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Maruoka

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[45] **Dec. 18, 1973**

[54] **VEHICULAR AIR-POLLUTION PREVENTIVE APPARATUS**

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[51] **Int. Cl.** **F02n 17/00**
[58] **Field of Search** ..... 192/.092; 123/179 B, 123/179 BG

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[57] **ABSTRACT**

To prevent emission of toxic compounds from an automotive engine during idling as in the case where the motor vehicle is stopped at a crossing or on a jammed highway, an apparatus is provided which includes first switch means responsive to a temperature of the engine and second switch means responsive to an uncoupled condition of a power transmission system. These two switch means are connected to an ignition coil and de-energize the coil when the engine temperature is higher than a predetermined level and concurrently the transmission system is in an uncoupled condition.

16 Claims, 6 Drawing Figures

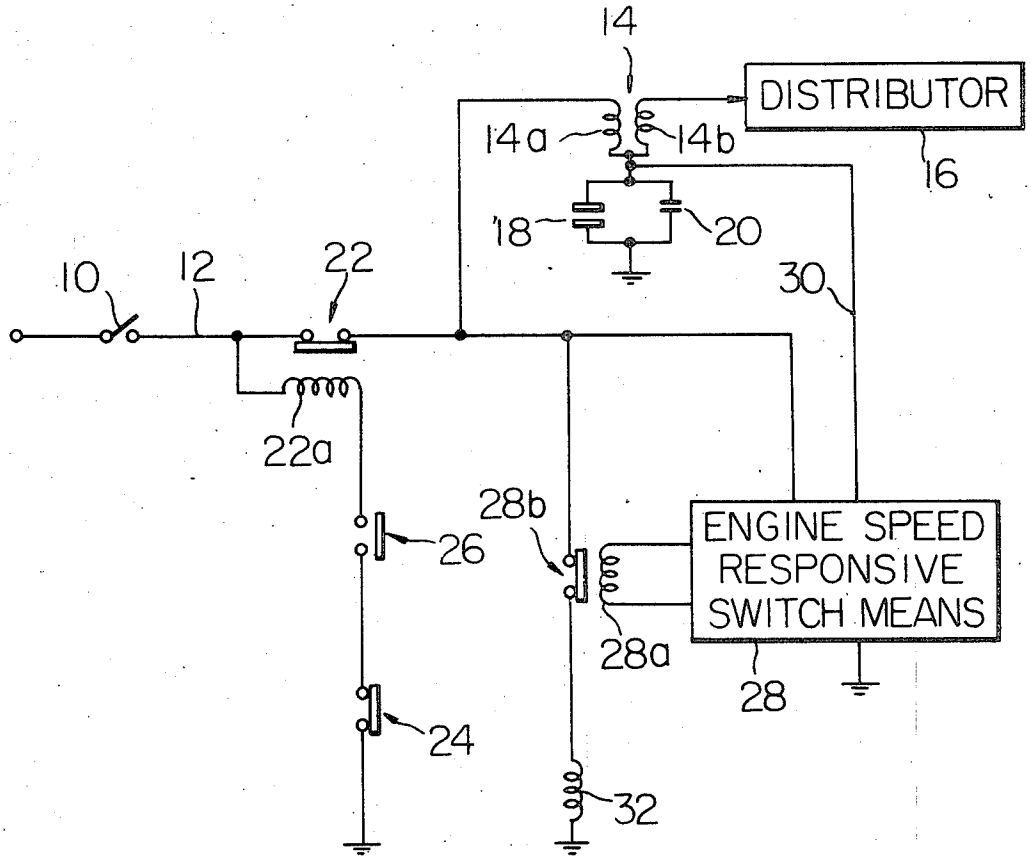


Fig. 1

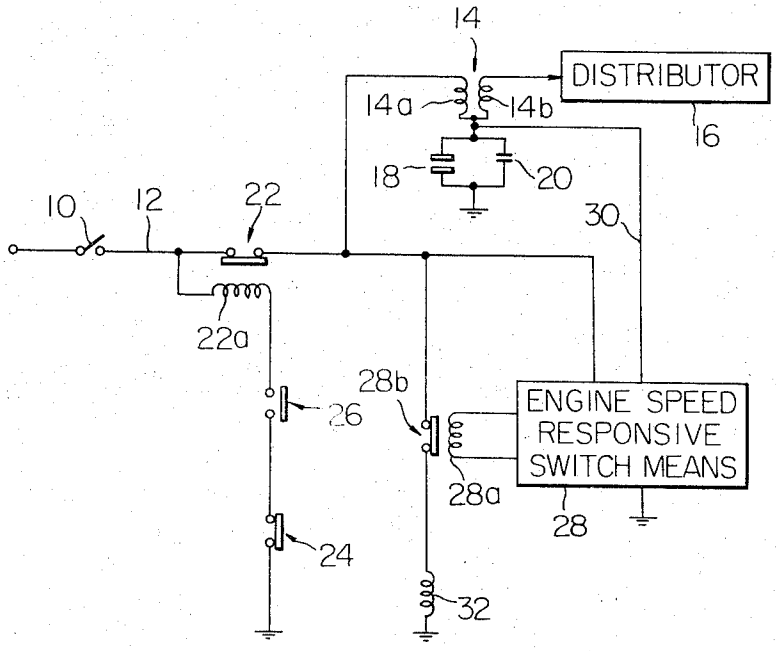

14
DISTRIBUTOR
14a
14b
16
18
20
10
12
22
30
22a
28b
26
ENGINE SPEED
RESPONSIVE
SWITCH MEANS
28a
28
24
32

Fig. 2

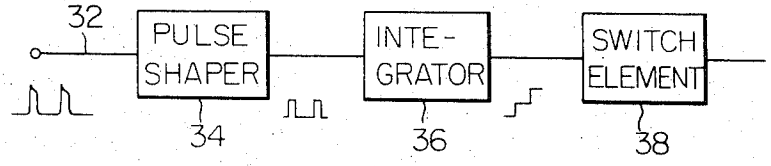

32
PULSE
SHAPER
INTE-
GRATOR
SWITCH
ELEMENT
34
36
38

Fig. 3

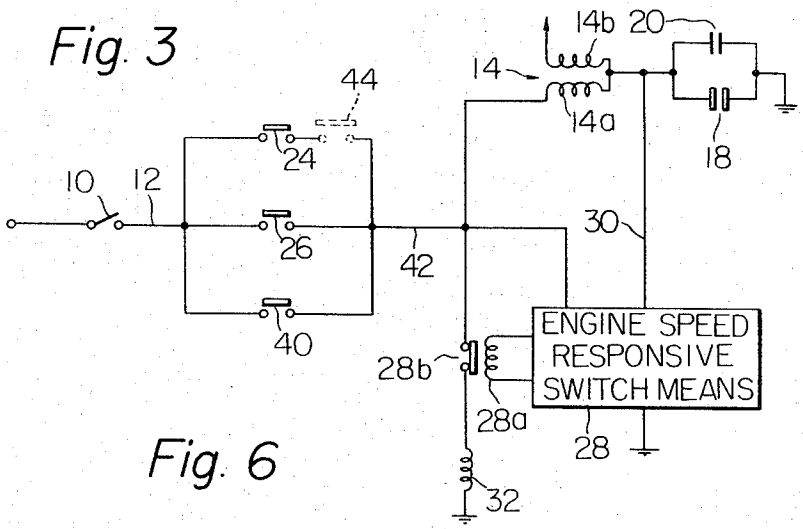


Fig. 6

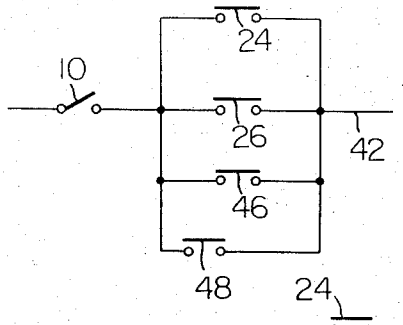
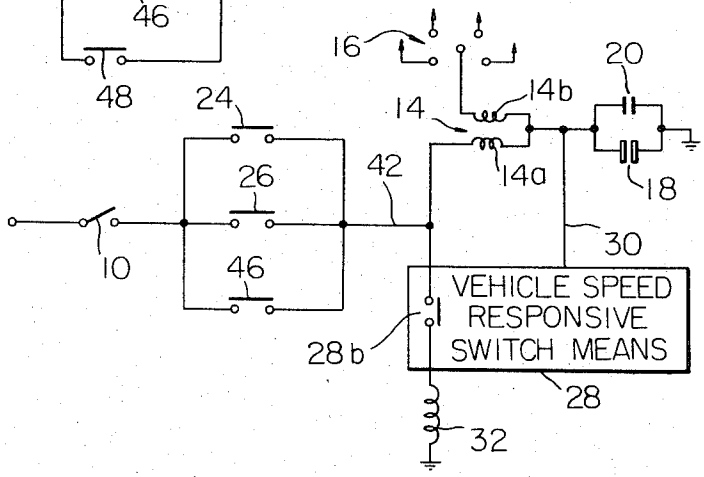


