H. JUNKERS.

COMPOUND ENGINE.

APPLICATION FILED OCT. 17, 1908.

990,140.

Patented Apr. 18, 1911.

2 SHEETS—SHEET 1.

Fig. 2.

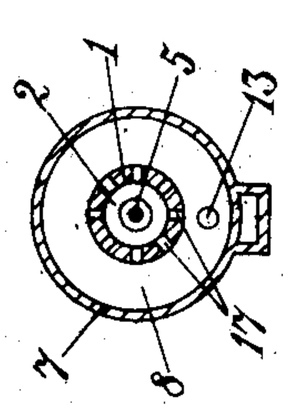


Fig. 4.

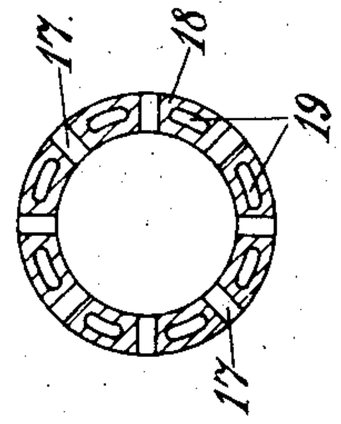


Fig. 1.

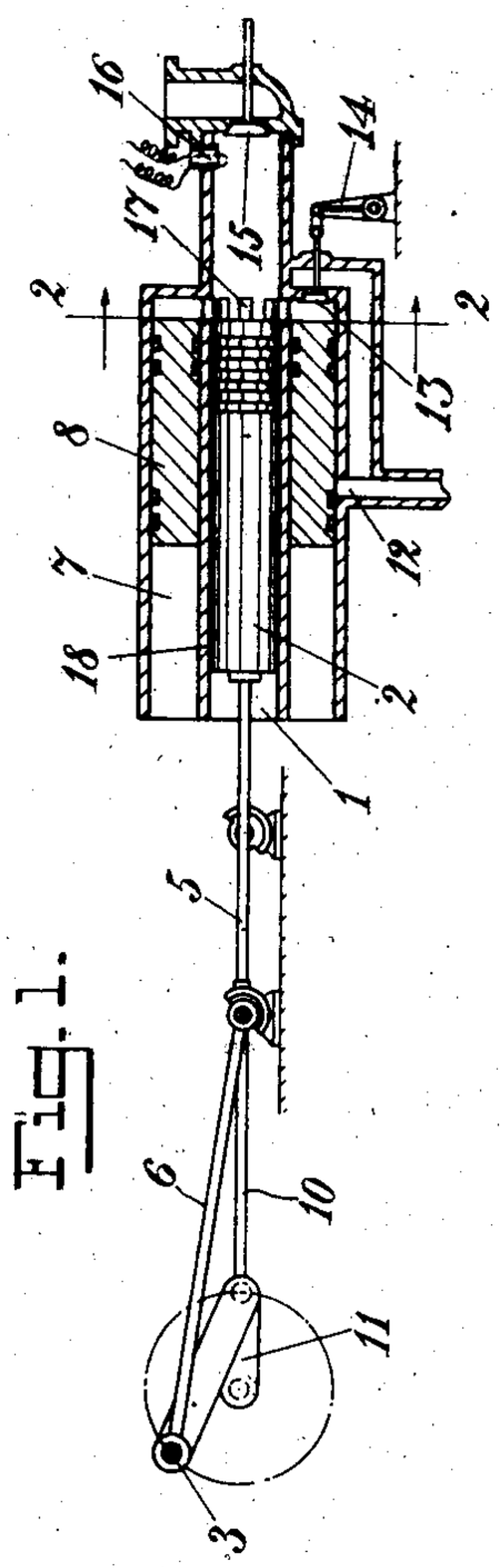
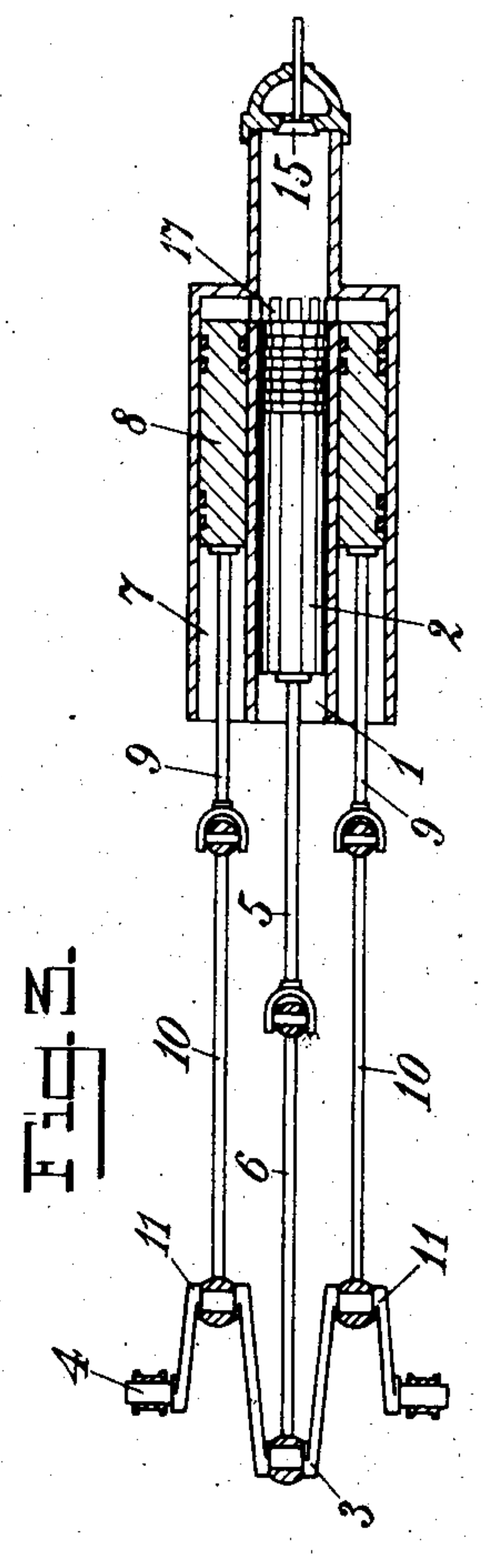


