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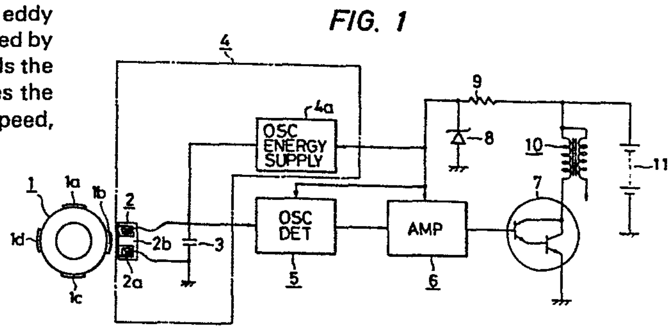
(54) **Ignition circuit for internal combustion engines.**

(57) An ignition circuit for internal combustion engines includes a resonant oscillation circuit (4) comprising a capacitor (3) in parallel with a coil (2a) of a sensor core (2b). The core is disposed adjacent an engine driven rotary metallic member (1) having a plurality of projections (1a-1d) spaced around its periphery and equal to the number of engine cylinders. The circuit resonates unless a projection lies opposite the core to suppress oscillations by eddy current loss. The oscillation signal amplitude is monitored by a threshold detector (5) whose switching output controls the supply of power to an ignition coil (10). This minimizes the ignition timing lag increase as a function of engine speed, and attendantly any engine power loss.

FIG. 1



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IGNITION CIRCUIT FOR INTERNAL COMBUSTION ENGINES

This invention relates to an ignition circuit for internal combustion engines, and more particularly to such a circuit including an oscillation type of pickup which detects and initiates the proper ignition timing by sensing a change in the state of a resonant oscillation which in turn is a function of the relative position of a rotating metallic member.

In accordance with this invention an ignition circuit for internal combustion engines is provided embodying a resonant oscillation type of pickup or sensor wherein the supply of electrical power to the primary winding of the ignition coil is initiated when the amplitude of an oscillating signal reaches a predetermined level, and is interrupted or terminated when the amplitude falls below such level. The power supply termination induces a sharp, high voltage spike in the secondary winding of the ignition coil which fires an associated spark plug. With such an arrangement the ignition timing delay or firing angle retardation as a function of the engine's rotational speed is minimized, which attendantly minimizes any reduction in the power output of the engine.

The invention is described in detail below with reference to drawings which illustrate a preferred embodiment, in which

Figure 1 shows a simplified electrical diagram of an ignition circuit constructed in accordance with the teachings of this invention,

Figures 2(a) through 2(e) show waveform diagrams for explaining the operation of the circuit shown in Figure 1, and

Figure 3 shows a plot of engine rotational speed versus firing angle lag which illustrates the operational characteristics of the invention.

Referring first to Fig. 1, a rotary metallic member 1 is driven by an internal combustion engine (not shown) and is provided with a plurality of projections 1a through 1d equally spaced around its outer periphery and corresponding to the number of cylinders of the engine. A sensor 2 is disposed opposite and closely adjacent to the rotational path of the projections 1a to 1d, and comprises a magnetically permeable core 2b having a coil 2a wound around its central leg. A capacitor 3 connected in parallel with the coil 2a forms a resonant circuit with the latter to which electrical energy is applied by an oscillation supply circuit 4a. The sensor 2, capacitor 3 and supply circuit 4a comprise, in combination, an electrical oscillation circuit generally designated by reference numeral 4. A threshold oscillation detector 5 connected to one end of the capacitor 3 detects the state of oscillation of the circuit 4 by monitoring the amplitude or amplitude envelope, for example, of the oscillating signal. The high or low/on or off output of the detector 5 is increased by an amplifier 6, whose output in turn switches a Darlington pair transistor 7 on or off. A Zener diode 8 and resistor 9 stabilize the power supply voltage derived from a battery 11, which also energizes an ignition coil 10.

