

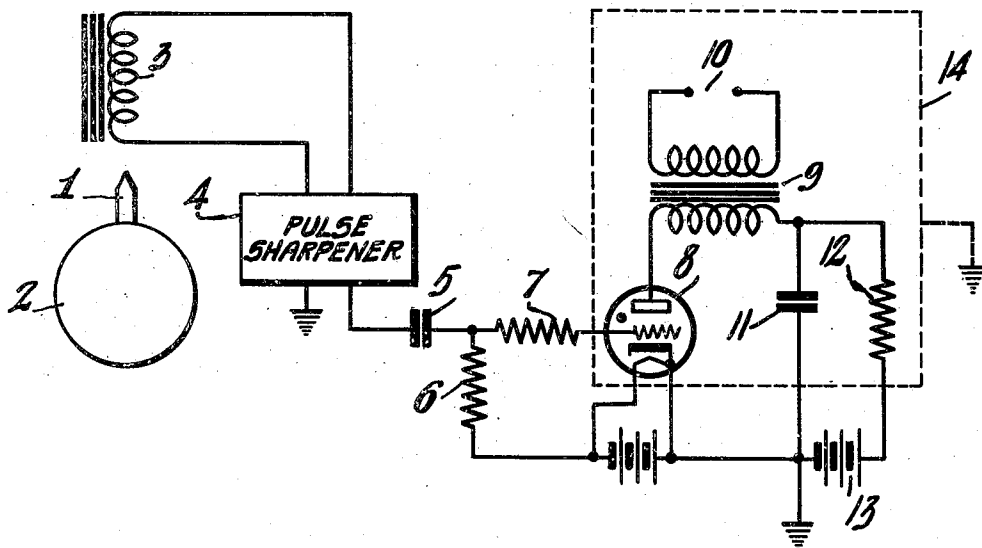
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TIMING CIRCUIT

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TIMING CIRCUIT

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1

My invention relates to electronic circuits and particularly to circuits in which a recurrent event must bear a time relationship to a previous cyclically recurrent event where the time interval between events is a function of the frequency of recurrence of the first event.

For purposes of illustration, I have shown my invention as applied to an ignition system of an internal combustion engine in which the firing of the spark in the cylinder bears a time relationship to the speed of the engine.

In an internal combustion engine, maximum fuel efficiency at a given speed is obtained when the spark occurs at a definite point in the stroke of the piston, but with changes in speed, the firing point of maximum efficiency is at different positions of the piston, wherein the firing point occurs earlier in the compression stroke as the engine speed increases.

Heretofore, in internal combustion engines, it has been necessary to select a point of firing that will be the same for all speeds, but most efficient at a predetermined speed which is generally in the middle range of speeds of which such engine is capable, or, in lieu thereof, to provide elaborate and complicated mechanical linkages for automatically or manually adjusting the spark time. These expedients have not proven entirely satisfactory in that they present additional moving parts which are subject to failure through wear and breakage.

In addition to the foregoing, previous ignition systems necessarily included other mechanisms, such as cam actuated relays and mechanically operated distributors, in the production and distribution of the spark producing pulses. These mechanisms are also subject to mechanical and electrical failure.

Another objection to the ignition systems now in use is that electrical disturbances are set up in the long high-tension conductors forming a part of such systems, which disturbances are reflected in any radio equipment that may be present, unless special care is taken to filter such disturbances from the equipment.

Accordingly, it is an object of my invention to provide an electrical circuit in which the time relationship between two series of events is automatically adjusted without the use of mechanical linkages to effect the adjustment where the time interval between such series is a function of the frequency of recurrence of the events in the first series.

Another object of my invention is to provide an electrical circuit that is adaptable to ignition

2

system for internal combustion engines wherein the time relationship between two series of cyclically recurrent events is automatically adjusted without the use of mechanical linkages to effect the adjustment. In accordance with the illustration I have chosen, the first series of events mentioned above would be the stroke of the piston or a part of the engine moving at a speed proportional to the stroke of the piston, for example, the cam shaft. The second series of events would be the firing of the spark in the cylinder.

Still another object of my invention is the provision of an electrical circuit that is suitable for ignition systems in which there are no moving parts that are subject to mechanical failure.

It is a further object of my invention to provide a circuit of the type mentioned in which all high tension conductors or elements occupy a small space and may be completely enclosed or shielded to reduce radio interference to a negligible amount.

