United States Patent [19]

Roos et al.

[11] **3,924,535**

[45] **Dec. 9, 1975**

[54] **PULSE GENERATING CIRCUIT**

[75] Inventors: **Dewey A. Roos**, Corona; **Kenneth A. Lawlor**; **Erwin I. Abadie**, both of Riverside, all of Calif.

[73] Assignee: **The United States of America as represented by the Secretary of the Navy**, Washington, D.C.

[22] Filed: **July 19, 1965**

[21] Appl. No.: **473,913**

[52] **U.S. Cl.** ..... **102/70.2 R**

[51] **Int. Cl.**[2] **F42C 15/40**

[58] **Field of Search** 102/70.2, 18; 307/88.5, 307/127; 328/61, 63, 66, 68, 74

[56] **References Cited**

UNITED STATES PATENTS

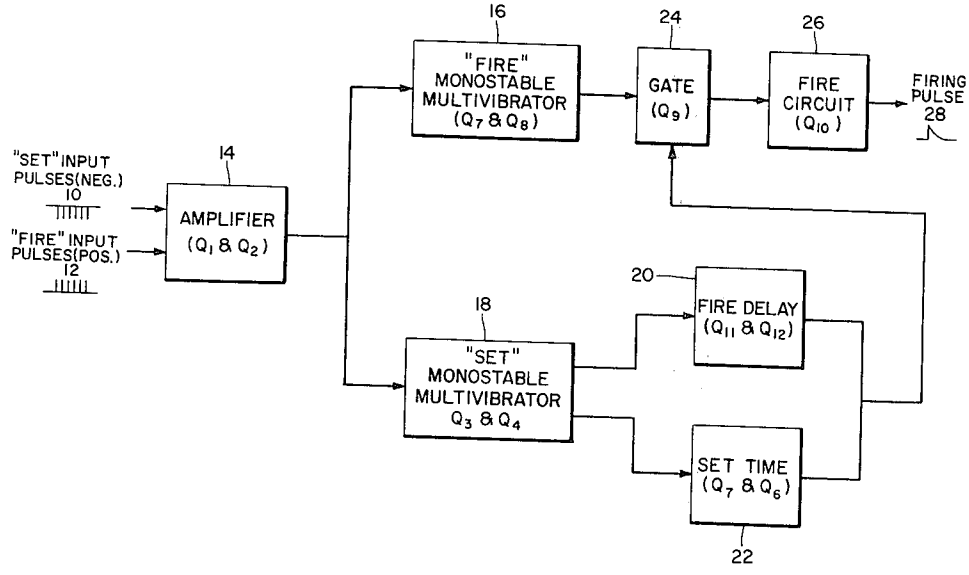
3,162,119 12/1964 Tate, Jr. et al. 102/18

Primary Examiner—Samuel Feinberg
Assistant Examiner—C. T. Jordan
Attorney, Agent, or Firm—Richard S. Sciascia; Joseph M. St. Amand; Howard J. Murray

[57] **ABSTRACT**

A pulse-generating circuit in which an output pulse is produced only if an input pulse of one polarity is received by the circuit within a predetermined period of time following the reception by the circuit of a second input pulse of a different polarity. The invention is particularly suitable in connection with a fire-control system for missiles incorporating a passive fusing network, and enables the missile electronics to be "set" for only a brief period of time after the arriving signals are received. If no "fire" pulses are intercepted in this period of time, the network is deactivated and must be set or armed again before firing can occur.

