Sept. 17, 1968 A. B. BLACKBURN 3,402,327

ENGINE OVERSPEED PROTECTION DEVICE

Filed March 25, 1966

FIG-1

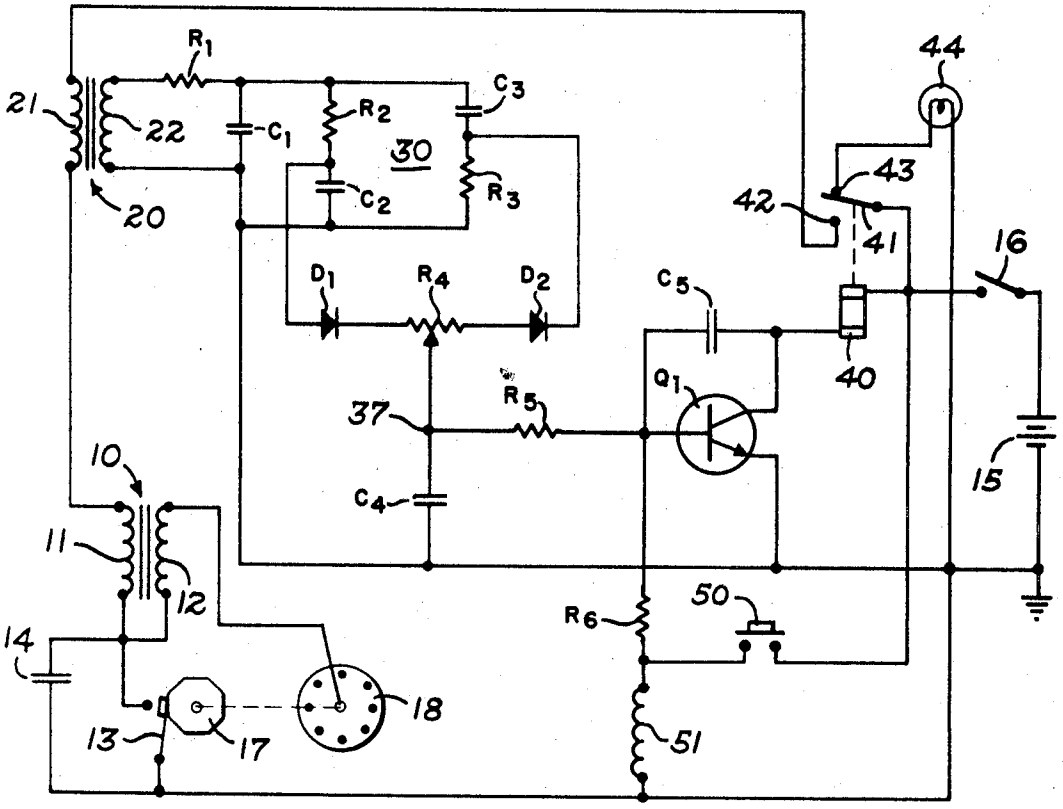
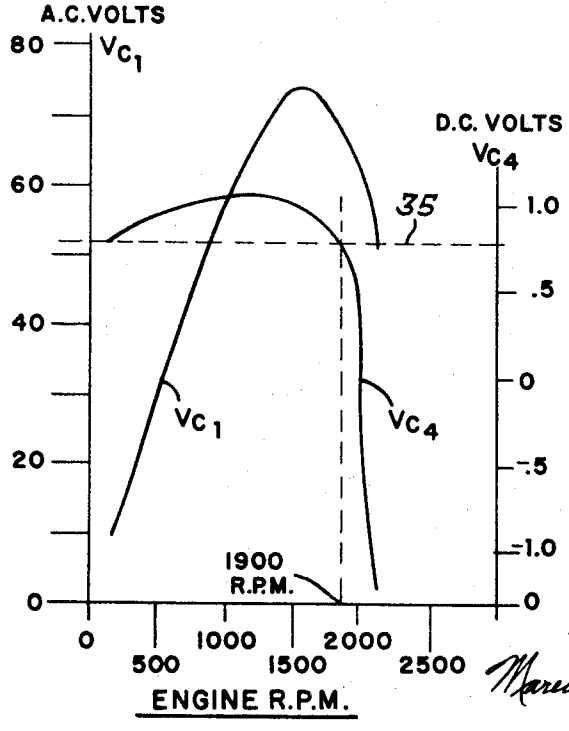



