(No Model.) 2 Sheets—Sheet 1.

N. G. HERRESHOFF.

STEAM ENGINE.

No. 578,697. Patented Mar. 9, 1897.

Fig. 1.

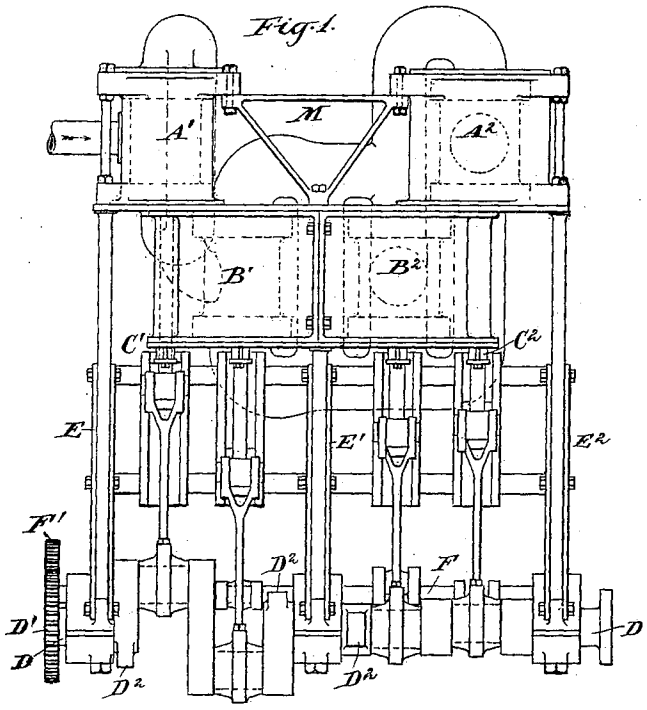


Fig. 2.

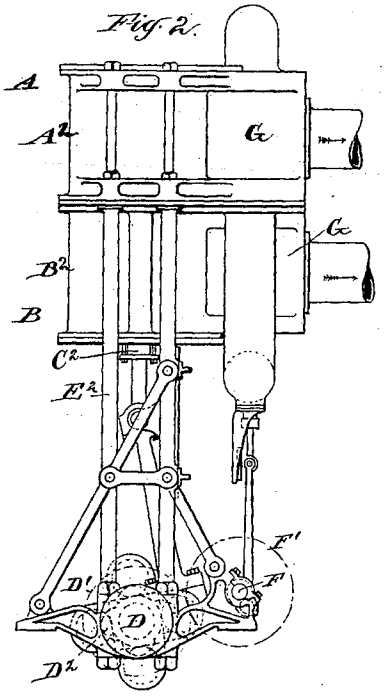


Fig. 3.

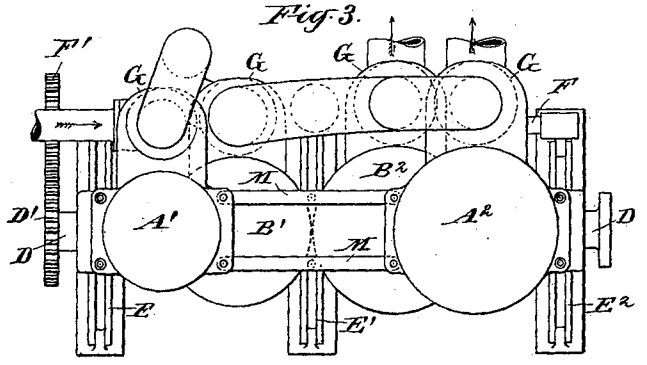


Fig. 4.

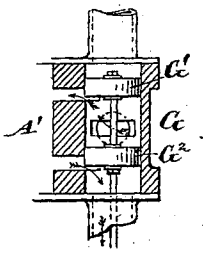


Fig. 5.

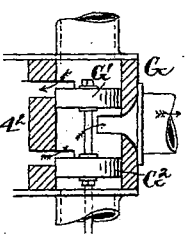


Fig. 6.

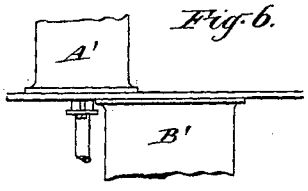
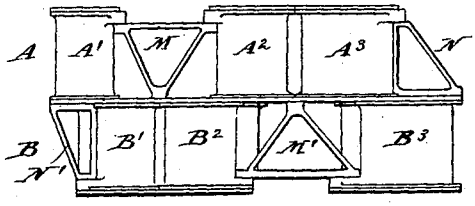


Fig. 7.



