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Marsee

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[45] **Apr. 30, 1974**

[54] **EXHAUST RECIRCULATION CONTROL**

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[73] Assignee: **Ethyl Corporation,** Richmond, Va.

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[21] Appl. No.: **304,734**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 228,053, Feb. 22, 1972, which is a continuation-in-part of Ser. No. 157,122, June 28, 1971, abandoned, and a continuation-in-part of Ser. No. 162,853, July 15, 1971, abandoned.

[52] **U.S. Cl.** ..... **123/119 A,** 123/117 A

[51] **Int. Cl.** **F02m 25/06,** F02m 31/08

[58] **Field of Search** ..... 123/119 A, 117 A

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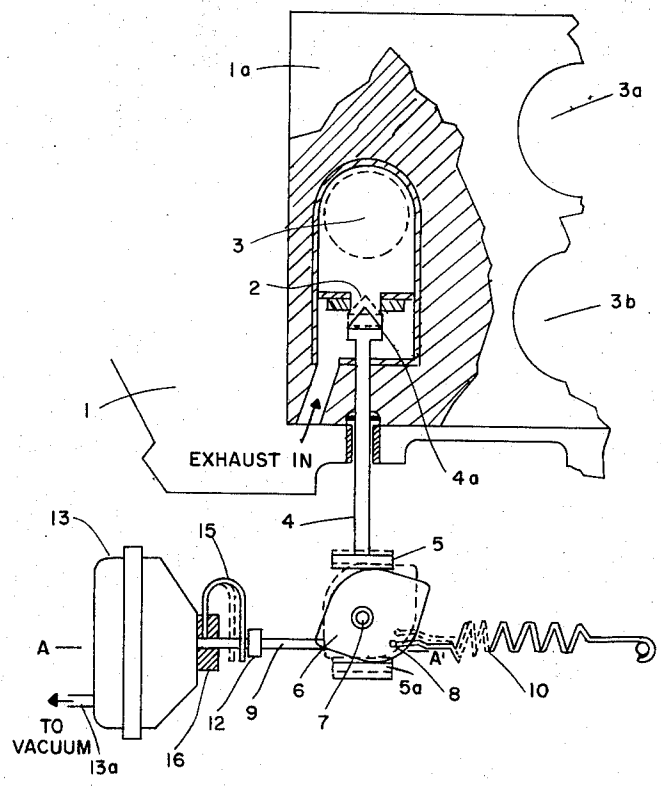
Primary Examiner—Wendell E. Burns

Attorney, Agent, or Firm—Donald L. Johnson; Robert A. Linn

[57] **ABSTRACT**

A system is described for recycling exhaust from the exhaust section of an internal combustion engine through a port in the intake manifold of said engine which features a vacuum controlled, temperature modulated means for metering the recycle exhaust; and this means comprises a valve for opening and closing said port, which is driven by a cam, which is so positioned as to provide rotation and transverse movement of the valve, the cam being actuated in response to a vacuum signal which is engine operating temperature modulated, and to an opposed biasing force.