FIG-2




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# ENGINE OVERSPEED PROTECTION DEVICE

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## ABSTRACT OF THE DISCLOSURE

In an engine overspeed detection device for disabling an engine during overspeed conditions, a primary winding of a transformer is placed in series with the ignition circuit and a capacitor is placed across the secondary winding to form a resonant circuit which develops an alternating voltage, the amplitude of which is a function of the engine speed, with the highest voltage output substantially corresponding to the highest allowable engine speed. Frequency sensitive bridge means for developing an output voltage proportional to the difference between the input frequency and the center frequency of the bridge is connected to the output of the resonant circuit with the sensitivity of the bridge means being directly proportional to the voltage applied thereto from the resonant circuit so that the greatest sensitivity to frequency changes is obtained when the engine approaches its maximum allowable speed. Voltage sensitive means are connected to the frequency sensitive bridge means to open the engine ignition circuit when the voltage output of the bridge means reaches a predetermined value indicating the occurrence of an overspeed condition.

This invention relates to an engine overspeed protection device of the type which completely disables an engine when the speed of the engine exceeds a predetermined maximum value.

Engines of the type employed to rotate generators in ground power units that supply electrical power to aircraft, welding units, auxiliary lighting units, and for other like uses are carefully regulated as to their speed of rotation, such as by a mechanical governor or regulator, so that the frequency and voltage output of the generator remain within predetermined limits regardless of the variations in load applied to the engine through the generator. Should the governor or regulator fail, an engine speed above a certain value would create an excessive voltage output from the generator which may damage the electrical equipment connected to its output and may cause mechanical damage to the generator due to excessive centrifugal forces, and should the engine speed obtain a high enough value, damage to the engine itself would result.

The engine overspeed protection device described herein may be used in conjunction with the usual governor or speed regulator on an engine to act as a safety protection device in the event that the governor or regulator malfunctions or is improperly adjusted. While the device described herein is particularly adapted for use with spark ignition internal combustion engines, it is understood that the principles of operation may be applied for use with compression igniton internal combustion engines as well. When used with a spark ignition type engine, the engine overspeed protection device of this invention functions to interrupt the ignition circuit and thereby disable the engine whenever the engine speed exceeds a specified predetermined maximum value. When used with compression ignition type engines, the engine overspeed device may function to interrupt the flow of fuel into the engine in the event of an overspeed condition.

A time delay feature is included in the overspeed protection device of this invention to provide an inverse time delay response in accordance with the amount of engine



overspeed. Thus, if the engine speed momentarily exceeds the predetermined value by a relatively small amount, then the engine would be disabled after a relatively long period of time. On the other hand, if the amount of overspeed were substantial, then the overspeed device would disable the engine almost immediately. This inverse time delay feature prevents frequent nuisance type engine disengagements for only minor and temporary overspeed conditions, but affords complete protection and disables the engine completely if the engine overspeed condition, even though minor, exists for a long period of time, or if a major overspeed condition occurs for a relatively short period of time.

Once the overspeed device of this invention disables the engine, a complete shutdown of the engine will occur even though the speed of the engine is subsequently reduced below the predetermined maximum allowable speed. This feature is provided since an overspeed condition usually indicates a malfunction in the engine speed regulator which must be corrected before further operation of the system is permitted. The engine overspeed protection device described herein is not intended to be an engine governor when used with a spark ignition type engine, although such a use may be made of the device with a compression ignition type engine, since the engine would load up on gasoline during periods when the ignition was disconnected, and might backfire if the ignition circuit were reconnected.