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(No Model.) 2 Sheets—Sheet 2.

N. G. HERRESHOFF.

STEAM ENGINE.

No. 578,697. Patented Mar. 9, 1897.

Fig. 8.

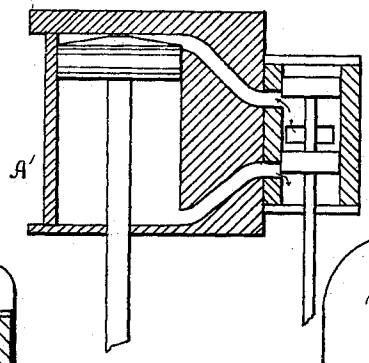


Fig. 9.

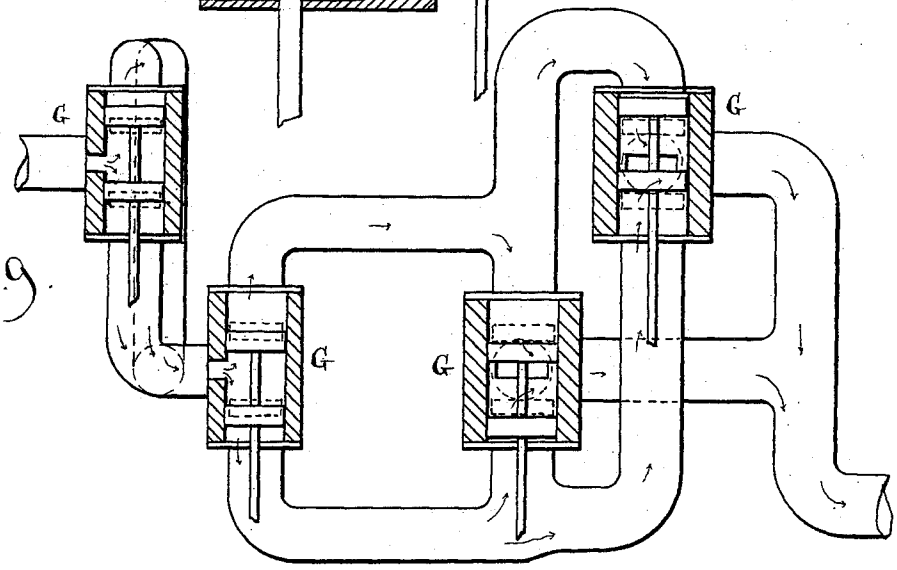
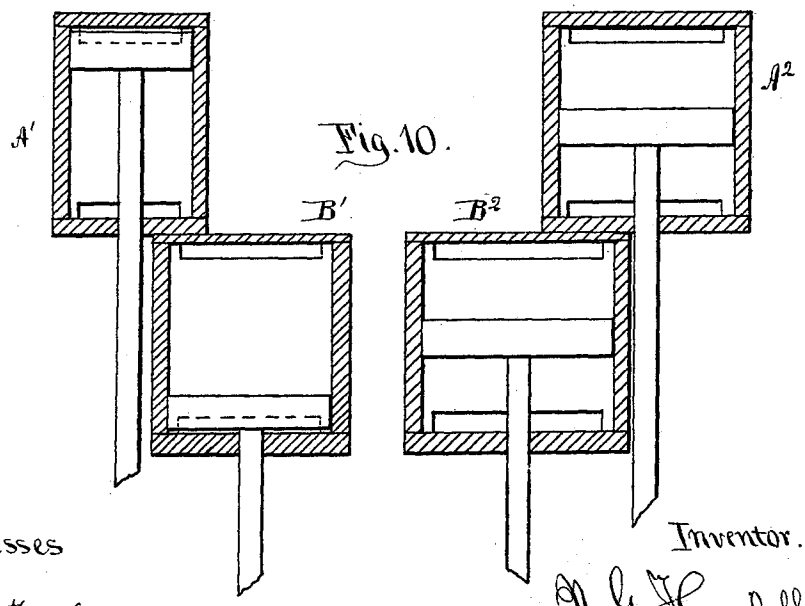


Fig. 10.



Witnesses

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UNITED STATES PATENT OFFICE.

