

[54] **PULSE GENERATOR FOR CONTROLLING THE VALVES OF AN INTERNAL COMBUSTION ENGINE**

3,587,536 6/1971 Inoue..... 123/32 EA
 3,596,640 8/1971 Bloomfield..... 123/32 EA
 3,612,009 10/1971 Hamazuka..... 123/32 EA

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[51] **Int. Cl.** F011 9/04, F02d 31/00

[58] **Field of Search** 123/90.11, 32 EA

[56] **References Cited**

UNITED STATES PATENTS

3,675,630	7/1972	Stratton	123/90.11
3,682,152	8/1972	Muller-Berner	123/90.11
2,520,537	8/1950	Forman.....	123/90.11
3,456,628	7/1969	Bassot	123/32 EA
3,522,794	8/1970	Reichardt	123/32 EA
3,543,734	12/1970	Mair	123/32 EA

[57] **ABSTRACT**

A pulse generator rotating synchronously with the crank shaft of the engine feeds pulses to a bistable multivibrator, the output of which is conductive to an integrator through a monostable multivibrator. The integrator output is fed to a further pulse generator for generating pulses of variable keying ratio independent of engine speed, the further pulse generator comprising an impedance convertor, a storage capacitor, and a voltage-time transducer. This arrangement operates one valve of one cylinder of the engine. Additional valves can be operated by two further pulse generators for each valve, the output of the first of the two additional pulse generators being used to deliver the pulses for the second of the two further pulse generators so as to prevent simultaneous operation of the inlet and outlet valves.

