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V. O. KNUDSEN  
OSCILLATION GENERATOR  
Filed Sept. 3, 1921

Fig. 1.

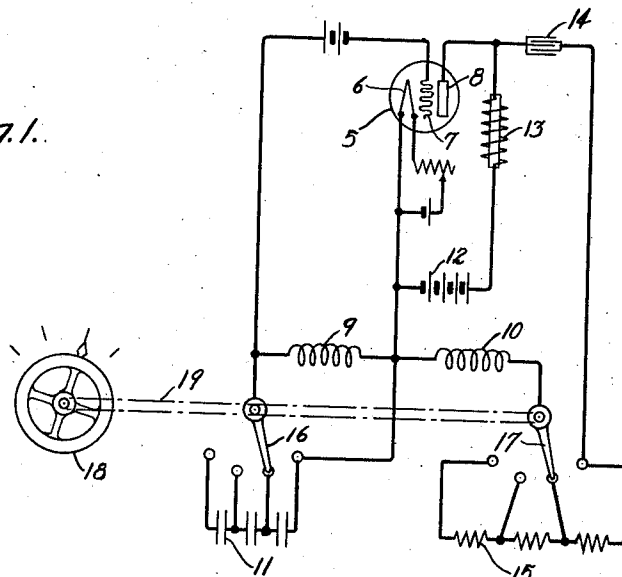
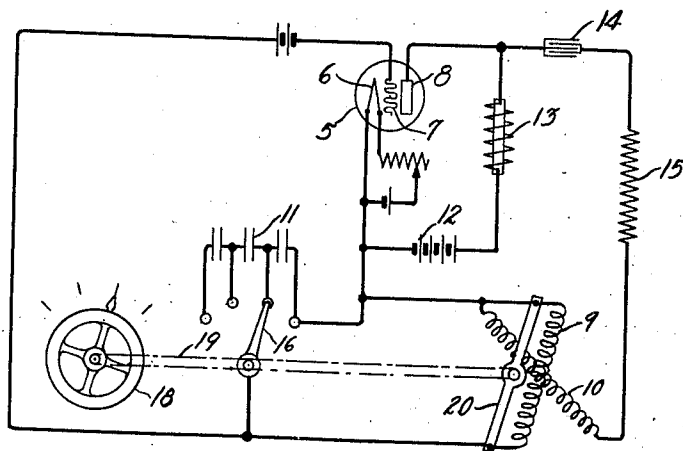


Fig. 2.



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## UNITED STATES PATENT OFFICE.

VERN O. KNUDSEN, OF CHICAGO, ILLINOIS, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

## OSCILLATION GENERATOR.

Application filed September 3, 1921. Serial No. 498,258.

To all whom it may concern:

Be it known that I, VERN O. KNUDSEN, a citizen of the United States, residing at Chicago, in the county of Cook, State of Illinois, have invented certain new and useful Improvements in Oscillation Generators, of which the following is a full, clear, concise, and exact description.

This invention relates to oscillation generators and more particularly to generators employing an electric discharge device having a cathode, an anode and an element for controlling the impedance of the discharge path.

One object of the invention is to provide a variable frequency oscillation generator arranged to give either constant amplitude or maximum amplitude of generated oscillations for each frequency.

Another object is to provide automatic means for accomplishing this result.

A feature of the invention is a variable resistance connected in the oscillation path of the oscillator output circuit.

Another feature is the provision of a divided space comprising a path for plate circuit current and a second path including an adjustable resistance for the generated oscillations.

Another feature is the provision of means to change the frequency of the generated oscillations and automatically to change the resistance in the plate circuit to maintain the amplitude of the generated oscillations either constant or at a maximum value.

Still another feature consists in mechanically changing the tuning condenser and the variable resistance by the same device.

Another feature consists in changing the tuning condenser and adjusting the magnetic feed back coupling by means of a single mechanical device while the resistance in the plate circuit remains unchanged.

In one embodiment of the invention the input circuit and output circuit of a three-electrode discharge device are inductively related to cause the generation of oscillations. A variable condenser is connected in shunt of one of the coupling coils, and a variable resistance is connected in series in

the oscillation path of a divided plate circuit. A variable condenser and a variable resistance are both controlled by the same mechanical device to change the frequency of the generated oscillations and to control their amplitude.

In another embodiment of the invention, the degree of coupling between the input and output circuits is variable. A variable condenser is connected in shunt with one of the coupling coils and a fixed resistance is connected in series in the oscillation path of a divided plate circuit. The variable condenser which determines the frequency of the generated oscillations and the coupling coils are all controlled by the same mechanical device.

