

Dec. 27, 1927.

1,654,085

G. T. LORANCE

VOLTAGE LIMITING DEVICE

Filed Oct. 21, 1925

Fig. 1.

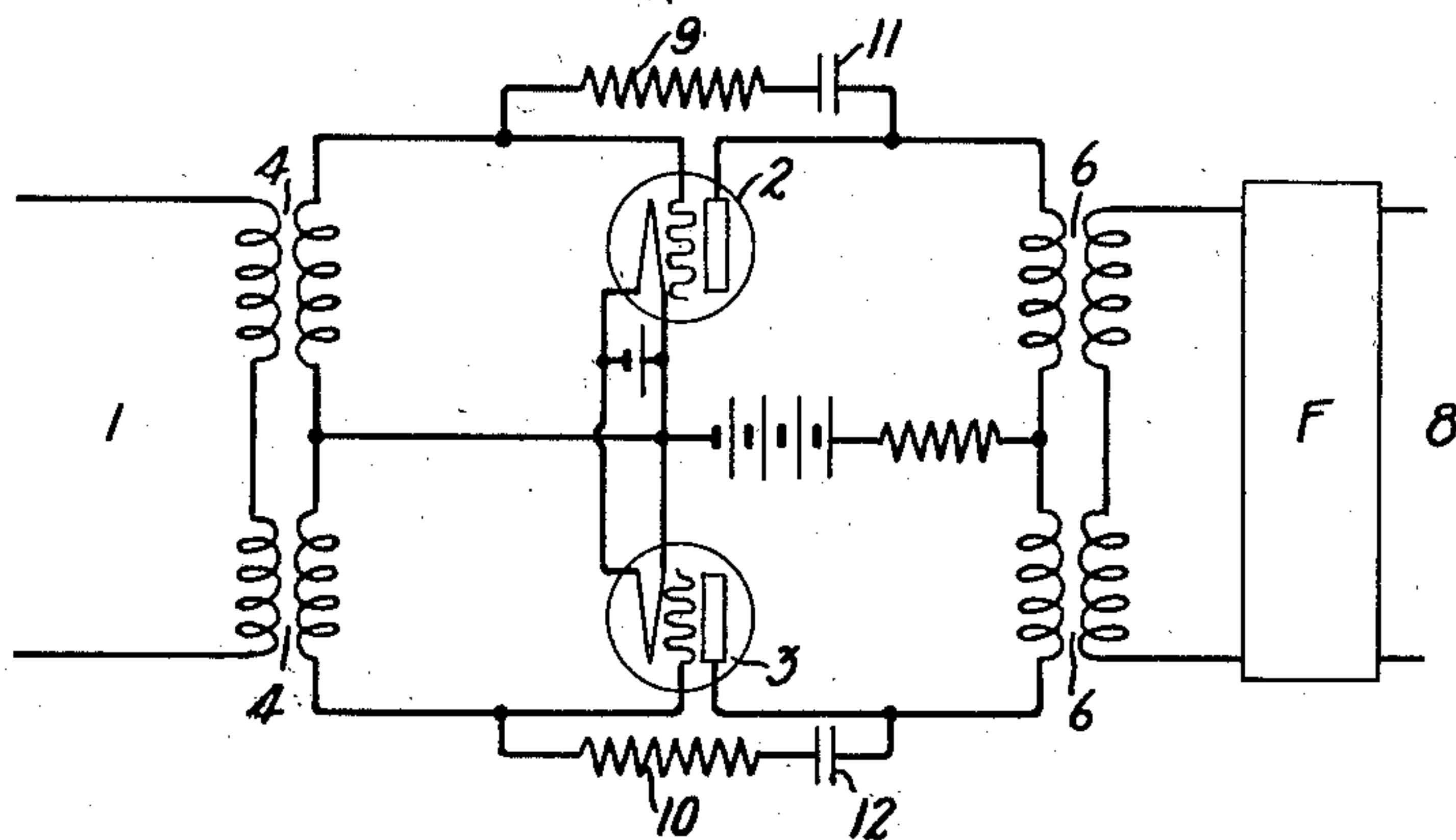


Fig. 2.

