July 13, 1954 F. C. WILLIAMS ET AL 2,683,802

PULSE SELECTING CIRCUITS

Filed Dec. 12, 1949 3 Sheets-Sheet 1

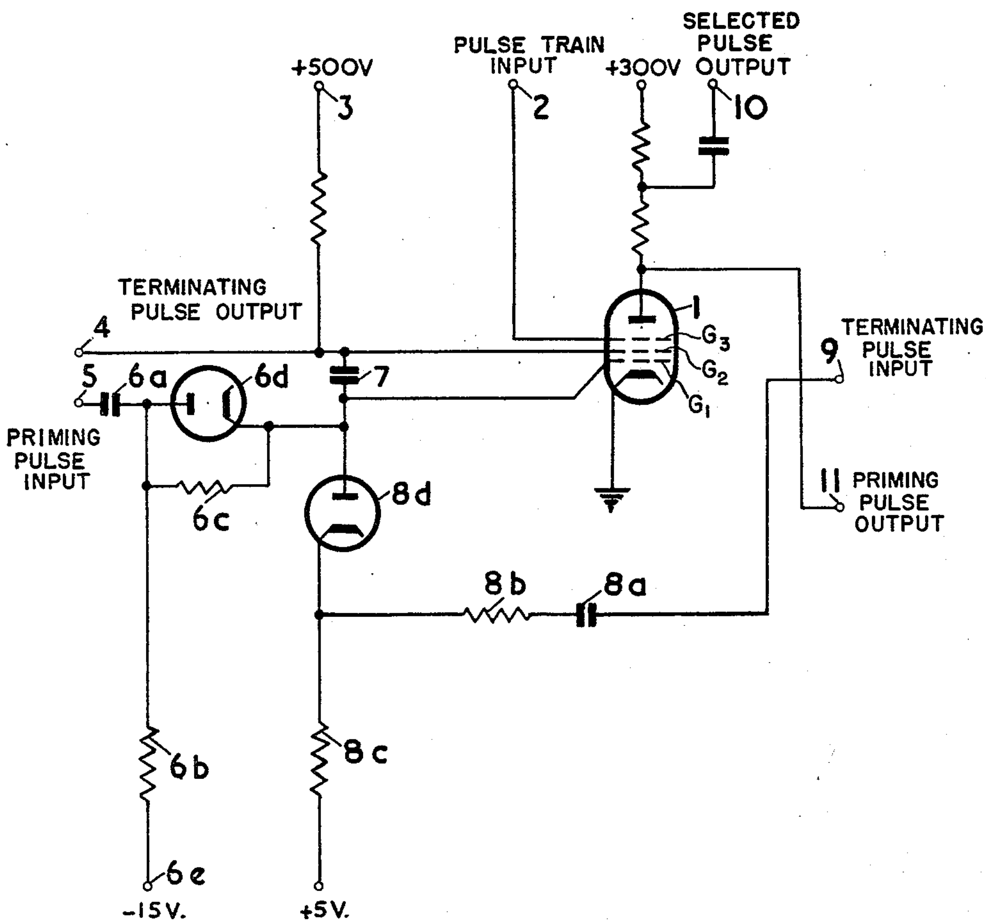

Fig. 1.