Fig. 3.



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2 SHEETS—SHEET 2.

FIG. 5.

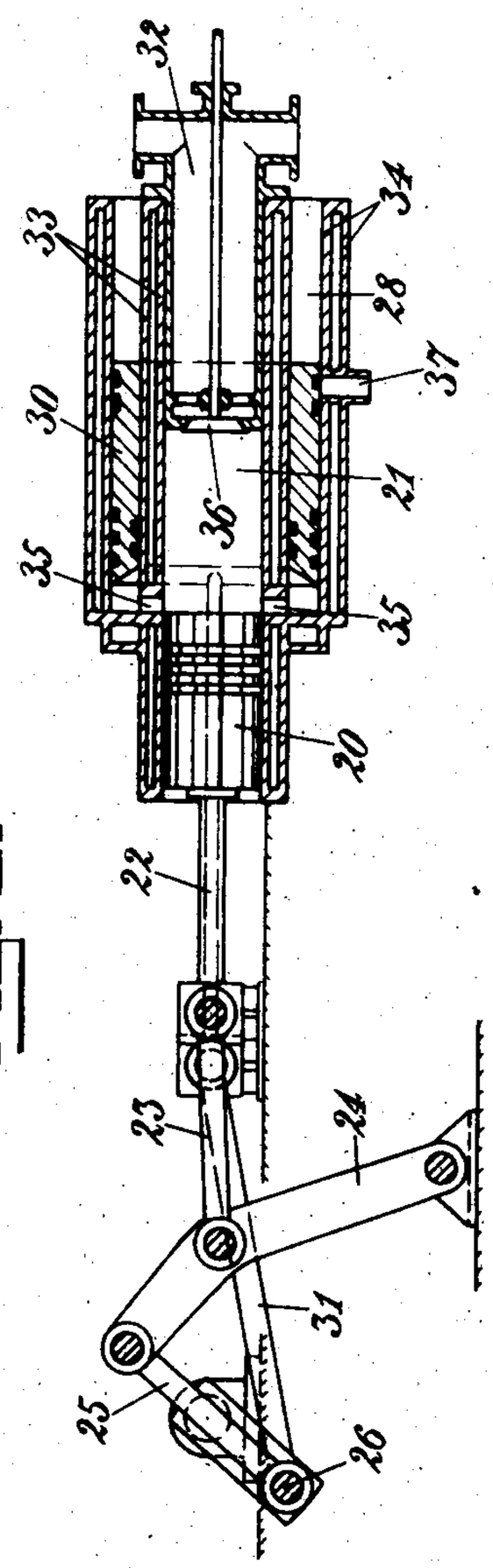
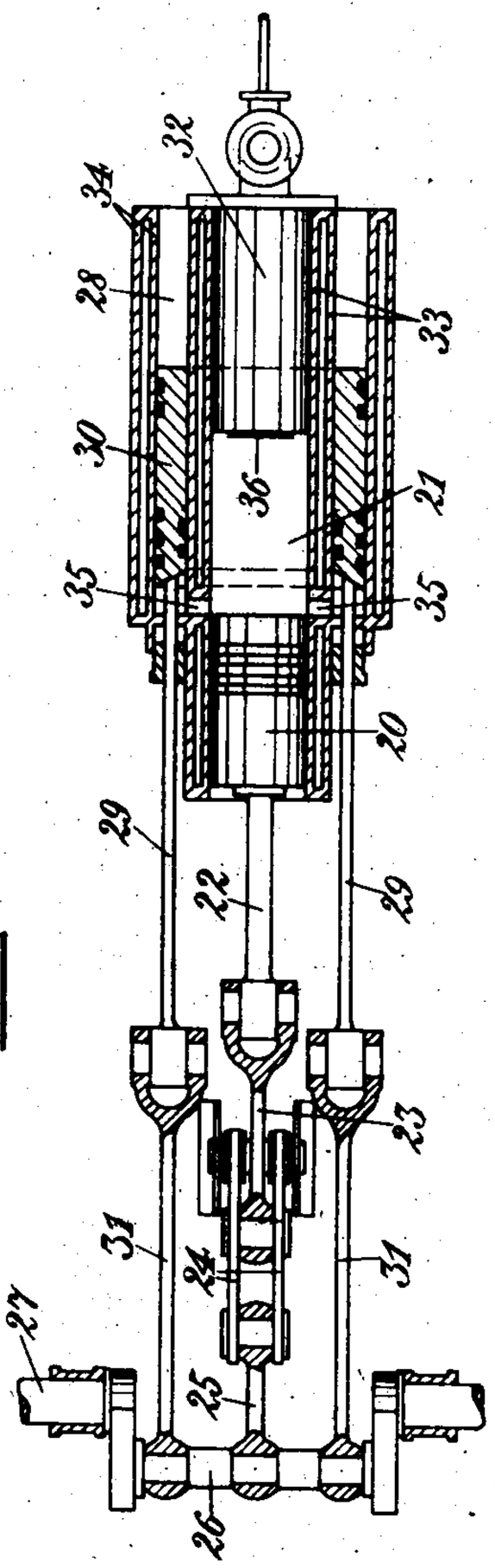


FIG. 6.



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COMPOUND ENGINE.

990,140. Specification of Letters Patent. Patented Apr. 18, 1911.

Application filed October 17, 1908. Serial No. 458,257.

To all whom it may concern:

Be it known that I, HUGO JUNKERS, professor in the Royal Polytechnicum at Aix-la-Chapelle, Germany, a subject of the King of Prussia, residing at No. 64 Brabantstrasse, Aix-la-Chapelle, in the Kingdom of Prussia, Empire of Germany, have invented certain new and useful Improvements in Compound Engines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My present invention relates to compound engines, built as explosion-engines, combustion-engines, steam-engines and so forth, and particularly to a compound-engine wherein a plurality of cylinders is arranged concentrically to each other, and in which the wall common to two cylinders is provided with communication-ports or slots for the passage of the driving-medium from the higher-stage pressure-cylinder into the lower-stage pressure-cylinder which ports are controlled by the hinge-stage pressure-piston.

