Feb. 24, 1953 H. GALLAY 2,629,856
PTM MODULATOR AND DEMODULATOR SYSTEM
Filed Dec. 19, 1949 2 SHEETS—SHEET 1

Fig. 1.

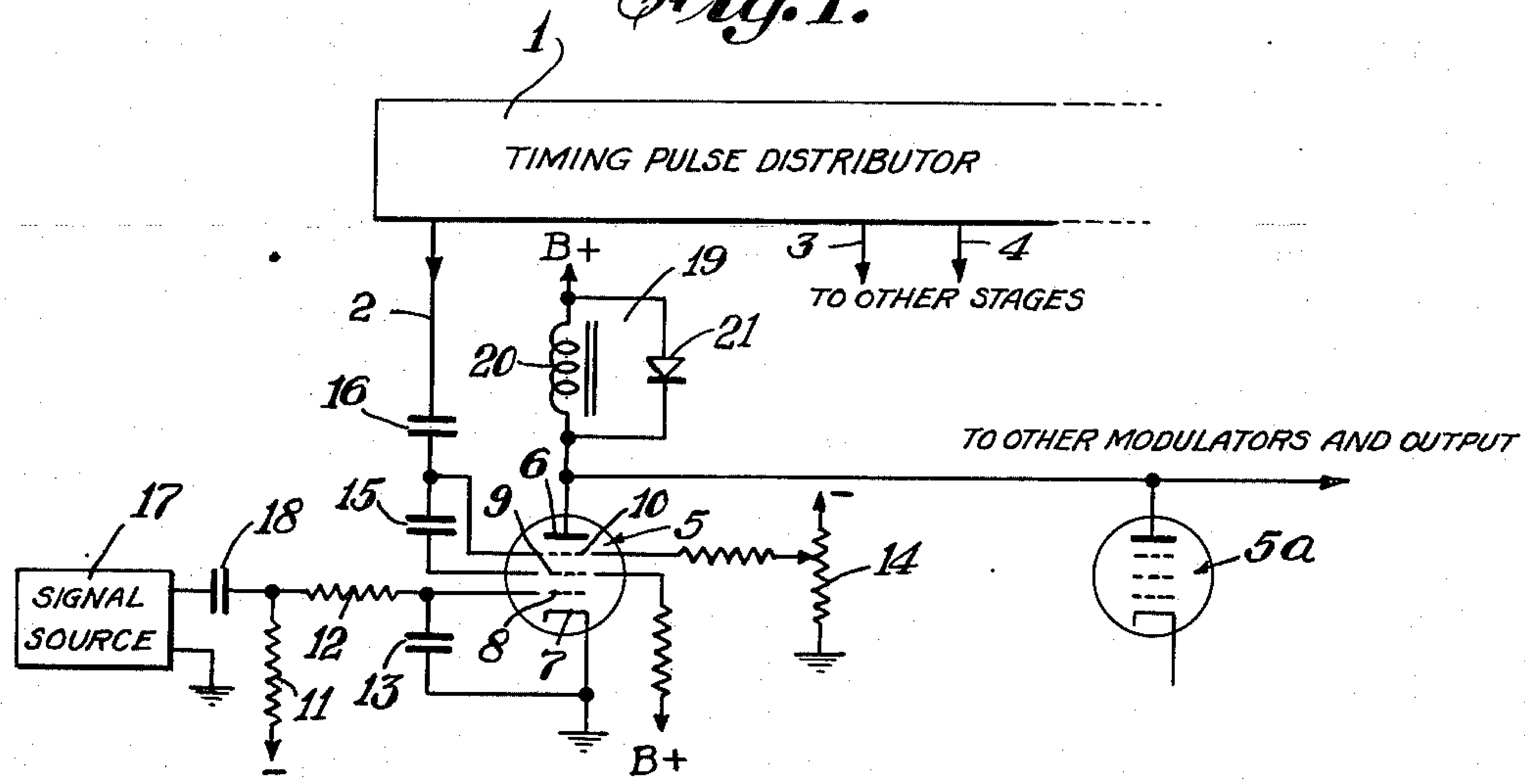


Fig. 2.

