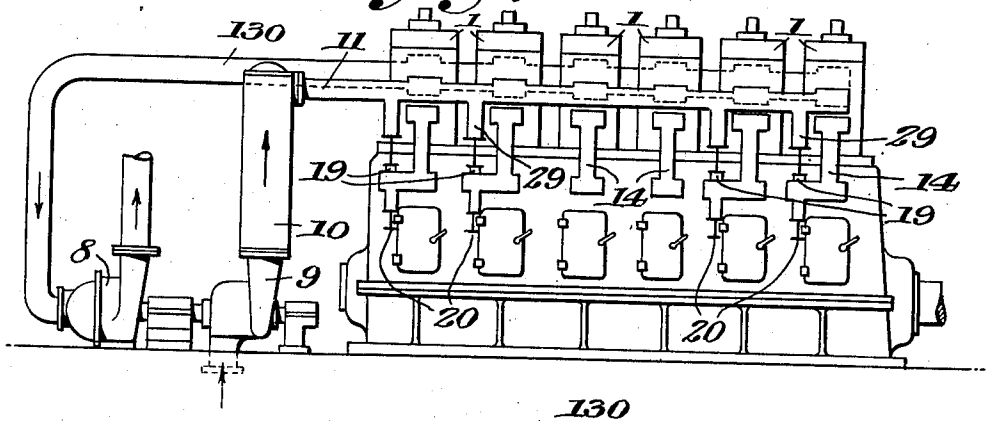
June 8, 1937. A. BÜCHI 2,082,780

INTERNAL COMBUSTION ENGINE

Original Filed Nov. 17, 1927 4 Sheets-Sheet 1

Fig. 1.



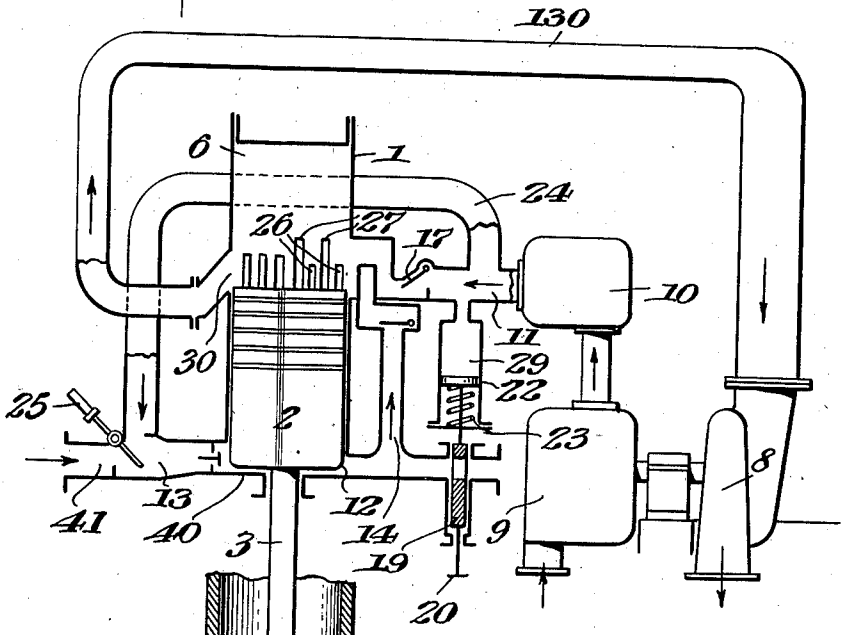
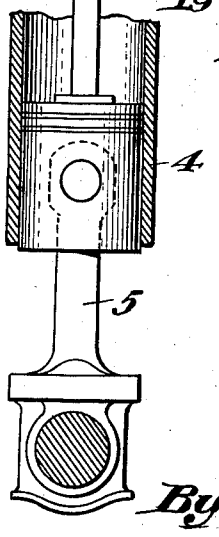


Fig. 2.



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INTERNAL COMBUSTION ENGINE

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Fig. 2a.

