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Croft et al.

[11] **3,814,069**

[45] **June 4, 1974**

[54] **INLET MANIFOLDS**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.**.... **123/52 M**, 123/119 R, 123/139 AW, 123/142, 123/52 MF

[51] **Int. Cl.** **F02m 23/04**, F02m 13/04

[58] **Field of Search** ..... 123/142, 139 AW, 52 M, 123/52 MF, 52 MU, 119 R

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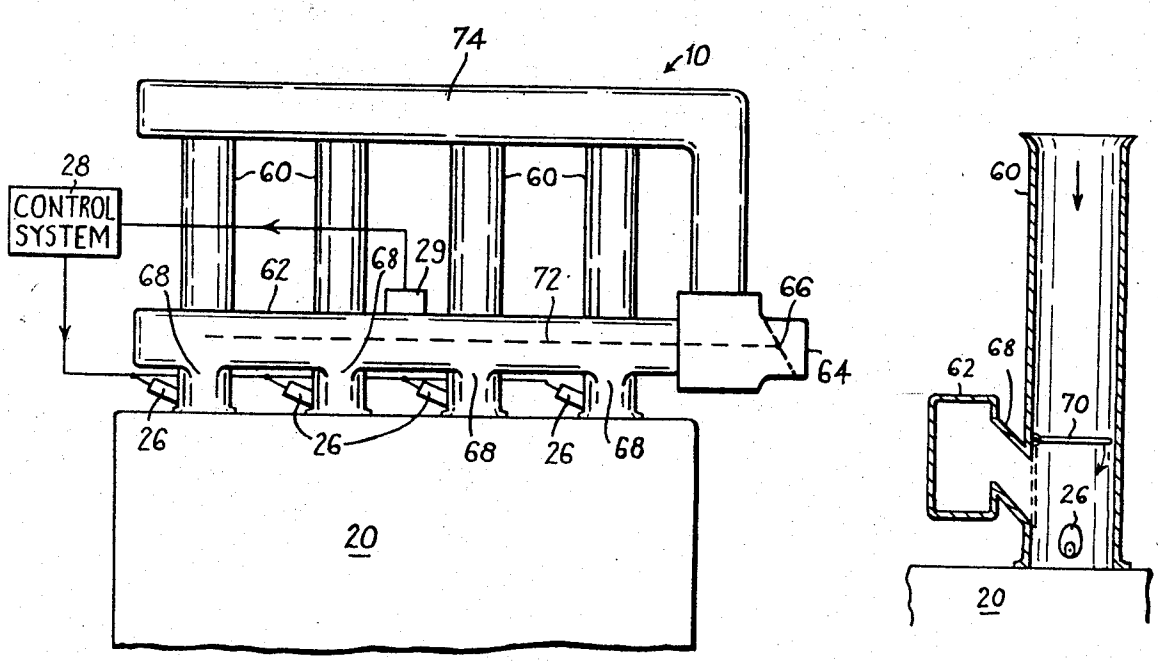
Primary Examiner—Wendell E. Burns

Attorney, Agent, or Firm—Brisebois & Kruger

[57] **ABSTRACT**

An inlet manifold for a multi-cylinder internal combustion engine comprises a plenum chamber which has an inlet containing at least one throttle valve and which has a plurality of outlet ducts each adapted to communicate with a respective cylinder of the engine via an inlet valve of the engine. A further valve is associated with each outlet duct which, in use, operates to control the flow of gas through that outlet duct under at least part of the range of operation of the throttle valve which controls the operation of the engine. The further valves may be respectively located in the outlet ducts, or alternatively may be respectively located in ram pipes which are connected one to each outlet duct.