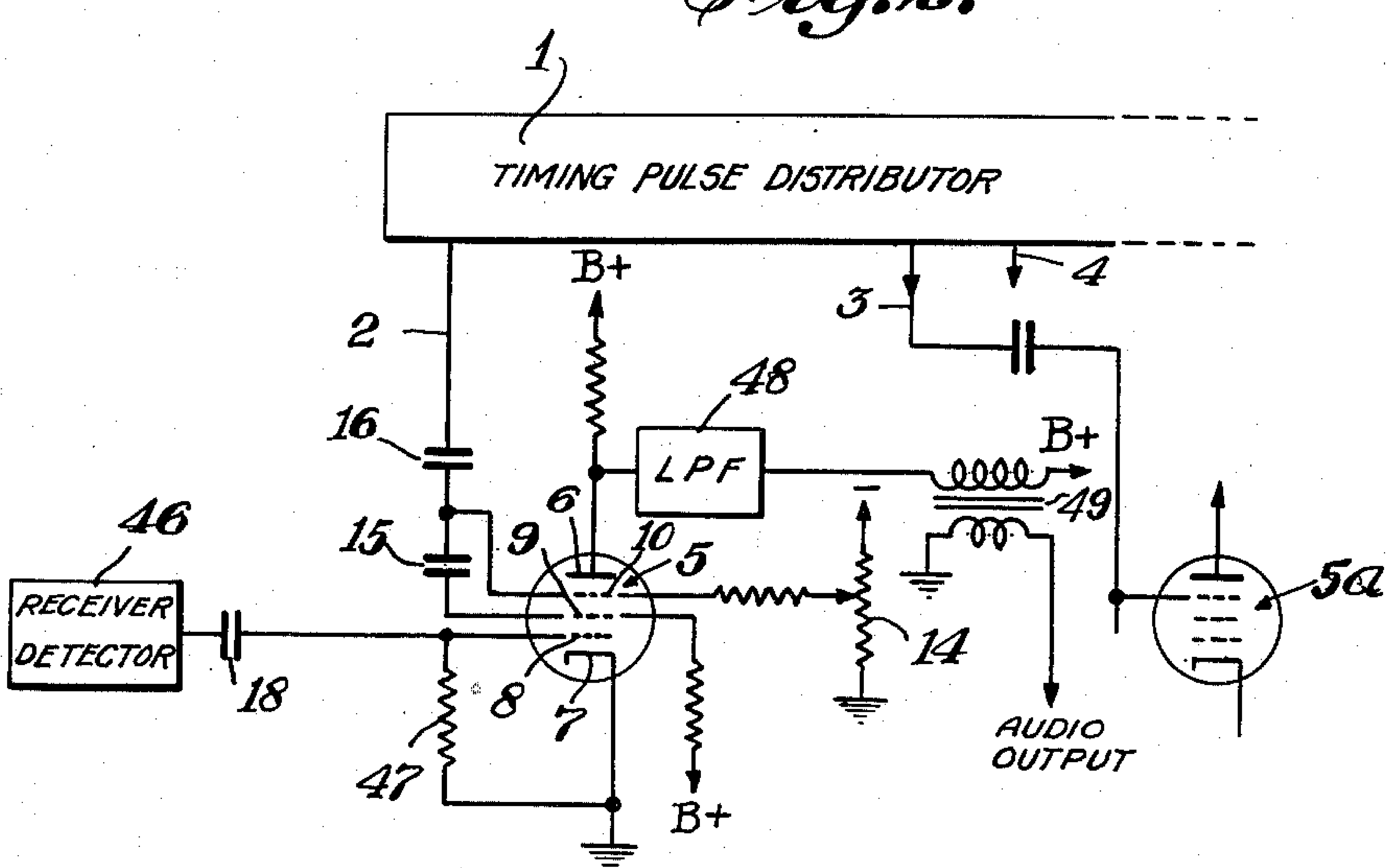


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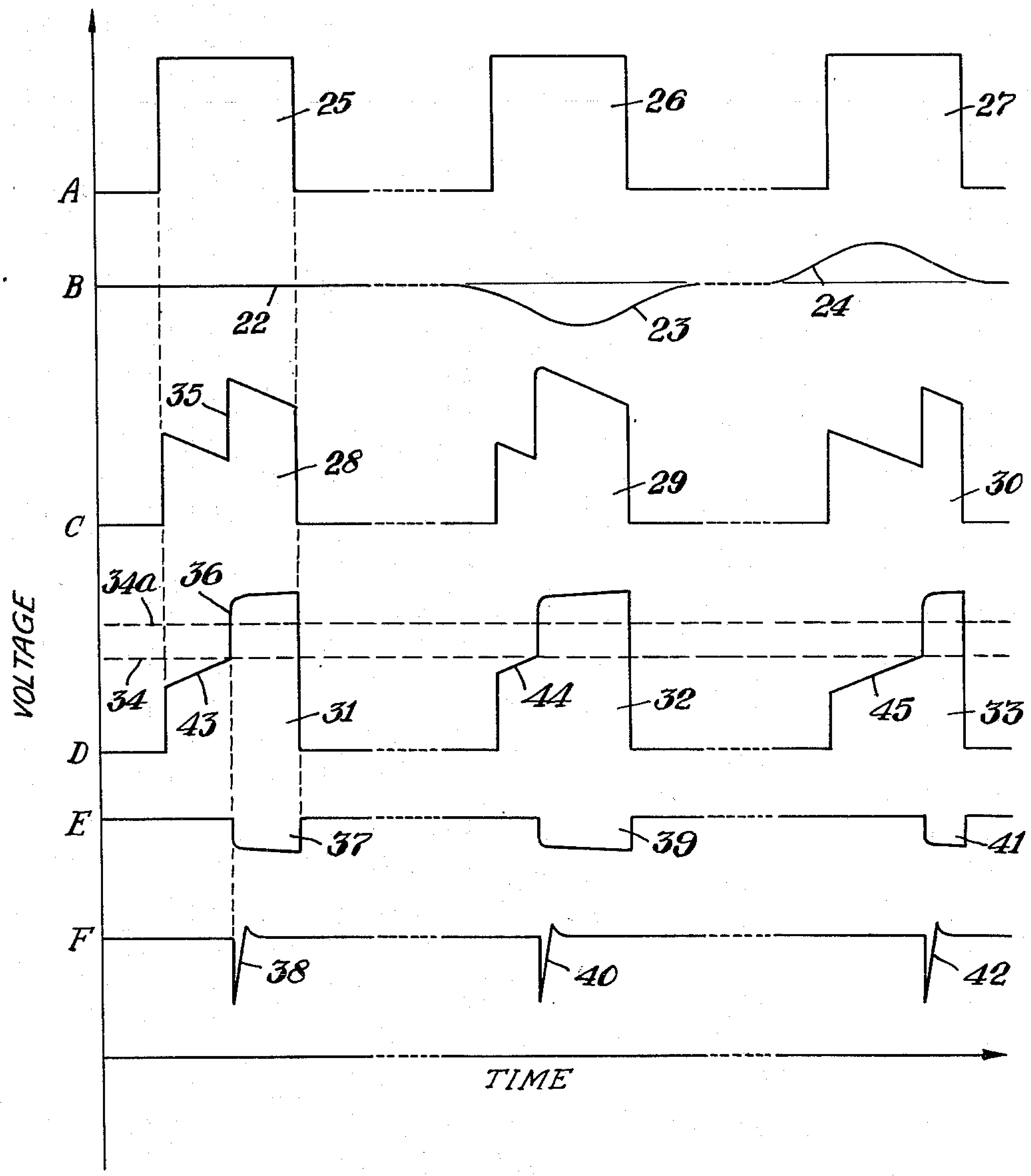
Fig. 3.

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## PTM MODULATOR AND DEMODULATOR SYSTEM

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This invention relates to pulse generators and more particularly to pulse generators controllable in time duration of produced pulses so that they may be used for pulse duration or time displacement modulators and demodulators.