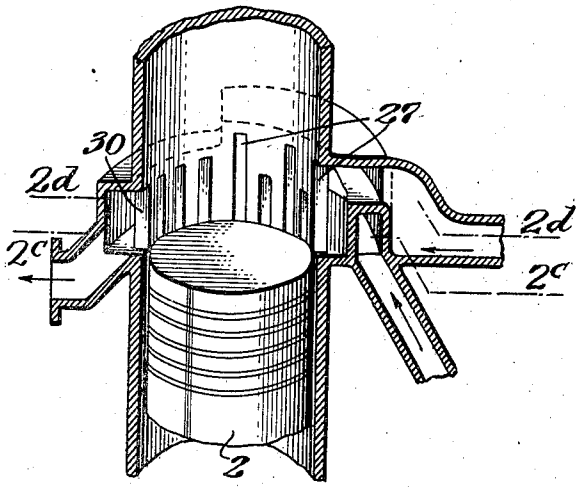


Fig. 2b.

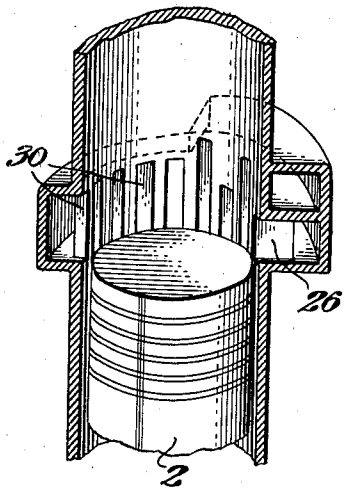


Fig. 2c.

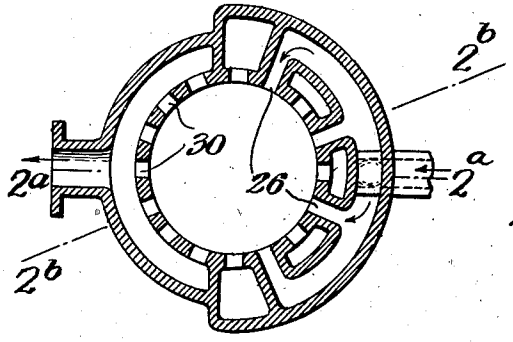
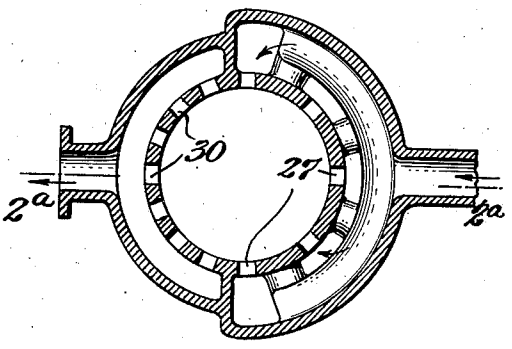


Fig. 2d.



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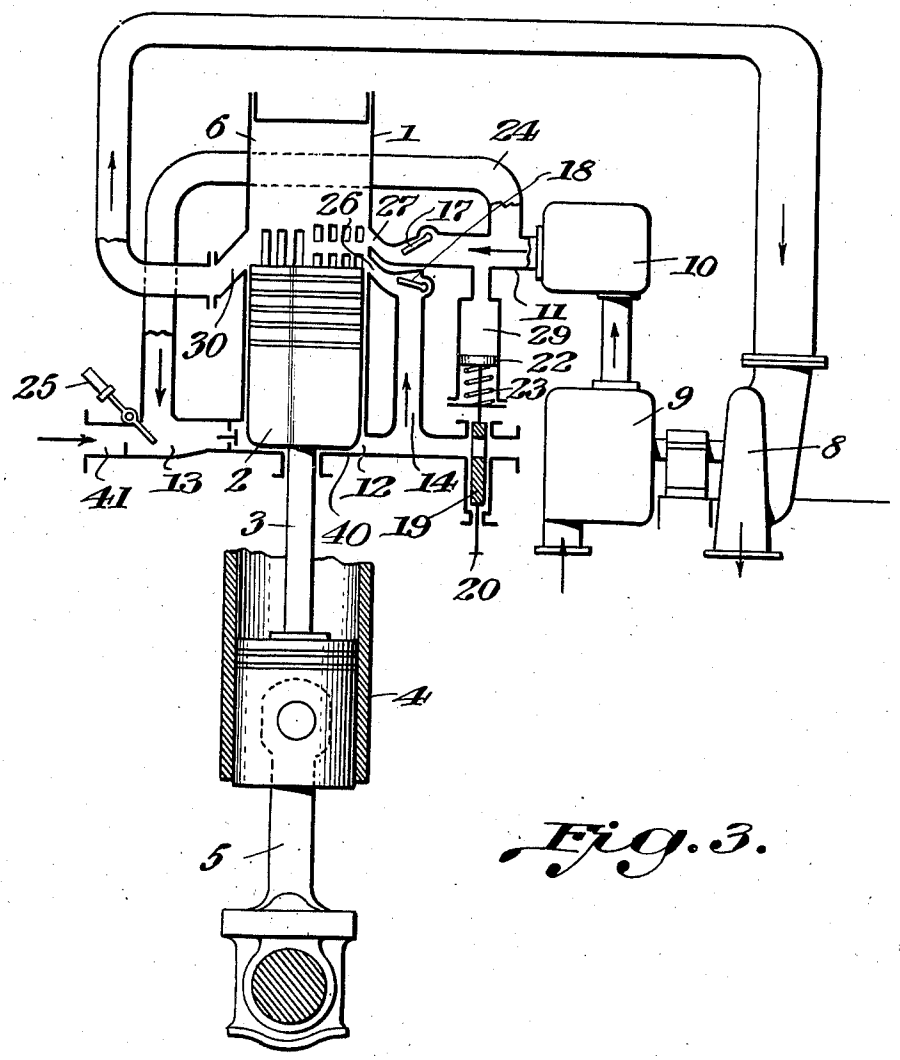