6 Claims, 3 Drawing Figures



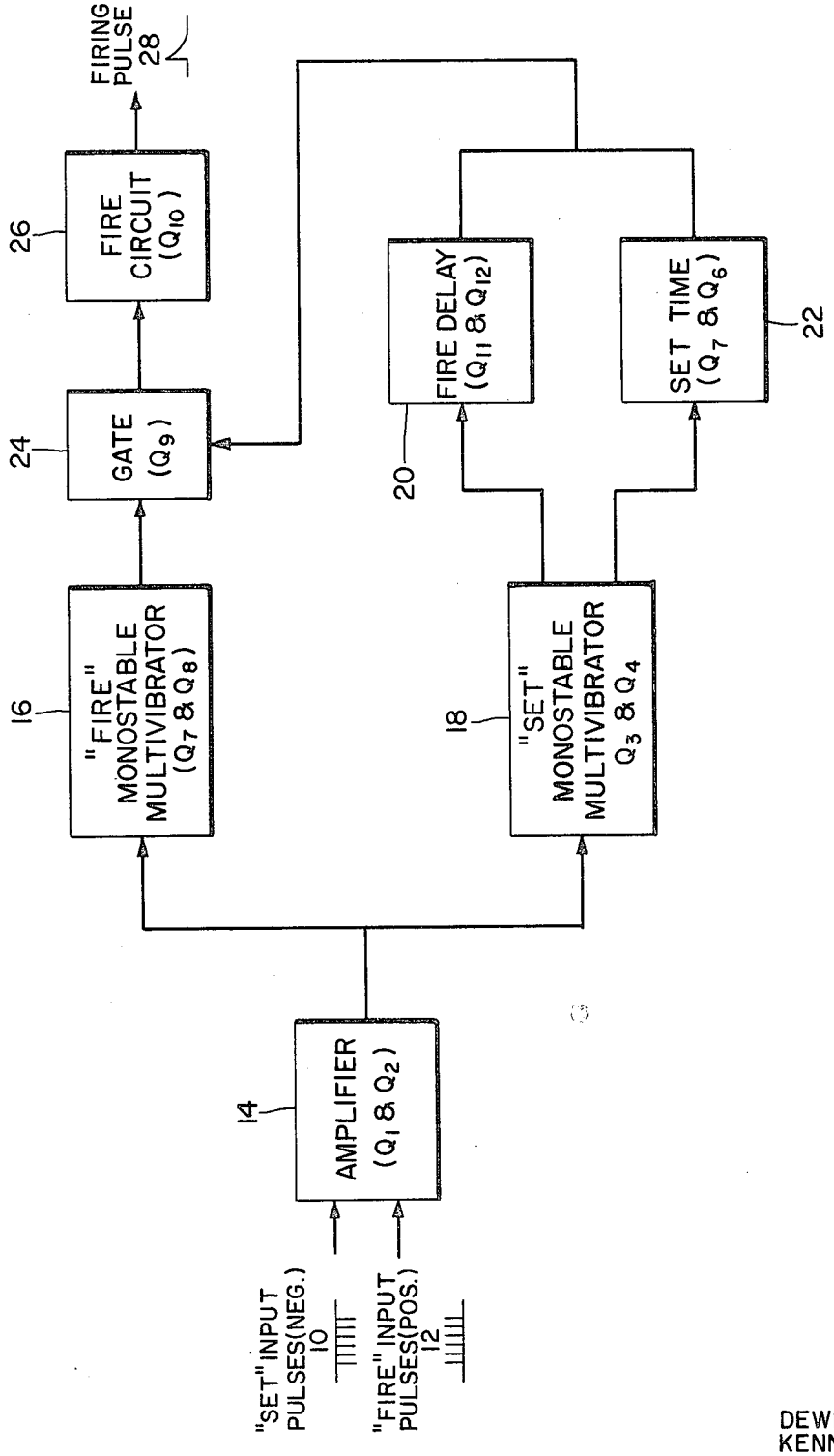


Fig. 1

INVENTORS
DEWEY A. ROOS
KENNETH A. LAWLOR
ERWIN I. ABADIE
BY Howard J. Murray, Jr. AGENT
O. Box & James ATTORNEY