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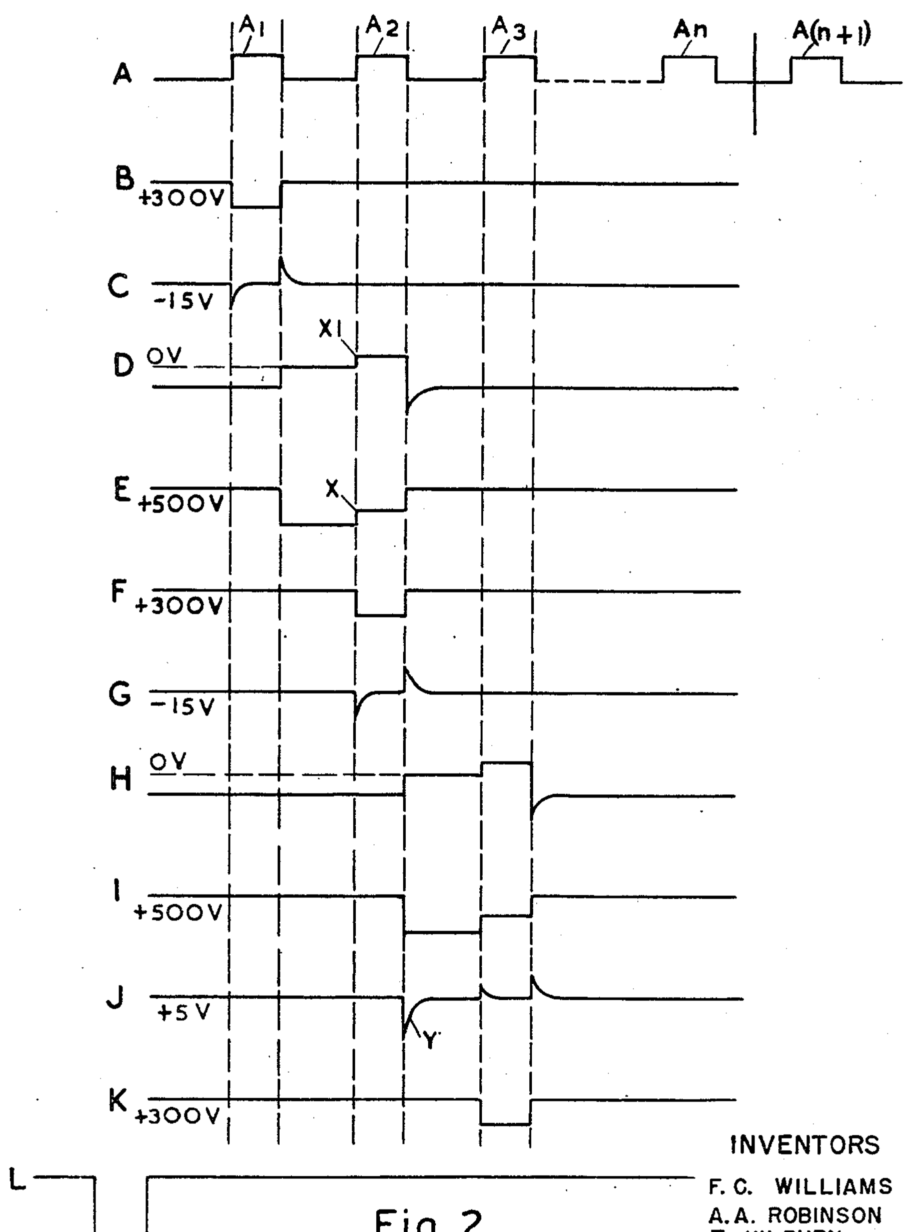

Fig. 2.