Fig. 3.

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INTERNAL COMBUSTION ENGINE

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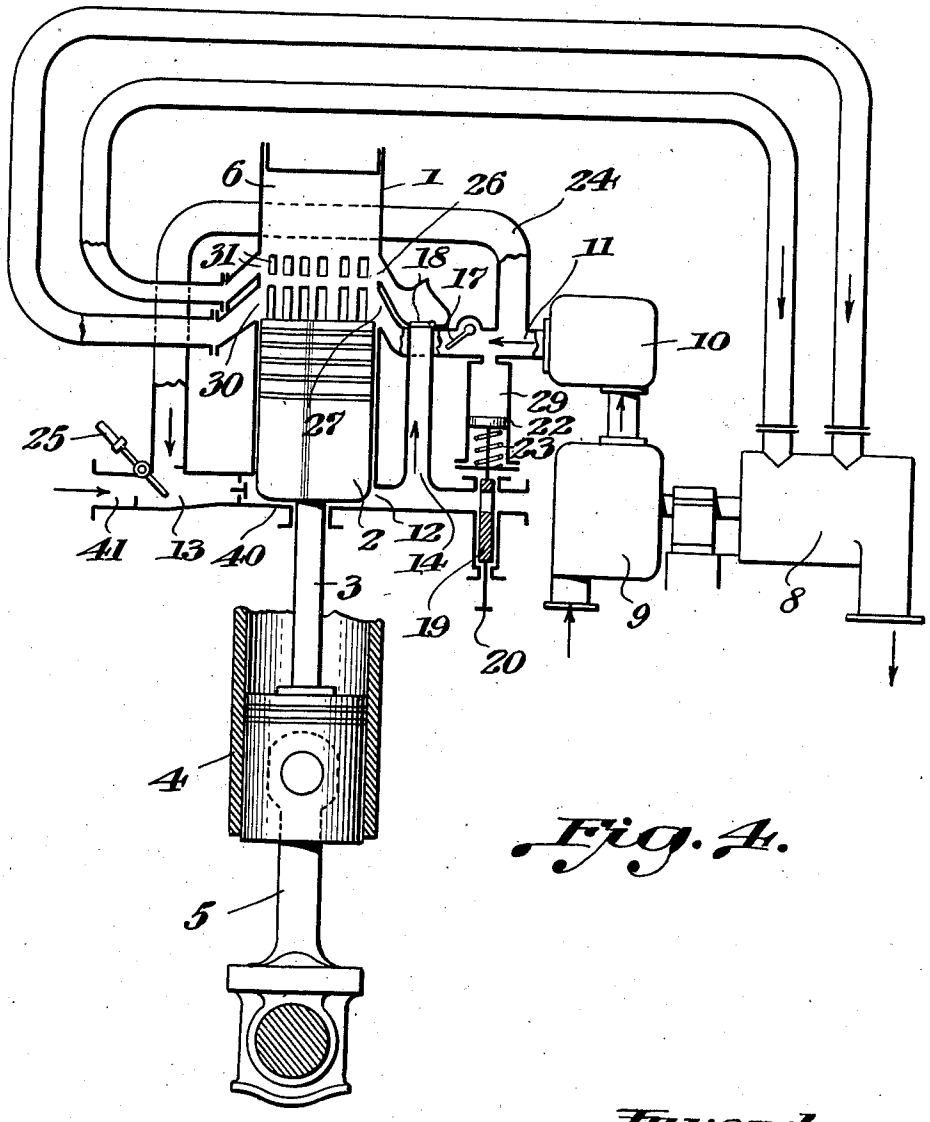


