

July 5, 1949.

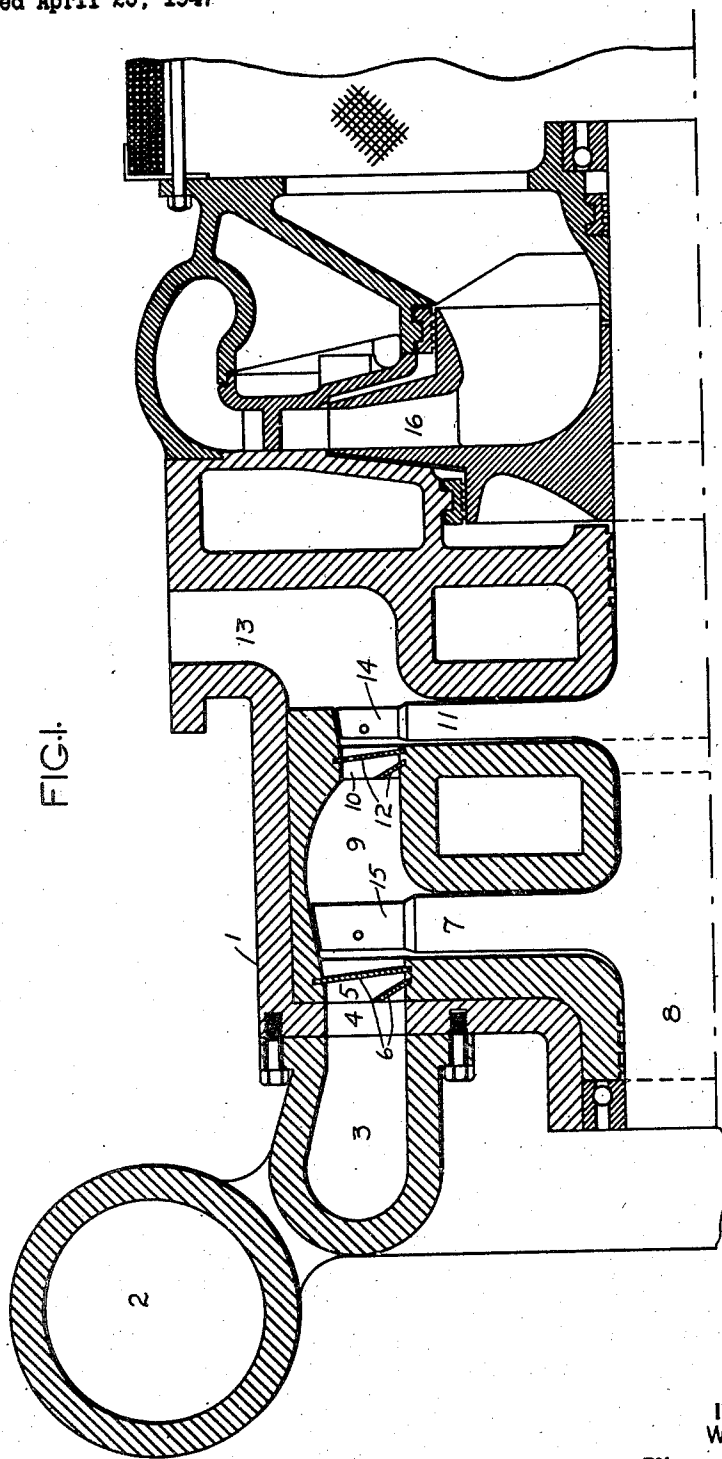
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2,475,151