A system of communication wherein signals are transmitted as modulations of a pulse envelope in time duration or time displacement have been quite widely exploited in recent years. In certain of these systems time duration pulses are provided by use of a relaxation oscillator of the multivibrator type controlled by audio waves to produce output pulses of varying time duration or width in accordance with audio input signals. These time duration modulated pulses may be differentiated to provide time displaced pulses at their leading or trailing edges. At the receiver end multivibrator circuits have also been triggered by time displaced pulses to reproduce variable pulse duration signals which may be filtered or otherwise processed to derive the original signalling envelope. With such systems special care must be exercised in construction of the multivibrator circuits in order that they precisely operate to produce the desired pulse duration with or without signals modulation to avoid distortion. It is also necessary that such circuits be made to change from one stable position to the other as abruptly as possible in order precisely to time the occurrence of pulses and thus avoid distortion. When such systems are used for multiplex communication a distributor is provided for keying separate modulator or demodulator circuits into operation sequentially for the selection of desired channels.

While pulse generator circuits may be of the multivibrator type other forms of relaxation or blocking oscillator systems have been provided. One such form of oscillator utilises a single pentode tube having the suppressor grid at a different voltage from the cathode and coupled back to the screen grid so that amplification and oscillation occurs therein. This form of oscillator is commonly known as a "Transitron" oscillator. The "Transitron" type of oscillator produces an ideal pulse form for the purposes described in that the internal coupling action of the tube itself provides for a steep rise in voltage when the tube becomes conductive. However, up to the present time such oscillator circuits have not been utilised for the purpose of time modulation or demodulation.

It is an object of this invention to provide a pulse generator utilising a pentode type tube together with a gating or selector pulse for providing output pulse which may be controlled in time duration for time modulation or demodulation purposes.

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According to a feature of this invention a pulse generator is provided comprising an electron discharge device having an anode, a cathode and first, second and third grids. Means are provided for applying positive voltages to the anode and screen grid. The control grid has less bias than the suppressor grid so that under normal conditions the cathode screen grid path is conductive. A source of positive pulses is provided and these pulses are applied to the suppressor grid tending to render this grid more positive so that conduction is established from the cathode to the anode of the tube. Signal voltages are applied to the control or first grid to vary the time of firing in accordance with input signals.

In an actual circuit arrangement utilising the pulse generator above described for time modulation the pentode is biassed negatively so that in the modulator the tube will be caused to become conductive intermediate the beginning and end of the positive pulses applied to the suppressor grid. The suppressor grid is capacitively coupled with the screen grid so that a partial differentiation of the applied positive pulse occurs at the screen grid and an integration at the suppressor grid. The voltages and circuit constants are so proportioned that the suppressor grid becomes sufficiently positive midway of the applied pulse to cause the tube to conduct in the absence of applied voltage on grid #1, the control grid. When audio or other signal energy is applied to the control grid the time when the tube becomes conductive in its plate circuit is varied dependent upon whether the signal voltage is positive or negative, so that output pulses varying in time duration in accordance with the envelope appear in the plate circuit. Because of the characteristics of the generator these pulses are sharply defined at the beginning of each plate pulse. If time displacement modulation is desired a differentiating circuit may be provided coupled to the plate circuit so that the output pulses are differentiated and only the variable edge is then defined by the pulses which may be used for transmission of a signal.

For use as a demodulator the biassing and circuit constants are so chosen that the positive gating or triggering pulses will cause the tube suppressor grid voltage to build up to a point insufficient to trigger the plate circuit into operation by itself. However, the tube will be triggered into operation by the time modulated pulses applied to the control grid of the tube. These pulses will trigger the tube into operation at times varying with their time displacement and the tube will then continue to conduct until the termination of the positive gating pulses. Thus in the output plate circuit will appear pulses of varying duration dependent upon the time displacement of the pulses applied to the control grid. These pulses may be filtered or otherwise processed to derive the original signal or intelligence.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, in which:

Fig. 1 illustrates a circuit in accordance with this invention operating as a modulator;

Fig. 2 illustrates a circuit in accordance with this invention operating as a demodulator, and

Fig. 3 is a set of graphs illustrating various voltage characteristics used in explanation of the operation of the modulator circuit.