Fig. 4



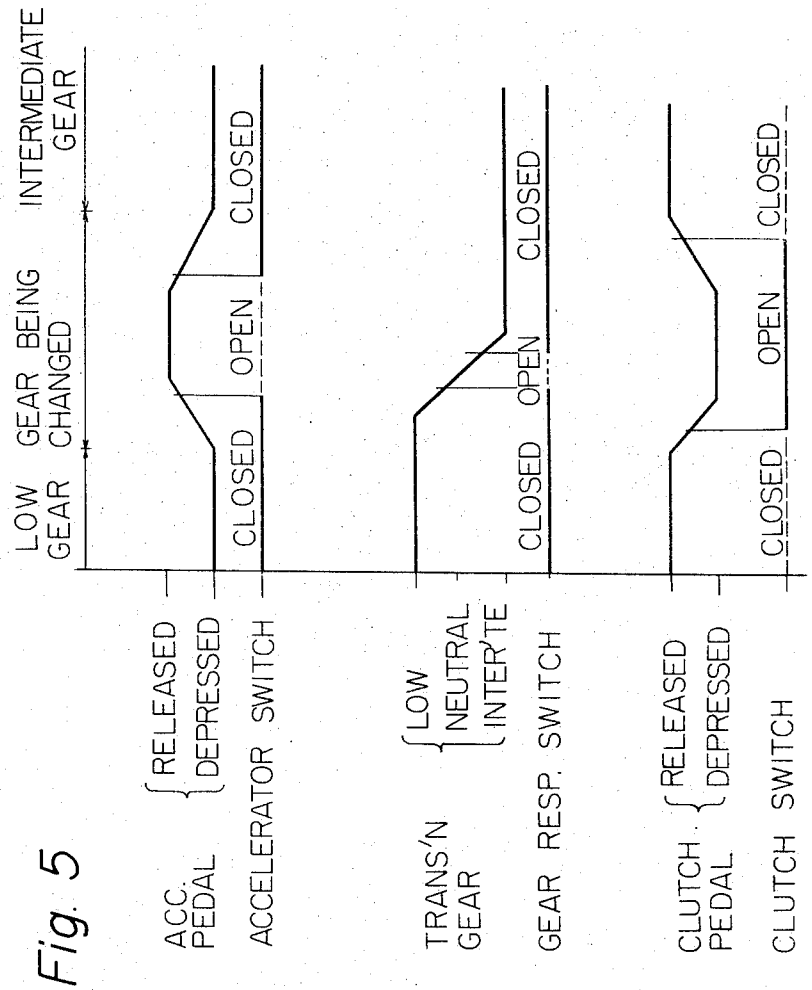

LOW GEAR BEING CHANGED
INTERMEDIATE GEAR
ACC. PEDAL
RELEASED
DEPRESSED
ACCELERATOR SWITCH
CLOSED
OPEN
CLOSED
TRANS'N GEAR
LOW
NEUTRAL
INTER'TE
GEAR RESP. SWITCH
CLOSED
OPEN
CLOSED
CLUTCH PEDAL
RELEASED
DEPRESSED
CLUTCH SWITCH
CLOSED
OPEN
CLOSED

Fig. 5

VEHICULAR AIR-POLLUTION PREVENTIVE APPARATUS

The present invention relates to apparatus for preventing air pollution resulting from emission of toxic compounds from automotive engines.

It is well known that increased quantities of toxic compounds are emitted from motor vehicles especially at crossings and jammed highways at which the motor vehicles very frequently decelerate or are brought to a standstill. When, thus, the motor vehicles are at rest with the engines idling at the crossings or jammed highways, the toxic compounds are contained in increased concentrations in the engine exhaust gases. To solve the vehicular air pollution problems in urban and highway traffic lines, it is highly preferable that the engines be shut down when the motor vehicles are brought to a full stop. The present invention contemplates provision of an apparatus which is adapted to stop the engine when the motor vehicle is brought to a halt and to start up the engine immediately before the motor vehicle is driven from rest.

In accordance with the present invention, this end is achieved by an apparatus which is associated with an ignition system for the engine and a power transmission system of any know character. Such apparatus basically comprises first switch means responsive to an engine temperature and second switch means responsive to an uncoupled condition of the power transmission system, when the first and second switch means are connected to a primary winding of an ignition coil of the ignition system so that the ignition coil is energized when the engine temperature is higher than a predetermined level and concurrently the power transmission system is in a coupled condition, viz., in operating conditions excepting the uncoupled or neutral condition. Preferably, the apparatus may further comprise third switch means connected to the ignition coil and to a cranking motor for the engine and responsive to an engine revolution speed. This third switch means is operable to actuate the engine cranking motor so as to start up the engine when the engine revolution speed is lower than a predetermined relatively low level. The third switch means is thus adapted to keep the engine cranking motor inoperative when the engine is driven at a relatively high speed.

To prevent the engine from being instantaneously shut down during a condition in which the transmission gears are shifted from one coupled position to another, switch means may be further provided which is connected between the ignition switch and coil and which is operable to provide connection therebetween when the engine is being driven with the first and second switch means are open concurrently.

In one preferred form of apparatus according to the present invention, the first and second switch means may be serially connected to normally-closed slow-release switch means which is connected between an ignition switch and an ignition coil. In this instance, the first or engine temperature responsive switch means is so arranged as to be kept open when the engine is driven cold and to be closed in response to an engine temperature which is higher than a predetermined level, while the second or transmission gear responsive switch means is arranged to be kept open when the power transmission system is in a coupled condition and closed in response to an uncoupled or neutral condition of the transmission system. The slow-release switch means is biased to close in a suitable manner and is opened when either of the engine temperature and transmission gear responsive switch means is open, viz., when the engine temperature is higher than the predetermined level and/or the power transmission is in the uncoupled condition, whereupon the ignition coil is deenergized and accordingly the engine is shut down.

In another preferred form of apparatus according to the present invention, the first and second switch means may be connected in parallel with a vehicle speed responsive switch means between the ignition switch and ignition coil. In this instance, the first or engine temperature responsive switch means is arranged as to be closed in response to an engine speed lower than a predetermined level while the second or transmission gear responsive switch means is arranged to be open when the power transmission system is in a coupled condition and closed in response to an uncoupled or neutral condition of the transmission system. The vehicle speed responsive switch means, on the other hand, is so arranged as to be closed in response to a vehicle speed which is lower than a predetermined relatively low level. With the apparatus thus constructed and arranged, the ignition coil is energized when at least one of the engine temperature, transmission gear and vehicle speed responsive switch means is closed. Where preferred, second transmission gear responsive switch means may be serially connected to the engine temperature responsive switch means for the reasons to be discussed later.

In still another preferred form of apparatus according to the present invention, the first and second switch means may be connected in parallel with an accelerator position responsive switch means between the ignition switch and coil so that the ignition coil is energized when at least one of these three switch means is closed. In this instance, the first or engine temperature responsive switch means is arranged to be kept closed when the temperature of the engine is lower than a predetermined level and opened in response to a temperature higher than the predetermined level, while the second or transmission gear responsive switch means is arranged to be closed when the power transmission system is in a coupled condition and opened in response to an uncoupled or neutral condition of the transmission system. The accelerator position responsive switch means, on the other hand, is associated or interlocked with an accelerator pedal so as to be opened when the accelerator pedal is released. Where preferred, clutch responsive switch means may be connected in parallel with the engine temperature, transmission gear and accelerator position responsive switch means and operatively associated or interlocked with the clutch or clutch pedal. The clutch responsive switch means is kept closed when a clutch of the power transmission system is in an uncoupled condition and is opened when a clutch pedal is released and the clutch is coupled.

