

Feb. 13, 1962

A. F. MESTRE
PLURAL GATED PULSE GENERATORS CONTROLLED
BY COMMON FEEDBACK PATH

3,021,484

Filed March 18, 1957

3 Sheets-Sheet 1

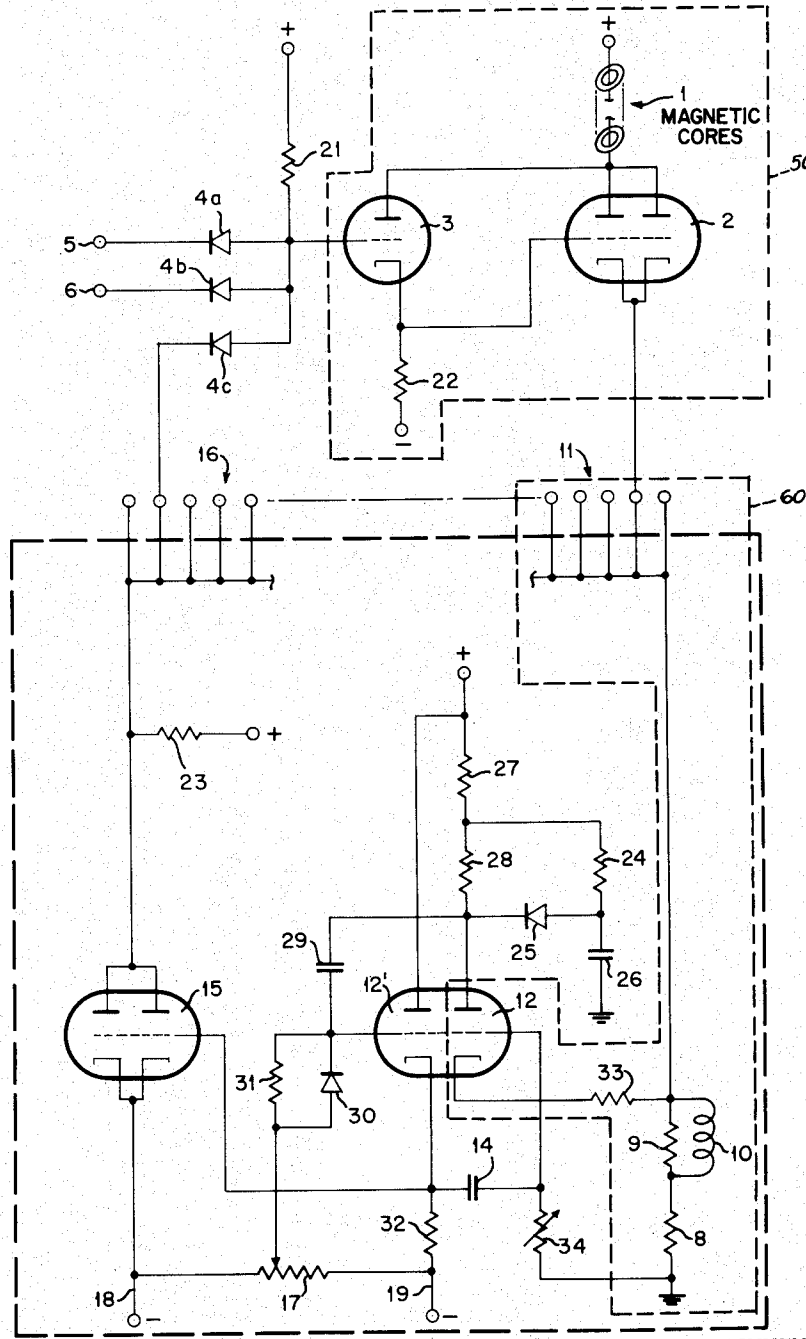


FIG. 1

INVENTOR.