17 Claims, 7 Drawing Figures



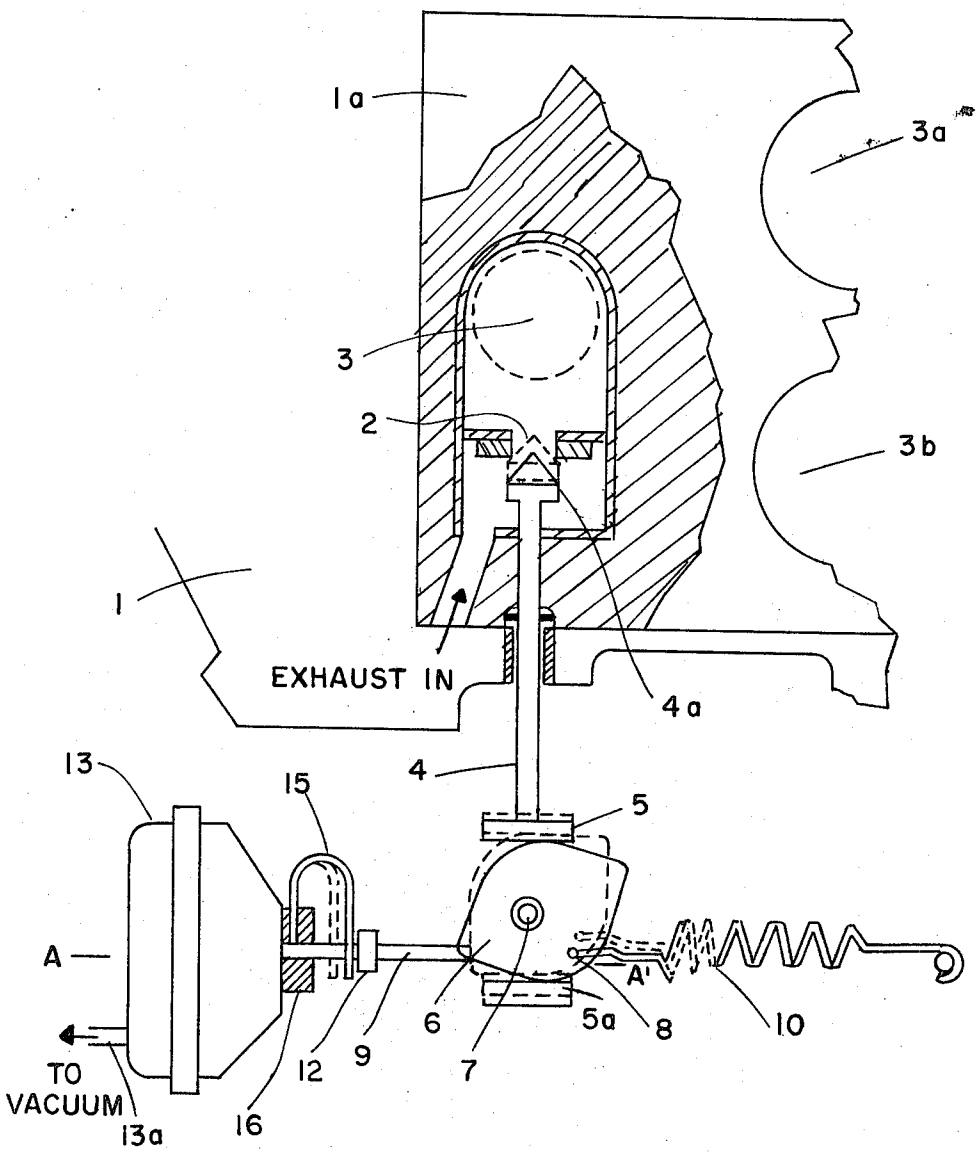

1a
3a
3
2
3b
1
EXHAUST IN
4a
4
13
15
5
A
A'
6
5a
8
10
12
9
7
TO
VACUUM
13a
16

FIGURE 1

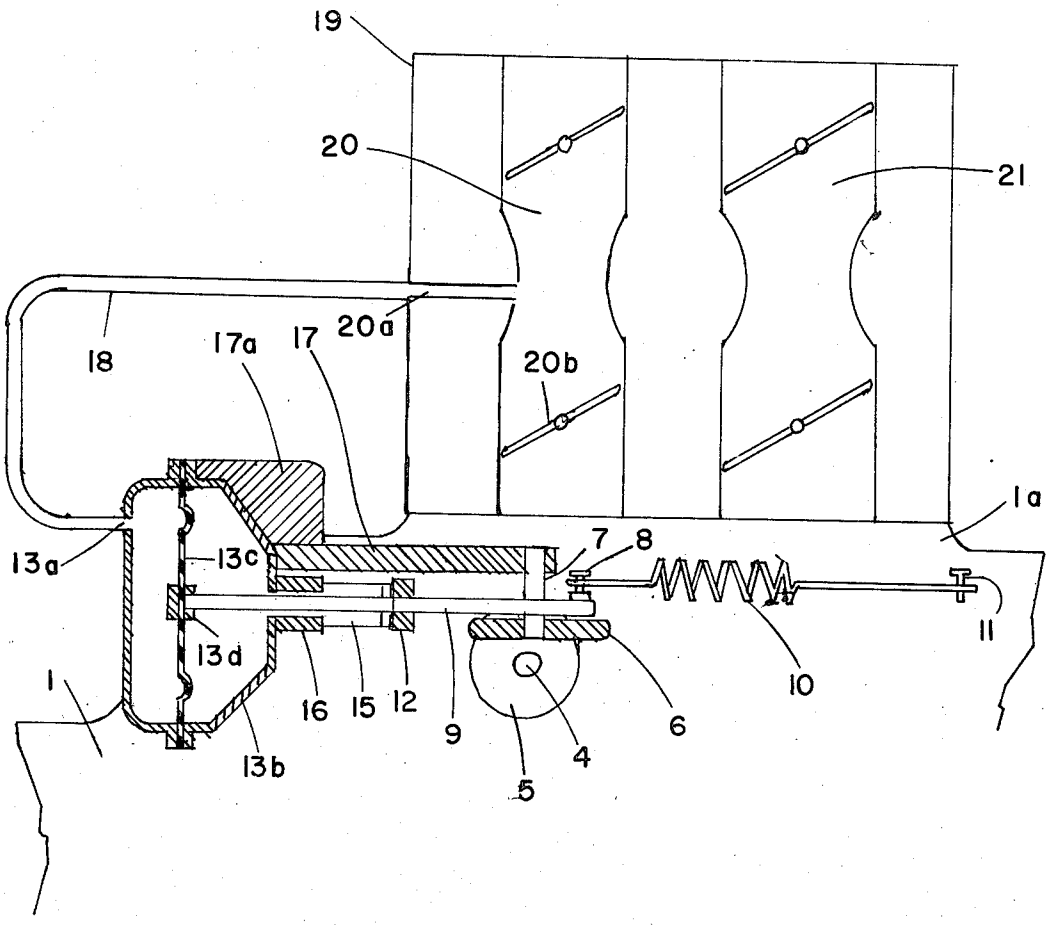

19
20
21
18
17a
17
20a
20b
1a
13a
13c
7
8
11
13d
10
1
16
15
12
9
6
13b
4
5

FIGURE 2

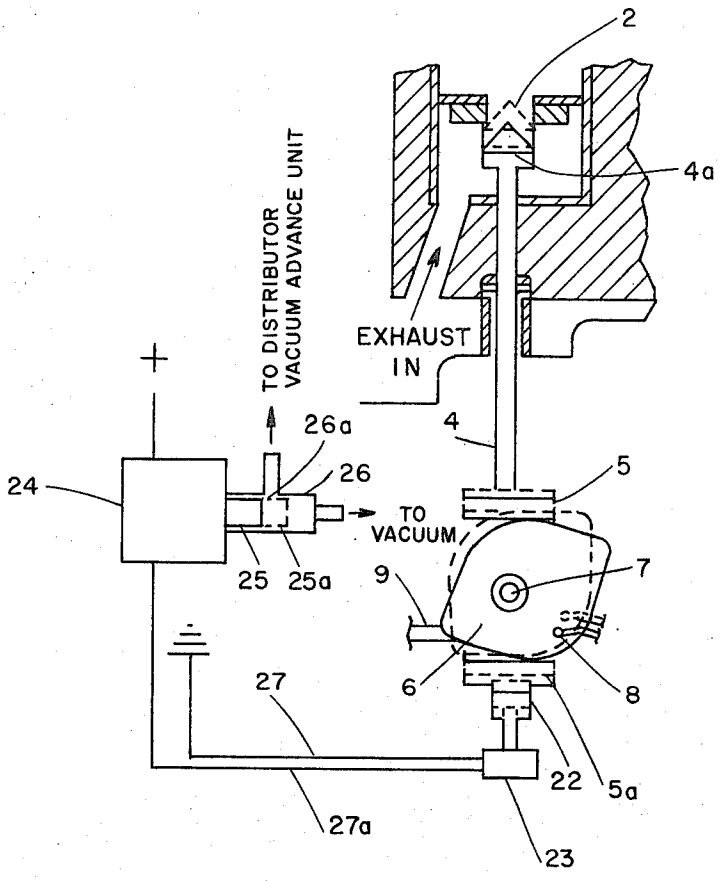

2
4a
TO DISTRIBUTOR
VACUUM ADVANCE UNIT
EXHAUST
IN
+
26a
26
24
4
5
TO
VACUUM
25
25a
9
7
6
8
27
22
5a
27a
23

FIGURE 3

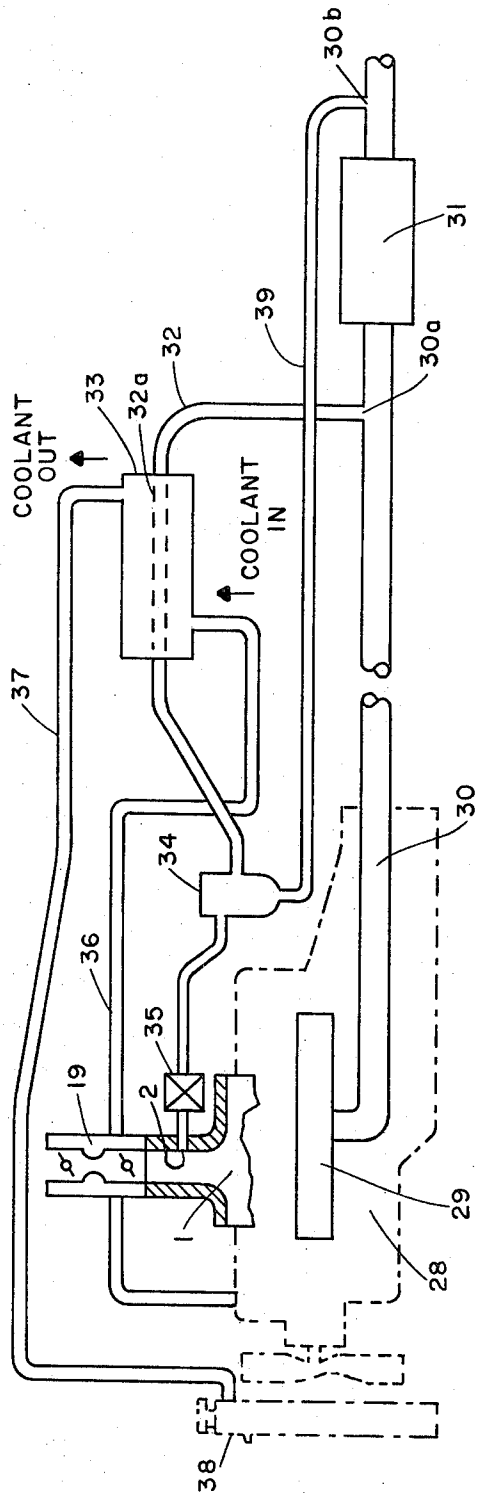

30b
31
39
32
30a
33
32a
COOLANT OUT
COOLANT IN
37
34
30
36
35
19
2
1
29
28
38

FIGURE 4

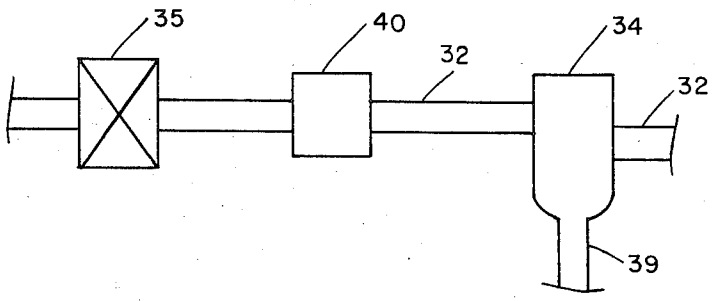


FIGURE 5

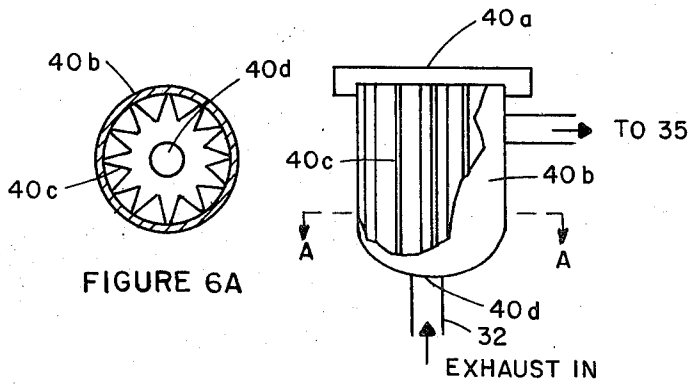


FIGURE 6A

FIGURE 6

EXHAUST RECIRCULATION CONTROL

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a (A) Continuation-in-Part of copending application Ser. No. 228,053, filed Feb. 22, 1972, now abandoned, which in turn is a Continuation-in-Part of Ser. No. 157,122, filed June 28, 1971, now abandoned, and (B) Continuation-in-Part of copending application Ser. No. 162,853, filed July 15, 1971 now abandoned.

BACKGROUND OF THE INVENTION

The subject matter of the present invention is an internal combustion engine modification for improving control of exhaust recycle.

Reduction of nitrogen oxide (NO_x) content of exhaust gases can be achieved by recycling part of the exhaust from an internal combustion engine back into the intake system as part of the fuel/air charge. This can be accomplished by simply providing a conduit from the exhaust system into the intake system of the engine. Various means of controlling the amount of exhaust which is fed into the intake manifold can be utilized. The present invention