The features and advantages of the vehicular air-pollution preventive apparatus having any of the above described general constructions will become more apparent from the following detailed description of the present invention taken in conjunction with the accompanying drawings in which like reference numerals designate corresponding parts and elements and in which:

FIG. 1 is a schematic circuit diagram showing a preferred form of vehicular air-pollution preventive apparatus according to the present invention;

FIG. 2 is a block diagram showing an example of the switching circuit which may form part of the engine speed responsive switch means of the apparatus illustrated in FIG. 1;

FIG. 3 is a schematic circuit diagram showing another preferred form of vehicular air-pollution preventive apparatus according to the present invention;

FIG. 4 is a schematic circuit diagram showing still another preferred form of apparatus according to the present invention;

FIG. 5 is a diagram showing modes of operation of some elements of the apparatus shown in FIG. 4; and

FIG. 6 is a schematic circuit diagram illustrating a modification of the apparatus shown in FIG. 4.

Reference will now be made to the accompanying drawings, first to FIG. 1 which illustrates a first preferred embodiment of the vehicular air-pollution preventive apparatus according to the present invention. As seen in FIG. 1, the air-pollution preventive apparatus herein disclosed is provided in association with a power transmission system (not shown) and an ignition system for the engine (not shown). The ignition system includes, as customary, an ignition switch **10** which is connected to a power source (not shown) of usually **12** volts. The ignition switch **10** is connected through a line **12** to an ignition coil **14** having primary and secondary windings **14***a* and **14***b*, respectively. The secondary winding **14***b* of the ignition coil **14** is connected to an ignition distributor **16** which is connected to spark plugs (not shown). The ignition coil **14** is connected to point contacts **18** and a storage condenser **20** which are, in turn, connected in parallel to ground.

In accordance with the present invention, a normally-closed slow-release relay switch **22** is connected between the ignition switch **12** and the primary winding **14***a* of the ignition coil **14.** The relay switch **22** has a coil **22***a* which is connected at one terminal to the power source through the ignition switch **10** and serially connected at the other terminal to an engine temperature responsive switch **24** and a transmission gear responsive switch **26.** The engine temperature responsive switch **24** is responsive to the temperature of cooling water for the engine while the transmission gear responsive switch **26** is responsive to the operating conditions of the power transmission system. Thus, the engine temperature responsive switch **24** is open when the engine temperature is lower than a predetermined level and closes when the engine temperature reaches or rises beyond the predetermined level. This predetermined level of the engine temperature usually ranges from 60° C to 70° C at which the engine is warmed up satisfactorily. The transmission gear responsive switch **26,** on the other hand, is closed when the power transmission is in an uncoupled or neutral position and opens when the transmission system is coupled to provide a selected gear ratio. The normally-closed relay switch **22** is thus maintained in a closed condition when at least either of the serially connected switches **24** and **26** is open or, in other words, when the engine temperature sensed by the switch **24** is lower than the predetermined level and/or the power transmission system as detected by the switch **26** is in the uncoupled or neutral position.

The embodiment herein shown further includes an engine speed responsive relay switch which is generally designated by reference numeral **28.** This relay switch **28** is connected to the ignition coil **14** through a line **30** so as to detect the engine revolution speed from the output pulses from the coil **14** and has a coil **28***a* and relay contacts **28***b*. These relay contacts **28***b* are serially connected on one side to the slow-release relay switch **22** and ignition switch **10** and on the other side to a relay coil **32** for an engine cranking motor (not shown) which is, as is well known, adapted to start up the engine when actuated from the power source. The relay contacts **28***b* are biased to close in a normal condition and are caused to open when the engine revolution speed detected by the relay switch **28** is higher than a predetermined level. This predetermined level of the engine speed may usually be about 500 r.p.m. The relay switch **28** has a switching circuit which may be constructed and arranged in a suitable manner insofar as it is capable of energizing the coil **28***a* in response to an engine speed which is higher than the predetermined level of, say, 500 r.p.m., as above noted. FIG. **2** illustrates an example of such switching circuit which comprises a pulse shaping unit **34** which is connected to the ignition coil **14** through the line **30** (FIG. **1**) for producing a train of shaped pulses from the signal pulses delivered from the ignition coil **14.** The pulse train thus delivered from the pulse shaping unit **34** is fed to an integrator unit **36** at which the input pulses are accumulated. The output signal from the integrator unit **36** is fed to a switching unit **38,** from which an output signal is delivered when the voltage impressed thereon reaches a predetermined value within a predetermined time interval, viz., when the engine revolution speed reaches the predetermined level. The switching unit **38** is connected to the relay coil **28***a* (FIG. **1**) so that the coil **28***a* is energized in the presence of a signal voltage on the output of the switching unit **36.**

Turning back to FIG. **1,** the operation of the vehicular air-pollution preventive apparatus of the described construction and arrangement will now be explained.