AUGUST MESTRE

BY

Edward S. Drake

AGENT

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3 Sheets-Sheet 2

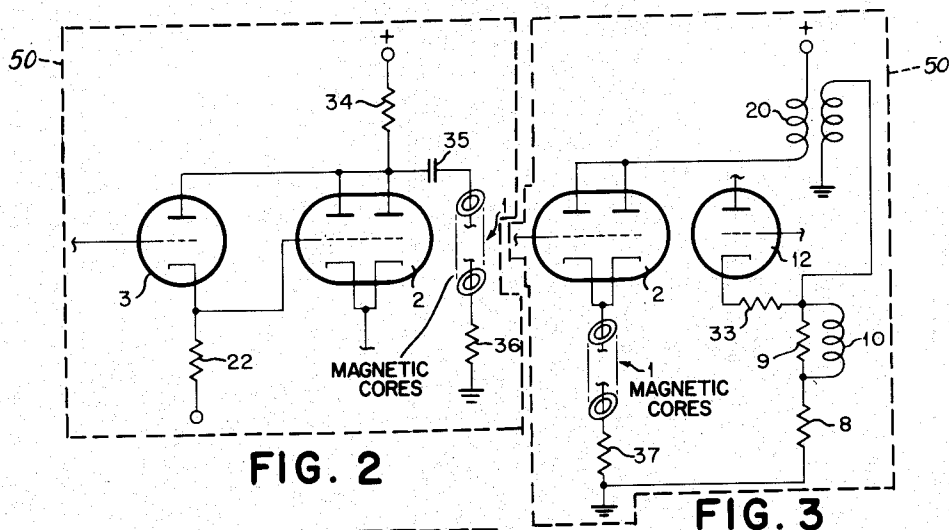


FIG. 2

FIG. 3

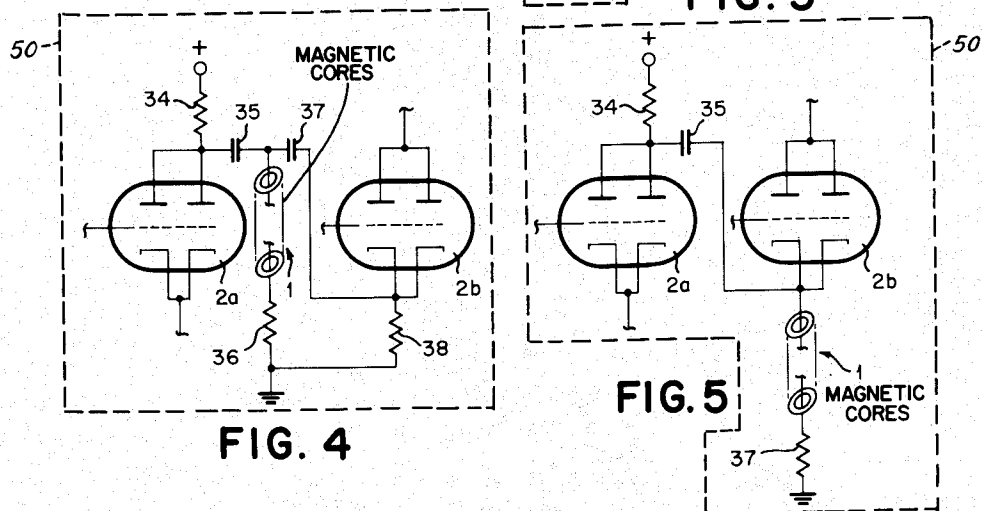


FIG. 4

FIG. 5

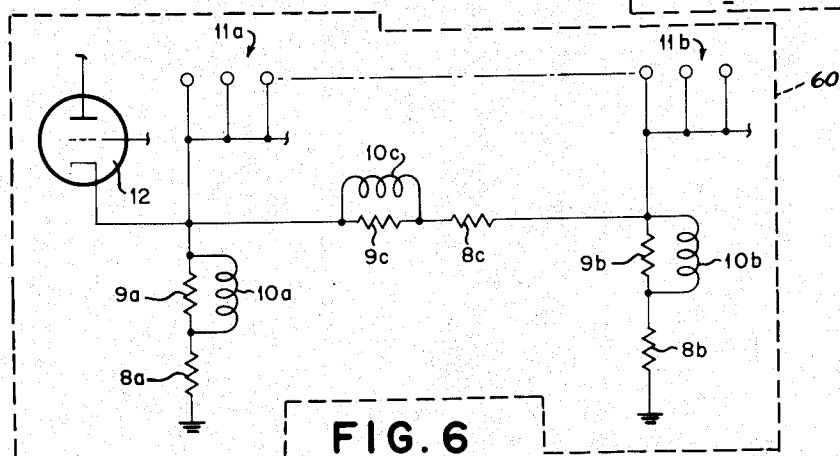


FIG. 6

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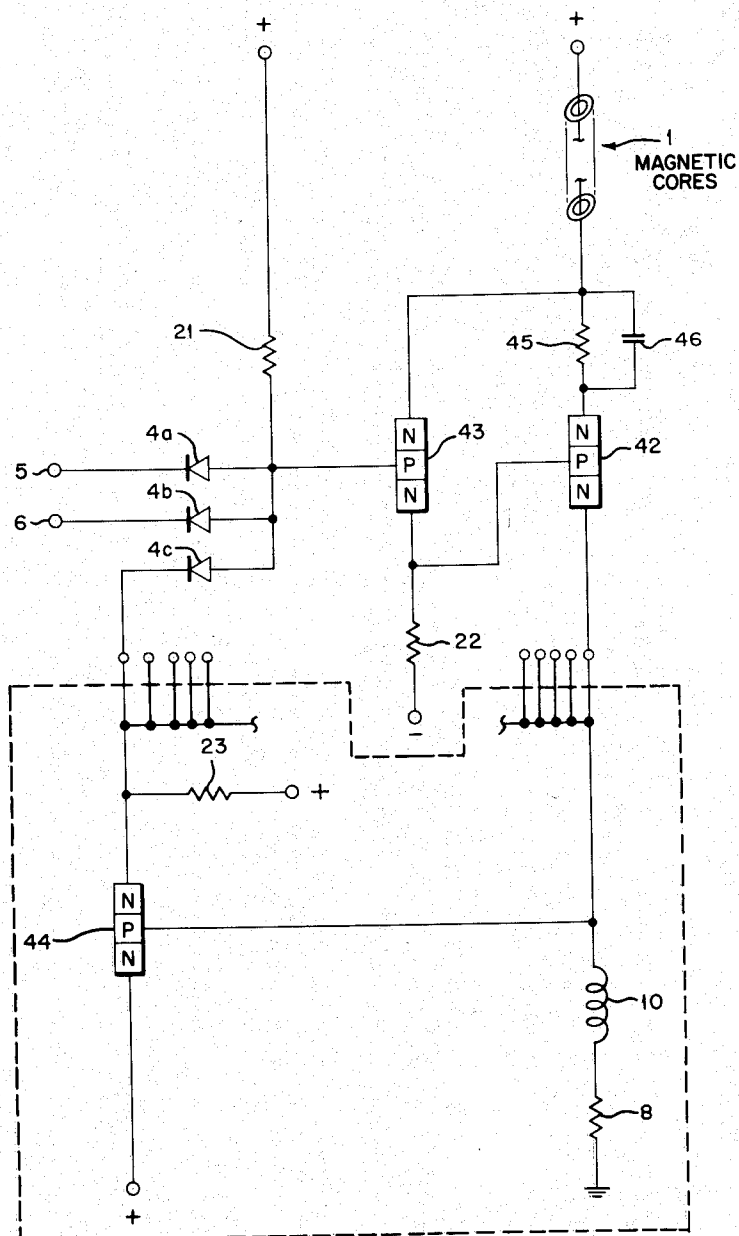


FIG. 7

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PLURAL GATED PULSE GENERATORS CONTROLLED BY COMMON FEEDBACK PATH

Auguste F. Mestre, Saint-Maur-des-Fosses, France, assignor to International Business Machines Corporation, New York, N.Y., a corporation of New York

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10 Claims. (Cl. 328—63)

The present invention relates to a pulse generator particularly of a type for driving a magnetic core array.