Turning now to Figure 2, the rectangular waveform 12 shown in Fig. 2(a) is actually a timing diagram which represents the presence or absence of one of the projections 1a to 1d of the rotary member opposite the sensor 2. The waveform 13 in Fig. 2(b) represents the voltage across the capacitor 3, i.e. the output voltage of the oscillation circuit 4, while curve 13a represents the envelope of the oscillating signal. The waveform 14 shown in Fig. 2(c) represents the output voltage of the oscillation detector 5 or the amplifier 6, while the waveform 15 shown in Fig. 2(d) represents the current flowing through the primary winding of the ignition coil 10, i.e. the collector current of transistor 7. The output voltage produced by the secondary winding of the ignition coil is shown by waveform 16 in Fig. 2(e).

The horizontal line designated V_{ON} in Fig. 2(b) represents the threshold or triggering level of the oscillation detector 5, and it will be noted that the high output of rectangular waveform 14 in Fig. 2(c) is only produced when this threshold level is exceeded by the oscillation envelope 13a.

In operation, the oscillation supply circuit 4a constitutes a negative conductance circuit, while the sensor 2 and capacitor 3 in combination constitute a negative conductance oscillator. When none of the projections 1a to 1d of the rotary member 1 are disposed opposite the sensor 2, the oscillation circuit 4 oscillates at a frequency substantially equal to the resonant frequency of the coil 2a and the capacitor 3.

When one of the rotating projections 1a to 1d reaches a position opposite the sensor 2, however, the parallel conductance of the coil 2a is decreased by the influence of eddy currents generated in the projection and metallic member 1, i.e. the Q value of the resonant circuit is decreased which causes an attendant increase in the energy loss. The circuit parameters are such that this energy loss or absorption is greater than the energy delivered by the supply circuit 4a, whereby the oscillation circuit 4 ceases to oscillate.

As the rotary metallic member 1 advances farther to a position whereat none of its projections are opposite the sensor 2, the parallel conductance of the coil 2a is increased. This in turn increases the Q value, the eddy current loss or absorption is decreased, and resonant oscillations are once again resumed.

Such operation will be explained more fully with continued reference to Figs. 2(a) through 2(e). Oscillation is initiated at a time t_1 at which none of the projections 1a to 1d are opposite the sensor 2. The oscillation output is gradually increased until, at a time t_2 which lags or follows time t_1 by a period of T_{ON}, its envelope 13a reaches the threshold voltage level V_{ON}. At this point the detector waveform 14 abruptly rises which switches the transistor 7 on to thereby develop the rising current waveform 15 in the primary winding of the ignition coil 10.

When one of the rotary member projections reaches a position opposite the sensor 2 at time t_3 the oscillation signal is gradually attenuated, and at a time t_4 which lags or follows t_3 by a period of T_{OFF}, its envelope 13a drops below the threshold voltage level V_{ON}, at which point the output of detector 5 returns to zero. This turns off transistor 7 to interrupt the primary winding current 15 flowing through the coil, whereby a sharp, high voltage output spike 16 is generated in the secondary winding of the coil and delivered as a firing pulse to an associated spark plug.

As will be apparent from the foregoing description there are two time lags involved in the operation of the circuit, a time lag T_{ON} from the moment at which one of the projections 1a to 1d advances out of alignment with the sensor 2 to the moment at which the oscillation detector 5 produces a raised output 14, and the time lag T_{OFF} from the moment at which one of the projections is brought into alignment with the sensor to the moment at which the output of detector 5 returns to the zero level. These time lags are substantially constant, and T_{ON} is always greater than T_{OFF} unless some specific countermeasures are taken. In other words, the growth of the oscillation signal always takes a longer period of time than the cessation or attenuation thereof.

The time lag characteristics plotted in Figure 3 are obtained by converting T_{ON} and T_{OFF} into corresponding angular values as a function of the rotational speed of the metallic member 1. More specifically, the abscissa axis in Fig. 3 represents the rotational speed of the member 1 which is, of course, equal or directly proportional to the engine speed, while the ordinate axis represents the time lag angles of T_{ON} and T_{OFF}. The straight lines 20 and 21 thus illustrate the delay angle characteristics of the time lags T_{ON} and T_{OFF}, respectively.

As is well known, in an internal combustion engine it is desired and advantageous to minimize any increase in the ignition timing or firing angle as a function of engine speed to thereby minimize any decrease in the engine output or power level. In fulfillment of this objective it will be noted from Fig. 3 that, with the ignition circuit of this invention, the time lag T_{OFF} until the moment t_4 at which the primary winding current 15 of the ignition coil 10 is interrupted is always relatively small regardless of engine speed, which accordingly minimizes any decrease or loss in the usable power output of the engine.

