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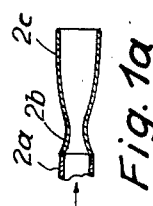
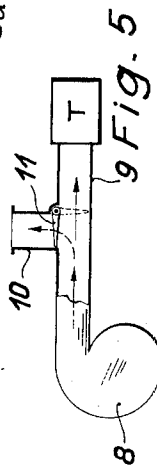
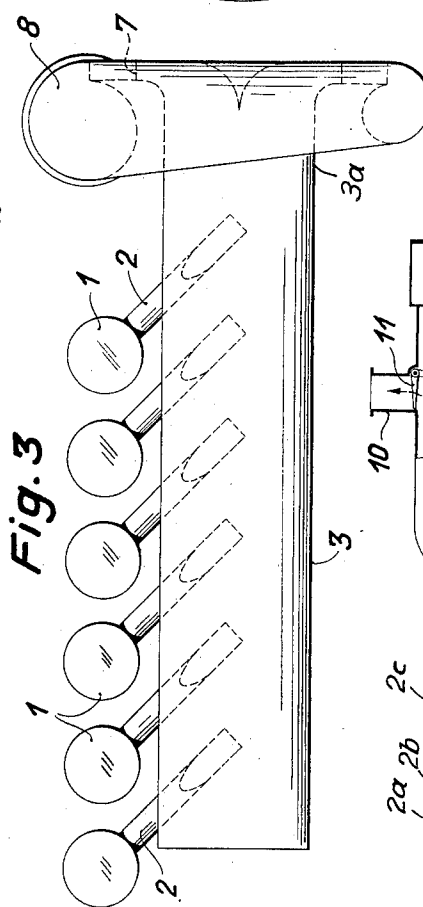
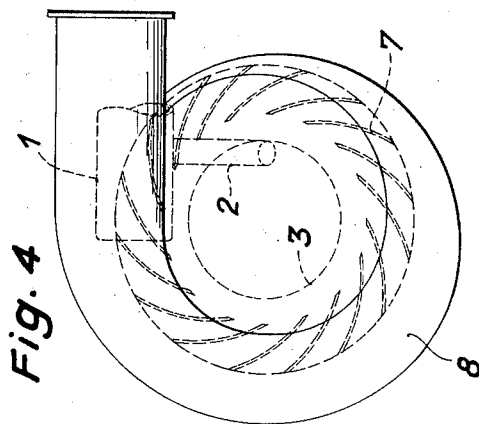
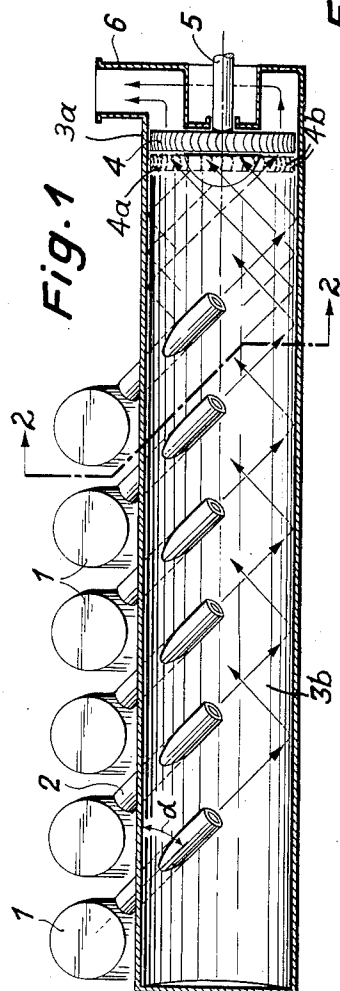
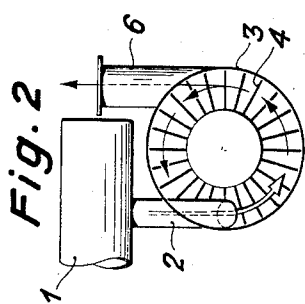
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3,221,492