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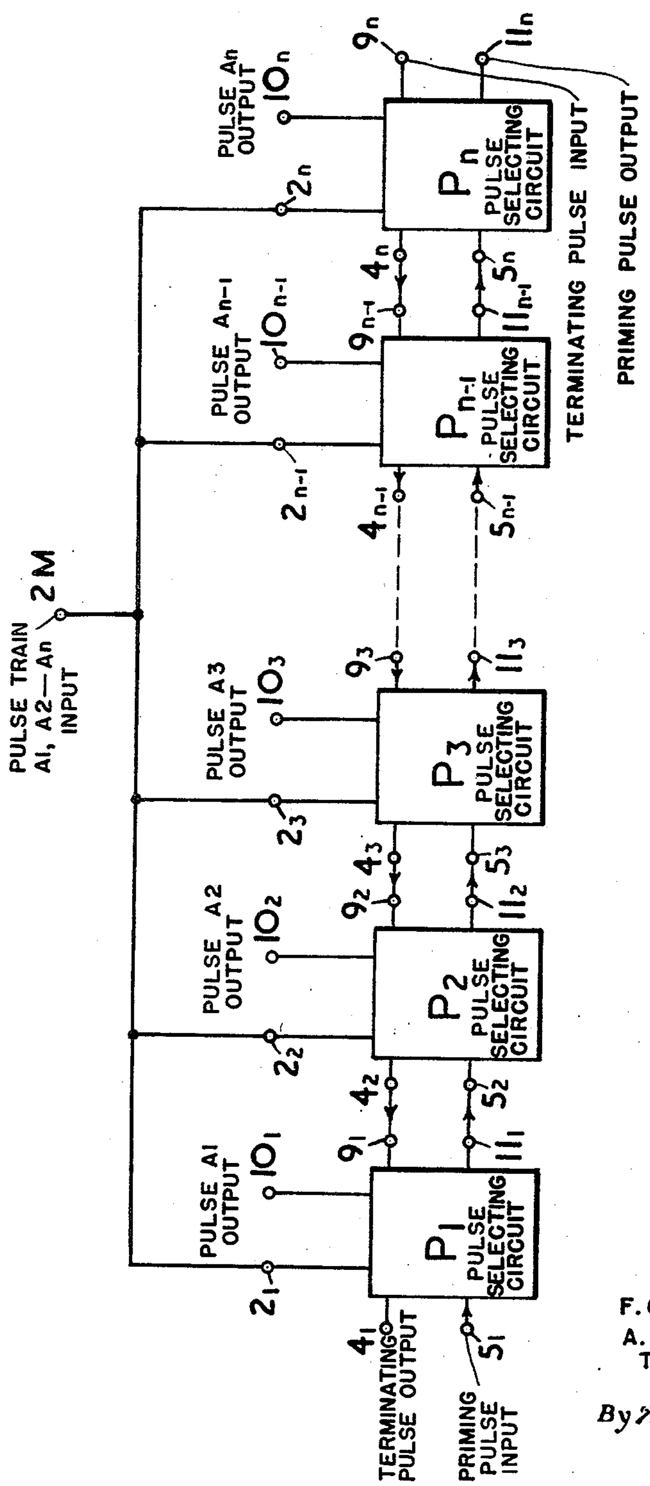

FIG. 3

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Patented July 13, 1954 2,683,802

UNITED STATES PATENT OFFICE

2,683,802

PULSE SELECTING CIRCUITS

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Application December 12, 1949, Serial No. 132,580

Claims priority, application Great Britain December 23, 1948

14 Claims. (Cl. 250—27)

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The present invention relates to pulse selecting circuits.

One object of this invention is to provide a pulse selecting circuit having a high reliability of operation which enables a given pulse to be selected from a train of pulses and presented at a particular output point.

Another object of this invention is to provide an arrangement comprising a chain of n pulse selecting circuits which enables each one of a train of n pulses to be presented at a different output point. Such an arrangement finds application, for example, in binary digital computing machines, e. g. the machine described in the specification of co-pending patent application Serial No. 141,176, filed January 30, 1950, by F. C. Williams and T. Kilburn.

According to the present invention in one aspect thereof, there is provided a pulse selecting circuit of the kind which enables a desired pulse to be selected from a train of pulses and presented at a particular output point and comprising a valve having at least the following electrodes in the order named a cathode, a grid G1, a grid G2, a grid G3 and an anode, means for feeding the train of pulses in positive going sense to the grid G3, means for applying a bias potential to the grid G1 to normally render the valve nonconducting, means for applying to an electrode of said valve a priming pulse, preceding in time the desired pulse, to render said valve conducting and a feedback path between the grids G2 and G1 to maintain the conductivity of said valve so established for a time embracing the desired pulse, whereby a negative pulse may be obtained from the anode of the valve, coincident with the desired pulse at the grid G3.

According to the present invention in another aspect thereof there is provided a pulse selecting circuit of the kind which enables a desired pulse to be selected from a train of pulses and presented at a particular output point and comprising a valve having at least the following electrodes in the order named, a cathode, a grid G1, a grid G2, a grid G3 and an anode, means for feeding the train of pulses in positive going sense to the grid G3, means for applying a bias potential to the grid G1 to normally render the valve nonconducting, means for applying to the grid G1 a positive priming pulse, preceding in time the desired pulse, to overcome said bias and render the valve conducting and a feedback path including a condenser between the grids G2 and G1 to maintain the conductivity of the valve so established for a time embracing the desired

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pulse, whereby a negative pulse may be obtained from the anode of the valve coincident with the desired pulse at the grid G3.