Claims:

1. An ignition circuit for internal combustion engines, characterised by a metallic member (1) adapted to be rotatably driven by an engine in synchronization with the rotation of the engine shaft; a sensor (2) disposed opposite and closely adjacent the path of rotation of said metallic member (1); an oscillation circuit (4) adapted to change a state of resonant oscillation in accordance with the rotational position of said metallic member (1); an ignition coil (10) supplied with electrical power from a D.C. source (11) in a controlled manner in accordance with the output of said oscillation circuit (4), and means for initiating the supply of electrical power to said ignition coil (10) as said oscillation circuit begins to oscillate and for terminating said supply of power as said oscillation circuit ceases to oscillate.

2. An ignition circuit as defined in claim 1, characterised in that said metallic member (1) embodies at least one element on its outer periphery which cooperates with said sensor (2) to suppress resonant oscillations.

3. An ignition circuit as defined in claims 1 or 2, characterised in that said means for initiating and terminating comprises a threshold detector (5) responsive to the output amplitude of said oscillation circuit (4), and switch means connected in series with said ignition coil (10) and power source (11) and responsive to an output of said detector.

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FIG. 1

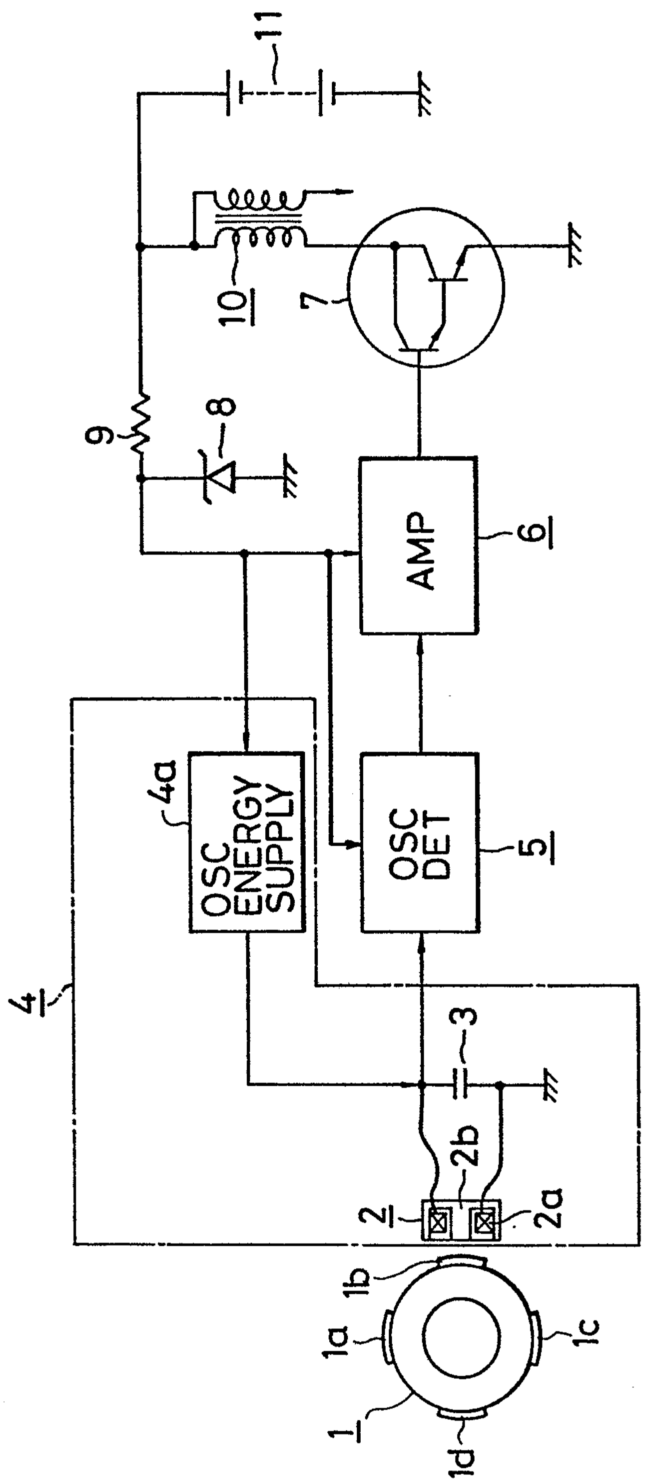


FIG. 2(a)
FIG. 2(b)
FIG. 2(c)
FIG. 2(d)
FIG. 2(e)