18 Claims, 4 Drawing Figures

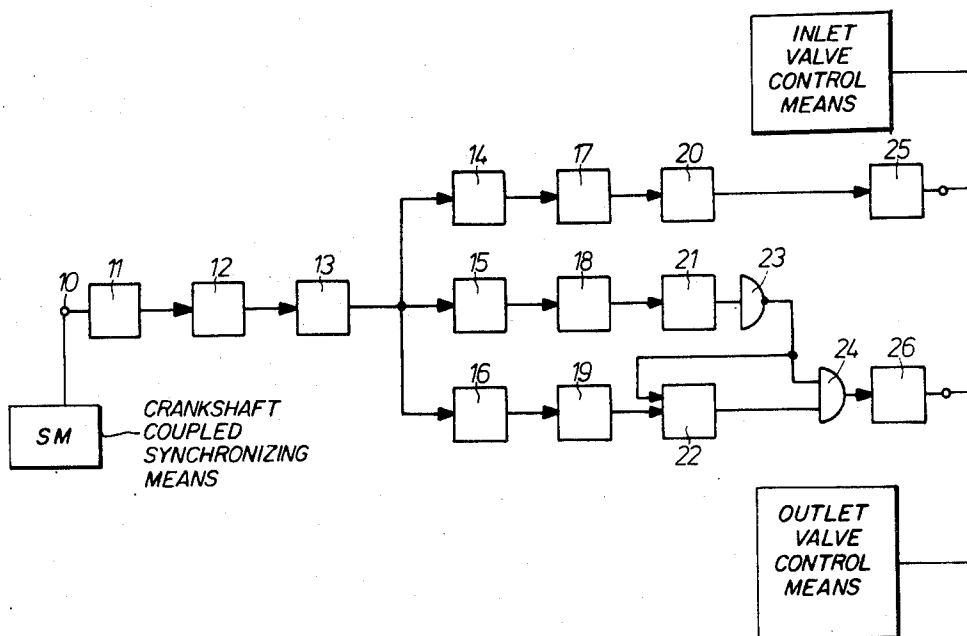


Fig. 1

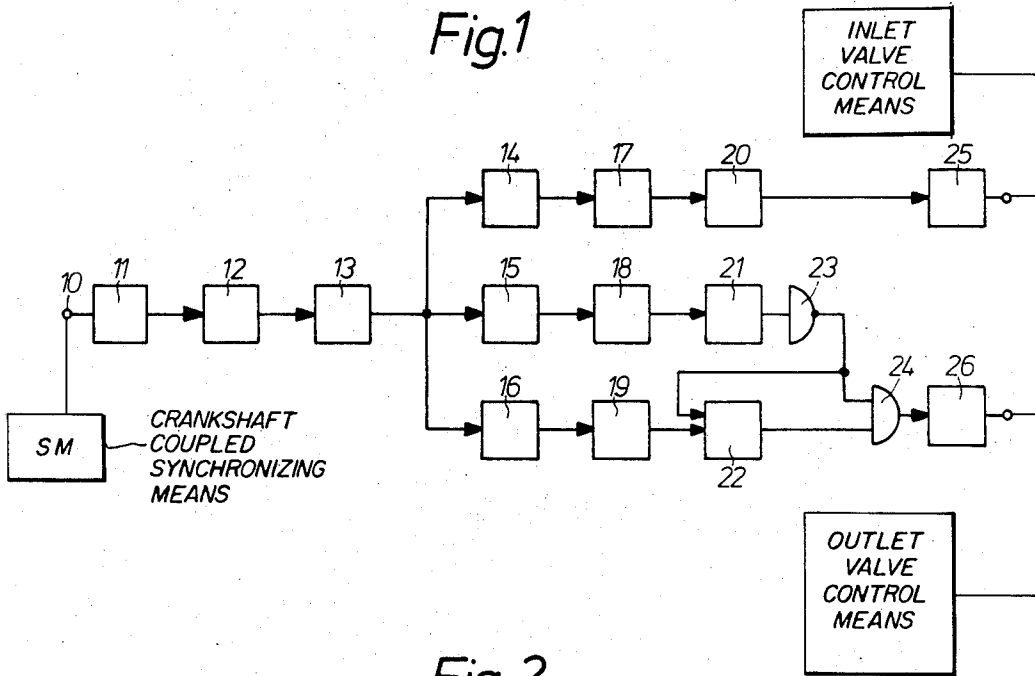
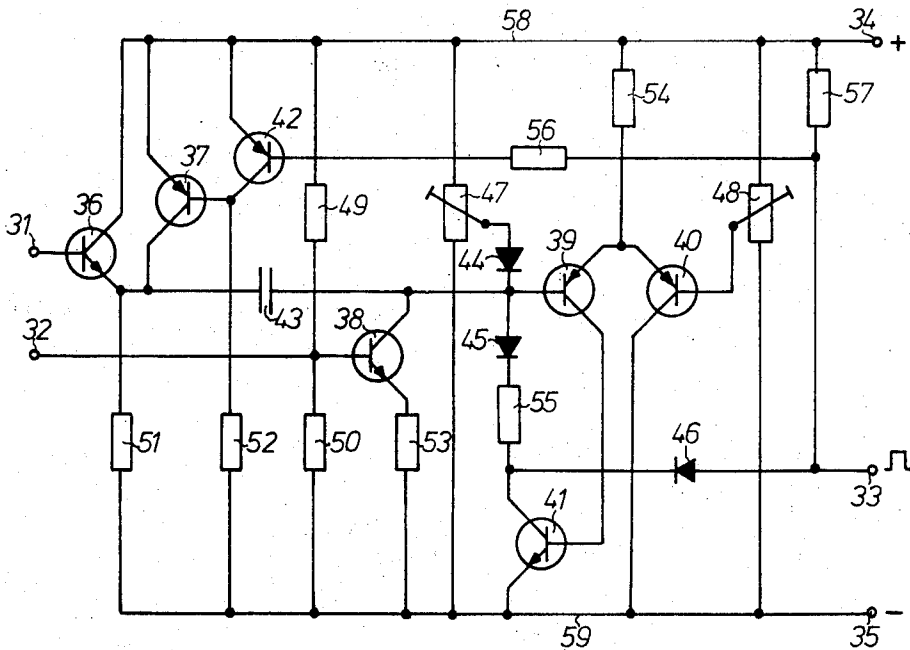