According to a feature of the invention the priming pulse is obtained by differentiation of the preceding pulse of the pulse train and is applied to the grid G1 through a unilaterally conducting device which serves to select the positive-going part of the differentiated pulse for application to the grid G1.

A further feature of the invention resides in the use of a chain of circuits according to the invention for isolating each pulse of the pulse train in turn, the priming pulse for each circuit being derived from the negative-going output pulse from the preceding circuit, in which case, moreover, a negative-going pulse obtained from the succeeding circuit may be employed to terminate conductivity of the valve.

In order that the invention may be more clearly understood and readily carried into effect reference will now be made to the accompanying drawings in which:

Figure 1 shows a circuit diagram of a pulse selecting circuit according to this invention which enables a given pulse to be selected from a train of pulses and presented at a particular output point;

Figure 2 shows waveforms illustrating the operation of the circuits shown in Figures 1 and 3 and

Figure 3 shows in block schematic form n pulse selecting circuits of the kind shown in Figure 1 connected in a chain, an arrangement which enables each one of a train of n pulses to be presented separately at n different output points.

In Figure 2A there is shown a train of n regularly recurring pulses A_1–A_n, in a particular arrangement occurring at a repetition frequency of, say, about 118 kc./s., from which it is desired to select, say, the second pulse A_2. This pulse train is applied via a terminal 2 of the circuit of Figure 1, to the suppressor grid of a pentode valve 1, but will normally produce no effect at the anode of the valve since the control grid of the valve is connected to a bias potential of −15 volts at terminal 6e via a high resistance leakage path consisting of resistances 6c and 6b.

It will now be shown how the pulse A_2 may be selected from the pulse train shown in Figure 2A and generated at the anode of the valve 1 by applying a negative pulse, shown in Figure 2B, to the terminal 5 of the circuit of Figure 1. This negative pulse is applied via the terminal 5 to a differentiating circuit, consisting of a condenser

6a and resistance 6b, which differentiates the pulse to produce a sharp negative-going pulse coincident with its leading edge and a sharp positive-going pulse coincident with its trailing edge, both of these sharp pulses being shown in Figure 2C. The differentiating circuit 6a, 6b is connected to the anode of a diode 6d the cathode of which is connected to the control grid of the valve 1, so that only the sharp positive pulse (Figure 2C) at the trailing edge of the negative pulse of Figure 2B is applied to the control grid of the valve 1. This sharp positive pulse acts as a priming pulse to turn on the valve current of the valve 1. The valve current then flows to the screen grid and the potential on the screen grid falls, the resting level of the pulses applied to the suppressor grid being sufficient still to prevent the valve current reaching the anode. A condenser 7, having a small capacity (e. g. 39 micro-microfarads), is connected between the screen grid and control grid of the valve 1 and the fall of potential on the screen grid is therefore transmitted back to the control grid; this in turn tends to resist the rise of potential on the control grid in the well known "Miller" manner of operation and as a result the potential on the control grid continues to be maintained after the end of the priming pulse at an equilibrium value, approximately equal to that on the cathode, which is sufficient to keep the valve current turned on.

The potential on the control grid of valve 1 is shown in Figure 2D and the potential on the screen grid in Figure 2E. During the occurrence of the next following or second pulse A_2 of the train of pulses applied to the suppressor grid, the potential of the latter will be raised above cut-off and current will flow to the anode of the valve 1 and a pulse will accordingly be developed there coincident with the pulse A_2, this pulse being shown in Figure 2F. Coincidently with the trailing edge of this pulse (Figure 2F) the current through valve 1 is cut off by applying a negative pulse to the control grid of the valve. Thus the remaining pulses A_3–A_n of the pulse train (Figure 2A) applied to the suppressor grid will produce no effect at the valves anode. An output terminal 10 is connected to the anode of the valve 1. The negative pulse which cuts off the valve current may conveniently be derived, for reasons later to be explained, by applying a potential shown in Figure 2I to the terminal 9. The terminal 9 is connected via a differentiating circuit consisting of a condenser 8a and resistances 8b and 8c to the cathode of a diode 8d, the anode of which is connected to the control grid of the valve 1. The potential, shown in Figure 2I is differentiated by the differentiating circuit 8a, 8b, 8c to produce a potential waveform as shown in Figure 2J which it will be seen has a negative pulse Y coincident with the trailing edge of the pulse A_2. The negative pulse Y gets through the diode 8d and cuts off the valve current.