TURBOSUPERCHARGER

Filed April 25, 1947

3 Sheets-Sheet 1



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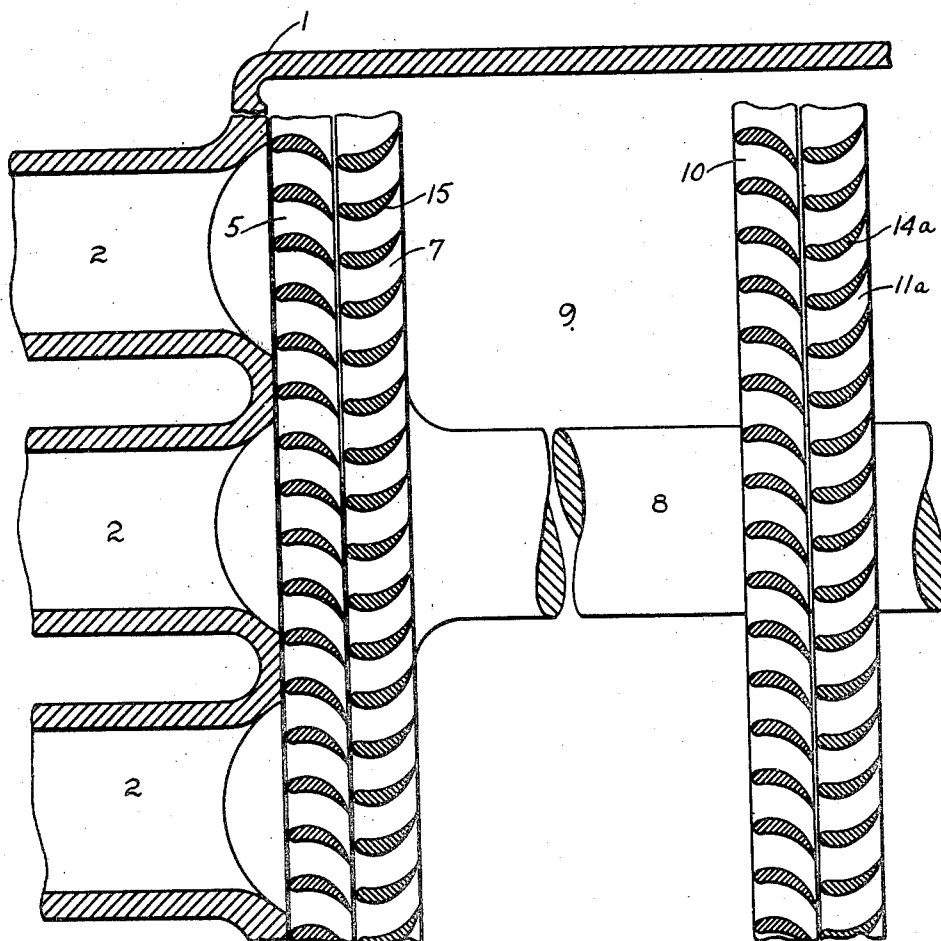
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FIG 2



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FIG. 3.

