

[54] IGNITION ADVANCE CIRCUIT

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[63] Continuation-in-part of Ser. No. 835,661, June 23, 1969, abandoned.

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[51] Int. Cl. **F02p 1/00**, F02p 5/04

[58] Field of Search 123/148 E, 146.5 A, 123/117 R

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[57] ABSTRACT

An ignition advance circuit which produces an advance varying linearly with engine speed and which advance reaches a maximum at some engine speed beyond which the advance remains fixed. Two voltage generators are driven by the engine. One generator has an output producing a series of time-separated pulses, each pulse increasing linearly from a fixed reference point. The other generator has an output which increases with engine speed. A pulse generator is controlled by a predetermined coincidence relationship between the outputs of the voltage generators.

2 Claims, 3 Drawing Figures

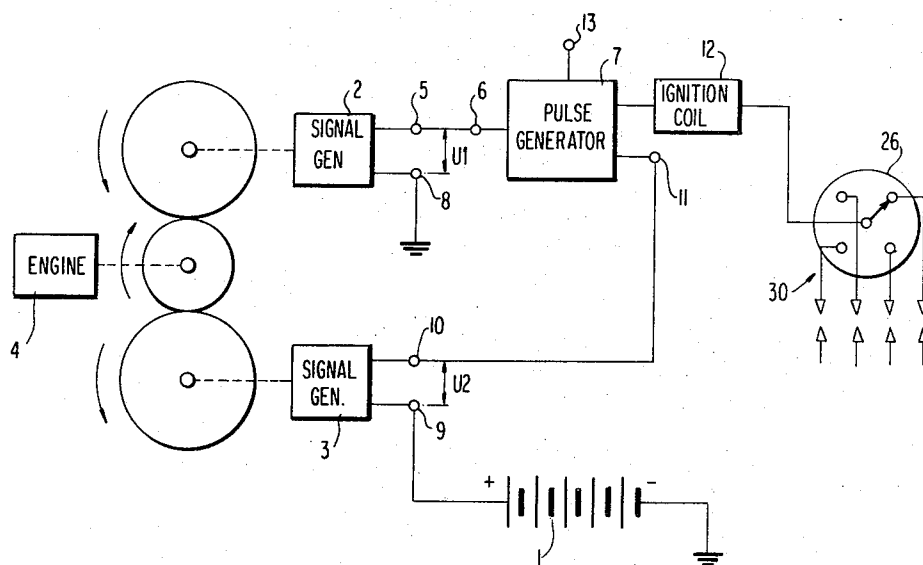


FIG 1

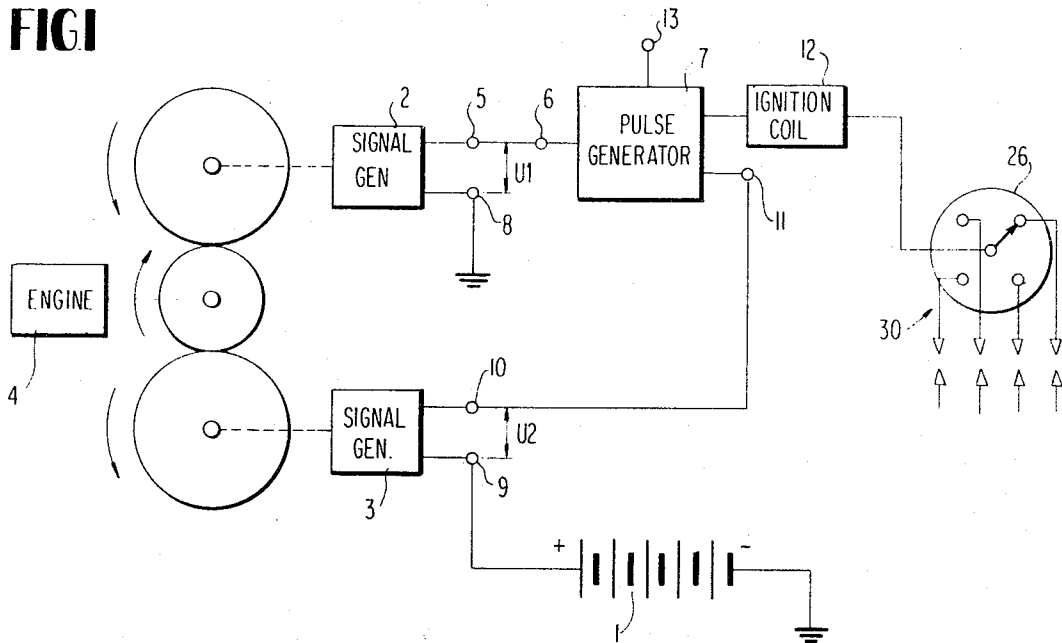


FIG 2

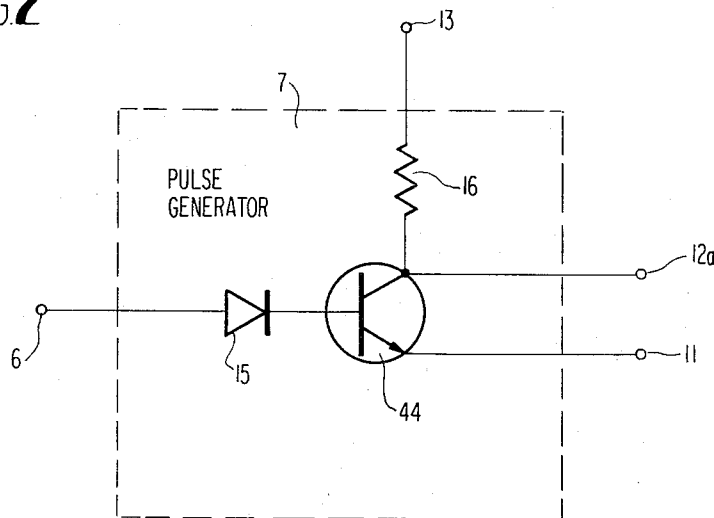
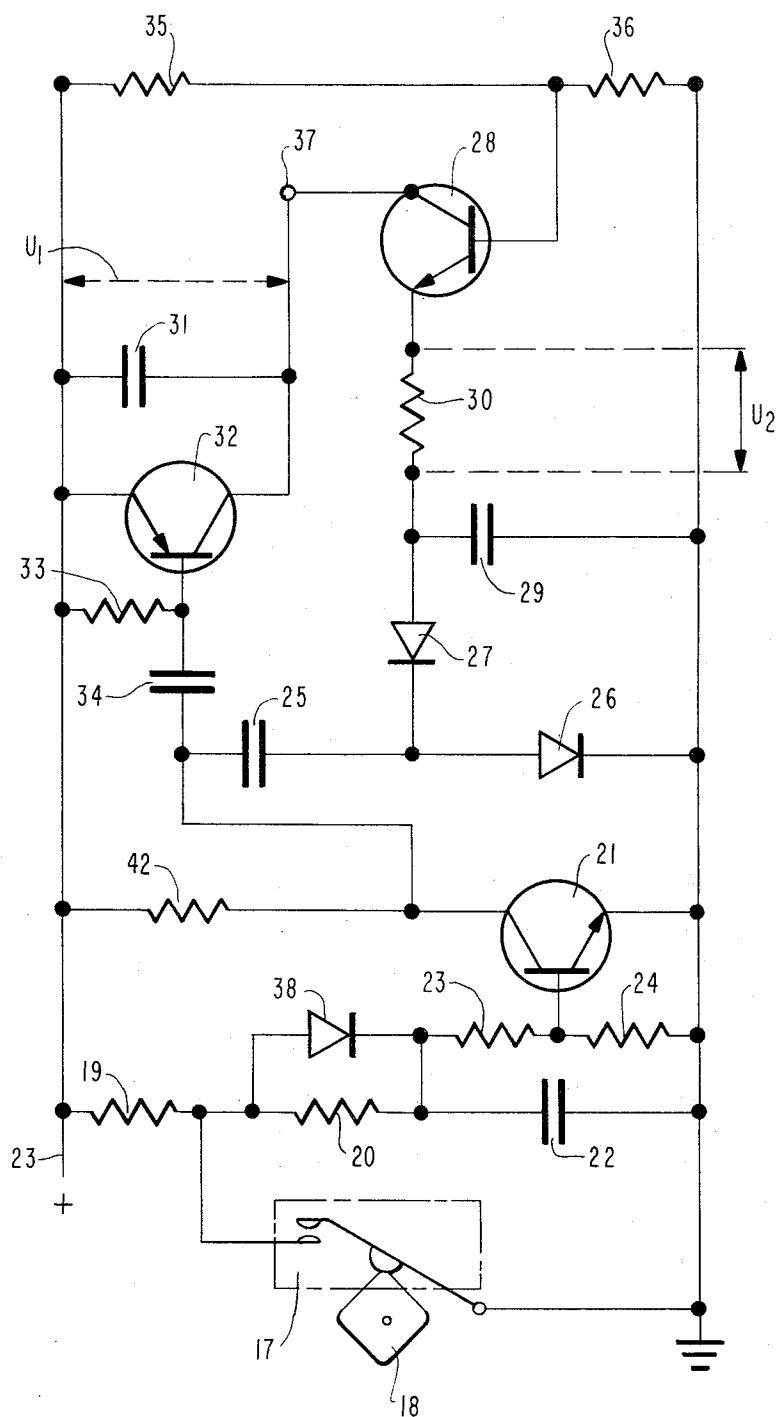


