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 APPARATUS FOR COMPARING THE INSTANTANEOUS
 VALUES OF TWO VOLTAGES
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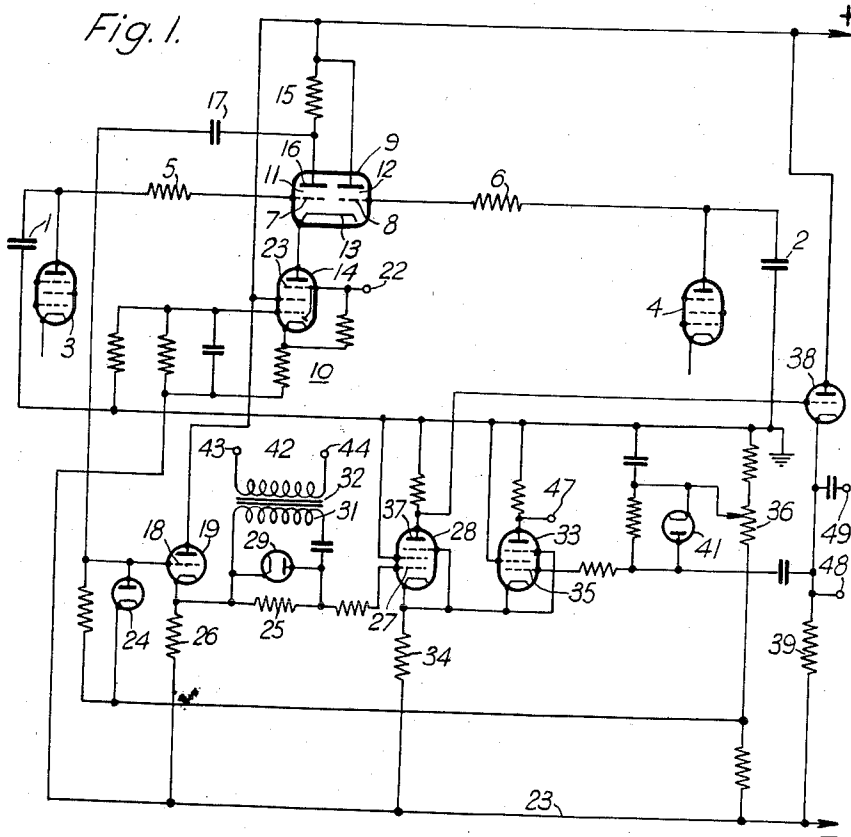
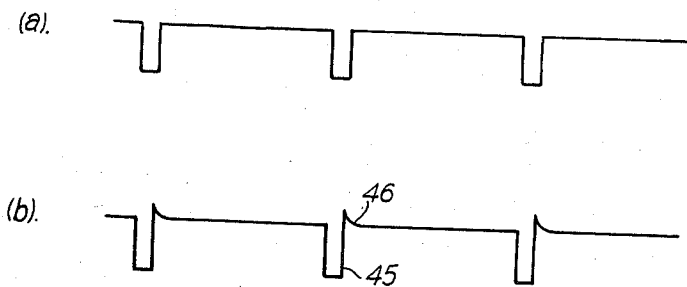


Fig. 2.



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APPARATUS FOR COMPARING THE INSTANTANEOUS VALUES OF TWO VOLTAGES

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6 Claims. (Cl. 250—27)

The present invention relates to apparatus for comparing the instantaneous values of two voltages.

According to the present invention, apparatus for comparing the instantaneous values of two voltages comprises means to derive a control voltage which at any instant is dependent upon the difference between the instantaneous values of the two voltages to be compared, and means responsive to the control voltage having a value beyond a predetermined value, the possible range of values of the control voltage being small in relation to the possible range of values of the two voltages being compared and the control voltage being substantially independent of the actual values of the two voltages.

Preferably the means to derive the control voltage comprises two grid-controlled thermionic valves having common cathode resistance and paths for supplying the two voltages to be compared to the control grids of the two valves respectively, one of the two valves having resistance in its anode circuit and any change in the instantaneous anode voltage of that valve constituting the said control voltage.