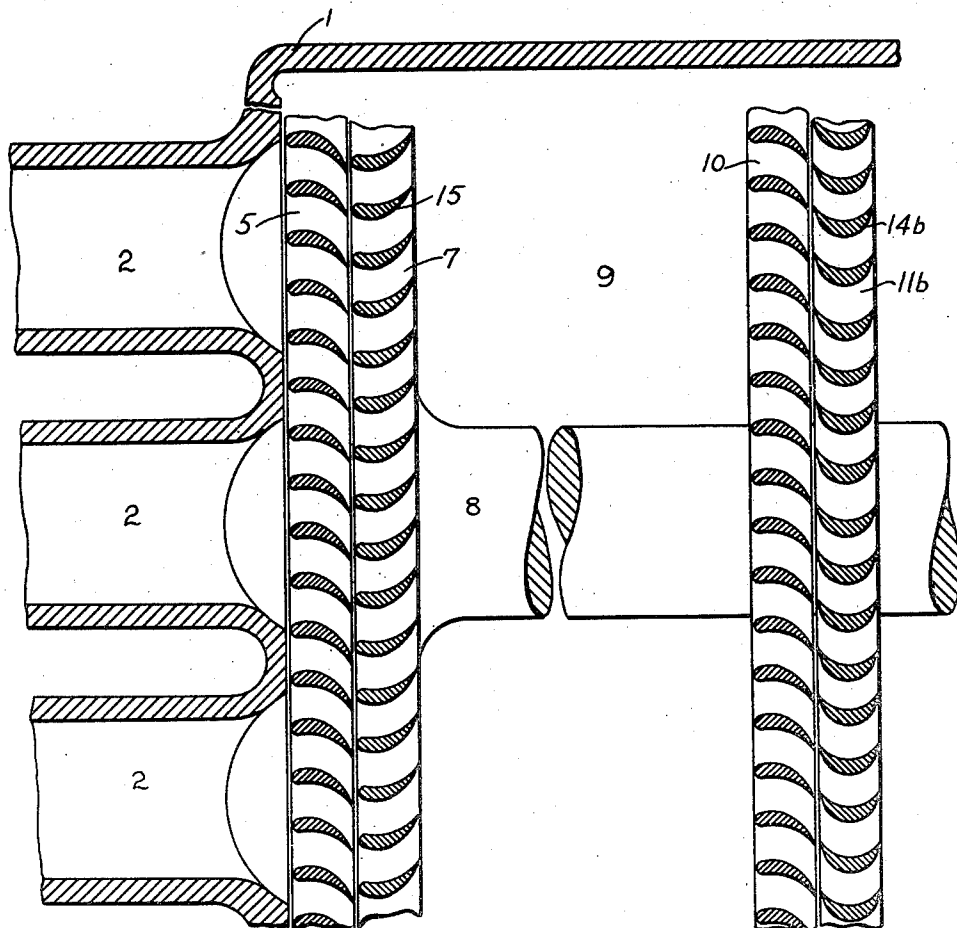
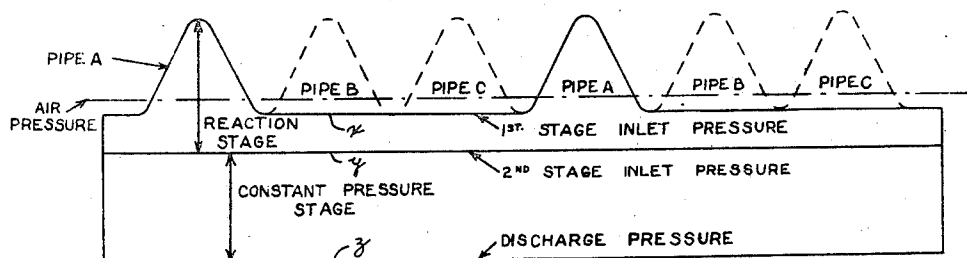


FIG. 4.



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2,475,151

TURBOSUPERCHARGER

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Application April 25, 1947, Serial No. 743,786

5 Claims. (Cl. 230-116)

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This invention relates to turbo-superchargers. The use of turbo-superchargers to provide scavenging and charging air for Diesel engines is well known. It is well known to use a variable pressure ratio of expansion, i. e., a pulsating pressure, in certain turbo-superchargers. It is also well known to use a constant pressure in a turbo-supercharger. Both the variable pressure and the constant pressure turbo-superchargers have their short-comings.

The present invention is directed toward providing a turbo-supercharger which is superior to both the conventional variable pressure turbo-supercharger and the the constant pressure turbo-supercharger.

The object of the present invention is to provide a multi-stage turbo-supercharger, the first stage of which is designed to use a variable pressure ratio of expansion, i. e., a pulsating pressure, and the second stage of which is designed for best performance with a constant pressure gas.

Another object is to provide a turbo-supercharger as aforesaid in which the first stage employs a reaction wheel and the second stage employs an impulse wheel.

A further object is to provide a turbo-supercharger as aforesaid in which both stages employ reaction wheels.

Other and further objects of this invention will appear from the following description, the accompanying drawings and the appended claims.

Referring to the drawings forming part of this application:

Fig. 1 shows, somewhat diagrammatically, in half axial section, a turbo-supercharger constructed according to the present invention;

Fig. 2 shows, somewhat diagrammatically, and in section, a turbine of a turbo-supercharger of the type shown in Fig. 1 wherein two reaction wheels are employed;

Fig. 3 shows, somewhat diagrammatically and in section, a turbine of a turbo-supercharger of the type shown in Fig. 1 wherein the first stage is a reaction wheel and the second stage is an impulse wheel; and

Fig 4 shows a pressure graph of the turbo-supercharger of the present invention.

