Dec. 2, 1941. F. H. GULLIKSEN 2,264,695

DISCHARGE APPARATUS

Filed Sept. 3, 1938

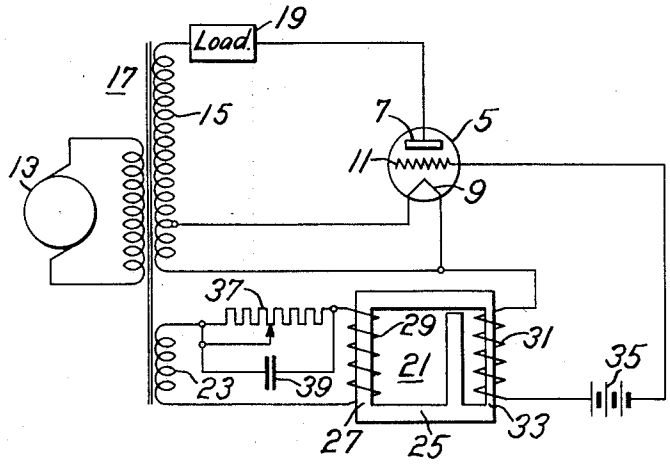

Fig. 1.

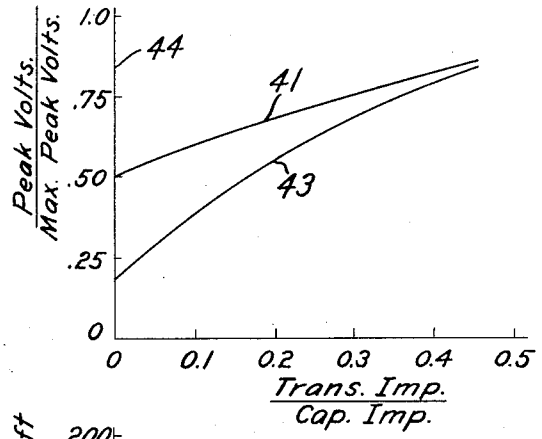

Fig. 2.

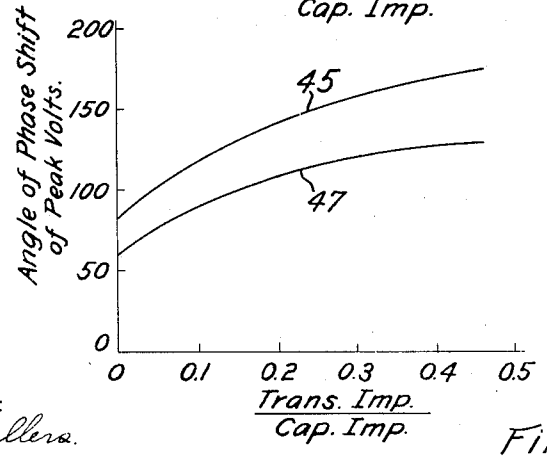

Fig. 3.

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Patented Dec. 2, 1941

2,264,695

UNITED STATES PATENT OFFICE

2,264,695

DISCHARGE APPARATUS

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Application September 3, 1938, Serial No. 228,329

9 Claims. (Cl. 250—27)

My invention relates to translating apparatus, and has particular relation to apparatus for producing potential impulses of peaked wave form for the control of electric discharge valves.

Electric discharge valves are often used in situations in which it is desirable that the control potential supplied shall be of short duration compared to the periods or half-periods of a supply source. Control impulses of this wave form are obtained by interposing a saturable transformer between the supply source and the point at which the impulses are impressed. With the primary of the saturable transformers connected directly across the source, the peaked impulses derived from the secondary occur at points in the half waves of the source displaced by 90° from the zero potential points. A shift in the phase of the peaked potential relative to the source waves is attained in accordance with the teachings of the prior art of which I am aware, by connecting a variable resistor in series with the primary of the transformer. As the series resistance increases, the angle of shift is increased. With this arrangement, however, the maximum phase shift attainable is somewhat less than 90° and, therefore, it has no utility in the numerous situations in which a shift greater than 90° is desirable. Another disadvantage of the device arises from the fact that as the resistance is increased, the amplitude of the peaked potential derived in the secondary of the transformer decreases so that for a substantial shift in phase the secondary potential is relatively small and as a matter of fact, does not have the desired peaked wave form.

It is accordingly an object of my invention to provide an arrangement for driving, from a source of periodically pulsating potential, potentials of short duration compared to the periods of the source which may be shifted in phase with reference to the waves of the source by a substantial angle.

Another object of my invention is to provide apparatus for deriving, from a source of alternating potential, impulses of short duration compared to the half-periods of the source which shall occur at points in the half waves of the source that may be selected at will over an angle substantially greater than 90°.