FIG. 3



IGNITION ADVANCE CIRCUIT

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of my co-pending application, Ser. No. 835,661, filed June 23, 1969, now abandoned.

BACKGROUND OF THE INVENTION

The advance characteristics required for efficient operation of an internal combustion engine are commonly achieved by the use of a set of breaker points whose time of opening is controlled by a centrifugal advance mechanism, often combined with a so-called "vacuum advance" device to accommodate for engine load the breaker point controlling the primary circuit of an ignition coil to achieve automatic ignition advance with increasing engine speed.

Mechanical devices of this type, however, are subject to rapid deterioration of the breaker points even though they have been developed to a high degree so as to produce the requisite automatic ignition advance characteristics.

Electronic circuits have also been proposed as a sinusoidal voltage generator in combination with an RLC circuit. A combination of this type, however, requires that the generator be of very accurate output, such a generator being however, not only expensive, but also easily damaged in the rugged environment of a motor vehicle.

Other electrical circuits such as transistorized types and capacitor discharge types also have been proposed.

Transistorized devices, however, have been characterized by complexity and capacitor discharge types are characterized by difficulty in obtaining the desired advance characteristics.

SUMMARY OF THE INVENTION

The present invention relates to an automatic ignition advance circuit of simple and economical form which will produce an automatic advance of desired form which increases up to but not beyond some predetermined engine speed. The advance characteristics may be linear if desired, or a desired non-linearity may be introduced.

The circuit consists essentially of a pair of voltage generators controlling a pulse generator which may be used to control the primary of a conventional ignition coil. One voltage generator produces an output which increases as some reference point or reference points determined by the angular position of the engine crankshaft are reached and exceeded, thereby to produce a series of time-separated voltage pulses of constant peak amplitude whose leading edges increase in slope with engine speed. The other voltage generator has a continuous output related to engine speed. The pulse generator comprises a single transistor and a diode connected to produce an output pulse to the primary winding of the engine ignition coil when the instantaneous voltage of the first generator reaches some fixed value with respect to the voltage output of the second voltage generator. The outputs of the two voltage generators may be linear or non-linear correspondingly to produce the desired automatic advance characteristics.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

FIG. 1 is a schematic block diagram illustrating the principles of the present invention;

FIG. 2 is a schematic circuit diagram of the pulse generator, and

FIG. 3 is a schematic circuit diagram illustrating operation of the signal generators of FIG. 1.

DETAILED DESCRIPTION OF THE INVENTION

With reference to FIG. 1, an internal combustion engine 4 synchronously drives a pair of signal generators 2 and 3 having output signals U_1 and U_2 respectively. The output signal U_1 varies in a manner related to a fixed reference point or points with respect to the angular disposition of the crankshaft of the engine 4 whereas the output signal U_2 varies in a manner related to the speed of rotation of the engine.

These two output signals are applied to a trigger device 7 which produces an output to the primary of the engine ignition coil 12 at a time determined by the attainment of instantaneous relative values of the signals U_1 and U_2 . The secondary winding of coil 12 is connected to high voltage distributor 30 which applies a spark to the appropriate cylinder (not shown) of the engine 4 at that angular disposition of the crankshaft conducive to proper burning of the fuel mixture taking into account the speed of rotation of the engine crankshaft.

The signal U_1 , disregarding any variation due to manifold pressure, may be of the form:

$$U_1 = kx, \text{ where:}$$

k is constant, and

x = the angular distance from some fixed reference point with respect to the angular position of the engine crankshaft.