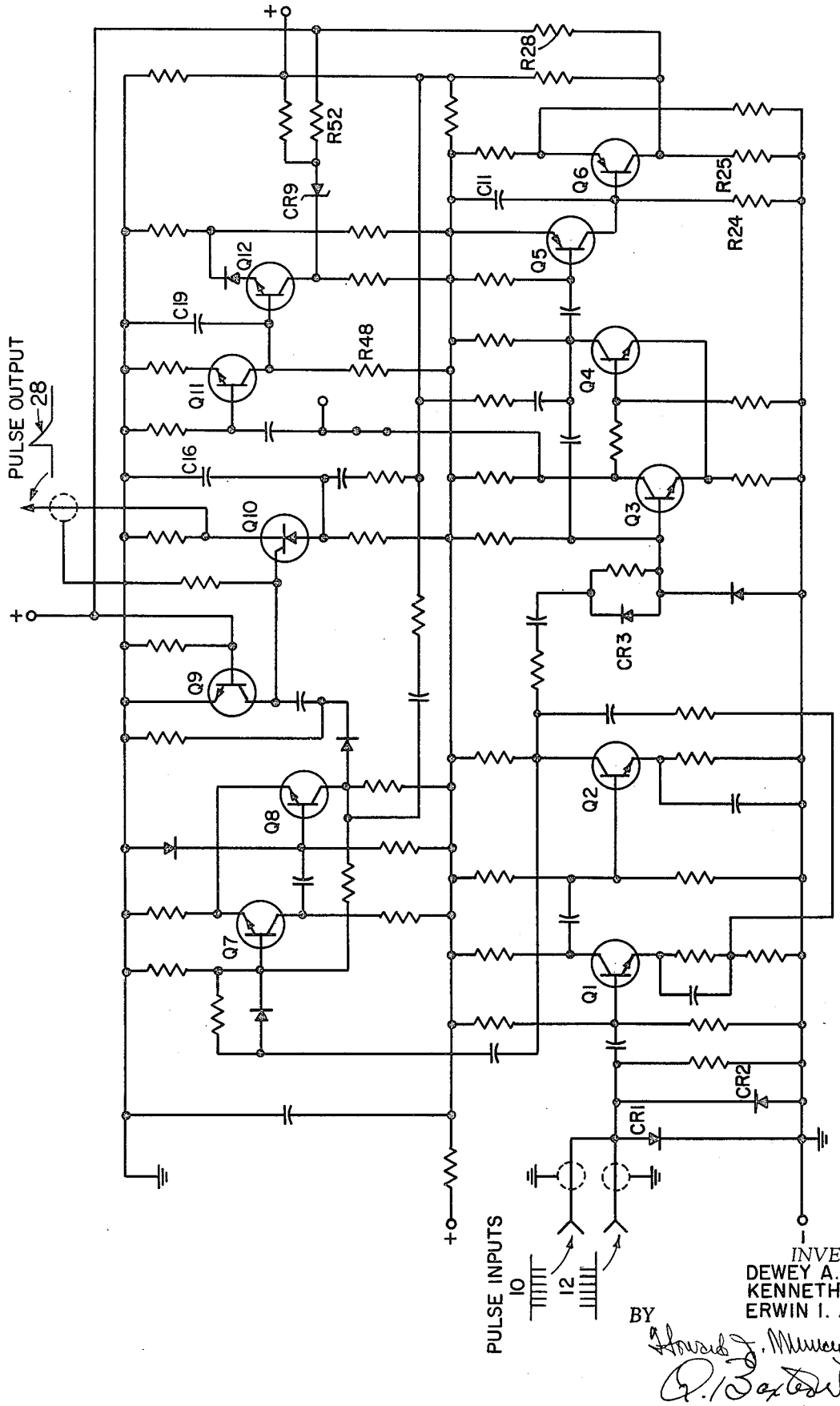


Fig. 2

INVENTORS
DEWEY A. ROOS
KENNETH A. LAWLOR
ERWIN I. ABADIE
BY
Howard J. Mercy Jr. AGENT
ATTORNEY

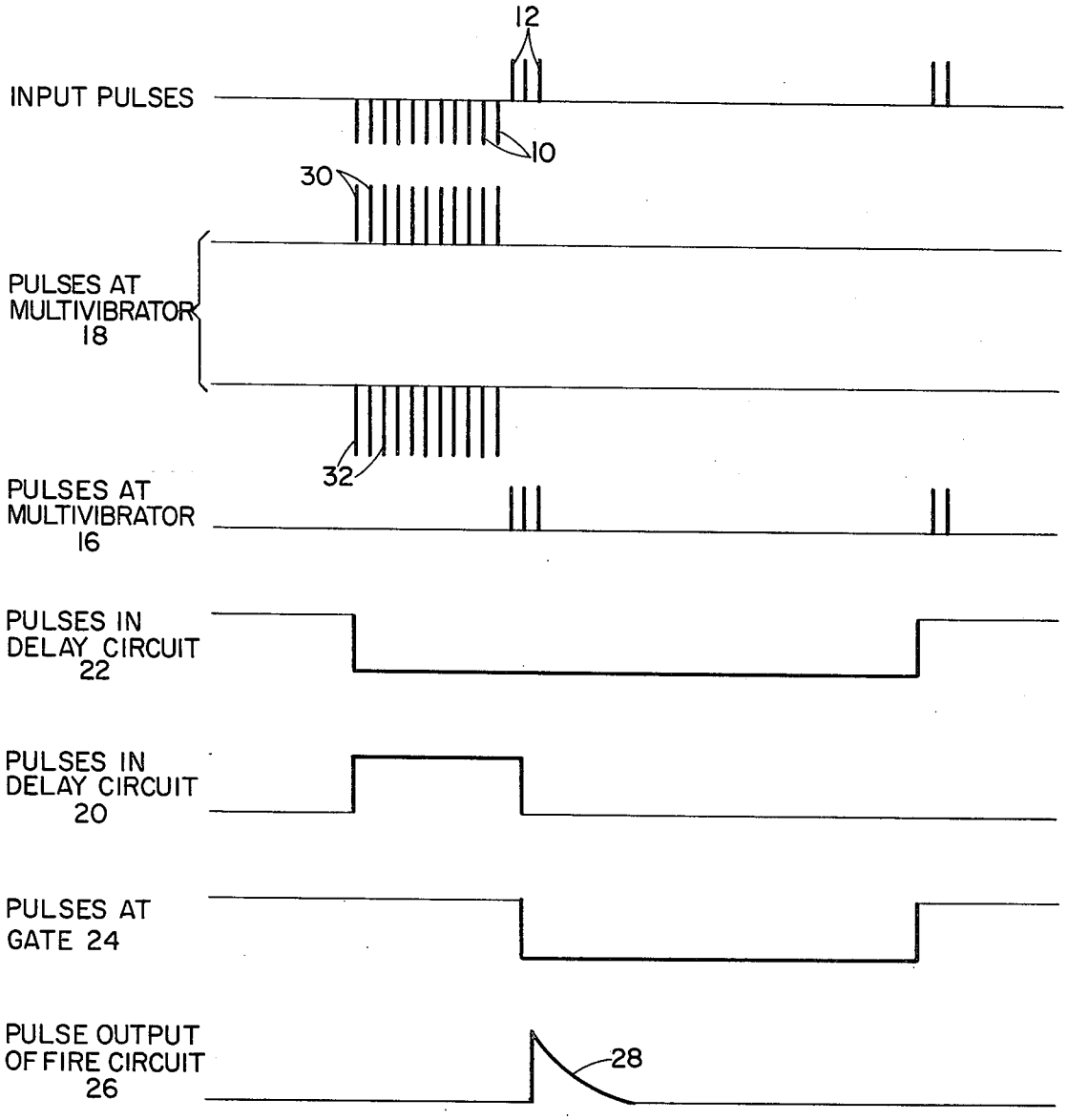


Fig. 3

INVENTORS
DEWEY A. ROOS
KENNETH A. LAWLOR
ERWIN I. ABADIE
BY Arnold J. Murray Jr. AGENT
F. Baxter Warner ATTORNEY

PULSE GENERATING CIRCUIT

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

The present invention relates to pulse generating circuits. The disclosed concept is particularly useful in a passive fusing system for missile fire-control applications, but is adaptable to any environment in which it is desirable to establish a limited time interval during which operation of a device may occur.