Fig. 2

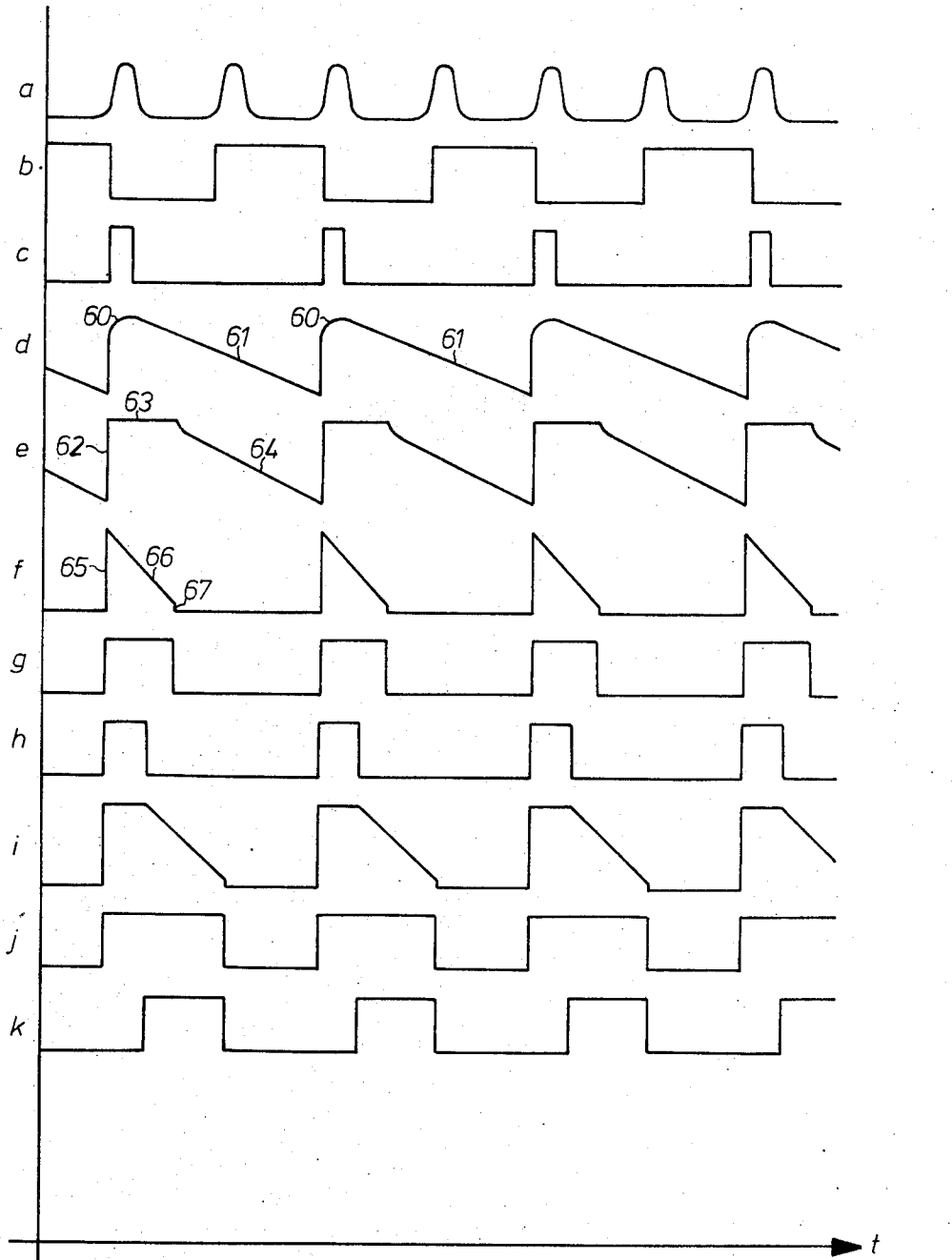


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Fig. 3



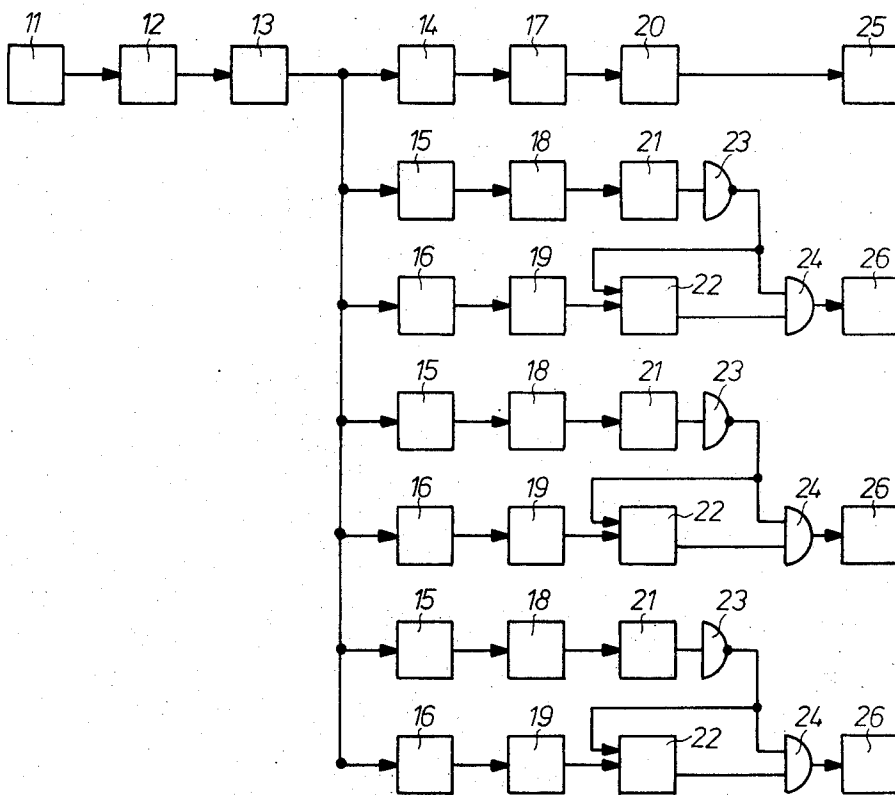
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Fig. 4



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PULSE GENERATOR FOR CONTROLLING THE VALVES OF AN INTERNAL COMBUSTION ENGINE

BACKGROUND OF THE INVENTION

The invention relates to a pulse generator for operating the electrohydraulic or electropneumatic control for the inlet and outlet valves of an internal combustion engine.

