United States Patent [19]

Muroki et al.

[11] **3,812,673**

[45] **May 28, 1974**

[54] **FORCED DRAFT COOLING SYSTEM FOR AN EXHAUST GAS PURIFYING DEVICE**

[75] Inventors: **Takumi Muroki**, Aki; **Tomoo Tadokoro**, Kure, both of Japan

[73] Assignee: **Toyo Kogyo, Ltd.**

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[21] Appl. No.: **165,463**

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July 31, 1970	Japan	45-76943
July 31, 1970	Japan	45-77075
July 31, 1970	Japan	45-77076

[52] **U.S. Cl.** **60/286,** 60/289, 60/290, 60/298

[51] **Int. Cl.** **F02b 75/10,** F01n 3/10

[58] **Field of Search** 60/286, 289, 290, 298

[56] **References Cited**

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Primary Examiner—Douglas Hart
Attorney, Agent, or Firm—Craig and Antonelli

[57] **ABSTRACT**

A forced draft cooling system for an exhaust gas purifying device for forcibly cooling the latter without any substantial reduction of the temperature within the interior of the device in which combustion of unburned noxious compounds of an exhaust gas emitted from the exhaust system of an internal combustion engine take place, which comprises means for supplying a cooling air to the surrounding of the device to effect the forced cooling and means for supplying a secondary air to the interior of the device, the supply of said cooling air to the surrounding of the device being effected in association with the supply of said secondary air in response to the engine condition or the temperature of the engine or of the exhaust system. Also provided is a single valve structure into which various valving devices employed are assembled.

32 Claims, 18 Drawing Figures

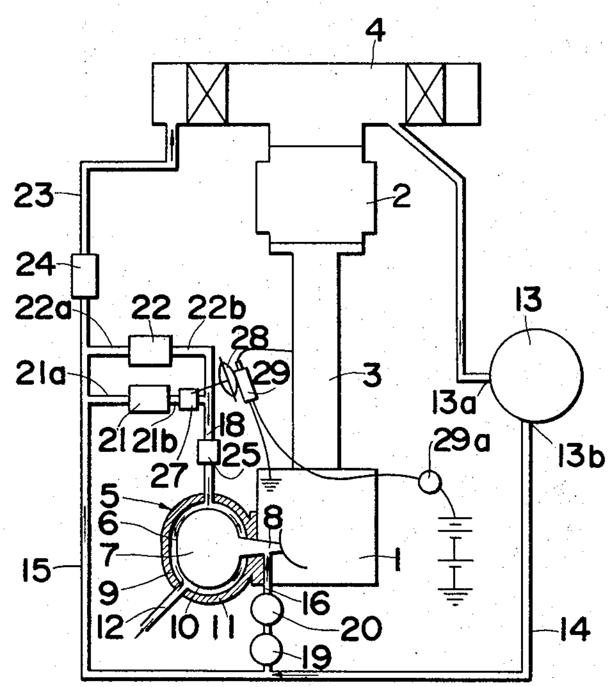


FIG. 1

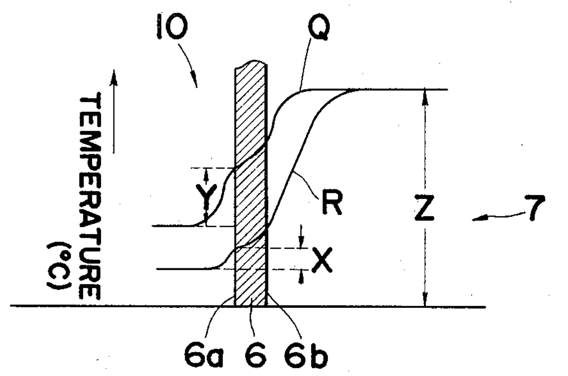
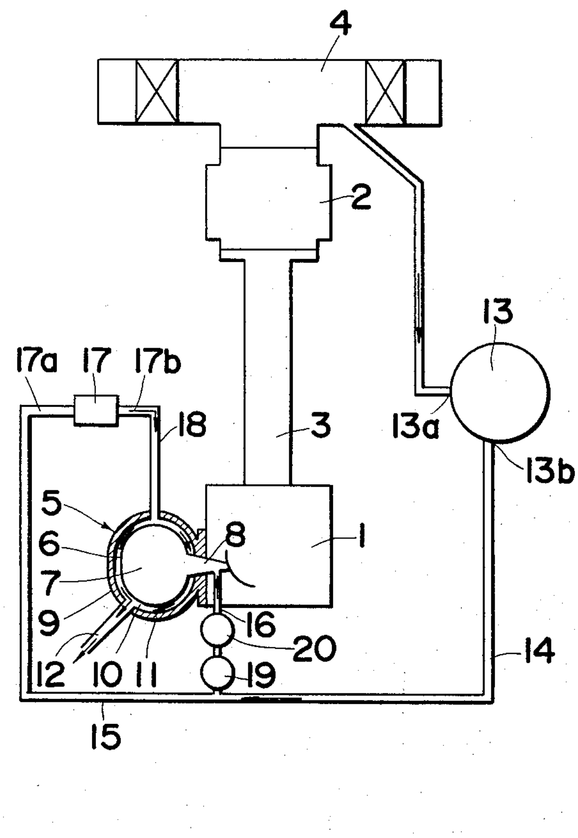


FIG. 2



INVENTORS

TAKUMI MUROKI and TOMOO TADOKORO

BY

Craig, Antonelli & Hill

ATTORNEYS

FIG. 3

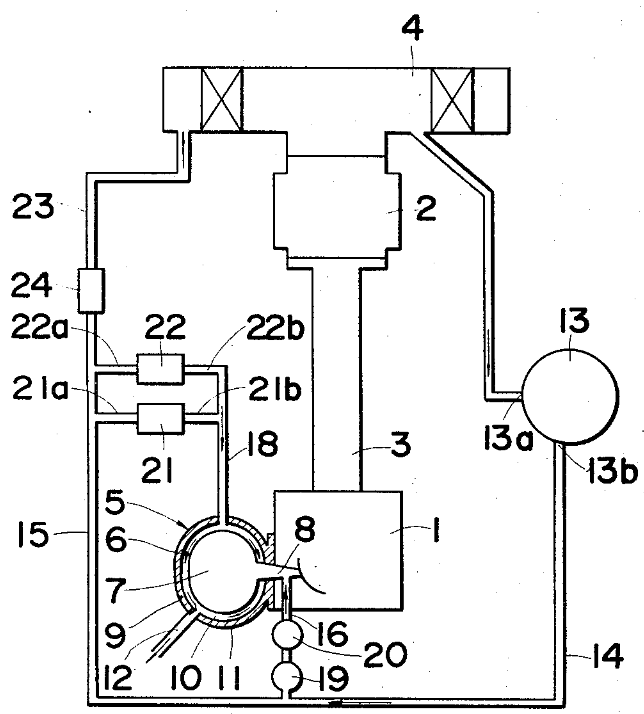
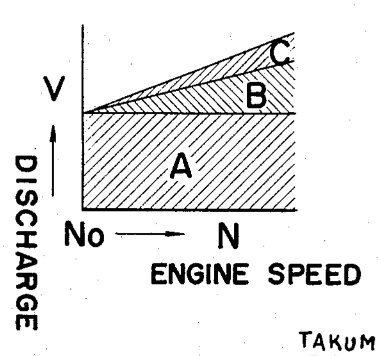


FIG. 4



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TAKUMI MUROKI and TOMOO TADOKORO

BY

Craig, Antonelli & Hill

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FIG. 5

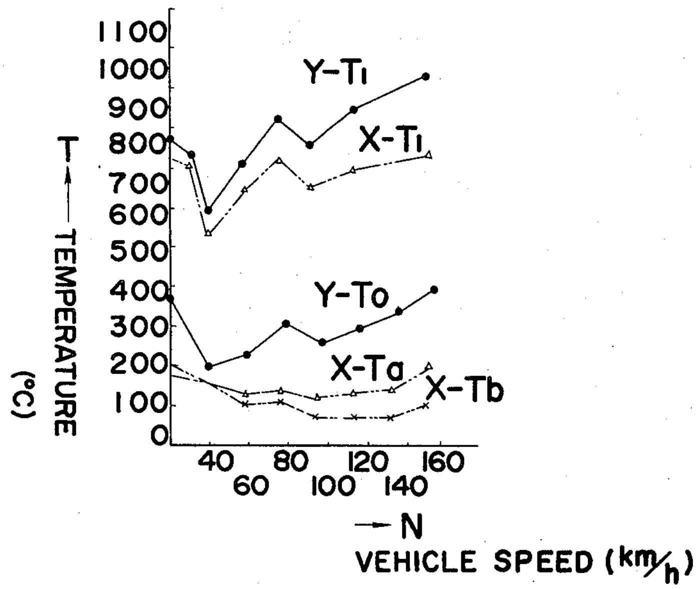


FIG. 6

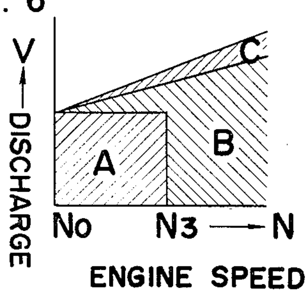


FIG. 7

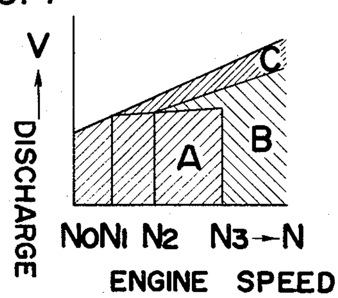


FIG. 8

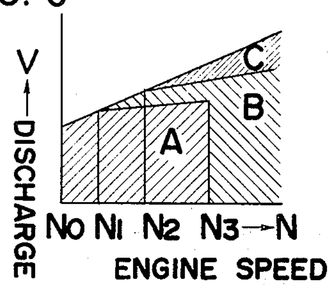


FIG. 9 (a)

