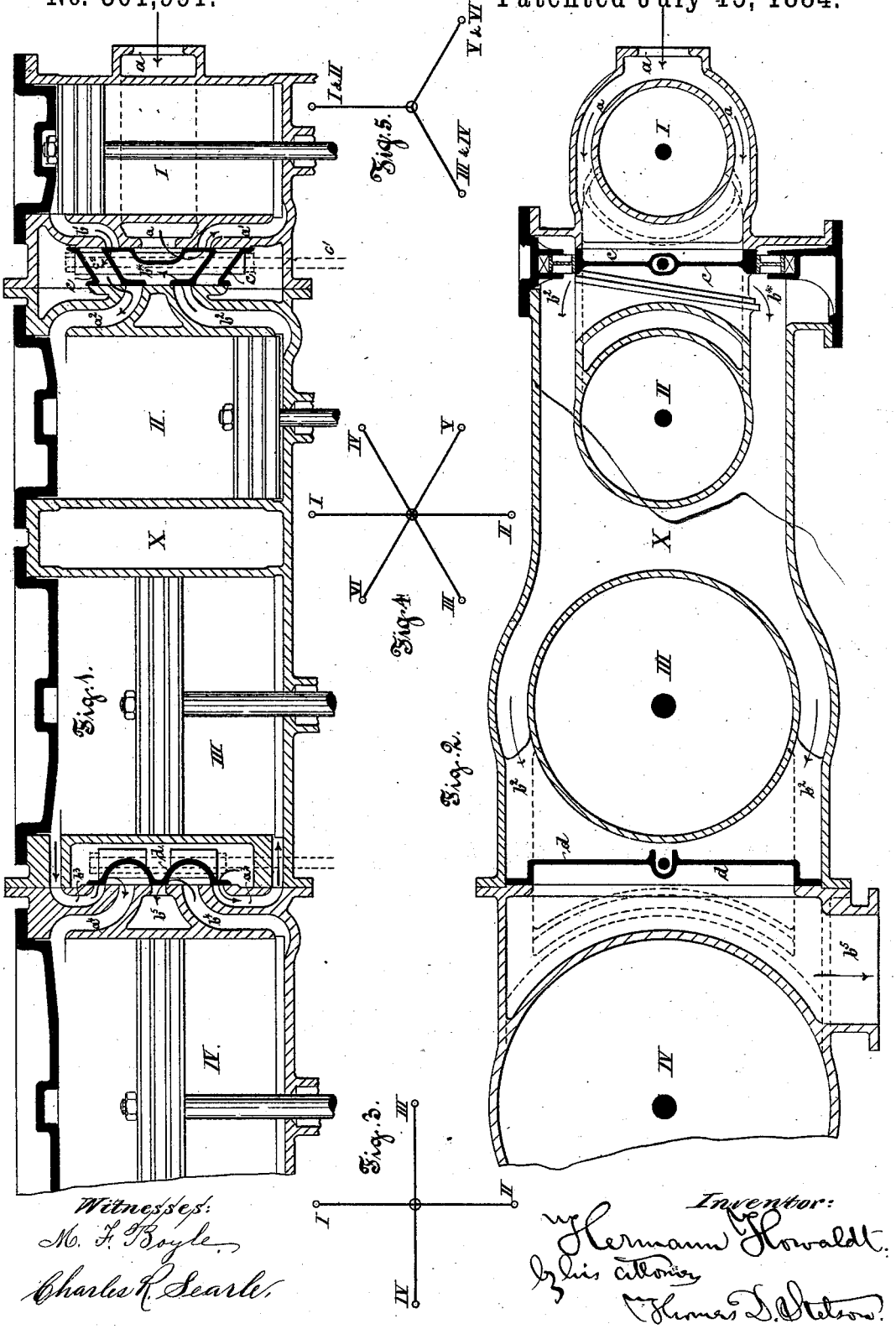
(No Model.)

H. HOWALDT.

COMPOUND STEAM ENGINE.

No. 301,991. Patented July 15, 1884.