Fig. 4.

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Patented June 8, 1937

2,082,780

UNITED STATES PATENT OFFICE

2,082,780

INTERNAL COMBUSTION ENGINE

Alfred Büchi, Winterthur, Switzerland

Original application November 17, 1927, Serial No. 234,014, now Patent No. 1,955,620. Divided and this application January 13, 1933, Serial No. 651,611. In Switzerland November 19, 1926

11 Claims. (Cl. 60—13)

This invention which has been divided from my copending application Serial No. 234,014 (Patent No. 1,955,620, April 17, 1934) relates to internal combustion engines used in combination with charging blowers driven by exhaust turbines and a plurality of piston pumps driven by the internal combustion engine which act as additional charging blowers. A plurality of piston pumps is provided for the purpose of making the delivery of the scavenging and charging air to the cylinders more uniform. When the internal combustion engine runs at low loads or is being started, the energy in the exhaust gases is very low. The blowers driven by the exhaust gas turbines deliver then only a small quantity of air and at a low pressure. The piston pumps driven off the engine shaft deliver at full pressure at all loads. With increasing load on the internal combustion engine, the energy in the exhaust gases increases, more power is available in the exhaust turbines. The exhaust turbine driven blowers deliver therefore more air and at a higher pressure and the delivery of at least a part of the piston pumps may with no disadvantage be interrupted. The interruption of the delivery may be effected automatically or at will. When the piston pumps are cut out, the power absorbed by these pumps is available at the crankshaft, so that the external power of the internal combustion engine increases. The efficiency becomes therefore higher. Each combustion cylinder may be provided with a piston pump which may be arranged in the extension of the axis of the combustion cylinder. In single-acting engines the lower side of the piston may be used as the pump space. In double-acting engines the cross-head guides may be arranged as pumps.

In the accompanying drawings several constructional examples of the invention are shown, the same or similar parts bearing the same reference numerals.

Figure 1 shows by way of example a six-cylinder internal combustion engine to which the invention is applied.

Figure 2 shows a single-acting two-stroke internal combustion engine such as might form part of the engine shown in Figure 1; the cylinder is shown in section.

Figure 2*a* is a sectional view along the line 2*a*—2*a* of Fig. 2*c*.

Figure 2*b* is a similar view to Figure 2*a*, along the line 2*b*—2*b* of Fig. 2*c*.

Figures 2*c* and 2*d* are plans of sections taken upon the lines 2*c*—2*c* and 2*d*—2*d* respectively in Figure 2*a*.

Figures 3 and 4 are modifications of the arrangement shown in Figure 2.

In Figure 2 of the drawings 1 is the cylinder of a single-acting two-stroke internal combustion engine with the piston 2, the piston rod 3, the cross-head guide 4, the connecting rod 5 and the combustion space 6. The exhaust gas turbine 8 is driven by means of the exhaust gases of the internal combustion engine, which leave the cylinder through the ports 30. The blower 9 is directly coupled with the exhaust gas turbine 8. The air conveyed by the blower passes by way of a cooler 10 into the pipe 11 and from there by way of a non-return valve 17 through the ports 27 into the cylinder of the internal combustion engine. The lower part of the piston 2 works as an air pump 40 with the pump space 12. On the piston ascending air is drawn in by way of the pipe 13 according to the position of the flap valve 25 either from the pipe 24 or from the atmosphere. During the downward stroke this air is forced into the pipe 14 from where it passes by way of the non-return valve 18 and the ports 26 into the cylinders of the internal combustion engine, unless the device 19 opens the way to the atmosphere. The ports 27 are longer than the ports 26.

