

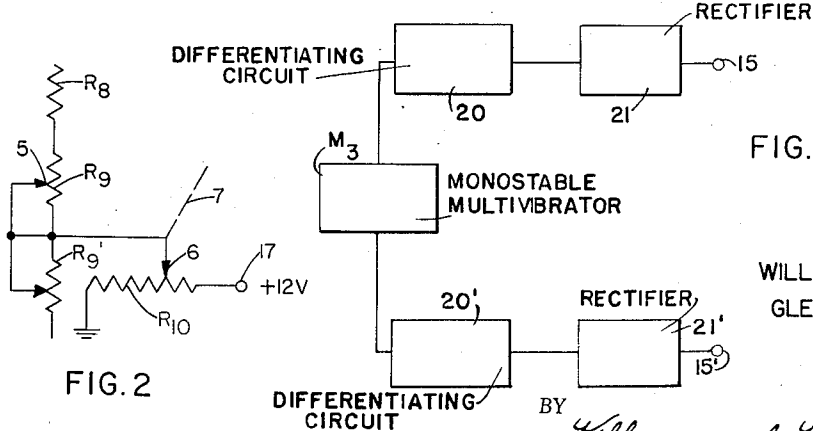
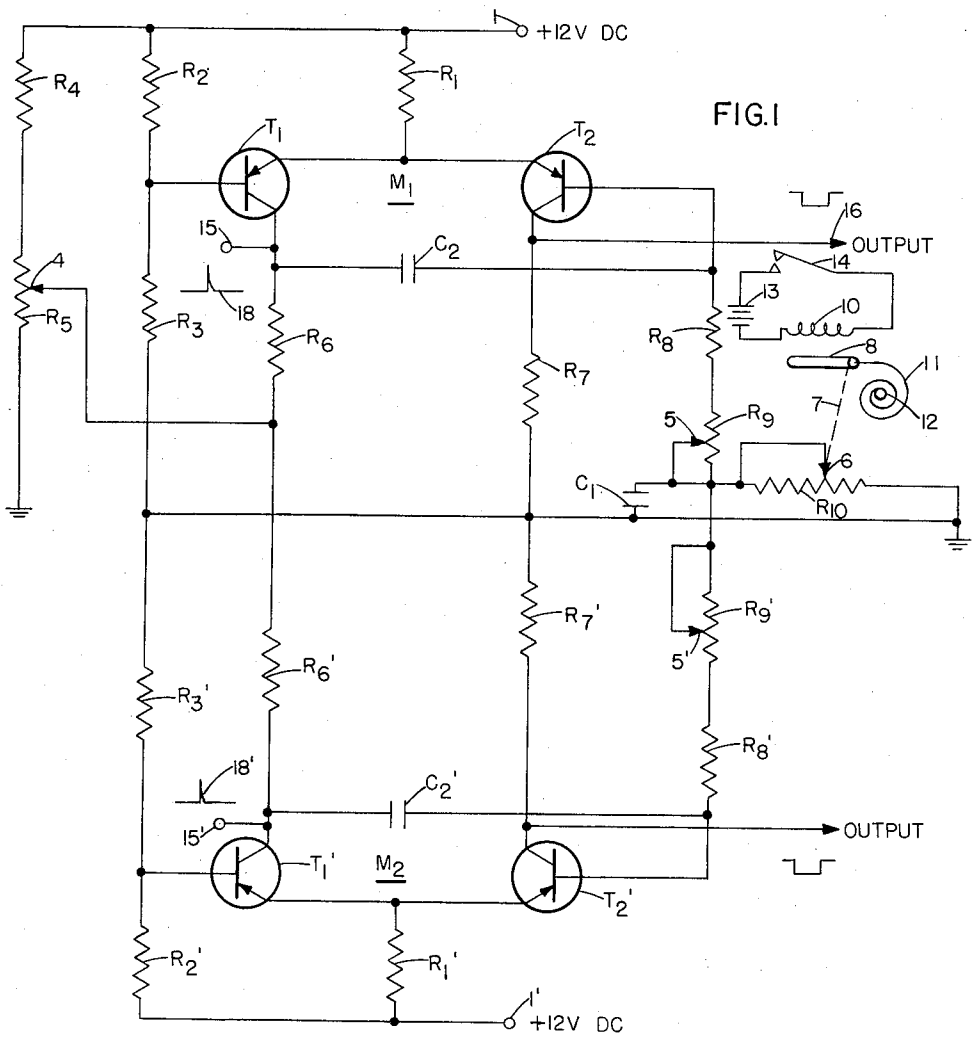
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W. L. GRYDER ET AL

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AUXILIARY CONTROL MEANS FOR PULSE PRODUCING CIRCUIT

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WILLIAM L. GRYDER
GLENN L. HAUGEN
INVENTOR.