When, in operation, the ignition switch **10** is closed by the driver of the motor vehicle, then the current flows through the normally-closed relay switch **22** because, in this condition, the engine temperature is in a cool condition and accordingly the engine temperature responsive switch **24** is kept open. The primary winding **14***a* of the ignition coil **14** is accordingly energized. At this instant, the engine (not shown) remains at rest so that the engine speed responsive switch **28** has its closed position maintained in the absence of a signal on the output of the switch unit **38** (FIG. **2**) of the switching circuit. The relay coil **32** for the engine cranking motor (not shown) is consequently energized from the power source through the relay switch **22** in the closed condition, whereby the engine is started up by the cranking motor. Under this condition, the engine is driven at a speed ranging from about 100 to 300 r.p.m. so that the engine speed responsive relay switch **28** is maintained to have its coil **28***a* unexcited and accordingly its relay contacts **28***b* closed. The engine is thus cranked and driven at an increasing revolution speed with the ignition plugs (not shown) actuated through the ignition coil **14,** point contacts **18** and storage condenser **20** of the ignition system, as customary. When the revolution speed of the engine reaches the predetermined level of, say about 500 r.p.m. as previously

noted, then an output signal is delivered from the switching unit **36** of the circuit shown in FIG. **2** so that the coil **28***a* of the relay switch **28** is excited and accordingly the relay contacts **28***b* are opened. This causes the relay coil **32** for the engine cranking motor to be disconnected from the relay switch **22** in the closed condition, whereupon the engine cranking motor is shut down and accordingly the engine is driven under an unloaded condition. It will be understood that the engine speed responsive relay switch **28** is intended to maintain the engine cranking motor in an inoperative condition once the engine has been driven at a speed higher than the predetermined level.

Since, in this condition, the engine temperature still remains lower than the predetermined level, the engine temperature responsive switch **24** is kept open so that the coil **22***a* of the slow-release relay switch **22** remains unexcited irrespective of the position of the transmission gear responsive switch **26.** The engine is thus driven under the unloaded condition until it is warmed up to the predetermined temperature. During this unloaded driving condition of the engine, it is preferable that the throttle valve of the carburetor be held appropriately wide open and that the ignition timings be suitably retarded, because an increased quantity of toxic compound would be emitted from the engine and the fuel consumption economy would be impaired if the engine is to be driven cold under a loaded condition as is the case with the conventional engines.

When, now, the predetermined temperature is reached by the engine, the engine temperature responsive switch **24** closes and, as a consequence, the condition of the normally-closed slow-release relay switch **22** is dictated by the transmission gear responsive switch **26** connected in series with the engine temperature responsive switch **24** which is now in a closed condition. Since, in this instance, this transmission gear responsive switch **26** is open except when the power transmission system is in an uncoupled or neutral position, the normally-closed relay switch **22** remains closed as long as this particular condition is maintained, whereby the engine is operable under usual conditions unless the power transmission system is brought to the uncoupled condition.

When the motor vehicle is brought to a full stop and the power transmission system brought into the uncoupled condition, then the transmission gear responsive switch **26** closes. Both the engine temperature switch **24** and transmission gear responsive switch **26** are now concurrently closed so that the relay coil **22***a* of the normally-closed slow-release relay switch **22** is energized from the power source through the ignition switch **10.** The slow-release relay switch **22** is consequently opened at a timing which is retarded for a predetermined time interval. This retarded timing of the relay switch **22** being opened is intended to prevent an instantaneous interruption of the operation of the engine as would otherwise be caused transiently when the power transmission gears are shifted from one to another through the neutral. For this purpose, the time interval of the delay in releasing the relay switch may be set to be about 1 second, as empirically ascertained by the inventor.

The sparks on the spark plugs (not shown) of the ignition system cease in this manner and engine is completely shut down as soon as or more exactly in a certain interval of, say **1** second or so, after the power transmission system is brought into the uncoupled condition. The motor vehicle being thus stopped with the engine shut down, emission of exhaust gases containing toxic compounds from the engine can be practically completely avoided especially when the motor vehicle is on a jammed highway or at a crossing as previously discussed.

When the gears in the power transmission system are then shifted from the neutral to a coupled position which is usually a low-gear position, the transmission gear responsive switch **26** opens so that the relay coil **22***a* becomes de-energized and accordingly the normally-closed relay switch **22** restores its closed position. Since, in this condition, the engine is sufficiently warmed up, the engine is immediately started up when the ignition coil **14** is energized from the power source for a second time.

Experiments were conducted by the inventor for the purpose of examining the starting performance of the motor vehicle using the arrangement above described. According to the experiments, it has turned out that the motor vehicle is started from rest in about 0.5 second after the transmission gears are shifted from the neutral with the engine kept warmed sufficiently. It is apparent that the retardation of this degree is practically fully acceptable because usually a time interval of about one second is required for working on the clutch after the gears have been shifted and before the motor vehicle is started up.

Another preferred embodiment of the vehicular air-pollution preventive apparatus according to the present invention is now illustrated in FIG. **3.** The circuit arrangement herein shown is adapted to dispense with the relay switch of the slow-release character as incorporated in the circuit arrangement shown in FIG. **1** for the purpose of preventing the ignition system from being instantaneously disconnected from the power source when the power transmission gears are shifted through the neutral position.

Referring to FIG. **3,** those parts and elements which have their counterparts in the arrangement of FIG. **1** are designated by corresponding reference numerals and characters. Different from the arrangement shown in FIG. **1,** the embodiment shown in FIG. **3** includes a vehicle speed responsive switch **40** which is connected in parallel with the engine temperature responsive and transmission gear responsive switches **24** and **26,** respectively, which are also connected in parallel between the ignition switch **10** and the ignition coil **14** of the ignition system through a line **42.** The engine temperature responsive switch **24** is kept closed when the engine temperature is lower than a predetermined level and opens in response to an engine temperature higher than the predetermined level while the transmission gear responsive switch **26** is closed when the power transmission system is in the coupled condition and opens in response to the uncoupled or neutral condition of the transmission system, contrary to their counterparts in the arrangement shown in FIG. **1.** The vehicle speed responsive switch, on the other hand, is open when the vehicle speed is lower than a predetermined relatively low level of, for instance, 4 km/hr. and closes when the motor vehicle is driven at a higher speed. For this purpose, the vehicle speed responsive switch means may be associated with wheel axle or axles or with any desired parts which are adapted to produce a

signal representative of or approximating the vehicle speed.

When, thus, the engine is driven cold, the engine temperature responsive switch **24** remains closed so that the ignition coil **14** is energized through this switch **24** and concurrently the relay coil **32** for the engine cranking motor (not shown) energized through the relay contacts **28***b* which are in a closed condition with the coil **28***a* de-energized. The engine is thus started by the aid of the cranking motor and in the meantime warmed up to an operating temperature. The engine temperature responsive switch **24** will thus be opened when the predetermined temperature is reached by the engine but the connection between the ignition switch and coil **10** and **14**, respectively, is maintained when the transmission gears are shifted from the neutral and accordingly the transmission gear responsive switch **26** is closed. The engine is thus driven under a normal condition.

When, now, the motor vehicle is braked to a halt with the engine maintained at an elevated temperature and when the transmission system is brought into the uncoupled or neutral condition, when the switches **24, 26** and **40** are all opened so that the ignition coil **14** is disconnected from the power source. The sparks on the spark plugs connected to the ignition distributor **16** consequently cease so that the engine is shut down. When the transmission gears are then shifted from the neutral to the low-gear position, the transmission gear responsive switch **26** closes so as to energize the ignition coil **14** for a second time. At an instant at which the transmission gears are shifted from one to another coupled position through the neutral, during operation of the motor vehicle, the vehicle speed responsive switch **40** serves to keep the ignition coil **14** energized so that the instantaneous interruption of the engine at such an instant can be prevented.

In the arrangement above described, it may happen that the motor vehicle is started unwantedly if the engine temperature responsive switch **24** is closed with the power transmission system left in the coupled condition. This will be avoided through provision of a second transmission gear responsive switch **44** which is serially connected to the engine temperature responsive switch **24** as indicated by broken lines in FIG. **3.** This additional transmission gear responsive switch **44** is so arranged as to be closed when the power transmission system is in the uncoupled condition with the result that the ignition coil **14** is prevented from being objectionably energized even if the engine temperature responsive switch **24** closes with the transmission system left in the coupled condition.

The engine speed responsive relay switch **28** is constructed entirely similarly to its counterpart in the arrangement shown in FIGS. **1** and **2,** and accordingly, acts to have the relay contacts **28***b* opened when the engine speed reaches a predetermined level whereby the engine cranking motor (not shown) is made operative once the engine has been driven under usual conditions.

FIG. **4** illustrates a modification of the circuit arrangement of FIG. **3.** In this modified form of apparatus according to the present invention, the vehicle speed responsive switch **40** of the arrangement shown in FIG. **3** is substituted by an accelerator position responsive switch **46.** This accelerator position responsive switch **46** and previously described engine temperature responsive and transmission gear responsive switches **24** and **26** respectively, are connected in parallel between the ignition switch **10** and ignition coil **14** through the line **42.** These engines temperature and transmission gear responsive switches **24** and **26,** respectively, are constructed and arranged similarly to those used on the circuit arrangement of FIG. **3.** Thus, the engine temperature responsive switch **24** opens when the engine temperature rises beyond a predetermined level which may range from 60° C to 70° C as previously mentioned while the transmission gear responsive switch **26** opens when the power transmission system is in the uncoupled or neutral position. The accelerator position responsive switch **46,** on the other hand, is interlocked or otherwise associated with an accelerator pedal (not shown) so as to be closed when the accelerator pedal is depressed.

When, in operation, the ignition switch **10** is started, the engine temperature responsive switch **24** is in the closed position because the temperature of the engine is below the predetermined level. The power source (not shown) is therefore connected to the ignition coil **14** and relay contacts **28***b* of the engine speed responsive switch **28** through the line **42** so that the engine (not shown) starts to be driven by the aid of the cranking motor (not shown) connected to the relay coil **32** which is energized. Under this condition both the transmission gear responsive and accelerator position responsive switches **26** and **46** are kept open because the power transmission system is in the uncoupled and concurrently the accelerator pedal is kept released.

As soon as the engine revolution speed reaches a predetermined value which may be about 500 r.p.m. as previously noted, then the engine speeds responsive switch **28** is actuated so as to energize the relay coil **28***a* whereby the normally closed relay contacts **28***b* are opened, thereby disconnecting the relay coil **32** for the engine cranking motor. The engine cranking motor is accordingly stopped and the engine is driven under an unloaded condition. By this instant, the engine has been warmed up sufficiently so that the engine temperature responsive switch **24** is opened. In this condition, however, the transmission gears are shifted from the neutral to a coupled condition or usually a low-gear position so that the transmission gear responsive switch **26** is closed for maintaining the ignition coil **14** energized and the engine driven under usual conditions.

When the transmission gears are shifted to the neutral and the accelerator pedal released so as to bring the motor vehicle to a full stop as on a jammed highway or at a crossing in an urban area, then the transmission gear responsive switch **26** and the accelerator position responsive switch **46** open concurrently. The engine temperature responsive switch **24** remaining open with the engine kept warmed, the connection between the ignition switch and coils **10** and **14,** respectively, through the switches **24, 26** and **46** is interrupted to cause the engine shut down in the absence of the sparks on the spark plugs (not shown) connected to the ignition distributor **26.** Thus, the engine does not idle even through the motor vehicle is stopped and, as a consequence, no toxic compounds are emitted from the engine while the motor vehicle is at rest. It is noted in this instance that the engine can be shut down and thus discharges no toxic compounds even when the motor vehicle is not completely brought to a halt as in the case

where the transmission gears are shifted to the neutral during cruising of the motor vehicle.

When the transmission system is brought to the coupled position so as to start the motor vehicle from rest, then the transmission gear responsive switch **26** closes, thereby energizing the ignition coil **14** and relay coil **32** for the engine cranking motor for a second time. The engine cranking motor is thus actuated and the engine started up by the aid of the cranking motor.

If the motor vehicle is to be stopped frequently for a short while, the operation performance of the engine will be impaired as a result of the repeated interruption of the operation of the engine. This is avoided in the above described circuit arrangement in which the accelerator position responsive switch **46** is provided for the purpose of maintaining the ignition coil **14** in the energized condition as long as the accelerator pedal is kept depressed by the driver.

FIG. **5** illustrates graphically a relationship (*a*) between the accelerator positions (released and actuated) and the switch **46** which is responsive thereto and a relationship (*b*) between the transmission gear positions (low-gear, neutral and intermediate-gear) and the switch **26** which is responsive thereto. As seen from these graphic representations, when the transmission gears are shifted from the low-gear to intermediate-gear position, the accelerator position and transmission gear responsive switches **46** and **26**, respectively, turn off during an interval in which the transmission gears are being shifted from the low to intermediate gear positions. During this interval, the engine will be brought to a shut off condition for a short while and, therefore, it is desired that such interval be shortened as much as possible to achieve satisfactory operation performance of the engine. For this purpose, the transmission gear responsive switch **46** may preferably be arranged in such a manner as to be become open substantially at an instant at which the neutral position is established in a power transmission system and to be closed before and after the transmission gears are shifted to the neutral positions. By virtue of this arrangement of the transmission gear responsive switch **46**, the shifting between the low and intermediate gear positions can be completed before the engine speed responsive relay switch **28** and accordingly the cranking motor for the engine are actuated objectionably. This is because of the fact that the engine remains driven by inertia even though the ignition coil **14** is instantaneously disconnected from the power source and the spark plugs (not shown) fail to be energized. The engine cranking motor is in this manner prevented from objectionably actuated during the interval in which the transmission gears are being shifted between one gear position to another.

To enable an unexperienced driver to properly effect the gear shifting operation during cruising, the accelerator position responsive switch **46** may be so arranged as to become open in a certain delay time of, for instance, 1 to 2 seconds. This arrangement will permit the switch **46** to be turned off in 1 to 2 seconds after the accelerator has been released.

FIG. **6** illustrates still another preferred embodiment of the apparatus according to the present invention. The apparatus herein shown is modified from the embodiment shown in FIG. **4** with a view to enabling the engine to be driven continuously when the transmission gears are being shifted from one coupled position to another. As illustrated, the circuit arrangement shown in FIG. **6** has incorporated therein a clutch responsive switch **48** in addition to the engine temperature responsive switch **24**, transmission gear responsive switch **26** and accelerator position responsive switch **46**, all of which are arranged entirely similarly to their equivalents in the circuit arrangement of FIG. **4**. All these switches **24**, **26**, **46** and **48** are connected in parallel to the ignition coil **14**. The clutch responsive switch **48**, in particular, is so arranged as to be open when the clutch of the power transmission system is in a coupled condition and to close when the clutch is uncoupled with the clutch pedal depressed.

During a condition in which the motor vehicle is at rest, the clutch responsive switch **48** is open with the clutch pedal released. Since, in this condition, the engine temperature responsive switch **24**, transmission gear responsive switch **26** and accelerator position responsive switch **46** are all open similarly to the arrangement shown in FIG. **4**, the ignition coil **14** is deenergized and accordingly the engine is shut down. When in starting the motor vehicle from rest, at least one of the transmission gear responsive switch **26**, accelerator position responsive switch **46** and clutch responsive switch **48** is closed so that the ignition coil **14** is energized from the power source and the engine is driven.

When the transmission gears are shifted from one coupled position to another, such as from the low-gear to intermediate-gear position as indicated graphically in (*c*) of FIG. **5**, the clutch pedal is kept depressed and that the clutch responsive switch **48** is kept closed during the interval in which the transmission gear shifting is being effected. The engine is thus prevented from being stopped instantaneously during this transmission gear shifting operation.

What is claimed is:

1. A combination with an ignition system and a power transmission system of a motor vehicle, of first switch means responsive to an engine temperature and second switch means responsive to an uncoupled condition of the power transmission system, the first and second switch means being connected to a primary winding of an ignition coil of the ignition system for deenergizing the ignition coil when the engine temperature is higher than a predetermined temperature and concurrently the power transmission system is in an uncoupled condition.

2. A combination with an ignition system and a power transmission system of a motor vehicle, of first switch means responsive to an engine temperature, second switch means responsive to an uncoupled condition of the power transmission system, the first and second switch means being connected to a primary winding of an ignition coil of the ignition system for deenergizing the ignition coil when the engine temperature is higher than a predetermined level and concurrently the power transmission is in an uncoupled condition, and third switch means connected to the ignition coil and to a cranking motor for the engine and responsive to an engine revolution speed, said third switch means being closed to actuate the cranking motor when the engine revolution speed is lower than a predetermined relatively low level.

