Aug. 17, 1954 K. V. ANDERSON 2,686,398

ROTATING VALVE FOR SEPARATING HIGH AND LOW PRESSURE EXHAUST GASES

Filed Oct. 29, 1952 3 Sheets-Sheet 1

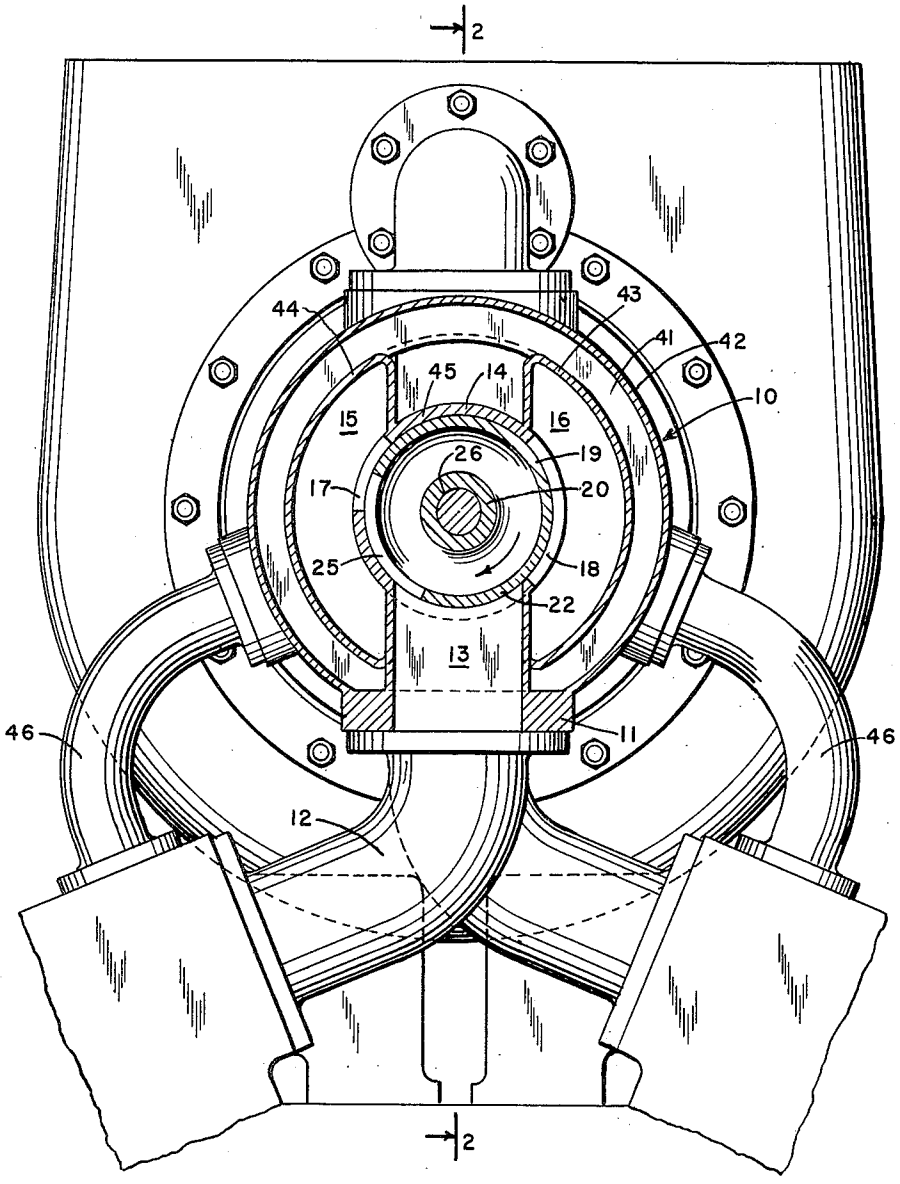


FIG. 1.