3 Claims, 8 Drawing Figures



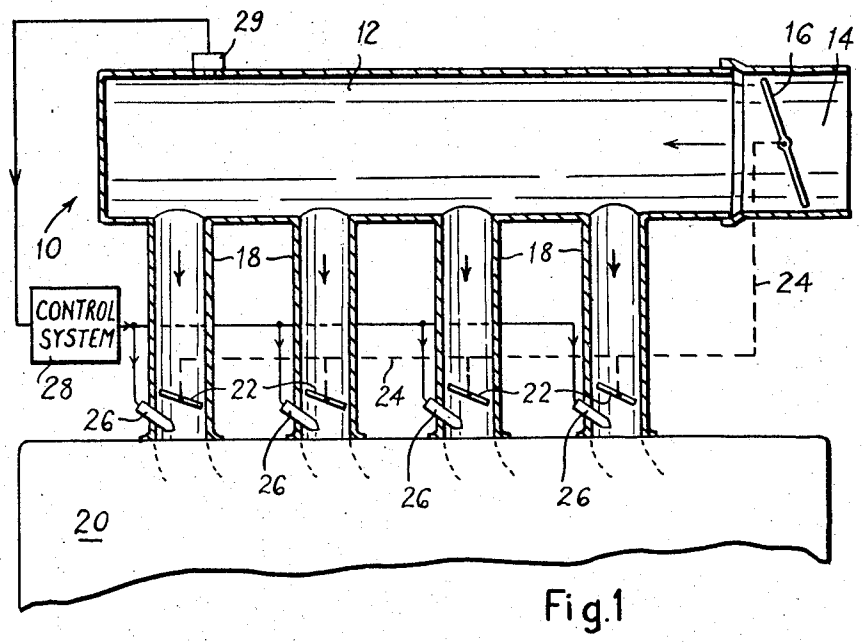

29
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CONTROL SYSTEM
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Fig.1