provides a positive control system which meters the recycle exhaust efficiently, maximizing the NO_x reduction obtained and maintaining good engine performance characteristics. This system utilizes a valve for opening and closing the recycle exhaust port in the intake manifold, featuring a cam control which is responsive to a vacuum signal and engine temperature.

In addition, it has been discovered that by cooling the recycle exhaust (to temperatures between about 150°F. and 250°F.) before it is introduced into the intake system, an additional reduction in nitrogen oxide content of the exhaust is unexpectedly achieved; and an additional benefit is obtained since the cooling device removes other material suspended in the exhaust.

SUMMARY OF THE INVENTION

A control system for metering exhaust from the exhaust section of an internal combustion engine through a port provided in the intake manifold of said engine which comprises a valve positioned to open and close the port, said valve being driven by a cam which is in contact with the valve and so arranged that on actuation the cam rotates the valve and moves it into and out of said port; the cam movement is responsive to (1) a vacuum signal which is engine operating temperature modulated and (2) a biasing force. In a second embodiment, heat exchange means are additionally provided to cool said exhaust.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top view in partial section of a control system of the present invention.

FIG. 2 is a side view partial section of the control system of FIG. 1, through A, A'.

FIG. 3 is a top view of a portion of the FIG. 1 control system with a distributor vacuum advance control.

FIG. 4 is a schematic illustration of an improved exhaust recirculation system of the present invention. The drawing is not to scale.

FIG. 5 is a schematic illustration of one portion of the improved exhaust recirculation system of FIG. 1 with a particulate trap added.

FIGS. 6 and 6A are illustrations in partial section of a type of particulate trap.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A first embodiment of the present invention is a positive control system for recycling exhaust from a spark ignition internal combustion engine into the intake manifold of said engine. A preferred embodiment is a control system for metering exhaust from a spark ignition internal combustion engine into the intake manifold of said engine which comprises in combination,

a. a port in said intake manifold through which said exhaust is introduced,

b. valve means for opening and closing said port,

c. cam means for moving said valve means from fully closed through to fully open position, said cam means being positioned in contact with said valve means so that actuation of said cam means causes simultaneous rotational and transverse movement of said valve means, and

d. cam actuating means for driving said cam means said cam actuating means being responsive to a vacuum signal which is engine operating temperature modulated and to an oppositely directed biasing force such that the response to said vacuum signal causes said cam means to move said valve means toward an open position while the response to said biasing force causes said cam means to move said valve means toward a closed position, whereby the nitrogen oxides content of the exhaust emitted into the atmosphere is reduced.