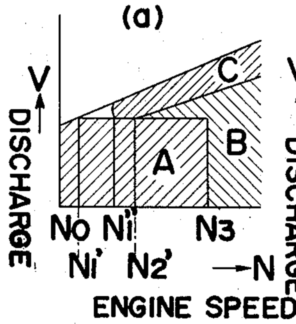
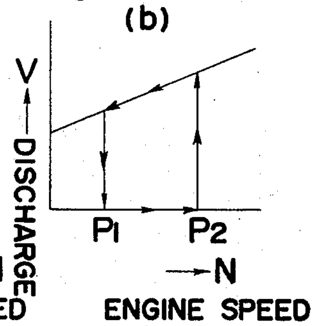


FIG. 9 (b)



INVENTORS

TAKUMI MUROKI and TOMOO TADOKORO

BY

Craig, Antonelli & Hill

ATTORNEYS

FIG. 10

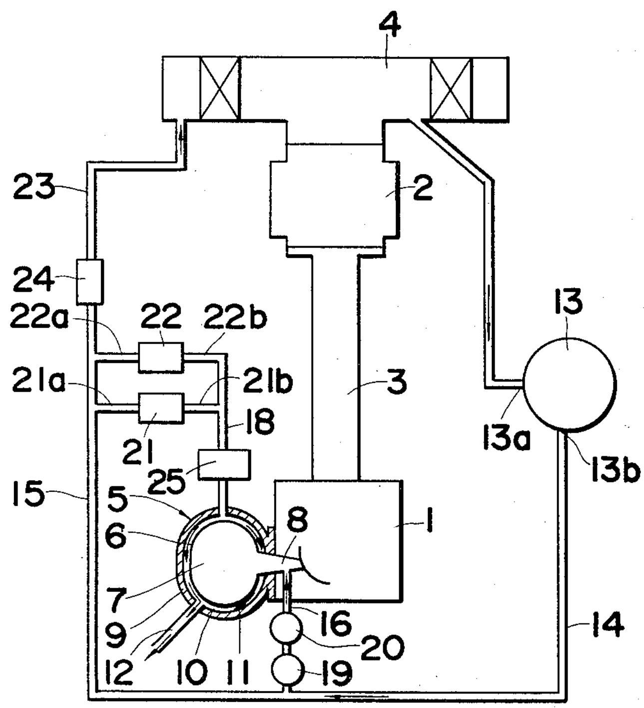
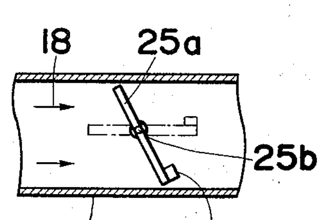


FIG. 11



INVENTORS
TAKUMI MUROKI and TOMOO TADOKORO
BY
Craig, Antonelli & Hill
ATTORNEYS

FIG. 12

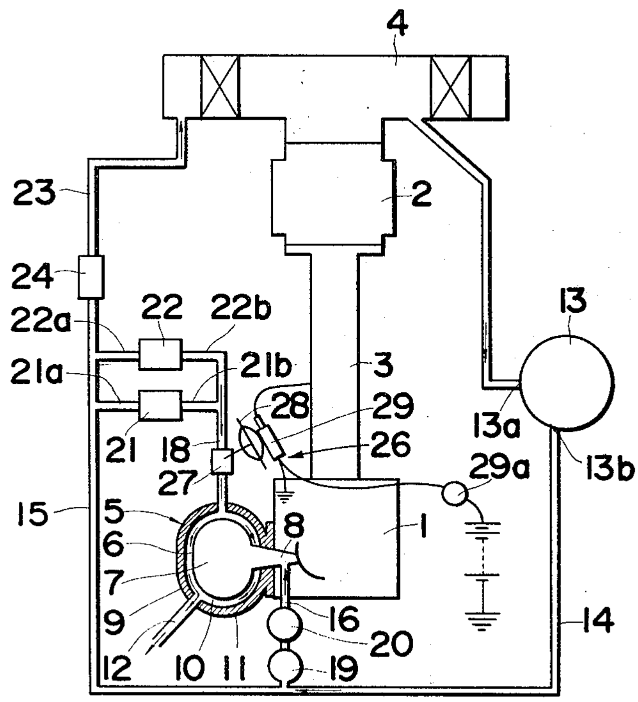
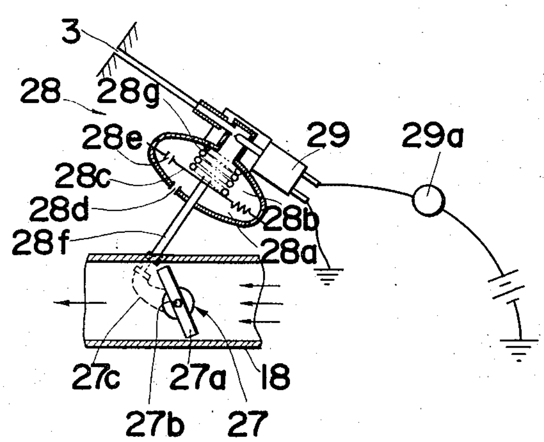


FIG. 13



INVENTORS
TAKUMI MUROKI and TOMOO TADOKORO
BY Craig, Antonelli & Hill
ATTORNEYS

FIG. 14

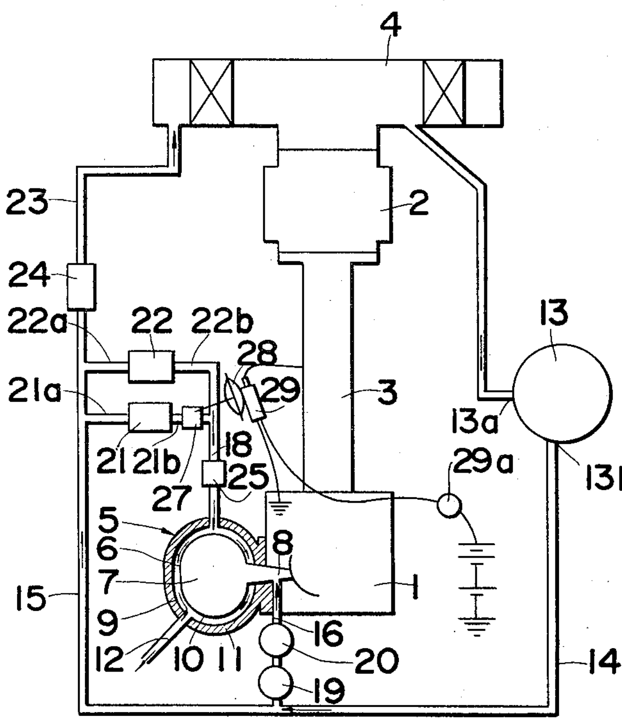
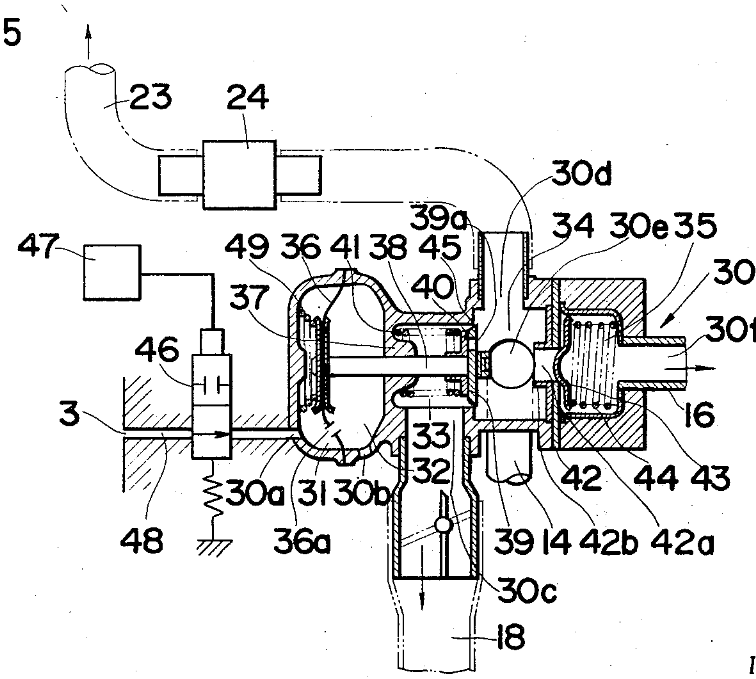