Another object of my invention is to provide apparatus for deriving, from a source of periodically pulsating potential, potential impulses of short duration compared to the periods of the source, which shall have substantially a uniform amplitude regardless of the phase angle between the impulses and the maxima of the waves of the source.

More specifically stated, it is an object of my invention to provide apparatus of simple and inexpensive structure for attaining potentials of peaked wave form to control an electric discharge valve.

According to my invention, a capacitor is connected in parallel with the variable resistor in the primary circuit of the saturable transformer. I have found that when the capacitor has the maximum capacity permitted by the rating of the transformer, the phase of the potential derived from the secondary of the transformer may be shifted over an extensive angle relative to the waves of the source, and when a shift is introduced, the derived potential does not vary substantially in amplitude.

While in the preferred practice of my invention the control transformer is saturable, I do not intend to limit its scope only to apparatus incorporating transformers of this type. Where the teaching of my invention is used with an ordinary non-saturable transformer, it is intended that such use shall constitute an equivalent within its scope. It is further to be noted that while in the specific practice of my invention disclosed herein the variable resistor and the capacitor are connected to the primary winding of the transformer, these impedances may also be connected to an auxiliary winding. Such connection, when made for the purpose of attaining the same results attained by my invention, is intended to be included within the scope of my invention.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with additional objects and advantages thereof, will best be understood from the following description of a specific embodiment when read in connection with the accompanying drawing, in which:

Figure 1 is a diagrammatic view showing an embodiment of my invention;

Fig. 2 is a graph showing certain results attained with apparatus constructed in accordance with my invention; and

Fig. 3 is another graph showing further results attained with the apparatus.

The apparatus shown in Figure 1 comprises an electric discharge valve 5 preferably, but not necessarily, of the arc-like type. The valve has an anode 7, a hot cathode 9 and a control elec-

trode 11. Anode-cathode potential is supplied to the valve from an alternating-current source 13 which may be of the ordinary commercial frequency type. The anode 7 of the valve is connected to one terminal of a secondary section 15 of a transformer 17, energized from the source, through the load 19 supplied through the valve and the cathode 9 is connected to the other terminal.

Control potential is supplied to the discharge valve 5 from a saturable transformer 21 which is supplied with potential through another secondary section 23 of the supply transformer 17. The saturable transformer 21 is of the usual structure having a saturable core 25 on the wide leg 27 of which the primary 29 is wound, while the secondary 31 is wound on the narrow leg 33. The secondary 31 of the transformer 21 is connected between the control electrode 11 and the cathode 9 through a biasing source 35. The impulses impressed between the control electrode 11 and the cathode 9 when the primary 29 of the transformer 21 is energized counteract the effect of the biasing source 35 and render the valve 5 conductive.

To shift at will the phase of the points in the half-waves of the source 13 at which the impulses occur, a rheostat 37 is connected in series with the primary 29 of the saturable transformer 21 and a capacitor 39 is connected in parallel with the resistor. I have found that the most satisfactory results are attained when the capacitor 39 has the highest possible impedance permitted by the rating of the saturable transformer 21. The value of the maximum impedance may be derived from the simple consideration that for the maximum current flow the inequality $X_C - X_L > X_L$ must be satisfied. In this inequality, X_C is the capacity impedance and X_L is the impedance of the saturable transformer 21. From the above relationship it is seen that the minimum capacity impedance is given by the expression

$$X_C = 2X_L$$

or

$$\frac{X_L}{X_C} = \frac{1}{2}$$

This relationship is well borne out by experiments which I have carried out.

The tests were made with an impulse transformer 21 having a primary reactance of 247 ohms and a rated primary current of .45 ampere. The transformer was supplied through various rheostats 37 and capacitors 39 from a 60-cycle source 13 of the ordinary commercial type. The plots in Figs. 2 and 3 are graphs showing the results of the tests.

In Fig. 2 the ratio of the amplitude of the peak potential actually attained to the maximum peak potential attained when the resistance 37 in series with the primary 29 of the saturable transformer 21 is zero, is plotted vertically and the ratio of the transformer impedance to the capacity impedance

$$\left(\frac{X_L}{X_C}\right)$$

is plotted horizontally. The upper curve 41 shows the results obtained for a resistance 37 of 1,000 ohms and the lower curve 43 shows the results for a resistance of 2,000 ohms. It will be noted that as the ratio of the transformer impedance to the capacity impedance approaches ½, the ratio plotted as ordinate approaches 1. That is to say, when the ratio of the impedances is substantially one-half, the variation in the amplitude of the peaked potential derived from the secondary 31 is a minimum. The condition which exists in the absence of a capacitor 39 is represented by the points of intersection of the curves 41 and 43 and the axis of ordinates 44. These points show that with the capacitor absent, the amplitude of the peaked potentials is reduced to less than ¼ of its maximum value when the resistance is 2,000 ohms and to ½ of its maximum value with 1,000 ohms resistance.