The turbo-supercharger is indicated in Fig. 1 by the reference numeral 1. It has a multi-part casing. Starting from the left, this casing includes an inlet pipe 2 which may be the exhaust manifold of a Diesel engine, by way of example. If the Diesel engine employs multiple manifolds, then instead of there being only one pipe 2, there may be more than one pipe 2. The pipe or pipes

2, as the case may be, open into the annular chamber 3. Where one pipe 2 is provided, the annular chamber 3 is continuous. If two pipes are used the chamber 3 will be partitioned in halves, and so on.

The chamber 3 directs the gas entering it from pipe 2 through outlet ports 4 to the nozzles 5. The nozzles 5 include the usual guiding vanes 6 which direct the gas to the reaction turbine wheel 7, which is secured on the turbo-supercharger shaft 8. The gas passes through and drives the reaction wheel 7 and then enters a constant pressure chamber 9 from which it flows through outer nozzles 10 to another turbine wheel 11 secured to shaft 8. Thus the second-stage nozzle ring comes from one common chamber between the first-stage and second-stage turbines. The nozzles 10 have the usual guiding vanes 12. The turbine wheel 11 may be a reaction turbine wheel or it may be an impulse turbine wheel. In either event the gases leave the wheel 11 and flow from the turbo-supercharger through the outlet or exhaust passage 13. It will be noted that the nozzles 10 are smaller than the nozzles 5 and the blades 14 of the wheel 11 are smaller than the blades 15 of the wheel 7. A centrifugal blower 16 is secured to the shaft 8 and driven thereby to provide the supercharging and scavenging air for the Diesel engine.

While the invention has been shown in connection with a supercharger in which the blower is on the turbine shaft, it is to be understood that the blower is, broadly speaking, a load, and the turbines can drive other loads instead of the blower, if desired, without departing from the present invention. For example, the blower could be driven by the engine directly and the turbines could put work back into the engine or could drive auxiliaries.

In Fig. 2 the shaft 8 is shown provided with two reaction wheels 7 and 11a. Three pipes 2 are shown for delivering the fluctuating pressure gas from the Diesel engine to the turbo-supercharger.

In Fig. 3 the shaft 8 is provided with a reaction turbine wheel 7 and with an impulse turbine wheel 11b.

The wheels 7 shown in Figs. 1, 2 and 3 are, of course, the same wheel, and the reaction blade 15 has very little curvature on the inlet. This allows for a wide variation in relative directional velocity without excessive shock losses.

The wheel 7 operates efficiently with the variable pressure ratio of expansion. However, the gas in chamber 9 is at constant pressure and if the supercharging of the Diesel engine is in-

creased beyond a certain value the whole pressure level is raised, thereby putting more and more importance on the constant pressure part of the expansion which takes place in the wheels 11a or 11b as the case may be, and less and less importance on the pulsating pressure part which takes place in the wheel 7. Thus, if the turbo-supercharger consisted only of the wheel 7 it would not be efficient, and if it consisted only of a constant pressure wheel it would not be efficient.

The turbo-supercharger of the present invention is adapted to operate efficiently where the inlet pressure fluctuates between a high and a low value, that is to say where the pressure in the chamber 3 so fluctuates. The lowest pressure in chamber 3 is, however, substantially higher than the pressure in the exhaust passage 13.

If the turbo-supercharger of the present invention is used in connection with a Diesel engine it will provide both the scavenging and the charging air, and the fluid flowing to the turbo-supercharger through the pipe or pipes 2 will be exhaust gas followed by and intermixed with scavenging air, so that both stages of the turbine are driven not only by the residual products of combustion but also, if desired, by scavenging air.

Requirements for the greatest efficiency of the wheel 7, that is of the first stage of the turbine, are that the back pressure, i. e., the pressure in chamber 9, should be as close as possible to the lowest part of the pulsating inlet pressure, i. e., the pressure in chamber 3, and the blades 15 should be so designed as to allow the scavenging and cooling air to pass through at this low pressure with a minimum loss. This necessitates the reaction blade 15.