FIG. 15



INVENTORS

TAKUMI MUROKI and TOMOO TADOKORO

BY

Craig, Antonelli & Hill

ATTORNEYS

FIG. 16

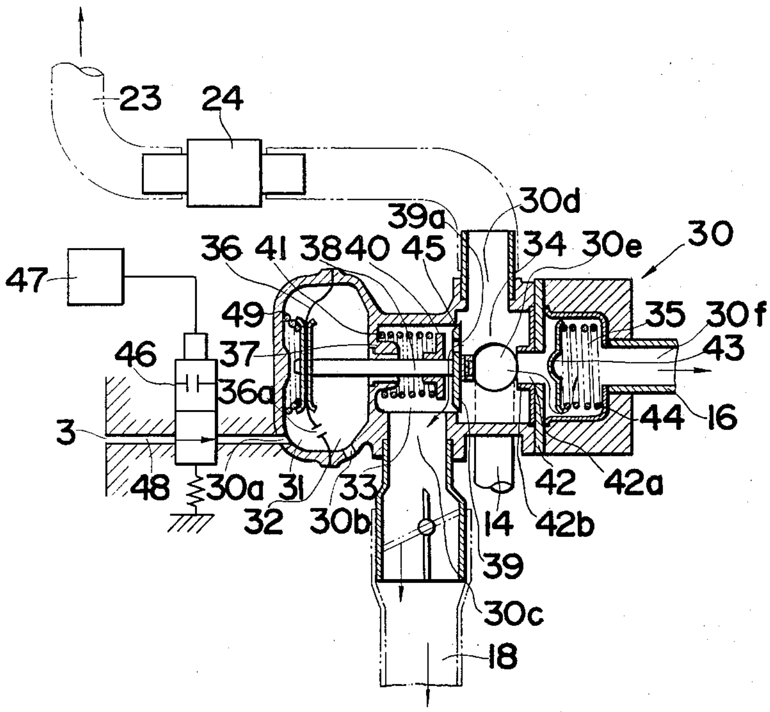
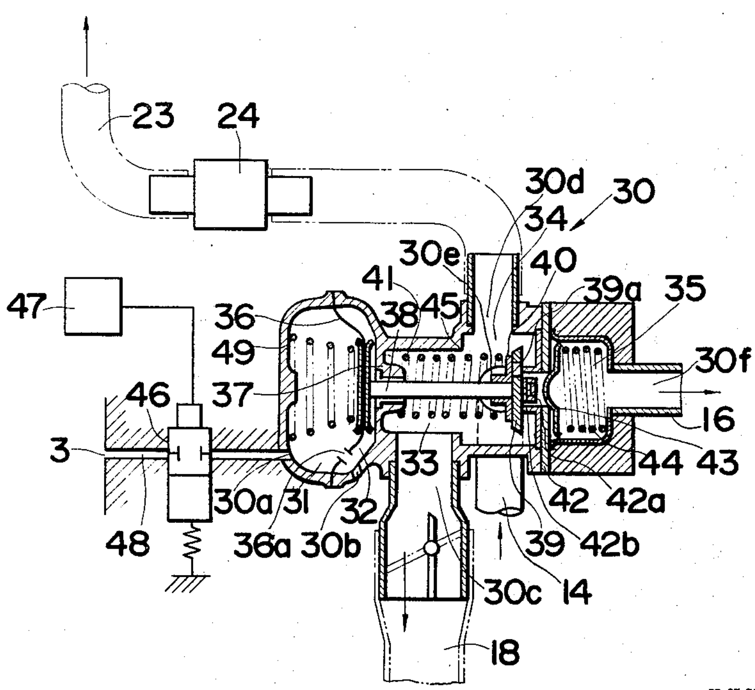


FIG.17



INVENTORS

TAKUMI MUROKI and TOMOO TADOKORO

BY Craig, Antonelli & Hill

ATTORNEYS

FORCED DRAFT COOLING SYSTEM FOR AN EXHAUST GAS PURIFYING DEVICE

The present invention relates to a novel cooling system and, more particularly, to a forced draft cooling system adaptable in an exhaust gas purifying device for purifying noxious compounds present in an exhaust gas emitted from the exhaust system of an internal combustion engine, which is effective to forcibly cooling the purifying device to improve the durability thereof.

It has been well known that a majority of automotive vehicle having an internal combustion engine emits noxious gas compounds from its exhaust system of the engine and therefore an exhaust gas purifying device has been provided for reducing the amount of the noxious gas compounds. The thermal reactor or afterburner is one of the exhaust gas purifying devices heretofore proposed, wherein noxious gas compounds present in an exhaust gas emitted from the exhaust system of the internal combustion engine are burned in the reaction chamber thereof with the aid of an additionally supplied fresh air so that the amount of the noxious gas compounds can be reduced before letting them escape to the atmosphere.

In this case, the higher the temperature within the reaction chamber of the thermal reactor, the more efficiently combustion of the noxious gas compounds takes place in the reaction chamber. However, on the contrary thereto, it has often occurred that the higher temperature accelerates deterioration of material employed for a shell surrounding the reaction chamber, in addition to oxidation of the shell. In any event, material ordinarily used for the shell of the reactor has a definite heat resistance and, once this material is affected by the temperature higher than the heat resistance, heat deformation will take place. Accordingly, the thermal reactor heretofore largely employed has a tendency that the durability thereof is substantially reduced, and replacement of the used reactor for a new one is oftentimes necessitated.

To improve the durability of the reactor and/or to facilitate the use of material for the shell which has a relatively lower heat resistance than heretofore required, the reactor must be cooled. However, if cooling is merely effected to the reactor, combustion of the unburned noxious compounds will not undergo efficiently. In other words, the amount of cooling air to be used for cooling and the amount of secondary air to be supplied to the reaction chamber must be efficiently controlled with respect to the engine condition. This will be explained with reference to FIG. **1** in which the temperature distribution with respect to the shell **6** is shown.

Referring now to FIG. **1**, reference numerals **6***a* and **6***b* designate the outside and inside surfaces of the shell **6**, respectively, facing toward the cooling air and the reaction chamber. It is here assumed that the temperature required for effecting a normal combustion of the unburned noxious compounds in the reaction chamber is the value Z. In the case where the cooling is not effected, the temperature curve follows as indicated by Q, while follows as indicated by R in the case where it is effected.

In FIG. **1**, it is true that the air in the static condition in contact with the outside surface **6***a* of the shell **6** has a temperature higher than that of in the dynamic or flowing condition in contact therewith and, in the proximity of the outside surface **6***a*, the temperature of the air in the static condition has a tendency to be elevated by the heat transmitted from the reaction chamber through the shell, in a value greater than that given by the air in the dynamic condition. This is illustrated by the difference between the values X and Y shown in FIG. **1**. Despite the fact that the air in the dynamic condition is effective to cool the shell as compared with the air in the static condition, a zone of the higher temperature Z should exist from the proximity of the inside surface **6***b* of the shell **6**, or otherwise the efficient combustion of the unburned noxious compounds will not be ensured. In this connection, in view of the fact that the temperature of the inside surface **6***b* of the shell **6**, affected by the air in the static condition, still remains higher than the temperature thereat affected by the air in the dynamic condition, it is obviously clear that the employment of a forced draft cooling system affords to advantageously reduce the temperature of the shell **6**.

In view of the foregoing description, it is preferable to reduce or stop the supply of the secondary air to the reaction chamber and concurrently to effect the cooling to the shell to avoid an unnecessary increase of the temperature of the shell, particularly when the engine is driven at a relatively higher rate in which condition not only the temperature within the reaction chamber is sufficiently elevated, but also the amount of the noxious compounds present in the exhaust gas is substantially very small from beginning. The same may apply to the case where the engine is driven at the relatively higher rate with low load. However, in the latter case, the cooling is preferably concentrated more extensively than in the former case. In other words, the supply of the secondary air to the reaction chamber even during this condition will result in the unnecessary increase of the temperature of the shell.

Accordingly, an essential object of the present invention is to provide a novel forced draft cooling system for cooling the surrounding of an exhaust gas purifying device without any substantial reduction of the temperature of an exhaust gas emitted from the exhaust system of an internal combustion engine in response to the engine condition.

Another object of the present invention is to provide a novel forced draft cooling system for cooling the surrounding of an exhaust gas purifying device in response to the engine condition which can improve the durability of an exhaust gas purifying device without any substantial reduction of the performance.

A further object of the present invention is to provide a novel forced draft cooling system for cooling the surrounding of an exhaust gas purifying device in response to the engine condition which facilitates the use of material for that device having a relatively lower heat resistance.

A still further object of the present invention is to provide a novel forced draft cooling system for cooling the surrounding of an exhaust gas purifying device which comprises, in its simplified form, means for supplying a cooling air to the surrounding of the exhaust gas purifying device and means for supplying a secondary air to the interior of the exhaust gas purifying device, the supply of said cooling air being performed in association with the operation of the second mentioned means with respect to the condition in which an internal combustion engine is placed.

A still further object of the present invention is to provide a novel forced draft cooling system for cooling the surrounding of an exhaust gas purifying device which can be installed in connection with an internal combustion engine equpped with the conventional exhaust gas purifying device at lower cost and in a simplified procedure.