The means responsive to the control voltage may comprise two grid-controlled thermionic valves having common cathode resistance, a path for supplying the control voltage, possibly through a cathode follower stage, to a control grid of one of these valves, and means to supply a steady bias voltage to the control grid of the other valve, the arrangement being such that these two valves form a two-state circuit in each state of which one valve is conducting and the other cut off. Thus, if these two valves are like valves, the one to which the control voltage is supplied will be cut off when that voltage is less than the said bias voltage but will be conducting when the control voltage is greater than the bias voltage. There may be means periodically to superimpose a negative-going voltage pulse on the control voltage supplied to this means so as to ensure that the valve to which the control voltage is supplied is cut off upon the occurrence of such a pulse while upon the cessation of the pulse the two-state circuit either remains in that state or changes over to the other state in dependence upon the value of the control voltage. The valve to which the control voltage is supplied may be effectively resistance-capacity coupled to the control grid of the other valve so as to assist this changeover if the control voltage is above the changeover value.

One arrangement of apparatus in accordance with the present invention will now be described by way of example with reference to the two figures of the accompanying drawing in which Figure 1 shows the circuit diagram of the apparatus while Figure 2 shows two waveforms.

This apparatus constitutes the slicer forming part of the coding apparatus of the pulse code modulation signalling system described in the specification of co-pending United States patent application Serial No. 413,910, filed March 3, 1954, for Electric Signalling Systems of the Kind Using Pulse Code Modulation. Thus, referring now to Figure 1 of the accompanying drawing, the slicer is

required to compare the voltages across two condensers 1 and 2 a number of times during the coding cycle of each sample of the input signal and to determine whether the voltage across the condenser 1 is greater than that across the condenser 2 or vice versa. One side of each of the condensers 1 and 2 is connected directly to earth while current may be supplied to the condensers 1 and 2 through valves 3 and 4 as described more fully in the specification of the said co-pending application.

The live sides of the two condensers 1 and 2 are connected through grid stopper resistors 5 and 6 to control grids 7 and 8 of a double triode thermionic valve 9 formed by two individual triodes 11 and 12 that have a common cathode 13. A pentode thermionic valve 14 is provided in the common cathode circuit of the triode valves 11 and 12. It will be understood, of course, that the valve 9 may be replaced by two separate triode thermionic valves having a common cathode circuit.

The valve 9 is such that each of the individual triode valves 11 and 12 has a relatively short grid base. In other words, each of these valves 11 and 12 when operating under normal conditions requires a relatively small negative bias to be supplied to its control grid 7 or 8 to bring it to the condition of cut-off. It will be realised that when the two individual valves 11 and 12 are conducting, any relative variation of the voltage on the grid 7 or 8 causes a change in the voltage of the cathode 13. Any change in the instantaneous anode voltage of the valve 11 is arranged to provide a control signal which is dependent upon the difference between the instantaneous voltages across the condensers 1 and 2, this valve having an anode load resistor 15.

If now the voltages across the condensers 1 and 2 are the same, the anode voltage of the valve 11 will have a particular value and, if the two voltages are changed in like manner, there will be substantially no change in the anode voltage since the common cathode resistance 10 of the valves 11 and 12 has a relatively large value. If, however, the voltage across the condenser 1 rises or the voltage across the condenser 2 falls for example, there is an increase in the voltage drop across the resistor 15 with a consequent fall in the voltage of the anode 16.