In another preferred first embodiment, the control system comprising the (a), (b), (c) and (d) combination additionally includes switch means responsive to movement of any of the elements of said combination, said switch means in turn controlling a second valve means which controls vacuum signal to a distributor vacuum advance unit. A distributor vacuum advance unit is a common art-recognized component of spark ignition internal combustion engines.

Although the present control system can be used with any fuel induction system arrangement, for example, fuel injection, it is especially useful where a carburetor-/intake manifold comprises the induction system. The carburetor provides a preferred source for the vacuum signal which actuates the cam controlling the metering valve.

An important feature of the present system is that a cam actuates the valve which controls the amount of exhaust metered into the intake manifold. This cam is so positioned that when it is actuated it not only opens and closes the valve, but it causes the valve to rotate thus effecting a cleaning action; and ensuring better seating and sealing of the exhaust entry port in the intake manifold. This aids in assuring leak-free operation. Actuation of the cam can be achieved by mechanical, electrical, electronic means or by a combination of these.

It is preferred that this novel cam control is actuated in response to a vacuum signal and an opposed biasing force. The vacuum signal acts through a vacuum motor causing the cam to move the metering valve towards the open position while the biasing force acts to cause the cam to move the valve towards the closed position.

While the valve is in an open position, both the biasing force and the vacuum signal are acting simultaneously. When the valve is in the fully closed position, only the biasing force is acting. Another feature of this system is that the vacuum signal acting through the response is engine operating temperature modulated. This is accomplished by positioning a temperature sensitive element, for example, a bimetallic element, in the cam actuating section of the present system. This temperature sensitive element senses and responds to the air temperature above the engine, as a measure of the engine operating temperature and then acts to exert force on the cam actuating means to restrict opening of said valve before the engine has reached operating temperature.

The construction of one embodiment is illustrated in the accompanying drawings. Operating of the system is further understood from a consideration of these drawings.

FIG. 1 illustrates a top view in partial section of a complete control system showing a portion of the intake manifold and the position of the control system relative thereto. In the drawing, the intake manifold **1** is shown having a raised carburetor base portion **1***a* showing three openings (**3** in phantom, **3***a* and **3***b*) over which a three-barrel carburetor would ordinarily be placed. The opening **3** is the opening over which the primary venturi of such a carburetor would be situated. The port **2** in the intake manifold **1** through which exhaust is metered into the intake manifold, is shown in partial sectioned carburetor base portion **1***a*. The port **2** communicates directly with said opening **3.** The head **4***a* of the valve means **4** has two parallel stop elements **5** and **5***a*. The cam **6** is positioned between the two parallel stop elements **5** and **5***a*. The cam **6** has a fastening element **8** to which the control rod **9** and the spring **10** are connected. The spring **10** is attached at its opposite end to a post **11.** The control rod **9** is attached to vacuum operator **13** and has a stop element **12** which contacts the bimetallic element **15.** The vacuum operator **13** receives its vacuum signal via port **13***a*.

The entire control unit assembly, that is, the cam, the vacuum operator, the valve means, etc., is mounted on a portion of the intake manifold using any conventional mounting means; only a portion **16** of the mounting means is shown in FIG. **1.** This vacuum signal can be obtained from the intake manifold, from a port in the primary venturi of a carburetor, or from a combination of both of these sources.

In operation, when no vacuum signal is fed to the vacuum operator **13,** the spring **10** maintains the valve means with the head **4***a* in the closed position. This closed position is illustrated in FIG. **1** in phantom. When a vacuum signal is fed to the vacuum operator **13** the control rod **9** causes the cam **6** to pivot on axle **7** against the valve closing action of the spring **10** causing the valve head to rotate and move away from port **2** to an open position. The valve means, spring, and cam elements in the open position are shown in full view in the Figure.

The movement of the control rod **9** in response to a vacuum signal is engine operating temperature modulated by means of the bimetallic element **15.** The full view of bimetallic element **15** illustrates its position when the engine is cold. Under this engine condition then, the bimetallic element **15** partially counteracts the movement of the control rod **9** in response to a vacuum signal since this element **15** is engaged by stop **12** mounted on said control rod **9.** In effect, by retarding the opening of port **2** when the engine is cold, the tendency of the engine to stall due to excess exhaust dilution of the fuel/air charge, is effectively reduced. When the engine has warmed sufficiently the bimetallic element **15** moves to the position shown in phantom and has little modulating effect on the control system. Thus, without the engine operating temperature modulation feature, the efficiency of engine operation, especially on starting when the engine is cold, is significantly improved.