The second stage of the turbo-supercharger can, as aforesaid, have either reaction or impulse type blading designed, however, for maximum efficiency with steady flow conditions. This second stage receives the products of combustion and scavenging air in series with the first stage.

If the blading 15 was impulse blading rather than reaction blading, then when the gas pressure in chamber 3 was low it would not be able to enter the wheel 7 since its entrance would be opposed by the shape of the inlet portion of the impulse blading, and since this low pressure gas would be repulsed by the impulse wheel, thorough scavenging of the engine cylinder would be prevented.

The graph of Fig. 4 shows, in a solid line, the pressure waves of one pipe 2, assuming a six-cylinder engine having three exhaust manifolds 2. The pressures in the other two pipes are indicated by broken lines. It will be seen that the pressure rises and falls in each of the pipes A, B, C with two peaks in each pipe. There would thus be two peaks in pipe 2 and in that portion of chamber 3 to which it discharged, or if all six cylinders exhausted into pipe 2 then pipe 2 would have all six peaks shown in Fig. 4. The peaks are considerably above the air pressure supplied by the blower 16, but the pressure drops between peaks to below the air pressure. The pressure in the chamber 3 is therefore indicated by the solid line *x* which line includes two peaks. The pressure in the chamber 9 is indicated by the uniform line *y*, and the pressure in the passage 13 is indicated by the uniform line *z*. Thus the work done by the wheel 7 is represented by the area enclosed between lines *x* and *y* where the supercharging air pressure is, as indicated, relatively high, and the work done by the wheel 11a or 11b is indi-

cated by the area enclosed between the lines *y* and *z*. In other words at high supercharging air pressures, more work is done by the constant pressure wheel of the second stage than by the variable pressure wheel of the first stage. However, the second stage work need not necessarily be greater than the first stage work. Actually, in case of moderately low supercharge, the second stage work is less than the first stage work.

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.

The invention claimed and desired to be secured by Letters Patent is:

1. A turbo-supercharger adapted to receive exhaust gases at a fluctuating pressure from an internal combustion engine and deliver scavenging and charging air to said internal combustion engine comprising an inlet chamber for said exhaust gases; a nozzle ring having guiding vanes communicating with said chamber; a first-stage turbine having a reaction wheel adapted to be driven by the gases passing through said nozzle ring; another nozzle ring having guiding vanes at the outlet side of said first-stage turbine; a chamber between said first-stage turbine and said other nozzle ring for delivering the gas from said first-stage turbine to said other nozzle ring at constant pressure; a second-stage turbine at the outlet side of said other nozzle ring adapted to be driven by said constant pressure gas; an exhaust passage at the outlet side of said second-stage turbine adapted to discharge said gases at a pressure below the lowest pressure in said inlet chamber; means connecting said turbines; and a blower driven by said turbines, said blower and turbines being proportioned so that said blower delivers air at a higher pressure than the lowest pressure in said inlet chamber but below the highest pressure in said inlet chamber, and the work done by expansion of the constant pressure gas through said second-stage turbine exceeds the work done by said fluctuating pressure gas in said first-stage turbine.

2. A turbo-supercharger adapted to receive exhaust gases at a fluctuating pressure from an internal combustion engine and deliver scavenging and charging air to said internal combustion engine comprising an inlet chamber for said exhaust gases; a nozzle ring having guiding vanes communicating with said chamber; a first-stage turbine having a reaction wheel adapted to be driven by the gases passing through said nozzle ring; another nozzle ring having guiding vanes at the outlet side of said first-stage turbine; a chamber between said first-stage turbine and said other nozzle ring for delivering the gas from said first-stage turbine to said other nozzle ring at constant pressure; a second-stage turbine having a reaction wheel at the outlet side of said other nozzle ring adapted to be driven by said constant pressure gas; an exhaust passage at the outlet side of said second-stage turbine adapted to discharge said gases at a pressure below the lowest pressure in said inlet chamber; means connecting said turbines; and a blower driven by said turbines, said blower and turbines being proportioned so that said blower delivers air at a higher pressure than the lowest pressure in said inlet

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chamber but below the highest pressure in said inlet chamber, and the work done by expansion of the constant pressure gas through said second-stage turbine exceeds the work done by said fluctuating pressure gas in said first-stage turbine.