In accomplishing these objects, I have provided an electrical pulse generator which consists of a pick-up coil closely associated with a small high quality permanent magnet which is rigidly mounted on some cyclically moving part from which the time reference is to be taken, as on the cam shaft of an internal combustion engine. The pulses thus produced are used to trigger a gas discharge tube which acts as a gate for the current flowing through a suitable load device which, in my illustration, would be the ignition transformer. Between the pulse generator and the tube, I have provided a pulse sharpening circuit to give a more positive control, and an electrical phase shifter which is responsive to the frequency of the pulses produced at the generator, to give the automatic time relation between the two series of events as a function of the frequency of recurrence of the events in the first series.

A better understanding of my invention may be had from the following description taken in conjunction with the accompanying drawing in which the single figure schematically represents an embodiment of my invention.

Referring to the figure, there has been provided a permanent magnet 1, rigidly secured to a cyclically moving part, such as the cam shaft 2 of an internal combustion engine. Closely associated with the magnet is a pick-up coil 3, connected to a simple pulse sharpening circuit 4, which may be of the well-known simple resistance-capacitance type. One line from the pulse sharpening device is grounded and the other line is connected

through a capacitor 5 and a grid resistor 7, to the control grid of a gas discharge tube 8, the cathode of which is grounded. A second resistor 6 is connected between the point of junction of the capacitor 5 and the grid resistor 7, and the cathode of the gas discharge tube through its cathode heater. The anode of the tube is connected through a suitable load device, which in the illustrated example is the primary of an ignition transformer 9 and a capacitor 11, and thence to ground. The junction between the load device and the capacitor 11 is connected through a resistor 12 and an anode supply battery 13, to ground. In the example selected, the terminals of the secondary of the transformer 9 are connected directly to a spark gap 10.

In operation, the system functions as follows: The cyclically moving part, which is represented by the cam shaft 2, periodically carries the permanent magnet 1 past the pick-up coil 3. The changing magnetic field caused by the motion of the magnet induces pulses of electrical energy in the coil. The pulses thus produced are passed through the pulse sharpening circuit 4, where their shape is modified to produce pulses with a steep leading edge thus providing more accurate time control. The pulses are then passed through the capacitor 5 and grid resistor 7 to the control of the gas discharge tube 8, causing it to become conductive, since it had been conditioned to be ready to fire at this time by the charging of the capacitor 11 by the battery 13, through the resistor 12, while the tube was in the non-conducting state.

This action of the tube is due to the characteristics of a gas discharge tube wherein the tube is conditioned to conduct when the anode potential is at a fixed level above the potential of the cathode, but the firing is restrained by a charge on the control grid which is negative with respect to the cathode. When the control grid is made sufficiently positive with respect to the cathode, the restraining force is removed and the tube conducts, at which time the control grid loses all control over the conduction of the tube which must be extinguished by reducing the potential of the anode to a point substantially equal to, or below the sustaining ionization potential. When the tube is thus extinguished the control grid resumes control over the conduction of the tube until it fires again.

When the tube 8 is conducting, current flows through the load device, here, the primary of the transformer 9, and thereby induces a sufficiently high potential in the secondary of the transformer to produce a spark across the gap 10.

The same current discharges the capacitor 11, reducing the anode potential sufficiently to extinguish the tube. Thereupon, the capacitor 11 immediately starts charging up again and the tube is thus made ready for the next pulse from the coil 3.

The arrangement of the capacitor 5 and the resistor 6 constitute a phase shifting combination which is responsive to changes in the frequency of the pulses passing through it. Since the pulses are generated at the same frequency as the movement of the moving part to which the magnet is fixed, such as a cam shaft, which is proportional to the speed of the internal combustion engine, the frequency of the pulses will be proportional to the speed of the engine. The angle of phase lag is inversely proportional to the frequency. Therefore, the slower the speed of the engine the more the spark is retarded, and,

as the speed of the engine is increased, the spark is automatically advanced. By properly proportioning the values of the capacitor 5 and the resistor 6, the spark may be timed to give maximum efficiency at all speeds of the engine.

By having a separate system for each spark gap of an internal combustion engine, the usual distributor may be eliminated. The desired firing order may be obtained by properly spacing and offsetting the permanent magnets, one of which is shown at 1, about the periphery of the cam shaft, or by using a single magnet and distributing the coils radially around the cam shaft.

A preferred embodiment of my invention as applied to ignition systems contemplates the inclusion of the tube 8, the spark-gap 10, the transformer 9, the capacitor 11, and the resistor 12, into a single compact unit enclosed in a shielding container, represented schematically on the drawing by the dotted line 14. The purpose of this arrangement is to eliminate the necessity for long high-tension leads and thus reduce to a minimum the extraneous oscillations that cause radio interference.

While I have shown and described my invention as applied to ignition systems for internal combustion engines, it is to be understood that, to those skilled in the art, other uses and applications of my invention and modifications thereof will be obvious without departing from the spirit and scope thereof. For example, it could be used as a means of stroboscopic excitation wherein the moving part to which the magnet is secured would be the part under observation.

What I claim is:

1. An ignition system for an engine having a cam shaft, comprising a source of electrical pulses including a permanent magnet secured to said cam shaft and a pick-up coil associated therewith, a pulse sharpening device connected to said coil, a discharge tube, said tube being triggered by said pulses, a series connected capacitor and resistor forming a phase shifting device responsive to changes in the frequency of said pulses connected intermediate said pulse sharpening device and said tube, a transformer having a primary and a secondary winding, the current in said primary winding being controlled by said tube, and a spark gap connected across said secondary winding.

2. An ignition system for an engine having a cam shaft, comprising a source of electrical pulses synchronized with the rotation of said cam shaft, a pulse sharpening device connected to said source, a gas discharge tube, said tube being triggered by said pulses, a series connected capacitor and resistor forming a phase shifting device responsive to changes in the frequency of said pulses connected intermediate said pulse sharpening device and said tube, a transformer having a primary and a secondary winding, the current in said primary winding being controlled by said tube, and a spark gap connected across said secondary winding.

3. An ignition system for an engine having a cam shaft, comprising a source of electrical pulses synchronized with the rotation of said cam shaft, a gas discharge tube, said tube being triggered by said pulses, a series connected capacitor and resistor forming a phase shifting device responsive to changes in the frequency of said pulses connected intermediate said source and said tube, a transformer having a primary and a secondary winding, the current in said primary winding being controlled by said tube, and a

5

spark gap connected across said secondary winding.

4. An electrical circuit for use in conjunction with a mechanism having a cyclically moving part comprising, a source of electrical pulses including a permanent magnet secured to said moving part, a pick-up coil associated therewith, a pulse sharpening device connected to said coil, a gas discharge tube, said tube being triggered by said pulses, a series connected capacitor and resistor forming a phase shifting device responsive to changes in the frequency of said pulses connected intermediate said pulse sharpening device and said gas discharge tube, and a load device, the current through said load device being controlled by said tube.

5. An electrical circuit for use in conjunction with a mechanism having a cyclically moving part comprising, a source of electrical pulses including a permanent magnet secured to said moving part, a pick-up coil associated therewith, a gas discharge tube, said gas discharge tube being triggered by said pulses, a series connected capacitor and resistor forming a phase shifting device responsive to changes in the frequency of said pulses connected intermediate said coil and said gas discharge tube, and a load device, the current through said load device being controlled by said tube.

6. An electrical circuit for use in conjunction with a mechanism having a cyclically moving part comprising, a source of electrical pulses synchronized with said cyclically moving part, a gas discharge tube, said tube being triggered by said pulses, a series connected capacitor and resistor forming a phase shifting device responsive to changes in the frequency of said pulses connected intermediate said source and said tube, and a load device, the current through said load device being controlled by said tube.

7. An ignition system for an engine having a cam shaft, comprising a source of electrical pulses including a permanent magnet secured to said cam shaft and a pick-up coil associated therewith, a pulse sharpening device connected to said coil, a discharge tube having a cathode and a control grid, a capacitor connected between said pulse sharpening device and said control grid, a resistor shunting said control grid and said cathode, said capacitor and said resistor forming a phase shifting device, a transformer having a primary and secondary winding, the current in said primary winding being controlled by said tube, and a spark gap connected across said secondary winding.

6

8. An electrical circuit for use in conjunction with a mechanism having a cyclically moving part comprising, a source of electrical pulses including a permanent magnet secured to said moving part, a pick-up coil associated therewith, a pulse sharpening device connected to said coil, a discharge tube having a cathode and control grid, a capacitor connected between said pulse sharpening device and said control grid, a resistor shunting said control grid and said cathode, said capacitor and said resistor forming a phase shifting device, a load device, the current through said load device being controlled by said tube.

9. An ignition system for an engine having a cam shaft, comprising a source of electrical pulses including a permanent magnet secured to said cam shaft and a pick-up coil associated therewith, a pulse sharpening device connected to said coil, a discharge tube, said tube being triggered by said pulses, an impedance network forming a phase shifting device responsive to changes in the frequency of said pulses connected intermediate said pulse sharpening device and said tube, a transformer having a primary and a secondary winding, the current in said primary winding being controlled by said tube, and a spark gap connected across said secondary winding.

10. An electrical circuit for use in conjunction with a mechanism having a cyclically moving part comprising, a source of electrical pulses including a permanent magnet secured to said moving part, a pick-up coil associated therewith, a gas discharge tube, said tube being triggered by said pulses, an impedance network forming a phase shifting device responsive to changes in the frequency of said pulses connected intermediate said coil and said tube, and a load device, the current through said load device being controlled by said tube.

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55