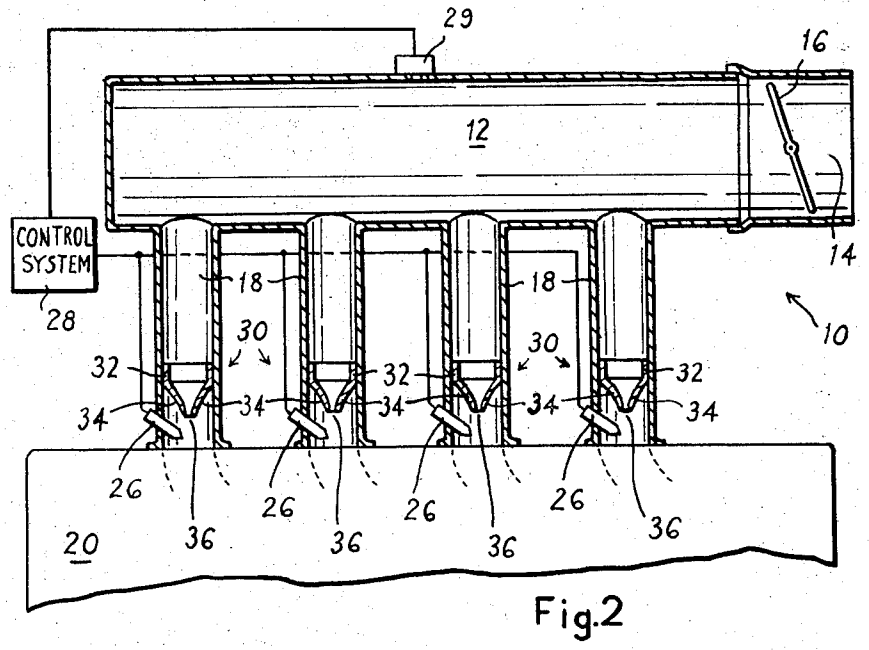

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Fig.2

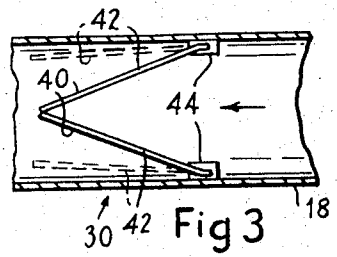


Fig 3

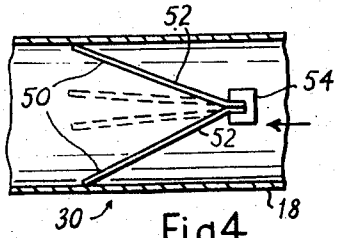


Fig.4

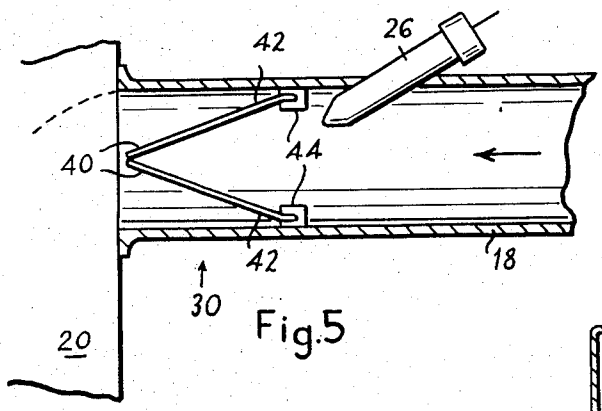


Fig.5

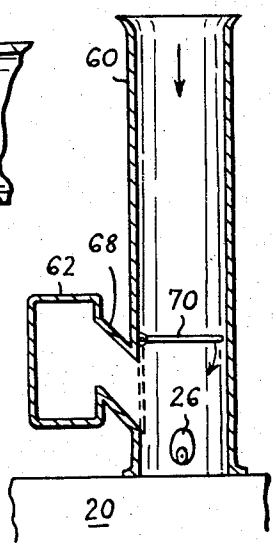


Fig.7

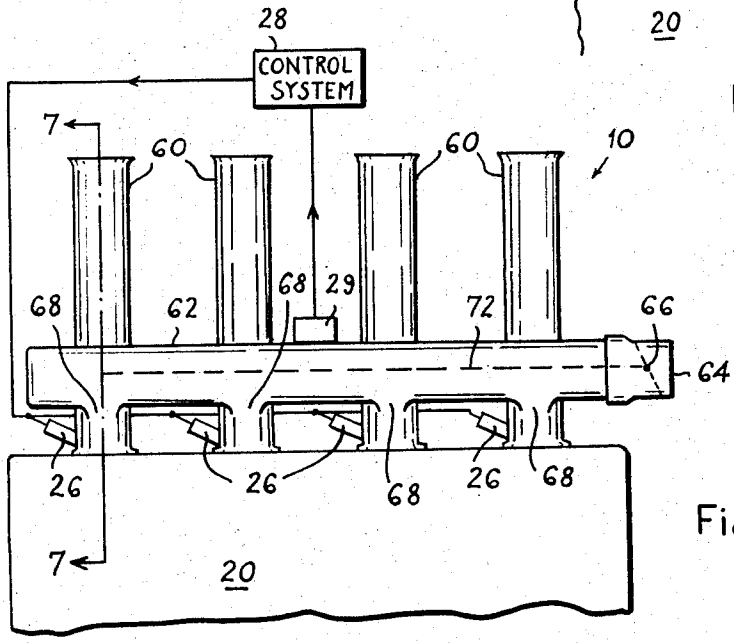


Fig.6

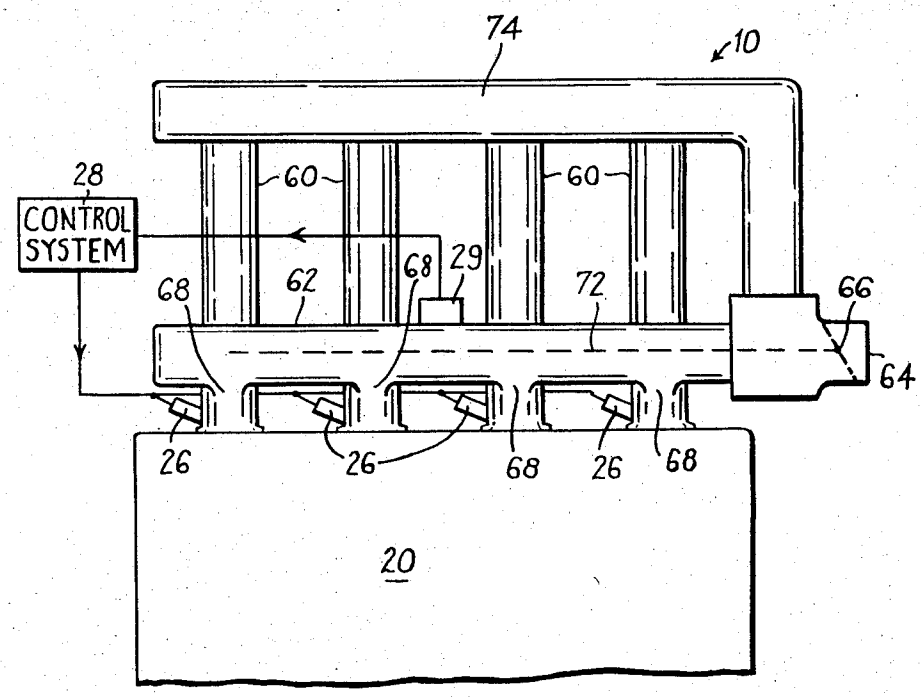


Fig.8

INLET MANIFOLDS

This invention relates to inlet manifolds for multi-cylinder internal combustion engines, particularly but not exclusively multi-cylinder internal combustion engines in which the fuel is injected into the inlet manifold just upstream of each inlet valve.