The arrangement of ports and conduits can be seen by referring to Figures 2*a*, 2*b*, 2*c* and 2*d*. The section lines 2*c*—2*c* and 2*d*—2*d* are each taken through one of the ports 26 and 27 respectively.

The blower 9 operates both as a scavenging and as a charging pump, while the air delivered by the piston pump 40 is used only for scavenging purposes. When for instance the internal combustion engine is under light load, the exhaust gases pass at a low pressure and at low temperatures from the exhaust ports 30 into the exhaust gas turbine 8. The energy given off to the turbine wheel is therefore small and may be insufficient for covering the whole of the charging and scavenging air requirement of the internal combustion engine. The piston pump 40 on the other hand always delivers air at the same pressure in a quantity which is directly proportional to the speed of revolution of the engine. The scavenging and charging operation takes place in such a manner that after the ports 27 have been opened by the piston 2 the non-return valve 17 is kept closed by the gas pressure in the cylinder until the piston also

uncovers the exhaust ports 30 and the exhaust gases can escape towards the turbine. Should the pressure of the air delivered by the blower 9 be sufficiently great to force the valve 17 open and to overcome the scavenging resistances of the cylinder and the counter-pressure of the exhaust gases of the cylinder, a slight preliminary scavenging takes place after the ports 27 are uncovered and until the ports 26 are uncovered. After the ports 26 have been uncovered by the piston 2 the scavenging air delivered by the piston pump 40 thoroughly scavenges the cylinder space. As when the load on the engine is small, the pressure of the scavenging air delivered by the piston pump 40 is considerably greater than that of the scavenging air and charging air delivered by the blower 9, the non-return valve 17 will remain closed after the opening of the ports 26 as long as the ports 26 are uncovered by the piston 2. On ascending, the piston 2 will again first close the ports 26. This will cause the pressure in the combustion space to drop and the valve 17 can again be opened by the air of the blower 9 and there will be a slight subsequent scavenging until the exhaust ports close. Even if the pump produces a greater pressure than the blower the charging pressure is the blower pressure since the excess air is given an opportunity to escape as scavenging air before the exhaust ports are closed. After the piston has closed the exhaust ports 30 as well, the combustion space 6 will be charged by the air delivered by the blower 9 until the piston 2 has also passed over the ports 27. By this means final charging is given by the blower which as explained charges in dependence upon the load; this is advantageous for engines working at high or medium and only for short periods at low loads. The compression of the charge by the piston 2 then commences.

When the internal combustion engine is operating with a large load, the exhaust gases escape through the exhaust ports 30 at a relatively high pressure and high temperatures. Consequently, the exhaust gas turbine turns much more rapidly and delivers more air at a higher pressure. In this case the blower 9 is capable of itself covering the total demand for scavenging and charging air. The delivery of additional scavenging air by the piston pump 40 is therefore not necessary and consequently at heavy loads the piston pump 40 is preferably put out of operation in order that the internal combustion engine may give off more power to the outside. This is effected by the device 19. The position of the piston 22 in the cylinder 20 is dependent on the pressure in the pipe 11. When this pressure is small (low load on the engine) the spring 23 will drive the piston 22 upwards and the slide valve 19 will be closed. When the pressure in the pipe 11 is high the piston 22 and the slide valve 19 will be forced downwards and the pipe 14 will be short-circuited with the atmosphere, that is to say, the pump 40 works idly. In this case the cylinder space 6 is scavenged only through the ports 27, the non-return valves 18 preventing the air from the blower passing out of the ports 26 into the pipe 14 and thus into the atmosphere.

When the internal combustion engine is under medium load, the slide valve 19 will not completely open to the atmosphere. The piston pump 40 is therefore used for delivering part of the scavenging air, but only when the pressure in the pipe 11 is not greater than that in the pipe 14.

Furthermore, with the device 25 the scavenging pressure can be increased, resulting in a particularly effective scavenging. On the device 25 being placed in such a position that the piston pump 40 draws air out of the pipe 24 instead of from the atmosphere, the piston pump 40 will be supplied from the blower 9 with precompressed air, so that the pressure of the air delivered by the pump 40 will be increased in the pipe 14 since the weight of air drawn by suction by the pump 40 out of the pipe 24 is greater.