Magnetic core arrays are generally fed with pulses of very short duration, for example, one to four microseconds, of a relatively high amplitude, for example, 400–800 milliamperes, and of a very low rise time, in the order of 0.2 to 0.4 microseconds. Although the duration in rise time of the pulses need not remain constant at all times, the amplitude must be accurately defined and maintained constant for the duration of the pulse.

Many different embodiments of pulse generators are known in the art in which their operation is regulated through various feedback devices. However, such devices usually fail to maintain current amplitude of the pulse generator in a high and constant form.

Therefore, the main object of this invention is to provide a simplified pulse generator capable of producing current pulses having a high amplitude that is maintained constant for the duration of the pulse.

Another object of this invention is to provide an improved feedback arrangement which may be used to regulate any one of a plurality of commonly connected pulse generators.

Another object of this invention is to provide an improved pulse generator that is capable of driving an array of ferrite cores with a current pulse of constant high amplitude.

Other objects of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which disclose, by way of examples, the principle of the invention and the best mode, which has been contemplated, of applying that principle.

In the drawings:

FIG. 1 illustrates the invention wherein vacuum tubes are employed.

FIG. 2 illustrates another embodiment of the generator without the feedback arrangement.

FIG. 3 illustrates a generator of the cathode follower type.

FIGS. 4 and 5 illustrate embodiments in which the array is controlled by two generators.

FIG. 6 illustrates the input of the common feedback circuit delivering two different currents.

FIG. 7 illustrates the invention wherein transistors are employed.

FIG. 1 illustrates a three-input control circuit for operating a pulse generator, in accordance with regulated pulses provided by a negative feedback arrangement connected between said generator and said input circuit, said pulse generator having its output line connected through an array of magnetic cores for the purpose of driving said cores with a current pulse of constant magnitude.

More specifically, the input circuit takes the form of diodes 4a–4c and resistor 21 arranged in the form of an AND circuit. The output of the AND circuit is connected to the grid of cathode follower 3. In operation the voltage developed by this cathode follower across resistor 22 is made available to the combined grids of duo-triode output tube 2. The current pulse developed in the plate circuit of output tube 2 is made available to all the ferrite cores in array 1. The duo-triode is herein employed because of its high level of current emission.

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Between commonly connected cathodes of output tube 2 and diode 4c of the input circuit is a negative feedback circuit (shown in broken lines). Although only one pulse generator is shown connected between terminals 11 and 16, it is understood that any number of such pulse generators can be so connected. The only requirement is that these pulse generators be controlled separately for operation by the common feedback circuit. Of course, it is understood that the pulse generators connected to the common feedback arrangement are required to deliver the same type of pulse to the core array which each pulse generator controls.

It will be noted that the common cathodes of output tube 2 are connected through one of the input terminals 11 of the feedback circuit and through the resistor 9-inductor 10 parallel-connected arrangement and resistor 8 to ground. Output tubes of other generators may be similarly connected through input terminal 11 to the input circuit of the feedback circuit.

The input triode 12 of the duo-triode in the feedback circuit operates as a class A amplifier. The voltage developed on the appropriate input terminal 11 by the operation of the corresponding output tube 2 is made available through resistor 33 to the cathode of input tube 12. The inductor 10 serves to balance the effect of the capacitance distributed between the electrodes of tube 12, such balancing action being particularly important in the rising portion of the pulse developed by output tube 2. Variable resistor 34 provides a variable grid potential for tube 12.

During the operation of input triode 12 the potential developed at its anode is a positive pulse having the same shape as the current pulse that is made available to the particular array 1. Actually, the array current is equal to the anode current of output tube 2 and a substantial portion of the anode current of tube 3. It is recognized that there is a definite relationship between the anode current of tube 3 and the cathode current of tube 2, the latter current passing through elements 8, 9 and 10 of the feedback input circuit. The anode of tube 12 is connected through a divided resistor network 27 and 28 to a positive source of potential. Resistor 24, diode 25 and capacitor 26, which are connected across resistor 28 in the anode circuit of tube 12, function to dampen the negative peak in the rising portion of the anode pulse.

