Jan. 2, 1951 C. E. CLEETON 2,536,035

MEANS FOR PRODUCING A VARIABLE NUMBER OF PULSES

Filed Dec. 12, 1939 2 Sheets-Sheet 1

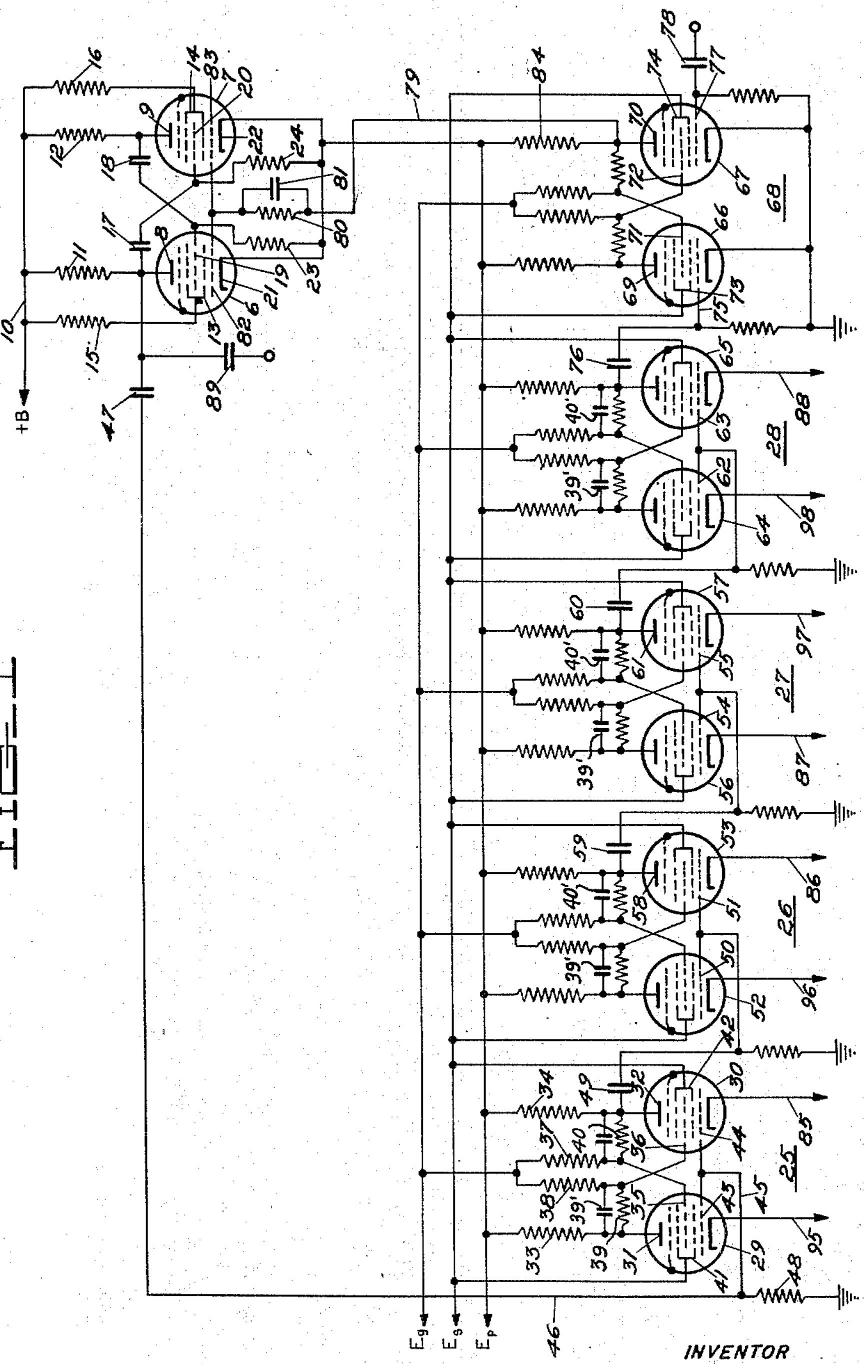

FIG. 1

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FIG. 2

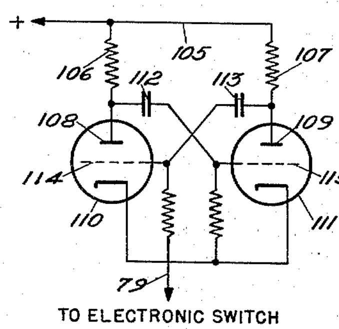


FIG. 3

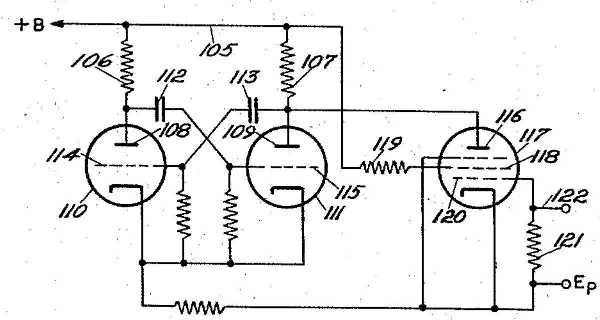


FIG. 4

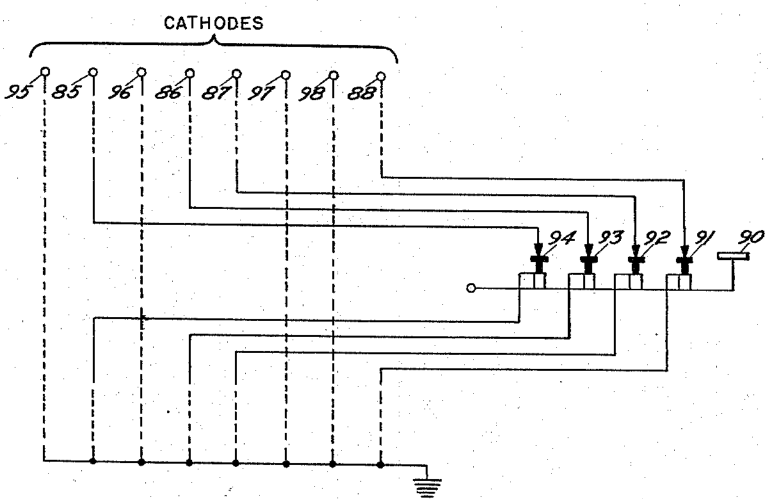
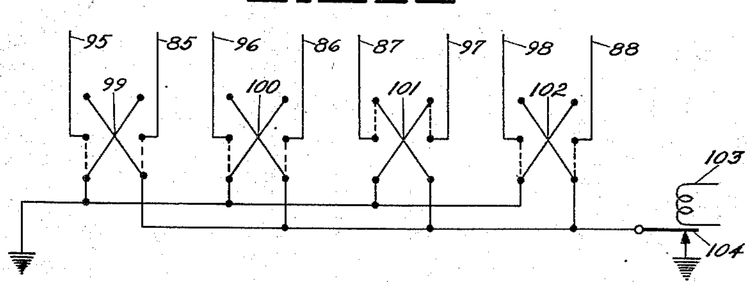


FIG. 5



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MEANS FOR PRODUCING A VARIABLE NUMBER OF PULSES

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14 Claims. (Cl. 250—27)

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This invention relates to apparatus for producing groups of pulses of alternating curent or voltage whereby the number of pulses in a group may be selectively predetermined.

Among the several objects of this invention are:

To provide means for producing current or voltage pulses in groups of varying number;

To provide means of the type specified having a plurality of stages that are combinable in different arrangements to give a number of pulse groupings much greater than the number of stages employed;

To provide apparatus of the type specified wherein the number of stages may be varied to produce any desired number of pulses per group up to the maximum of which the system is capable;

To provide simple means for predetermining the number of pulses per group.

The manner in which the foregoing and other objects are attained will more fully appear when the following specification is read in connection with the drawings wherein:

Fig. 1 is a schematic drawing of one embodiment of the present invention;

Fig. 2 is a diagram of a multivibrator circuit wherein oscillation may be started and stopped by varying the potential on the grid of one of the tubes;

Fig. 3 depicts schematically a multivibrator controlled by a tube that is in turn governed by varying current in a resistor;

Fig. 4 shows schematically how a keyboard may be arranged to select the number of pulses in a group;

Fig. 5 is a diagram of a switching arrangement for selecting the number of pulses in a group when it is not necessary that the change from one number to another be quickly effected.