In the case of multi-cylinder engines the lower part of each cylinder can be made in the form of an additional air pump or only some of the cylinders may be provided with this arrangement. The pumps can be connected singly, each to a cylinder. The compressed air delivered by each pump 40 is conveyed after passing a non-return valve 18 into the cylinders 1 of the internal combustion engine. In the case of multi-cylinder engines either only one exhaust gas turbine with a blower connected to a manifold or several turbines and blowers may be provided.

Figure 1 shows an internal combustion engine the cylinders of which are constructed in the manner shown in Figure 2. 1 are the separate cylinders. The exhaust gas turbine 8 driven by means of the exhaust gases of the internal combustion engine is directly coupled with the blower 9. The blower 9 forces the air by way of a cooler 10 into the pipe 11 of the internal combustion engine. The piston pumps 40, which are not shown, deliver their air by way of the pipe 14 into the ports 26 of each cylinder of the internal combustion engine. Of the six cylinders 1 of the internal combustion engine which are shown, only four for instance are provided with the shut-off arrangement 29 for the piston pumps 40. Thus two of the piston pumps 40 deliver scavenging air even when the internal combustion engine is under heavy load. Such an operation enables a more effective scavenging of all cylinders, by the following reason:

The scavenging of the two cylinders which are not provided with the shut off arrangement 29 is at least partially due to the air delivered by their pumps 40. As soon as the pressure in the pipes 14 of these two cylinders is higher than that in the pipe 11 (which must be the case at certain moments since the pressure of the air delivered by the pumps 40 continuously increases on the piston's downward stroke) the valve 17 will be closed and scavenging takes place by the air delivered by the pumps 40, thus saving the air delivered by the blower 9 for scavenging the other cylinders. By this means the pressure of the air delivered by the blower 9 will also be increased so that at the same time scavenging will be more efficient. On the other hand no uneven operation of the internal combustion engine can result by such an operation, because supercharging of all cylinders is due to the blower 9 alone, as the ports 27 are longer than the ports 26 which deliver scavenging air from pumps 40 to the cylinders 1.

The device 29 works in a way similar to that already described in connection with Figure 2, i. e., when the load on the internal combustion is light, the device 29 closes and opens when the load is large.

The use of separate inlet ports of different length is involved by the fact that one of the two air pumps 9 and 40 is used exclusively for supplying scavenging air, while the other supplies both scavenging and charging air the pres-

sure of the air supplied by the two types of pumps rarely coinciding. According to the description of Figures 1 and 2 the air supplied by the blower 9 is used predominantly for charging the internal combustion engine, since a blower, driven by waste gas, is excellently suited for such purposes insofar as the same, at least in ranges of heavier load, automatically establishes the most advisable charging pressure in every case, i. e. with heavy load a high charging pressure and with small load a smaller charging pressure. In comparison therewith the additional scavenging pumps 40 always supply air of practically the same pressure, at least as long as the load on the internal combustion engine has not yet become so large that according to the description of Figures 1 and 2 some of these pumps are disconnected.

In Figure 3 the special arrangement of inlet ports is shown. The air coming from the piston pumps 40 enters into the combustion cylinder through lower ports 26 and the air flowing in from the blower 9 and the pipe 11 through port 27 lying above them. Inlet port arrangements as shown in Figure 3 are cheaper in construction than those shown in Figure 2. Such arrangements are suitable for engines generally working at low loads. At small load all the piston pumps 40 deliver scavenging air to the cylinders of the internal combustion engine and as the pressure of the blower air is lower than that of the air coming from the piston pumps the scavenging air has to be delivered exclusively by the piston pumps 40. This may take place during the whole opening period of the slots 26. The arrangement of inlet ports as shown in Figure 3 is therefore quite sufficient for engines working at small loads.

In Figure 4 the converse arrangement of ports 26 and 27 is shown, that is, the air coming from the pipe 14 or the piston pumps 40 enters the cylinder through upper-ports 26 lying more towards the combustion dead center, and the air coming from the turbine driven blower 9 and the pipe 11 enters through the lower ports 27. With this arrangement it is possible to cause the air at low pressure coming from the blower 9 to be used more for scavenging and the more high compressed air from the piston pumps and the pipe 14 for charging purposes. Furthermore, the exhaust ports are arranged in Figure 4 in superposed rows, each of which exhaust into separate stages of the exhaust gas turbine. As a result the energy of the waste gases is better utilized, that is to say, the waste gas turbine can be operated with better efficiency, insofar as one stage can be built for higher pressures and the other stage for lower pressures. Moreover, in contradistinction to Figure 2 the upper inlet and outlet ports are made of the same length. As a result it is only possible to charge the internal combustion engine to the amount of the waste gas pressure in front of the turbine.