Arrangements are known in which a circuit is set, or conditioned for operation, by reception of a particular signal, and then activated or triggered by the subsequent reception of a different signal to generate an output pulse. Such systems are found, for example, in missile fire-control apparatus, where it is desired to "arm" the equipment shortly prior to the instant when a detonating signal is expected.

In many cases, however, it is necessary that the missile be fired at a particular point in its journey toward the target. However, once the detonating circuit has been armed, subsequent reception of a firing pulse will energize the missile's firing circuitry at any time subsequent to the reception of the arming signal. This can result in a detonation of the missile's warhead at a distance from the target which is too great to result in its effective destruction.

Although the present concept is of general application, it will be considered hereinafter in conjunction with a fire-control system for missiles, and in particular with the provision of means for providing a firing signal for a missile at a proper point in its trajectory. The basic advantage in the circuit herein described over arrangements previously known resides in the establishment of a finite time period within which detonation of the missile's warhead may occur following an arming of the firing circuitry. In previous arrangements, the missile's electronic apparatus was set as soon as arming pulses of one polarity were received thereby, and any fire pulses which reached the missile for the duration of its flight were effective to result in a detonation of the warhead. In the circuit of the present invention, the electronics is set for only a brief period of time after the arming pulses are received. If no fire pulses are received in this period of time, the circuit must be set or armed again before firing can occur. As a result, the missile's fusing system functions in an improved manner in a more complex operational environment.

One object of the present invention, therefore, is to provide a pulse generating circuit in which an output pulse is produced only if an input pulse of one polarity is received by the circuit within a predetermined period of time following the reception by the circuit of a second input pulse of a different polarity.

A further object of the invention is to provide an improved fire-control system for incorporation into missiles of the type designed with a passive fusing system.

An additional object of the invention is to provide a fire-control system for missiles which acts to process energy received from the target in order to provide a firing signal to detonate the warhead at a proper point along the missile's trajectory.

A still further object on the present invention is to provide a passive fusing system for a missile which is particularly effective when the missile is launched toward a pulsed radar transmitter.

Other objects and advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings wherein;

FIG. **1** is a block diagram of a preferred form of the present invention as applied to a fire-control system for missiles;

FIG. **2** is a schematic circuit diagram showing in greater detail certain components of the arrangement of FIG. **1**; and

FIG. **3** is a set of waveforms useful in explaining the operation of the system of FIGS. **1** and **2**.

As above stated, the invention herein set forth is broadly applicable to any apparatus in which it is desired to limit the operating period of a pulse-generating network following its energization. Nevertheless, the invention will be hereinafter described in connection with a missile fire-control system, since it is particularly applicable thereto. Although the details of such a missile form no part whatsoever of the present invention, it might advantageously incorporate a passive target-detecting device adapted to process energy received from the target in order to provide a firing signal to detonate the warhead. One arrangement of this type into which the present concept might be incorporated makes use of a so-called fusing antenna carried by the missile. A "cross-over angle" is developed, and pulses of one particular polarity received by the missile before this cross-over angle are utilized to set the electronics. In a similar manner, pulses of opposite polarity received after the cross-over angle are utilized to generate a firing pulse to detonate the missile's warhead.

Consequently, it will be assumed for the purpose of the following description that a series of pulses of negative polarity are received from a remote point prior to an instant of time which might be represented by the cross-over angle mentioned above. This series of negative pulses is illustratively represented in FIGS. **1** and **3**, and is identified by the reference numeral **10**. In a similar manner, a series of subsequently-received positive pulses is illustratively represented in FIGS. **1** and **3** and is identified by the reference numeral **12**. Both of these sets of pulses **10** and **12** are applied to the fire-control network illustrated in FIGS. **1** and **2** of the drawings.