Thus, it will be seen that the voltage U_1 increases linearly from the reference points and at a rate which increases with crankshaft speed of engine 4.

The signal generator 3, on the other hand, may produce a voltage of the form:

$$U_2 = \alpha n, \text{ where:}$$

α is a constant, and

n = engine RPM.

The device 7, as shown in FIG. 2 consists of an npn transistor 44 and a diode 15. The output U_1 is applied at the terminal 6 to the base of the transistor 44 whereas the output U_2 is applied at the terminal 11 of the emitter of the transistor. The collector-emitter path is through the load resistor 16 to the terminal 13 and the pulse output of the device is taken at the terminal 12a. The terminal 13 is connected to a suitable voltage source, which may be a battery 1, to the positive terminal of which the terminal 9 of the signal generator 3 is connected so that when $U_1 = \beta U_2$, β being a constant, the transistor will conduct to produce a pulse output at its terminal 12. Thus, since $U_1 = kx$ and $U_2 = \alpha n$, when $U_1 = \beta U_2$, $x = (\beta \alpha / k) n = Kn$, K being a constant.

Thus, the ignition point advances linearly with engine speed of engine 4 but approaches a limit corresponding to some engine speed beyond which the ignition advance remains fixed.

It will be appreciated that the parameters k and α may also be non-linear if desired. The value of β should be less than unity so that the width of the pulses at the output of the device 7 although variable, will be suffi-

cient in any case to provide for an ignition spark at 30 of sufficient energy to ignite the fuel mixture. The leading edges of the time-separated pulses produced by the generator 2 will be of increasing slope as the engine speed rises so that attainment of the condition $U_1 = \beta U_2$ 5 occurs earlier as the engine speed rises but will approach a limit established by the commencement of each time-separated pulse whereby the automatic advance may not exceed a predetermined maximum regardless of engine speed.

In FIG. 3, a schematic circuit diagram appears illustrating a suitable construction and mode of operation for signal generators 2 and 3 of FIG. 1 herein. Referring then to FIG. 3 a breaker device 17 appears, which is controlled by cam 18 driven off the engine cam shaft. Breaker device 17 is seen to be in a circuit with a resistor 19 to conductor 23, and also connected to resistor 20 and thence to the base of an NPN transistor 21. The emitter of transistor 21 is grounded and the collector thereof connected to a bridge of diodes 26 and 27 by means of capacitor 25. The said collector is also connected through a resistor 42 to the positive polarity side of the current source. Diode 27 of the diode bridge is connected to the emitter of a transistor 28 through filtering resistor 30. The base of transistor 28 is connected on one hand to ground by means of resistor 36 and on the other hand to conductor 23 via the resistor 35. Capacitor 29 is connected in parallel in the circuit consisting of resistor 30, emitter and base of transistor 28, and resistor 36.

The operation of the foregoing circuit is as follows: each time breaker 17, controlled by cam 18, opens, the bridge of resistors 19 and 20 ensures the saturation of transistor 21 by means of the circuit including resistors 23 and 24 and diode 38, which circuit prevents unwanted triggering of the system when breaker 17 bounces back during closing.

Saturation of transistor 21 controls the discharge of capacitors 25 by means of diodes 26 and 27 into the emitter/collector circuit of transistor 28. Capacitor 29 filters the output current of transistor 28 and makes it a direct current at point 37. This current is proportional to the speed of rotation of cam 18.

From the above current generator, a voltage generator output U_2 is obtained by adding several additional elements. In particular a PNP-type transistor 32 polarized by resistor 33, has its base connected to a capacitor 34, in turn connected to capacitor 25. Transistor 32 has its emitter connected to conductor 23 and its collector connected to point 37. Capacitor 31 is mounted in parallel in the emitter/collector circuit of transistor 32.