Fig. 1 of the drawing shows one embodiment of the invention in which the resistance in the plate circuit is varied to determine the amplitude of the generated oscillations, while Fig. 2 shows another embodiment in which the feed-back coupling is varied to accomplish the same result.

Referring now to Fig. 1 of the drawing, a three-electrode thermionic vacuum tube 5, having a filament 6, a grid or impedance controlling element 7 and a plate 8 is connected in circuit with feed-back coils 9, 10 and the variable condenser 11 to produce oscillations. The filament may be heated in any well-known manner such as by a battery, the current of which is controlled by a variable resistance. Plate circuit energy for the device is supplied by the source 12 through choke coil 13. The choke coil 13 allows flow of direct current, while substantially preventing any flow of generated oscillating current through this path. The circuit for the generated oscillations between the plate 8 and the filament 5 consists of a condenser 14, a variable resistance 15 and feed-back coil 10.

For a given feed-back coupling of coils 9 and 10, the amplitude of the generated oscillations is determined or controlled by the amount of variable resistance 15 connected in series in the path of the generated oscillations. For a given amplitude, the value of this resistance depends upon the capacity of the condenser 11 connected in shunt of the coil 9. A single mechanical

device comprising the connectors 16 and 17 is controlled by hand-wheel 18 through the intermediary of a shaft 19. By properly proportioning the elements of the variable resistance 15 and the variable condenser 11, either maximum amplitude or constant amplitude of generated oscillations may be automatically obtained for all of the generated frequencies by the operation of hand-wheel 18.

In the embodiment shown in Fig. 2 the resistance is maintained constant while the coupling between the feed-back coils is varied. Like reference characters are used for like parts in both figures.

In Fig. 2, instead of the connector 17 mounted on the shaft 19 of Fig. 1, is a revoluble arm 20 with which is fixedly mounted the feed-back coil 9. By the operation of the hand-wheel 18, not only is the value of the frequency controlling con-

denser 11 changed, but the coupling between coils 9 and 10 is varied in such a way as to keep the amplitude of the generated oscillations either constant or maximum or of any predetermined value. The resistance 15 connected in the path of the generated oscillations makes possible such an adjustment.

The generators may be associated with work circuits in any suitable manner, a variety of ways being known to those skilled in this art.

The value of the resistance to be used under any given condition may be determined either by experiment or mathematically. The invention, however, is not dependent upon the method of determining these values.

In order to mathematically determine the values of capacity of the condenser 11 and resistance of resistance element 15, the following formulæ may be used:

$$r = -r_0 + \frac{L_1 p}{r_2} \left[ (1 - k^2) L_2 p - \frac{1}{C p} (1 - k \mu \sqrt{\frac{L_2}{L_1}}) \right] \quad (1)$$

nd

$$C = \frac{1}{p^2 \left[ L_2 + \frac{r_2}{r_0 + r} L_1 \right]} \quad (2)$$

where

$r$ =resistance of chamber 15 in ohms,

$C$ =capacity of condenser 11 in microfarads,

$r_0$ =internal filament to plate impedance of tube 5 in ohms,

$p$ = $2\pi$  times the frequency of the generated oscillations,

$\mu$ =amplification factor of the tube,

$L_1$ =self-inductance of coil 10 in henrys,

$L_2$ =self-inductance of coil 9 in henrys,

$r_1$ =effective resistance of coil 10 in ohms,

$r_2$ =effective resistance of coil 9 in ohms,

$K$ =coefficient of coupling of coils 9 and 10.

The condenser 14 and choke coil 13 have such large capacity and inductance respectively, that they can be neglected.

These formulæ may be used whether constant amplitude or maximum amplitude is desired, since the amplitude of the generated oscillations is a function of the internal filament to plate impedance of the tube ( $r_0$ ). This function does not lend itself readily to mathematical expression and can best be determined experimentally. These formulæ apply only to the particular oscillator circuits shown in the drawing, but similar ones can be derived for any of the other well-known oscillator circuits.

While the invention has been specifically described in connection with two preferred embodiments, other embodiments will be obvious to those skilled in the art. The in-

vention is to be limited only by the scope of the appended claims.

What is claimed is:

1. In an oscillation generator, an amplifying device having an input and an output circuit, means to couple said input and output circuits to produce oscillations, means to determine the frequency of the generated oscillations, a variable resistance connected in series in said output circuit to determine the amplitude of the generated oscillations, and a single means to vary both the frequency determining means and said variable resistance.