The present invention comprehends, in general, a multivibrator oscillator controlled by an electronic "scale-of-two" counter and an electronic switch to control the oscillator. Any type of counter may be utilized in this system if it meets the requirements of speed and reliability.

Referring now to Fig. 1, the tubes 6 and 7 have their anodes 8 and 9 connected to a common anode supply 10 through resistors 11 and 12, respectively, and their screen grids 13 and 14 connected to the same source 10 through the resistors 15 and 16, respectively. Capacitors 17 and 18, respectively, couple the anodes 8 and 9 to the grids 20 and 19 of the tubes 7 and 6 whereby the drop of potential across the resistors 11 and 12 when the respective tubes draw current is ap-

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plied to the second grid of the other tube to hold such other tube in non-conducting condition. Grids 19 and 20 are connected to the cathodes 21 and 22 of the respective tubes through resistors 23 and 24.

The electronic counter is, in the instance depicted in Fig. 1, made up of four stages designated generally as 25, 26, 27 and 28. All of these stages are identical and the description of one applies equally to the others. It will be observed that stage 25 includes a first tube 29 and a second tube 30 having anodes 31 and 32 connected to a common supply E_p through resistors 33 and 34, the second grids 35 and 36 being connected to a common supply E_g through resistors 37 and 38 respectively. The anodes 31 and 32 are respectively connected through resistors 39 and 40 and shunting capacitors 39′ and 40′ to the second grid (35 or 36) of the other tube. Screen grids 41 and 42 are connected to a common supply E_s. First grids 43 and 44 have a common connection through leads 45 and 46 to capacitor 47 whereby the first grids 43 and 44 are coupled to anode 8 of tube 6, the said first grids being also connected to ground through resistor 48.

It will be apparent from the foregoing that when the multivibrator tubes 6 and 7 are oscillating, a negative pulse will be transmitted through capacitor 47 to the first grids 43 and 44 of the tubes 29 and 30, stopping the flow of current through the tube that may be conducting at that particular time and causing the other tube in the stage to conduct. If it be assumed, for purpose of illustration, that tube 29 is conducting when the negative pulse is applied, the flow of current through tube 29 will be arrested and the resultant rise of potential on anode 31 will be applied through resistor 39 and capacitor 39′ to grid 36 of tube 30, thereby causing the tube 30 to become conducting which in turn will apply the potential drop across resistor 34 to grid 35 of tube 29 to hold tube 29 in the non-conducting condition. At the same time, the potential drop across resistor 34 will be transmitted through capacitor 49 to first grids 50 and 51 of the tubes 52 and 53 in stage 26 and so will change the condition of conductivity of tubes 52 and 53, that is, the tube that is conducting when the pulse is applied will become non-conducting and the other tube in the stage will be caused to pass current since the only stable condition is with one tube conducting and the other non-conducting. It is obvious that if the tube 30 is passing current when the negative pulse is applied through capacitor 47 to first grids 43 and 44, the change in conductivity from tube 30 to tube 29 will not apply a negative pulse to grids 50 and 51 and hence the conductive condition of tubes 52 and 53 will remain unchanged.

First grids 54 and 55 of tubes 56 and 57 in stage 27 are likewise coupled to the anode 58 of tube 53 by capacitor 59 and capacitor 60 couples anode 61 of tube 57 to first grids 62 and 63 of tubes 64 and 65 in stage 28.

Tubes 66 and 67 in switching stage 68 have their anodes 69 and 70, their second grids 71 and 72 and their screen grids 73 and 74 connected in the same manner as do the tubes in stage 25 above described. However, only first grid 75 of tube 66 is coupled to the anode of tube 65 through capacitor 76, the first grid 77 of tube 67 being coupled through capacitor 78 to a keying or external control source. Anode 70 of tube 67 is connected by lead 79, through parallel connected resistor 80 and capacitor 81 to the first grids 82 and 83 of multivibrator tubes 6 and 7.

It is obvious that when tube 67 is conductive, the potential drop through resistor 84 is applied to first grids 82 and 83 of the multivibrator tubes 6 and 7 and oscillation of the multivibrator is prevented. However, if a negative pulse be applied through capacitor 78 to first grid 77 of tube 67, the flow of current through tube 67 will be arrested and the tube 66 will become conductive, the consequent rise of potential on anode 70 being transferred to grids 82 and 83 and the multivibrator being set into operation.