When current flows to the anode of the valve 1 the current flowing to the screen grid is reduced and a positive-going step is produced in the potential on the screen grid as shown at X in Figure 2E. By virtue of the feedback path between the screen grid and control grid provided by the condenser 7, this positive-going step in the screen grid potential produces a positive-going step in the control grid potential as shown at XI in Figure 2D. The effect of the positive-going step on the control grid is to cause current

to flow in the control grid circuit of the valve 1 and to make the anode current of the valve 1 greater than it would be if it were operating within its normal working range of grid voltage (i. e. within its grid base). This enables a low output impedance to be employed at the valve's output circuit whilst obtaining an output pulse (Figure 2F) of sufficient amplitude. The low output impedance permits the separated output pulse to be fed to a utilisation circuit without the necessity of providing an intermediate cathode follower stage. In a practical example of the circuit described above an EF50 type valve (manufactured by the Mullard Radio Valve Company) was employed and the anode load was provided by a pulse transformer which supplied the separated pulse at an amplitude of 15 volts across an impedance of 100 ohms. The screen grid of the valve was taken to a potential of 500 volts which is higher than the screen potential normally employed for the valve but was made possible because of the relatively short period in a complete cycle of operation during which the valve was made conducting.

From an examination of the waveform diagram, Figure 2, it will be seen that the pulse produced at the anode of the valve 1 (Figure 2F), and hence at the terminal 11 connected to this anode, is identical in shape with that applied to the terminal 5 (Figure 2B) and differs only in that it occurs after a time interval equal to that between two pulses in the train of pulses shown in Figure 2A. Such an output pulse can accordingly be used as a medium for deriving the requisite priming pulse for operating a similar circuit adapted to select the next following pulse A_3 of the train (Figure 2A) and it follows that n pulse selecting circuit shown in Figure 1 may be connected in a chain and arranged to deliver at their respective output circuits different pulses from a train of n pulses applied to them. Such an arrangement is shown in Figure 3 which shows n pulse circuits $P_1, P_2, P_3 \ldots P_{n-1}, P_n$ each of the kind shown in Figure 1 connected in a chain. Each circuit P_x (where x=1, 2, 3 . . . $n-1$, n) has terminals 2_x, 4_x, 5_x, 9_x, 10_x, and 11_x similarly connected to the terminals 2, 4, 5, 9, 10 and 11 respectively of the circuit shown in Figure 1. Each terminal 11_x of a circuit P_x is connected to the terminal 5_{x+1} of the succeeding circuit P_{x+1}. Thus the negative pulse at the terminal 11_x of the circuit P_x is differentiated by the differentiating circuit in the control grid circuit of the succeeding circuit P_{x+1} which produce a sharp positive pulse which serves as a priming pulse to turn on the valve current of the pentode valve in the circuit P_{x+1}. The train of n pulses (Figure 2A) is applied to the suppressor grids of the pentodes of all the circuits in parallel via a terminal 2M while an initiating pulse preceding the first pulse (A_1, Figure 2A) in the train is applied to the terminal 5_1 of the first stage P_1. Thus the circuit P_1 will produce at terminal 10_1 an output pulse shown in Figure 2B coincident with the first pulse A_1 of the pulse train, the circuit P_2 (i. e. the one described with reference to Figures 1 and 2) will produce at terminal 10_2 an output pulse shown in Figure 2F coincident with the second pulse A_2 of the train, the circuit P_3 will produce at terminal 10_3 an output pulse shown in Figure 2K coincident with the third pulse A_3 in the train and each succeeding circuit P_x will produce a pulse at terminal 10_x coincident with the x^{th} pulse in the train. The valve current in each circuit P_x is cut off at the desired instant immediately after the passage of the desired selected pulse by applying the potential on the terminal 4_{x+1} of the succeeding circuit P_{x+1} to the terminal 9_x. Thus the potential on the screen grid of the circuit P_3, shown in Figure 2I is fed via terminal 4_3 and 9_2, a differentiating circuit (8a, 8b, 8c of Figure 1) and a diode (8d of Figure 1) to the control grid of the pentode valve in the circuit P_2 and this cuts off the valve current at the termination of the pulse shown in Figure 2F in a manner already explained. Figure 2H shows the potential on the control grid of the pentode valve in the circuit P_3.