In high performance multi-cylinder internal combustion engines, there is normally a requirement that the inlet valve or valves in each cylinder should start to open before the exhaust valve or valves in the cylinder have fully closed. At low inlet manifold pressures, therefore, it is possible that exhaust gas may flow into the inlet manifold, where it mixes with and dilutes the incoming charge. This reduces combustion efficiency, which in turn leads to increased exhaust emissions (i.e. of pollutants) and reduced engine stability.

According therefore to one aspect of the present invention, an inlet manifold for a multi-cylinder internal combustion engine comprises a plenum chamber which has an inlet containing at least one main throttle valve and which has a plurality of outlet ducts each adapted to be connected to a respective cylinder of the engine, each outlet duct containing, adjacent the downstream end thereof, a respective further valve which, in use, offers a low flow resistance to gas flowing from the plenum chamber to the respective inlet valve of the engine but offers a high flow resistance to gas flowing towards the plenum chamber from the respective inlet valve of the engine, at least at low manifold pressures.

The main throttle valve conveniently comprises a butterfly valve pivotally mounted in said inlet.

In one embodiment of the invention, each further valve comprises a respective further butterfly valve which is arranged to be slightly open when the main throttle valve is closed or substantially closed and which is arranged to open fully over the first small portion (e.g. one quarter) of the opening movement of the main throttle valve.

Thus each further valve may be mechanically connected to the main throttle valve, or may be connected to be opened by means responsive to manifold pressure or engine rotational speed.

In an alternative and preferred embodiment of the invention, each further valve comprises a respective check valve.

Each check valve preferably comprises at least one movable flap member mounted in its respective outlet duct and movable, in response to the direction of the gas flow in the outlet duct, from a position in which the outlet duct is substantially blocked to a position in which the outlet duct is relatively unobstructed. Thus there may be two movable flap members substantially equiangularly disposed on opposite sides of the axis of the outlet duct and which are secured to the outlet duct adjacent their upstream ends. The respective upstream ends of the two flap members may be disposed on substantially opposite sides of the outlet duct in a plane substantially perpendicular to said axis: alternatively, they may both be disposed in a plane passing through said axis.

The or each flap member may be relatively flexible and rigidly secured to its outlet duct, or relatively stiff and flexibly secured to its outlet duct, or relatively flexible and flexibly secured to its outlet duct.

The or each flap member may be made of rubber or plastics material, or may be made from metal, for example spring steel.

Where the engine is adapted to operate with fuel injection into the inlet manifold, each fuel injector may be mounted in a respective outlet duct of the inlet manifold either downstream of the check valve or, preferably, immediately upstream of the check valve.

According to another aspect of the present invention, an inlet manifold for a multi-cylinder internal combustion engine comprises a plurality of ram pipes each adapted to be connected to a respective cylinder of the engine, and a relatively small plenum chamber which has an inlet containing a main throttle valve and which has a plurality of outlets each connected to a respective ram pipe adjacent the downstream end thereof, each ram pipe containing a respective secondary throttle valve which is arranged to move, as the engine approaches full load operation, from a first position in which its ram pipe is substantially blocked and the outlet from the manifold to the ram pipe is substantially open to a second position in which its ram pipe is substantially open and the outlet from the manifold to the ram pipe is substantially blocked.

Each secondary valve is preferably mechanically connected to the main throttle valve.

The upstream ends of the ram pipes may communicate with a further, relatively large, pleunm chamber which in turn communicates with the inlet containing the main throttle valve.

The invention also comprises a multi-cylinder internal combustion engine provided with an inlet manifold in accordance with any of the preceding statements of invention.

The invention will now be described, by way of non-limitative example only, with reference to the accompanying drawings, of which:

FIG. 1 is a diagrammatic representation of one embodiment of an inlet manifold in accordance with the present invention, fitted to a fuel-injected four cylinder internal combustion engine for a road vehicle;

FIG. 2 is a diagrammatic representation of another embodiment of an inlet manifold in accordance with the present invention, for use with the engine of FIG. 1;

FIGS. 3 and 4 are alternative forms of part of the inlet manifold of FIG. 2;

FIG. 5 shows one position for a fuel injection valve in the inlet manifold of FIG. 2;

FIG. 6 is a diagrammatic representation of a yet further embodiment of an inlet manifold in acordance with the present invention, for use with the engine of FIG. 1;

FIG. 7 is a section on the line 7—7 of FIG. 6; and

FIG. 8 shows a modification of the embodiment of FIGS. 6 and 7.

The inlet manifold 10 of FIG. 1 comprises a plenum chamber 12 having an air inlet 14 which is connected to receive filtered air from an air filter (not shown) and which contains a main throttle butterfly valve 16 for controlling the amount of the air flowing into the plenum chamber 12. The position of the throttle valve 16 is in turn controlled by the driver of the vehicle. The plenum chamber 12 has four circularsection outlet ducts 18 in the form of tuned ram pipes, which communicate with the respective inlet valves of the four cylinders of the engine 20.

Each duct **18** contains a respective further butterfly valve **22** at or adjacent the downstream end thereof, i.e. just upstream of the respective inlet valve of the engine **20.** Each of the butterfly valves **22** is mechanically connected to the main throttle valve **16** by a linkage indicated diagrammatically at **24.** The arrangement of the linkage **24** is such that when the main throttle valve **16** is closed or substantially closed, each butterfly valve **22** is slightly open, and when the main throttle valve **16** starts to open, each butterfly valve **22** opens fully over the first few degrees of movement of the main throttle valve **16.**

The engine **20** is provided with a fuel injection system which includes four electromagnetically operable fuel injection valves **26** which are positioned, one in each outlet duct **18,** immediately downstream of the respective butterfly valve **22.** The fuel injection valves **26,** which may for example be described in United Kingdom Pat. No. 1,064,679, are connected to be supplied with fuel at substantially constant pressure, for example as described in United Kingdom Pat. No. 1,038,541. The timing and duration of the opening periods of the fuel injection valves **26,** and hence the quantity of fuel supplied to the engine, are controlled in dependence upon engine operating parameters such as inlet manifold pressure, rotational speed and coolant temperature by an electronic control system **28,** which may be as described in United Kingdom Patent. No. 1,107,989. The electronic control system **28** is connected to receive as a control signal, inter alia, a signal which is indicative of inlet manifold pressure and which is produced by a pressure transducer **29** connected to the plenum chamber **12.**

In operation, the valve timing of the engine **20** is such that there is valve overlap, i.e. the inlet valve on each cylinder starts to open before the exhaust valve on the cylinder has fully closed. Thus when the engine **20** is idling, i.e. the main throttle valve **16** is closed or substantially closed, the pressure in the inlet manifold **10** is relatively low and there is a tendency for the exhaust gas in each cylinder to flow back into its respective outlet duct **18** during the valve overlap period. However, the butterfly valves **22** are only slightly open, the amount of the opening being chosen to offer a low flow resistance to the small relatively steady flow of idling air towards the engine but a high flow resistance to the short, fast "puffs" of exhaust gas trying to flow back through the inlet valves. The amount of exhaust gas which enters the inlet manifold **10** to dilute the incoming charge is thus substantially reduced, which in turn improves combustion efficiency and engine stability and reduces exhaust emissions.

At engine speeds substantially above idling, e.g. speeds above 1500–2000 R.P.M., the pressure in the inlet manifold **10** increases, and the problem is not so severe: the butterfly valves **22** are therefore arranged to open fully over the first few degrees, e.g. over the first quarter, of angular movement of the main throttle valve **16.**

The embodiment of the invention shown in FIG. **2** is very similar to the embodiment of FIG. **1,** so in the description which follows the same reference numerals will be used where appropriate and only the points of difference will be described. Thus in the FIG. **2** embodiment of the invention, the butterfly valves **22** and their associated linkage **24** of the FIG. **1** embodiment are replaced by respective automatic check valves **30** mounted in each outlet duct **18** adjacent the downstream end thereof.