As is well known, the multivibrator operates by automatically changing the condition of conductivity of the tubes in the multivibrator circuit and hence the tube 6 will be made alternately conducting and non-conducting, with the concomitant application of a negative pulse to first grids 43 and 44 of tubes 29 and 30 each time the tube 6 becomes conducting.

A simple expedient for determining which tube in each of the stages 25 to 28 shall be conducting is to open the ground connection of one of the tubes and thus necessarily the other tube in the stage will conduct. The number of pulses in any one group is determined by the condition of the counter stages before the group starts, since this will control the number of changes in conductivity of stage 25 necessary to go through the required series of combinations of operating conditions in the several stages to block tube 66 in switching stage 68 and thereby cause tube 67 to become conductive and stop the multivibrator.

As an example of the foregoing, let it be assumed that cathodes 85, 86, 87 and 88 of tubes 30, 53, 56 and 65, respectively, be open circuited, thereby causing tubes 29, 52, 57 and 64 to be in a conductive condition. As soon as the flow of current in these tubes is established the cathode circuits that were opened may be closed and the apparatus is conditioned for operation. A negative pulse is now applied to first grid 77 of tube 67 with the resultant beginning of oscillation of the multivibrator tubes 6 and 7. When tube 6 passes current, a negative pulse is applied to grids 43 and 44 of tubes 29 and 30 and, since tube 29 has been assumed to be conducting, this tube will be blocked and tube 30 will be rendered conductive which will in turn result in the application of a negative pulse through capacitor 49 to grid 50 of tube 52 and will block tube 52 while making tube 53 conductive. The negative pulse through capacitor 59 to grids 54 and 55 of tubes 56 and 57 will change the conductivity in stage 27 from tube 57 to tube 56 but since tube 57 is now rendered non-conducting there will be no change in

stage 28 and the conditions of conductivity in the various stages thus set up will continue until tube 6 again conducts and another negative pulse is applied through capacitor 47 to grids 43 and 44 of tubes 29 and 30.

If the notation "29 to 30" be used to designate that tube 29 is blocked and tube 30 becomes conductive, the sequence of operation will be as follows for the set-up that was assumed to have been established:

First pulse—29 to 30, 52 to 53, 57 to 56;
Second pulse—30 to 29;
Third pulse—29 to 30, 53 to 52;
Fourth pulse—30 to 29;
Fifth pulse—29 to 30, 52 to 53, 56 to 57, 64 to 65.

It is obvious that when tube 65 becomes conductive, a negative pulse will be applied through capacitor 76 to grid 75, that tube 67 will thus be rendered conductive and the oscillation of the multivibrator will be stopped and a group of five pulses will have been applied through output capacitor 89 to whatever instrumentality is controlled by the pulses. For example, a transmitter may be keyed to transmit a pulse each time a pulse is passed by capacitor 89, i. e., each time tube 6 becomes conducting. It will be apparent from the foregoing that any number of pulses in a group, from 1 to 16, may be transmitted by suitable setting of the conductivity conditions in the tubes of the stages 25 to 28. If a greater number of pulses per group should be desired it is necessary merely to add additional counter stages to the circuit and by suitable permutations to secure the desired number of pulses per group.

If it be desirable to change rapidly the number of pulses per group, a keyboard may be arranged whereby the cathode circuits of the tubes in stages 25 to 28 may be opened in any desired combinations. Fig. 4 shows a key 90 arranged to open simultaneously contacts 91, 92, 93 and 94 to break the connections to ground of cathodes 85, 86, 87 and 88 above described while leaving the cathodes 95, 96, 97 and 98 connected to ground to permit the respective tubes 29, 52, 57 and 64 to conduct. It is apparent that a keyboard of sixteen keys similar to 90 may be arranged to control the sixteen combinations of cathode connection and permit instantaneously changing the number of pulses per group.

Fig. 5 shows a double-pole, double-throw switching arrangement whereby the conductivity conditions of the tubes in the several stages may be controlled when rapid shift of the number of pulses per group is not required. With the connections of switches 99, 100, 101 and 102 as shown, when solenoid 103 is energized, contact 104 is opened and the set-up previously described is established. By suitably changing the settings of switches 99 to 102, the whole range of combinations may be attained and the number of pulses may be varied over the possible range established by the number of counter stages.