The operation of generator 2 is thus as follows: each time breaker 17, controlled by cam 18, opens, transistor 21 becomes saturated and allows transistor 32 to also become saturated by means of capacitor 34 and resistor 33 for a very short time, practically negligible but nevertheless sufficient to allow complete discharge of capacitor 31 and bring voltage U_1 at the terminals at said capacitor to zero. Once this very short time has elapsed, capacitor 31 is charged by the current generator previously described, the current i of which is proportional to the rotational speed of cam 18, which can be translated as follows:

The current generator produces a current

$$i = \delta \times N$$

δ = proportionality factor

N = speed of rotation of cam 18

Voltage U_1 at the terminals of condenser 31 is

$$U_1 = Q/C$$

Q = quantity of current

C = condenser's capacity

since $Q = i \times t$ with t = time elapsed between instant considered and opening of breaker 17

$$U_1 = (i \times t/c)$$

$$\text{or } U_1 = (\delta \times N \times t/c)$$

$$\text{Since } N = \alpha/T$$

where T = interval of time between two openings of the breaker

α = factor of proportionality

$$U_1 = (\delta \times \alpha/c) \times t/T$$

$\delta \times \alpha/c = K$ is a constant value

$$\text{therefore } U_1 = k \times t/T$$

We know that ratio t/T in the rotational movement of cam 18 is proportional to the angle of rotation of said cam between opening of breaker 17 and time t .

The angles of rotation are proportional to the time intervals and angle α max between two openings of breaker 17 is constant.

If W is the angular rotational speed of cam 18:

$$\alpha = W \times t$$

$$\alpha \text{ max} = W \times T$$

$$\text{therefore } \alpha/\alpha \text{ max} = t/T$$

and finally

$$U_1 = \boxed{\frac{\delta \times \alpha}{c \times \alpha \text{ max.}}} \times \alpha$$

constant factor

This particular form of realization of voltage generator 2 from a current generator of standard design as has been described allows the obtention of a tachometer generator 3 - the voltage U_2 of which is measured at the terminals of resistor 30.

I claim:

1. An electrical circuit for controlling the ignition advance characteristics of an internal combustion engine having a rotating crankshaft so that the ignition point advances linearly with engine speed comprising:

first signal generator means including impedance means connected to a breaker device controlled by a cam being driven from said crankshaft means, connected to a base of a NPN transistor having a grounded emitter and having its collector capacitively coupled to a PNP transistor having a grounded emitter, the collector of said PNP transistor having an output $U_1 = kx$, where k is a constant and x is the angular displacement of said crankshaft beyond a reference point, whereby said output U_1 comprises a series of time-separated pulses of constant peak amplitude having a leading edge the slope of which increases with engine speed and approaches a limit established by the commencement of each time-separated pulse as a fixed speed value is attained;

second signal generator means including said collector of said NPN transistor being capacitively coupled to a diode bridge, said diode bridge connected to a filter having a continuous output $U_2 = a n$, where a is a constant and n is the rotational speed of the crankshaft;

pulse generator means including a further NPN transistor and connected to said first and second signal generator means by said further NPN transistor having its collector connected to the collector of said PNP transistor, having its emitter connected to said filter, and having the base thereof providing an output when $U_1 = \beta U_2$, where β is a constant, said pulse generator output being utilized to control occurrence of the ignition spark in said engine, whereby said spark is advanced with engine speed and reaches a limit of advancement as said fixed speed value is reached in said engine.

2. Method for controlling the ignition advance characteristics of an internal combustion engine having a rotating crankshaft so that the ignition point advances linearly with engine speed comprising the steps:

generating by means of impedance means connected to a breaker device controlled by a cam being driven from said crankshaft in which said impedance means is connected to a base of a NPN transistor having a grounded emitter, its collector is capacitively coupled to a PNP transistor having a grounded emitter and having its collector thus producing a first signal output $U_1 = kx$, where k is a constant and x is the angular displacement of said crankshaft beyond a reference point, said first sig-

nal output U_1 comprising a series of time-separated pulses of constant peak amplitude having a leading edge the slope of which increases with engine speed and approaches a limit established by the commencement of each time-separated pulse as a fixed speed value is attained;

a separate step of generating by means of said collector of said NPN transistor being capacitively coupled to a diode bridge in which said diode bridge is connected to a filter thus producing a continuous signal output $U_2 = a n$, where a is a constant and n is the rotational speed of the crankshaft;

a further step of generating a pulse signal responsive to said first and second signal output means of a further NPN transistor having its collector connected to the collector of said PNP transistor, and in which the emitter thereof is connected to said filter and having the base thereof providing a pulse output when $U_1 = \beta U_2$, where β is a constant; and controlling the occurrence of the ignition spark in said engine in response to said pulse output, said spark being advanced with engine speed and reaches a limit of advancement as said fixed speed value is reached in said engine.

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