The object of my present invention is to carry out the compounding in a more favorable manner than it was hitherto possible in this kind of engines. This is effected by giving the piston of the lower-stage pressure-cylinder in regard to the piston of the higher-stage pressure-cylinder such a lead, that the former is beginning its outstroke when the latter begins to uncover the communication-ports in the common wall, so that the gases or vapors at first expand in the higher-stage pressure-cylinder until the end of the stroke is almost reached, whereupon they flow into the lower-stage pressure-cylinder to further expand therein until the piston of the lower-stage pressure-cylinder uncovers the exhaust-ports of the latter. In an engine with internal combustion (gas- or oil-engine for explosion or slow combustion) the charging of the high-pressure cylinder with a charge-mixture or fresh air takes place principally when the communication between both cylinders is open but the outlet of the lower-stage pressure-cylinder is closed, so that the charging-pressure in the higher-stage pressure-cylinder is greater than the atmospheric pressure and approximately equal to the inlet-pressure of the lower-stage pressure. After the communication-ports have been closed the gases expand in the lower-stage pressure-cylinder and the work expended for charging the higher-stage pressure-cylinder under a higher pressure than the atmospheric is mostly recovered in the lower-stage pressure-cylinder.

In a steam engine the steam enters the higher-stage pressure-cylinder in the usual manner at the beginning of the outstroke of the higher-stage piston, whereas the expansion in the higher-stage pressure-cylinder, the flow of the partially expanded steam into the lower-stage pressure-cylinder and the expansion in the latter take place as in an internal combustion-engine. The compression-engine differs from the steam-engine only in this respect, that it operates in the reverse way. More than two cylinders may be arranged concentrically to each other if necessary. The linear motion of the pistons may be transformed into rotary motion by means of a multicranked shaft, or by a combination of a one-throw crank-shaft with a suitable link motion.

I have elected to describe and illustrate my present invention as an internal combustion-engine having a high-pressure cylinder and a low-pressure cylinder, although it is applicable to other engines as well.

In the accompanying drawings:—Figure 1 is a vertical longitudinal sectional view of an internal combustion engine. Fig. 2 is a sectional view taken on line 2—2 of Fig. 1. Fig. 3 is a horizontal longitudinal sectional view of the engine shown in Fig. 1. Fig. 4 is a cross-sectional view of a divisional cylinder-wall provided with cooling-channels. Fig. 5 is a vertical longitudinal sectional view of a modification of the internal combustion engine shown in Fig. 1, wherein a one-throw crank-shaft and a link-motion are employed. Fig. 6 is a horizontal longitudinal sectional view of the modification of the engine shown in Fig. 5.

In the engine illustrated in Figs. 1 and 3 the inner cylinder 1 is the high-pressure cylinder wherein the piston 2 works. The latter is connected with the middle-crank 3 of the crank-shaft 4 by means of the piston-rod 5 and the connecting-rod 6. The annular or outer cylinder 7 is the low-pressure cylinder, wherein the annular piston 8 operates, which is connected by means of the piston-rods 9 and the connecting-rods 10 to the outer cranks 11 of said crank-shaft 4. In Fig. 1 one of the exhaust-channels 12 of the

low-pressure cylinder 7 is shown, which at one of its ends is provided with an auxiliary outlet-valve 13 operatable from without by the lever 14. This valve may, however, be omitted if so desired. The one end of the high-pressure cylinder 1 is provided with an inlet-valve 15 over which an igniter 16 is arranged. Both cylinders communicate with each other by means of the ports 17 arranged in the annular wall 18 common to the cylinders 1 and 7 and opened or closed at the right moments by the high-pressure piston 2. The water-cooling of these cylinders is not shown here, since it is not always required and may be arranged as circumstances may direct. If however necessary the annular wall 18 may be cooled, which can be advantageously done as shown on a larger scale in Fig. 4, wherein between the ports 17 channels 19 for the cooling-water are arranged. In every instance it is necessary that the high-pressure piston and the low-pressure piston do neither move alike nor in the opposite direction, on the contrary, it is necessary that in expansion-engines the low-pressure piston reaches its dead point before the high-pressure piston reaches its own dead point. A compression-engine is formed by simply reversing the direction of motion of the pistons of an expansion-engine. In the engine illustrated in Figs. 1 and 3 the necessary lead of one of the pistons is accomplished by arranging the cranks of the two-throw crank-shaft 4 under a suitable angle to each other, or as shown in the engine illustrated in the Figs. 5 and 6 by means of a single-throw crank-shaft and an oscillating link-motion.