EXHAUST MANIFOLD SYSTEM FOR INTERNAL COMBUSTION ENGINES

Filed Sept. 16, 1963

2 Sheets-Sheet 1



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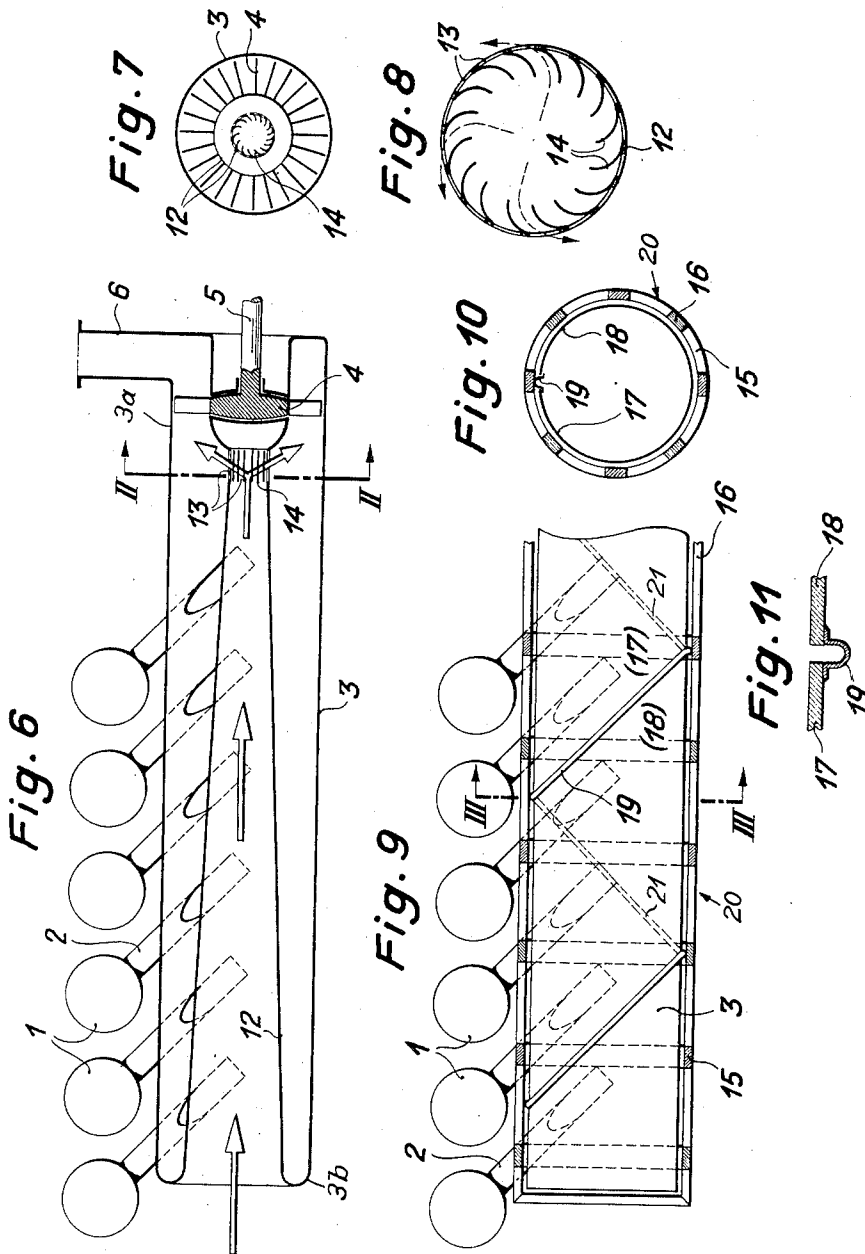
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EXHAUST MANIFOLD SYSTEM FOR INTERNAL COMBUSTION ENGINES

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The present invention relates to an improved exhaust manifold system for internal combustion engines of the type comprising at least one exhaust duct or pipe for each cylinder, the aforesaid ducts leading to a common receiver to which there is operatively connected an exhaust gas turbine. The exhaust manifold system of the present invention can be used to advantage with two-stroke-cycle and four-stroke-cycle engines.

It is generally known that for a pulse turbocharging system the gas pressure in the exhaust pipe between cylinder and turbine increases rapidly during blowdown, reaching high pressures which, in turn, are used by the turbine. During blowdown, however, before the pressure in the exhaust pipe reaches the cylinder pressure, heavy throttling losses occur between the cylinder and the exhaust pipe. It should be pointed out that for a blowdown system or pulse system the exhaust gas energy available in the cylinder is first transformed into velocity, such velocity is then transformed into pressure which in the turbine is again transformed into velocity. As will be apparent, these changes from potential energy to kinetic energy, and vice versa, are of course subject to losses in as much as the whole mass of gas in the exhaust pipe must be reaccelerated during each blowdown.