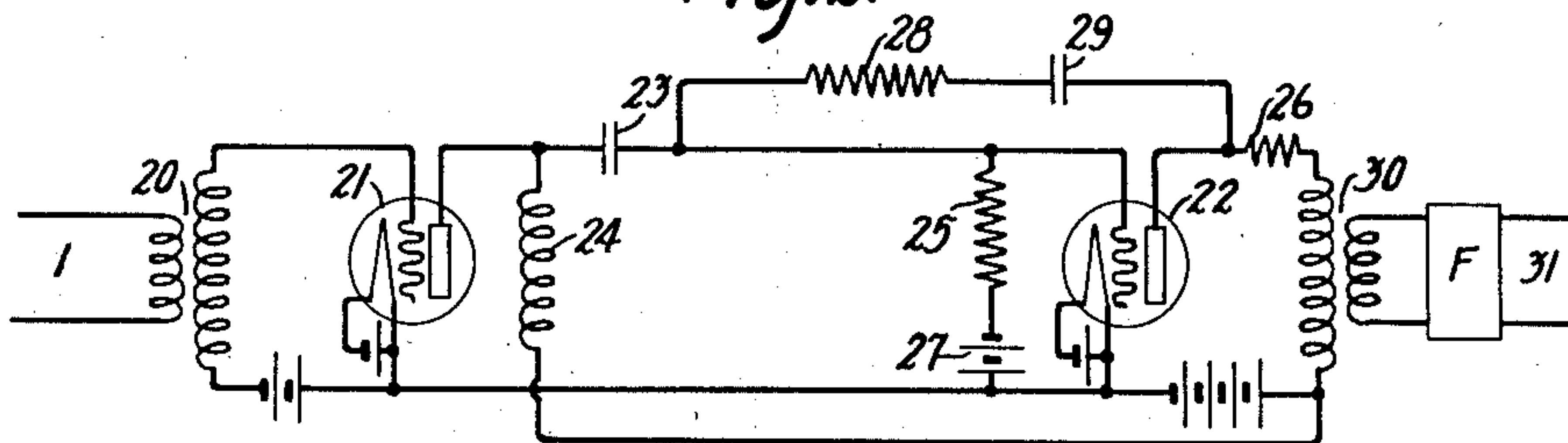
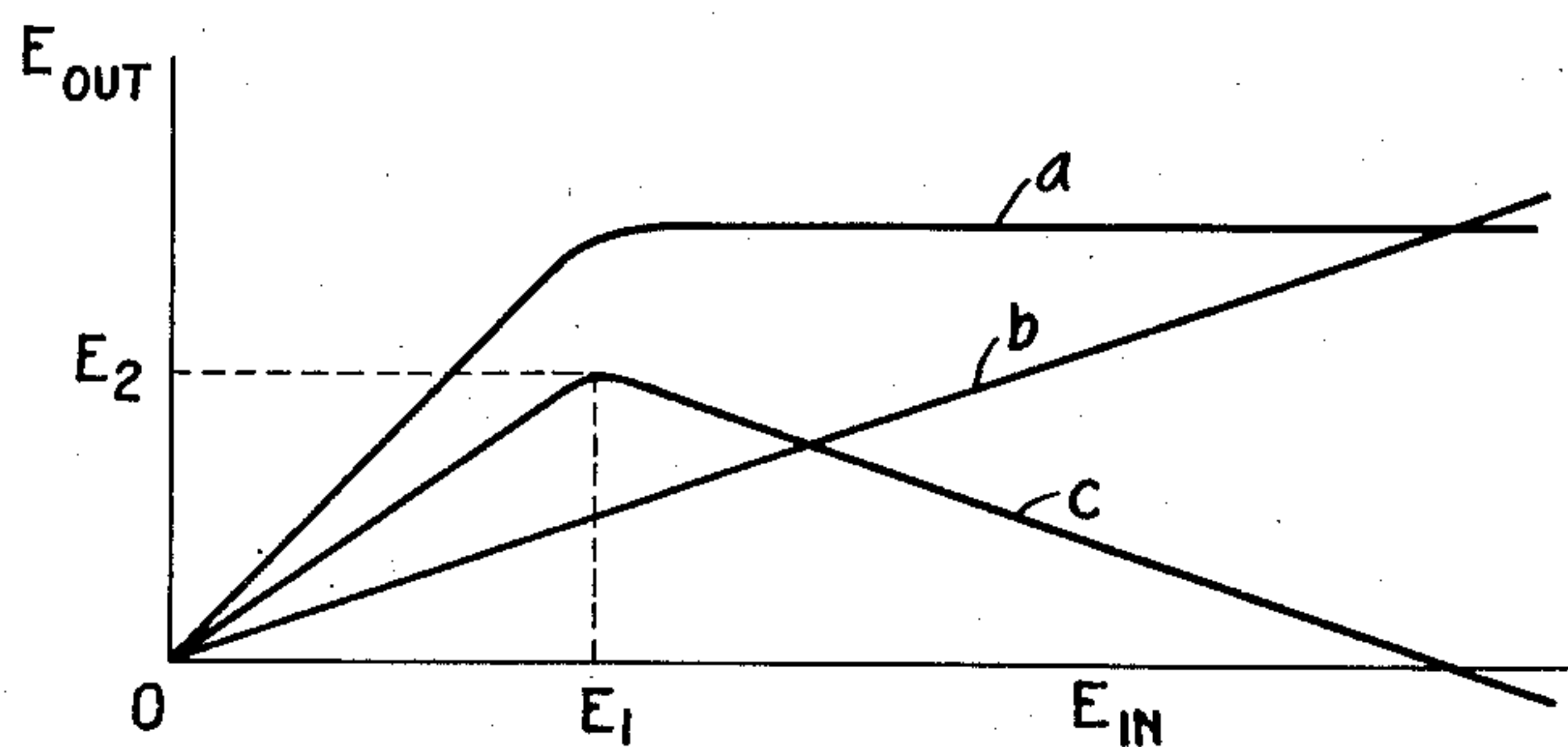


