Aug. 28, 1945. H. STEINER 2,383,625

FREE PISTON INTERNAL-COMBUSTION ENGINE

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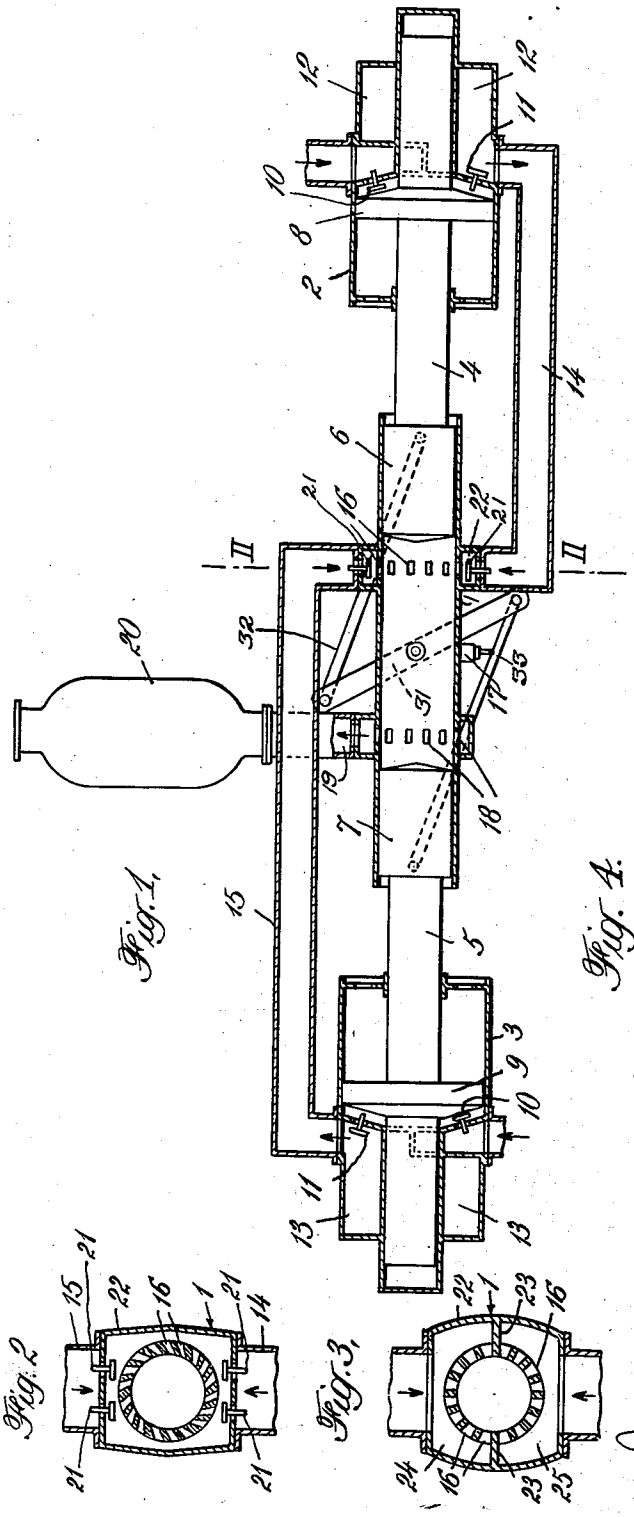


Fig. 1.