The pulse developed at the anode of tube 12 is made available through capacitor 29 to the control grid of triode 12', which serves as a cathode follower. Triode 12' is normally maintained non-conductive through a parallel connected diode 30-resistor 31 arrangement that is connected through potentiometer 17 to an appropriate negative source of potential. Potentiometer 17, which is shown connected between terminals 18 and 19, is adjusted for the proper grid bias of triode 12' for the purpose of determining the current level below which the feedback pulse developed by triode 12 cannot operate triode 12'. However, it should be noted that the bias voltage must be maintained exactly constant with respect to the commonly connected cathodes of tube 15 simply because it controls the delay in the negative feedback action. Capacitor 14 connects the cathode of triode 12' to the control grid of triode 12, and constitutes a partial negative feedback loop that increases the stability of amplification and improves the signal response of the step each pulse.

The operation of cathode follower 12' develops a potential across resistor 32 and drives the output duo-triode 15 of the feedback circuit. The commonly connected plates of tube 15 are connected through a resistor 23 to an appropriate source of positive voltage. The potential developed in the plate circuit output tube 15 of the feedback

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circuit is made available through one of the output terminals 16 to input diode 4c of the input AND circuit.

In operation a control pulse applied at input terminal 5, a timing pulse applied at input terminal 6 and a potential developed at one of the terminals 16 operates the input coincidence circuit to drive the input cathode follower 3 into a state of conductivity. The potential developed across resistor 22 makes the output duo-triode 2 conductive, which together with tube 3, develops a current pulse for array 1 of the desired magnitude. The current pulse made available to array 1 will be maintained constant even if there is any variation in the potentials made available to the electrodes of tubes 2 and 3, or in case there is the aging of said tubes.

As mentioned above, the operation of output tube 2 develops a cathode current flow that is reflected in the operation of the input tube 12 of the negative feedback circuit. Class A amplifier 12 is driven by its cathode, and provides a positive anode pulse in the same form as the driver current in its cathode circuit. An anode circuit, in the form of resistor 24, diode 25 and capacitor 26, dampens the negative thrust that would be collected on the return negative edge. The output pulse of tube 12 in turn drives cathode follower 12', which develops a potential for operating output tube 15 in a manner necessary to provide the desired feedback pulse for diode 4c. Clamping diode 30 guarantees the restoration of the signal D.C. component. The bias adjustment of resistor 17 determines the amplitude of the driver current at which the negative feedback is observed. This bias must be regulated if the current amplitude needs to be reduced when core matrix temperature increases. In such a case an automatic thermistor element may be employed. This feedback pulse, in conjunction with the pulses of constant magnitude applied at input terminals 5 and 6, serves to return the pulse generator to its optimum condition of operation and maintain it in this condition so that a constant pulse of high magnitude may be regularly available to the magnetic core array 1.

FIGS. 2-6 illustrate a number of variations of certain portions of the complete circuit of FIG. 1. The apparatus within dashed block 50, FIG. 1, may be replaced by the apparatus within blocks 50 of FIGS. 2-5, inclusive. Further, the apparatus within dashed block 60, FIG. 1, may be replaced by that within block 60 of FIG. 6. Components performing the same function in FIGS. 2-6 as in FIG. 1 will be identified by the same numbers, for example, tubes 2 and 3 in FIG. 2 corresponding to tubes 2 and 3 in FIG. 1. In the case of FIG. 2, resistor 34 connects the anodes of tubes 2 and 3 to a source of positive potential. The current pulse developed by tubes 2 and 3 is transmitted through capacitor 35 to the magnetic core array 1 and through resistor 36 to ground. Although the negative feedback circuit is not shown in FIG. 2 it is understood that it may take the same form as FIG. 1.