BY *Gillman and Gerst*
ATTORNEYS

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AUXILIARY CONTROL MEANS FOR PULSE PRODUCING CIRCUIT

William L. Gryder and Glenn L. Haugen, Baltimore, Md.,
assignors to Bendix Aviation Corporation, Towson,
Md., a corporation of Delaware

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This invention relates to means for producing a series of pulses of controllable duration and pulse repetition frequency and more particularly to an auxiliary means for controlling the duration of the pulses.

Such a pulse producing means, while generally useful, finds a particular use in systems of fuel injection for internal combustion engines in which fuel under pressure is fed to valves individual to the engine cylinders and the valves are solenoid actuated in synchronism with engine operation. The pulses are distributed by commutating devices to the various solenoids.

For engine speeds above a certain limit, it has been found necessary to utilize a pair of pulse producing means with the pulses of their outputs inter-mixed in alternation. A means is normally provided for controlling the duration of the pulses, the means being manually operable for the control of response to engine demands for power.

The starting of such engines, particularly in cold weather, creates fuel demands which are not met by the control means provided for normal operation and it is desirable to provide an auxiliary control for pulse duration to meet the needs peculiar to cold starting.

It is an object of this invention to provide an auxiliary control means for a dual channel pulse producing means for fuel injection in internal combustion engines which automatically responds to the action of starting the engine to increase the pulse duration and also varies the pulse duration as a function of engine temperature.

It is a further object of the invention to provide such a means which will introduce no interaction between the two pulse producing means of the dual system at engine cranking speeds.

It is another object of the invention to provide such a means which is simple and inexpensive.

These and other objects and advantages of the invention are realized by a means which actuates a pulsewidth controlling biasing means common to the two channels, the bias control means being automatically actuated through a fixed increment as long as the starter switch of the engine is closed and being further actuated in response to a temperature sensitive control means.

In the drawing:

Figs. 1 and 1a show a schematic diagram of a control circuit embodying the invention; and,

Fig. 2 is a schematic diagram of a modification of the circuit of Fig. 1.

In the drawing, the pulse producing means of the two channels are indicated as a pair of transistorized monostable multivibrators M_1 and M_2 . The multivibrator M_1 comprises a pair of transistors T_1 and T_2 , which are indicated as being of the PNP junction type. Their emitters are connected through a common resistor R_1 to a terminal 1, which is a positive terminal of a D. C. voltage source which is indicated as having a value of 12 volts. The terminal 1 is also connected through a resistor R_2 to the base of transistor T_1 . This base electrode is also connected to ground by way of a resistor R_3 . The ter-

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minal 1 is also connected to ground through a serial string of resistors R_4 and R_5 . A slider 4 in contact with resistor R_5 is connected to the junction of resistor R_6 and the corresponding resistor R_6' of multivibrator M_2 . The collector of transistor T_1 is connected by way of a resistor R_8 to ground. The collector of T_2 is connected to ground by way of a resistor R_7 .

The base electrode of T_2 is connected by way of a serial string of resistors R_9 , R_9 and R_{10} to ground. A slider 5 coacts with resistor R_9 and is connected to the junction of resistors R_9 and R_{10} and also by way of a capacitor C_1 to ground. The resistor R_{10} is also provided with a slider 6 connected to the junction of resistors R_9 and R_{10} . The slider 6 is actuated by way of a mechanical linkage indicated by the dashed line 7 in response to movement of a slug or armature 8 surrounded by an inductor 10. One end of the armature 8 is also secured to an end of a bimetallic temperature sensitive spring member 11 formed in the shape of a spiral, and having its other end fastened to a post or other fixed element 12. The coil 10 is part of a series circuit which includes a battery 13 and the starter switch 14 of the engine. The battery 13 may be the same voltage source energizing the terminal 1.

The collector of transistor T_1 is coupled to the base electrode of transistor T_2 by a capacitor C_2 . A terminal 15 is connected to the collector of T_1 and an output terminal 16 is connected to the collector of T_2 .

The multivibrator M_2 is, in most respects, identical with M_1 and its common components are indicated by the same reference characters as used with respect to multivibrator M_1 , the reference characters being primed. The resistor R_9' has its slider 5' connected to the junction of the resistors R_9 and R_9' . The resistor R_{10} , its slider and the control means therefor, exercise their control function on both multivibrators.