In order to cut off the valve current of the pentode in the last circuit P_n after the last pulse A_n of the pulse train two possible expedients exist. A suitable pulse obtained from some exterior source and timed to occur at the end of the pulse train may be used. Alternatively, if the spacing between the last pulse A_n of one train and the first pulse of the ensuring train $A(_{n+1})$ is equal to the spacing between the pulses of the train, a negative going pulse from terminal 4_1, of the first stage which will be a negative going version of the pulse $A(_{n+1})$, may be used to cut-off the valve in the last circuit. To render the valve in the first circuit P_1 conducting, a pulse of the form shown in Figure 2L could be applied to terminal 4_1. Such a pulse could be derived from some suitable exterior source or alternatively, in the particular case just mentioned where the first pulse of the second train follows immediately after the last pulse of the first train, it could be derived from the output of the last stage P_n.

It has been stated above that the arrangement comprising a chain of circuit according to the present invention finds application in digital computing apparatus. In such practical applications, the train of n pulses may represent the digit positions in a binary number. The whole binary number, in the "reading" and "writing" operations of the machine normally occupies a time interval defined by the run-down time of a saw-toothed time-base voltage.

An arrangement of the kind above described may therefore be used having a number of circuits corresponding to the number of pulse or digit positions occurring during the run-down period of the time base voltage in order to obtain at separate output points pulses corresponding to each digit position. In such an arrangement it is convenient to obtain the pulses for switching on the valve current of the first circuit of the arrangement and cutting off the last stage, from the fly-back portion of the time-base voltage. The pulse selection then remains accurately synchronised with such run-down period.

It will be seen that, in the arrangement according to the invention the valve of each circuit is required to conduct only during a short period embracing the actual pulse to be selected by the circuit. Considerable economy of current consumption is thereby achieved and also, as explained above, operating conditions which would not be permissable for continuous operation are allowable. Moreover since each circuit comprises only one valve, a minimum liability of trouble due to valve failure is introduced. These considerations render the invention particularly valuable for the purpose given by way of example, namely, for pulse separation in digital computing machines.

We claim:

1. A pulse selecting circuit of the kind which enables a desired pulse to be selected from a train of pulses and presented at a particular output point and comprising a valve having at least a cathode, a first, a second and a third grid and an anode in that order, a circuit for applying energising potentials to said second grid and said anode, means for feeding the train of pulses in positive-going sense to said third grid, means for applying a bias potential to said first grid to normally render the valve non-conducting, means for deriving a priming pulse preceding in time the desired pulse and means for applying said priming pulse to an electrode of said valve to render said valve conducting, a feedback path between said first and second grids to maintain the conductivity of said valve so established for a time embracing the desired pulse and a load impedance in the anode circuit of said valve to provide an output pulse from said anode coincident with the desired pulse at said third grid.

2. A pulse selecting circuit of the kind which enables a desired pulse to be selected from a train of pulses and presented at a particular output point and comprising a valve having at least the following electrodes in the order named, a cathode, first, second and third grids and an anode, a circuit for applying energising potentials to said second grid and said anode, means for feeding the train of pulses in a positive-going sense to said third grid, means for applying a bias potential to said first grid to normally render the valve non-conducting, means for deriving a positive priming pulse preceding in time the desired pulse and means for applying said priming pulse to said first grid to overcome said bias and render the valve conducting, a feedback path including a condenser between said first and second grids to maintain the conductivity of said valve so established for a time embracing the desired pulse and a load impedance in the anode circuit of said valve to provide a negative-going output pulse from said anode coincident with the desired pulse at said third grid.

3. A pulse selecting circuit according to claim 2 including means for deriving said priming pulse from the pulse preceding the desired pulse in said train of pulses.

4. An arrangement comprising a plurality of pulse selecting circuits according to claim 2 connected in a chain and including means for deriving the priming pulse for each of said circuits except the first in said chain from the output pulse of the preceding circuit, together with means for deriving a pulse from the output pulse of each of said circuits except the first in said chain and applying it to an electrode of the preceding circuit to terminate the conductivity of the valve in the circuit to which it is applied.

5. An arrangement according to claim 4 wherein said means for deriving said priming pulses comprise a differentiating circuit and a unilaterally conducting device connected between the anode of the valve of each circuit except the last in said chain and the first grid of the valve in the succeeding circuit, said unilaterally conducting device being connected in such polarity as to select the positive pulse obtained by differentiation of said output pulse for application to said first grid.

6. An arrangement according to claim 4 wherein said means for deriving said pulse to terminate the conductivity of the valve in each circuit except the last in said chain comprise a differ-

entiating circuit and a unilaterally, conducting device connected between the second grid of the valve in each circuit except the first in said chain and the first grid of the valve in the preceding circuit, said unilaterally conducting device being connected in such polarity as to select the negative pulse obtained by differentiation of the potential on said second grid for application to said first grid.

7. A pulse selecting circuit comprising a chain of valves each having at least the following electrodes in the order named, a cathode, a first grid, a second grid, a third grid and an anode, a circuit for applying energising potentials to said second grid and said anode, a feedback condenser connected between the first and second grids of each valve, means for applying a bias potential to the first grids of said valves to normally render the valves non-conducting, a connection including a first differentiating circuit and a first unilaterally conducting device between the anode of each valve except the last in said chain and the first grid of the succeeding valve, the anode of said first unilaterally conducting device being connected to said first differentiating circuit and the cathode being connected to said first grid, a connection including a second differentiating circuit and a second unilaterally conducting device between the second grid of each valve except the first in said chain and the first grid of the preceding valve, the cathode of said second unilaterally conducting device being connected to said second differentiating circuit and the anode being connected to said first grid, means for applying a train of positive pulses to the third grids of all the valves and means for applying an initiating pulse to the first valve in said chain to render it conducting.

8. An electric pulse selecting circuit of the kind which enables the selection and presentation at a particular output point of a desired pulse having a predetermined order of position in a series of sequential pulses and comprising an input terminal for connection to the source of said train of pulses, an output terminal for connection to means for receiving the selected pulse, a gating device connected between said input and output terminals, a source of bias potential connected to said gating device and normally inhibiting the transfer of pulses through such gating device from said input terminal to said output terminal, a priming pulse input terminal for connection to a source providing a pulse timed to precede the desired pulse, circuit means for applying said priming pulse to said gating device to overcome said inhibiting bias potential and thus to place it in a condition to allow transference of pulses from said input terminal to said output terminal, delay circuit means connected to said gating device and operating to maintain said device in said condition to transfer pulses therethrough subsequent to the termination of said priming pulse and until after the transfer of said desired pulse through said gating device to said output terminal.

9. An electric pulse selecting circuit according to claim 8 which includes a terminating pulse input terminal for connection to a source providing a pulse timed to follow the transfer of said desired pulse to said output terminal and circuit means connecting such terminating pulse input terminal to said delay circuit means for applying said terminating pulse to terminate the period of maintenance of said gating device in said pulse transferring condition.

10. An electric pulse selecting circuit according to claim 9 which includes a terminating pulse output terminal for connection to the terminating pulse input terminal of another similar pulse selecting circuit dealing with a pulse in said train of pulses immediately preceding said desired pulse and circuit means between said terminating pulse output terminal and said gating device for deriving an output terminating pulse from the change of conditions consequent upon said gating device being operated into a condition to transfer pulses therethrough.