A condenser 17 is connected between the anode 16 of the valve 11 and the control grid 18 of a triode thermionic valve 19 which is arranged as a cathode follower stage. Any change in the anode voltage of the valve 11, that is to say the control voltage, is thus fed through the condenser 16 to the control grid 18. By virtue of its short grid base characteristics, the valve 9 tends to limit the possible range of values of the anode voltage of the valve 11 with the result that the control voltage can only vary over a much smaller range of values than can the voltages across the condensers 1 and 2. The control voltage is thus dependent upon the difference between the voltages across the condensers 1 and 2 although it is substantially independent of the actual values of those voltages. In the example being described, the voltages across the condensers 1 and 2 may vary over ranges of 40 and 20 volts respectively, while the control voltage may vary over a range of only two volts. As already mentioned, it is necessary for the resistance 10 in the cathode circuit of the valve 9 to be relatively high. This condition is satisfied by providing the pentode thermionic valve 14 which is arranged to operate as a constant current source. The terminal 22 which is connected to the suppressor grid 23 of the valve 14 is normally maintained at the voltage of the negative supply line 23, but in order that the coding apparatus shall operate correctly under all conditions, the valve 14 is rendered non-conducting at the end of each coding cycle by the application of a more negative bias to the terminal 22.

As already mentioned the control voltage is supplied

to the control grid 18 of a triode valve 19 and a diode thermionic valve 24 is provided for the purpose of direct current restoration of the output from the cathode follower stage formed by the valve 19. The voltage developed across a resistor 25 is added to that developed across the resistor 26 in the cathode circuit of the valve 19 and the resultant voltage is applied to the control grid 27 of a pentode thermionic valve 28. The resistor 25 is connected in parallel with a diode thermionic valve 29 and is supplied from the secondary winding 31 of a pulse transformer 32. The valve 28 and another pentode thermionic valve 33 are provided with a common cathode resistor 34.

A steady bias is supplied to the control grid 35 of the valve 33 from a potentiometer 36 and the anode 37 of the valve 28 is effectively resistance-capacity coupled to the grid 35. In fact a cathode follower stage formed by a triode thermionic valve 38 and a resistor 39 is provided in this path between the anode 37 and the control grid 35, a diode thermionic valve 41 being arranged to operate in similar manner to the valve 24 whereby the more positive level of the voltage waveform supplied to the control grid 35 is determined by the potentiometer 36.

The circuit formed by the valves 28 and 33 has two states of operation in each of which one of the valves 28 or 33 is conducting and the other is cut off. This circuit is arranged to take up one or other of its two states in dependence upon whether the control voltage passed by the cathode follower stage formed by the valve 19 is or is not greater than the said bias voltage supplied to the grid 35. Each time a comparison of the voltages across the condensers 1 and 2 is to be effected, an interrogating pulse is supplied to the primary winding 42 of the pulse transformer 32. In fact a signal having the waveform of Figure 2(a) is supplied between the terminals 43 and 44 with the result that the voltage waveform across the resistor 25 is as shown in Figure 2(b).

Each negative-going pulse 45 causes the valve 28 to be cut off so that the circuit formed by the valves 28 and 33 takes up the state in which the valve 33 is conducting. Upon the cessation of each pulse 45 this circuit either remains in that state or changes over to its other state in dependence upon the relative value of the control voltage developed across the resistor 26 and the bias supplied to the grid 35. Change-over from the state in which the valve 28 is cut off to that in which it is conducting is assisted by means of coupling through the valve 38. This two-state circuit which takes up one or other of its states in dependence upon the value of the control voltage at the instant of comparison forms the subject of British patent application No. 23,468/53.

In order to prevent the two-state circuit formed by the valves 28 and 33 changing over from one state to the other between successive pulses 45, the waveform of Figure 2(b) is such that there is a small positive-going pip 46 at the end of each pulse 45 due to leakage inductance in the transformer 42.

The bias supplied to the control grid 35 is adjusted by means of the potentiometer 36 so that when the voltages across the condenser 1 and 2 are the same there is an equal chance of the circuit formed by the valves 28 and 33 taking up either of its two states after a pulse 45.

The apparatus described above has a balanced output that is developed at terminals 47 and 48, and it will be appreciated that the voltage on each of the terminals 47 and 48 can have only one of two values between successive pulses 45 depending upon the relative instantaneous voltages across the condensers 1 and 2 at the last instant of comparison. The pulse code output of the coding apparatus of which the slicer described above forms part is taken from the terminal 49 and the cathode follower stage which includes the valve 38 serves as a buffer stage between the output terminal 49 and the valve 28.