The check valves **30** shown in FIG. **2** are each moulded in one piece from a suitably temperature resistant natural or synthetic rubber and each comprise an annular portion **32** which is bonded or otherwise suitably secured to the internal surface of its respective outlet duct **18.** Two converging flap members **34** are substantially equiangularly disposed on opposite sides of the axis of the outlet duct **18** and extend in a downstream direction from diametrically opposed parts of the annular portion **32.** The flap members **34** are joined together at their sides so as to form a tapering nozzle terminating in a slit-like aperture **36** almost equal in width to the diameter of the outlet duct **18.**

In operation, the check valves **30** offer a very low flow resistance to gas flowing through the outlet ducts **18** towards the inlet valves of the engine **20,** since the flexibility of the rubber flap members **34** permits them to separate in response to the pressure exerted on their internal surfaces by the flow, so distorting the slit-like aperture **36** to a relatively large approximately circular shape. However, gas flow in the opposite direction i.e. from the inlet valves of the engine **20,** is strongly resisted, since it acts on the external surfaces of the rubber flap members **34** to urge them into contact with each other, so substantially closing the slit-like aperture **36** and blocking the outlet duct **18.** The check valves **30** thus affect exhaust emissions and engine stability in a manner similar to that described with reference to FIG. **1,** but are more effective than the valves **22,** over a wider range of pressures in the inlet manifold **10,** by virtue of the fact that they substantially completely block the reverse flow of exhaust gases into the inlet manifold **10.**

An alternative form for the check valves **30,** suitable for use when the outlet ducts **18** are substantially rectangular in cross-section, is shown in FIG. **3,** and comprises a pair of substantially rectangular flap members **40** which are substantially equal in width to the width of their outlet duct **18** and made of spring steel or plastics material such as that available under the trade name "TUFNOL" (Registered Trade Mark). The flap members **40** are substantially equiangularly disposed on opposite sides of the axis of the outlet duct **18** and converge in a downstream direction, and their upstream ends **42** are flexibly secured in respective rubber blocks **44** bonded to opposite sides of the outlet duct **18:** it will be appreciated, however, that if the flap members **40** are sufficiently flexible, their ends **42** may be directly secured to opposite walls of the outlet duct **18** and the rubber blocks **44** may be omitted.

In operation, the flap members **40** are easily urged apart so as to open their respective outlet ducts **18** in response to gas flow towards the inlet valve of the engine **20,** but are urged into contact with each other so as to substantially close their respective outlet duct **18** in response to gas flow from the inlet valve of the engine **20.**

In FIG. **4** there is shown a further alternative form for the check valve **30,** again, suitable for use in outlet ducts **18** of substantially rectangular cross-section. The check valve **30** of FIG. **4,** however, comprises a pair of flap members **50** which are individually similar to the flap members **40** of FIG. **3** but whose upstream ends **52** are flexibly secured in a common rubber block **54** which extends across the middle of the outlet duct **18**

normal to the axis thereof. The flap members **50** are still substantially equiangularly disposed on opposite sides of the axis of the outlet duct **18,** but diverge in a downstream direction. In this embodiment, the flap members **50** are easily urged towards each other in the centre of the outlet duct **18,** so as to open it, by gas flowing towards the inlet valve, but are respectively urged into contact with opposite sides of the outlet duct **18,** so as to substantially close it, by gas flowing from the inlet valve.

If desired, the block **54** can be replaced by a pivot pin (not shown) to which each flap member **50** is pivotally secured, the flap members **50** then being urged apart by a light torsion spring. Alternatively, if the flap members **50** are sufficiently flexible, their upstream ends **52** may be directly secured to a transverse pin normal to the axis of the outlet duct **18.**

In general the flap members **40** and **50** of FIGS. **3** and **4** may be relatively flexible and rigidly secured, or relatively stiff and flexibly secured, or relatively flexible and flexibly secured, within the outlet duct **18.**

In the embodiments of the invention described with reference to FIGS. **2, 3** and **4,** the fuel injection valves **26** are shown positioned immediately downstream of their respective check valves **30.** However, in these embodiments, particularly the FIG. **3** embodiment, it may be advantageous to position the fuel injection valves **26** just upstream of their respective check valves **30** as shown in FIG. **5.** In this case, the timing of the instant of opening of each injection valve **26** becomes less significant (as long as it is before the instant that air starts to flow through the respective check valves **30**), since the injected fuel will collect on the upstream side of the check valves **30,** between the flaps **34, 40** or **50,** until the check valves **30** open. Further, the flow of air past the flaps **34, 40** or **50** when the check valves **30** open tend to cause them to vibrate rapidly, which vibration assists good atomisation of the fuel.