With experimental internal combustion engines, the valves are electrohydraulically or electropneumatically controlled, with a view to increasing the torque at very high rpms by more quickly opening and closing the valves than is possible with mechanical valve control operated by the cam shaft. The average of the cross-sectional area of the opening over the whole of the open time of the valve can be enlarged, and more fuel can be supplied to the cylinder.

It has been attempted to produce the valve control pulses with an electric distributor. Since in some circumstances the control pulses for the inlet and outlet valves must overlap even with a single cylinder, an engine having two or more cylinders requires a distributor having a plurality of switching decks. These distributors have the further widely recognized disadvantages of contact bounce, chatter, and burn associated with mechanical switches. When using electrohydraulically and electropneumatically controlled valves for experimental and high power engines, there is the additional requirement that the opening time and the length of opening of the valves must be adjustable.

SUMMARY OF THE INVENTION

An object of the invention is an electronic pulse generator for operating at least one valve of an internal combustion engine.

Another object of the invention is the electronic pulse generator of the preceding object, which pulse generator operates at least two valves of the internal combustion engine.

Another object of the invention is a pulse generator for operating one or more valves of an internal combustion engine, the pulse generator opening the valve or valves at a predetermined angle of the crank shaft and holding the valve or valves opened while the crank shaft rotates through an angle that is independent of engine speed.

Briefly, the invention consists of means for generating at least one first and at least one second train of electric pulses in synchronism with the engine speed and having a keying ratio independent of engine speed, each first pulse train being for operation of a respective inlet valve, and each second pulse train being for operation of a respective out valve, the means including means for shifting, in degrees of crank shaft rotation, the first and second pulse trains with respect to each other independent of engine speed.

In accordance with the invention, the pulses for operating the inlet valves and the pulses for operating the outlet valves can be made to overlap.

The control pulses fed to the pulse generator of the invention can be obtained from a distributor having a single switching deck, or from a magnetic or photoelectric pulse generator.

The novel features which are considered as characteristic for the invention are set forth in particular in

the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of the first embodiment of the invention;

FIG. 2 is a wiring diagram of part of the circuit shown in FIG. 1;

FIG. 3 graphically shows the voltages at different points in the circuits of FIGS. 1 and 2;

FIG. 4 is a block diagram of the circuit shown in FIG. 1 expanded;

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to FIG. 1, there is shown a block diagram of a pulse generator for the inlet valve and the outlet valve of a cylinder of an internal combustion engine. A bistable multivibrator 11, the input 10 of which is connected to a crankshaft-coupled synchronizing means, is connected by a monostable multivibrator 12 to an integrator 13. The output of the integrator 13 is connected to three impedance convertors 14, 15, and 16. The output of the first impedance convertor 14 is connected by a first storage capacitor 17 and a discharge circuit means 20 to a first pulse amplifier 25.

Components 13, 14, 17, 20 constitute first electronic pulse generating means having an input connected to the source of crankshaft-synchronizing pulses, and operative upon receipt of a synchronizing signal for generating a first timing pulse having a leading edge and a duration corresponding to a predetermined fraction of a crankshaft rotation independently of engine speed. Similarly, components 13, 15, 16, 18, 19, 21-24 together constitute second electronic pulse generating means having an input connected to the source of crankshaft-synchronizing pulses and operative upon receipt of a synchronizing signal for generating a second timing pulse having a duration corresponding to a predetermined fraction of a crankshaft rotation and having a leading edge delayed relative to the leading edge of said first pulse by a time period corresponding to a predetermined fraction of a crankshaft rotation. Similarly, the outputs of the impedance convertors 15 and 16 are connected by respective storage capacitors 18 and 19 to respective constant-current discharge circuits 21 and 22. An inverting stage 23 connects the output of the second voltage-time transducer 21 both to the first input of an AND gate 24 and to the second input of the third discharge circuit 22. The output of the AND gate 24 is connected to a second pulse amplifier 26.