The apparatus described above has a substantially infinite input impedance, so that during coding it does not

appreciably affect voltages across the condensers 1 and 2. I claim:

1. Apparatus for periodically comparing the instantaneous value of two voltages comprising comparison means to derive a control voltage which at any instant is dependent upon the difference between the instantaneous value of the two voltages to be compared and which has a value that lies within a range of values that is small compared with the range of possible values of the voltages to be compared and means responsive to the control voltage having a value beyond a predetermined value, the means responsive to the control voltage comprising a circuit having two stable states that is formed by a pair of thermionic valves each of which has a cathode, a control grid and an anode and a cathode circuit which is common to the two valves of this pair and which includes resistance, in each of the stable states of this circuit one of the valves of this pair being conducting and the other cut off, a path to supply the control voltage to the control grid of one of the valves of the said pair, means to supply a steady bias voltage to the control grid of the other valve of the said pair, means operable periodically and for a time immediately before each comparison of the instantaneous value of the two voltages to be compared to cause the circuit having two stable states to take up a predetermined one of the two states so that at the end of such a time the circuit either remains in that state or changes over to the other state in dependence upon the magnitude of the control voltage relative to the said bias voltage, and resistance connected in the anode circuit of one of the valves of the said pair, the anode voltage of that valve of the said pair that has the said resistance in its anode circuit having one of two values dependent upon the magnitude of the control voltage.

2. Apparatus for periodically comparing the instantaneous value of two voltages comprising comparison means to derive a control voltage which at any instant is dependent upon the difference between the instantaneous value of the two voltages to be compared and which has a value that lies within a range of values that is small compared with the range of possible values of the voltages to be compared and means responsive to the control voltage having a value beyond a predetermined value, the said comparison means comprising a first pair of thermionic valves each of which has a cathode, a control grid and an anode, a cathode circuit which is common to these two valves and which includes a resistive impedance, paths for supplying the two voltages to be compared to the control grids of the two valves of the first pair respectively, resistance in the anode circuit of one of the two valves, and means responsive to changes in the anode voltage of that valve having the said resistance in its anode circuit to provide the said control voltage, and the means responsive to the control voltage comprising a circuit having two stable states that is formed by a second pair of thermionic valves each of which has a cathode, a control grid and an anode and a cathode circuit which is common to the two valves of the second pair and which includes resistance, in each of the stable states of this circuit one of the valves of the second pair being conducting and the other cut off, a path to supply the control voltage to the control grid of one of the valves of the second pair, means to supply a steady bias voltage to the control grid of the other valve of the second pair, means operable periodically and for a time immediately before each comparison of the instantaneous value of the two voltages to be compared to cause the circuit having two stable states to take up a predetermined one of the two states so that at the end of such a time the circuit either remains in that state or changes over to the other state in dependence upon the magnitude of the control voltage relative to the said bias voltage, and resistance connected in the anode circuit of one of the valves of the second pair, the anode voltage of that valve of the second pair that has the said resistance in its anode cir-

cuit having one of two values dependent upon the magnitude of the control voltage.

3. Apparatus according to claim 2 wherein the said resistive impedance is formed by a pentode thermionic valve which is arranged to operate as a source of constant current.

4. Apparatus according to claim 2 wherein the said path for supplying the control voltage to the control grid of one of the second pair of valves includes a cathode follower stage.

5. Apparatus according to claim 2 wherein the said means periodically to cause the circuit that has two stable states to take up one of its stable states comprises an impedance connected in the said path for supplying the control voltage to the control grid of one of the valves of the second pair and means periodically to develop a voltage pulse across the said impedance.

6. Apparatus according to claim 5 wherein the valve of the second pair to the control grid of which is supplied the control voltage is caused to be cut off upon the

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occurrence of a voltage pulse across the said impedance as aforesaid and wherein the valve of the second pair to the control grid of which the control signal is supplied is effectively resistance-capacity coupled to the control grid of the other valve of that pair.

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