FIG. 3 illustrates a magnetic core array control arrangement in which the series of cores 1 is located in the cathode circuit of output tube 2. In operation the current pulse for array 1 is developed in the cathode circuit of tube 2 through grounded resistor 37. Negative feedback voltage is developed in the secondary winding of the 1:1 ratio transformer 20, whose primary winding is connected to the anodes of tube 2. In such a circuit, when the pulse duration is appreciable with respect to the period of repetition, it is not necessary to provide a special device for balancing the mean current developed in the secondary winding of transformer 20 inasmuch as this action may be performed automatically by clipping diode 30 (FIG. 1) in the grid circuit of triode 12'.

For the purpose of driving magnetic core array 1 with alternately positive and negative pulses, two output tubes as shown in FIGS. 4 and 5, may be employed. In FIG. 4, tube 2a drives the array in one direction, and tube 2b drives it in another direction. As illustrated in the case

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of FIG. 2, conduction of tube 2a in FIG. 4 develops a current pulse that passes through capacitor 35 to the cores in array 1. Tube 2b, which may be of identical character to tube 2a, is energized in some conventional manner (not shown). When operated its cathode resistor 38 develops a potential that is delivered through capacitor 37 to array cores 1. FIG. 5 also shows an embodiment wherein the cores in array 1 are energized in one direction through the plate circuit of tube 2a and in another direction through the cathode circuit of tube 2b.

FIG. 6 illustrates a situation wherein two groups of pulse generators (not shown), which deliver two different currents, are connected to a common feedback circuit. A network comprising elements 8, 9 and 10 is associated with each group of pulse generators through appropriate terminals 11, and a similar network, in this case shown as elements 8c, 9c and 10c, connects the outputs of the two generators. The networks are so designed that the currents developed in either terminals 11a or 11b (only one terminal at a time in both groups) develop a potential condition at the cathode of input tube 12 which operates the feedback circuit in the same manner for both groups of pulse generators.

FIG. 7 illustrates a regulated pulse generator, according to the invention wherein transistor elements are substituted for vacuum tubes. As in the case of FIGS. 2-6 the electrical components in FIG. 7 that operate identically to those in FIG. 1 will have corresponding numbers, except for transistors 42 and 43 which correspond to tubes 2 and 3 respectively. Although the circuit is shown using the NPN type transistors it is understood that the PNP type, or some other modified form, may be used to achieve the same results. Similarly, although the circuit of FIG. 7 shows a single transistor pulse generator whose operation is controlled by a transistor feedback circuit, it is also understood that, as in the case of FIG. 1, a plurality of said pulse generators may be connected to a single feedback circuit and may be controlled by the latter, provided only that more than one such parallel-connected pulse generator is not operated simultaneously.

Briefly, the transistorized circuit of FIG. 7 operates like the circuit of FIG. 1. A pulse of sufficient magnitude developed by the input coincidence circuit represented by diodes 4a, 4b and 4c and resistor 21 is made available to the base of transistor 43. It is assumed, of course, that signals appear simultaneously at input terminals 5 and 6 and the input of diode 4c. Transistor 43 operates in a manner that the emitter voltage follows the base voltage, which is similar to the operation of cathode follower 3 in FIG. 1. Current flow in the emitter circuit of transistor 43 provides potential, through resistor 22, for operating transistor 42. The current pulses developed in the collector circuits of both transistors 42 and 43 are made available to the array cores. The collector of transistor 42 is connected through parallel connected resistor 45 and capacitor 46 to the cores.

Operation of transistor 42 develops a current flow in the emitter thereof which provides a potential through resistor 8 and inductor 10 for the base of feedback transistor 44. It may be mentioned that the voltage in the emitter circuit of transistor 42 is proportional to the current flowing through the array 1 during the operation of the pulse generator. The emitter of transistor 44 is connected to an adequate source of positive voltage, which, it is assumed, is maintained constant during the operation of the feedback circuit.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art, without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. In a pulse generator of the type employed to drive a plurality of magnetic cores, an input coincidence circuit to provide a control pulse of a desired magnitude, a first discharge device controlled by said input pulse, a second discharge device controlled by said first discharge device through the cathode circuit of said first discharge device, with the anodes of said first and second discharge devices being connected together to provide a combined current pulse for driving said cores, a third discharge device controlled by said second discharge device through the cathode circuit of said second discharge device, a fourth discharge device controlled by the voltage swing in the anode circuit of said second discharge device, a bias varying means for controlling the potential level of operation of said fourth discharge device and a fifth discharge device controlled by the fourth discharge device through its cathode circuit for developing a balancing potential for the input coincidence circuit for the purpose of maintaining the current pulse developed by said first and second discharge devices in a constant condition of desired amplitude.