An important feature of this circuit is the series connection of the impedance convertor, storage capacitor, and discharge circuit. The wiring diagram of this series circuit is shown in FIG. 2. One plate of the storage capacitor 43 is connected to the emitter of a first transistor 36, which is connected emitter-follower with the emitter-resistor 51. The other plate of the storage capacitor is connected both to the collector of a third transistor 38 and to the base of a fourth transistor 39. The third transistor 38 constitutes together with its

emitter-resistor 53 and the base voltage divider 49 and 50 a constant current source.

The fourth transistor 39 and the fifth transistor 40, together with their common emitter-resistor 54 and the two base voltage dividers 47 and 48, constitute a monostable circuit having an adjustable switching hysteresis. The pulse output of this trigger is amplified by a sixth transistor 41, which has a collector resistor 55 that is connected by a second diode 45 to the base of the fourth transistor 39. A first diode 44 connects the base of the fourth transistor 39 to the associated base voltage divider 47.

A third diode 46 connects the collector of the sixth transistor 41 to the pulse output terminal 33. A resistor 57 and the positive rail 58 connect the terminal 33 to the positive terminal 34. A further resistor 56 connects the base of a seventh transistor 42 to the pulse output terminal 33. The transistors 42 and 37 constitute a Darlington circuit, of which the common junction between the base and the collector of these two transistors is connected by a resistor 52 to the negative rail 59, which has the negative terminal 35. The collector of the second transistor 37 is connected to the left plate of the storage capacitor 43 and to the emitter of the first transistor 36.

FIG. 3 graphically shows the variation with respect to time of the voltages at different points of the circuits shown in FIGS. 1 and 2.

In FIG. 3, 3a shows a train of synchronizing pulses produced by the electromagnetic synchronizing means, which is rigidly coupled to the crank shaft, and the output of which is connected to the terminal 10 (see FIG. 1) to control the bistable multivibrator 11.

In FIG. 3, 3b shows a train of output pulses from the bistable multivibrator 11, 3c a train of output pulses from the monostable multivibrator 12, 3d the voltage at the output of the integrator 13, 3e the voltage measured between the collector of the second transistor 37 and the positive rail 58.

Continuing, 3f shows the voltage between the collector of the third transistor 38 and the negative rail 59 (with suppressed null point), and 3g shows the shape of the output pulses that appear between the output terminal 33 and the positive terminal 34. Thus, 3g shows the output signal of the first discharge circuit 20, shown in FIG. 1.

Still continuing, 3h shows, by way of example, the output signal of the second discharge circuit 21, 3i the voltage between the collector of the third transistor and the negative rail in the third discharge circuit 22 (again with suppressed null point), 3j the output voltage of the third discharge circuit 22, and 3k the output voltage of the AND gate 24.

In the embodiments being described, there is provided crankshaft-coupled synchronizing means operative for generating a synchronizing signal when said crankshaft assumes a predetermined angular orientation. This synchronous pulse generator can comprise, for example, a permanent magnet fixed to the crank shaft of the internal combustion engine, the magnet inducing a voltage pulse, such as that shown at *a* in FIG. 3, in a coil that is fixed to the housing of the engine. The bistable multivibrator 11 divides the pulse frequency (see *b* of FIG. 3) by two. This is essential, because the valves of a four-cycle internal combustion engine are operated only during every other rotation of the crank shaft. The bistable multivibrator 11 controls

the monostable multivibrator 12, the output of which is shown at *c* in FIG. 3.

When the monostable multivibrator 12 is in its unstable state, it returns the integrator 13 to zero voltage by discharging the capacity within the integrator through a resistance that is as small as possible. The integrator 13 can be a Miller integrator, an operational amplifier of which the output is connected out of phase to the input by a capacitor, or a capacitor charged by a constant current. As shown by the curve 61 at *d* of FIG. 3, the output voltage of the integrator 13 falls linearly to a more and more negative value between two pulses of the monostable multivibrator 12. Curve 60 shows that the capacity within the integrator 13 is discharged exponentially while the monostable multivibrator 12 delivers a pulse.

The voltage (shown at *e* of FIG. 3) on the emitter of the first transistor 36 substantially follows the curve at *d* of FIG. 3. The voltage plateau 63 is caused by the second transistor 37 and will be explained. The magnitude of the positive voltage jump 62 depends upon the value of the output voltage of the integrator 13 at the end of the period; in other words, it is proportional to the length of the period. The length of the period is defined as the time required for two complete rotations of the crank shaft.

