Dec. 21, 1948. R. LEE ET AL 2,456,960

PULSE SHAPING CONTROL SYSTEM

Filed July 27, 1945

Fig. 1.

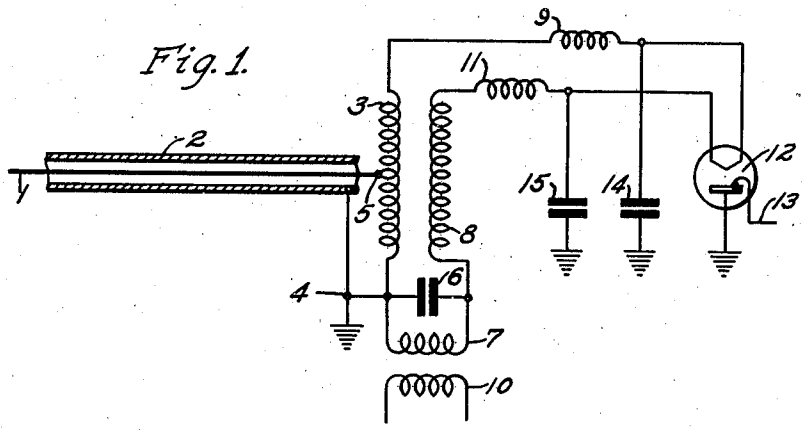


Fig. 3.

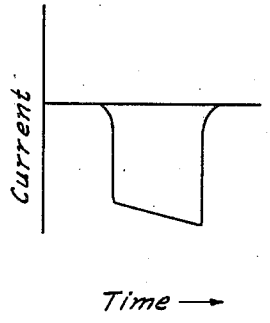


Fig. 2.

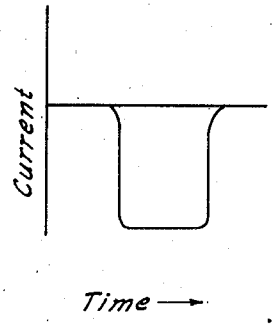
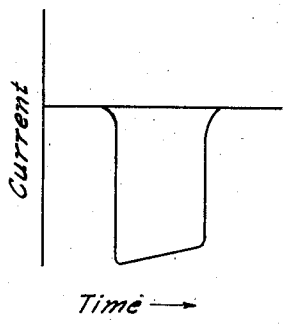


Fig. 4.



WITNESSES:

Leon M. Garman

Wm. C. Groome

INVENTORS

Reuben Lee and

Philip A. Duffy, Jr.

BY

F. W. Lee

ATTORNEY

Patented Dec. 21, 1948

2,456,960

UNITED STATES PATENT OFFICE

2,456,960

PULSE SHAPING CONTROL SYSTEM

Reuben Lee, Linthicum Heights, and Philip A. Duffy, Jr., Baltimore, Md., assignors to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application July 27, 1945, Serial No. 607,434

2 Claims. (Cl. 250—27)

1

Our invention relates to current pulse shaping network and, in particular, relates to such networks for transmitting square topped current pulses substantially without distortion to operating loads such as the anode-to-cathode circuit of magnetron oscillation generators.

For many purposes, it has been found desirable to supply current to the anodes of magnetron oscillation generators and other loads in successive pulses of rectangular wave form; that is to say, in pulses having a substantially flat top and vertical edges. It is frequently desirable to be able to transform the voltage and current values of such pulses to different magnitudes from that at which they are transmitted over transmission lines from their point of generation to the load they supply. However, it has been found that the design of transformers for this purpose imposed very great difficulties and that it was in fact practically impossible to produce a transformer which would, when a rectangular voltage pulse was impressed on its primary, transmit to a magnetron or other load a current pulse which was a true replica of the impressed pulse. Instead of yielding a flat topped pulse of the desired form illustrated in Fig. 2, a pulse of the form shown in Fig. 3 having an obtuse angle adjacent its beginning edge and an acute angle at its trailing edge, was actually produced. When supplied to a magnetron, it was found that pulses of the Fig. 3 form produced undesirable frequency modulation and other undesirable features in the magnetron output. Some arrangement which would transmit a pulse of the type shown in Fig. 2 without distortion was accordingly much to be desired.

One object of our invention is accordingly to produce a transmission network capable of transforming the voltage and current of an impressed pulse of the rectangular type without producing substantial distortion.

Another object of our invention is to provide means for controlling the shape of the output voltage of a transformer system when a rectangular voltage pulse is impressed on its input terminals.

Still another object of our invention is to provide a network capable of transforming the magnitude of a voltage impressed on its input terminals and at the same time to produce an output pulse having vertical edges and a trough making an acute angle with the beginning-edge.

Other objects of our invention will become apparent from reading the following description taken in connection with the drawing, in which:

2

Figure 1 is a schematic diagram of a transformation network for impressing rectangular current on the anode-to-cathode circuit of a magnetron or other load,

Fig. 2 is a time vs. current curve showing the desired form of output pulse to be impressed by such a network on a magnetron,

Fig. 3 is a time vs. current curve showing the type of output pulse produced by transformation networks of the prior art, and

Fig. 4 is a time vs. current curve showing an over-compensated type of output pulse derivable in accordance with the principles of my invention by properly proportioning the circuit constants.