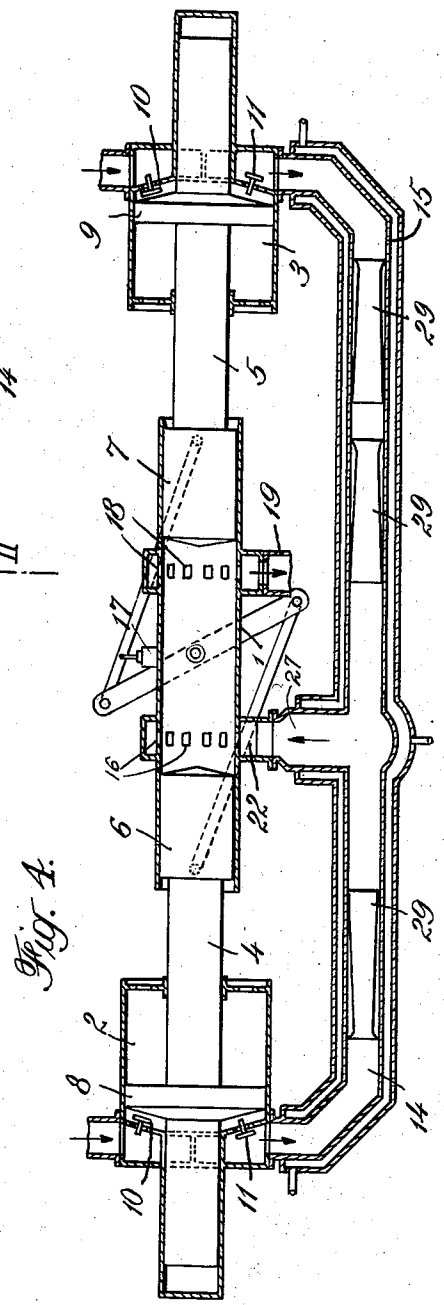


Fig. 4.

Fig. 2

Fig. 3.

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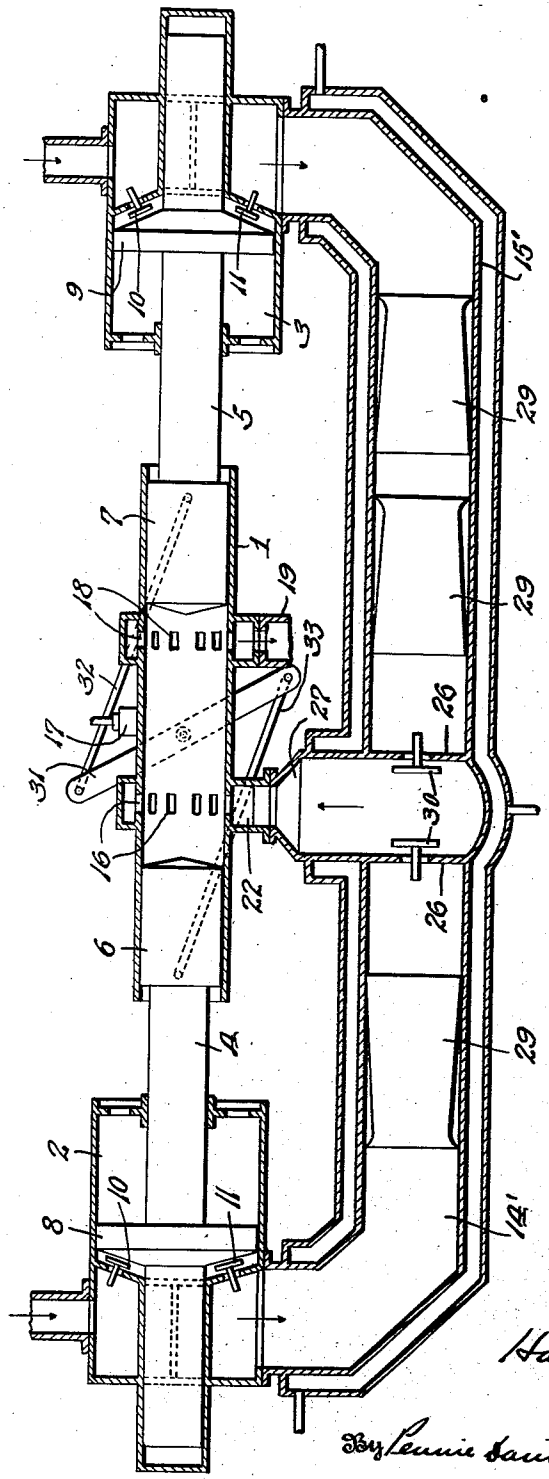
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Fig. 5.