The engine overspeed protection device of the present invention incorporates a novel means connected in the ignition circuit to sense the frequency of the ignition pulses in the primary circuit of the ignition coil and to disconnect the engine ignition in the event that the frequency of the pulses representing the speed of the engine exceeds a specified value. A holding circuit is provided to keep the ignition circuit energized once the engine has started and before an overspeed condition occurs. This holding circuit is broken if an overspeed condition occurs causing the engine to shut down completely and remain off until restarted by the operator.

The pulses applied in the primary winding of the ignition transformer also pass through a transformer designed to produce a substantially sinusoidal wave form output from an essentially square wave input. The output of this transformer is connected to a frequency sensitive circuit where a voltage is developed which has a predetermined relation to the frequency of the input. The center frequency of this circuit is nominally adjusted to correspond to the maximum allowable engine speed, although this adjustment is not critical. The voltage output from the frequency sensitive bridge means controls a relay having contacts in the engine ignition circuit and, as the engine speed exceeds the preset value, the relay will become deenergized to disconnect the engine ignition where it will remain disconnected until the engine is restarted by the operator.

The overspeed device is constructed with solid state components which may be packaged in a small, compact volume, and which may be installed on a spark ignition engine without modification to the engine itself. The device only requires electrical connections in the primary winding of the ignition coil, to the starter solenoid, and to the engine battery, but no additional components added to or mounted on the engine are necessary. With this type of construction and installation, a minimum of time is required to modify existing engines to include this equipment.

Accordingly, it is a primary object of this invention to provide an engine overspeed protection device which will completely disable an engine after a time delay if an overspeed condition occurs, the time delay being inversely proportional to the magnitude of the overspeed so that

temporary, short duration variations in speed above the maximum allowable speed will not interrupt the operation of the engine while a small overspeed lasting for several seconds or a large, short duration overspeed will cause the engine thereafter to be completely disabled.

Another object is to provide an engine overspeed protection device which is relatively inexpensive to construct and which may be easily adapted to completely disconnect the ignition circuit of an internal combustion engine at any desired predetermined speed and which may further be adjusted to be non-responsive to small overspeeds of short duration.

It is a further object of this invention to provide an engine overspeed protection device which may be easily installed on existing spark ignition internal combustion engines without modification of the engine itself and which utilizes the pulses in the ignition circuit to operate a frequency sensitive circuit including a relay having its contacts in the ignition circuit to open that circuit when the number of ignition pulses, and thus the speed of the engine, exceeds a predetermined value.

It is another object of this invention to provide an engine overspeed protection device which may be constructed with solid state elements and which is made more sensitive to changes in speed of the engine as the engine speed approaches the maximum allowable speed.

Other objects and advantages of the invention will be apparent from the following description, the accompanying drawings, and the appended claims.

In the drawings—

FIG. 1 is an electrical schematic diagram showing an electronic engine overspeed protection device constructed according to this invention installed in an engine ignition system; and

FIG. 2 is a pair of curves showing the voltage developed across the input circuit to the frequency sensitive bridge means and the voltage output from the frequency sensitive bridge means, both of the curves being referenced against the speed of the engine.

Referring to the drawings which show a preferred embodiment of the invention, a typical ignition system for an internal combustion engine is shown in FIG. 1 and includes an ignition coil **10** having a primary winding **11** and a secondary winding **12**, a set of breaker points **13** in series with the primary winding of the ignition coil, a capacitor **14** connected in parallel with the breaker points, and a source of power such as a battery **15** to supply the necessary current through an ignition switch **16** to the ignition coil winding **11**. A cam **17** is rotated by the engine and causes the breaker points **13** to open intermittently and interrupt the current through the ignition coil thereby to produce a high voltage pulse in the secondary winding. The secondary winding **12** of the ignition coil is connected to the center terminal of the distributor **18**, and from the distributor the high voltage pulses are sequentially applied to the individual spark plugs in the engine, not shown. The pulses in the ignition coil primary will have a substantially square wave form due to the action of the breaker points **13** and will have a pulse repetition rate directly related to the speed of rotation of the engine. In an eight cylinder, four-cycle engine for example, there will be four ignition pulses for each revolution of the crank shaft.

In series with the primary winding of the ignition coil is a transformer **20** designed to transform the generally square wave form ignition pulses in the ignition coil circuit into an essentially sinusoidal output wave form substantially comprising a single frequency. The transformer **20** has a primary winding **21** in series with the primary winding **11** of the ignition coil and a secondary winding **22** loosely coupled to the primary winding. The construction of transformer **20** is such that the maximum current passing through the primary winding is not sufficient to cause saturation of the core material upon which the primary is wound. The secondary winding **22** is loosely coupled to the primary winding **21** and may have in the order of thirty times the number of turns of the primary winding and a coefficient of coupling in the order of between 0.4 and 0.7. The transformer provides a voltage output of sufficient magnitude to allow the proper operation of the remainder of the circuit and yet has an approximately sinusoidal wave form at the same frequency as the ignition pulses so that accurate frequency measurements may be made.

Further to obtain a sinusoidal output wave form, a resonant circuit is formed by placing a capacitor **C1** in series with the secondary winding. The reactance of capacitor **C1** is selected to equal the reactance of the secondary winding **22** at approximately the frequency produced in the ignition circuit at the highest allowable engine speed thereby to form a resonant circuit with the secondary winding of the transformer. In order to insure a voltage appearing across capacitor **C1** is of sufficient magnitude to allow operation of the remainder of the circuit at engine speeds different from the maximum allowable, the Q of the resonant circuit is made fairly low, i.e., in the range between 1 and 5, by the additional of a resistance element **R1** in series with the capacitor **C1** and secondary winding **22**. The resistor **R1** represents the resistance of the secondary winding **22** of the transformer as well as the resistance of an additional resistor. With certain designs of transformer construction, however, it may not be necessary to include a separate resistor **R1** in order to reduce the Q of the circuit since the resistance of the transformer secondary winding itself may be sufficient.

In FIG. 2, the curve labeled $V_{C1}$ shows the relationship between the speed of the engine and the voltage appearing across capacitor **C1**. A voltage sufficient to permit the operation of the circuit is obtained in the preferred embodiment of this invention when the engine speed exceeds approximately 150 r.p.m. As the engine speed increases from that value, the voltage output from the resonant circuit formed by the secondary winding **22** and capacitor **C1** increases steadily and obtains maximum value when the engine speed reaches about 1600 r.p.m. In the embodiment of the invention described herein, the maximum allowable speed of the engine is determined to be 1900 r.p.m. At this speed, the output across capacitor **C1** is substantial, but, as shown in curve $V_{C1}$, the voltage decreases as the speed of the engine continues to increase.

The frequency of the ignition pulses and thus the speed of the engine is sensed by a frequency sensitive bridge means **30** connected across capacitor **C1**. This bridge means produces an output voltage which is primarily related to the frequency of the input voltage which appears across capacitor **C1**. The sensitivity of the bridge means **30** is dependent upon the magnitude of the voltage applied thereto, however, and decreasing the voltage on **C1** from a maximum value while at the same time increasing the frequceny will produce a rapid change in the voltage output from the bridge means **30** as the speed of the engine approaches the maximum allowable speed.

The frequency sensitive bridge means **30** contains a low pass circuit including resistor **R2** and capacitor **C2** and a high pass circuit including resistor **R3** and capacitor **C3**. The output of the frequency sensitive bridge is applied to charge capacitor **C4**, the voltage across which will be primarily dependent on the frequency of the input to the bridge.

Referring again to FIG. 2, the voltage across capacitor **C4** is represented by the curve labeled $V_{C}4$ with the horizontal line **35** indicating the minimum voltage output of the bridge means necessary to complete the engine ignition circuit. As shown in the curve $V_{C}4$, an engine speed in excess of approximately 150 r.p.m. is necessary to provide a sufficient voltage to maintain engine operation while an engine speed in excess of 1900 r.p.m. will cause the voltage occurring across capacitor **C4** to fall below the minimum required voltage. The slope of the curve $V_{C}4$ increases substantially near the maximum allowable engine speed,

and as the engine speed increases beyond that speed, the slope of the curve $V_{C}4$ also further increases until it becomes substantially vertical. Therefore, for engine speeds in excess of the maximum allowable value, an increasingly larger change will be observed in the output voltage measured across capacitor C4.

The voltage across capacitor C4 is developed by the action of the frequency sensitive bridge means **30** in response to the frequency of the signal appearing across capacitor C1. With a low frequency input appearing across capacitor C1, the low pass circuit consisting of resistor R2 and capacitor C2 will be effective in charging capacitor C4 to a positive voltage. At the same frequency, however, the high pass circuit comprising resistor R3 and capacitor C3 will be relatively ineffective in tending to charge the capacitor to a negative voltage. As the input frequency to the bridge means increases, however, the effective charging path through the low pass circuit will decrease while the discharging path through the high pass circuit will increase. It is therefore apparent that a frequency will be obtained where the charging rate through the low pass circuit is equal to the discharging rate through the high pass circuit, and under such conditions, the voltage across capacitor C4 will become zero. As the frequency increases further, capacitor C4 will thereafter become negatively charged.

At low engine speeds, and hence low ignition pulse repetition rates, the current path from the junction of resistor R2 and capacitor C2 through diode D1 to ground, when the voltage across capacitor C1 is positive, will develop a positive voltage at terminal **37**, the magnitude of which will be determined in part by the position of the adjustable tap on potentiometer R4. When the voltage across capacitor C1 becomes negative, current will tend to flow from capacitor C4 through the remaining portion of potentiometer R4 and diode D2 to the junction between capacitor C3 and resistor R3 and thereby tend to reduce the effective charge on capacitor C4. Since the reactance of capacitor C3 will decrease as the frequency of the input to the bridge means **30** increases, the current flow through capacitor C3 will increase and cause the positive charge on capacitor C4 to be reduced, and as the frequency further increases, capacitor C4 will eventually assume a negative charge. The position of the adjustable tap on potentiometer R4 will also determine the frequency at which the voltage across capacitor C4 becomes zero. This frequency is commonly called the cross over frequency. By adjusting the position of the adjustable tap on potentiometer R4 to the left as shown in FIG. 1, the average positive voltage on capacitor C4 will tend to increase, assuming a constant frequency input, since less resistance is included in the charging path from the low pass circuit of resistor R2 and capacitor C2 and more resistance is included in the discharging path to the junction of resistor R3 and capacitor C3.

The position of the adjustable tap on potentiometer R4 will therefore determine the frequency above which the transistor Q1 will cease conduction. While it is important to choose the values for R2, R3, C2 and C3 so that the center frequency of the frequency sensitive bridge means is at the predetermined value corresponding to the highest allowable engine speed, it nevertheless appears that the specific frequency chosen as the highest allowable frequency may be determined by the setting of the adjustable tap on potentiometer R4.

The voltage across capacitor C4 is sensed by transistor Q1 which forms a voltage sensitive circuit for controlling the circuit supplying the voltage to the ignition coil in response to the frequency of the ignition pulses or to the engine speed. Transistor Q1 includes a relay coil **40** in the collector circuit with the contacts **41** and **42** of the relay connected in the ignition circuit. While other connections of the transistor, relay and relay contacts may also be used, the embodiment shown is preferred since it provides a fail-safe condition in that failure of either the relay, transistor, or power supply to the circuit will cause deenergization of the relay and disable the engine ignition circuit. An indicator circuit including relay contact **43** and lamp **44** may also be provided to indicate when the relay **40** is deenergized.

Transistor Q1 has the base electrode connected to the capacitor C4 through a resistor R4. As long as the capacitor C4 retains a positive charge and thereby provides a positive voltage to the base of the transistor, the transistor will remain in a conducting state and current will flow through the relay coil. When the engine speed increases to the predetermined value selected by the setting of R4, the voltage on capacitor C4 will fall below the voltage required to maintain Q1 in conduction and the relay **40** will deenergize to disable the engine. It is noted here that as the engine speed subsequently falls below the predetermined overspeed value, the ignition voltage will not be reapplied since all voltage has been removed from the ignition circuit and no further current is available from the bridge to charge capacitor C4.

The bias required on the base electrode of transistor Q1 to maintain conduction is determined by the characteristics of the transistor and the voltages applied to the collector and emitter electrodes. In the embodiment shown, the bias required to maintain transistor Q1 in conduction is shown in FIG. 2 by line **35** and is in the order of 0.8 volt. The bias voltage is supplied during normal operating of the engine from capacitor C4 through resistor R5. During starting of the engine, however, an auxiliary source of bias is required since the pulses developed in the ignition circuit while the engine is cranking is in the order of 50 r.p.m., and this value is below that necessary to provide an adequate voltage output from the transformer **20**.

When the starter switch **50** is closed, current is supplied to the starter solenoid **51** to cause cranking of the engine. At the same time, a bias voltage is applied through the starter switch **50** and through resistor R6 to the base of transistor Q1 to cause conduction and energize relay **40** to complete the ignition circuit. As stated before, the engine cranking speed is not sufficiently fast enough to produce a voltage output across capacitor C1 large enough to maintain transistor Q1 in conduction, but immediately upon the starting of the engine, the engine idle speed will be sufficient to provide the necessary voltage. It should be noted that capacitor C4 will obtain a charge through resistors R5 and R6 from the starter switch, and the discharge path of capacitor C4 has a high enough resistance to allow the capacitor to maintain the proper biasing voltage in the interval between the release of the starter switch and the attainment of sufficient engine speed to maintain the capacitor C4 charged through the action of the frequency sensitive bridge.

A time delay means is also provided in this invention to prevent the immediate deenergization of the ignition circuit in the event of an engine overspeed condition of small magnitude and of short duration. It is necessary, however, to insure that the engine overspeed condition does not last for a substantial length of time or that the magnitude of the overspeed condition is not sufficiently large to cause permanent damage to the equipment associated with the engine. For this reason, an inverse time delay circuit is provided which disables the ignition circuit almost immediately an overspeed condtion of approximately ten percent over the predetermined allowable speed, but which will disable the ignition circuit after a delay of several seconds in the event that the engine overspeed condition amounts to only one percent of the maximum speed.

The inverse time delay means includes capacitor C4 connected directly between the base and collector electrode of transistor Q1 and resistor R5 which connects the base electrode to capacitor C4. Capacitor C5 functions to reflect a change in collector voltage to the base electrode, thus forming an integrating circuit having a time delay

characteristic which may be placed at any value required to accomplish the desired results by selecting appropriate values for R5 and C5. Once the rate of change of collector voltage is established, a small change in voltage will require a fairly long time delay to cause the relay **40** to deenergize while a large magnitude voltage change across capacitor C4 will cause the transistor to cease conduction quickly and deenergize the relay **40** to interrupt the ignition circuit.

In an overspeed detection device for use with an eight cylinder engine with the maximum allowable speed set at 1900 r.p.m., the typical values for the components are as follows:

| | | |
|---|---|---|
| R1 | ohms | 180 |
| R2 | do | 12K |
| R3 | do | 12K |
| R4 | do | 5K |
| R5 | do | 1K |
| R6 | do | 33K |
| C1 | mfd | 1.5 |
| C2, 3 | do | 0.1 |
| C4 | do | 33 |
| C5 | do | 6.8 |
| Q1 | | 2N3904 |
| D1, 2 | | 1N4003 |

While the device herein described is particularly useful in protecting spark ignition internal combustion engines wheren the pulses existing in the ignition system are used to develop a single frequency sinusoidal wave form, the frequency of which is measured in the manner described, it is understood that the invention could also be applied to compression ignition internal combustion engines as well. Although a compression ignition engine does not have an electrical ignition system, an alternating current input could be supplied to a frequency determining bridge from an alternator connected to the crank shaft of the engine. The magnitude of the voltage output from such an alternator will increase as the speed of the engine increases thereby to provide a maximum allowable frequency corresponding to the maximum engine speed permitted. Rather than disconnecting the ignition circuit, however, the output from the bridge means may be used to disable the engine by removing the fuel supply.

In the event that the particular engine being utilized to drive a ground power type generator includes an alternator as part of the battery charging system, the output of this alternator could be used to provide the sinusoidal single frequency wave form used in the frequency measurement with the circuit described herein. It is also contemplated that other forms of alternating current generating means could be employed, such as a magnetic pickup means situated near a rotating shaft having a cam means thereon to alter the magnetic field thereby to produce pulses proportional to the speed of the engine, or other similar means.

While the form of apparatus herein described constitutes a preferred embodiment of the invention, it is to be understood that the invention is not limited to this precise form of apparatus, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

**1.** An electronic engine overspeed protection device for disabling an engine in response to an overspeed condition, said device comprising:

means operably associated with said engine for developing an alternating voltage output having a frequency proportional to the speed of said engine, the voltage output of said means being a function of the speed of said engine with the highest voltage output substantially corresponding to the highest allowable engine speed;

frequency sensitive bridge means connected to the output of said alternating voltage means and having a center frequency approximately equal to the frequency output of the alternating voltage means corresponding to the highest allowable engine speed, the sensitivity of said bridge means being directly dependent on the voltage applied thereto from said alternating voltage means thereby to provide increased sensitivity to frequency changes as the engine speed attains the highest allowable speed;

voltage sensitive means connected to said frequency sensitive bridge means to provide an output when the voltage output from said bridge means reaches a predetermined value;

and control circuit means actuated by said voltage sensitive means to disable said engine upon the occurrence of an overspeed condition.

**2.** An electronic engine overspeed protection device as defined in claim **1** wherein said means connected to said engine for developing an alternating voltage includes:

a transformer having the primary winding in the ignition circuit of said engine and a secondary winding loosely coupled to said primary winding;

a capacitor in the secondary winding to form a resonant circuit therewith having a resonant frequency in the range of the frequency of ignition pulses corresponding to the highest allowable engine speed;

said resonant circuit further including sufficient resistance to allow a substantial voltage to be developed across said capacitor at frequencies substantially different from said resonant frequency;

said transformer and resonant circuit thereby providing a frequency output which is proportional to said engine speed and having an output voltage as a function of engine speed with the highest voltage output substantially corresponding to the highest allowable engine speed.

**3.** An electronic engine overspeed protection device as defined in claim **1** wherein said voltage sensitive means includes:

a transistor biased into conduction by the output of said frequency sensitive means as long as the speed of said engine is below the highest allowable speed and wherein said transistor will cease conduction when said engine speed exceeds the highest allowable speed;

and wherein said control circuit means includes a relay in the output circuit of said transistor having contacts in the ignition circuit of said engine whereby nonconduction of said transistor will deenergize said relay and open the ignition circuit thereby to disable said engine;

said overspeed protection device further including means to initially bias said transistor into conduction during the starting of said engine while the engine speed remains below the value necessary to cause a sufficient biasing voltage to be applied to said transistor through said frequency sensitive bridge means.

**4.** An electronic overspeed engine protection device as defined in claim **1** wherein said voltage sensitive means includes a time delay means for preventing the immediate disabling of the engine upon the occurrence of an overspeed condition exceeding said highest allowable speed, the magnitude of the time delay being inversely proportional to the difference between the actual engine speed and the highest allowable speed whereby said voltage sensitive means will actuate said control circuit means to disable the engine after an overspeed condition exists for a period of time longer than said time delay.

**5.** An electronic engine overspeed protection device for disabling an engine in response to an overspeed condition of said engine, said device comprising:

means connected to said engine for developing an alternating voltage having a frequency proportional to the speed of said engine;

output means connected to said alternating voltages means for providing an output when the frequency of said alternating voltage exceeds of predetermined value;

time delay means included in said output means for preventing an immediate output from said output means upon the occurrence of frequencies exceeding said predetermined value, the magnitude of the time delay being inversely proportional to the difference between the frequency of the alternating voltage and said predetermined value; and

control circuit means to disable said engine actuated by said output means upon the occurrence of an overspeed condition of a period of time longer than said time delay.

**6.** An electronic engine overspeed protection device as defined in claim **5** wherein said means connected to said engine for developing an alternating voltage includes:

a transformer having the primary winding thereof connected in the ignition circuit of said engine and having the secondary winding thereof coupled loosely to said primary winding whereby the output of said secondary winding comprises a substantially sinusoidal wave form at the same frequency as the ignition pulses.

**7.** An electronic engine overspeed protection device as defined in claim **5** wherein said means connected to said engine for developing an alternating voltage includes:

transformer means having a primary winding connected to the ignition circuit of said engine and having a secondary winding coupled loosely to said primary winding whereby the output from said secondary winding comprises a substantially sinusoidal wave form having a frequency which is directly related to the frequency of the ignition pulses of said engine;

a capacitor connected in series with the secondary winding of said transformer to form a resonant circuit therewith having a resonant frequency in the range of the frequency of ignition pulses corresponding to the maximum allowable engine speed;

and said resonant circuit further including sufficient resistance to permit a substantial voltage to be developed across said capacitor at frequencies substantially different from said resonant frequency.

**8.** An electronic engine overspeed protection device as defined in claim **5** wherein said output means connected to said alternating voltage means includes a frequency sensitive bridge having a center frequency approximately equal to that frequency of ignition pulses which correspond to the highest allowable engine speed and which has a sensitivity to changes in frequency dependent upon the voltage applied thereto whereby an increase in sensitivity to frequency changes is obtained near the frequency corresponding to the highest allowable engine speed.

**9.** An electronic engine overspeed protection device as defined in claim **8** wherein said frequency sensitive bridge



comprises a low frequency charging path and a high frequency discharging path;

resistance means connecting said paths having a voltage developed thereacross which is a function of the frequency of the input to said bridge means;

a first capacitor connected to an adjustable tap on said resistance means, said capacitor retaining a positive charge as long as the frequency input to said bridge means remains below said predetermined value, said predetermined value being adjustable in accordance with the position of the tap on said resistance means;

a transistor having the base electrode connected to said first capacitor and being normally biased into conduction by said first capacitor when the frequency input to said bridge means remains below said predetermined value;

wherein said time delay means includes a second capacitor connected between the collector electrode and the base electrode of said transistor and a resistor connected in series between the base electrode and said first capacitor, said time delay means forming an integrating circuit having an inverse time delay characteristic whereby changes in base electrode voltage which causes changes in the voltage at the collector electrode are integrated thereby to reduce the action of the transistor in accordance with the magnitude of the voltage change applied to the base electrode;

and wherein said control circuit means including a relay with the winding thereof in the collector circuit of said transistor and with the contacts thereof in the ignition circuit of said engine whereby deenergization of said relay due to an overspeed condition will open its contacts and remove current from the engine ignition system;

said overspeed protection device further including means to initially bias said transistor into conduction during the starting of said engine thereby to provide ignition current during starting while the engine speed is below that necessary to cause sufficient output from said alternating voltage means.

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