tube is, of course, a function of the potential on its grid, and to permit the tube to reionize after an interval as described above, we compensate for the negative grid potential employed by providing sufficient positive potential for the tube plate.

The circuit including tube B is identical with the circuit including tube A except that the constants Rb, Rb_1, Rb_2 and Cb are so chosen that tube B will operate only on alternate impulses from the plate-to-cathode control circuit of tube A. As many circuits may be cascaded as desired. The drawing shows three; and more may be connected to the leads 1, 2 and 3 in the way shown. In one practice of our invention we have used a type 885 tube.

There are a number of advantages in our arrangement. The values of the capacities and resistances for the several frequency dividers are not critical, and no provision need be made for critical tuning. Hence the frequency control for the stable master oscillator need be the only variable control in the system. Also, if the master oscillator or any frequency divider circuit should become inoperative, the subsequent divider circuits go into a stage of continuous discharge, and no longer produce oscillations. Thus they are prevented from oscillating at an uncontrolled frequency, which would be undesirable. The system is further inexpensive to construct and maintain.

Having thus described our invention, what we claim as new and desire to secure by Letters Patent is:

1. In a frequency divider, a gaseous glow discharge tube including an anode, a cathode and a grid, an anode-to-cathode circuit for said tube including a resistance and a source of steady positive potential above the striking potential of said tube, a second anode-to-cathode circuit for said tube including a capacity and a resistance of a value high enough in relation to the size of said capacity and the characteristics of said tube to prevent self oscillations in said tube, and a grid-to-cathode circuit for said tube containing a source of steady negative bias potential of such value as to permit said tube to be in a state of continuous discharge, and means for producing in said grid-to-cathode circuit electrical impulses for rendering said grid sufficiently negative to interrupt said discharge.

2. In a frequency divider, a gaseous glow discharge tube including an anode, a cathode and a grid, an anode-to-cathode circuit for said tube including a resistance and a source of steady positive potential above the striking potential of said tube, a second anode-to-cathode circuit for said tube including a capacity and a resistance of a value high enough in relation to the size of said capacity and the characteristics of said tube to prevent self oscillations in said tube, and a grid-to-cathode circuit for said tube containing a source of steady negative bias potential of such value as to permit said tube to be in a state of continuous discharge, and means for producing in said grid-to-cathode circuit electrical impulses for rendering said grid sufficiently negative to interrupt said discharge, said means including a source of stabilized electrical oscillations, the time constant of charge of said capacity in conjunction with said resistances being equal at least to the oscillatory period of said source of stabilized oscillations.

3. In a frequency divider, a gaseous glow discharge tube including an anode, a cathode and a grid, an anode-to-cathode circuit for said tube including a resistance and a source of steady positive potential above the striking potential of said tube, a grid-to-cathode circuit for said tube containing a source of steady negative bias potential of such value as to permit said tube to be in a state of continuous discharge, means for impressing on said grid negative pulsations of sufficient magnitude to cause extinction of said discharge, said means including a source of electrical oscillations, and a second anode-to-cathode circuit for said tube including a resistance and a capacity having in conjunction with said resistances a time constant of charge greater than the period of said source of oscillations so that the discharge in said tube having once been extinguished is not re-ignited by the time of occurrence of a succeeding impulse from said source of oscillations, the resistance in said second mentioned anode-to-cathode circuit being of a value high enough in relation to the size of said capacity and the characteristics of said tube to prevent self oscillations in said tube.

4. In an electrical musical instrument, a source of electrical oscillations, and a cascaded series of frequency dividing devices comprising each a discharge tube of controllable conductivity having at least an anode, a cathode and a grid, an anode-to-cathode feed circuit for said tube containing a source of steady positive potential above the potential which produces substantial con-

ductivity in said tube, means associated with said tube for providing a steady difference in potential between said grid and said cathode, said circuit and said means being of inherently aperiodic nature and such that said tube is in a given state of substantially uniform conductivity, and a control circuit associated with said tube, containing a capacity and a resistance and of inherently aperiodic nature such that said tube is permitted to be in said given state of conductivity, means for coupling said source of oscillations to the grid and cathode of the first device of said series with sufficient intensity to cause substantial variations in the conductivity of said first device, and means for coupling each preceding device to the grid and cathode of the succeeding adjacent device in said series with sufficient intensity to cause substantial variations in the conductivity of said succeeding device, the time constant of the control circuit of each device being substantially double that of the control circuit of the preceding device in said series, and the time constant of the control circuit of the first device in said series being equal at least to the period of said source of oscillations, whereby under influence of said source said devices produce electrical pulsations corresponding respectively to the octavely related notes in a musical instrument, and means for deriving output pulsations corresponding to said notes from the respective said devices.

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