2. In an oscillation generator, an amplifying device having an input and an output circuit, means to couple said input and output circuits to produce oscillations, a variable condenser to determine the frequency of the generated oscillations, a variable resistance connected in series in the output circuit to determine the amplitude of the generated oscillations, and a single means to vary both the frequency determining condenser and the amplitude determining resistance.

3. In an oscillation generator, an amplifying device having an input and an output circuit, means to couple said input and output circuits to produce oscillations, a variable condenser to determine the frequency of the generated oscillations, a variable resistance connected in series in the output circuit to determine the amplitude of the generated oscillations, and a mechanical de-

vice to vary simultaneously the frequency determining condenser and the amplitude determining resistance.

4. In an oscillation generator, a vacuum tube amplifying device having an input and an output circuit, means to couple said input and output circuits to produce oscillations, means to determine the frequency of the generated oscillations, a variable resistance connected in series in said output circuit to determine the amplitude of the generated oscillations, and a single means to vary both the frequency determining means and said variable resistance.

5. In an oscillation generator, a vacuum tube amplifying device having an input and an output circuit, means to couple said input and output circuits to produce oscillations, a variable condenser to determine the frequency of the generated oscillations, a variable resistance connected in series in the output circuit to determine the amplitude of the generated oscillations, and a single means to vary both the frequency determining condenser and the amplitude determining resistance.

6. In an oscillation generator, a vacuum tube amplifying device having an input and an output circuit, means to couple said input and output circuits to produce oscillations, a variable condenser to determine the frequency of the generated oscillations, a variable resistance connected in series in the output circuit to determine the amplitude of the generated oscillations, and a mechanical device to vary simultaneously the frequency determining condenser and the amplitude determining resistance.

7. In an oscillation generator, a thermionic tube having an anode, a cathode and an impedance controlling element, an input circuit for said tube comprising an impedance controlling element and cathode, an output circuit for said tube comprising said anode and said cathode, means to couple said input and output circuits to produce oscillations, means to determine the frequency of the generated oscillations, a variable resistance connected in series in said output circuit to determine the amplitude of the generated oscillations, and a single means to vary both the frequency determining means and said variable resistance.

8. In an oscillation generator, a vacuum tube having an anode, a cathode and an impedance controlling element, an input circuit for said tube comprising an impedance controlling element and cathode, an output circuit for said tube comprising said anode and said cathode, means to couple said input and output circuits to produce oscillations, a variable condenser to determine the frequency of the generated oscillations, a variable resistance connected in series in the output circuit to determine the

amplitude of the generated oscillations, and a single means to vary both the frequency determining condenser and the amplitude determining resistance.

9. In an oscillation generator, a thermionic vacuum tube having an anode, a cathode and an impedance controlling element, an input circuit for said tube comprising an impedance controlling element and cathode, an output circuit for said tube comprising said anode and said cathode, means to couple said input and output circuits to produce oscillations, a variable condenser to determine the frequency of the generated oscillations, a variable resistance connected in series in the output circuit to determine the amplitude of the generated oscillations, and a mechanical device to vary simultaneously the frequency determining condenser and the amplitude determining resistance.

10. In an oscillation generator, an amplifying device having an input circuit including a tuned circuit and a divided output circuit, means to couple said input and output circuits to produce oscillations, a source of energy for said divided output circuit connected in one path thereof, means in said path to prevent the flow of generated oscillations therein, and a resistance in the other path connected in series with said coupling means to determine the amplitude of the generated oscillations.

11. In an oscillation generator, a thermionic vacuum tube amplifying device having an input circuit including a tuned circuit and a divided output circuit, means to couple said input and output circuits to produce oscillations, a source of energy for said divided output circuit connected in one path thereof, means in said path to prevent the flow of generated oscillations therein, and a resistance in the other path connected in series with said coupling means to determine the amplitude of the generated oscillations.

12. In an oscillation generator, an electric discharge device having an anode, a cathode and an impedance controlling element, an input circuit for said tube comprising said impedance controlling element and cathode and a tuned circuit, a divided output circuit for said tube comprising said anode and said cathode, means to couple said input and output circuits to produce oscillations, a source of energy for said divided output circuit connected in one path thereof, means in said path to prevent the flow of generated oscillations therein, and a resistance connected in series in the other path between said anode and coupling means to determine the amplitude of the generated oscillations.

In witness whereof, I hereunto subscribe my name this 31st day of August A. D., 1921.

VERN O. KNUDSEN.