Referring first to the block diagram of a preferred embodiment of the invention as set forth in FIG. **1**, it will be seen that this arrangement consists of a wide-band amplifier **14**, a pair of monostable multivibrators **16** and **18** to each of which the output of the amplifier **14** is applied, and a pair of timing circuits **20** and **22** each of which receives the output of the monostable multivibrator **18**. The respective outputs of the timing circuits **20** and **22** are combined and applied to a gate **24** which also receives a signal from the monostable multivibrator **16**. Depending upon the status of the gate **24**, a firing circuit **26** is energized to develop a single firing pulse **28** in the output thereof.

It has been stated above that both the negative-going pulses **10** and the positive-going pulses **12** are received from the target, the former comprising the network-conditioning pulses and the latter constituting the "firing" pulses. Both types of pulses are received by the antenna (not shown) of the missile, and are applied to the amplifier **14** of FIG. **1**. To facilitate a description of the invention, the schematic diagram of FIG. **2** will be referred to for an explanation of the manner in which the various circuit portions operate. For example, it will be

recognized that the two transistors Q1 and Q2 constitute a wide-band class A amplifier. It is necessary that this amplifier operate in class A fashion so that both the negative pulses **10** and the positive pulses **12** may be amplified to a substantially equal degree. Although variations are permissible, it might be said purely for the sake of an example that the gain of the amplifier **14** is in the neighborhood of 200, and that it possesses a bandwidth of approximately 5 megacycles. Inasmuch as this type of amplifier is well known in the art, no detailed explanation of its operation will be set forth, except to state that the two diodes CR1 and CR2 in the amplifier's input circuit have the function of limiting the amplitude of the input pulses **10** and **12** to a predetermined value. In one operating prototype embodying the concept herein set forth, the input pulses **10** and **12** were limited in amplitude by the diodes CR1 and CR2 to a value of approximately .6 volt.

A further pair of transistors Q3 and Q4, along with their associated circuitry, comprise the set monostable multivibrator **18** of FIG. **1**. The arrangement and operation of this multivibrator **18** is conventional in all respects, and it need only be pointed out that the negative pulses **10** in the output of the amplifier **14** are "steered" thereto by the action of the diode CR3. The two outputs of the multivibrator **18** consist of pulses of constant amplitude and pulse width, which are respectively fed to the timing circuits **20** and **22**. The output of Q3 (which is initially conducting) is represented by the reference number **30** in FIG. **3**. These positive-going pulses **30** are applied to the fire delay timing circuit **20** (FIG. **1**). The output of Q4, which is initially cut off, is represented by the negative-going pulses **32** in FIG. **3**. These negative pulses are applied to the set timing circuit **22**.

The arrangement being described includes the two timing or delay circuits **20** and **22** of FIG. **1**. The set timing circuit **22** consists of the transistor stages Q5 and Q6. Initially, Q6 is cut off, allowing C11 to charge up. This results in the conduction of Q6 to develop a voltage (in the neighborhood of 10 volts) across resistor R25. This voltage across resistor R25 is applied to the base of a further transistor Q9 through a resistor R28. When negative pulses are received from the set monostable vibrator **18** of FIG. **1**, then Q5 is turned on, allowing C11 to discharge to the supply voltage. This turns Q6 off. With Q6 off, there is no longer a voltage developed across R25. It will be noted that Q5 will continue to conduct as long as the negative pulses **32** are present. When the pulses **32** are no longer present, Q5 will return to its original nonconductive condition, allowing C11 to charge up through R24. C11 will discharge in approximately **15** milliseconds, allowing Q6 to again become conductive.