3. A combination with an ignition system and a power transmission system of a motor vehicle, of first switch means responsive to an engine temperature, second switch means responsive to an uncoupled condition of the transmission system, the first and second

switch means being connected to a primary winding of an ignition coil of the ignition system for energizing the ignition coil when the engine temperature is higher than a predetermined level and concurrently the power transmission system is in a coupled condition, and third switch means connected to said primary winding of the ignition coil and closed when an engine of the motor vehicle is being driven and yet said first and second switch means are open.

4. A combination with an ignition system and a power transmission system of a motor vehicle, of engine temperature responsive switch means opened in response to an engine temperature which is lower than a predetermined level, transmission gear responsive switch means closed in response to an uncoupled condition of the power transmission and normally closed slow-release switch means connected between an ignition switch and an ignition coil of the ignition system and serially to the engine temperature and transmission gear responsive switch means for energizing the ignition coil when at least either of the engine temperature and transmission gear responsive switch means is open, said slow-release switch means being opened at a retarded timing with both of said engine temperature and transmission gear responsive switch means are closed in response to an engine temperature higher than said predetermined level and to the uncoupled condition of the power transmission system.

5. A combination with an ignition system and a power transmission system of a motor vehicle, of engine temperature responsive switch means opened in response to an engine temperature which is lower than a predetermined level, transmission gear responsive switch means closed in response to an uncoupled condition of the power transmission system, normally-closed slow-release switch means connected between an ignition switch and an ignition coil of the ignition system and serially to the engine temperature and transmission gear responsive switch means for energizing the ignition coil when at least either of the engine temperature and transmission gear responsive switch means is open, said slow-release switch means being opened at a retarded timing when both of said engine temperature and transmission gear responsive switch means are closed in response to an engine temperature which is higher than said predetermined level and to the uncoupled condition of the power transmission system, and engine speed responsive switch means connected to the ignition coil and to a cranking motor for the engine and closed to energize the cranking motor in response to an engine speed which is lower than a predetermined relatively low level.

6. A combination with an ignition system and a power transmission system of a motor vehicle, of engine temperature responsive switch means closed in response to an engine temperature which is lower than a predetermined level, transmission gear responsive switch means closed in response to a coupled condition of the power transmission system, and vehicle speed responsive switch means closed in response to a vehicle speed which is lower than a relatively low predetermined level, said engine temperature, transmission gear and vehicle speed responsive switch means being connected in parallel between an ignition switch and an ignition coil of the ignition system for energizing the ignition coil when at least one of the three switch means is closed.

7. A combination as claimed in claim 6, further comprising second transmission gear responsive switch means serially connected to said engine temperature responsive switch means and open in response to the coupled condition of the power transmission system.

8. A combination with an ignition system and a power transmission system of a motor vehicle, of engine temperature responsive switch means closed in response to an engine temperature which is lower than a predetermined level, transmission gear responsive switch means closed in response to a coupled condition of the power transmission system, vehicle speed responsive switch means closed in response to a vehicle speed which is higher than a relatively low predetermined level, said engine temperature, transmission gear and vehicle speed responsive switch means being connected in parallel between an ignition switch and an ignition coil of the ignition system for energizing the ignition coil when at least one of the three parallel switch means is closed, and engine speed responsive switch means connected to the ignition coil and to a cranking motor for the engine, said engine speed responsive switch means being closed in response to an engine revolution speed which is lower than a predetermined relatively low level.

9. A combination as claimed in claim 8, further comprising second transmission gear responsive switch means serially connected to said engine temperature responsive switch means and open in response to the coupled condition of the power transmission system.

10. A combination with an ignition system and a power transmission system of a motor vehicle, of engine temperature responsive switch means closed in response to an engine temperature which is lower than a predetermined level, transmission gear responsive switch means closed in response to a coupled condition of the power transmission system, and accelerator position responsive switch means which is open in response to a condition in which an accelerator pedal is released, said engine temperature, transmission gear and accelerator position responsive switch means are connected in parallel between an ignition switch and an ignition coil of the ignition system for energizing the ignition coil when at least one of the three switch means is closed.

11. A combination as claimed in claim 10, further comprising clutch responsive switch means connected between said ignition switch and ignition coil and in parallel to said three switch means and closed in response to an uncoupled condition of a clutch of the power transmission system.

12. A combination with an ignition system and a power transmission system of a motor vehicle, of engine temperature responsive switch means closed in response to an engine temperature which is lower than a predetermined level, transmission gear responsive switch means closed in response to a coupled condition of the power transmission system, accelerator position responsive means which is open in response to a released condition of an accelerator pedal, said engine temperature, transmission gear and accelerator position responsive switch means being connected in parallel between an ignition switch and an ignition coil of this ignition system for energizing the ignition coil when at least one of these three switch means is closed, and engine speed responsive switch means connected to said ignition coil and to a cranking motor for the en-

gine and closed in response to an engine speed which is lower than a relatively low level.

13. A combination as claimed in claim **12,** further comprising clutch responsive switch means connected between said ignition switch and said ignition coil and in parallel to said three switch means and closed in response to an uncoupled condition of a clutch of the power transmission system.

14. A combination as claimed in claim **1,** in which said level of the engine temperature ranges from about 60° C to about 70° C.

15. A combination as claimed in claim **2,** in which said predetermined level of the engine revolution speed is about 500 r.p.m.

16. A combination as claimed in claim **4,** in which said slow-release switch means is adapted to open at a timing retarded for about 1 second.

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