A further object of the present invention is to provide the forced draft cooling system of the above character wherein means is provided for preventing a possible destruction of various components of the system which may result, if not provided, from an increase of the pressure of air supplied from an air source.

A still further object of the present invention is to provide the forced draft cooling system of the above character wherein means is provided for supplying the substantially whole amount of air to the surrounding of the exhaust gas purifying device without permitting the flow of air to the interior of the purifying device depending upon the engine condition.

A still further object of the present invention is to provide the forced draft cooling system of the above character wherein means is provided for supplying the air to the surrounding of the exhaust gas purifying device in response to the temperature of the engine or the exhaust system of the engine.

A still further object of the present invention is to provide the forced draft cooling system of the above character wherein means is provided for preventing the backflow of air to be supplied to the surrounding of the exhaust gas purifying device and/or a portion of the exhaust gas leaking through the purifying device from flowing to the air source through various components of the system.

A still further object of the present invention is to provide the forced draft cooling system of the above character wherein means is provided for controlling the flow of air to the interior of the exhaust gas purifying device in response to the engine condition.

It is a related object of the present invention to provide a single valve structure comprising various valving devices necessitated to constitute means for supplying a cooling air to the surrounding of the exhaust gas purifying device and means for supplying a secondary air to the interior of the exhaust gas purifying device.

According to the present invention, the system herein provided can be advantageously employed in connection with any type of exhaust gas purifying devices such as thermal reactor, catalitic converter and exhaust gas recirculation system, although application thereof in connection with the thermal reactor exhibits the optimum results.

These and other object and features of the present invention will become apparent from the following description made in conjunction with some preferred embodiments of the present invention with reference to the accompanying drawings, in which;

FIG. 2 is a schematic block diagram of a forced draft cooling system for cooling a thermal reactor in one embodiment of the present invention,

FIG. 3 is a schematic block diagram of the forced draft cooling system in another embodiment,

FIG. 4 through FIG. 8 are each a graph showing the timing of operation of various valving devices employed in the system, except for FIG. 5 which is a graph showing a performance character of the system of FIG. 3,

FIG. 9 is a graph showing the performance of the system of the present invention,

FIG. 10 is a schematic block diagram of the system in a further embodiment,

FIG. 11 is a schematic diagram showing a structure of one valve device employed in the system of FIG. 10,

FIG. 12 is a schematic block diagram of the system in a still further embodiment,

FIG. 13 is a schematic diagram showing a structure of one valve device employed in the system of FIG. 12,

FIG. 14 is a schematic diagram showing a modification of FIG. 12,

FIG. 15 is a longitudinal sectional view of a valve structure comprising various valving devices employed in each embodiment of the present invention, and

FIG. 16 and FIG. 17 show respectively the single valve structure of FIG. 15 in the operative positions.

Before the description of the present invention proceeds, it is to be noted that like parts are designated by like numerals throughout the accompanying drawings.

Referring to the drawings, an internal combustion engine 1 has a plurality of combustion chambers (not shown) in which combustion of a fuel-air mixture fed from a carburetor 2 through an intake passage 3 takes place in sequence. A primary air used to form the fuel-air mixture in the carburetor 2 is adapted to be fed from a suitable air source such as air cleaner 4 and an exhaust gas produced upon combustion of the fuel-air mixture in the combustion chambers is adapted to be exhausted to the atmosphere through a thermal reactor 5 disposed on the exhaust system.

The arrangement so far described may be of any known construction and, accordingly, the details thereof are herein omitted for the sake of brevity. In addition, although the thermal reactor for burning HC and CO emissions before letting them escape to the atmosphere is involved in the description of the present invention, structural compenents other than herein necessitated are also omitted for the sake of brevity.

The thermal reactor 5 employed adaptable in the forced draft cooling system throughout the preferred embodiments of the present invention basically comprises a shell 6 defining therein a reaction chamber 7 for burning noxious compounds present in the exhaust gas which has been fed from the engine combustion chambers through an exhaust passage 8. This shell 6 is surrounded by a double-walled casing 9 which constitutes a cooling air jacket 10 therebetween, the operation of which will be mentioned later. The double-walled casing 9 has outer and inner wall members with a spacing formed therebetween in which a suitable heat insulating material 11 is packed. The structure of the thermal reactor 5 so far described is fully disclosed in the pending U. S. Pat. application No. 44,847 (now U.S. Pat. 3,665,711), filed on June 9, 1970 and assigned to the same assignee. However, while the details thereof other than above recited are omitted, it is to be noted that an outlet passage 12 through which the air having circulated in the cooling air jacket 10 is exhausted to the atmosphere may be connected with an exhaust conduit (not shown) through which the exhaust gas having passed through the thermal reactor 5 is exhausted to the atmosphere.

The forced draft cooling system for forcibly cooling the thermal reactor **5** basically comprises an air pump **13** having a suction port **13***a* connected with the air cleaner **4** and a discharge port **13***b* connected concurrently with a secondary air supply means for supplying a fresh air to the exhaust passage **8** and then to the reaction chamber **7** to cause the exhaust gas to be reburned and with means for supplying the air therefrom to the cooling air jacket **10** to effect the reduction of the temperature of the shell **6** of the reactor **5.** In this instance, the second mentioned means may be connected with a different air pump independent of the pump **13** as can be easily anticipated by those skilled in the art. However, in view of the engine room of an automotive vehicle limited in space and economy, the concurrent use of the single pump **13** for the both means is preferable.

In an alternative arrangement, the second mentioned means may be provided with a valving device for permiting the flow of the cooling air therethrough in response to the vehicle driving condition, such as shown in FIG. **2.**

Referring now to FIG. **2,** the cooling air supply means comprises a common passage **14,** one end of which is connected with the discharge port **13***b* of the air pump **13** and the other end of which is connected with a first passage **15** and a second passage **16,** the first passage being in turn connected with an intake passage **17***a* of a cooling air control device **17,** an outlet passage **17***b* of said device **17** being connected with the air jacket **10** through a third passage **18,** and the second passage **16** being in turn connected with a secondary air control device for controlling the flow of the fresh air therethrough to the exhaust passage **8** in response to the vehicle driving condition.

In the instance as shown, the secondary air control device includes a cut-off valve **19** operable in response to the driving condition of the engine **1** in such a manner that said valve **19** can be brought into the open position during a period in which the engine speed is of a relatively lower value and into the closed position during a period in which the engine speed is of a relatively higher value, and a check valve **20** capable of permiting the flow of the air from the cut-out valve **19** to the exhaust passage **8** in proportion to the vehicle driving condition and concurrently preventing the exhaust gas in the exhaust passage **8** from flowing to the cut-out valve **19.**

The cooling air control device **17** may be a manually operated one, in which case it is necessary for the operator to handle the cooling air control device **17** only when he realizes that the temperature of the shell **6** of the reactor **5** is considerably increased during the drive of his vehicle. Alternatively, in a simple form of automation of the cooling air control device **17,** various methods can be contemplated, one of which is the provision of a temperature detector capable of operating the cooling air control device **17** in response to the temperature detected of the shell **6** of the reactor **5.**

Referring to FIG. **3,** the cooling air control device **17** shown in FIG. **2** is replaced by a pair of parallely disposed metering valve **21** and positive relief valve **22** to enable the cooling air from the passage **15** to be supplied to the air jacket **10** in an amount proportional to the engine driving condition. In this arrangement, the metering valve **21** and the positive relief valve **22** are respectively provided with intake passages **21***a* and **22***a*, both connected with the first passage **15,** and outlet passages **21***b* and **22***b*, both connected with the third passage **18.** The metering valve **21** acts to regulate the flow of the cooling air therethrough in response to the engine driving condition in such a manner that the amount of the cooling air passing therethrough increases in proportion to the increase of the engine speed. The positive relief valve **22** is designed such as to be brought into the open position only during a period in which the engine speed is of a relatively higher value for letting the substantial whole amount of the air from the air pump **13** flow to the air jacket **10** whereby no air can be substantially supplied to the exhaust passage **8** through the cut-off valve **19** and the check valve **20.**

Disposed on a passage **23** connecting between the first passage **15** and the air cleaner **4** or the atmosphere is a relief valve **24** operable for discharging the air in the passages **14** and **15** to the atmosphere only when the pressure of the air present therein exceeds over a predetermined value thereby to prevent a possible destruction of various components of the cooling system of the present invention.

However, if no provision has been made of the positive relief valve **22** in the cooling system shown, a relation between the amount of air supplied to the cooling air jacket **10** and that supplied to the reaction chamber **7** will be such as illustrated in FIG. **4,** wherein the axis of abscissa represents the engine speed while the axis of ordinate represents the amount of air discharged from the discharge port **13***b* of the air pump **13,** the intersecting point between the both axes being assumed to represent a certain value No of the engine speed at which the pressure of air present in the first passage **15** is sufficient enough to open the metering valve **21** and the relief valve **24.** As can be understood from FIG. **4,** as the engine speed increases from the value No on, the the air passing through the first passage **15** can be in part supplied to the air jacket **10** as a cooling air and in part to the atmosphere as an excess air, the amount of the cooling air, as defined by B, and the amount of the excess air, as defined by C, both increasing in proportion to the engine speed, whereas the amount of the air, as defined by A, passing through the second passage **16** to the reaction chamber **7** of the reactor **5** maintains a constant value.