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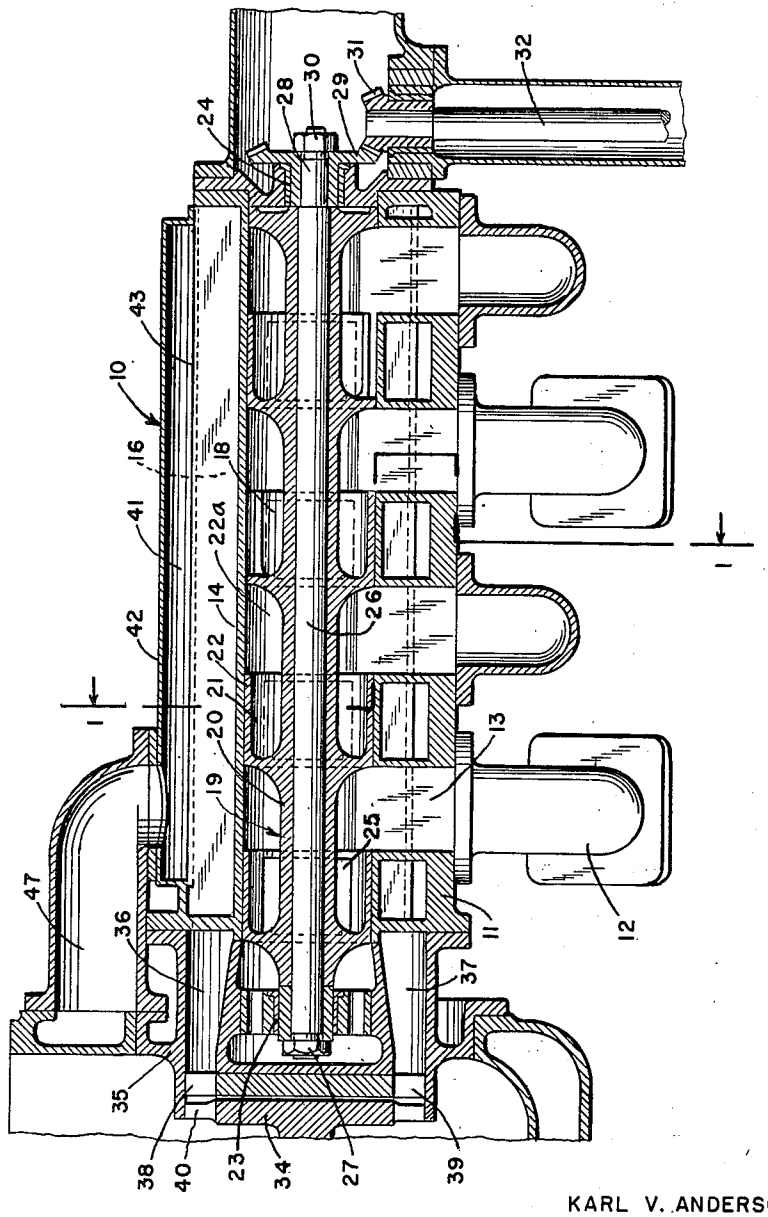


FIG. 2.

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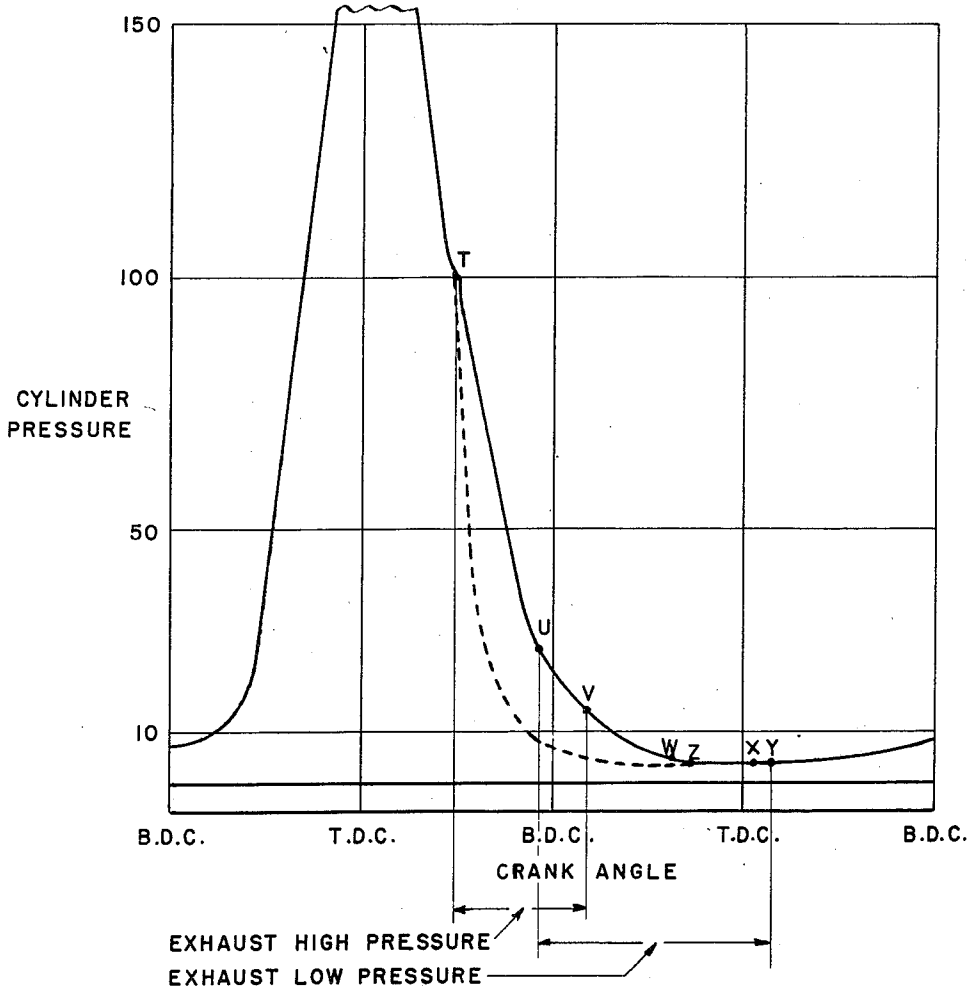