In Fig. 2 is depicted a multivibrator circuit employing triodes in the multivibrator instead of pentagrid tubes as in Fig. 1.

The anode supply 105 is connected through resistors 106 and 107 to anodes 108 and 109 of tubes 110 and 111, the anodes 108 and 109 being respectively coupled by capacitors 112 and 113 to the grids 115 and 114 of the other tube and the grid 114 being connected by lead 79 to switching stage 68.

Fig. 3 illustrates a different method of control, using the triode multivibrator of Fig. 2. Anode

116 of tube 117 is connected to anode supply 105 through anode resistor 107 of tube 111 and grid 118 of tube 117 is connected to supply 105 through grid current limiting resistor 119. Plate supply E_p is connected to grid 120 of tube 117 through a resistor 121 and the tubes 29, 52, 56 and 64 derive their plate current from lead 122 through resistor 121 instead of directly from supply E_p. Consequently, when any one of the tubes 29, 52, 56 or 64 is drawing current, tube 117 is blocked. However, when none of tubes 29, 52, 56 or 64 is conducting, tube 117 becomes conductive and the drop across resistor 107 so reduces the potential on anode 109 that tube 111 will not draw current and the multivibrator cannot oscillate. The condition of the counter stages 25 to 28 that stops oscillation of the multivibrator is that none of the tubes 29, 52, 56 or 64 draws current and consequently with the apparatus of Fig. 3 and the conductivity conditions as above described, the number of pulses per group with the device of Fig. 3 will be determined exactly as in Fig. 1.

The wave form of the pulse is determined only by the constants of the electronic oscillator used. The frequency of the pulses may be anything from one cycle every few seconds to several thousand per second and is determined only by the limit of frequency of oscillation of the multivibrator oscillator and the electronic counters associated with the system. Equipment embodying this invention has been operated at 30,000 cycles with a maximum of 512 pulses per group. If it is desired to space the pulses closer together, the maximum number transmitted per group has to be decreased or the time constants of the counting circuits decreased.

The invention described herein may be manufactured and/or used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

I claim:

1. Apparatus for producing a variable number of voltage pulses in a group, comprising a multivibrator oscillator including two vacuum tubes each having a cathode, an anode, first and second grids and a screen grid, anode supply means, a respective resistance connecting each said anode and screen grid to said supply means, a capacitance connecting each said anode to the second grid of the other tubes; variable counter means comprising a plurality of stages, a switching stage, each said stage including a first and a second vacuum tube each having a cathode, an anode, first and second grids and a screen grid; grid, screen grid and anode supply means common to all tubes of all said stages, a respective resistance connecting each said anode to said common anode supply, a respective resistance connecting the second grid of each tube in all said stages to said common grid supply, a resistance and capacitance in parallel connecting the anode of each tube in each said stage to the second grid of the other tube in the same stage, a capacitance coupling the anode of the second tube in each counter stage to the first grids of both tubes in the next succeeding stage whereby the potential drop across the anode resistor of a second tube when such tube passes current is impressed upon the first grids of the tubes in the said succeeding stage to reverse the conductivity conditions of such tubes, a grid leak resistance connected to the first grids in the tubes of each stage, a capacitance coupling the anode of the second tube in the last counter stage to the first grid of the first tube in the switching stage, a capacitance coupling the anode of one of said multivibrator tubes to the first grids of the tubes in the first counter stage, means connecting the anode connected terminal of the anode resistance of the second tube in said switching stage to the first grids of the multivibrator tubes, means to impress a negative potential on the first grid of the second tube in said switching stage, and output means coupled to the anode of said one of the multivibrator tubes.