The storage capacitor 43 conducts the voltage jump 62 to the base of the fourth transistor 39, triggering the monostable trigger, composed of the transistors 39 and 40, to its second, unstable, state. This trigger is so designed that the fourth transistor 39 and the pulse amplifier sixth transistor 41 are conductive when the storage capacitor 43 conducts no voltage to the base of the transistor 39. The base current for the transistor 39 is conducted by the transistor 41, the resistor 55, the diode 45, and by the transistor 38. The first diode 44 prevents the voltage at the base of the transistor 39 from falling below the value set by the base voltage divider 47. In other words, the potentiometer enables setting of the fundamental voltage at which the monostable circuit is triggered, the voltage conducted by the capacitor 43 being superimposed on this fundamental voltage.

The potentiometer 48 is so set that the base voltage of the fifth transistor 40 is more positive than the emitter voltage when the fourth transistor 39 is conductive, thereby causing a voltage drop across the common emitter-resistor 54. Consequently, the transistor 40 is cut off when the transistor 39 conducts. The potentiometer 48 enables setting of the trigger threshold of the trigger stage. When the storage capacitor 43 conducts a voltage jump 65 (see *f* of FIG. 3) to the base of transistor 39, the base becomes more positive and the transistor 39 is cut off, thereby also cutting off the transistor 41. The emitter voltage of the fifth transistor 40 becomes more positive than the base voltage, as determined by the potentiometer 48, so that transistor 40 conducts.

Before the voltage jump 65 appears, the storage capacitor 43 has charged to a voltage proportional to the length of the period inversely proportional to speed. This capacitor is now discharged with constant current through the constant current source composed of the transistor 38 and the resistors 49, 50, and 53, the voltage at the base of the transistor 39 thereby falling linearly in accordance with curve 66 at *f* in FIG. 3. When the voltage across the storage capacitor has fallen suffi-

ciently, the transistor 39 begins once again to conduct. The voltage drop across the common emitter-resistor 54 increases, and the transistor 40 cuts off as soon as the trigger threshold voltage, set by the potentiometer 48, is reached. This occurrence is shown as the vertical line 67 at f in FIG. 3.

The sixth transistor 41 amplifies the output pulses of the trigger stage, the output of the transistor 41 being conducted by the third diode 46 to the output terminal 33. The voltage at this terminal is shown at g in FIG. 3.

The two transistors 37 and 42 serve to keep the left plate of the storage capacitor 43 at the voltage of the positive rail 58, while the transistor 40 is conductive. As soon as the transistor 41 cuts off, the transistor 42 also cuts off; and the transistor 37 is rendered conductive, thereby holding the left plate of the storage capacitor 43 at positive voltage. For this reason, as long as the transistor 41 is cut off, there exists the plateau 63 at e in FIG. 3. This plateau continues until the transistor 41 again conducts, whereupon the voltage at the collector of the transistor 38 falls linearly in accordance with the curve 64.

The pulse generator thus far described, having one of the storage capacitors 17, 18 or 19 and one of the discharge circuits 20, 21, or 22, produces pulses having a frequency independent keying ratio. These pulses can be synchronized with other pulses of any shape and greatly varying frequency. The arrangement, however, can only control one valve.

A second input 32 (see FIG. 2) of the voltage-time transducer enables the pulse generator to be used to deliver control pulses for as many valves as is desired. If the second or blocking input 32 is made negative, the constant current source (38, 49, 50, and 53) is cut off, and the storage capacitor 43 cannot discharge. In this way, the output pulses of the voltage-time transducer can be lengthened as much as is desired.

As shown in FIG. 1 and at g to j of FIG. 3, the pulse lengths can be added together. The output pulse of the second discharge circuit 21 is conducted by the inverting stage 23 (see FIG. 3 at h) to the constant current source of the third discharge circuit 22, rendering the current source non-conductive. FIG. 3 at i shows the change in voltage at the collector of the third transistor 38 of the third discharge circuit 22. Consequently, the output pulses of the third circuit 22 have the shape shown at j in FIG. 3. However, these output pulses are not suited to the control of the second valve, such as the associated outlet valve, since both valves (the inlet valve and the outlet valve of the same cylinder) would be opened simultaneously. The arrangement of the AND gate 24 and the inverting stage 23 provide at the output of the AND gate pulses as shown at k in FIG. 3, because the AND gate 24 delivers a pulse only when the second discharge circuit 21 delivers no pulse and the third discharge circuit 22 delivers a pulse.

By suitable design of the constant current source, the length of the pulses is determined. The first discharge circuit 20 delivers the control pulses for the first valve; the second discharge circuit 21 determines the delay time between the control pulses for the first and second valves; and the AND gate 24 delivers the control pulses for the second valve.

A pulse generator as shown in FIG. 1 is required for each cylinder of the internal combustion engine, since the pulse generator delivers control pulses for only two

valves. The embodiment shown in FIG. 4 ensures an appreciable saving in components, because for each additional valve controlled, there is connected to the output of the same integrator 13 two further impedance convertors, storage capacitors, and voltage-time transducers, together with the associated inverting stage and AND gate. The operation of the embodiment shown in FIG. 4 is apparent from the description of the circuit shown in FIG. 1.