With the exception of the shock-like acceleration of the gas masses and apart from the divided manifold arrangement, the character of the losses is basically the same in a constant pressure system, wherein also a transformation of velocity into pressure takes place in the receiver and thereafter a transformation of pressure into velocity occurs in the turbine. Since the pressure in the receiver remains constant the aforementioned throttling losses between cylinder and manifold take place during the entire period of the pre-exhaust.

Accordingly, it is a primary object of the present invention to considerably reduce all of the aforementioned losses.

A further important object of the present invention is to provide an improved exhaust manifold system for internal combustion engines and the like wherein the gas flow originating at the engine cylinders is directed to a turbine without energy transformation or without appreciable energy transformation such that the losses normally associated with such energy transformation are avoided or at least substantially minimized.

Another important object of the present invention is the provision of an exhaust manifold system permitting of improved utilization of the exhaust energy and which will assist in engine scavenging.

Generally speaking, and to this end in accordance with the invention, the previously mentioned exhaust ducts or pipes tangentially enter into a receiver of substantially round or circular cross-section in the downstream direction. In consequence thereof, a spiral-shaped or helical screw-line rotational gas stream is created within the receiver by the exhaust discharges emanating from the different cylinders. The spiral-shaped rotational gas stream possesses the same flow direction as the discharge flow egressing from the exhaust pipes. Advantageously, these pipes may possess the shape of or be provided with Laval nozzles at their discharge end.

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It should be recognized that since the exhaust pulses from each cylinder flow into a velocity field which is directed towards the turbine, it is therefore no longer necessary to transform the velocity of such pulses into pressure. Consequently, the gas flow originating at the cylinders is directed to the turbine without energy transformation and, hence, all the losses that would be attendant therewith are obviated. Quite obviously, there will be friction losses along the wall of the receiver, but, however, they are not expected to be larger than the losses in any other pipe system. Additionally, there will be an "ejector-action" on the pipes by the velocity field, and such will assist in scavenging.

The improved utilization of the exhaust energy according to the invention will render it possible to cover the entire load range including starting of a cross-scavenged, steady-state turbocharged two-stroke-cycle engine, without the aid of a mechanically driven scavenge pump.

It will be advantageous to construct and dimension the receiver and to select for the exhaust pipes an angle of entry α in such a manner that the spiral gas stream enters the turbine rotor without shock losses. In this event, the normally employed guide vanes are no longer necessary, thus allowing for an additional reduction of friction losses. Of course, if such losses are tolerable it would be possible to use such guide vanes for equalizing and accelerating the gas flow. Such guide vanes will then not only permit the use of the velocity field, but also make use of an eventual pressure head in the receiver. It is therefore to be understood that the invention is not limited to a determined pressure level in the receiver.

The receiver and the turbine can be coaxially arranged, or the receiver can terminate at the downstream side with a coaxially arranged diffuser—with or without guide vanes—provided with a scroll. The high pressure appearing after the scroll can be employed in a turbine, or, on the other hand, a direct expansion into the atmosphere is possible. In the latter instance, the pressure in the receiver will drop below atmospheric pressure and the engine will be scavenged by suction through the receiver. A two-stroke-cycle engine, for example, could therefore operate normally aspirated in the event of turbocharger breakdown.

With proper layout and dimensioning of the manifold system it will be possible to maintain the pressure in the center of the receiver beneath atmospheric pressure. Such will result in the advantageous possibility of using a centrally disposed conduit or the like for the admission of fresh air. The aforesaid conduit will advantageously possess guide vanes before the turbine so that the air will issue therefrom in the direction of the gas stream. Under determined assumptions, which depend upon engine speed, exhaust temperature, weight flow, pressure and temperature in the cylinder during the discharge period, receiver size and turbine characteristics, the larger weight flow through the turbine due to such air admission will be more effective than the ensuing reduction of the temperature in front of the turbine, with there resulting a power increase for the turbine.

Respecting the design of the receiver it will be of advantage if it possesses a cylindrical or conical configuration and if it is composed of spiral-shaped sheet metal parts which are connected through bellow-like elastic expansion joints, the entire unit being mounted within a frame or housing incorporating rigid rings and longitudinal beams. Such an arrangement advantageously permits of free thermal expansion without the exertion of forces on the pipes leading to the cylinders.