Witnesses:
M. F. Boyle
Charles R. Searle

Inventor:
Hermann Howaldt.
by his attorney
Thomas D. Stetson.

UNITED STATES PATENT OFFICE.

HERMANN HOWALDT, OF DIETRICHSDORF, NEAR KIEL, PRUSSIA, GERMANY.

COMPOUND STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 301,991, dated July 15, 1884.

Application filed February 20, 1884. (No model.)

To all whom it may concern:

Be it known that I, HERMANN HOWALDT, of Dietrichsdorf, near Kiel, Prussia, Germany, have invented certain new and useful Improvements in Compound Steam-Engines, of which the following is a specification.

The object of the invention is to utilize high-pressure steam to the best advantage, and expand it down to the lowest pressure at which it can be available, working either condensing or non-condensing. I combine two or more pairs of cylinders. The two cylinders of each pair are of unequal size. The steam is exhausted from the smaller into the larger cylinder of a pair directly or with no intermediate chamber. The pistons of these two cylinders are opposite. Where two pairs only are used, the cranks for one pair are set at right angles to the cranks for the opposite pair. The steam is expanded from the larger cylinder of the first pair into a reservoir of considerable capacity. From this reservoir the steam is received at the proper time into the smaller cylinder of the next pair. I have devised a construction in which the reservoirs inclose the cylinders and form a jacket for them. When three pairs of cylinders are employed, the cranks for each pair should be set at sixty degrees to the cranks of the other pairs. In what I esteem as the most complete form of the invention, one slide-valve of suitable size serves as the means for introducing and discharging the steam for one pair of cylinders. Four of my cylinders, all of different sizes, are operated by only two valves. Six cylinders are operated by three valves.

The accompanying drawings form a part of this specification and represent what I consider the best means of carrying out the invention.

Figure 1 is a horizontal section showing four pistons and their respective rods, which may be understood as operating, through proper cross-heads and connecting-rods, with four cranks in a single continuous horizontal shaft. Fig. 2 is a corresponding vertical section.

Similar letters of reference indicate corresponding parts in both the figures.

The drawings represent the novel parts with so much of the ordinary parts as is necessary to indicate their relation thereto.

The parts not represented may be of any ordinary or suitable construction.

Figs. 3 and 4 are diagrams indicating the arrangements of the cranks as seen in a view lengthwise of the shaft. Fig. 5 is a diagram merely aiding to understand the effective action of three pairs of cylinders and pistons. Fig. 3 represents the arrangements of the cranks for the two pairs of cylinders which are shown in Figs. 1 and 2.

The drawings represent two pairs of cylinders. I is the smallest cylinder, and II is the second cylinder, considerably larger than I. These two, I and II, constitute the first pair of cylinders. III, considerably larger than II, is the smaller cylinder of the second pair. IV, larger than III, is the largest cylinder of the set. The cylinders III and IV constitute the second pair.

Between the two pairs of cylinders is a capacious reservoir, X, which I term a "receiver," sufficiently large and so arranged as to embrace the cylinders II and III. This reservoir X may be heated by conducting the products of combustion through or around it. I have not deemed it necessary to represent such provision. All the cylinders may be covered with non-conducting material or jacketed with steam at a pressure equal to or above that which enters the first and smallest cylinder I. The two cranks of the pair I and II are arranged opposite to each other. (See correspondingly marked points in the diagram Fig. 3.) The cranks of the cylinders III and IV are placed opposite to each other and at right angles to the cranks of I and II. (See the points so marked in Fig. 3.) A single valve, *c*, operated by a rod, *c'*, controls the admission of steam from the boiler into the first cylinder, I. This same valve also controls its discharge from each end alternately of the cylinder I into the adjacent end of the cylinder II. The same valve also controls the discharge of the steam from the ends alternately of the cylinder II into the reservoir X. A single valve also controls the admission of steam from the receiver X into the ends alternately of the cylinder III. The same valve also controls the discharge of steam from the ends alternately of the cylinder III into the adjacent ends of the cylinder IV. The same valve also controls the discharge of steam