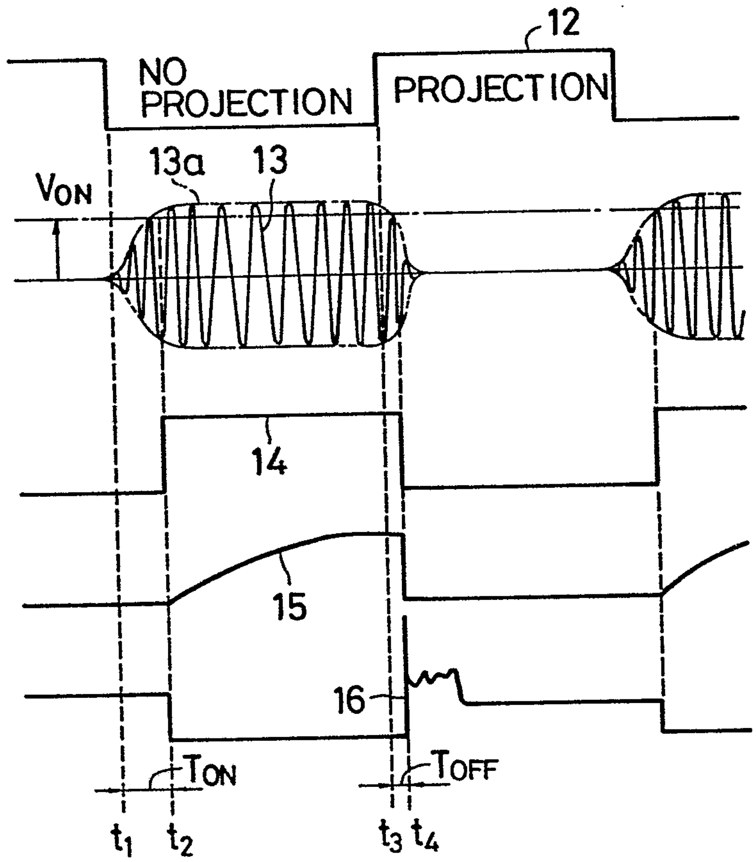
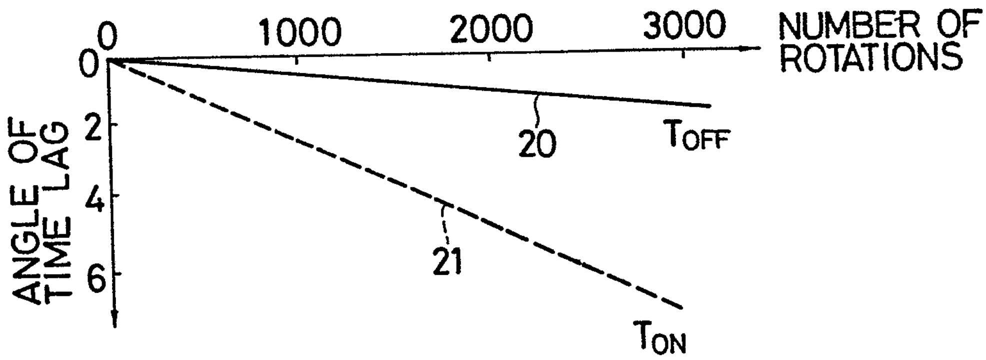


FIG. 3



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EUROPEAN SEARCH REPORT

0077483
Application number

EP 82 10 9081

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
X	US-A-3 853 106 (R.E. CANUP) * Figures 2-4; page 1, abstract; column 1, line 63 - column 2, line 27; column 5, line 45 - column 6, line 35 *	1-3	F 02 P 7/06 F 02 P 3/04
A	GB-A-2 067 295 (S.J. LUMBROSO) * Whole document *	1	
A	FR-A-2 266 870 (DECELLIER) * Whole document *	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
			F 02 P

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	02-02-1983	GODIN CH.G.

CATEGORY OF CITED DOCUMENTS

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