Referring in detail to Fig. 1, a supply line, which may comprise a central core 1 and a sheath 2 is fed with energy to impress across the inductive winding 3 to which is connected a current pulse of the rectangular type shown in Fig. 2. Where it is desired to step up the amplitude of the voltage pulse to be transmitted to the load, the conductors 1 and 2 are connected across two points 4 and 5 of the winding 3, of which point 4 is preferably one of the end terminals. The point 4 is connected through a capacitor 6 shunted by a secondary winding 7 to the homologous end of a second winding 8, preferably identical with winding 3. The free ends of the windings 3 and 8 are respectively connected through inductors 9 and 11 to the respective ends of the cathode filament of a magnetron 12 or other similar load. The secondary winding 7 is energized by a primary winding 10 to supply heating current to the cathode of magnetron 12. The terminal 4 and the anode of the magnetron 12 are preferably connected to ground. An output circuit may be coupled to a loop 13 of the magnetron 12. Capacitors 14, 15 are preferably connected between ground and the terminals of the cathode of magnetron 12.

Were the inductors 9, 11 and capacitors 14, 15 omitted from the circuit of Fig. 1, an output pulse of the form shown in Fig. 3 would be impressed between the cathode and anode of the magnetron 12 when a pulse of the form shown in Fig. 2 was impressed on the input terminals 4, 5. By properly proportioning the inductance of the inductors 9, 11, the self-inductance inherent in the windings 3 and 8, and the inductance in the leads between the cathode of magnetron 12 and such windings, to the capacitors 14, 15 and the effective capacitance of the circuit connected to the cathode of magnetron 12, it is possible to alter the output pulse impressed between the

anode and cathode of the magnetron 12 from the form shown in Fig. 3 to conform to the rectangular pulse shown in Fig. 2; and even to overcompensate it to the form shown in Fig. 4. Methods of determining such effective inductances and capacitances are well known to those skilled in the electrical art; specific illustrations appear in Lee Patent No. 2,412,893, filed October 21, 1943, and assigned to the assignee of this application.

The addition of the inductors 9 and 11 and the capacitors 14 and 15 may vary somewhat the width of the pulse applied to the magnetron. In order to keep the pulse width within practical limits, the following relationships may be adopted.

Calling L the total inductance in circuit with the cathode of magnetron 12 (i. e., L is the sum of the self (i. e., the leakage) inductance in henries of windings 3 and 8 and self-inductance of inductors 9 and 11 and the line wires connected to the cathode of magnetron 12); and calling C the total capacitance in farads of the same circuit (i. e., C is the sum of the effective capacitance of capacitors 14 and 15 plus magnetron capacitance plus the effective capacitance of windings 3 and 8, inductors 9 and 11, and the line wires connecting to the cathode of magnetron 12), the following relations should be fulfilled in order to produce an output pulse different from that shown in Fig. 3.

$$(1) \qquad \sqrt{\frac{L}{C}}=K_1R$$

$$(2) \qquad \sqrt{LC}=K_2T$$

Where R is the ratio of the anode-to-cathode voltage pulse impressed on the magnetron to the peak anode-to-cathode amperes through the magnetron, T is the pulse width in microseconds, K_1 is a factor which may vary between the limits of 0.25 and 3.0, and K_2 is a factor which may vary between 0.05 and 0.20.

The foregoing equations thus permit the evaluation of L and C, and hence, from known data as to the self inductance and capacitance of the windings 3 and 8 and the transmission lines connecting them to the cathode of magnetron 12, permit the calculations of the inductance of inductors 9, 11 and capacitors 14, 15.

When it is desired to produce an output voltage of the form in Fig. 4, the capacitors 14 and 15 should be given larger values than that corresponding to the foregoing calculations. The amount of such increase in the values of capacitors 14 and 15 will depend upon the angle of slant to be given to the trough of the voltage wave in Fig. 4.

We claim as our invention:

1. In combination with a source of substantially rectangular voltage pulses, a transformer winding having one end terminal and an intermediate terminal impressed with said pulses, a second transformer winding having an end connected to said one end by a channel offering substantially zero impedance to the frequencies embodied in said voltage pulses, a load circuit having a pair of connections at one terminal, two inductors respectively connected between said pair of connections and the free ends of said windings, a pair of capacitors connected between ground and the terminals of said inductances adjacent said load, and an interconnection between said one end and the other side of said load circuit, the square root of the ratio of the total inductance in henries of the circuit connected to said pair of connections to its effective capacitance in farads lying between the limits of 0.25 and 3.0 times the resistance in ohms of said load circuit.

2. In combination with a source of substantially rectangular voltage pulses, a transformer winding having one end terminal and an intermediate terminal impressed with said pulses, a second transformer winding having an end connected to said one end by a channel offering substantially zero impedance to the frequencies embodied in said voltage pulses, a magnetron having its anode grounded and having a cathode with two connections, a pair of capacitors connecting the ends of said cathode to ground, two inductors respectively connected between said pair of connections and the free ends of said windings, and an interconnection between said one end and ground, the square root of the ratio of the total inductance in henries of the circuit connected to said pair of connections to its effective capacitance in farads lying between the limits of 0 25 and 3.0 times.

REUBEN LEE.
PHILIP A. DUFFY, JR.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,860,114	Okabe	May 24, 1932
2,103,362	Hansell	Dec. 28, 1937
2,412,893	Lee	Dec. 17, 1946