11. An arrangement for enabling each one of a train of n successive electric pulses to be presented at a predetermined and different one of n separate output points which comprises a first source of pulses providing a starting pulse timed to precede the first pulse of each of said trains of n pulses, a second source of pulses providing a terminating pulse subsequent to the last pulse of each of said trains of n pulses and n electric pulse selecting circuits each including an input terminal, an output terminal, a normally inhibited gating device connected between said input and output terminals, a priming pulse input terminal, a terminating pulse input terminal, circuit means associated with said gating device and connected to said priming pulse and said terminating pulse input terminals to cause removal of said inhibition of said gating device upon application of a pulse at said priming pulse input terminal and reapplication of said inhibition upon application of a terminating pulse at said terminating pulse input terminal, means for generating a terminating pulse in time coincidence with the removal of the inhibition of said gating device and a terminating pulse output terminal connected to said generating means, said pulse selecting circuits being interconnected as a chain with the priming pulse input terminal of the first of said pulse selecting circuits connected to said first source of pulses and the priming pulse input terminals of each of the remaining pulse selecting circuits connected to the output terminal of the immediately preceding pulse selecting circuit and with the terminating pulse input terminal of the last of said pulse-selecting circuits connected to said second source of pulses and the terminating pulse input terminals of each of the remaining pulse selecting circuits connected to the terminating pulse output terminal of the immediately succeeding pulse selecting circuit, the train of n successive pulses to be selected being applied simultaneously in parallel to each of said input terminals of said pulse selecting circuits and the selected pulses being derived, in turn, from each of said output terminals of said pulse selecting circuits.

12. A circuit arrangement for selecting and reproducing from a train of electric pulse signals, a given pulse signal whose time of occurrence has a predetermined relationship to the time of occurrence of the other pulse signals of said train, which comprises input terminals for receiving said train of electric pulse signals, output terminals for supplying said selected and reproduced pulse signal, a normally inhibited gating device connected between said input and output terminals, a priming pulse input terminal, circuit means associated with said gating device and connected to said priming pulse input terminal for causing removal of the normal inhibition of said gating device by and at the time of a priming pulse applied to said priming pulse input terminal condition-sustaining means for maintaining

the removal of said inhibition of said gating device after decay of said priming pulse and means for reimposing said inhibition subsequent to the passage through said gating device of the next pulse signal arriving at said input terminals following said priming pulse.

13. A circuit arrangement for selecting and reproducing from a train of electric pulse signals in unaltered timing or form a given pulse signal whose time of occurrence has a predetermined relationship to the time of occurrence of the other pulse signals of said train, which comprises input terminals for receiving said train of electric pulse signals, output terminals for supplying said selected and reproduced pulse signal, a gating device connected between said input and output terminals, means for supplying a control-potential to said gating device which normally inhibits passage of signals therethrough, a priming pulse input terminal, circuit means associated with said control potential supply means and connected to said priming pulse input terminal for causing removal of said inhibiting control potential from said gating device by and at the time of a priming pulse applied to said priming pulse input terminal, condition sustaining means for maintaining the removal of said inhibiting control potential from said gating device after decay of said priming pulse and means for reimposing said inhibiting control potential subsequent to the passage through said gating device of the next pulse signal arriving at said input terminals following said priming pulse.

14. A circuit arrangement for selecting and reproducing from a train of electric pulse signals a desired pulse having a given sequential position in said pulse train which comprises input terminals for receiving said input pulse signal train, output terminals for supplying said desired pulse signal, normally inhibited gating means connected between said input and output terminals, a priming pulse input terminal for receiving a priming pulse signal coincident in timing with that of the pulse signal in said input signal train which immediately precedes said desired pulse signal, circuit means associated with said gating device and said priming pulse input terminal for rendering said gating device conductive upon application of a priming pulse at said priming pulse input terminal, condition-sustaining means for maintaining said gate device in such conductive condition subsequent to decay of said priming pulse, a terminating pulse input terminal for receiving a terminating pulse signal occurring after the end of said desired pulse signal and further circuit means associated with said condition sustaining means and said terminating pulse input terminal for terminating the operation of said condition sustaining means upon application of said terminating pulse signal.

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