NATHANIEL GREENE HERRESHOFF, OF BRISTOL, RHODE ISLAND, ASSIGNOR TO THE HERRESHOFF MANUFACTURING COMPANY, OF SAME PLACE.

STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 578,697, dated March 9, 1897.

Application filed December 2, 1895. Serial No. 570,781. (No model.)

To all whom it may concern:

Be it known that I, NATHANIEL GREENE HERRESHOFF, a citizen of the United States, residing at Bristol, in the county of Bristol, in the State of Rhode Island, have invented a certain new and useful Improvement in Steam-Engines, of which the following is a specification.

My improvement applies to the class in which there are two or more cylinders in pairs, peculiarly arranged, with one above and partially overlapping upon the other, so as to bring their piston-rods close together, with the cranks for each pair correspondingly close together, to allow a high velocity in the parts with the strains balanced and so nearly in line as to avoid vibration.

The invention is intended more especially for use in the upright position, with the shaft below the cylinders, and I will designate the cylinders as thus arranged, calling one the "upper" and the other the "lower" of each pair, but it will be understood that it may be worked in an inverted or horizontal or in any desired inclined position.

I provide for delivering the steam to the middle part of the high-pressure valves and for exhausting from the middle part of the low-pressure valves. I mount the valves for each pair side by side, each arranged laterally relatively to the cylinder which it is to serve, thus occupying little room fore and aft, and I connect each to operative devices which are carried on a connected shaft, the devices for each pair being so nearly adjacent on the counter-shaft that the same effect is realized with the valves as with the heavier pistons, the weight and momentum of one member of a pair balances that of the other at all speeds.

I will describe the engine as "triple-expansion," receiving the steam in one cylinder, discharging therefrom into a larger one, and discharging from this second into the two last, which I will refer to collectively as the "low-pressure" cylinders.

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 side elevation. Fig. 2 is an end view. Fig. 3 is a plan view. Fig. 4 is a vertical section of the valve and valve-chest of the high-pressure cylinder on a larger scale. Fig. 5 is a corresponding section of the valve and valve-chest of a low-pressure cylinder. Figs. 4 and 5 show by arrows the different conditions in regard to receiving and discharging steam. Fig. 6 is a section of a portion showing a modification in the arrangement of the stuffing-boxes for the upper cylinder. Fig. 7 is a side view, on a small scale, showing a modification. Figs. 8, 9, and 10 are sectional diagrams aiding to illustrate the action. Fig. 8 is a vertical section through the high-pressure cylinder and its valve-chest and valve. Fig. 9 is a vertical section through all the valve-chests and valves, showing the reception of the very hot steam in the first and second cylinders out of contact with the packing of their stuffing-boxes and the delivery of the very weak steam from the third and fourth cylinders, also out of contact with the packing of their stuffing-boxes, so that a slight leakage will not draw in air; and Fig. 10 is a section through all the cylinders, showing their arrangement.

Similar letters of reference indicate corresponding parts in all the figures where they appear.

Referring to Figs. 1 to 6, inclusive, the upper cylinders are marked A, and the several lower cylinders are marked B. The pairs are distinguished by supernumerals, one pair being composed of the cylinders A' B' and the other pair of the cylinders A^2 B^2. Each upper cylinder is set just so far out of line with its mate—the corresponding lower cylinder—that the piston-rod of the upper cylinder shall reciprocate immediately adjacent to the side of the corresponding lower cylinder. Each lower cylinder is cast with a straight passage, which I will term a "sleeve," extending the whole length of one side. Through this the extended piston-rod of the corresponding upper cylinder reciprocates. The stuffing-boxes C' C^2 C^3 for the upper piston-rods are arranged each at the bottom of the corresponding passage in the lower cylinder.

The main shaft is marked D. Cranks are forged therein to receive the connecting-rods from the pistons in the several cylinders. The cranks are arranged in pairs, the cranks

of each pair opposite to each other and set at an angle with the cranks of the other. The arrangement allows the cranks of each pair to be close together and directly connected. It follows that the pistons may reciprocate and the cranks may be revolved at a high velocity without any serious vibration. The momentum of the pistons and the piston-rods and cross-heads balance each other, and the centrifugal force of the connecting-rods being also balanced by the ordinary means D^2 the balancing may be absolutely perfect except for the small extent that the two cylinders of each pair are out of line with each other, and this latter is too slight to be serious.