The advantage of the cooling system shown in FIG. **3** without the provision of the positive relief valve **22** which was supported by the experiment conducted in connection therewith is illustrated in FIG. **5** wherein the axis of abscissa represents the vehicle speed per hour while the axis of ordinate represents the temperature. In FIG. **5,** the curve $X–T_1$ represents variations in the temperature of the shell **6** of the reactor of the construction substantially disclosed in the pending Patent application (now U.S. Pat. No. 3,665,711) hereinbefore recited and the curves X–T*a* and X–T*b* represent variations in the temperature detected respectively of the outer wall member of the casing **9** at a position adjacent to the engine and at a position opposite to the engine. For comparision, variations in the temperature of the shell of the conventional reactor without the cooling system are shown by the curve $Y–T_1$ and variations in the temperature detected of a single-walled casing surrounding the shell of the conventional reactor are shown by the curve Y–T*o*. From the graph of FIG. **5,** it will be clearly understood that the reactor **5** employed in the present invention can be advantageously cooled as compared with the conventional one. The reduction of the temperature of the reactor involves the possibility of use of an inexpensive material for the reactor which may have a relatively lower durability than exhibited by the expensive material necessitated therefor to overcome the elevated heat. In addition, it will be clearly understood that, should the reactor be disposed beneath the cabin floor of the vehicle, increase of the temperature within the cabin affected by the elevated temperature of the reactor can be advantageously prevented as compared with the employment of the conventional thermal reactor.

On the other hand, if the positive relief valve **22** is provided as shown in FIG. **3**, the relation between the amount of air supplied to the air jacket **10** and that supplied to the reaction chamber **7** will be such as illustrated in FIG. **6**, the graph of which being of the substantially same construction as that of the graph of FIG. **4**. However, since the positive relief valve **22** is adapted to be brought into the open position when the engine is driven at a relatively higher rate so that substantially the whole amount of the air supplied from the discharge port **13***b* of the air pump **13** can be supplied to the air jacket **10** without the flow of air to the reaction chamber **7** through the second passage **16**, maintenance of the flow of the secondary air to the reaction chamber at the substantially constant value can be stopped when the engine speed attains the value N_3 higher than the value No. Accordingly, after the engine speed has attained the value N_3, the amount of the cooling air can be increased by the amount of air which would have been supplied to the reaction chamber **7** if the positive relief valve **22** is in the closed position or no provision thereof is made, and substantially no air can be supplied to the reaction chamber **7** through the second passage **16** and then the exhaust passage **8**. This is advantageous in that, since no re-burning of the exhaust gas in the reaction chamber **7** takes place without the secondary air, unnecessary or aimless increase of the temperature of the reactor **5** can be prevented.

It is to be noted that, by suitably selecting the design of each of the metering valve **21** and the relief valve **24**, the timing relation of operation between the both valves **21** and **24** can be displaced such as illustrated in FIGS. **7** through **9**. The graph of FIG. **7** shows that the relief valve **24** is first brought into the open position to discharge the excess air therethrough to the atmosphere in an amount as defined by the area C when the engine speed is of the value N_1 and then the metering valve **21** is brought into the open position to supply the cooling air to the air jacket **10** in an amount as defined by the area B when the engine speed attains the value N_2, the positive relief valve **22** being adapted to be opened to limit the amount of the secondary air as defined by the area A when the engine speed increases to the value N_3. The graph of FIG. **8** shows that the metering valve **21** is first brought into the open position to supply the cooling air to the air jacket **10** in an amount as defined by the area B when the engine speed is of the value N_1 and then the relief valve **24** is brought into the open position to discharge the excess air therethrough to the atmosphere in an amount as defined by the area C when the engine speed attains the value N_2, the positive relief valve **22** being adapted to be opened to limit the amount of the secondary air as defined by the area A when the engine speed increases to the value N_3. Furthermore, the graph of FIG. **9** (*a*) shows that, should the relief valve **24** be designed such as to exhibit a hysteresis characteristics that relief valve **24** can be closed when the pressure of air discharged by the air pump **13** is of a relatively lower value P_1 and opened when the pressure thereof is of a relatively higher value P_2 as shown in FIG. **9** (*b*), the amount of the secondary air to be supplied can be reduced to the substantially constant value when the engine speed during the acceleration of the vehicle attains the value N_1'' in which condition the pressure of the air discharged by the air pump **13** is of the value P_2 sufficient enough to cause the relief valve **24** to discharge the excess air to the atmosphere therethrough and, on the other hand, the amount of the secondary air can be reduced to the substantially constant value when the engine speed during the deceleration of the vehicle is reduced to the value N_1' in which condition the pressure of the air discharged by the air pump **13** is of the value P_1 sufficient enough to close the relief valve **24**.

In FIG. **10**, means is provided in the cooling system for preventing a portion of the exhaust gas from flowing to the third passage **18** and then to the first passage **15** through either or both of the metering valve **21** and the positive relief valve **22** upon leakage thereof into the cooling air jacket **10** which may possibly occur when an abnormal afterburning occurs in the reactor **5** or the engine **1**. Said preventing means comprises a nonreturn valve **25** disposed on the passage **18** about one end thereof adjacent to the reactor **5**, the structure of which being shown in FIG. **11**.

Referring now to FIG. **11**, the non-return valve **25** is constructed with a valving plate **25***a* disposed within the passage **18** and pivotably supported at its intermediate portion by a shaft **25***b* extending from a wall portion to the opposite wall portion of a tubing **18***a* which constitutes the passage **18**. The valving plate **25***a* may be of the oval shape, the smallest diameter thereof being substantially equal to the inner diameter of the tubing **18***a*, and is provided with a weight **25***c* at a portion of the peripheral edge of the surface thereof facing toward the cooling air jacket **10** so that the valving plate **25***a* can be pivoted under its own gravity to the closed position unless otherwise pressure acts on the opposite surface thereof facing toward the metering valve **21** and the position relief valve **22**. In the construction above referred to, it will be clearly understood that the flow of air in the direction as indicated by the arrows can be permitted at which time the valving plate **25***a* is brought into the open position as indicated by the imaginary line while the backflow thereof can be advantageously prevented.

The provision of the non-return valve **25**, it is clearly understood, eliminates a possible contact of the exhaust gas to the relevant circuit components of the cooling system shown in FIG. **10**.

The forced draft cooling system shown in FIG. **12** is such that the air to be used to cool the reactor **5** can be supplied to the air jacket **10** only when the temperature of the thermal reactor **5** exceeds over a predetermined value. To this end, the cooling system of FIG. **12** is provided with a thermal valve assembly **26** including a choke valve **27** disposed on the passage **18** about one end thereof adjacent to the reactor **5**, a diaphragm actuator **28** having first and second working chambers **28***a* and **28***b* and a diaphragm member **28***c*, and a solenoid valve **29** including a thermosensor **29***a*. The structure of this thermal valve assembly 26 which may be employed to achieve the objects of the present invention in an optimum result is illustrated in FIG. 13.

Referring now to FIG. 13, the choke valve 27 includes a valving plate 27*a* disposed within the passage 18 and rigidly connected at its intermediate portion with a shaft 27*b* extending across the diameter of a tubing 18*a* constituting the passage 18, one end of said shaft 27*b* being rotatably supported by a wall portion of the tubing 18*a* and the other end thereof being situated outside the passage 18, a lever 27*c* having one end rigidly connected with the end of the shaft 27*b* situated outside the passage 18. The diaphragm actuator 28 has the first working chamber 28*a* communicated to the atmosphere through a small hole 28*d* and the second working chamber 28*b*, both chambers being partitioned by the diaphragm member having a small hole 28*e* communicating with the first working chamber 28*a* to the second working chamber 28*b*. One surface of the diaphragm member 28*c* facing to the first working chamber 28*a* is rigidly connected with the adjacent end of a connecting rod 28*f*, the other end of which being connected with the other end of the lever 27*c* of the choke valve 27 so that the displacement of the diaphragm member 28*c* causes the operation of the valving plate 27*a*. This diaphragm member 28*c* is normally urged toward the first working chamber 28*a* by the action of a resilient member, for example a compression spring 28*g* disposed in the second working chamber 28*b* so that the choke valve 27 can be maintained in the open position.

The second working chamber 28*b* is communicated with the intake passage 3 whereby the displacement of the diaphragm member 28*c* against the spring 28*g* takes place when the pressure in the second working chamber 28*b* is sharply reduced by the negative pressure acting in the intake passage 3. This condition is illustrated in FIG. 13 and therefore, the choke valve is in the closed position.

However, the solenoid valve 29 is adapted to close and open the communication between the second working chamber 28*b* and the intake passage 3 depending upon the temperature detected by the thermo sensor 28*a*. In the instance as shown, the solenoid valve 29 can be brought into the closed position in which condition the communication between the working chamber 28*b* and the intake passage 3 is cut off, when the temperature detected by the sensor 29 is of a relatively higher value and into the open position in which condition the communication therebetween is established, when the temperature detected by the sensor 29*a* is of a relatively lower value. However, it is to be noted that the thermo sensor 29*a* may be adapted to detect the temperature of any one of engine body, engine cooling medium, shell of the reactor 5, casing 9, and other elements affected by the heat of the exhaust gas.