Turning first to Fig. 1, there is illustrated a multiplex time modulating circuit only one of the multiplex stages being shown complete. Reference character 1 denotes a timing pulse distributor of finite output impedance which provides pulses preferably of rectangular wave form properly timed for the production and sequential operation of the separate channel modulators. Output from the timing distributor 1 may be applied over lines 2, 3, 4 etc. to the separate modulating stages. The operation of a modulating stage coupled to line 2 will be explained in connection with this figure. In this arrangement there is provided a pentode tube 5 having an anode 6, a cathode 7 and first, second and third grid electrodes 8, 9 and 10. Grid 8 is a normal control grid, grid 9 the screen grid and grid 10 the normal suppressor grid. Voltages are supplied to anode 6 and screen grid 9 as indicated. Control grid 8 is provided with a low bias applied thus resistors 11. Suppressor grid 10 is biassed negatively to a relatively high negative value over potential 14. A coupling capacitor 15 is provided for intercoupling screen grid 9 and suppressor grid 10.

The timing pulses from distributor 1 are applied over line 2 and coupling condenser 16 directly to suppressor grid 10. By means of coupling condenser 15 this pulse is also applied to screen grid 9. Energy from a signal source 17 which may be an input voice channel or other intelligence bearing source is applied over coupling condenser 18 to resistor 12 to the control grid 8. Coupled to the anode 6 is shown a differentiating circuit 19 comprised of a choke coil 20 by-passed by a rectifier 21. Pulses appearing in the plate circuit will be differentiated so that the leading edge will produce a narrow pulse, the rectifier serving to suppress further oscillation of the differentiator 19. Other stages similar to tube 5 and its accompanying circuits may be provided for additional channels such as those supplied over connections 3, 4, etc., one such additional stage being indicated at 5*a*.

Turning now to Fig. 1 and Fig. 3, a description of the operation of the system will be given. An audio signal from source 17 which may include a step up transformer and a conventional amplitude limiter is applied to the modulator circuit over coupling condenser 18. At graph B of Fig. 3 the audio envelope is illustrated as being at zero voltage at 22, negative at 23 and positive at 24. In a circuit actually built an audio frequency amplitude of approximately .43 volt amplitude level was required for a 100% modulation. Electron discharge device 5 which performs the modulation is a sharp cut-off pentode. The control grid bias applied via resistor 11 was approximately −1½ volts in the given set up for a class A operation. In this same circuit negative 50 volt supply was connected to potentiometer resistor 14. This negative bias tends to increase the grid current flow to the screen grid rather than reduce it since it prevents flow through to the anode circuit. Since this does not cut-off the screen grid flow, the cathode 7, control grid 8 and screen grid 9 form effectively a triode audio amplifier while the plate current is cut-off. Gating pulses as shown at 25, 26 and 27 in graph A are applied over coupling condenser 16 to the suppressor grid 10, and as previously mentioned, these may be applied from any timing pulse distributor system such as a ring type oscillator for example. These pulses are preferably rectangular and flat top waves. The loading effect of the triode amplifier formed by the cathode screen grid path 7, 9 together with coupling condenser 15 tends to cause the positive pulses 25, 26, and 27 to be differentiated at the screen grid as indicated at 28, 29 and 30 and integrated at the suppressor as indicated at 31, 32, 33, graph D. In the absence of audio signal on control grid 8 the integration of the pulse causes the anode, cathode circuit to reach a triggering potential indicated by the anode cut-off line 34 in graph D midway of pulse 31. At this point plate current starts to flow setting up a triggering response as follows: The start of plate current flow causes a corresponding drop in screen grid current, resulting in a screen voltage rise. This rise is coupled to suppressor grid 10 via condenser 15 causing a further rise in plate current as the suppressor grid becomes more positive. This effect is accumulative and results in a step rise in suppressor grid voltage as shown at 35 in graph C. Coincidentally, there is a steep rise in plate current which approaches saturation as indicated at 36 and remains at saturation until the trailing edge of the gating pulse 25 passes, when the plate circuit is driven back to cut-off where it remains until its next gate pulse occurs. This results in an output pulse 37, graph E in the plate circuit. This pulse is differentiated at 19 producing negative pulse 38 shown in graph F. The trailing edge of pulse 37 would form a positive pulse but rectifier 21 cuts this off as well as further oscillations.