2. Apparatus for producing a variable number of voltage pulses in a group, comprising a multivibrator oscillator including two vacuum tubes, a plurality of counter stages each including a first and a second vacuum tube each of which has an anode, a cathode and first and second grids, anode supply means, a respective anode resistance connecting each anode to said supply, means to apply to the second grid of each tube the potential drop across the anode resistance of the other tube in the same stage, whereby when one tube in a stage is passing current the other tube in the same stage is held non-conducting until changed by application of an externally derived voltage, means to apply to the first grids of both tubes in a stage changes of potential at the anode of the second tube in the preceding stage whereby to change the conductivity conditions of the tubes in each stage to which a negative potential is thus applied, means to apply to the first grids of the tubes in the first stage a negative potential from one tube in said multivibrator to reverse the conducting conditions of the tubes in said first stage, a switching stage including a first and a second vacuum tube each having a cathode, an anode, first and second grids, a respective anode resistor connecting the anode of each tube in said switching stage to said anode supply, means to impress upon the first grid of the first tube in said switching stage a potential drop across the anode resistor of the second tube in the last counter stage, means to impress upon the first grid of the second tube in said switching stage an externally derived negative potential, means to impress upon the first grids of the said multivibrator tubes the drop in potential across the anode resistor of said second tube in the switching stage, and output means coupled to the anode of said one tube of said multivibrator.

3. Apparatus for producing a variable number of voltage pulses in a group, comprising a multivibrator oscillator including two vacuum tubes, a plurality of counter stages each including a first and a second vacuum tube each of which has an anode, a cathode and first and second grids, anode supply means, a respective anode resistance connecting each anode to said supply, means to apply to the second grid of each tube the potential drop across the anode resistance of the other tube in the same stage, whereby when one tube in a stage is passing current the other tube in the same stage is held non-conducting until changed by application of an externally derived voltage, means to apply to the first grids of both tubes in a stage changes of potential at the anode of the second tube in the preceding stage whereby to change the conductivity conditions of the tubes in each stage to which a negative potential is thus applied, means to apply to the first grids of the tubes in the first stage a negative potential from one tube in said multivibrator to reverse the conducting conditions of the tubes in said first stage, and switch-

ing means controlled by a negative potential drop across the anode resistor of the second tube in the last counter stage to stop said multivibrator from operating.

4. Apparatus for producing a variable number of voltage pulses in a group, a self-oscillatory device for generating periodic voltage pulses; variable counter means comprising a plurality of stages, a switching stage, each said stage including a first and a second vacuum tube each having a cathode, an anode, first and second grids and a screen grid; grid, screen grid and anode supply means common to all tubes of all said stages, a respective resistance connecting each said anode to said common anode supply, a respective resistance connecting the second grid of each tube in all said stages to said common grid supply, a resistance and capacitance in parallel connecting the anode of each tube in each said stage to the second grid of the other tube in the same stage, a capacitance coupling the anode of the second tube in each counter stage to the first grids of both tubes in the next succeeding stage whereby the potential drop across the anode resistor of a second tube when such tube passes current is impresesd upon the first grids of the tubes in the said succeeding stage to reverse the conductivity conditions of such tubes, a grid leak resistance connected to the first grids in the tubes of each stage, a capacitance coupling the anode of the second tube in the last counter stage to the first grid of the first tube in the switching stage, a capacitance coupling said device to the first grids of the tubes in the first counter stage whereby a negative pulse from said device changes the conductivity condition of the tubes in said first stage, means connecting the anode connected terminal of the anode resistance of the second tube in said switching stage to apply a negative potential to said device to inhibit operation of said device when said second switching tube is conducting for the first grids of the multivibrator tubes, means to impress a negative potential on the first grid of the second tube in said switching stage, and output means coupled to said device to transfer pulses for utilization externally of said apparatus.

5. Oscillatory apparatus, comprising two vacuum tubes each having a cathode, an anode, and a grid, anode supply means, a respective resistor connecting each said anode to said supply means, a respective capacitor coupling each said anode to the grid of the other tube; a third vacuum tube having a cathode, an anode, a screen grid, a suppressor grid and a control grid, means connecting the anode of said third tube to the anode of one of said two tubes, means connecting said screen grid to said anode supply, a second anode supply circuit including a resistor having a high potential end connected to the cathode of said third tube and a low potential end connected to the control grid of said third tube whereby current flow in said second anode supply circuit applies a negative potential to said control grid, means connecting said high potential end to said suppressor grid and to the cathodes of both said two tubes, and a respective grid resistor connecting each grid of said two tubes to the cathodes thereof.

6. Apparatus as described, comprising a multivibrator oscillator, counter means including a plurality of stages each having two alternative conducting paths, a first one of said stages being connected to have the current changed from one path to the other by a negative pulse from said multivibrator, electronic switching means having two alternative conducting paths, a last stage of said counter means having one said path connected to apply a pulse to one path in said switching means, all said stages except said last stage having each one path connected to apply a negative potential to change the flow of current from one path to the other in the next succeeding stage, and means connecting the other path in said switching means to apply a pulse to stop said multivibrator when a pulse is applied to said one path of said switching means as aforesaid.

7. Apparatus as described, comprising a multivibrator oscillator including two vacuum tubes each having an anode, a third vacuum tube having an anode and a control grid, a first resistor connected in series with the anodes of said third tube and one of said multivibrator tubes, an anode supply circuit including a resistor in series with said control grid whereby when current flows in said anode supply circuit said third tube is blocked, but when no current flows in said anode supply circuit said third tube draws current and said multivibrator is blocked.

8. An apparatus for producing a group of periodic pulses in precise time relation with a controlling influence comprising periodic pulse generating means, means initiating operation of said generating means in precise synchronism with said controlling influence, counting means for the generated pulses, means terminating operation of said generating means when a predetermined number of pulses are counted by said counting means, and selectively operable means for varying said predetermined number.

9. An apparatus for producing a predetermined number of pulses in a group comprising periodic pulse generating means, a control signal, means responsive to said control signal initiating operation of said generating means to produce periodic pulses in synchronism therewith, counting means for the produced pulses, and means terminating operation of said generating means when a number of pulses equal to said predetermined number are counted by said counting means.

10. An apparatus for producing a variable number of pulses in a group, comprising an oscillator for generating voltage pulses, electronic control means connected to the oscillator to initiate and terminate operation thereof, said electronic control means including means operative responsively to a control signal to initiate operation of the oscillator in exact phase relation therewith, permuting counter means having a plurality of stages including one stage coupled to the oscillator, means conditioning said stages to interact in a predetermined combination each time a pulse from the oscillator is impressed upon said one stage whereby, after a predetermined number of pulses from said oscillator, said counter produces an output pulse, and said electronic control means including means operative responsively to the counter output pulse to terminate operation of the oscillator.

11. An apparatus for producing a variable number of voltage pulses in a group, comprising an oscillator for generating voltage pulses, electronic control means connected to the oscillator to initiate and terminate operation thereof, said electronic control means including means operative responsively to a control signal to initiate operation of the oscillator in exact phase relation therewith, permuting counter means having a plurality of stages including a first stage cou-

pled to the oscillator and a last stage, means conditioning said stages to effect interaction of certain of said stages in a predetermined combination when a pulse from the oscillator is impressed upon said first stage, and automatically to change the combination at each successive pulse applied to the first stage until the last stage produces an output pulse after a predetermined number of pulses are applied to the first stage, and said electronic control means including means operative responsively to the output pulse of the last stage to terminate operation of the oscillator.

12. An apparatus for producing a group of periodic pulses in precise time relation with a controlling influence, comprising periodic pulse generating means, electronic control means operative responsively to the controlling influence to initiate operation of said generating means in exact phase relation therewith, counting means fed by the generating means to produce an output pulse when a predetermined number of pulses are counted thereby, and electronic control means operative responsively to the output of the counting means to terminate operation of the generating means.

13. The method of producing a predetermined number of periodic electrical energy pulses in precise time relation with a control signal which comprises precisionally initiating generation of equally-spaced electrical energy pulses responsively to the control signal with the first electrical energy pulse abruptly generated in exact phase relation with the control signal, counting each of the generated electrical energy pulses, and abruptly terminating generation of the electrical energy pulses when a number of pulses equal to said predetermined number are counted.

14. The method of operating an electrical energy pulse oscillation generator to produce a predetermined number of electrical energy pulses in precise time relation with a controlling influence, which comprises precisionally initiating operation of the oscillation generator responsively to the controlling influence to produce periodic electrical energy pulses with the first electrical energy pulse abruptly generated in exact phase relation with the controlling influence, counting each of the electrical energy pulses produced by the pulse oscillation generator, producing a control signal when a predetermined number of electrical energy pulses are counted, and abruptly terminating operation of the oscillation generator responsively to the control signal.

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