Still further objects and the entire scope of applicability of the present invention will become apparent from the

detailed description given hereinafter; it should be understood, however, that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

In the drawings wherein like reference numerals generally denote similar or analogous elements:

FIGURE 1 is a schematic view of a first embodiment of exhaust manifold system designed according to the invention as seen in longitudinal section, with the upper portion of the receiver having been removed to render visible the internal construction;

FIGURE 1a is a fragmentary, enlarged view, of details of a modified form of exhaust pipe means;

FIGURE 2 is a cross-sectional view of the apparatus of FIGURE 1, taken along lines 2—2 thereof;

FIGURE 3 schematically illustrates a second embodiment of the invention, similar to the device of FIGURE 1, but where a spiral diffuser with scroll is mounted at one end of the receiver;

FIGURE 4 is an end view of the device of FIGURE 3 as seen when viewed from the right-side thereof;

FIGURE 5 is a schematic view generally similar to FIGURE 4, depicting the diffuser in reduced scale, and here provided with a possible conduit and valve arrangement rendering it possible to conduct the exhaust gases to a turbine or directly to an exhaust stack;

FIGURE 6 illustrates a longitudinal section of a third embodiment of the invention provided with an arrangement whereby fresh air is added to the exhaust gases;

FIGURE 7 is a cross-sectional view of the device of FIGURE 6, taken along lines II—II thereof;

FIGURE 8 is an enlarged view of a portion of the device of FIGURE 7, depicting details of the arrangement provided with fresh air channels;

FIGURE 9 is a longitudinal sectional view of another variant form of the invention;

FIGURE 10 is a cross-sectional view of the device of FIGURE 9, taken along lines III—III thereof; and

FIGURE 11 is a fragmentary view showing a detail of the device illustrated in FIGURES 9 and 10.

Referring now to the drawings and, more specifically, to the arrangement of FIGURES 1 and 2, it will be seen that the cylinders 1 of an internal combustion engine, which for convenience in illustration has been schematically depicted as incorporating six cylinders, each have associated therewith at least one exhaust duct or pipe 2 which enters a common cylindrical receiver 3 tangentially in downstream direction at an angle of entry α . In this embodiment there is depicted a coaxially arranged, axial flow turbine 4 located at the downstream side of the receiver 3, and here shown, by way of example, to be mounted directly at the downstream end 3a of said receiver. The turbine 4 is operatively connected through the agency of a shaft member 5 with a compressor wheel (not shown), and the direction of gas flow within the interior of the receiver 3 is determined by the aforesaid angle of entry α of the exhaust pipes 2. The exhaust gases leaving the turbine 4 pass through a conduit 6 into a suitable exhaust stack.

The exhaust gases emanating from the cylinders 1, after the exhaust valves or ports have opened, pass through the associated exhaust pipe 2, the discharge portion of which could be configured as Laval nozzles, and enter the receiver 3 with high velocity. In FIGURE 1a of the drawings there is depicted a modified form of exhaust pipe 2a having its discharge portion configured or equipped with a Laval nozzle. It will be seen that such nozzle incorporates a converging portion 2b and a diverging portion 2c. Naturally, the Laval nozzle of FIGURE 1a could be employed with any of the other embodiments disclosed herein.

The receiver 3, as shown, is a continuous undivided

flow chamber of substantially circular cross-section and of given diameter. The exhaust pipes 2 have a diameter which is a minor fractional dimension of the given diameter of the receiver, and such exhaust pipes are arranged in spaced disposition axially along the receiver. The angle of entry of the exhaust pipes into the receiver, or the angle formed between the axis of an exhaust pipe and the axis of the receiver, is less than 90° , and in the example shown in FIGURES 1 and 2, is about 45° .

The angle of entry α and the dimensions of the receiver 3 must be accommodated to one another such as to generate a spiral-shaped rotating velocity field which has the same direction as the gas flow issuing from the exhaust pipes 2. Thus, the exhaust gases will not be decelerated and accelerated, rather they proceed with constant high velocity in the direction of the turbine 4 along the spiral or helical screw-line indicated by the arrows of FIGURE 1. Such gases will directly enter the rotor blades of the turbine 4 without shock losses and without passing through a nozzle ring. After transmitting their energy to the turbine 4 they pass into the stack via the conduit 6.

It will be recalled that it was previously mentioned that, a nozzle ring could under certain circumstances be employed. To this end then, in FIGURE 1, such a nozzle ring 4a with guide vanes 4b is shown arranged forwardly of the turbine 4, as depicted in phantom lines. Here again, it should be mentioned that such a nozzle ring 4a could be employed when desired with the turbine structure depicted in the other embodiment disclosed herein.