FIG. **2** shows a side view of the FIG. **1** system through section A, A'. In addition to the elements shown in FIG. **1,** FIG. **2** shows the construction of the vacuum operator **13** comprising the housing **13***b*, the diaphragm **13***c*, and the fastening element **13***d* which holds the control rod **9** to the diaphragm **13***c*. A carburetor **19** is schematically illustrated in position on the exhaust manifold base **1***a*. The schematic illustration shows the primary barrel **20** and one secondary barrel **21** of the carburetor **19.** The Figure also shows a preferred source of the vacuum signal for the vacuum operator **13.** This is schematically shown in the Figure as a conduit **18** leading from the port **13***a*, in the vacuum operator housing **13***b*, to a vacuum port **20***a* in the primary barrel **20** in the venturi portion of the barrel above the throttle blade **20***b*. Although the schematic illustration is of a three-barrel carburetor, the system can be used with any carburetor design. It is also useful with a fuel injection system, provided that an intake manifold is also part of such a system.

FIG. **2** also shows additional structural and mounting elements **17** and **17***a*, not shown in FIG. **1.**

FIG. **2** shows the control assembly elements when the exhaust control valve is in the closed position (illustrated in phantom in FIG. **1**) when the engine is cold.

To further improve the effectiveness of this exhaust recirculation control system, a switch arrangement is also provided to control the distributor vacuum advance unit. By providing such an ancillary control, recycle of the exhaust is ensured when the engine is operating under highest NO_x producing conditions. FIG. **3** illustrates one such switching control arrangement. This distributor vacuum advance ancillary control is made up of a switch **23,** connected to a solenoid **24** which actuates a valve **25** (or **25***a*) in the conduit **26** through which vacuum is supplied to the distributor vacuum advance unit (not shown). This ancillary control system is arranged so that when switch **23** is in the open position, the solenoid **24** maintains the valve in position **25***a*, closing port **26***a* and preventing vacuum signal from acting on the advance unit; and when switch **23** is in the closed position, solenoid **24** maintains the valve in position **25** thus allowing vacuum signal to act on the advance unit. As FIG. **3** illustrates, opening and closing of the solenoid control valve **25** is accomplished by positioning a switch actuator **22** adjacent to the stop element **5,** so that the actuator **22** does not contact the stop element **5** when no exhaust is being recycled (position of stop element **5** in phantom); but when stop element **5** moves to the position shown by the solid line drawing to permit exhaust to be recycled, actuator **22** is contacted by stop element **5** and is moved to close switch **23,** thus causing the solenoid **24** to move valve to the **25** position permitting

vacuum to act on the distributor advance unit. The wiring circuit for the system is illustrated by lines **27** and **27***a*.

Although the switch actuator **22** is positioned to be responsive to the movement of the stop element **5** the actuator **22** can be positioned or linked to any portion of the exhaust recycle control system which will effect an analogous movement of the actuator **22.** For example, the actuator could be made responsive to movement of the control rod **9** or the flexible return means **10.**

The switch **23** is shown as an electrical switch. Other switch means, e.g., mechanical switch, vacuum switch, and combinations of such switch means can also be used.

The exhaust which is metered into the intake manifold may be obtained from any portion of the exhaust system of the engine. It is preferred, however, that the exhaust be obtained at a point downstream of the exhaust manifold and more preferably that it be obtained from the exhaust pipe at a point upstream of the muffler (as will be described below). Although the cam valve drive arrangement used in the present control system features rotational movement of the valve to effect a cleaning action which improves the sealing characteristics of the valve, a coating of a fluorinated hydrocarbon resin, for example, Teflon, applied to the valve head and/or the recycle exhaust port area, further enhances the sealing characteristics of the valve.

As pointed out above, recycling a portion of the exhaust from an internal combustion engine into the intake section of said engine effects noticeable reduction in nitrogen oxides content of the exhaust as it finally is emitted into the atmosphere. The first embodiment of the present system for metering this recycle exhaust offers the following advantages: it is a relatively simple unit; it offers positive control which is responsive to an engine vacuum signal; it provides a novel cam control which effects a valve cleaning action which helps prevent recycle exhaust leakage; and by including engine operating temperature modulation of the vacuum signal response, the tendency of the engine to stall caused by excess exhaust recycle on cold starting of the engine is reduced.

In a second embodiment, the recirculation control system is provided with a heat exchange device for cooling the exhaust which is to be recirculated. In a preferred second embodiment, a condensate trap is provided downstream of said heat exchange device. It a most preferred second embodiment, the heat exchange device utilizes engine coolant as the heat exchange medium. A most preferred second embodiment of this invention is illustrated in FIG. **4,** which is considered in more detail below.

In FIG. **4,** an engine **28** (in phantom) is shown having an induction system comprising an intake manifold **1,** a carburetor **19,** and an exhaust system comprising an exhaust manifold **29,** an exhaust pipe **30,** and a muffler **31.** Although not shown, the exhaust system may also include catalytic converters, afterburners, and the like between the exhaust manifold **29** and the muffler **31.** The exhaust for recirculation is obtained through an opening **30***a* in the exhaust pipe **30** upstream of said muffler **31,** and is carried through conduit **32** into the exhaust manifold **29** through opening **2** below said carburetor **19.** The recirculation exhaust conduit **32** is provided with a heat exchange device **33,** a condensate trap **34** downstream of said heat exchange device **33** and a metering device **35,** which is illustrated in FIGS. **1, 2** and **3.** The heat exchange device **33** utilizes engine coolant as the heat exchange medium. Engine coolant flows from the engine **28** through conduit **36** into the heat exchange device **33** and the coolant is returned via conduit **37** to the radiator **38** (in phantom). Although a separate liquid heat exchange medium and circulating system could be provided, use of engine coolant and circulation system is convenient, simple, and economical.