A monostable multivibrator M_3 , shown in Fig. 1a, has its output applied to a differentiating circuit 20 and thence by way of a rectifier 21 to the terminal 15. Another output of multivibrator M_3 , oppositely phased from the first output, is applied to a differentiating circuit 20' and thence to terminal 15'. The signals applied at the terminals 15, 15' are trains of positive going impulses as indicated by the graphs 18, 18'.

In Fig. 2 the resistor R_{10} has one of its terminals connected to ground and the other to a positive terminal 17 of the 12 volt source. The slider 6 is connected to the junction of R_9 and R_9' . The slider 5 of R_9 , and the corresponding slider 5', of R_9' are connected to the same junction.

In the operation of the circuit of Fig. 1 the multivibrators M_1 and M_2 operate in the same manner and, accordingly, only the operation of the multivibrator M_1 will be explained. The values of the resistor R_2 and R_3 are such that the voltage at the base electrode of T_1 is normally more positive than that existing at the emitter thereof. T_1 is, therefore, normally in a non-conducting state. T_2 is normally conducting to saturation with a voltage at the base electrode thereof more negative than that existing at its emitter. A series of positive-going voltage impulses, as indicated by the graph 18, is applied at the terminal 15. Each of these impulses is coupled to the base electrode of T_2 by means of the capacitor C_2 , causing conduction to be lowered in that transistor. This, by virtue of the common resistor R_1 , causes the emitter of T_1 to be raised in voltage to the point where conduction commences in transistor T_1 . The initiation of conduction will cause the collector of that transistor to become more positive, thus driving the base of T_2 in a more positive direction and this regenerative action will cause T_2 to be cut off and T_1 to conduct a saturation. This condition will persist until condenser C_2 discharges

through resistors R_8 , R_9 , R_{10} , and R_5 to the point where the voltage on the base electrode of T_2 has fallen sufficiently for conduction to be initiated in transistor T_2 . This will reduce the conduction in T_1 and this regenerative action will persist until the multivibrator has reverted to its stable state. The time elapsing between the beginning of the astable state and the reversion to the stable state is governed primarily by the position of the slider 4 on resistor R_5 . This controls the bias voltage applied across the resistor R_6 to the collector electrode of T_1 . The slider 4 is normally driven, in the case of a fuel injection system, by a connection to the manifold of the engine and its position along the resistor R_5 is thus a function of the manifold pressure.

The multivibrator M_2 is driven in the same fashion by an identical series of voltage impulses 18' applied to the terminal 15'. The pulses of this series are, however, offset in time from those of the series applied to the multivibrator M_1 so that the pulses of the two series occur in alternation. This is accomplished by commutating devices synchronized with engine operation and forming no part of this invention. By way of example, however, there is shown in Fig. 1a, a block diagram of a circuit arrangement which could be used to provide the signals 18, 18'. A monostable multivibrator M_3 , which could be triggered by an engine driven commutator, has two outputs applied to differentiating circuits 20, 20'. These outputs are square waves and are taken at such points in the multivibrator circuit that they are oppositely phased. The differentiation and rectification of these signals in the circuits 20, 21 and 20', 21' will produce positive going pulse trains of the form shown at 18 and 18' with the pulses of each train occurring in alternation with those of the other. Such an arrangement is shown in U. S. Patent 2,747,096, to Brockway et al., issued May 22, 1956, where the tubes 7 and 8 constitute a multivibrator such as M_3 . Outputs are taken from the plates of these tubes and applied respectively by lead 46, differentiating circuit 47, 50 to rectifier 48, and by leads 26 and 43 and differentiating circuit 44, 49 to rectifier 45. The remainder of the operation of multivibrator M_2 is identical with that described with respect to M_1 .

The control means which governs pulse duration, as described above, operates satisfactorily for normal conditions of engine operation, except at the time of starting the engine and particularly when this occurs in cold weather. Under such conditions a pulsewidth greatly in excess of those required for normal running is necessary to provide sufficient fuel to start the engine and maintain it in operation until it has warmed up. This additional pulse duration is provided by means of the resistor R_{10} and its associated mechanism. The resistor R_{10} forms with its slider 6 a potentiometer which, under normal warm running conditions, is completely short-circuited. The slider 6, driven by the linkage 7, is positioned in accordance with the position of the armature 8 of solenoid 10. The winding of this solenoid is in circuit with the starting of the switch 14 and the battery 13. The position of the armature 8, when the solenoid is deenergized, is governed by its connection to the temperature responsive spring 11. When the engine is warm, the spring, which is usually situated in close proximity to the manifold, will position the slider so that the resistor R_{10} is completely short-circuited. When the engine is cold the slider will be so positioned as to include a small portion of the resistor R_{10} in the multivibrator circuit. When the starter switch 14 is closed and the solenoid 10 energized, the armature 8 will be withdrawn within the solenoid to the extent permitted by the spring 11, and a corresponding additional length of the resistor R_{10} will be included in the circuit. When the starting action is completed and the switch 14 again opened, the position of the armature 8 will again be governed by the spiral spring 11.

The purpose of the potentiometers R_9 and R_9' is to

equalize the operation of the two multivibrators with respect to pulse duration.

The potentiometer R_{10} operates, during starting and warm up, to greatly increase the resistance in the RC pulsewidth determining circuit including the capacitor C_2 and the resistors R_8 , R_9 , a portion of R_5 , and R_6 . This operation will normally occur only when the potentiometer R_5 is already providing a large pulsewidth, say of four or five milliseconds duration. It also occurs only at the low cranking and idling speeds. As long as the resistance in the base leg of T_2 remains an appreciable part of the total resistance of the RC circuit, there will be no appreciable interaction between the two multivibrators until a high repetition rate is reached.

Should more complete freedom from interaction be desired, however, the circuit of Fig. 2 may be used. In this modification the potentiometer R_{10} has one terminal connected to a positive terminal 17 of the voltage source and the remaining terminal grounded. The slider is connected to the junction of R_9 and R_9' , with the capacitor C_1 omitted.

This form of the invention varies the bias applied to the RC circuit rather than the resistance.

What is claimed is:

1. In a dual channel pulse producing system for producing a pair of pulse trains with the pulses of said trains occurring in alternation, said system comprising a pair of monostable multivibrators and means triggering said multivibrators in alternation, each of said multivibrators comprising a pair of amplifying stages, regenerative feedback means coupling said stages, capacitive means coupling the output of a first of said stages to the input of the second, a resistive discharge circuit for said capacitive coupling means, and means variably biasing said capacitive coupling means to provide a first control of the duration of the pulses of the output of said multivibrator: the combination therewith of means for additionally controlling said pulse duration operable to automatically increase said duration as a function of a localized temperature variation within a selected range and to further increase said duration by a fixed amount in response to the completion of a control circuit, the last named means comprising a potentiometer connected to said discharge circuit in a manner to vary the discharge time thereof as the setting of said potentiometer is varied, an element reciprocable along a certain path, means connecting said element and said potentiometer whereby the setting of said potentiometer is varied by movement of said element along said path, temperature deformable means connecting said element to a fixed point and operable with change of temperature within a given range to variably position said element along a portion of said path, and a solenoid operable on said element when said control circuit is complete to move said element along the remainder of said path.

2. In a dual channel pulse producing system for producing a pair of pulse trains with the pulses of said trains occurring in alternation, said system comprising a pair of monostable multivibrators and means triggering said multivibrators in alternation, each of said multivibrators comprising a pair of amplifying stages, regenerative feedback means coupling said stages, capacitive means coupling the output of a first of said stages to the input of the second, a resistive discharge circuit for said capacitive coupling means, and means variably biasing said capacitive coupling means to provide a first control of the duration of the pulses of the output of said multivibrator: the combination therewith of means for additionally controlling said pulse duration operable to automatically increase said duration as a function of a localized temperature variation within a selected range and to further increase said duration by a fixed amount in response to the completion of a control circuit, the last named means comprising a potentiometer forming a part of said discharge circuit and thereby varying the discharge time thereof

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as the setting of said potentiometer is varied, means connecting said element and said potentiometer whereby the setting of said potentiometer is varied by movement of said element along said path, an element reciprocable along a certain path, temperature deformable means connecting said element to a fixed point and operable with change of temperature within a given range to variably position said element along a portion of said path, and a solenoid operable on said element when said control circuit is complete to move said element along the remainder of said path.

3. In a dual channel pulse producing system for producing a pair of pulse trains with the pulses of said trains occurring in alternation, said system comprising a pair of monostable multivibrators and means triggering said multivibrators in alternation, each of said multivibrators comprising a pair of amplifying stages, regenerative feedback means coupling said stages, capacitive means coupling the output of a first of said stages to the input of the second, a resistive discharge circuit for said capacitive coupling means, and means variably biasing said capacitive coupling means to provide a first control of the duration of the pulses of the output of said multivibrator: the combination therewith of means for additionally controlling said pulse duration operable to automatically increase said duration as a function of a localized temperature variation within a selected range and to further increase said duration by a fixed amount in response to the completion of a control circuit, the last named means comprising a potentiometer having its slider connected to said discharge circuit and a source of voltage connected between its terminals thereby varying the discharge time of said discharge circuit as the setting of said potentiometer is varied, an element reciprocable along a certain path, means connecting said element and said potentiometer whereby the setting of said potentiometer is varied by movement of said element along said path, temperature deformable means connecting said element to a fixed point and operable with change of temperature within a given range to variably position said element along a portion of said path, and a solenoid operable on said element when said control circuit is complete to move said element along the remainder of said path.