The important features of the pulse generator will now be summarized. An integrator, the output voltage of which increases (in a negative direction) linearly with time, is reset to zero voltage after every second rotation of the crank shaft. The resulting voltage jump, appearing at the output of the integrator, is proportional to the length of the period and is stored in the storage capacitor, which discharges through a constant current source. A trigger converts the voltage jump into a pulse of which the length is proportional to the period. The trigger is controlled by the storage capacitor, and is designed to trigger to its unstable state when the voltage jump appears and to return to its stable state when the voltage across the capacitor falls below a lower threshold value. Consequently, the length of the pulses from the trigger is proportional to the time required for two complete rotations of the crank shaft, and thus inversely proportional to speed.

The great advantage of the electronic pulse generator of the invention, as against the distributors described in the introduction, is the great ease with which the opening times of the valve are altered in dependence on the operating parameters of the engine, and thus, for example, with which an optimum amount of fuel is supplied to a cylinder.

The change of the pulse length or of the delay time is easily obtained by varying the amount of current passing through the constant current source. The current is varied by conducting a voltage to the second input terminal 32. If all of the pulse lengths and the delay times are to be influenced in the same way, a correction voltage can be conducted to the integrator 13.

In accordance with the invention, the bistable multivibrator 11 can be omitted, the pulses shown at b in FIG. 3 being produced by a simple switch that is operated by a cam. Care must be taken, however, that the monostable multivibrator is not triggered by chattering contacts of the switch.

The embodiment shown in FIG. 4 is not limited to controlling the valves of an internal combustion engine. It can also be used as a pulse generator for controlling the fuel injection arrangement or the ignition of the engine. Both the time when the fuel is injected and when the mixture is ignited must be altered in dependence on the engine operating parameters. Control signals that reflect these parameters can be conducted by way of the input terminal 32 (see FIG. 2).

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of constructions differing from the types described above.

While the invention has been illustrated and described as embodied in a pulse generator for controlling the valves of an internal combustion engine, it is not intended to be limited to the details shown, since various modifications and structural changes may be

made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims;

1. A pulse generator for operating the electrohydraulic or electropneumatic control for the inlet and outlet valves of an internal combustion engine, comprising, in combination, means for generating at least one first and at least one second train of electric pulses in synchronism with engine rotation and having a keying ratio independent of engine speed, each pulse of said first pulse train being for operation of a respective control for an inlet valve, and each pulse of said second pulse train being for operation of a respective control for an outlet valve, and including means for shifting, in degrees of crankshaft rotation, the first and second pulse trains with respect to each other independent of engine speed, and comprising a first, a second and a third storage capacitor, resettable integrating means for applying to each of said storage capacitors a voltage inversely proportional to engine speed, and a first a second and a third discharge circuit each connected to a respective one of said storage capacitors and operative for discharging the respective storage capacitor and generating a pulse whose duration corresponds to the duration of the discharge of the respective storage capacitor.

2. In combination with an internal combustion engine having a crankshaft and at least one engine cylinder having an inlet valve and an outlet valve, a valve timing arrangement comprising inlet-valve control means having an input for receipt of a valve-opening pulse; outlet-valve control means having an input for receipt of a valve-opening pulse; synchronizing means coupled with said crankshaft and operative for generating a crankshaft-position synchronizing signal when said crankshaft assumes a predetermined angular orientation; first electronic pulse generating means having an output connected to the input of said inlet-valve control means and having an input connected to said synchronizing means and operative in response to receipt of a crankshaft-position synchronizing signal for generating a first timing pulse and applying the same to the input of said inlet-valve control means, and including crankshaft-speed-responsive first pulse-duration varying means operative for varying the duration of said first pulse inversely to crankshaft speed; and second electronic pulse generating means having an output connected to the input of said outlet-valve control means and having an input connected to said synchronizing means and operative in response to receipt of a crankshaft-position synchronizing signal for generating a second timing pulse and applying the same to the input of said outlet-valve control means, and including crankshaft-speed-responsive second pulse-duration varying means operative for varying the duration of said second pulse inversely to crankshaft speed, and further including crankshaft-speed-responsive electronic delay means operative for delaying the leading edge of said

second timing pulse relative to the leading edge of said first timing pulse by a time period which varies inversely to crankshaft speed.