In the arrangement shown in FIG. 12, it will be clearly understood that, even if the cooling air is supplied to the thermal valve assembly from either or both of the metering valve 21 and the positive relief valve 22, the flow of the cooling air therethrough to the cooling air jacket 10 can be restricted unless otherwise the temperature detected by the thermo sensor 29*a* attains or exceeds over the predetermined value.

The arrangement shown in FIG. 12 is advantageous not only in that over-heating of the reactor shell 6 can be prevented with the result of substantial improvement of the durability of the reactor 5, but also in that an excessive reduction of the temperature within the reactor which has been necessitated to effect reburning of the exhaust gas can be eliminated.

It is to be noted that the thermal valve assembly shown in FIG. 13 may be disposed such as shown in FIG. 14 in combination with the non-return valve 25 shown in FIGS. 10 and 11. In this case, while the non-return valve 25 is disposed as shown in FIG. 10, the choke valve 27 of the thermal valve assembly is disposed on the outlet passage 21*b* of the metering valve 21, wherefor even during a period in which the thermal valve assembly or the choke valve 27 is in the closed position due to the fact that the temperature detected by the thermo sensor 29*a* has not yet attained the predetermined value, the cooling air can be supplied to the air jacket 10 through the positive relief valve 22 and then the non-return valve 25 so long as the engine speed is of the higher value.

Although the present invention has been hereinbefore described with reference to the block diagrams of the cooling system wherein the cut-out valve 19, the check valve 20, the metering valve 21 and the positive relief valve 22 are individually shown, it is to be noted that these valves 19 through 22 can be assembled into a single valve structure such as shown in FIG. 15. In practice, this single valve structure is usually employed rather than the individual valves 19 through 22 and, in the present invention, is advantageously employed in the cooling system shown in FIGS. 3, 10, 12 and 14.

Referring now to FIG. 15, the valve structure including the cut-out valve 19, the check valve 20, the metering valve 21 and the positive relief valve 22 as hereinbefore described comprises a casing generally indicated by 30 having therein a first diaphragm chamber 31 communicated with the intake passage 3 through an opening 30*a*, a second diaphragm chamber 32 communicated with the atmosphere through another opening 30*b*, a first working chamber 33 communicated with the passage 18 through a first port 30*c*, a second working chamber 34 communicated through a second port 30*d* with the air cleaner 4 via the relief valve 24 and through a third port 30*e* with the air pump 13 via the passage 14, and a third working chamber 35 communicated through a fourth port 30*f* with the exhaust passage 8 via the passage 16, said openings 30*a* and 30*b* and said ports 30*c* through 30*f* being all formed in the casing 30. The first and second diaphragm chambers 31 and 32 are partitioned by a diaphragm member 36 formed with a small hole 36*a* communicating therebetween.

Slidably extending through a partition 37 partitioning between the second diaphragm chamber 32 and the first working chamber 33 is a piston rod 38, one end of which is rigidly connected with the diaphragm member 36 and the other end is rigidly connected with a valve member 39 of the diameter slightly larger than that of the first working chamber 33 and, in the condition as shown in FIG. 15, partitioning between the first working chamber 33 and the second working chamber 34. The valve member 39 is formed with a small hole 39*a* which may communicate between said working chambers 33 and 34. However, this small hole 39*a* of the valve member 39 is normally closed by an auxiliary valve member 40 slidably mounted on the piston rod 38 and urged to the valve member 39 by the action of a compression spring **41** disposed within the first working chamber **33** around said piston rod **38.**

The second and third chambers **34** and **35** are divided by a rigid member **42** formed with a hole **42***a* in alignment with the axis of the piston rod **38.** This rigid member **42** is provided with an anuular valve seat **42***b* for receiving the valve member **39** when the latter is moved thereto. The hole **42***a* is adapted to communicate therebetween and, however, is normally closed by a valve member **43** situated within the third working chamber **35** and normally urged toward the second working chamber **34** by the action of a compression spring **44.**

It is to be noted that, when the piston rod **38** is moved to the left against the spring **49** disposed within the first diaphragm chamber **31** for urging said rod **38** to the right, the valve member **39** can be seated against an annular valve seat, formed at **45,** so as to close the first working chamber **33** as shown in FIG. **15.**

To operate the valve structure thus constructed, a solenoid valve **46** operable by an electrical signal representative of the engine speed which has been fed from an engine speed detector **47** is disposed on the passage **48** connecting between the intake passage **3** and the first diaphragm chamber **31.**

While in the construction as hereinbefore fully described, the valve structure operates in the following manner.

Assuming now that the engine speed is of the lower value and, therefore, the solenoid valve **46** has been operated by the detector **47** so as to permit the communication between the intake passage **3** and the first diaphragm chamber **31,** the air present in the first diaphragm chamber **31** can be sucked into the passage **48** so that the piston rod **38** is moved to the left to establish either of the conditions shown in FIG. **15** or FIG. **16.** The condition of FIG. **15** is the case in which the relief valve **24** is in the open position and, therefore, the air supplied from the air pump **13** into the second working chamber **34** by means of the passage **14** escapes to the atmosphere. The condition of FIG. **16** is the case in which the relief valve **24** is in the closed position and, therefore, the air supplied into the second working chamber **34** acts to push the auxiliary valve member **40** and the valve member **43** in the opposite directions respectively against the springs **41** and **44** whereby said air can be in part supplied to the air jacket **10** through the port **30***c* and in part to the exhaust passage **8** through the port **30***f*. At this time, the valve member **39** is, of course, seated against the valve seat **45** and, however, the portion of the air supplied to the air jacket **10** flows through the hole **39***a*.

On the other hand, when the engine speed is of the higher value irrespective of deceleration or acceleration of the vehicle, the solenoid valve **46** can be brought into the closed position thereby to establish the condition as shown in FIG. **17.** In this condition, the piston rod **38** is moved to the right by the action of the compression spring **49** so that the valve member **39** can be seated against the valve seat **42***b*. At this time, the auxiliary valve member **40** is also moved to the right by the compression spring **41** along with the rightward movement of the piston rod **38.** Accordingly, it will be clearly understood that the whole amount of air supplied from the air pump **13** into the second working chamber **34** which has been completely communicated with the first working chamber **33** can be supplied to the air jacket **10** through the port **30***c* unless otherwise the relief valve **24** is in the open position.

In view of the foregoing description of the valve structure shown in FIG. **15,** it may be possibly said that the valve member **39** and the valve seat **42***b* constitutes the cut-off valve **19,** the velve member **43** normally seated against the hole **42***a* of the rigid member **42** constitutes the check valve **20,** the hole **39***a* of the valve member **39** and the auxiliary valve member **40** constitutes the metering valve **21,** and the valve member **39** and the valve seat **45** constitutes the positive relief valve **22.**

In any one of the foregoing embodiments, the forced draft cooling system for forcibly cooling the exhaust gas purifying device according to the present invention works, in a primitive form, to prevent the exhaust gas purifying device from being overheated, by supplying a cooling air to the purifying device in response to various drive conditions of the internal combustion engine and the vehicle mounted with such engine.

Although the present invention has been fully disclosed in conjunction with the preferred embodiments thereof with reference to the accompanying drawings employed merely for the purpose of description, it is to be noted that various modification and change are apparent to those skilled in the art. For example, by suitably selecting the resiliency of each or both of the compression springs **41** and **44** with respect to the resiliency of the compression spring **49,** the timing of operation of the valves which are formed into the single valve structure such as shown in FIG. **15** can be changed as desired to give the operational patterns shown in FIGS. **7** and **8.**

What is claimed is:

1. A forced draft cooling system adaptable in an exhaust gas purifying device including a thermal reactor for purifying noxious compounds present in an exhaust gas emitted from the exhaust system of an internal combustion engine, which comprises an air source, means connected with said air source for supplying air to said reactor, said reactor including a cooling air jacket surrounding a shell which defines therein a reaction chamber in which reduction of the amount of the noxious gas present in the exhaust gas can be effected by re-burning said noxious compounds, said air from said air source through said air supply means being supplied to said air jacket of said reactor as a cooling air for forcibly cooling said shell, means connected with said air source for supplying secondary air to said reaction chamber to enable the reburning of said noxious compounds to take place in said reaction chamber, means disposed on the connection between said first mentioned means and said air jacket for controlling the flow of the cooling air in response to an engine condition, and a non-return valve connected in series with said controlling means for preventing the flow of air, that has been passed through said controlling means, from said air jacket to said cooling air supply means while permitting the flow of said air from said cooling air supply means to the air jacket.

2. A system as claimed in claim **1,** wherein said air source includes an air pump adapted to be driven by said engine.

3. A system as claimed in claim **1,** wherein said controlling means is a thermo valve adapted to control the flow of the cooling air in response to the temperature of at least one of the engine and the exhaust system.

4. A system as claimed in claim 1, further comprising a relief valve disposed on the connection between said air source to the atmosphere for exhausting the air to the atmosphere when the pressure of said air supplied from said air source exceeds a predetermined value.

5. A system as claimed in claim 1, wherein said secondary air supply means includes a secondary air controlling device for controlling the flow of the secondary air in response to the engine condition.

6. A system as claimed in claim 3, wherein said secondary air supply means includes a secondary air controlling device for controlling the flow of the secondary air in response to an engine condition.