3. A turbo-supercharger adapted to receive exhaust gases at a fluctuating pressure from an internal combustion engine and deliver scavenging and charging air to said internal combustion engine comprising an inlet chamber for said exhaust gases; a nozzle ring having guiding vanes communicating with said chamber; a first-stage turbine having a reaction wheel adapted to be driven by the gases passing through said nozzle ring; another nozzle ring having guiding vanes at the outlet side of said first-stage turbine; a chamber between said first-stage turbine and said other nozzle ring for delivering the gas from said first-stage turbine to said other nozzle ring at constant pressure; a second-stage turbine having an impulse wheel at the outlet side of said other nozzle ring adapted to be driven by said constant pressure gas; an exhaust passage at the outlet side of said second-stage turbine adapted to discharge said gases at a pressure below the lowest pressure in said inlet chamber; means connecting said turbines; and a blower driven by said turbines, said blower and turbines being proportioned so that said blower delivers air at a higher pressure than the lowest pressure in said inlet chamber but below the highest pressure in said inlet chamber, and the work done by expansion of the constant pressure gas through said second-stage turbine exceeds the work done by said fluctuating pressure gas in said first-stage turbine.

4. A turbo-supercharger adapted to receive exhaust gases at a fluctuating pressure from an internal combustion engine and deliver scavenging and charging air to said internal combustion engine comprising an inlet chamber for said exhaust gases; a nozzle ring having guiding vanes communicating with said chamber; a first-stage turbine having a reaction wheel adapted to be driven by the gases passing through said nozzle ring; another nozzle ring having guiding vanes at the outlet side of said first-stage turbine; a chamber between said first-stage turbine and said other nozzle ring for delivering the gas from said first-stage turbine to said other nozzle ring at constant pressure; a second-stage turbine at the outlet side of said other nozzle ring adapted to be driven by said constant pressure gas, said other nozzle ring and said second-stage turbine being smaller than said first mentioned nozzle ring and said first-stage turbine respectively; an exhaust passage at

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the outlet side of said second-stage turbine adapted to discharge said gases at a pressure below the lowest pressure in said inlet chamber; means connecting said turbines; and a blower driven by said turbines, said blower and turbines being proportioned so that said blower delivers air at a higher pressure than the lowest pressure in said inlet chamber but below the highest pressure in said inlet chamber, and the work done by expansion of the constant pressure gas through said second-stage turbine exceeds the work done by said fluctuating pressure gas in said first-stage turbine.

5. A turbo-supercharger adapted to receive exhaust gases at a fluctuating pressure from an internal combustion engine and deliver scavenging and charging air to said internal combustion engine comprising an inlet chamber for said exhaust gases; a nozzle ring having guiding vanes communicating with said chamber; a first-stage turbine having a reaction wheel provided with blades having very little curvature at the inlet and adapted to be driven by the gases passing through said nozzle ring; another nozzle ring having guiding vanes at the outlet side of said first-stage turbine; a chamber between said first-stage turbine and said other nozzle ring for delivering the gas from said first-stage turbine to said other nozzle ring at constant pressure; a second-stage turbine at the outlet side of said other nozzle ring adapted to be driven by said constant pressure gas, said other nozzle ring and said second-stage turbine being smaller than said first mentioned nozzle ring and said first-stage turbine respectively; an exhaust passage at the outlet side of said second-stage turbine adapted to discharge said gases at a pressure below the lowest pressure in said inlet chamber; means connecting said turbines; and a blower driven by said turbines, said blower and turbines being proportioned so that said blower delivers air at a higher pressure than the lowest pressure in said inlet chamber but below the highest pressure in said inlet chamber, and the work done by expansion of the constant pressure gas through said second-stage turbine exceeds the work done by said fluctuating pressure gas in said first-stage turbine.

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