FIG. 3.

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ROTATING VALVE FOR SEPARATING HIGH AND LOW PRESSURE EXHAUST GASES

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8 Claims. (Cl. 60—13)

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This invention relates to exhaust manifolds for internal combustion engines, and particularly to that class of manifolds which conducts the exhaust gases to the turbine wheel of a turbocharger.

In conventional manifolds, the risers from the engine cylinders generally open into a single or multiple pipe system which permits free communication among all of the risers or at least among several of them. Such an arrangement is objectionable since the exhaust gases collected in the manifold from all the cylinders present a back pressure to each exhausting cylinder which prevents proper scavenging thereof. Furthermore, pressure waves are generated by the exhaust gases in the manifold which are reflected back through the risers to the engine cylinders to interfere with scavenging.

The main object of this invention, therefore, is to provide an exhaust manifold for a multicylinder internal combustion engine which minimizes back pressure and prevents reflected waves from interfering with the scavenging operation of all of the cylinders. Another object is to provide such a manifold which, in addition to achieving the foregoing results, provides for the utilization of all the available energy of the exhaust puff to drive the supercharger turbine.

Another object is to provide such a manifold having two separate conductors leading the exhaust gases to the turbine, said conductors being controlled by a valve so that the leading or high pressure portion of each exhaust puff is received by one conductor and the trailing or low pressure portion of the puff is received by the other conductor, such valve being so designed that the exhaust gases from each of the cylinders is isolated from the other cylinders so as not to interfere with the scavenging operation of such other cylinders. Still another object is to provide such a manifold which includes a timed rotary valve adapted (*a*) to distribute the first or high pressure portion of each exhaust puff into one conductor in such manner that back pressure and reflected waves are prevented from reaching any of the other power cylinders, and (*b*) to distribute the later or low pressure portion of the puff free of the high pressure effects into a second conductor, both conductors being adapted to supply pressure to the supercharger turbine. Still another object is to provide such a manifold, which achieves the objects last mentioned, and also allows a portion of the scavenging air to pass out of the power cylinder into the low pressure conductor to impinge upon the turbine to cool it.

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

In the drawings:

Fig. 1 is a cross section through the manifold taken on line 1—1 of Fig. 2.

Fig. 2 is an elevation cross section taken on line 2—2 of Fig. 1; and,

Fig. 3 is a graph of the cylinder pressure illustrating the valve operation.

Referring now to Fig. 1, the manifold of the invention is illustrated as applicable to a V-type four-stroke cycle engine having four power cylinders. It may, however, be designed for in-line engines, or for two-stroke cycle engines, or for engines having more or fewer cylinders. The manifold comprises a cylindrical housing, generally indicated as 10, which extends substantially the full length of the engine and has a bottom flange 11 at its foot for securement to the flanged exhaust risers 12 of the engine. Extending upwardly from the flanges into the housing are a plurality of passages 13 leading into a cylindrical center collector 14 which extends substantially the full length of the apparatus. Secured to the opposite sides of the collector and extending the full length thereof are two gas conductors 15 and 16 which are arcuate in cross section, as best shown in Fig. 1. In each of the lateral sides of the wall of the collector 14 is a series of four longitudinally spaced ports, one series 17 providing communication between the collector and conductor 15 at four places and the other series 18 providing communication between the collector and conductor 16 at four places. Each of the ports 18 is disposed approximately opposite one of the ports 17. The ports 18 are larger than ports 17, having approximately twice their cross sectional area in the embodiment shown.

Arranged within the collector 14 is a rotary distributing valve, generally indicated as 19, comprising a central cylindrical body 20 having spaced cup portions 21 thereon (see Fig. 2). The outside wall 22 of each cup portion has a close rotary sliding fit with the collector 14 so that the valve forms four separate compartments 22*a* in the collector 14. Valve 19 is mounted at its ends in bearings 23 and 24 and is provided with a series of four longitudinally spaced openings 25. Each of the openings 25 is so arranged that, as the valve rotates, it is brought progressively into registration with a port 17 and a port 18. Openings 25 are disposed angularly at 90° from each other around the periphery of valve 19.

Obviously engines of other than four cylinders would require different angular displacement of the openings 25. Disposed within valve body 20 and extending its entire length is a driving shaft 26, the left end of which, as viewed in Fig. 2, is threaded for the reception of nut 27 and the right end of which is formed with a reduced portion 28 upon which is mounted a bevel gear 29. Shaft 26 is conventionally secured to the body 20 by means not shown to rotatably drive the latter. Nut 30, by a conventional key, maintains the gear in mounted position. Meshed with gear 29 is a second bevel gear 31 mounted upon shaft 32 which is rotated by the engine cam shaft by connecting means not shown. Shaft 32 is so geared to the cam shaft that the R. P. M. of valve 19 is one half the R. P. M. of the engine crankshaft. Hence, in a four-stroke cycle engine, the valve openings 25 are brought into registration with each of the ports 17 and 18 once for each exhaust stroke. Obvious changes in construction may be made to provide for valve rotation equal to engine crankshaft speed in case the manifold should be applied to a two-stroke cycle engine.

Upon the forward end of the housing 10 (the left end as viewed in Fig. 2), there is mounted a header 35 having two ducts 36 and 37, arcuate in cross section, which register with conductors 16 and 15 respectively to connect the conductors with nozzles 38 and 39. These nozzles each include substantially half the turbine circumference and are separated from one another. Means are thus provided to direct the exhaust gases from conductors 15 and 16 into impingement upon the blades 40 of the turbine 34 which serves to actuate the supercharger. The jacket 41, which is defined by housing wall 42, the outer walls 43 and 44 of conductors 16 and 15, and by wall portion 45 of collector 14 carries cooling water which is supplied through inlet pipes 46 and which is drawn off by outlet pipes 47. Such cooling means is resorted to in order to maintain the wall of collector 14 at a temperature low enough to prevent seizure of the rotating distributing valve 19.

Referring again to Fig. 1, it is seen that the valve is so timed that the exhaust puff from the engine cylinder passes up riser 12, through passage 13 into the compartment 22*a* and into the cup portion 21 of the distributing valve 19. The first or high pressure portion of the puff escapes into conductor 15 since opening 25 and port 17 are in communication. The valve rotates clockwise, as viewed in Fig. 1, and its speed of rotation is such that the puff is cut off after its first or high pressure portion enters conductor 15. Then, as the valve continues its rotation, opening 25 overlaps port 18 and the remaining or low pressure portion of the puff escapes into conductor 16 over a longer period of time. Also, by such rotation, the valve cuts off passage of gas into conductor 15. The construction of the valve, including the cup portion 21, is such that each puff is segregated from communication with the other risers and hence the cylinders. Back pressure on the other cylinders of the engine is thus avoided. A slight simultaneous overlap of opening 25 with both ports 17 and 18 is preferred to avoid pressure build-up in the compartments 22*a*. That is, opening 25 registers with port 18 slightly before it moves out of registry with port 17.

In Fig. 3 there is shown by the solid line a pressure curve for a single cylinder of a four-stroke cycle multi-cylinder engine equipped with a manifold of the invention, such curve being plotted to show the cylinder pressure in relation to the crank angle. Hereafter this curve is referred to as the "invention curve." Superimposed on this invention curve is the pressure curve for a similar cylinder equipped with a conventional multi-piped manifold. This curve is indicated by the dotted line, except where it coincides with the solid line of the invention curve. Hereafter this curve is referred to as the "conventional curve." In the first quarter section of the chart, the invention curve shows the pressure rise which takes place during the compression stroke. In the second quarter section of the chart, the curve indicates that the pressure continues to rise after the piston has passed top dead center and begins the power stroke. The piston is now descending and the combustion space is expanding so that the pressure drops, as indicated. At point T on the invention curve the engine exhaust valve opens, and the rotary valve 19 brings opening 25 into communication with port 17 to lead the exhaust gases into high pressure conductor 15. It should be here noted that the slope of the curve at this point becomes greater, indicating an increased rate of pressure drop because of the opening of the exhaust valve. At point U on the curve, which is in close proximity to the bottom dead center position of the crank, valve 19 brings opening 25 into communication with port 18 to start exhausting the trailing portion of the exhaust puff into low pressure conductor 16. At point V on the curve valve 19 moves opening 25 out of communication with port 17. The overlap of opening 25 in relation to ports 17 and 18 is indicated on the curve as the distance UV. When port 17 is closed, the leading or high pressure portion of the exhaust puff is trapped in conductor 15 to supply the turbine and is of course isolated from the power cylinder. The invention curve indicates the low pressure in the cylinder. The pressure continues to drop until the engine inlet valve opens for the admission of scavenging air from the supercharger. This occurrence is indicated at point W on the invention curve. Since the exhaust valve is still open to permit the scavenging operation, the scavenging air passes directly through the cylinder. The invention curve then levels off to indicate such condition. In the fourth quarter section, X indicates the point at which the engine exhaust valve closes and at which the engine cylinder pressure begins to rise during the intake stroke. Further on the curve in the fourth quarter, Y indicates the point at which the opening 25 is moved out of communication with port 18 to close off the low pressure conductor 16. It should be here observed that the distance XY on the curve indicates an interval in which the scavenging air passes through the cylinder into low pressure conductor 16. This effects a cooling effect upon the turbine. The remainder of the curve in the fourth quarter section indicates a continuance of the gradual rise in pressure as the cylinder is charged on its intake stroke.

The conventional curve indicates the pressure in the cylinder equipped with a conventional multi-piped manifold and coincides with the invention curve to point T where the exhaust valve opens. Then the conventional curve, as indicated by the dotted line portion, becomes steeper than the invention curve because the turbine equipped with the present invention is designed to maintain a higher pressure in conductor 15 than in the conventional manifold pipe. The conventional curve rejoins the solid line curve at point Z which is close to point W and follows the

same course thereafter throughout the cycle. The space between the two curves in the interval TZ represents the increase in the energy extracted from the exhaust by the present invention.

Thus, the present manifold invention, by the unique separation of each exhaust puff into high and low pressure portions, provides for the extraction of more energy and the diminution of back pressure on the cylinders during scavenging. The cylinders then operate with no interference from each other. The invention, therefore, provides for the generation of more horsepower per unit of fuel.

While there has been hereinbefore described an approved embodiment of this invention, it will be understood that many and various changes and modifications in form, arrangement of parts and details of construction thereof may be made without departing from the spirit of the invention, and that all such changes and modifications as fall within the scope of the appended claims are contemplated as a part of this invention.

What I claim is:

1. An exhaust manifold for a turbo-supercharged multi-cylinder internal combustion engine comprising a collector for receiving the exhaust puffs from each cylinder, a valve within the collector compartmented to segregate the exhaust puffs of one cylinder from the exhaust puffs of the other cylinders, independent high and low pressure conductors intermittently in communication with the collector through said valve, and means to operate said valve to divide each segregated puff into predetermined high and low pressure portions and direct said portions into the corresponding conductors to a point of use.

2. An exhaust manifold for a turbo-supercharged multi-cylinder internal combustion engine comprising a collector for receiving the exhaust puffs from each cylinder, a rotary valve within the collector compartmented to segregate the exhaust puffs of one cylinder from the exhaust puffs of the other cylinders, independent high and low pressure conductors intermittently in communication with the collector through said rotary valve, and means to rotate said valve to divide each segregated puff into predetermined high and low pressure portions and direct said portions into the corresponding conductors to a point of use.

3. An exhaust manifold for a turbo-supercharged multi-cylinder internal combustion engine comprising a cylindrical collector for receiving the exhaust puffs from each cylinder, a rotary valve within the collector compartmented to segregate the exhaust puffs of one cylinder from the exhaust puffs of the other cylinders, independent high and low pressure conductors adjacent said collector, ports in said valve to permit intermittent sequential communication between the collector and conductors, and means to rotate said valve, whereby upon said sequential communication a predetermined portion of each puff is supplied to said high and low pressure conductors successively, said conductors then conducting said predetermined portions to a point of use.

4. An exhaust manifold for a turbo-supercharged multi-cylinder internal combustion engine comprising a collector, separate passages to transmit the exhaust gases from each engine cylinder to the collector, two conductors to receive the exhaust gases from the collector and transmit them to the supercharger turbine, ports in the collector to permit the passage of exhaust gases therefrom into one conductor, ports in the collector to permit the passage of exhaust gases therefrom into the other conductor, and a rotary valve divided into compartments each of which separately receives the exhaust puffs from said separate passages, means to rotate said valve, said valve having an opening in each compartment adapted to register with a port in the first conductor and then with a port in the second conductor to transmit predetermined portions of the exhaust gases to the respective conductors.

5. An exhaust manifold for a turbo-supercharged multi-cylinder internal combustion engine comprising a collector, a rotary valve in the collector divided into a number of compartments equal to the number of engine cylinders, means to admit exhaust gases into each valve compartment, separate passages adapted to separately lead the exhaust gases from each engine cylinder into a valve compartment, an opening in each valve compartment to permit the escape of exhaust gases therefrom, two conductors adjacent the collector to lead exhaust gases to a point of use, a series of ports in the first of the two conductors spaced so that each port registers with a valve compartment opening on each valve rotation, a series of ports in the second of the conductors likewise spaced so that each port registers with a valve compartment opening on each valve rotation, and means to rotate the valve in timed relation to the firing of the cylinders, the arrangement of the elements being such that each cylinder exhaust puff passes through a separate passage into a valve compartment whence a predetermined portion thereof passes through a port into one conductor and then a second predetermined portion thereof passes through a port into the other conductor.

6. An exhaust manifold for a turbo-supercharged multi-cylinder internal combustion engine comprising a cylindrical collector, separate passages adapted to separately lead the exhaust gases from each engine cylinder to the collector, two separate conductors to receive the exhaust gases from the collector to transmit them to the supercharger turbine, a rotary valve in the collector divided into a number of compartments equal to the number of engine cylinders, each of the compartments being adapted to receive the exhaust gases from a separate passage, a series of ports in the first of said conductors, each port being disposed opposite a valve compartment, a series of ports in the second conductor each port being disposed opposite a valve compartment, and a series of openings in the valve, one for each compartment, the arrangement of said ports and openings being such that as the valve rotates, each exhaust puff proceeding from an engine cylinder into the collector is divided by the valve so that a predetermined portion thereof passes through a valve opening and a conductor port into one conductor and a second predetermined portion subsequently passes through said valve opening and a conductor port into the other conductor.

7. An exhaust manifold for a turbo-supercharged multi-cylinder four-stroke cycle internal combustion engine comprising a collector, a rotary valve in the collector divided into a number of compartments equal to the number of engine cylinders, separate passages adapted to separately lead the exhaust puffs from each engine cylinder into a valve compartment, an opening in each compartment to permit the escape of exhaust puffs therefrom, two conductors

adjacent the collector to lead exhaust puffs to a point of use, a series of ports in the first of the two conductors spaced so that each port registers with an opening in a valve compartment on each valve rotation, a series of ports in the second of the conductors likewise spaced so that on each valve rotation each port registers with an opening in a valve compartment, the dimensions of the latter opening being such that its registration with such ports at one time overlap, and means to rotate the valve in timed relation to the firing of the engine cylinders so that predetermined portions of each exhaust puff are supplied to the conductors successively.

8. An exhaust manifold for a turbosupercharged multi-cylinder four-stroke cycle internal combustion engine comprising a collector, independent means to conduct the exhaust puffs from each cylinder to the collector, a rotary valve within the collector, said valve having a compartment for each cylinder, independent high and low pressure conductors adjacent the collector, means to rotate the valve at one-half

engine speed, means in the valve and the conductors to permit successive communication therebetween upon rotation of the valve whereby the exhaust puffs from each cylinder are divided into predetermined high and low pressure portions in their respective conductors and the timing of valve rotation permits the high pressure portion of the cylinder exhaust puff to be out of communication with its cylinder when said cylinder is scavenging.

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