7. A system as claimed in claim 5, wherein said secondary air controlling device comprises a check valve.

8. A system as claimed in claim 5, wherein said secondary air controlling device comprises a series connected combination of a check valve and a cut-off valve capable of cutting off the communication between said air source and said check valve when the engine speed exceeds a predetermined value.

9. A forced draft cooling system adaptable in an exhaust gas purifying device including a thermal reactor for purifying noxious compounds present in an exhaust gas emitted from the exhaust system of an internal combustion engine, which comprises an air source, means connected with said air source for supplying air to said reactor, said reactor including a cooling air jacket surrounding a shell which defines therein a reaction chamber in which reduction of the amount of the noxious gas present in the exhaust gas can be effected by re-burning said noxious compounds, said air from said air source through said air supply means being supplied to said air jacket of said reactor as a cooling air for forcibly cooling said shell, means connected with said air source for supplying secondary air to said reaction chamber to enable the re-burning of said noxious compounds to take place in said reaction chamber, a cooling air control device included in said first mentioned means for controlling the flow of the cooling air in response to an engine condition, and a non-return valve connected in series with said cooling air control device between the latter and said air jacket for preventing the flow of air, that has been passed through said control device, from said air jacket to said control device while permitting the flow of said air from said control device to said air jacket.

10. A forced draft cooling system adaptable in an exhaust gas purifying device including a thermal reactor for purifying noxious compounds present in an exhaust gas emitted from the exhaust system of an internal combustion engine, which comprises an air source, means connected with said air source for supplying air to said reactor, said reactor including a cooling air jacket surrounding a shell which defines therein a reaction chamber in which reduction of the amount of the noxious gas present in the exhaust gas can be effected by re-burning said noxious compounds, said air from said air source through said air supply means being supplied to said air jacket of said reactor as a cooling air for forcibly cooling said shell, means connected with said air source for supplying secondary air to said reaction chamber to enable the re-burning of said noxious compounds to take place in said reaction chamber, a cooling air control device included in said first mentioned means for controlling the flow of the cooling air in response to an engine condition, and a thermo valve connected in series with said cooling air control device between the latter and said air jacket for controlling the flow of the cooling air therethrough in response to the temperature of at least one of the engine and the exhaust system.

11. A forced draft cooling system adaptable in an exhaust gas purifying device including a thermal reactor for purifying noxious compounds present in an exhaust gas emitted from the exhaust system of an internal combustion engine, which comprises an air source, means connected with said air source for supplying air to said reactor, said reactor including a cooling air jacket surrounding a shell which defines therein a reaction chamber in which reduction of the amount of the noxious gas present in the exhaust gas can be effected by re-burning said noxious compounds, said air from said air source through said air supply means being supplied to said air jacket of said reactor as a cooling air for forcibly cooling said shell, means connected with said air source for supplying secondary air to said reaction chamber to enable the reburning of said noxious compounds to take place in said reaction chamber, said first mentioned means including a metering valve for controlling the flow of the air from the air source to the air jacket in response to the engine speed, a positive relief valve connected in parallel with said metering valve for permitting the substantially whole amount of air from the air source to flow to the air jacket when the engine speed exceeds a predetermined value, and a relief valve disposed between said air source and said parallely disposed metering valve and positive relief valve for exhausting the air to the atmosphere when the pressure of said air supplied from said air source exceeds a predetermined value.

12. A system as claimed in claim 11, wherein said secondary air supply means includes a secondary air control device for controlling the flow of the secondary air therethrough in response to an engine condition.

13. A forced draft cooling system adaptable in an exhaust gas purifying device including a thermal reactor for purifying noxious compounds present in an exhaust gas emitted from the exhaust system of an internal combustion engine, which comprises an air source, means connected with said air source for supplying air to said reactor, said reactor including a cooling air jacket surrounding a shell which defines therein a reaction chamber in which reduction of the amount of the noxious gas present in the exhaust gas can be effected by re-burning said noxious compounds, said air from said air source through said air supply means being supplied to said air jacket of said reactor as a cooling air for forcibly cooling said shell, means connected with said air source for supplying secondary air to said reaction chamber to enable the reburning of said noxious compounds to take place in said reaction chamber, said first mentioned means including a metering valve for controlling the flow of the air from the air source to the air jacket in response to the engine speed, a positive relief valve connected in parallel with said metering valve for permitting the substantially whole amount of air from the air source to flow to the air jacket when the engine speed exceeds a predetermined value, and a thermo valve connected between said parallely disposed metering valve and positive relief valve and said air jacket for controlling the flow of the cooling air

therethrough in response to the temperature of at least one of the engine and the exhaust system.

14. A forced draft cooling system adaptable in an exhaust gas purifying device including a thermal reactor for purifying noxious compounds present in an exhaust gas emitted from the exhaust system of an internal combustion engine, which comprises an air source, means connected with said air source for supplying air to said reactor, said reactor including a cooling air jacket surrounding a shell which defines therein a reaction chamber in which reduction of the amount of the noxious gas present in the exhaust gas can be effected by re-burning said noxious compounds, said air from said air source through said air supply means being supplied to said air jacket of said reactor as a cooling air for forcibly cooling said shell, means connected with said air source for supplying secondary air to said reaction chamber to enable the reburning of said noxious compounds to take place in said reaction chamber, said first mentioned means including a metering valve for controlling the flow of the air from the air source to the air jacket in response to the engine speed and a positive relief valve connected in parallel with said metering valve for permitting the substantially whole amount of air from the air source to flow to the air jacket when the engine speed exceeds a predetermined value, and a non-return valve connected between said parallely disposed metering valve and positive relief valve and said air jacket for preventing the flow of air, that has been passed through at least one of said metering valve and said positive relief valve, from said air jacket to at least one of said metering valve and said positive relief valve while permitting the flow of said air in the reverse direction.

15. A system as claimed in claim **14,** further comprising a thermo valve disposed between said metering valve and said positive relief valve and said non-return valve for controlling the flow of the cooling air therethrough in response to the temperature of at least one of the engine and the exhaust system.

16. A system as claimed in claim **14,** wherein said secondary air supply means includes a secondary air control device for controlling the flow of the secondary air therethrough in response to an engine condition.

17. A forced draft cooling system adaptable in an exhaust gas purifying device including a thermal reactor for purifying noxious compounds present in an exhaust gas emitted from the exhaust system of an internal combustion engine, which comprises an air source, means connected with said air source for supplying air to said reactor, said reactor including a cooling air jacket surrounding a shell which defines therein a reaction chamber in which reduction of the amount of the noxious gas present in the exhaust gas can be effected by re-burning said noxious compounds, said air from said air source through said air supply means being supplied to said air jacket of said reactor as a cooling air for forcibly cooling said shell, means connected with said air source for supplying secondary air to said reaction chamber to enable the reburning of said noxious compounds to take place in said reaction chamber, said first mentioned means including a metering valve for controlling the flow of the air from the air source to the air jacket in response to the engine speed and a positive relief valve connected in parallel with said metering valve for permitting the substantially whole amount of air from the air source to flow to the air jacket when the engine speed exceeds a predetermined value, a non-return valve connected between parallely disposed metering valve and positive relief valve and said air jacket for preventing the flow of air, that has been passed through of said metering valve and said positive relief valve, from said air jacket to of said metering valve and said positive relief valve while permitting the flow of said air in the reverse direction, and a relief valve disposed on the connection between said air source and the atmosphere for exhausting the air to the atmosphere when the pressure of said air supplied from said air source exceeds a predetermined value.

18. A system as claimed in claim **17,** wherein said secondary air supply means includes a secondary air control device for controlling the flow of the secondary air therethrough in response to an engine condition.

19. A forced draft cooling system adaptable in an exhaust gas purifying device including a thermal reactor for purifying noxious compounds present in an exhaust gas emitted from the exhaust system of an internal combustion engine, which comprises an air source, means connected with said air source for supplying air to said reactor, said reactor including a cooling air jacket surrounding a shell which defines therein a reaction chamber in which reduction of the amount of the noxious gas present in the exhaust gas can be effected by re-burning said noxious compounds, said air from said air source through said air supply means being supplied to said air jacket of said reactor as a cooling air for forcibly cooling said shell, means connected with said air source for supplying secondary air to said reaction chamber to enable the re-burning of said noxious compounds to take place in said reaction chamber, said first mentioned means including a metering valve for controlling the flow of the air from the air source to the air jacket in response to the engine speed and a positive relief valve connected in parallel with said metering valve for permitting the substantially whole amount of air from the air source to flow to the air jacket when the engine speed exceeds a predetermined value, a non-return valve connected between said parallely disposed metering valve and positive relief valve and said air jacket for preventing the flow of air, that has been passed through at least one of said metering valve and said positive relief valve, from said air jacket to at least one of said metering valve and said positive relief valve while permitting the flow of said air in the reverse direction, a thermo valve disposed between said pair of parallely disposed metering valve and positive relief valve and said non-return valve for controlling the flow of the cooling air therethrough in response to the temperature of at least one of the engine and the exhaust system, and a relief valve disposed on the connection between said air source and the atmosphere for exhausting the air to the atmosphere when the pressure of said air supplied from said air source exceeds a predetermined value.