The fire delay timing circuit of FIG. **1** consists of the transistor stages Q11 and Q12. Initially, Q11 is cut off, allowing C19 to charge up and holding Q12 on. The output of Q12 is coupled to the gate Q9 through a 12-volt Zener diode CR9 and a resistor R52. This gate Q9 is identified by the reference numeral **24** in FIG. **1**. When Q12 is conducting, there is a low potential at the anode of CR9. When the positive pulses **30** are received from the set monostable multivibrator **18** of FIG. **1**, then Q11 is rendered conductive, allowing C19 to discharge therethrough. When the voltage across C19 is removed, Q12 becomes nonconductive. The voltage on the collector electrode of Q12 rises to approximately 20 volts, thus causing CR9 to conduct and apply a voltage to the base electrode of Q9. Q12 will remain off as long as positive pulses are received from the monostable multivibrator **18**, and will start to conduct 0.5 milliseconds after the last pulse received from the monostable multivibrator **18**. This period of time is determined by the values of C19 and R48.

As above mentioned, the transistor Q9 acts as a gate, and this transistor is connected across the input of a silicon-controlled rectifier Q10. As best shown in FIG. **2**, the respective outputs of Q6 and Q12 are summed and fed to the base of Q9. Initially, with both transistors Q6 and Q12 conducting, the sum of their outputs is at a high voltage potential, causing Q9 to conduct and thus shorting out the input to the silicon-controlled rectifier Q10. When negative pulses are present at the input to the amplifier **14** of FIG. **1**, the set monostable multivibrator **18** is triggered, and this reverses or "flips" the state of the two timing circuits **20** and **22**. When this occurs, the transistors Q6 and Q12 are rendered non-conductive, but the voltage in the outputs thereof is still at a high value, and this causes Q9 to continue to conduct.

When the negative input pulses **10** are no longer large enough to trigger the set monostable multivibrator **18** of FIG. **1**, then the transistors Q5 and Q11 will be turned off, allowing C19 to charge up and causing Q12 to again become conductive. This action occurs in approximately 0.5 milliseconds. However, Q6 is still cut off because of the 15 millisecond time period required to charge up C11. Therefore, the sum of the outputs of Q9 and Q12 is low, and this turns Q9 off. The input to Q10 is not shorted out until C11 has charged up, thus causing Q6 to again conduct. The voltage applied to the base of Q9 is now sufficiently high to cause it to conduct, thereby resulting in the input to Q10 again becoming shorted. As a result of this mode of operation, Q10 can be triggered only during the period of time in which Q12 is conducting, or approximately 14.5 milliseconds. It should be noted that Q6 must be cut off during this period.

Referring again to the diode CR5, it has been stated above that this diode is employed to "steer" the positive pulses **12** of FIG. **1** to the "fire" monostable multivibrator **16**. This multivibrator consists of the transistor stages Q7 and Q8 as shown in FIG. **2**. The arrangement of the fire monostable multivibrator **16** may be identical to that of the set monostable multivibrator **18** except that it is arranged to be triggered with a positive pulse rather than with one of negative polarity. The output of the multivibrator **16** is taken from the collector electrode of transistor Q8 on which positive pulses appear. These output pulses are fed to the gate Q9 of the siliconcontrolled rectifier Q10. From the arrangement of FIG. **2**, it will be appreciated that if these positive pulses are present when the gate Q9 is conducting, they will be started to ground. If, on the other hand, the gate Q9 is cut off when these positive pulses are received thereby, the latter will trigger the silicon-controlled rectifier Q10.

The silicon-controlled rectifier Q10 is incorporated in the firing circuit **26** of FIG. **1**. Normally, Q10 is not conducting, and the capacitor C16 is charged up to approximately 24 volts. Assuming that the circuitry herein being described is employed for missile firecontrol purposes, then, when the missile passes through the cross-over angle, the positive pulses **12** of FIG. **1** will be received. These in turn will develop positive pulses at the output of the fire monostable multivibrator **16**, and

the silicon-controlled rectifier Q10 will be turned on if the gate Q9 is not conducting at that time. When Q10 conducts, the capacitor C16 is allowed to discharge. In a representative example, a discharge of C16 has delivered an output of at least 20,000 ergs to the missile detonating apparatus (such as a bridge wire primer) within a time period of approximately 100 microseconds.

FIG. 3 of the drawings sets forth representative waveforms of voltages appearing in the various portions of the network of FIGS. 1 and 2. The periods during which conduction of the transistors may occur is of course dependent upon the time constance of the various delay networks. These may be selected in accordance with the particular operating results desired.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

We claim:

1. In a pulse generating system, the combination of:
an amplifier adapted to receive a series of negative pulses followed by a series of positive pulses, said amplifier being adapted to amplify equally pulses of both polarities;
a pair of monostable multivibrators;
a circuit for applying the output of said amplifier to one of said multivibrators, so that said one multivibrator receives only pulses of positive polarity;
means for applying the output of said amplifier to the other of said multivibrators so that such other multivibrator receives only pulses of negative polarity and develops pulses of both polarities in response thereto;
a pair of timing circuits;
means for applying the positive pulse output of said other multivibrator to one of said timing circuits;
means for applying the negative pulse output of said other multivibrator to the remaining one of said circuits;
a gating network;
means for combining the respective outputs of said timing circuits and applying such combined outputs to said gating network;
means for applying the output of said one multivibrator to said gating network;
and a utilization circuit receiving the output of said gating network and energized only when said gating network is open.

2. A fire-control circuit adapted to receive both a series of negative-going pulses and a series of positive-going pulses, the former being employed to set the circuit for subsequent operation and the latter being employed to generate a firing pulse in the event that said second-mentioned series of pulses arrives within a predetermined period of time following the last one of said first-mentioned series of pulses, said circuit including:
an amplifier to which is applied a series of set input pulses of negative polarity followed by a second series of fire input pulses of positive polarity, said amplifier acting to amplify equally well pulses of both polarities;
a pair of monostable multivibrators, one such multivibrator being of a set character and the other said multivibrators being of a fire character;
means for applying the negative pulse output of said amplifier to said set multivibrator;
means for applying the positive pulse output of said amplifier to said fire multivibrator;
a "set time" network;
circuit means for applying the negative pulse output of said set multivibrator to said set time network;
a "fire delay" network;
means for applying the positive pulse output of said set multivibrator to said fire delay network;
a gating circuit;
means for combining the respective outputs of said set time and said fire delay networks and applying such
combined outputs to said gating circuit;
means for applying the output of said "fire" multivibrator to said gating circuit together with the combined outputs of said set time and said fire delay networks;
a firing circuit adapted to develop an output firing pulse;
and a connection from said gating circuit to said firing circuit so that the latter is energized when said gating circuit is open.

3. The combination of claim 2, in which said set time network includes a pair of transistors one of which is normally non-conductive and which is rendered conductive by the reception thereby of pulses of negative polarity from said set multivibrator, said set time network also including an energy-storage device on which a charge is developed during the period when said one transistor is cut off, said charge being reduced upon conduction of said one transistor, and means for applying the charge on said energy-storage device to the remaining transistor of said pair to control the conduction of such remaining transistor.

4. The combination of claim 3 in which said gating circuit includes a further transistor to which is applied the charge developed on said one transistor of said set time network.

5. The combination of claim 4 in which the combined outputs of said set time and said fire delay networks are applied to the said further transistor included in said gating circuit so as to render said further transistor conductive whenever said combined outputs exceed a predetermined value.

6. The combination of claim 5, in which said gating circuit includes a silicon-controlled rectifier associated with said further transistor, said silicon-controlled rectifier being rendered non-conductive by the conduction of said further transistor, a further energy-storage device and means for connecting said further energy-storage device to said firing circuit, said silicon-controlled rectifier being rendered conductive by reception of positive pulses from said fire multivibrator in the event that said further transistor is non-conductive to discharge said further energy-storage device and energize said firing circuit.

* * * * *