from the ends of the cylinder IV into a condenser. (Not represented.) These valves are operated by devices (not represented) impelled by the engine. The means for connecting the several pistons to cranks on the shaft and for actuating these valves by eccentrics or cams on the said shaft may be of any ordinary or suitable character, and need not be especially described. The two valves and their connecting ports and passages may be alike, except that the valve between the cylinders III and IV should be larger than that between the cylinders I and II. I have represented different valves. Either of these forms of valves may be used in both positions. The steam at a pressure of six atmospheres (more or less) is received from the boiler, (not represented,) and conducted through a belt, *a a*, which surrounds the cylinder I, and discharged into a hollow throat in the valve *c*. The reciprocating motion of the valve presents this throat with its charge of strong steam alternately to the ports leading to the opposite ends of the cylinder I. Suppose the valve *c* to be moved downward, it introduces the live steam through the port *a'* into the lower end of the cylinder I, forcing the piston upward. At the same time a transverse passage, c^2, in the valve *c* is presented to the port *b'* and allows the steam to be discharged therefrom, still at a high pressure, but lower than that in the other end. The steam thus discharged from the cylinder I is delivered through the port a^2 into the adjacent end of the cylinder II. The same position of the valve *c* also presents the cavity *b** of the valve to the port b^2, connecting with the opposite end of the cylinder II. The cavity *b** discharges downward (see Fig. 2) into the receiver X. In case the same form of valve is used between the cylinders III and IV, a precisely corresponding construction, but much larger, may be employed. The form of valve shown at *d* may be used with nearly equal success between the cylinders I and II. The valve *d* is equivalent to two of the ordinary slide-valves, known as "short D-valves." The steam from the receiver X fills the space between the cylinder III and the flat face of the cylinder IV. When the valve *d* is by the action of the eccentrics and valve-gear (not represented) moved upward, the steam from the receiver X flows past its lower end into the lower end of III, while the steam from the upper end of III exhausts through the uppermost of the two hollow throats and flows through the port a^4 into the upper end of the cylinder IV. The elevated position of the valve *d* also presents the lower of the two hollow throats to form a connection between the port b^4 and the port b^5, which leads downward to the condenser. (See Fig. 2.)

It is unnecessary to explain elaborately that the changing of the position of the valves reverses the action and causes the steam to urge the pistons in the opposite directions. The pistons in the pair of cylinders I and II, by moving in the opposite directions, tend to balance each other and facilitate the bringing the engine to rest in any position desired. The balancing also has an effect on the momentum, and allows my engines to be run with greater speed than the ordinary. The receiver X performs an important function in modifying the pressure and causing it to be received at a nearly uniform pressure from the cylinder II and be delivered at substantially the same uniform pressure into the cylinder III, notwithstanding the pistons in these two cylinders come to their dead-points and perform their respective movements at quite different periods of time.

The importance of the receiver X has been long appreciated in connection with ordinary compound engines. The uniting of two cylinders directly together to constitute a pair, and then uniting this with another pair through the intervention of the receiver, is substantially different.

Modifications may be made additional to those described without departing from the principle or sacrificing the advantages of the invention. I can combine four pairs of cylinders. It will be understood that where three pairs of cylinders are combined there is another receiver equivalent to X between the fourth and fifth cylinders. Where four pairs are combined there are three receivers X. There is always one receiver between each pair of cylinders and the next succeeding pair. I use the term "combination steam-engine" to indicate the style of engine having pairs of cylinders thus united.

I claim as my invention—

The combination, with the cylinders I, II, III, and IV, arranged in pairs and of different sizes, of the reservoir X, embracing the larger cylinder of one pair and the smaller cylinder of the other pair, the single valve *c*, operating in relation to both cylinders I and II, and the single valve *d* in relation to the cylinders III and IV, the whole adapted to serve as and for the purposes set forth.

This specification signed by me this 21st day of December, 1883.

HERMANN HOWALDT.

Witnesses:

CLARUS KÖHNHOLD,

ERNST BRÖCKELMANN.