2. The invention according to claim 2 wherein the feedback voltage is developed in the anode circuit of the second discharge device and the current pulse for driving the series of magnetic cores is developed in the cathode circuit of said second device.

3. The invention according to claim 2 wherein said feedback circuit comprises a first amplifier that is driven through its cathode circuit by current developed in the cathode circuit of said driver amplifier, a negative peak clipping circuit in the anode circuit of said amplifier, a cathode follower controlled by the operation of said amplifier and said negative peak clipping circuit, a bias varying element for adjusting the level of operation of said cathode follower, and an output amplifier controlled by said cathode follower for providing a balancing voltage for said input circuit for the purpose of maintaining the current pulse for driving said magnetic cores at a fixed amplitude.

4. A regulated pulse generator comprising a plurality of input coincidence circuits to provide a plurality of input control pulses, a plurality of first transistor circuits controlled by said plurality of input pulses, a plurality of second transistor circuits controlled by said plurality of first transistor circuits, each first and second transistor circuit of said plurality of first and second transistor circuits having common electrodes to provide a combined current pulse, and a common feedback circuit controlled by said plurality of second transistor circuits for providing a balancing potential at said plurality of input circuits for the purpose of regulating the current pulses developed by said plurality of first and second transistor circuits.

5. The invention according to claim 4 wherein the transistors are of the NPN type and in which the first and second transistors of said plurality of transistor circuits are driven through their base regions to provide a

combined collector pulse for driving the series of magnetic cores.

6. The invention according to claim 4 wherein each input coincident circuit comprises three diodes with one of said diodes being controlled for operation by the collector pulse of said third transistor.

7. A regulated pulse generator comprising a common feedback circuit having a plurality of input terminals and a plurality of output terminals, a plurality of driver circuits, an output for each of said driver circuits connected to one of said plurality of input terminals, a coincidence switch for each of said driver circuits having a plurality of inputs and an output connected to control the associated driver circuit, means connecting one of said output terminals to a first input of each of said coincidence switches, and means for applying control signals to a second input of said coincidence switches whereby a single feedback circuit accommodates a plurality of driver circuits to regulate output pulses therefrom.

8. Apparatus according to claim 2 wherein said feedback circuit includes a class A amplifier.

9. A regulated pulse generator as in claim 7 wherein said plurality of driver circuits are separated into groups and each of said groups, providing a different current pulse, is connected to one of said plurality of input terminals of said common feedback circuit through an appropriate impedance.

10. A regulated pulse generator comprising a plurality of diode type coincidence circuits for providing a plurality of input control pulses, a plurality of first transistor circuits each being operated by the application of an input pulse to the base thereof, a plurality of second transistor circuits connected to be controlled by pulses developed in the emitter circuits of said plurality of first transistor circuits to provide a plurality of combined current pulses which are developed in the collector circuits of said plurality of first and second transistor circuits, and a common feedback circuit connected to said plurality of first and second transistor circuits, said common feedback circuit comprising a third transistor circuit controlled by pulses developed in the emitter circuits of said plurality of second transistor circuits for developing a balancing pulse for said plurality of input diode type coincidence circuits for the purpose of regulating the combined current pulses developed by said plurality of first and second transistor circuits.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,021,484

February 13, 1962

Auguste F. Mestre

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, lines 66 and 67, for "potial" read -- potential --; column 5, line 23, for the claim reference numeral "2" read -- 1 --; column 6, line 20, for the claim reference numeral "2" read -- 7 --.

Signed and sealed this 8th day of January 1963.

(SEAL)
Attest:

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