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FREE-PISTON INTERNAL-COMBUSTION ENGINE

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6 Claims. (Cl. 123—46)

The invention relates to a free-piston internal combustion engine, with several scavenging-air pipes leading to the internal combustion cylinder and having the scavenging-air currents directed opposite to each other and consists in one or more members being provided to restrict or prevent the passage of scavenging-air from one pipe into another. Preferably at least one scavenging-air pipe is provided with one or more non-return valves. In addition to the members affecting the passage of scavenging-air from one pipe into another on the one hand, a collecting space may be built into the piping near the scavening-air compressor and may have a volume which is a multiple of the cylinder volume swept by the internal combustion piston associated with the compressor, on the other hand the pipe connecting the space to the internal combustion cylinder may have preferably the same or a smaller cross-section than the cross-section of the internal combustion cylinder.

In contrast to known free-piston engines, particularly to those in which the air inlet into the internal combustion cylinder takes place directly out of a scavenging-air collecting space surrounding the internal combustion cylinder on all sides, the invention has the advantage that it prevents disturbances in the scavenging from drops in pressure in the internal combustion cylinder and fouling of the air contents through the exhaust gases.

In the drawings examples of constructions according to the invention are shown diagrammatically.

Fig. 1 is a longitudinal section through a free-piston engine with collecting chambers on the compressor cylinders.

Fig. 2 is a cross-section on the line II—II of Fig. 1.

Fig. 3 illustrates a subdivision of the inlet ports of the air space surrounding the inlet ports of the internal combustion cylinder.

Fig. 4 is a longitudinal section through a free-piston engine with a chamber at the internal combustion cylinder.

Fig. 5 is a longitudinal sectional view through a free-piston engine generally similar to that shown in Fig. 4.

The free-piston engine in Fig. 1 has an internal combustion cylinder 1 and two compressor cylinders 2 and 3 in which the free pistons 4 and 5 work with the internal combustion pistons 6 and 7 and the compressor pistons 8 and 9. The compressor cylinders 2 and 3 have suction and delivery valves 10 and 11 and are connected through the collecting chambers 12 and 13 and the scavenging-air pipes 14 and 15 to the inlet ports 16 of the internal combustion cylinder 1. The internal combustion cylinder 1 has a fuel valve 17 and outlet ports 18 and is connected by means of the power gas pipe 19 to the power-gas container 20.

During the inward stroke of the free pistons 4 and 5 the compressor pistons 8 and 9 draw air in, which they compress in the first part of the outward stroke; after that the compressed air is forced out of the cylinders 2 and 3 into the collecting chambers 12 and 13. In the internal combustion cylinder 1 towards the end of the outward stroke, the outlet ports 18 are opened and through them the combustion gases or power gases flow into the container 20. When the pressure in the internal combustion cylinder has fallen sufficiently far, the inlet ports 16 begin to open, thereby admitting scavenging air from the chambers 12 and 13 into the internal combustion cylinder 1.

The difference in time between the beginning of the separate phases of the expulsion of the air from the compressor cylinders and the scavenging-air entry at the internal combustion cylinder on the one hand, of the outlet phase and of the scavenging phase at the internal combustion cylinder on the other hand, as necessitated by the free-piston operation, makes it possible for the air columns to oscillate or for pressure waves to form in the scavenging-air piping between the outlet and the inlet, whereby the scavenging of the internal combustion cylinder 1 may be interfered with. Also the different lengths of the scavenging-air pipes 14 and 15, necessitated by the symmetrical arrangement of the compressors 2 and 3 and the one-sided arrangement of the inlet ports 16 with respect to the combustion space of the internal combustion cylinder 1, may cause such oscillations or pressure waves.

The device which damps or prevents the oscillation of the air column in the scavenging-air pipes 14 and 15 or the occurrence of a pressure wave, consists in Fig. 1 on the one hand of the collecting chambers 12 and 13 arranged in the pipes 14 and 15 close to the compressors 2 and 3, the volume of each collecting chamber being two, three or more times that of the volume of the internal combustion cylinder swept by the pistons 6 and 7 associated with the compressors 2 and 3 respectively, and on the other hand of the pipes 14 and 15 connecting the chambers 12 and 13 to the internal combustion cylinder 1, the cross-section of these pipes being preferably con-

siderably less than or exactly the same size as the cross-section of the internal combustion cylinder 1. In special cases, however, the pipes 14 and 15 may also have a cross-section greater than that of the internal combustion cylinder 1.