20. A system as claimed in claim **19,** wherein said secondary air supply means includes a secondary air control device for controlling the flow of the secondary air therethrough in response to an engine condition.

21. A forced draft cooling system adaptable in an exhaust gas purifying device including a thermal reactor for purifying noxious compounds present in an exhaust gas emitted from the exhaust system of an internal combustion engine, which comprises an air source, means connected with said air source for supplying air to said reactor, said reactor including a cooling air jacket surrounding a shell which defines therein a reaction chamber in which reduction of the amount of the noxious gas present in the exhaust gas can be effected by re-burning said noxious compounds, said air from said air source through said air supply means being supplied to said air jacket of said reactor as a cooling air for forcibly cooling said shell, means connected with said air source for supplying secondary air to said reaction chamber to enable the re-burning of said noxious compounds to take place in said reaction chamber, said first mentioned means including a metering valve for controlling the flow of the air from the air source to the air jacket in response to the engine speed and a positive relief valve connected in parallel with said metering valve for permitting the substantially whole amount of air from the air source to flow to the air jacket when the engine speed exceeds a predetermined value, a non-return valve connected between a pair of parallely disposed metering valve and positive relief valve and said air jacket for preventing the flow of air, that has been passed through at least one of said metering valve and said positive relief valve, from said air jacket to at least one of said metering valve and said positive relief valve while permitting the flow of said air in the reverse direction, said secondary air supply means including a series connected combination of a check valve and a cut-off valve capable of cutting off the communication between said air source and said check valve when the engine speed exceeds a predetermined value, and a relief valve disposed on the connection between said air source and the atmosphere for exhausting the air to the atmosphere when the pressure of said air supplied from said air source exceeds a predetermined value.

22. A system as claimed in claim **21,** wherein said metering valve, said positive relief valve, said check valve and said cut-off valve are all assembled into a single valve structure which comprises a casing having first through fifth working chambers, the first working chamber being communicated with a vacuum generating area of the engine, the second working chamber being communicated with the atmosphere, the third working chamber being communicated with the air jacket, the fourth working chamber being communicated with the atmosphere through said relief valve and the air source, and the fifth working chamber being communicated with the reaction chamber of the reactor through the exhaust system, a piston rod having one end situated within the second working chamber and rigidly connected with a diaphragm member partitioning between said first and second working chambers, said diaphragm member being normally urged to a first position by a compression spring, and the other end situated within said third working chamber and rigidly connected with a first valving member of the size sufficient enough to close said third working chamber, said first valving member being formed with a hole adapted to communicate between said fourth working chamber and said third working chamber, a second valving member slidably mounted on said piston rod within said third working chamber and normally urged to the first valving member by a compression spring so as to close said hole of said first valving member, a rigid member partitioning between said fourth and fifth working chamber and formed with a hole of the diameter smaller than that of said first valving member which is adapted to communicate between said fourth and fifth working chambers, a third valving member disposed within said fifth working chamber and normally urged to said rigid member by a compression spring so as to close said hole, whereby, when the piston rod is in the other position and the pressure of the air supplied from the air source to said fourth working chamber is of the value lower than the resiliency of said second mentioned compression spring, the air in the fourth working chamber can be supplied to the reaction chamber pushing the third valving member against the third mentioned compression spring and in part to the relief valve and, when the piston rod is in said other position and the pressure of the air supplied from the air source to said fourth working chamber is of the value sufficient enough to overcome the resiliency of said second mentioned compression spring, the air in the fourth working chamber can be in part supplied to the air jacket through the hole of the first valving member and then the third working chamber, in part to the relief valve and in part to the reaction chamber through the fifth working chamber, provided that the latter can be achieved only when the pressure of that portion of the air in the fourth working chamber is of the value sufficient enough to overcome the resiliency of the second mentioned compression spring, and, when said piston rod is in the first position, said hole of said rigid member can be closed by said first mentioned valving member so that the air supplied to the fourth working chamber can be in part supplied to the air jacket through the third working chamber and in part to the relief valve.

23. An exhaust gas purifying installation for an internal combustion engine comprising:

an air source for supplying air under pressure,

a thermal reactor including a cooling air jacket surrounding a shell which defines therein a reaction chamber in which reduction of the amount of noxious compounds present in the exhaust gas can be effected by re-burning said exhaust gas,

cooling air line means connected between said air source and said cooling air jacket for supplying cooling air to said cooling air jacket,

and cooling air control means interposed in said cooling air line means for controlling the amount of cooling air supplied to said cooling air jacket,

said cooling air control means including a cooling air control device for controlling the flow of cooling air in said cooling air line means as a function of an engine operating condition and a thermo valve connected in series with and between said cooling air control device and said cooling air jacket, said thermo valve including means for controlling the flow of cooling air therethrough as a function of the temperature of at least one of the engine and the exhaust system of the engine.

24. An exhaust gas purifying installation for an internal combustion engine comprising:

an air source for supplying air under pressure,

a thermal reactor including a cooling air jacket surrounding a shell which defines therein a reaction chamber in which reduction of the amount of noxious compounds present in the exhaust gas can be effected by re-burning said exhaust gas,

cooling air line means connected between said air source and said cooling air jacket for supplying cooling air to said cooling air jacket, cooling air control means interposed in said cooling air line means for controlling the amount of cooling air supplied to said cooling air jacket,

wherein said cooling air control means includes a metering valve and a positive relief valve arranged in said cooling air line means in parallel flow relationship with one another,

wherein said metering valve includes means for varying the flow of air therethrough as a function of at least one engine operating parameter, wherein said positive relief valve is closed at low engine speeds such that said metering valve effectively controls the cooling air flow to said cooling air jacket during low engine speed operation,

wherein said positive relief valve is opened in response to engine speeds above a predetermined value such that substantially the whole amount of cooling air supplied by the air source is supplied as cooling air to said cooling air jacket irrespective of the position of said metering valve, and

a non-return valve interposed between said cooling air jacket and said parallely disposed metering and positive relief valves for preventing the backflow of cooling air from said cooling air jacket to said metering and positive relief valves and said air source.

25. An installation according to claim **24,** wherein said at least one engine operating parameter controlling said metering valve includes engine operating speed.

26. An exhaust gas purifying installation for an internal combustion engine comprising:

an air source for supplying air under pressure,

a thermal reactor including a cooling air jacket surrounding a shell which defines therein a reaction chamber in which reduction of the amount of noxious compounds present in the exhaust gas can be effected by re-burning said exhaust gas,

cooling air line means connected between said air source and said cooling air jacket for supplying cooling air to said cooling air jacket,

cooling air control means interposed in said cooling air line means for controlling the amount of cooling air supplied to said cooling air jacket,

wherein said cooling air control means includes a metering valve and a positive relief valve arranged in said cooling air line means in parallel flow relationship with one another,

wherein said metering valve includes means for varying the flow of air therethrough as a function of at least one engine operating parameter, wherein said positive relief valve is closed at low engine speeds such that said metering valve effectively controls the cooling air flow to said cooling air jacket during low engine speed operation,

wherein said positive relief valve is opened in response to engine speeds above a predetermined value such that substantially the whole amount of cooling air supplied by the air source is supplied as cooling air to said cooling air jacket irrespective of the position of said metering valve, and

a thermo valve interposed between said cooling air jacket and said parallely disposed metering and positive relief values for controlling the flow of cooling air therethrough as a function of the temperature of at least one of the engine and the exhaust system of the engine.

27. An installation according to claim **26,** further comprising a relief valve in said cooling air line means between said air source and said parallely disposed metering and positive relief valves for exhausting cooling air to atmosphere when the pressure supplied from said air source exceeds a predetermined value.

28. An installation according to claim **24,** further comprising a relief valve in said cooling air line means between said air source and said parallely disposed metering and positive relief valves for exhausting cooling air to atmosphere when the pressure supplied from said air source exceeds a predetermined value.

29. An installation according to claim **24,** further comprising a thermo valve interposed between said non-return valve and said parallely disposed metering and positive relief valves for controlling the flow of cooling air therethrough as a function of the temperature of at least one of the engine and the exhaust system of the engine.

30. An installation according to claim **29,** further comprising a relief valve in said cooling air line means between said air source and said parallely disposed metering and positive relief valves for exhausting cooling air to atmosphere when the pressure supplied from said air source exceeds a predetermined value.

31. A system as claimed in claim **4,** wherein said secondary air supply means includes a secondary air controlling device for controlling the flow of the secondary air in response to an engine condition.

32. A system as claimed in claim **13,** wherein said secondary air supply means includes a secondary air control device for controlling the flow of the secondary air therethrough in response to an engine condition.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,812,673 Dated May 28, 1974

Inventor(s) Takumi Muroki and Tomoo Tadokoro

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 16, line 2, which now reads:

"return valve connected between parallely disposed me-"

should read as follows:

"return valve connected between said parallely disposed me- --.

Column 16, line 5, which now reads:

"through of said metering valve and said positive relief"

should read as follows:

-- through at least one of said metering valve and said positive relief --

Column 16, line 6, which now reads:

"valve, from said air jacket to of said metering valve and"

should read as follows:

-- valve, from said air jacket to at least one of said metering valve and --

Signed and sealed this 22nd day of October 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents