Nov. 3, 1925. 1,559,656

I. J. THORP

METHOD OF AND MEANS FOR INCREASING VOLTAGES

Filed April 26, 1921

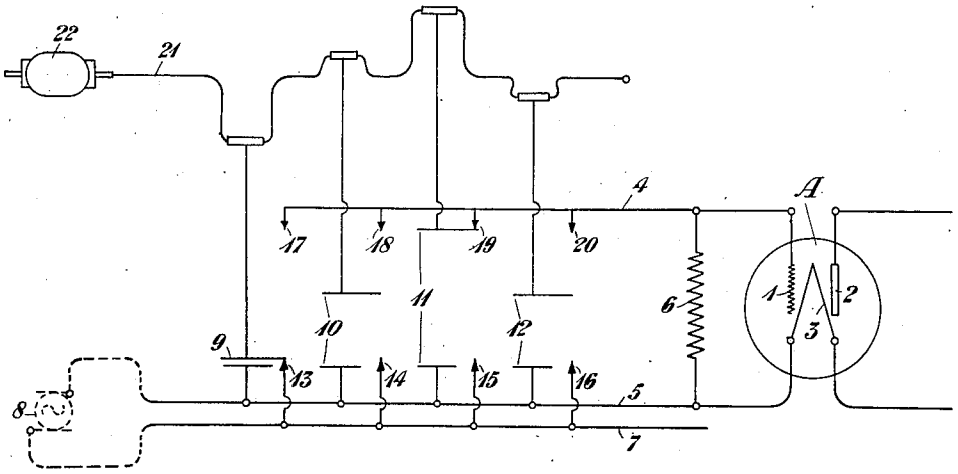

Fig. 1

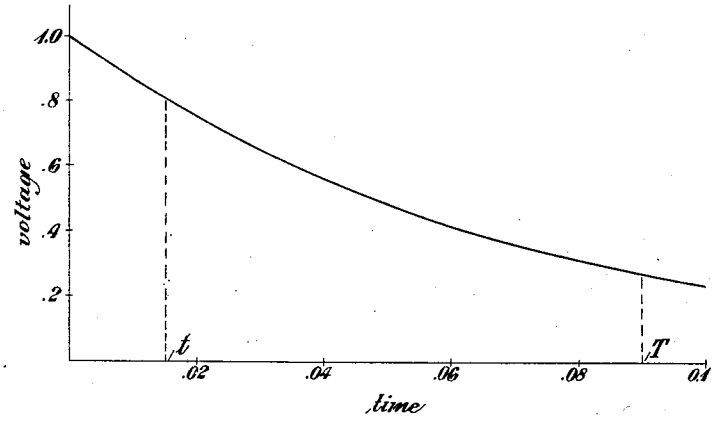

Fig. 2

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Patented Nov. 3, 1925. 1,559,656

UNITED STATES PATENT OFFICE.

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METHOD OF AND MEANS FOR INCREASING VOLTAGES.

Application filed April 26, 1921. Serial No. 464,709.

To all whom it may concern:

Be it known that I, I. JAY THORP, residing at Maplewood, in the county of Essex and State of New Jersey, have invented certain Improvements in Methods of and Means for Increasing Voltages, of which the following is a specification.

This invention relates to arrangements for increasing or augmenting voltages applied from a source of potential to a device associated therewith.

A specific instance in which the arrangements of the invention might be utilized would be in cases in which the amplification of low frequency currents is involved. With the arrangements of the invention the potential applied by such currents to the grid of a vacuum tube amplifier may be materially increased and thus provide a greater degree of amplification. Furthermore these arrangements might be utilized to advantage when it might be desired to measure variations in potential of very weak currents. The method herein disclosed for increasing the voltage applied to a device, such as to the grid of a vacuum tube amplifier, employs a variable capacity condenser. The condenser, whose plates are close together at the outset and whose capacity is therefore maximum, is first connected to the source of potential to be amplified or measured so as to charge the condenser. The plates of the condenser are then pulled apart so as to decrease the capacity while maintaining the charge on the plate constant, thus increasing the voltage, and the condenser is then applied to the grid of the amplifier. In other words mechanical energy devoted to the pulling apart of the condenser plates is translated and developed into an increase in the applied voltage.

The invention may be more fully understood from the following description together with the accompanying drawing in the Fig. 1 of which is illustrated a circuit diagram of a preferred form of the invention and in Fig. 2 is shown graphically a curve illustrating the principles of operation thereof.

In Fig. 1 is shown a vacuum bulb amplifier A connected through the arrangements of the invention to a source 8 of potential. The vacuum bulb contains a plate 2, a filament 3, and a grid 1. The grid is connected to a conductor 4 and the filament to a conductor 5. The source 8 is connected to conductor 5 and also to a conductor 7. Associated with the conductors 4, 5, and 7 are the condensers 9, 10, 11, and 12. These condensers have their upper plates connected to a rotating shaft 21 whereby the plates of the condensers may be pulled apart and the capacities varied. The rotating shaft may be operated by any suitable source of mechanical power, such as the motor 22. The lower plates of the condensers are rigidly fixed and are attached to conductor 5. Associated with conductor 7 are the contact points 13, 14, 15, and 16, and associated with conductor 4 are the contact points 17, 18, 19, and 20.