Constructions according to Figure 4 are advantageous for internal combustion engines which operate predominantly with small load, in which case less energy is available at the turbine 8 for supplying scavenging air. As the slide valve 19 will be closed when the Diesel engine runs under light load the air delivered by the pump 40 is able to work as charging and scavenging air so that it is possible by arrangements according to Figure 4 to scavenge the cylinder space 9 vigorously even with small load right at the commencement of the exhaust operation, that is to say while the exhaust gases are still very hot, whereas less vigorous scavenging by the blower air starts only when exhaust gases and cylinder walls are cooled to a considerable amount and a vigorous scavenging is no longer required. Furthermore the pressure of the charging air in arrangements according to Figure 4 is independent of the energy content of the waste gases, because the charging air is supplied by the piston pumps 40. This is very desirable because with small loads the pressure of the air supplied by the blower 9, as experience has shown, may drop at least below the pressure of the waste gases in front of the high pressure turbine, so that charging would no longer be possible. According to the arrangement of the ports in Figure 4 the cylinder space 6 can be charged up at least to the amount of the counter-pressure of the high pressure turbine.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:—

1. In an internal combustion engine having a plurality of combustion cylinders, exhaust ports in each combustion cylinder, an exhaust gas turbine mechanically independent of the shaft of said internal combustion engine, a conduit between said exhaust ports and said exhaust gas turbine, a charging blower driven by said exhaust gas turbine, a first set of inlet ports in each combustion cylinder, a conduit between said charging blower and said first set of inlet ports, a non-return valve in said conduit to the inlet ports, a piston pump for each combustion cylinder, that piston pump driven by the internal combustion engine, a second set of inlet ports, a conduit between said piston pump and said second set of inlet ports and a non-return valve in this conduit.

2. In an internal combustion engine having a plurality of combustion cylinders, a piston in each cylinder, exhaust ports in each combustion cylinder, an exhaust gas turbine mechanically independent of the shaft of said internal combustion engine, a duct leading from the exhaust ports to the gas turbine, a charging blower driven by said exhaust gas turbine, a first set of inlet ports in each combustion cylinder, a conduit between said charging blower and said first set of inlet ports, a non-return valve in said conduit to the inlet ports, a piston pump for each combustion cylinder driven by the internal combustion engine, a second set of inlet ports arranged so as to be shut by the piston on the compression stroke earlier than the former set of inlet ports, a conduit between said piston pump and said second set of inlet ports and a non-return valve in this conduit.

3. In an internal combustion engine having a plurality of combustion cylinders, an exhaust gas turbine mechanically independent of the shaft of said internal combustion engine, a charging blower driven by said exhaust gas turbine, a first set of inlet ports in each combustion cylinder, a conduit between said charging blower and said first set of inlet ports, a piston pump for each combustion cylinder, a second set of inlet ports, a conduit between said piston pumps and said second set of inlet ports, said first set of inlet ports of greater length from said second set of inlet ports and a non-return valve in each of said conduits.

4. In an internal combustion engine having a plurality of combustion cylinders, a piston and exhaust ports in each combustion cylinder, an

exhaust gas turbine mechanically independent of the shaft of said internal combustion engine, a duct leading from the exhaust ports to the gas turbine, a charging blower driven by said exhaust gas turbine, a first set of inlet ports in each combustion cylinder, a conduit between said charging blower and said first set of inlet ports, a non-return valve in said conduit to the inlet ports, a piston pump for each combustion cylinder driven by the internal combustion engine, a second set of inlet ports arranged so as to be shut by the piston in the compression stroke earlier than the exhaust ports, a conduit between said piston pump and said second set of inlet ports and a non-return valve in this conduit.