Referring now to FIGS. **6** and **7,** the inlet manifold **10** shown therein comprises four tuned ram pipes **60** each communicating with a respective inlet valve of the four cylinders of the engine **20.** The upstream ends of the ram pipes **60** are open to atmospheric pressure. The ram pipes **60** are joined together by a relatively small plenum chamber or balance pipe **62** which has an air inlet **64** containing a main throttle butterfly valve **66** and which has four outlets **68** each connected to a respective one of the ram pipes **60** adjacent the downstream end thereof. The inlet **64** is connected to receive filtered air from an air filter (not shown).

Each ram pipe **60** contains, adjacent the respective outlet **68,** a respective further valve **70** which is connected to the main throttle valve **66** by a linkage indicated diagrammatically at **72.** The arrangement of the linkage **72** is such that as the main throttle valve **66** approaches its fully open position, e.g. when the engine is operating at about 90 percent of its full load, each of the valves **70** moves from a first position in which it substantially blocks the ram pipe **60** and opens the outlet **68** to a second position in which it substantially blocks the outlet **68** and opens the ram pipe **60.** Thus at part engine loads, air is supplied to the engine **20** via the main throttle valve **66** and the small plenum chamber **62,** while at full load air is supplied to the engine **20** directly via the ram pipes **60.**

The engine **20** is provided with a fuel injection system substantially identical to that described with reference to FIG. **1,** the fuel injection valves **26** being positioned in the ram pipes **60** immediately downstream of the outlets **68,** and the pressure transducer **29** being connected to the small plenum chamber **62.**

Since the volume of the plenum chamber **62** is relatively small, the tendency of the exhaust gas to flow back into it during the valve overlap period, at part engine loads, is reduced, which leads to the reduced exhaust emissions and improved engine stability already mentioned. At full engine load, however, the plenum chamber **62** would restrict the amount of air entering the engine **20,** whereas the ram pipes **60** offer little restriction and permit full engine power to be developed readily.

The upstream ends of the ram pipes **60** can each be provided with respective coarse filters (not shown) to prevent the ingress of small stones and similar debris. Alternatively, as shown in FIG. **8** they may all be connected to a further, relatively large plenum chamber **74** incorporating an air filter and silencer (not shown) arranged in parallel with the plenum chamber **62**: in this case the inlet **64** would be enlarged and would serve as the inlet for both plenum chambers.

It will be appreciated that many modifications may be made to the described embodiments of the invention. For example, the check valves **30** of FIGS. **3** and **4** could readily be adpated for use in circular-section ducts, while the butterfly valves **22** of FIG. **1** and the check valves **30** of FIG. **2** would readily be adapted for use in rectangular-section ducts. Also, both the linkage **24** of FIG. **1** and the linkage **72** of FIGS. **6** and **7** could be replaced by a suitable automatic device which operates the respective valves **22** or **70** in response to e.g. a predetermined manifold pressure or range of manifold pressures, or a predetermined engine rotational speed or range of rotational speeds. Moreover, if desired more than one main throttle butterfly valve **16** (or **66**) may be provided. Finally, the inlet manifolds of the present invention are not only applicable to fuel injected engines: they can be modified for use with multi-cylinder internal combustion engines having one or more carburettors.

We claim:

1. An inlet manifold for a multi-cylinder internal combustion engine comprising a plurality of ram pipes each adapted to be connected to a respective cylinder of the engine, and a relatively small plenum chamber which has an inlet containing a throttle valve and which has a plurality of outlets each connected to a respective ram pipe adjacent the downstream end thereof, each ram pipe containing a further valve which is arranged to move, as the engine approaches full load operation, from a first position in which its ram pipe is substantially blocked and the outlet from the plenum chamber to the ram pipe is substantially open to a second position in which its ram pipe is substantially open and the outlet from the plenum chamber to the ram pipe is substantially blocked.

2. An inlet manifold as claimed in claim **1,** wherein the upstream ends of the ram pipes communicate with a further, relatively large, plenum chamber which in turn communicates with said inlet containing the throttle valve.

3. An inlet manifold as claimed in claim **1,** for use with an engine adapted to operate with fuel injection into the inlet manifold, wherein a fuel injector is mounted in each outlet duct of the inlet manifold downstream of the further valve.

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