3. An arrangement as defined in claim 2, wherein said first pulse-duration varying means consists of means operative for causing said first pulse to have a value inversely proportional to crankshaft speed, and wherein said second pulse-duration varying means consists of means operative for causing said second pulse to have a value inversely proportional to crankshaft speed, and wherein said crankshaft-speed-responsive electronic delay means consists of means operative for delaying the leading edge of said second timing pulse relative to the leading edge of said first timing pulse by a time period inversely proportional to crankshaft speed, whereby the duration of said first and second timing pulses and also the duration of the delay between the leading edges of said first and second timing pulses are each equal to the time required for said crankshaft to turn through respective predetermined fixed angles irrespective of the prevailing engine speed.

4. The arrangement defined in claim 2, wherein said first pulse has a trailing edge and wherein the leading edge of said second pulse precedes said trailing edge of said first pulse.

5. The arrangement defined in claim 4, wherein the duration of said first pulse is different from the duration of said second pulse.

6. The arrangement defined in claim 2, wherein the duration of said first pulse is different from the duration of said second pulse.

7. The arrangement defined in claim 2, wherein said first electronic pulse generating means and first varying means comprises a storage capacitor, integrating means operative for transmitting to said storage capacitor a voltage inversely proportional to engine speed, and discharge circuit means connected to said storage capacitor for discharging the latter and generating a pulse whose duration corresponds to the duration of the discharge of said storage capacitor.

8. The arrangement defined in claim 7, said integrating means being resettable, and wherein said synchronizing means comprises a monostable multivibrator triggered in synchronism with crankshaft rotation and operative upon transition to its unstable state for resetting said integrating means.

9. The arrangement defined in claim 7, wherein said second pulse generating and varying means and delay means includes first and second additional storage capacitors, integrating means operative for transmitting to each of said additional capacitors an amount of charge inversely proportional to engine speed, first additional discharge circuit means connected to said first additional capacitor and operative for discharging said first additional capacitor and generating a respective first additional pulse whose duration corresponds to the duration of the discharge of said first additional capacitor and equals the time period between the leading edges of said first and second timing pulses, second additional discharge circuit means connected to said second additional capacitor and operative for discharging said second additional capacitor and generating a respective second additional pulse constituting said second timing pulse, and means for delaying the start of said second additional pulse until the end of said first additional pulse.

10. The arrangement defined in claim 9, wherein said first pulse generating means and first varying means include an impedance transformer connected between said integrating means and said storage capacitor of said first pulse generating means, and wherein said second pulse generating means includes first and second additional impedance transformers respectively connected between said integrating means of said second pulse generating means and said first and second additional capacitors.

11. The arrangement defined in claim 10, wherein said impedance transformers are emitter-follower transistor stages.

12. The arrangement defined in claim 9, wherein said first and second electronic pulse generating means share the same integrating means, and wherein said integrating means comprises a Miller integrator.

13. The arrangement defined in claim 9, wherein each of said discharge circuit means comprises a constant current source connected to the respective storage capacitor for discharging the latter at constant current and also a monostable circuit connected to the respective storage capacitor and undergoing a first change of state when the voltage on the respective storage capacitor falls below a predetermined lower threshold value and undergoing a reverse change of state when the voltage on the respective storage capacitor exceeds a predetermined higher threshold value.

14. The arrangement defined in claim 13, wherein at least the constant current source of said second additional discharge circuit means has a blocking input for receipt of a blocking pulse for rendering the constant current source non-conductive, and wherein said means for delaying is connected between the output of said first additional discharge circuit means and said blocking input.

15. The arrangement defined in claim 14, wherein said means for delaying comprises an inverter having an input connected to the output of said first additional discharge circuit means and having an output connected to said blocking input, and also an AND-gate having one input connected to the output of said inverter and another input connected to the output of said second additional discharge circuit means.

16. The arrangement defined in claim 9; and further including third electronic pulse generating means having the same circuit configuration as said second electronic pulse generating means but operative for generating a third timing pulse having a duration corresponding to a predetermined fraction of a crankshaft rotation and having a leading edge delayed relative to the leading edge of said second pulse by a time period corresponding to a predetermined fraction of a crankshaft rotation.

17. The arrangement defined in claim 16; and further including fourth electronic pulse generating means having the same circuit configuration as said second electronic pulse generating means but operative for generating a third timing pulse having a duration corresponding to a predetermined fraction of a crankshaft rotation and having a leading edge delayed relative to the leading edge of said third pulse by a time period corresponding to a predetermined fraction of a crankshaft rotation.

18. The arrangement as defined in claim 9, wherein at least one of said constant current sources has a blocking input for receipt of a blocking pulse for rendering the respective constant current source non-conductive, whereby to permit receipt of blocking pulses for delaying discharge of the respective storage capacitor.

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