Fig. 3.



Inventor:
George T. Lorange
by *E. W. Adams* Att'y.

UNITED STATES PATENT OFFICE.

GEORGE T. LORANCE, OF NEW YORK, N. Y., ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

VOLTAGE-LIMITING DEVICE.

Application filed October 21, 1925. Serial No. 64,049.

This invention relates to signaling systems and more particularly to a method and means for limiting the voltage applied to a specific part of a transmission system.

5 In a transmission system, in order to attain a high transmission efficiency, it is necessary to use various elements included in the circuit at their maximum rated power. In order to do this and to prevent an excess
10 voltage being applied to these elements when the power in the supply circuit is unexpectedly increased, particularly in the case of high power apparatus where such an overload would cause interruptions of the service,
15 it is desirable to employ a device for limiting the voltage applied to the power apparatus to a certain predetermined value irrespective of the voltage applied to the input side of the device.

20 In previously known systems, including voltage limiting devices adapted to limit to a predetermined value the voltage supplied to apparatus to be protected, the form of the voltage wave applied to the apparatus may
25 be flat-topped, that is, of constant amplitude during the time the instantaneous value of the voltage supplied to the limiting device exceeds the desired value. As a flat-top wave is composed of a component of applied
30 frequency having a maximum amplitude greater than the flat-top, and various harmonics thereof; a wave of amplitude greater than the predetermined maximum will occur in a circuit which selects the wave of applied
35 frequency and rejects its harmonics.

A system of the above type will only limit the voltage applied to a load circuit provided this circuit does not discriminate against harmonic frequencies. The potential across
40 the terminals of any circuit in the system selective to the applied frequency will not be limited to the predetermined maximum, but will depend upon the length of the flat-top portion and the slope of the sides.

45 An object of this invention is to limit to a predetermined maximum value the voltage of a wave applied to a circuit of the above mentioned character.

50 Another object is to limit to a predetermined value the amplitude of a wave of de-

sired frequency in a transmission system, whereby the system may be operated at maximum efficiency.

These objects and others which will be apparent as the nature of the invention is
55 disclosed are accomplished in accordance with the present invention by employing a voltage limiting device comprising two channels, having different transmission characteristics, to which the current to be regulated is applied. One channel includes a
60 space discharge device the amplification characteristic of which may be adjusted within certain limits and the other channel includes a resistance path.
65

The energy transmitted through the two channels is superimposed in an output circuit in such a manner that as the instantaneous input voltage is increased, the voltage of the output circuit increases up to a
70 certain point and then continuously decreases. Hence, when the input voltage is greater than a given value the resultant wave in the output circuit comprises a component of fundamental frequency and various components
75 harmonically related thereto, but the amplitude of the component of fundamental frequency is always less than the predetermined maximum.

Although the novel features which are believed to be characteristic of this invention
80 will be pointed out with particularity in the claims appended hereto, the invention itself, its objects and advantages, the manner of its organization and the mode of its operation
85 will be better understood by referring to the following description taken in connection with the accompanying drawing forming a part thereof in which:

Fig. 1 shows diagrammatically one embodiment of this invention,
90

Fig. 2 illustrates a different form thereof, and

Fig. 3 shows a series of curves to be used in explanation of the operation of the systems shown in Figs. 1 and 2.
95

Referring to Fig. 1, the input circuit 1 represents the portion of the circuit supplying current to the two transmitting channels which cooperate to limit to a predetermined
100

value the amplitude of the current supplied to a load circuit. Circuit 1 is coupled to the common input circuit of space discharge devices 2 and 3 by means of a transformer

4. Space discharge devices 2 and 3 are connected in opposing or so-called push-pull relationship in such a manner that currents in the output circuit of one tube increase as current in the output circuit of the other tube decreases. The output circuits of tubes 2 and 3 are coupled by means of a transformer 6 to the filter F. This filter is adapted to pass, without appreciable attenuation, current of a definite frequency or a band of frequencies below a certain cut-off frequency to transmission line 8.

Resistance 9 and condenser 11 are connected between the grid and anode of tube 2 and resistance 10 and condenser 12 are connected between the grid and anode of tube 3 to form a shunt path between the input and output circuits of the device for the purpose to be hereinafter set forth. The condensers 11 and 12 are of large capacity, so that their impedance to the energy transmitted through the channels is negligible. In other words, the impedances of the shunt paths are determined by the resistances 9 and 10.

The operation of this system may be best understood by referring to the series of curves in Fig. 3. In that figure curve *a* represents the amplification characteristic of the channel including space discharge devices 2 and 3, the voltage in the input circuit being plotted against the voltage of the anode circuit. Curve *b* represents the transmission characteristic of the resistance paths between the input and anode circuits through resistances 9 and 10. Inasmuch as phase reversal occurs in space discharge devices 2 and 3, whereas currents in the shunt circuits including resistances 9 and 10 are transmitted without phase change, the corresponding voltages produced in response to the voltage impressed from line 1 will be in opposed relationship in the anode circuit of the space discharge channel. Hence the resultant current may be found by subtracting the ordinates of curve *b* from those of curve *a*. The result is plotted as curve *c*. The peak value of this curve may be controlled by varying the amplification characteristic of the amplifying channel or by varying the transmission characteristic of the parallel resistance channel to produce transmission characteristics represented by curves *a* and *b*.

It will be seen in curve *c* that as the voltage E_{in} applied to the input circuit is varied between the limits zero and E_1 , the voltage E_{out} at the output terminal will be directly proportional to voltage E_{in} but as the input voltage E_{in} increases beyond the

value E_1 , the voltage of the output circuit E_{out} decreases. It is apparent therefore that, irrespective of the maximum value of voltage E_{in} , the maximum instantaneous value of the voltage E_{out} may be limited by adjusting the channels to produce the desired transmission characteristics such as shown in curves *a* and *b* whereby the apparatus connected to the circuit 8 may be protected against instantaneous voltages greater than the limiting value.

If an alternating voltage having a maximum peak voltage less than E_1 is applied to line 1, a voltage having the same wave form will occur in line 8. If the peak voltage of the applied wave is greater than E_1 , the voltage applied to the filter will no longer be of the same form as the applied wave. Instead of a flat-top wave, such as that produced by previously known voltage limiting systems, a wave having a dip in its top portion will be supplied to the filter F due to the decrease in the value of voltage in E_{out} as voltage E_{in} is increased beyond E_1 . Thus there will be supplied to the filter a wave consisting of a component of frequency corresponding to the impressed wave the maximum amplitude of which is limited to a predetermined value and components harmonically related thereto.

The amplitude of the harmonics depends upon the amount by which the maximum potential E_{in} exceeds voltage E_1 and the constants of the transmission channels. Hence, if the constants are properly selected, as the amplitude of voltage E_{in} is increased to a certain value, the voltage of the fundamental frequency in the output circuit becomes a maximum and then decreases, but as the voltage E_{in} is further increased only the harmonics are increased in amplitude. Since the filter F suppresses the harmonics, while it passes the fundamental frequency substantially without attenuation there will be supplied to the line 8, or apparatus connected thereto, a voltage wave corresponding to the impressed wave, the maximum value of which is fixed and independent of the voltage applied to the limiting device over line 1.

By suitably selecting the values of voltages E_{in} and E_1 the third harmonic may be made predominant. If means selective of the third harmonic is included in line 8, this arrangement may be used to produce a wave of frequency, triple that of the wave received over the line 1.

Referring to Fig. 2, current from line 1 is transferred by means of transformer 20 to the input circuit of amplifier tube 21. The output circuit of amplifier 21 is coupled to the input circuit of space discharge device 22 by means of condenser 23 and inductance 24. Battery 27 is adapted to impress a negative biasing potential upon the control

electrode or grid of tube 22. The circuit through which biasing potential is supplied to the grid includes a resistance 25. Resistance 28 and condenser 29 form a shunt path
 5 between the input and output circuits of tube 22. As described in connection with Fig. 1, the impedance of the shunt path is determined by resistance 28. Current in the output circuit of this tube is transferred by
 10 means of transformer 30 to filter F which is adapted to pass currents of a given frequency, or a band of frequencies, to transmission line 31.

In certain cases, it may be desirable to
 15 use a resistance 26 in series with the primary of the transformer 30. This resistance appears to operate to establish a definite ratio between the impedance of the circuit external to the tube as the cathode-plate im-
 20 pedance of the tube, whereby the current transmitted through the shunt path 28—29 may be in the desired phase relation, with respect to the wave impressed upon the input circuit, to properly control the opera-
 25 tion of the tube as a limiting device. Obviously, if the impedance of the output circuit, including the transformer 30, is of the proper value to produce the desired ratio, the resistance 26 will not be used.

30 Amplifier tube 21 serves to raise the potential of the applied wave to a value sufficiently large to operate the voltage limiting apparatus and to compensate for the loss inherent therein. An additional function
 35 is served by tube 21, however, in that when the input voltage has increased to a value sufficient to cause curve *c* to pass the zero axis, beyond which point the absolute value of the output voltage would again increase,
 40 amplifier 21 will reach its overload point and prevent further increase in potential.

Consequently, the system as a whole including amplifier 21 will positively prevent
 45 the output voltage from exceeding the peak value represented by curve *c* irrespective of the applied voltage. Obviously, such an amplifier may be incorporated in the circuit arrangement shown in Fig. 1 to produce the same result.

50 The operation of the circuit shown in Fig. 2 including space discharge path 22 and shunt resistance path 28 is similar to that of Fig. 1 and may be understood by reference to the description of the operation of
 55 Fig. 1 and the curves illustrated in Fig. 3.

Although this invention has been shown and described as applicable to a particular system, it is not to be limited thereto, but only in accordance with the scope of the fol-
 60 lowing claims.

What is claimed is:

1. In a signaling system an incoming line and an outgoing line, a voltage limiting
 65 device comprising a pair of transmission channels connected between said lines trans-

mitting waves in phase opposition to said outgoing line, one of said channels including a space discharge amplifier.

2. In a signaling system an incoming line and an outgoing line, a voltage limiting de-
 70 vice comprising a pair of transmission channels connected in phase opposition, one of said channels including a space discharge amplifier and the other of said channels in-
 75 cluding a resistance path.

3. A voltage limiting device, comprising a pair of transmission channels, one of said channels including a space discharge ampli-
 80 fier and means for governing the transmission characteristics of said amplifier, the other of said channels including a resistance path, and a space discharge amplifier con-
 85 nected between the input circuit and said channels whereby the value of the current impressed upon said channels is controlled.

4. In a signaling system, an incoming line and an outgoing line, two transmission chan-
 90 nels therebetween, common input means in said channels, one of said channels amplifying waves from said incoming line, the other of said channels transmitting said waves
 95 with substantially no amplification, common output means to impress the difference in amplitudes of the outputs of said channels on said outgoing line to limit the voltage in
 100 said outgoing line irrespective of the voltage in said incoming line.

5. In a signaling system, an incoming line and an outgoing line, two transmission
 105 channels therebetween, common input means for said channels, one of said channels comprising a space discharge amplifier for amplifying the waves from said incoming line, the other of said channels transmitting said
 110 waves with substantially no amplification, output means common to said channels for impressing the outputs of said channels on said outgoing line in opposite phase relation
 115 to limit the voltage in said outgoing line.

6. In a signaling system, an incoming
 120 line and an outgoing line, two transmission channels therebetween, input means common to both channels, one of said channels comprising a space discharge amplifier for amplifying waves from said incoming line, the
 125 other of said channels comprising substantially a resistance path and transmitting said waves with no amplification, output means common to said channels for impres-
 130 sing the outputs of said channels on said outgoing line in opposite phase relation to limit the voltage in said outgoing line to a predetermined value.

7. In combination in a signaling system, an incoming line and an outgoing line, a
 135 voltage limiting device comprising a plurality of transmission channels between said lines, input means common to said channels, one of said channels comprising a space dis-
 140 charge amplifier for amplifying and revers-

ing the frequencies in said incoming line, the other of said channels comprising a substantially pure resistance path for transmitting the frequencies from said incoming
5 line with no phase change, output means common to said channels for impressing the difference in amplitude of the outputs of said channels on said outgoing line for controlling the voltage in said outgoing line, and a filter in said output circuit for attenuating certain of said incoming frequencies. 10
In witness whereof, I hereunto subscribe my name this 20th day of October, A. D., 1925.

GEORGE T. LORANCE.