If desired, an air cooled heat exchange device, e.g., a finned tube construction, could be utilized in place of the liquid cooled jacketed heat exchange device **33.** Combinations of air cooled and a liquid cooled heat exchange device might also be used. Although the size or capacity of the heat exchange device is not critical, it should be of sufficient size to permit cooling the exhaust gas to temperatures between about 150°F. and 250°F. and preferably between about 170°F. to about 185°F.

In addition the section **32***a* of conduit **32** which passes through the heat exchange device **33** is shown to be a straight tube. It is advantageous to provide some baffling within this section **32***a* in order to effect a turbulent, mixing action, thus improving the efficiency of the heat exchange device. Various baffle arrangements to accomplish this are available. A baffle system which has maximum mixing efficiency and minimum back pressure effect is preferred. An especially useful baffle configuration is described in U. S. Pat. No. 3,286,992.

The condensate trap **34** can be of any conventional design. As FIG. **4** shows, it is preferred that this condensate trap **34** be physically located behind and below said heat exchange device **33.** In this way, if any condensate forms in the **32***a* portion of the conduit within the heat exchange device **33,** then it can freely flow via conduit **32** down into the trap **34.** The condensate which is collected in trap **34** is bled via conduit **39** into the exhaust pipe **30** through opening **30***b* downstream of said muffler **31** to be discharged into the atmosphere. This condensate is principally water. Although conventional direct drainage of the condensate can be utilized, the novel arrangement illustrated in FIG. **4** is preferred since it offers the advantage of being positive and continuous.

The schematic illustration of FIG. **4** shows the exhaust for recirculation to be obtained at a point **30***a* in the exhaust pipe **30** upstream of said muffler **31.** It is preferred to obtain exhaust for recirculation at this point. However, the exhaust for recirculation can be obtained from any point in the exhaust system as desired. Thus, for example, exhaust for recirculation could be obtained from the exhaust manifold **29** or any other point along the exhaust pipe **30.** By obtaining the exhaust for recirculation further down the exhaust system (e.g., as in FIG. **4**) two advantages are realized — (1) the initial exhaust temperature is lower, and (2) there are fewer suspended materials in the exhaust. Since the exhaust is cooler to begin with, a lower capacity heat exchange device can be utilized; and since fewer suspended materials are in the exhaust, there is less possibility of clogging small openings and valve in the system, such as those which might be found in the metering device (e.g., element **35** in FIG. **4**).

Although FIG. 4 shows a condensate trap 34 in the system, this trap is not a required element. It provides the benefit of removing most of the condensate from the recycle exhaust stream; but it is essentially the cooling of the exhaust and not the lowered condensate content which effects the unexpected additional lowering of NO_x emissions.

With regard to the suspended material in this recirculated exhaust, the heat exchange device used in the present system has also been found to trap more of the suspended materials. This further reduces deposit formation in the portion of the exhaust recycle system downstream from the heat exchange device.

Although the heat exchange system illustrated in FIG. 4 does effect removal of a portion of suspended particulate matter from the exhaust which is recirculated, it is advantageous to remove substantially all of this particulate matter to minimize engine wear problems. This is conveniently accomplished by placing particulate trap means in the present system. This particulate trap means may be of any suitable design or configuration and may be positioned anywhere in the system at or downstream from the opening 30*a* in FIG. 4, the point at which exhaust gas is obtained from the exhaust system. However, a most preferred placement of the particulate trap means is that illustrated in FIG. 5. In FIG. 5, particulate trap means 40 is positioned near the metering device 35 and downstream from the condensate trap 34. Placing the particulate trap means 40 in this location, offers a number of important advantages. One advantage is that the particulate trap means 40 will be more efficient and effective because it takes advantage of the aforesaid particulate removal effected by the downstream portion of the exhaust recirculation cooling system. Another advantage is that the exhaust flowing to particulate trap means 40 is relatively cool and also substantially free from condensate (which is principally water) — consequently, said particulate trap means 40 can be a simple filter means having a filter element made of common, inexpensive, readily available filter construction material, e.g., glass wool, fiber glass, paper, other cellulosic materials and the like. Finally, by positioning the particulate trap means 40 as shown in FIG. 5, that is, near the metering device 35, the particulate trap means is readily accessible for maintenance.