The above explanation holds when the applied signal is substantially zero for negative signals applied to the control grid the system will operate to trigger into conductive condition earlier as indicated at 29, 32 and 39 producing the pulse 40 at an earlier time relative to the gating pulse than was the production of pulse 38. If the audio signal is positive as shown at 24 the triggering action takes place at a later period as shown at 30, 33, 41 producing a pulse at a later time as indicated at 42. Since the gating pulses are relatively short about 7 microseconds more or less, compared to the audio frequency wave, the audio wave may be considered as substantially constant during the gating interval. The effect of the instantaneous polarity of the audio signal on the control grid is to raise or lower effectively lines 43, 44 and 45 of pulse 31, 32 and 33 of graph D causing the suppressor grid voltage to reach the plate circuit cut-off axis 34 sooner or later.

In practice in a multi-channel system the odd number channels are modulated in one group of modulator tubes and differentiated in a common differentiating circuit while the even numbered channels make up a second group of modulators with its common plate differentiating circuit, thus producing two trains of pulses to be later combined together with a marker channel for multiplex transmission. Since this type of operation is known in the art no specific illustration or further description is required.

With the above type of modulator system the following advantages are obtained:

An audio voltage amplification of approximately 26 db gain is provided by the screen grid triode. The pulse integrator provides the required linear slope for effecting pulse width or time duration modulation from the amplitude varying signals. The triggered amplifier provides a steep sided plate pulse whose time duration is a linear function of the amplified audio voltage. The differentiated plate output circuits converts the time duration modulation to pulse time displacement modulation also providing a pulse of the proper amplitude and shape. The bias potentiometer 14 serves to control the pulse positioning, it being the only adjustable control in the circuit. The stability depends only upon the constancy of bias and supply voltages which can be maintained satisfactorily by conventional voltage regulation. Signals to noise ratios for a complete system modulator and demodulator have been found to be better than 70 db. The audio distortion of the complete system is only a fraction of one per cent. The crosstalk in the modulator circuit is negligible.

Turning now to Fig. 2, the demodulator circuit is illustrated. It will be noted that in this circuit a timing pulse distributor and a pentode pulse generator similar to that shown in Fig. 1 is provided. For convenience of reference the same reference characters are used for the parts of this circuit which are substantially identical to those of Fig. 1. Tube 5 in this instance has its suppressor grid voltage adjusted relative to the input pulses and the circuit constants, such that the integration of the gating pulses will bring the tube to a point just below the tube anode cut-off potential. For simplification of illustration this is shown in Fig. 3 by a variation in the tube cut-off position as indicated by line 34*a*. In this demodulator, as in the demodulator of Fig. 1, the separate channels are gated but in sequence by means of pulses similar to those of 25, 26, 27 graph A, Fig. 3. The distributor 1 is properly synchronized with the incoming channel by means of any known form of synchronisation. This synchronisation serves to center the gating pulses so that they occur properly centered with the zero modulation position of the incoming time displacement pulses. The incoming signal is applied over a receiver detector arrangement as illustrated at 46. These pulses, as derived from the transmission medium and processed in the receiver, are negative pulses similar to pulses 38, 40 and 42 shown in graph F of Fig. 3. These pulses are preferably of about 1 volt and are applied to the control grid 8 over coupler 18. However in this case, control grid 8 is only slightly negative due to the charge in the coupling condenser 18 from the applied negative pulses, and the drop in resistor 47. The cathode 7, screen grid 9 circuit therefore acts as a triode amplifier in the absence of plate conduction and amplifies the pulses applied to the control grid also inverting their polarity. Gate pulse 25 is synchronised so that somewhere



along lines 43, 44 and 45, graph D, Fig. 3, the amplified and inverted channel pulse will drive the suppressor grid into the plate current conduction region. The increase of plate current from zero to any finite value results in a reduction of the screen current and therefore in a simultaneous rise in screen voltage. This instantaneous voltage rise is coupled back to the suppressor grid via condenser 15 causing it to further rise and become more positive in a manner similar to that described in connection with the modulator of Fig. 1. Since this effect is cumulative it results in a steep rise in the suppressor grid voltage and a rise in plate current. The effect of these channel pulses as applied in succession to the control grid produces in the plate circuit a series of pulses of different widths or time duration depending upon the time and application of the pulses 38, 40, 42 as shown at 37, 39, and 41, graph E, Fig. 3. Thus there is produced in the output plate circuit a train of pulses varying in time duration in accordance with the time displacement modulation. These pulses may be passed over a conventional low pass filter 48 and coupled to the individual audio channels over a transformer 49. This audio signal may then be passed on to any desired audio amplifiers and translator circuits. Here again the same advantages of the simple circuit as described in connection with the modulator is obtained.