The dimensions of the receiver 3 and the exhaust pipes 2 depend upon the type and size of the engine, that is to say, they are related to cylinder number, engine speed, weight flow, pressure and temperature of the exhaust gases during pre-exhaust and scavenging. The angle of entry α is determined by the dimensions of the receiver 3 and the characteristics of the turbine 4. In order to attain the highest efficiency the different components of the exhaust manifold system must be adapted through computation and tests.

In the variant form of the exhaust manifold system according to FIGURES 3, 4 and 5, it will be seen that the exhaust gases here do not pass directly into the turbine. In this embodiment there is provided a diffuser 8 having vanes 7, such diffuser being similar to the type used in radial compressor design, which is mounted at the downstream end 3a of the receiver 3. In the diffuser 8 the high velocity of the gases is transformed into pressure which, as shown in FIGURE 5, can be used either in a turbine, schematically represented by reference numeral T, disposed at the downstream side of the receiver 3 and operatively connected to the outlet end of a conduit 9 communicating with said diffuser, or else, can be discharged through the conduit 10 directly into an exhaust stack.

The valve member 11 located in the conduit 9 permits selectively communicating the diffuser 8 with the turbine T or conduit 10, as shown by the full-line and phantom-line positions of the aforesaid valve structure 11. The conduit 9 to the turbine T is rendered free for flow during normal turbocharging operation. Actuation of the valve 11 will be undertaken only after turbocharger breakdown in order to operate the engine normally aspirated. The diffuser 8 will then discharge directly into the atmosphere which results in a pressure drop in the receiver below atmospheric pressure. Such makes it possible to scavenge the engine by suction through the engine.

With proper layout and dimensioning of the arrangement shown in FIGURES 6, 7 and 8 it is possible to create a pressure level beneath atmospheric pressure at the center of the receiver 3 by means of the vortex action of the spiral velocity field. This negative pressure is employed to advantage to draw-in fresh air through a con-

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duit or channel 12 located centrally of the receiver 3. The receiver 3 is opened at its upstream end 3b and at this location is connected in suitable manner with the conical channel 12. Advantageously, the conduit or channel 12 is provided with slot-like openings or apertures 13 with which guide vanes 14 communicate, such openings 13 and guide vanes 14 being advantageously arranged close to the turbine 4. As best seen by inspecting FIGURE 8, the dimension and curvature of these guide vanes is such that the fresh air flow will leave conduit 12 in the direction of the spiral-shaped velocity field. The weight flow through the turbine 4 will therefore be increased. By proper design of the installation such will result in a power increase for the turbine, notwithstanding the lower gas temperature in front of said turbine. The arrows in FIGURES 6 and 8 depict the direction of flow for the incoming fresh air.

In FIGURES 9 and 10 there is shown a longitudinal section and a cross-sectional view, respectively, of a receiver 3 designed according to a further concept of the invention. It will be seen that the discharge end of the receiver and the turbine located at the downstream side of the receiver, whether such turbine be directly connected to the downstream receiver end 3a as in FIGURES 1 or 6, or as in the arrangement of FIGURE 3, have been omitted for convenience in illustration. In this embodiment the receiver 3 is composed of different sheet metal members 17 and 18 which are connected along a parting line defining a spiral or helical screw-line or path 21. The entire unit is mounted within a housing or frame 20 incorporating rigid rings 15 and longitudinal beams 16. Advantageously, the connection means between the sheet metal parts 17 and 18 is defined by an elastic bellow-type joint connection element 19 which is preferably welded along the inside or outside of the members 17, 18. The dotted portions of the helical screw-line 21 visible in the longitudinal section of FIGURE 9 depict that portion of the spiral connection located in the receiver-half disposed above the plane of the drawing, having been applied to facilitate understanding of this embodiment. The construction above-described has the advantage that the receiver 3 can expand freely without transmitting forces to the pipes 2 that lead to the cylinders 1. By way of completeness, it should be pointed out that, it has been found that in actual practice the herein-mentioned angle of entry α should approximately assume a value within the range of 30 to 60 degrees.

While there is shown and described present preferred embodiments of the invention, it is to be distinctly understood that the invention is not limited thereto but may be otherwise variously embodied and practised within the scope of the following claims.