In Fig. 3 the angle over which the phase of the peaked potential relative to the half-waves of the source 13 may be shifted is plotted vertically and the ratio of the impedances 37 and 39 is plotted horizontally. The upper curve 45 corresponds to a 10,000 ohms variable resistor 37 and the lower curve 47 to a 2,000 ohms resistor. In this case it will be noted again that an angle of shift of 180° may be attained by selecting the ratio to be approximately 0.5. Attention is called to the fact that for the ratio of zero, that is to say, for a situation in which the capacitor is entirely absent, the angle of shift is approximately 60° for the 2,000 ohms resistor and 85° for the 10,000 ohms resistor.

Although I have shown and described certain specific embodiments of my invention, I am fully aware that many modifications thereof are possible. My invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. For use in converting the pulsations of a source of periodically pulsating potential into pulses of short duration compared to a period of the source displaced in phase relative to the pulsations of the source by an angle which is predeterminable at will, the combination comprising a saturable transformer having primary winding means in circuit with said source, and secondary winding means, and variable resistance means shunted by capacitative means in circuit with one of said winding means.

2. For use in converting the pulsations of a source of periodically pulsating potential into pulses of short duration compared to a period of the source displaced in phase relative to the pulsations of the source by an angle which is predeterminable at will, the combination comprising a saturable transformer having primary winding means in circuit with said source, and secondary winding means, and variable resistance means shunted by capacitative means in circuit with said primary winding means.

3. For use in converting the pulsations of a source of periodically pulsating potential into pulses of short duration compared to a period of the source displaced in phase relative to the pulsations of the source by an angle which is predeterminable at will, the combination comprising a saturable transformer having primary winding means in circuit with said source, and secondary winding means, and variable resistance means shunted by capacitative means in circuit with said primary winding means, said capacitative means having a reactance ratio with said transformer of the order of 1 to 2.

4. For use in converting the pulsations of a source of periodically pulsating potential into pulses of short duration compared to a period of the source displaced in phase relative to the pulsations of the source by an angle which is predeterminable at will, the combination comprising a saturable transformer having primary winding means in circuit with said source, and

secondary winding means, and variable resistance means shunted by capacitative means in circuit with said primary winding means, said capacitative means having a value such that

$$\frac{X_L}{X_C}$$

approaches one-half, where X_L is the transformer reactance, at the frequency of said source and X_C is the reactance of said capacitative means at said frequency.

5. In combination, an electric discharge device having a control electrode and a plurality of principal electrodes, a saturable transformer having primary and secondary windings, a source of periodically pulsating potential, means for connecting the secondary of said transformer between said control electrode and one of said principal electrodes, and means for connecting the primary of said transformer to said source, the last said connecting means including variable resistance means and capacity means connected in parallel with said resistance means.

6. In combination, an electric discharge device having a control electrode and a plurality of principal electrodes, a saturable transformer having primary and secondary windings, a source of periodically pulsating potential, means for impressing a potential from said source between said principal electrodes, means for connecting the secondary of said transformer between said control electrode and one of said principal electrodes, and means for connecting the primary of said transformer to said source, the last said connecting means including variable resistance means and capacity means connected in parallel with said resistance means.

7. In combination, an electric discharge device having a control electrode and a plurality of principal electrodes, a saturable transformer having primary and secondary windings, a source of periodically pulsating potential, means for connecting the secondary of said transformer between said control electrode and one of said principal electrodes, and means for connecting the primary of said transformer to said source, the last said connecting means including variable resistance means and capacity means connected in parallel with said resistance means and capacity means having a reactance ratio with said transformer of the order of 1 to 2.

8. In combination, an electric discharge device having a control electrode and a plurality of principal electrodes, a saturable transformer having primary and secondary windings, a source of alternating potential, means for connecting the secondary of said transformer between said control electrode and one of said principal electrodes, and means for connecting the primary of said transformer to said source, the last said connecting means including variable resistance means and capacity means connected in parallel with said resistance means.

9. In combination, an electric discharge device of the arc-like type having a control electrode and a plurality of principal electrodes, a saturable transformer having primary and secondary windings, a source of periodically pulsating potential, means for connecting the secondary of said transformer between said control electrode and one of said principal electrodes, and means for connecting the primary of said transformer to said source, the last said connecting means including variable resistance means and capacity means connected in parallel with said resistance means.

FINN H. GULLIKSEN.