Since the collecting chambers 12 and 13 are in immediate proximity to the delivery valves 11, they prevent oscillation occurring during the pressure stroke of the compressors 2 and 3, whilst the greater speed of the air in pipes 14 and 15, in consequence of their small cross-section, prevents oscillation of the air column or a pressure wave occurring in it when scavenging. In addition to that, the pipes 14 and 15 are shut off from the space 22 surrounding the inlet ports 16 by means of the non-return valves 21 (Figs. 1 and 2) so that any oscillation of the power gases in the container 20 occurring during the outlet phase cannot adversely affect the scavenging operation through a back-flow of air or a pressure wave in the pipes 14 and 15 in a direction contrary to the scavenging-air flow.

The air speed in the scavenging-air pipes 14 and 15 caused by arranging the collecting chambers 12 and 13 close to the compressor cylinders 2 and 3, brings, in addition to that, the advantage that favourable conditions are obtained in the internal combustion cylinder 1 from the end of the scavenging phase until the closing of the scavenging ports 16 in consequence of the kinetic energy of the air columns in these pipes.

The different lengths of the pipes 14 and 15, when the compressor pistons 8 and 9 begin simultaneously to force air into the receivers 12 and 13, may also cause different pressure conditions at different times at the outlet of the pipes 14 and 15 into the space 22. In order to prevent air flowing through from pipe 14 into pipe 15, or vice versa because of such differences in pressure, the space 22 in Fig. 3 is subdivided into two spaces 24 and 25 by means of a partition wall 23, instead of having the non-return valves 21 as in Fig. 2.

The scavenging-air pipes 14 and 15 in Fig. 4 are connected direct to the compressor cylinders 2 and 3, omitting the chambers 12 and 13 as in Fig. 1. Their outlet ends 26 are arranged with respect to each other at the container 27 in such a way that the currents of scavenging-air flowing from them are directed opposite to each other. For damping pressure waves or checking air flowing back into pipes 14 and 15, special throttling nozzles 29 are built into the pipes 14 and 15. The throttling nozzles 29 may also be designed in some other manner. They may be used instead of the non-return valves or together with them.

The free-piston engine shown in Fig. 5 is similar to that shown in Fig. 4 except that the scavenging-air pipes 14' and 15' are of greater diameter than the internal combustion cylinder 1 and their outlet ends are provided with non-return valves 30 in order to avoid possible troubles in consequence of the two pipes being of different lengths.

In each of Figs. 1, 4 and 5 a synchronizing mechanism comprising two-arm lever 31 and connecting rod 32 connected to one arm of said lever and free-stroke piston 6 and a connecting rod 33 connected to the other end of said lever and free-stroke piston 7 is provided for assuring countermovement of the pistons.

I claim:

1. A free-piston internal combustion engine with several scavenging-air pipes leading to circumferentially spaced intake ports of the internal combustion cylinder and having the scavenging-air current directed opposite to each other in the cylinder, which comprises means for causing the air to flow from each of the several pipes through the inlet ports leading into the cylinder and for at least restricting the scavenging-air from flowing from one pipe into another.

2. A free-piston engine according to claim 1 which comprises a non-return valve in at least one of the pipes.

3. A free-piston engine according to claim 1 which comprises at least one throttling nozzle in each pipe to restrict the flow of air from one pipe into another.

4. A free-piston engine according to claim 1 which comprises a compressor piston driven by each free-piston to compress the scavenging-air, a collecting space connected to each pipe for receiving the air from each compressor, the diameter of the pipes being not greater than the diameter of the engine cylinder.

5. A free-piston internal combustion engine with at least two scavenging-air pipes which are connected to the inlet ports of the internal combustion cylinder arranged opposite to each other, which comprises wall-means forming a space surrounding the cylinder and the intake ports, a partition dividing the space into two parts, a scavenging-air pipe being connected to each part of the space, whereby air does not flow from one pipe into another, the intake ports being so arranged in the cylinder that ports in one space are diametrically opposite ports in the other space.

6. A free-piston engine according to claim 1 which comprises a compressor piston driven by each free piston to compress the scavenging-air, a collecting space connected to each pipe for receiving the air for each compressor, the volume of the collecting space being not less than twice the volume of the cylinder swept by the engine piston, the diameter of the pipes being not greater than the diameter of the engine cylinders.

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