In Figs. 5 and 6 the piston 20 of the high-pressure cylinder 21 is connected by means of the piston-rod 22 and the link 23 to the oscillating lever 24, whose free end is connected by the connecting-rod 25 to the crank 26 of the one-throw crank-shaft 27. The working-space of the low-pressure cylinder 28 lies toward said crank-shaft 27. The two piston-rods 29 of the low-pressure piston 30 pass through said working-space and are connected with the crank-shaft 27 by means of the connecting-rods 31. The cover 32 of the high-pressure cylinder 21 is tubular in shape and its length chosen to reduce the bore of the high-pressure cylinder to the right length. In this arrangement the cylinder-wall 33 and 34 as well as the short ports 35 arranged in the cylinder-wall 33 are water-cooled. The inlet-valve 35 is arranged in the cover 32 as best shown in Fig. 5 which also shows one of the exhaust-channels 37 of the low-pressure cylinder 28.

When more than two concentric cylinders are utilized the same principles employed in the engines shown here by way of example are put into practice, *i. e.* any two adjacent cylinders which communicate with each other coöperate in a manner similar to t one explained above.

I claim:—

1. A compound engine with a plurality cylinders by which the expansion of t driving medium first takes place in t higher-stage pressure cylinder until near t end of stroke of the higher-stage piston a the further expansion is effected nearly du ing the whole stroke of the lower-stage p ton having a wall common to adjacent cyli ders and provided with communicatio ports, a piston governing the exhaust-por of the lower-stage pressure cylinder, a p ton arranged in the higher-stage pressu cylinder and governing said communicatio ports, means for moving said higher-sta piston to uncover said communication-por when the lower-stage piston begins its ou stroke and to cover said communicatio ports before said exhaust-ports of the lowe stage pressure-cylinder are opened, mea for admitting to said higher-stage pressu cylinder a charge of higher than atmo pheric pressure and means for transformi the linear motion of said pistons into rota motion.

2. A compound engine with a plurality cylinders by which the expansion of t driving medium first takes place in th higher-stage pressure cylinder until near t end of stroke of the higher-stage pisto and the further expansion is effected near during the whole stroke of the lower-stag piston having a wall common to adjace cylinders and provided with communicatio ports, a piston governing the exhaust-por of the lower-stage pressure cylinder, a pi ton arranged in the higher-stage pressu cylinder and governing said communicatio ports, means for moving said higher-stag piston to uncover said communication-por when the lower-stage piston begins its ou stroke and to cover said communicatio ports before said exhaust ports of the lowe stage pressure cylinder are opened, mean for admitting to said higher-stage pressu cylinder a charge of higher than atmos pheric pressure when said communicatio ports are open but the exhaust-ports of th lower-stage pressure cylinder are closed, an means for transforming the linear motion o said pistons into rotary motions.

3. A compound engine with a plurality o cylinders by which the expansion of th driving medium first takes place in th higher-stage pressure cylinder until near th end of stroke of the higher-stage piston an the further expansion is effected nearly dur ing the whole stroke of the lower-stage pis ton having a wall common to adjacent cyl inders and provided with communication ports a piston governing the exhaust port of the lower-stage pressure cylinder, a pis ton arranged in the higher-stage pressur

cylinder and governing said communication-ports, means for moving said higher-stage piston to cover said communication-ports when the lower-stage piston begins its outstroke and to cover said communication-ports before the exhaust-ports of the lower-stage pressure cylinder are opened, means for admitting live-steam at the beginning of the outstroke of the higher-stage pressure-piston, and means for transforming the linear motion of said piston into rotary motion.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

HUGO JUNKERS.

Witnesses:

ABRAHAM SCHLESINGER,

LOUIS MUELLER.