5. In an internal combustion engine having a plurality of combustion cylinders, a piston and exhaust ports in each combustion cylinder, an exhaust gas turbine mechanically independent of the shaft of said internal combustion engine, a duct leading from the exhaust ports to the gas turbine, a charging blower driven by said exhaust gas turbine, a first set of inlet ports in each combustion cylinder arranged so as to be shut by the piston on the compression stroke later than the exhaust ports, a conduit between said charging blower and said first set of inlet ports, a non-return valve in said conduit to the inlet ports, a piston pump for each combustion cylinder, driven by the internal combustion engine, a second set of inlet ports arranged so as to be shut by the piston on the compression stroke earlier than the exhaust ports, a conduit between said piston pump and said second set of inlet ports and a non-return valve in this conduit.

6. In an internal combustion engine having a plurality of combustion cylinders, a piston and exhaust ports in each combustion cylinder, an exhaust gas turbine mechanically independent of the shaft of said internal combustion engine, a charging blower driven by said exhaust gas turbine, a duct leading from said exhaust ports to said turbine, a first set of inlet ports in each combustion cylinder, a conduit between said charging blower and said first set of inlet ports, a non-return valve in said conduit to the inlet ports, a piston pump for each combustion cylinder and driven by the internal combustion engine, a second set of inlet ports arranged so as to be shut by the piston on the compression stroke before the former inlet ports begin to be covered, a conduit between said piston pump and said second set of inlet ports and a non-return valve in this conduit.

7. In an internal combustion engine having a plurality of combustion cylinders, a piston and exhaust ports in each combustion cylinder, an exhaust gas turbine mechanically independent of the shaft of said internal combustion engine, ducts leading from the exhaust ports to the gas turbine, a charging blower driven by said exhaust gas turbine, a first set of inlet ports in each combustion cylinder arranged so as to be shut by the piston on the compression stroke earlier than the exhaust port or ports, a conduit between said charging blower and said first set of inlet ports, a non-return valve in said conduit to the inlet ports, a piston pump for each combustion cylinder driven by the internal combustion engine, a second set of inlet ports arranged so as to be shut by the piston on the compression stroke later than the former inlet ports, a conduit between said piston pump and said second set of inlet ports and a non-return valve in this conduit.

8. In an internal combustion engine having a plurality of combustion cylinders, a piston and sets of exhaust ports in each combustion cylinder, one set being shut later than the others, two stages of an exhaust gas turbine mechanically independent of the shaft of said internal combustion engine, ducts leading from the exhaust ports to the stages of the gas turbine, a charging blower driven by said exhaust gas turbine, a first set of inlet ports in each combustion cylinder arranged so as to be shut by the piston on the compression stroke before that set of exhaust ports which is shut later, a conduit between said charging blower and said first set of inlet ports, a non-return valve in said conduit to the inlet ports, a piston pump for each combustion cylinder driven by the internal combustion engine, a second set of inlet ports arranged so as to be shut by the piston on the compression stroke later than the former set of inlet ports, a conduit between said piston pump and said second set of inlet ports and a non-return valve in this conduit.

9. In an internal combustion engine having a plurality of combustion cylinders, a piston and sets of exhaust ports in each combustion cylinder, one set being shut later than the others and another set being shut earlier than the others, two stages of an exhaust gas turbine mechanically independent of the shaft of said internal combustion engine, ducts leading from the exhaust ports to the stages of the gas turbine, a charging blower driven by said exhaust gas turbine, a first set of inlet ports in each combustion cylinder arranged so as to begin to be covered and to be shut simultaneously with that set of exhaust ports which is shut earlier, a conduit between said charging blower and said first set of inlet ports, a non-return valve in said conduit to the inlet ports, a piston pump for each combustion cylinder driven by the internal combustion engine, a second set of inlet ports arranged so as to begin to be covered and to be shut simultaneously with that set of exhaust ports which is shut later, a conduit between said piston pump and said second set of inlet ports and a non-return valve in this conduit.

10. Apparatus as claimed in claim 1, a conduit from the delivery side of the piston pump to the atmosphere, a valve member, said valve member inserted in the last mentioned conduit, a spring loaded piston, said piston connected to the said valve member and operated by the pressure in the delivery pipe of the exhaust gas turbine driven blower.

11. Apparatus as claimed in claim 1, a conduit between the delivery side of the exhaust gas turbine driven blower and the suction side of the piston pump, a conduit from the atmosphere to the before mentioned conduit and a valve member therein, said valve member adapted to connect the suction side of the piston pump selectively to the atmosphere or to the delivery side of the exhaust gas turbine driven blower.

ALFRED BÜCHI.