Having thus described the present invention, what is desired to be secured by United States Letters Patent, is:

1. Exhaust manifold system for a multicylinder combustion engine comprising:

an axially elongated cylindrical receiver defined by a generally continuous body wall which forms there-within a continuous undivided flow chamber of substantially circular cross-section and of given diameter; said receiver being adapted for gas flow therethrough toward a downstream end thereof;

a turbine means disposed at said downstream end of said receiver;

said turbine means including a rotatable portion;

at least one exhaust pipe connecting each cylinder of said multicylinder combustion engine to said receiver each of said exhaust pipes passing through said receiver body wall and having an outlet end disposed within said undivided flow chamber;

said exhaust pipes being arranged in spaced disposition axially of said receiver and hence passing through said body wall at locations successively spaced along the elongated length thereof;

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said exhaust pipes having diameters which are a minor fractional dimension of said given diameter; each of said exhaust pipes having its axis extending from the outlet end thereof toward its connected cylinder;

each of said exhaust pipe axes being disposed at an angle of less than 90° to said receiver axis;

said exhaust pipe outlet ends being positioned so that gas flow therefrom will have a directional component toward the downstream end of said receiver, whereby the cumulative gas flow through said exhaust pipes creates a spiral-shaped rotational velocity field within said flow chamber which traverses to said turbine means to rotate the rotatable portion thereof.

2. Exhaust manifold system for multicylinder combustion engines as defined in claim 1 wherein a nozzle ring is arranged in front of said receiver means to equalize and accelerate the gas flow discharges.

3. Exhaust manifold system for multicylinder combustion engines as defined in claim 1 wherein said exhaust pipes extending to said receiver include discharge portions configured as Laval nozzles.

4. Exhaust manifold system for multicylinder internal combustion engines comprising a common receiver, at least one exhaust pipe for each cylinder of the internal combustion engine extending to said common receiver, a turbine disposed at the downstream side of said common receiver with respect to the direction of gas flow therethrough, said common receiver possessing a substantially circular cross-section, said exhaust pipes entering said common receiver tangentially in the downstream direction thereof such that the gas discharges from the cylinders create a spiral-shaped rotational velocity field within said common receiver and the gas flow discharges themselves possess the same direction as said spiral-shaped rotational velocity field, a fresh air conduit located substantially centrally of said common receiver, said conduit being provided with openings and guide vanes communicating with said openings in close proximity to said turbine, the fresh air moving through said fresh air conduit in the direction of said openings being oriented by said guide vanes to flow into said common receiver in the same direction as said gas flow discharges moving through said spiral-shaped rotational velocity field.

5. Exhaust manifold system for multicylinder internal combustion engines comprising a common receiver, at least one exhaust pipe for each cylinder of the internal combustion engine extending to said common receiver, a turbine disposed at the downstream side of said common receiver with respect to the direction of gas flow therethrough, said common receiver possessing a substantially circular cross-section, said exhaust pipes entering said common receiver tangentially in the downstream direction thereof such that the gas discharges from the cylinders create a spiral-shaped rotational velocity field within said common receiver and the gas flow discharges themselves possess the same direction as said spiral-shaped rotational velocity field, said common receiver being composed of individual sheet metal members arranged adjacent one another, with the parting line between said sheet metal members defining a spiral path, connecting means for interconnecting said sheet metal members along said spiral path, said connecting means being defined by bellow-type elastic connecting members, a frame within which said common receiver is mounted, said frame comprising spaced rigid rings and interconnecting rigid longitudinal beams.

6. Exhaust manifold system for a multicylinder combustion engine comprising:

an axially elongated cylindrical receiver defined by a generally continuous body wall which forms there-within, a continuous undivided flow chamber of substantially circular cross-section and of given diameter; said receiver being adapted for gas flow therethrough

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toward a downstream end thereof;
 a spiral diffuser means disposed at said downstream
 end of said receiver;
 at least one exhaust pipe connecting each cylinder of
 said multicylinder combustion engine to said receiver; 5
 each of said exhaust pipes passing through said re-
 ceiver body wall and having an outlet end disposed
 within said undivided flow chamber;
 said exhaust pipes being arranged in spaced disposition
 axially of said receiver and hence passing through 10
 said body wall at locations successively spaced along
 the elongated length thereof;
 said exhaust pipes having diameters which are a minor
 fractional dimension of said given diameter;
 each of said exhaust pipes having its axis extending from 15
 the outlet end thereof toward its connected cylinder;
 each of said exhaust pipe axes being disposed at an
 angle of less than 90° to said receiver axis;
 said exhaust pipe outlet ends being positioned so that
 gas flow therefrom will have a directional compo- 20
 nent toward the downstream end of said receiver,

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whereby the cumulative gas flow through said ex-
 haust pipes creates a spiral-shaped rotational velocity
 field within said flow chamber which traverses to said
 spiral diffuser means.

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