While this invention has been described in connection with simplified schematic diagram it is clear that the principles as set forth herein apply equally to circuits having variations from those shown herein. Many modifications and variations in the circuit will occur to those skilled in the art.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention.

What I claim is:

1. A pulse generator comprising an electron discharge device having an anode, a cathode and first and second and third grid electrodes, means for applying a voltage positive with respect to said cathode to said second grid electrode and said anode electrode, to render the path defined by said cathode and second grid electrodes normally conductive, means for normally biasing said third grid electrode negatively with respect to said cathode to render the anode-cathode discharge path of said device normally non-conductive, capacitive means inter-coupling said second and third grid electrodes, a source of positive pulses, means for applying said positive pulses to said third grid electrode to overcome the bias on said third grid to tend to render said anode-cathode path conductive, and means for applying voltages from a source to said first grid electrode to control the timing of the period of conductivity of said anode-cathode path.

2. A generator according to claim 1, wherein said source of positive pulses provides regularly repeated pulses, and said source of control voltages comprises a source of signal modulated voltage.

3. A generator according to claim 2, wherein said negative bias and said positive pulses are proportioned to provide conductivity in said anode-cathode path intermediate the duration of said positive pulses, and said source of signal modulated voltage comprises an audio communi-

cation channel whereby pulses varying in duration in accordance with said channel signals are produced in the anode circuit of said device.

4. A generator according to claim 3, further comprising a differentiating circuit coupled to said anode, to produce narrow pulses modulated in time position in response to said pulses of varying duration.

5. A generator according to claim 2, wherein said negative bias and said positive pulses are proportioned to cause said anode-cathode path to be rendered more nearly conductive at the termination of said positive pulses, and said source of signal modulated pulses comprises a communication channel carrying negative time displacement signal modulated pulses, whereby pulses varying in time duration in accordance with the time displacement of said negative pulses are produced at said anode.

6. A generator according to claim 5, further comprising a low pass filter coupled to said anode, to derive the signal modulation from said pulses varying in time duration.

7. A signal controllable pulse generator comprising an electron discharge device having an anode, a cathode and first, second and third grid electrodes, means for applying a voltage positive with respect to said cathode to said second grid electrode and to said anode electrode to render the path defined by said cathode, first and second grid electrodes normally conductive, means for normally biasing said third grid electrode negatively with respect to said cathode to render the cathode-anode discharge path of said electron discharge device normally nonconductive, capacitive means for coupling together said second and third grid electrodes, a source of regularly repeated positive pulses, means for applying said positive pulses to said third grid electrode, whereby the integrating effect of said capacitive means and the conductivity of said cathode, first and second grid electrodes will cause said third grid electrode to become gradually more positive tending to render said anode-cathode path conductive, and means for applying signal voltage to said first grid electrode to control the timing of



the period of conductivity of said anode-cathode path.

8. A pulse generator according to claim 7, wherein said negative bias, said means and said positive pulses are proportioned to render said anode-cathode path conductive substantially at the mid-point of said positive pulses in the absence of said signal voltages, and said means for applying signal voltage includes an audio communication channel whereby pulses varying in time duration in accordance with said channel voltages are produced at said anode.

9. A pulse generator according to claim 8, further comprising a differentiator coupled to said anode to differentiate said varying time duration pulses to provide time displacement modulated pulses.

10. A pulse generator according to claim 7, wherein said negative bias, said capacitive means and said positive pulses are proportioned to render said anode-cathode path more nearly conductive at the termination of said positive pulses, and said means for applying signal voltage includes a communication channel carrying negative time displaced signal modulated pulses, whereby pulses varying in time duration in accordance with the time displacement of said negative pulses are produced at said anode.

11. A generator according to claim 10, further comprising a low pass filter coupled to said anode, to derive the signal modulation wave from said pulses varying in time duration.

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