When the plates of one of the condensers are close together, as shown in the drawing for condenser 9, one of the contact points, such as contact 13, will be connected to the upper plate of the condenser. As the lower plate is at the same time connected to conductor 5 the condenser will be charged. As the rotating shaft 21 revolves the upper plate of condenser 9 will be pulled away from the lower plate and from contact 13. The charge on the upper plate will remain constant but the pulling apart of the plates will decrease the capacity and thus increase the voltage on the upper plate. When the shaft 21 has revolved further the upper plate of condenser 9 will come into contact with the contact point 17 which is connected to the conductor 4 leading to the grid of the amplifier A and the increased potential will thus be applied to the grid. The upper plate of condenser 11 is shown in this position and is applying increased potential to contact point 19 and to the grid. The plates of condensers 10 and 12 are shown in half opened positions by the operation of shaft 21. As has been pointed out the pulling apart of the plates of the condensers, while maintaining the charge thereon constant, will decrease the capacity but will increase the voltage, so that with the arrangement shown when the upper plates come into contact with the contact points 17, 18, 19 and 20 an increased potential will be applied to the grid of the amplifier.

In Fig. 2 is shown an exponential time-voltage curve upon which are based the following calculations made to obtain an idea of the capacities which the condensers, such as 9, 10, 11, and 12, would need to have in

order to effect a voltage amplification of 9:1, assuming the ratio of maximum to minimum capacity of the condensers is 10:1 and also assuming four condensers discharged at a rate of 1000 discharges per minute. Let t_1 be the time of discharge of each condenser and—

$$t_1 = \frac{1}{4} \times 60 \times \frac{1}{1000} = .015 \text{ seconds.}$$

The equation of the curve is

$$v = Ve^{-\frac{t}{CR}} \quad (1)$$

where v is the variable voltage, V is the maximum voltage, e is the base of the Naperian logaritham, t is the time of discharge, C is the capacity of the circuit, and R is the resistance of the circuit.

The time constant T of a circuit is by definition that value of the time t for which $\frac{t}{CR}$ in the equation (1) of the curve becomes unity. In other words T is that value of the time t at which $t = CR$ and

$$\therefore T = CR \quad (2)$$

Assume the average voltage from 0 to t_1 on the curve to be .9 of the maximum, which maximum on the curve is given as 1.0

$$\text{Let } \frac{t_1}{T} = X \quad (3)$$

X being the proportion which t_1 bears to the time constant T.

Now since the average voltage during the interval from time 0 to time t_1 is known and since from equation (1) the voltage at time T is e^{-1}, the value of X may be readily computed to be .215.

Then from equation (3) it follows that in order that the average voltage should equal .9 of the maximum, the time constant T should be such that

$$.015 : T :: .215 : 1$$

and hence

$$T = \frac{.015}{.215} = .07 \text{ seconds.}$$

Assume that the grid leak equals 5 megohms. Now from equation (2)

$$C = \frac{T}{R} = \frac{.07}{5} = .014 \text{ m. f.}$$

In other words the condensers should each have a capacity of .014 microfarads at the time of greatest separation to give a voltage amplification under the above conditions of 9:1.

While the arrangements of the invention have been shown as associated with a vacuum bulb amplifier, it is pointed out that they might equally well be utilized for increasing potentials applied to other devices. Furthermore the number of condensers, the speed of operation, and capacities of the condensers may be varied if desired. Accordingly while the invention has been disclosed in certain arrangements which have been deemed desirable, it is understood that it is capable of embodiment in many and widely varied forms without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. A source of potential, a device to which voltage from said source is to be applied, a condenser having its plates connected to said source, mechanical means for periodically and uniformly pulling one of the plates of said condenser away from the other while maintaining the charge thereon constant, and means for discharging said condenser plate on said device.

2. A source of potential, a device to which voltage from said source is to be applied, a mechanically rotated shaft, and a plurality of condensers having their lower plates connected to said source and their upper plates connected to said shaft, whereby said upper plates may be alternately connected to said source and charged and may be moved away from said lower plates and discharged on said device.

3. A source of potential, a vacuum tube device to the grid circuit of which voltage from said source is to be applied, a plurality of condensers, means for connecting the plates of said condensers to said source, mechanical means for pulling the plates of each of said condensers apart in rotation and disconnecting one of the plates of each of said condensers from said source, and means for applying said last mentioned plates of said condensers in rotation to the grid circuit of said vacuum tube whereby said plates may be discharged on said grid circuit.

In testimony whereof, I have signed my name to this specification this 25th day of April, 1921.

I. JAY THORP.