FIG. 6 illustrates a type of simple filter means which is useful as a particulate trap means. This filter means comprises a body 40*b* which has a removable cover 40*a*. This body 40*b* contains a filter element 40*c* which is shown as a fluted, cellulosic material. This filter element is replaceable. The exhasut enters through conduit 32 into the body 40*b*, through filter element 40*c*, then out opening 40*d* to the metering device 35 (not shown). FIG. 6A is a section through the FIG. 6 filter means showing the approximate disposition of the elements within the FIG. 6 filter means. The filter means illustrated in FIG. 6 is readily serviced by removing cap 40*a* and replacing the filter element 40*c*. The filter element 40*c* can be made of any suitable material of construction. Many materials are known or are readily suggested to those skilled in the art and need not be described in any detail here.

If the cooling system does not have a condensate trap 34 as illustrated in FIGS. 4 and 5, filter means can still be used as particulate trap means 40 and is preferably positioned near the metering device 35.

The addition of particulate trap means and especially a simple filter in the present exhaust recirculation system has been shown to be an economical and effective way to reduce wear in certain engine areas, e.g., the timing gear section.

In order to demonstrate the effectiveness of the second embodiment of the present recirculation system on NO_x emissions, an 8-cylinder, V-8 spark ignition internal combustion engine having a carburetor/intake manifold induction system, insulated exhaust manifold and exhaust ports as described in U. S. Pat. No. 3,577,727, was provided with an exhaust recirculation system as illustrated in FIG. 1, but without a heat exchange device, particulate trap means or a condensate trap. The carburetor used was of the type disclosed in my copending application Ser. No. 157,087, filed June 28, 1971; the recycle metering device used was the device of the first embodiment disclosed above. The NO_x emissions for this engine were determined according to the 1970 Federal Test Procedure for Emissions Determination using a leaded gasoline fuel. The temperature of the exhaust as it entered the intake manifold was between 400°F. and 800°F.

The exhaust recirculation system of the engine was then modified by providing a heat exchange device as illustrated in FIG. 4, again without the condensate trap. The temperature of the exhaust as it entered the intake manifold was about 180°F. The NO_x emissions were then determined for the engine using the same leaded fuel and the Federal Test Procedure. The NO_x emissions for this engine (which was equipped with a heat exchange device) were 10°/o lower then the NO_x emissions from the engine when no heat exchange device was provided. In addition, on dismantling the heat exchange device, it was found that particulate matter suspended in the exhaust had also been trapped therein. Thus, by providing a heat exchange device to cool the exhaust which is recirculated into the intake system of an engine (1) there is a substantial lowering of NO_x emissions from the engine, and (2) there is an additional removal of suspended particulates from the exhaust.

Claims to the invention follow.

I claim:

1. Control system for metering exhaust from a spark ignition internal combustion engine into the intake manifold of said engine which comprises in combination, elements

a. a port in said intake manifold through which said exhaust is introduced,

b. valve means for opening and closing said port,

c. cam means for moving said valve means from fully closed through to fully open position, said cam means being positioned in contact with said valve means so that actuation of said cam means causes simultaneous rotational and transverse movement of said valve means, and

d. cam actuating means for driving said cam means, said cam actuating means being responsive to a vacuum signal which is engine operating temperature modulated and to an oppositely directed biasing force such that the response to said vacuum signal causes said cam means to move said valve means toward an open position while the response to said biasing force causes said cam means to move said valve means toward a closed position,

whereby the nitrogen oxides content of the exhaust emitted into the atmosphere is reduced.

2. The control system of claim **1** wherein said engine utilizes a carburetor to provide air/fuel mixture to said manifold and said vacuum signal is obtained from the primary venturi section of said carburetor.

3. The control system of claim **2** wherein said engine operating temperature modulation is accomplished using a bimetallic element.

4. The control system of claim **2** wherein said biasing force is applied using an elastic means.

5. The control system of claim **4** wherein said elastic means is a spring.

6. The control system of claim **1** wherein the portion of said port where said valve means seats has a fluorinated hydrocarbon resin coating.

7. The bontrol system of claim **1** wherein the portion of said valve means which seats in said port has a fluorinated hydrocarbon resin coating.

8. The control system of claim **1** wherein said combination additionally has switch means responsive to movement of any of the elements of said combination, said switch means being in turn linked to a second valve means which controls vacuum signal to a distributor vacuum advance unit.

9. The control system of claim **8** wherein said switch means is responsive to the transverse movement of said valve means.

10. The control system of claim **9** wherein said second valve means is a solenoid.

11. The control system of claim **1** additionally provided with heat exchange means upstream from said port to lower said exhaust temperature to between about 150°F. and 250°F.

12. The control system of claim **1** wherein a particulate trap is provided downstream from said heat exchange means.

13. The control system of claim **12** wherein a condensate trap is provided between said heat exchange means and said particulate trap.

14. The control system of claim **13** wherein said heat exchange means utilizes engine coolant as the heat exchange medium and the temperature is between about 170°F. and 180°F.

15. The control system of claim **14** wherein said particulate trap is a filter means.

16. The control system of claim **15** wherein said filter means uses a replaceable filter element.

17. The control system of claim **16** wherein said filter element is a cellulosic composition.

* * * * *