

[54] **FREQUENCY RESPONSIVE SWITCHING CIRCUIT**

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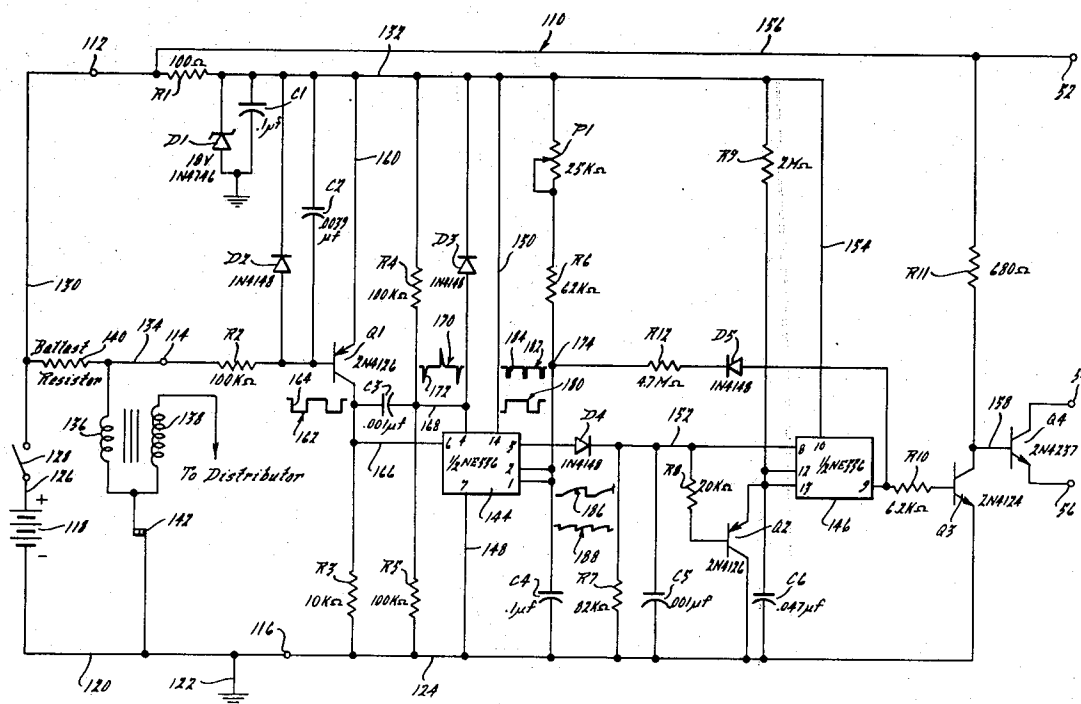
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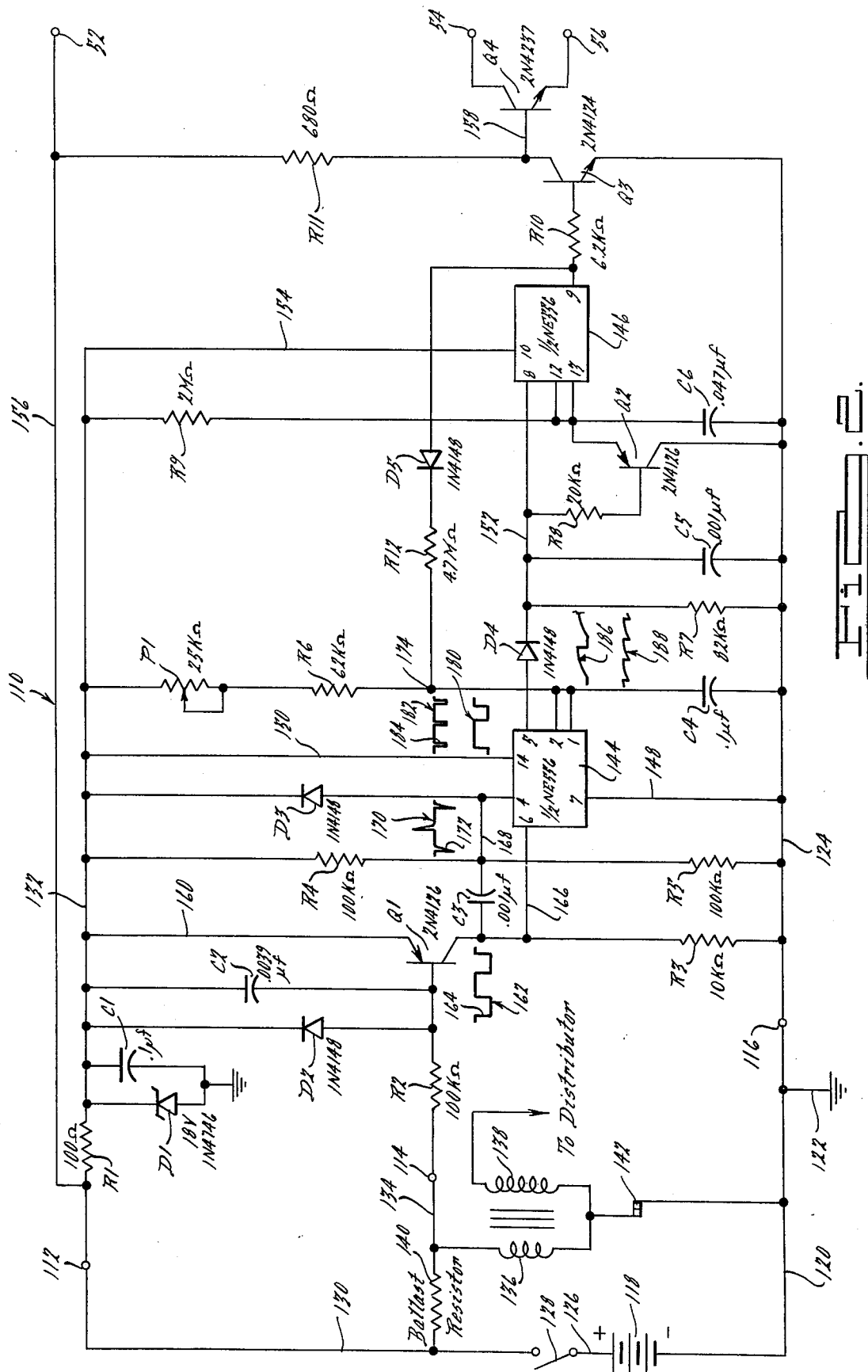
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[57] **ABSTRACT**

A frequency responsive switching circuit particularly suitable for use with apparatus for limiting the position of the throttle of an internal combustion engine at a predetermined engine speed. The circuit includes first and second retriggerable monostable multivibrators, each having a different timing circuit, which cooperate with one another to produce a switched output signal when the frequency level of the circuit input signal has reached a predetermined magnitude. The frequency responsive switching circuit is designed for use in a motor vehicle environment and may derive its input signal from the primary winding of an ignition coil conventionally included in motor vehicles.

10 Claims, 2 Drawing Figures





FREQUENCY RESPONSIVE SWITCHING CIRCUIT

BACKGROUND

This invention relates to a frequency responsive switching circuit. More particularly, the invention relates to a frequency responsive switching circuit which may be used in a motor vehicle to control the setting of an actuator that limits the position of the engine throttle such that the throttle cannot be fully closed, but rather must be at least partially open, when the engine speed is above a predetermined level.

In certain vehicle applications, it is desirable to maintain the throttle of an internal combustion engine in a partially open condition at engine speeds above a predetermined level for the purpose of minimizing undesirable engine exhaust emissions. Maintaining the throttle in a partially open position may be especially desirable during engine deceleration. Apparatus which limits throttle position to a partially open condition when engine speeds are above a predetermined level are in commercial use and thus are known in the prior art.

SUMMARY OF THE INVENTION

The present invention provides a novel electronic circuit particularly suitable for use in motor vehicles to limit throttle position in the manner described above. The circuit utilizes retriggerable monostable multivibrators to achieve a switching function at a predetermined input frequency magnitude. Separate timing circuits are provided for each of two retriggerable monostable multivibrators in the circuit, and the multivibrators are interconnected with the timing circuits in a manner which provides hysteresis in the switching operation. This hysteresis causes the frequency responsive switching circuit to produce an output signal in a first condition at a first predetermined frequency level of the input signal, as the frequency of that input signal increases, and to produce switching of its output to a second condition at a second predetermined frequency lower than the first predetermined frequency as the frequency of the input signal decreases. This hysteresis provides stability in the switching function of the circuit.

Preferably, the two retriggerable monostable multivibrators are included in a single integrated circuit package preferably of the commercially available type 556 and it is specifically preferred that they be a Signetics Corporation type NE556 dual timer.

The invention may be better understood by reference to the detailed description which follows and to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic view of apparatus for limiting or setting the position of the throttle in the engine of a motor vehicle in response to an electrical signal; and

FIG. 2 is a schematic diagram of a frequency responsive switching circuit suitable for use in controlling the apparatus illustrated in FIG. 1.

DETAILED DESCRIPTION

With reference now to the drawings, wherein like numerals refer to like parts in the two views and wherein component values and type numbers for circuit components are given by way of example and not limitation,

there is shown in FIG. 1 a diagrammatic view of apparatus for limiting or setting the position of the throttle of an internal combustion engine. The engine includes an intake manifold 10 on which is positioned a carburetor 12. The carburetor 12 has a throttle plate 14 shown in its fully closed position. The throttle plate 14 is mounted for pivotal movement about its mounting axis in the conventional manner. A link 16 is secured by a screw 18 to one end of the shaft about which the throttle plate 14 rotates. A linking wire 20 is pivotally connected to the link 16 at 22. The opposite end 24 of the linking wire is formed in a manner which permits it to be inserted in and move within a slot 26 in the movable arm 28 of a vacuum 30.

The vacuum motor 30 includes a flexible diaphragm 32 which divides the vacuum motor housing 34 into chambers 36 and 38. Atmospheric air is free to enter the chamber 36 through a slot in the housing 34 through which the movable arm 28 passes. The diaphragm 32 is urged in the direction of the chamber 36 by a compression spring 40 located in the chamber 38. When vacuum is applied to the chamber 38 through an inlet passage 42 communicating therewith, the diaphragm 32 is drawn to the left as viewed in FIG. 1 against the force of the compression spring 40. The leftward travel of the diaphragm 32 is limited by an adjustable screw 44. When the diaphragm 32 moves, the movable arm 28 attached thereto also moves toward the left as viewed in FIG. 1.

The vacuum motor 30 is secured to the housing of the carburetor 12 by a mounting bracket 46. When the vacuum signal is applied to the vacuum motor inlet passage 42, the movable arm 28 is pulled to the left and pulls the linking wire 20 with it which, in turn, pivots the link 16 and the throttle plate 14 about its axis. This opens the throttle plate 14 to a minimum partially open position. The amount that the throttle plate is opened is determined by the setting of the adjustable screw 44 which limits the travel of the vacuum motor diaphragm 32. Of course, the throttle plate 14 may be opened to a greater extent than that produced by actuation of the vacuum motor 30 because the linking wire 20 is freely movable within the slot 26.

The vacuum motor 30 is controlled by a solenoid valve 48, a transistor Q4 and, if desired, a vacuum switch 50 responsive to the vacuum level in the engine intake manifold 10.

Electrical terminals 52, 54, and 56 are terminals of the electronic circuit shown in FIG. 2. Lead wire 58 connected to terminal 52 supplies DC voltage through an electrical connector 60 to one lead of an electrical coil 62 controlling the operation of the solenoid valve 48. The other lead of the electrical coil 62 passes into the electrical connector 60 and is connected by a lead wire 64 to the terminal 54 of the electronic circuit in FIG. 2, which includes the transistor Q4. Transistor Q4 is a power transistor the collector of which is connected to the terminal 54 and the emitter of which is connected to the terminal 56.

A lead wire 66 connects the terminal 56 of the transistor Q4 to a terminal 68 of the vacuum switch 50. The vacuum switch 50 includes a housing formed from cup-shaped portions 70 and 72 between which a flexible diaphragm 74 is clamped. The chamber 76 formed between the diaphragm 74 and the housing portion 72 is in communication with atmospheric pressure through an opening 78. A chamber 80 is formed between the

diaphragm 74 and the housing portion 70, and this chamber 80 communicates, through tubing 82, T-connection 84, and tubing 86, with the interior of the intake manifold 10. When the level of vacuum within the intake manifold 10 is sufficiently high, a movable contact arm 88 attached to terminal 68 of the vacuum switch 50 is urged, by the diaphragm 74 and against the force of a compression spring 90, into electrical contact with an electrode 92 electrically connected with a grounded terminal 94 of the vacuum switch 50. The vacuum switch 50 may be calibrated to achieve electrical continuity between its terminals 68 and 94 at, for example, vacuum levels in the chamber 80 of about 19 inches of mercury.

The solenoid valve 48 has a movable plunger 96 which has the position shown when its electrical coil 62 is de-energized. In this condition, atmospheric air freely enters the solenoid valve through a passage 98. This passage has a small orifice 100. Air may flow through this orifice, alongside the movable plunger 96, which is of noncircular cross-section, and into an outlet passage 102 which communicates via tubing 103 with the chamber 38 in the vacuum motor 30.

When the electrical coil 62 of the solenoid valve 48 is energized, the movable plunger 96 is pulled upwardly as viewed in FIG. 1 to block the orifice 100 and to permit the outlet passage 102 to communicate with a passage 104. A porous metal filter 106 provides an atmospheric bleed to the passage 104 to assist the operation of the solenoid valve 48. The passage 104 is in communication, via tubing 108, T-connection 84 and tubing 86, with the interior of the intake manifold 10. Thus, when the solenoid valve 48 is energized, manifold vacuum is applied to chamber 38 of the vacuum motor 30 via passage 104 and valve outlet passage connected by tubing 103 to the chamber 38. Thus, whenever the coil of the solenoid valve 48 is energized, the vacuum motor 30 is actuated to prevent the throttle plate 14 from being fully closed, that is, to maintain it at least at a partially open position.

The function of the apparatus shown in FIG. 1 is to prevent the throttle plate 14 from becoming fully closed when engine speed is above a predetermined level, for example, 1850 rpm, particularly when the engine is decelerating. The vacuum switch 50 senses engine decelerations because the level of manifold vacuum increases under such conditions. The collector-emitter output circuit of the transistor Q4 is connected in series with the vacuum switch 50 and in series with the electrical coil 62 of the solenoid valve 48. The transistor Q4 output circuit is fully conductive whenever the engine speed is above a predetermined level and, if the manifold vacuum is sufficiently high to close the vacuum switch 50, the solenoid valve 48 is energized to actuate the vacuum motor 30 and to limit the position of the throttle plate 14.

Of particular importance to the present invention is the electronic circuit shown in FIG. 2 of which the output transistor Q4 forms a part. The circuit in FIG. 2 includes a frequency responsive circuit, generally designated by the numeral 110, which has input terminals 112, 114, and 116, the voltage supply terminal 52 and output terminals 54 and 56. A source of DC electrical energy 118, which preferably is a conventional vehicle DC storage battery, has its negative terminal connected by a lead 120 to ground at 122 and to the input terminal 116 of the frequency responsive circuit 110. Thus,

a lead 124 in the circuit 110 is a ground voltage supply lead. The positive terminal of the DC source 118 is connected by a lead 126 to a conventional vehicle ignition switch 128. The opposite terminal of the ignition switch 128 is connected by a lead 130 to the input terminal 112 of the frequency responsive circuit 110. This provides the positive voltage supply for the circuit 110.

Terminal 112 of the circuit 110 is connected through a resistor R1 to a positive voltage supply lead 132. This lead is maintained at substantially the potential on supply lead 130 connected to terminal 112. A zener diode D1 has its cathode connected to the voltage supply lead 132 and its anode is connected to ground. A capacitor C1 is connected in parallel with the zener diode D1. The zener diode protects the frequency responsive circuit 110 against voltage transients which might occur at terminal 112. The capacitor C1 acts as a high frequency power supply filter.

Input terminal 114 of the frequency responsive circuit 110 is connected by a lead 134 to one terminal of the primary winding 136 of the ignition coil conventionally included in a vehicle ignition system. The secondary winding 138 of the ignition coil is connected to the ignition system distributor. A balast resistor 140 is connected between the voltage supply lead 130 and the terminal of the ignition coil primary winding connected to input terminal 114. Preferably, the impedance of the balast resistor matches the impedance of the primary winding 136. Conventional breaker contacts 142, or the electronic equivalent, open and close in timed relation to engine operation to initiate and interrupt current flow in the ignition coil primary winding 136 in the conventional manner. This produces a periodic waveform on lead 134 connected to input terminal 114. With a twelve-volt DC source 118, the periodic signal at input terminal 114 varies from about a maximum of 12 volts, when the breaker contacts 142 are open, to a minimum of about 6 volts when the breaker contacts 142 are closed during the ignition system dwell time.

The frequency responsive switching circuit 110 includes a Signetics Corporation type NE556 dual timer. This dual timer is commercially available and is depicted in FIG. 2 as circuit elements 144 and 146, each of these being designated as one-half of the type NE556 dual timer. The pin numbers indicated in the circuit elements 144 and 146 are conventional for the commercially available dual timer. Each of the circuit elements 144 and 146 is a retriggerable monostable multivibrator and hereinafter is referred to as such.

With respect to multivibrator 144, its ground pin 7 is connected by a lead 148 to the circuit ground lead 124. Its voltage supply pin 14 is connected by a lead 150 to the voltage supply lead 132. Pin 1 is the discharge terminal of multivibrator 144 and is connected to its pin 2, which is the threshold terminal for its external timing circuit. Pin 4 is the reset input of multivibrator 144 and pin 6 is its trigger input. Pin 5 is the output terminal for multivibrator 144 and is connected through a blocking diode D4 and by a lead 152 to the trigger input pin 8 of the multivibrator 146.

Pin 13 is the discharge terminal for the external timing circuit of multivibrator 146 and is connected with pin 12, which is the threshold terminal. Pin 10 of multivibrator 146 is its voltage supply terminal and is connected by a lead 154 to the voltage supply lead 132. Pin 9 is the output terminal of multivibrator 146.

The output pin 9 of multivibrator 146 is connected through a current limiting resistor R10 to the base of a transistor Q3 whose emitter is connected to ground supply lead 124. The collector of the transistor Q3 is connected through a current limiting resistor R11 to a voltage supply lead 156 connected to voltage input terminal 112; it should be noted that supply lead 156 provides the positive voltage supply for the solenoid valve 48 connected to terminal 52. The collector of the transistor Q3 is connected by a lead 158 to the base of the transistor Q4. Multivibrator 146 switches its pin 9 output between low and high voltage levels. At its low voltage level (approximately 0.1 volt), the transistor Q3 is nonconductive which places its collector at the voltage on supply lead 156 and renders the transistor Q4 conductive to energize the coil 62 of the solenoid valve 48. When the pin 9 output voltage is at its highest level (approximately 1.6 volts below the voltage supply on lead 132), the transistor Q3 is conductive and the transistor Q4 is non-conductive resulting in de-energization of solenoid valve 48. Transistors Q3 and Q4 provide power amplification of the signal on output pin 9 of multivibrator 146.

The alternating input signal at terminal 114 of the frequency responsive switching circuit 110 is applied through a current limiting resistor R2 to the base of a transistor Q1 whose emitter is connected by a lead 160 to the voltage supply lead 132 and whose collector is connected through a current limiting resistor R3 to the ground lead 124. A diode D2 has its anode connected to the base of transistor Q1 and has its cathode connected to voltage supply lead 132. Diode D2 protects the base-emitter junction of the transistor Q1 against transients. A capacitor C2 is connected in parallel with the diode D2. Capacitor C2 acts as a high frequency filter for the voltage oscillations normally associated with the primary side of a vehicle ignition system. Since the alternating signal applied at the input terminal 114 is referenced to the positive voltage supply of the circuit, transistor Q1 and resistors R2 and R3 are incorporated to provide an alternating signal at the collector of Q1 that is referenced to ground potential and that has increased rise and fall rates as compared to the input signal.

When the input signal at terminal 114 is a high voltage level corresponding to open breaker contacts 142, the transistor Q1 is nonconductive and the collector of transistor Q1 is at ground potential. When the breaker contacts 142 close to initiate the ignition system dwell time, the input signal applied to terminal 114 falls to about 6 volts in a 12-volt vehicle ignition system, and the transistor Q1 is rendered conductive placing its collector at substantially supply line 132 voltage. The resulting waveform at the collector of Q1 is indicated at 162 where the negative-going edges 164 of this alternating waveform correspond to the end of the ignition system dwell time occurring upon the opening of the breaker contacts 142. This alternating waveform 162 is applied by a lead 166 to the trigger input pin 6 of the multivibrator 144.

Preferably, equal-value resistors R4 and R5 are connected in series with one another between the voltage supply leads 132 and 124. This forms a voltage divider that provides a quiescent operating point, equal to one-half the voltage on supply lead 132, on a lead 168 connecting the junction of the resistors R4 and R5 to the reset input pin 4 of the multivibrator 144. A coupling

capacitor C3 is connected between the collector of the transistor Q1 and the junction between resistors R4 and R5. Capacitor C3 modifies the waveform 162 on the collector of the transistor Q1 to produce a waveform 170 at the reset pin 4 of multivibrator 144. This waveform 170 consists of voltage spikes which are negative and positive going with respect to the quiescent voltage level established at the junction between the resistors R4 and R5. The negative-going voltage spikes 172 correspond to the negative-going edges 164 of the waveform 162, whereas the positive-going spikes correspond to the positive-going edges of waveform 162. A clamping diode D3 has its anode connected to reset pin 4 and its cathode connected to voltage supply lead 132. This diode limits the voltage at pin 4 to one diode voltage drop above the potential of voltage supply lead 132.

The external timing circuit for the multivibrator 144 is an RC circuit. This circuit includes a variable resistance P1, a resistor R6 and a capacitor C4. These elements are connected in series with one another and between the voltage supply leads 132 and 124. Also, a resistor R12 has one of its terminals connected to the junction 174 formed between the resistor R6 and the capacitor C4 and has its other terminal connected to the cathode of a blocking diode D5 whose anode is connected to the output pin 9 of the multivibrator 146. When the output voltage at pin 9 of the multivibrator 146 is at its high voltage level, the diode D5 is forward-biased placing the resistor R12 in parallel with series-connected resistances P1 and R6. Thus, under this circumstance, the resistor R12 forms a part of the timing circuit for multivibrator 144. As is further explained hereinafter, this provides hysteresis in the frequency-switching function of the circuit 110 because it affects the charging rate of the capacitor C4 and because the voltage across this capacitor is applied to pins 1 and 2 of multivibrator 144.

The multivibrator 144 has an internal transistor whose collector-emitter output circuit is connected between its discharge pin 1 and ground pin 7. This internal transistor is conductive when the voltage at output pin 5 is at its low level. Conduction of the internal transistor discharges the capacitor C4 to ground. Preferably, resistor R6 is of the carbon film type and capacitor C4 is of the mylar type. These components then have positive and negative temperature coefficients, respectively, and their RC time constant is substantially independent of temperature in the range from about -40°F. to 185°F.

The output at pin 5 of the multivibrator 144 is applied through blocking diode D4 to lead 152. A filter network comprises a resistor R7 having one of its leads connected to the cathode of the diode D4 and having its other lead connected to ground voltage supply lead 124. A capacitor C5, connected in parallel with the resistor R7, also forms a part of the filter network.

A timing circuit for the multivibrator 146 includes a resistor R9 and a capacitor C6 connected in series between the voltage supply leads 132 and 124. The junction between the resistor R9 and the capacitor C6 is connected to interconnected threshold pin 12 and discharge pin 13 of multivibrator 146. The emitter of a transistor Q2 is connected to this junction and the collector of the transistor Q2 is connected to ground supply lead 124. The base of the transistor Q2 is connected through a resistor R8 to the lead 152. The transistor Q2

when conductive in its emitter-collector output circuit discharges the capacitor C6.

In the operation of the frequency responsive switching circuit 110, the retriggerable monostable multivibrators 144 and 146 are triggered by falling waveforms applied to their respective trigger inputs 6 and 8. Also, the trigger pulse applied to the trigger input of the multivibrator 144 renders its internal discharging transistor nonconductive and initiates the charging of the timing capacitor C4. The internal circuitry of the multivibrators is such that when the voltage at their threshold pin reaches two-thirds of the potential of supply lead 132, their outputs are switched from the high voltage level to the low or substantially ground potential level. Also, a negative-going pulse applied to the reset input renders the internal discharge transistor conductive. The length of time required to charge the timing capacitor C4 to two-thirds of the supply lead 132 potential determines the duration of the high voltage level pulse at output pin 5 of multivibrator 144. The timing circuit components P1, R6 and C4 determine the maximum duration of this high level pulse width according to the equation $f_0 = 1/1.1(R6+P1)C4$ where f_0 is a predetermined frequency of response for the multivibrator 144 which is equal to the reciprocal of the pulse duration at its output pin 5. When the output pin 9 of multivibrator 146 is at a high voltage level to place the resistor R12 in parallel with resistances P1 and R6, the capacitor C4 charges more rapidly and the duration of the output pulse at pin 5 of multivibrator 144 is decreased. The reciprocal of this pulse duration corresponds to a frequency f_1 defined by the equation:

$$f_1 = \frac{R6 + P1 + R12}{1.1(R6 + P1)(R12)C4}$$

When the voltage level on output pin 5 of multivibrator 144 falls to ground potential, the blocking diode D4 is reverse-biased and the base of the transistor Q2 is coupled to ground through resistor R8 and the filter network including resistor R7 and capacitor C5. This renders the transistor Q2 conductive to discharge the capacitor C6. A negative-going signal appears on the lead 152 to trigger the monostable multivibrator 146. Its output pin 9 then goes to a high potential level.

As was previously mentioned, the timing circuit for the multivibrator 146 includes resistor R9 and capacitor C6. The capacitor C6 begins to charge when the multivibrator 146 is triggered. The timing circuit provides an output pulse duration on pin 9 of the multivibrator 146 the reciprocal of which corresponds to a frequency $f_2 = 1/1.1(R9)C6$ that is much lower than either of the frequencies f_0 or f_1 .

Let it be assumed that the frequency of the input signal at terminal 114, and of the shaped corresponding waveform 162, is less than f_0 . In such case, consecutive negative-going edges 164 of the input waveform 162 are spaced too far apart in time to retrigger the multivibrator 144 before it has completed its timing cycle. In other words, during each period of the input waveform 162, the capacitor C4 is charged to two-thirds of the voltage on supply line 132, the internal discharging transistor in the multivibrator 144 is rendered conductive, and capacitor C4 is discharged. Thus, the output at pin 5 of multivibrator 144 has the waveform shown at 180. The corresponding signal on pins 1 and 2 of multivibrator 144 is shown at 186.

Each of the negative-going edges of the waveform 180 are coupled by diode D4 and lead 152 to the trigger input of the multivibrator 146. Once the multivibrator 146 is triggered to produce a high voltage level at its output pin 9, this high voltage level is maintained because each negative-going signal on lead 152 retriggers multivibrator 146 before capacitor C6 has had sufficient time to charge to a potential equal to two-thirds of the potential on supply lead 132. Also, each of these negative-going edges on lead 152 renders the transistor Q2 conductive and discharges the capacitor C6. In view of this, the output signal on pin 9 of multivibrator 146 is maintained at its high voltage level, transistor Q3 is conductive, and transistor Q4 is nonconductive maintaining solenoid valve 48 deenergized.

With the voltage at pin 9 of multivibrator 146 high, the resistor R12 is connected in parallel with the resistances P1 and R6 so that the frequency setting for multivibrator 144 is the frequency f_1 . As engine speed increases, the frequency of the input signal at terminal 114 increases as does the frequency of the waveform 162. When the input frequency reaches the predetermined frequency f_1 , the multivibrator 144 no longer is able to complete its timing cycle because it is retriggered by the negative-going pulses 172 and negative-going edges 164 applied, respectively, to its reset pin 4 and its trigger pin 6. Each of the pulses 172 applied to reset pin a discharges the capacitor C4. The output waveform 182 illustrates the signal appearing at pin 5 when the frequency of the input signal 162 exceeds the predetermined frequency f_1 . Waveform 188 shows the signal on multivibrator pins 1 and 2.

From the waveform 182, it may be seen that the output voltage on pin 5 is maintained in a high voltage level condition except for short-duration negative-going pulses 184. The pulses 184 unfortunately are the result of applying the negative going spikes 172 to the reset pin 4 and are of equal duration.

The filter network comprising resistor R7 and capacitor C5 is designed effectively to remove the negative going pulses 184 at pin 5 from the waveform appearing on lead 152. When the negative-going pulses 184 occur, the diode D4 is reverse-biased and the capacitor C5, having been charged when the waveform 182 was at its high voltage level, can discharge only through the resistor R7. The time constant $(R7)(C5)$ is sufficiently large to prevent the negative-going pulses 184 from triggering multivibrator 146. As a result the signal on lead 152 is maintained at a substantially constant high voltage level and multivibrator 146 is not retriggered. It therefore times out so that its output pin 9 falls from a high voltage level to a low voltage level rendering transistor Q3 nonconductive and rendering transistor Q4 conductive. This energizes solenoid valve 48.

When the voltage at pin 9 of multivibrator 146 falls to its low level, the diode D5 is reverse-biased and resistor R12 no longer is in parallel with the resistances P1 and R6 in the timing circuit for multivibrator 144. Thus, the multivibrator 144 frequency is set at f_0 , a lower frequency than the frequency f_1 . This provides hysteresis in the circuit such that the frequency of the input signal applied to terminal 114 must fall below the frequency f_0 in order to cause the pin 9 output of multivibrator 146 once again to attain the high voltage level required to de-energize solenoid valve 48.

It should be noted that the multivibrator 144 is triggered on each negative-going edge 164 of the input

waveform 162 and that its output pulse duration is independent of the duty cycle of the waveform 162. Output pulse duration is determined exclusively by the external timing circuit connected to pins 1 and 2 of multivibrator 144.

With the component values indicated in FIG. 2, the frequency f_0 equals about 123 Hz and the frequency f_1 is about 125 Hz. These values correspond, respectively, in a four cycle, eight-cylinder engine application, to 1845 and 1875 engine rpm, a difference between them of about 30 rpm. Of course, the ignition system of an engine having a smaller number of cylinders produces a lower frequency input signal at terminal 114. The timing circuits for the multivibrators 144 and 146 necessarily would have to be adjusted accordingly to achieve switching operation of the circuit 110 at corresponding engine rpm levels.

Based upon the foregoing description of the invention, what is claimed is:

1. A frequency responsive switching circuit, which comprises, in combination:
 - an integrated circuit dual timer comprising first and second retriggerable monostable multivibrators;
 - circuit means coupling the output of said first multivibrator to the input of said second multivibrator;
 - timing circuits for each of said multivibrators, the timing circuit for said first multivibrator being set to produce an output pulse duration less than the output pulse duration set by the timing circuit for said second multivibrator; and
 - circuit means for modifying the timing characteristic of said timing circuit for said first multivibrator in response to the occurrence of a signal condition at the output of said second multivibrator.
2. A frequency responsive switching circuit according to claim 1 wherein said first multivibrator includes a trigger input and a reset input and wherein said frequency responsive switching circuit further includes a capacitor for coupling a signal applied to said trigger input to said reset input.
3. A frequency responsive switching circuit, which comprises, in combination:
 - first and second retriggerable monostable multivibrators;
 - a first timing circuit, associated with said first multivibrator, said first timing circuit determining the maximum frequency of an input signal applied to said first multivibrator that will permit said first multivibrator to complete its timing cycle before being retriggered;
 - a second timing circuit, associated with said second multivibrator, said second timing circuit determining the maximum frequency of an input signal applied to said second multivibrator that will permit said second multivibrator to complete its timing cycle before being retriggered, said maximum frequency determined by said second timing circuit being lower than said maximum frequency determined by said first timing circuit; and
 - circuit means coupling said first timing circuit to the output of said second multivibrator, said maximum frequency determined by said first timing circuit being capable of being modified by a change in voltage level at said output of said second multivibrator.
4. A frequency responsive switching circuit, which comprises, in combination:

first and second retriggerable monostable multivibrators, each of said multivibrators having a trigger input and an output, said multivibrators being capable of producing pulse output signals in response to trigger input signals, the output of said first multivibrator being coupled to the input of said second multivibrator,

first timing circuit means, associated with said first multivibrator, for determining the time duration of pulses occurring at said output of said first multivibrator;

second timing circuit means, associated with said second multivibrator, for determining the time duration of pulses occurring at said output of said second multivibrator;

circuit means for resetting said first timing circuit means as a function of the frequency of the signal applied to said trigger input of said first multivibrator;

circuit means for resetting said second timing circuit means as a function of the frequency of the signal applied to said trigger input of said second multivibrator; and

circuit means, coupled to said output of said second multivibrator and to said first timing circuit means, for modifying the timing characteristic of said first timing circuit means in response to a change in the output of said second multivibrator.

5. A frequency responsive switching circuit according to claim 4 which further includes circuit means for retriggering said first multivibrator during each period of an alternating signal applied to said trigger input of said first multivibrator.

6. A frequency responsive switching circuit according to claim 5 which further includes circuit means for retriggering said second multivibrator in response to a change in voltage level at said output of said first multivibrator.

7. A frequency responsive switching circuit according to claim 5 wherein said circuit means for retriggering said first multivibrator includes a voltage divider, said first multivibrator having a reset input coupled to said voltage divider, and wherein said frequency responsive switching circuit further includes a capacitor coupled between said voltage divider and said trigger input of said first multivibrator.

8. A frequency responsive switching circuit according to claim 5 wherein said first multivibrator has a reset input and wherein said frequency responsive switching circuit further includes circuit means for establishing a quiescent voltage level at said reset input and a capacitor coupled to said reset input and to said trigger input of said first multivibrator to retrigger said first multivibrator at a frequency corresponding to the frequency of the signal applied to said trigger input of said first multivibrator.

9. A frequency responsive switching circuit according to claim 5 which further includes circuit means for rendering the output response of said first multivibrator independent of the duty cycle of the signal applied to said trigger input of said first multivibrator.

10. A frequency responsive switching circuit according to claim 5 wherein said first timing circuit means comprises an RC timing circuit including a carbon film resistor and a mylar capacitor, said resistor and capacitor having temperature characteristics rendering said first timing circuit means substantially independent of temperature in the range from about -40°F. to 185°F.

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