4. In a dual channel pulse producing system for producing a pair of pulse trains with the pulses of said trains occurring in alternation, said system forming part of a fuel injection system for an internal combustion engine wherein said pulses individually actuate respective valves of said fuel injection system, said pulse producing system comprising a pair of monostable multivibrators and means triggering said multivibrators in alternation, each of said multivibrators comprising a pair of amplifying stages, regenerative feedback means coupling said stages, capacitive means coupling the output of a first of said stages to the input of the second, a resistive discharge circuit for said capacitive coupling means, and means variably biasing said capacitive coupling means to provide a first control of the duration of the pulses of the output of said multivibrator: the combination therewith of means for additionally controlling said pulse duration to automatically increase said duration as a function of the temperature existing at the manifold of said engine and to further increase said duration by a fixed amount in response to the completion of the starting circuit of said engine, the last named means comprising a potentiometer connected to said discharge circuit in a manner to vary the discharge time thereof as the setting of said potentiometer is varied, an element reciprocable along a certain path, means connecting said element and said potentiometer whereby the setting of said potentiometer is varied by movement of said element along said path, temperature deformable means connecting said element to a fixed point at said manifold and operable with change of temperature within a given range to variably position said element along a portion of said path, and a solenoid operable on said

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element when said starting circuit is completed to move said element along the remainder of said path.

5. In a dual channel pulse producing system for producing a pair of pulse trains with the pulses of said trains occurring in alternation, said system forming part of a fuel injection system for an internal combustion engine wherein said pulses individually actuate respective valves of said fuel injection system, said pulse producing system comprising a pair of monostable multivibrators and means triggering said multivibrators in alternation, each of said multivibrators comprising a pair of amplifying stages, regenerative feedback means coupling said stages, capacitive means coupling the output of a first of said stages to the input of the second, a resistive discharge circuit for said capacitive coupling means, and means variably biasing said capacitive coupling means to provide a first control of the duration of the pulses of the output of said multivibrator: the combination therewith of means for additionally controlling said pulse duration to automatically increase said duration as a function of the temperature existing at the manifold of said engine and to further increase said duration by a fixed amount in response to the completion of the starting circuit of said engine, the last named means comprising a potentiometer forming a part of said discharge circuit and thereby varying the discharge time thereof as the setting of said potentiometer is varied, an element reciprocable along a certain path, means connecting said element and said potentiometer whereby the setting of said potentiometer is varied by movement of said element along said path, temperature deformable means connecting said element to a fixed point at said manifold and operable with change of temperature within a given range to variably position said element along a portion of said path, and a solenoid operable on said element when said starting circuit is completed to move said element along the remainder of said path.

6. In a dual channel pulse producing system for producing a pair of pulse trains with the pulses of said trains occurring in alternation, said system forming part of a fuel injection system for an internal combustion engine wherein said pulses individually actuate respective valves of said fuel injection system, said pulse producing system comprising a pair of monostable multivibrators and means triggering said multivibrators in alternation, each of said multivibrators comprising a pair of amplifying stages, regenerative feedback means coupling said stages, capacitive means coupling the output of a first of said stages to the input of the second, a resistive discharge circuit for said capacitive coupling means, and means variably biasing said capacitive coupling means to provide a first control of the duration of the pulses of the output of said multivibrator: the combination therewith of means for additionally controlling said pulse duration to automatically increase said duration as a function of the temperature existing at the manifold of said engine and to further increase said duration by a fixed amount in response to the completion of the starting circuit of said engine, the last named means comprising a potentiometer having its slider connected to said discharge circuit and a source of voltage connected between its terminals, thereby varying the discharge time of said discharge circuit as the setting of said potentiometer is varied, an element reciprocable along a certain path, means connecting said element and the slider of said potentiometer whereby the setting of said potentiometer is varied by movement of said element along said path, temperature deformable means connecting said element to a fixed point at said manifold and operable with change of temperature within a given range to variably position said element along a portion of said path, and a solenoid operable on said element when said starting circuit is completed to move said element along the remainder of said path.