M is a frame firmly bolted to lugs on the upper part of the corresponding upper cylinders and to the tops of the lower cylinders, or to an intermediate plate, as shown. The frame constitutes, with the series of cylinders, a deep and stiff girder, which performs the functions of the ordinary bed-plate to receive and resist the strains due to the action of the steam.

The shaft D is formed with bearings of proper length adjacent to each pair of cranks. E E' E^2 are upright frames which connect these bearings with the strong assemblage of cylinders and frames above. The arrangement allows the lower heads of the lower cylinders to be easily removed and replaced when required.

I use piston-valves G, one for each cylinder, composed each of two pistons G' G^2, with a liberal space between, playing vertically in a valve-chest which is a truly-bored cylinder parallel to the main cylinder and connected by ports near each end. I admit the steam to the space between the pistons G' G^2 for each of the cylinders A' B'. To give steam to the upper ends of these cylinders, I move the corresponding valves upward. The valves and passages for the low-pressure pair A^2 B^2 are arranged in the opposite manner, so that the exhaust connects to the middle of the valve. To supply steam to the upper ends of these cylinders, the valves are moved downward.

In a light engine used at high speed to drive dynamos or to propel vessels, carriages, locomotives, or the like it is often impossible to have a heavy foundation of an engine that will hold it steady against the inertia of the working parts. My invention attains such conditions that no such foundation is necessary. The engine takes up less room fore and aft than the ordinary arrangement. The engine is steady and very light, and I believe will be durable.

The guide-rods may be of any suitable form. They should be bolted to the upright frames E E', &c., so that they can be easily detached to allow the removal of the lower pistons and piston-rods through the bottoms of their respective cylinders.

By receiving the steam at the mid-length of the valve for the cylinders A' B', Fig. 4, I preserve the packing around the valve-stems from high pressure and intense heat, because only the lower-pressure steam exhausted from the cylinders ever reaches such packing. For the low-pressure cylinders A^2 B^2 these conditions are reversed. By discharging the steam at the mid-length of the valve for each of these cylinders, Fig. 5, I avoid the leakage of air inward because the packing is only exposed to steam which is near or above the atmospheric pressure.

The valves are operated each by a direct connection from an eccentric or crank carried on a counter-shaft F, which latter is operated from the main shaft D by the aid of smoothly-cut gear-wheels D' F'. As the valves of each pair have opposite motions, one sinking while the other rises, their momentum is exactly balanced one by the other. That is to say, when the valve of the forward cylinder sinks down the corresponding valve for the after cylinder rises. My arrangement brings the valves for each pair of cylinders near together. When the momentum of one valve exerts a force to lift the counter-shaft, the momentum of the other acts at a point adjacent thereto, tending with equal force to depress it.

Modifications may be made without departing from the principle or sacrificing the advantages of the invention. The stuffing-boxes may be at the top, dispensing with the sleeves. Fig. 6 shows such an arrangement. I can use the invention with only one pair of cylinders instead of the two pairs shown.

I can use more than two pairs of cylinders. Fig. 7 shows three pairs. With this number I use an additional frame corresponding to the frame M and place it in the properly-reversed position between the lower cylinders, as indicated by M'. The cranks of each pair need not be exactly opposite, but they should be so nearly opposite as to cause the momentum of each to practically balance that of the other. The frames N N' contribute to further stiffen the framing.

I claim as my invention—

1. In an engine with two or more pairs of cylinders and cranks, having one cylinder of each pair above and partially overlapping its mate, the lower cylinders of the two pairs being in direct contact with each other and having the several valve-chambers out of the plane of the axes, the combination therewith of the frame M constituting with the cylinders a rigid supporting-girder performing the functions of a bed-plate, and the frames E, E', E^2, connecting such girder with the shaft-bearings, the several last-mentioned frames being arranged so far out of the line of the cylinders as to allow the removal of the heads and pistons from the lower ends of the lower cylinders after detaching the slides without disturbing the frames, all substantially as herein specified.

2. In a compound engine with the cylinder and cranks in pairs, the double-piston valves G', G^2, working in the valve-chests A', A^2, ar-

ranged as described, the valve-chest for the high-pressure cylinder receiving steam between the pistons and exhausting at the ends, and the valve-chest for the low-pressure cylinders each receiving its weaker steam at the ends and exhausting from the space between the valve-pistons, all combined and arranged substantially as herein specified.

3. An engine having two pairs of cylinders, with double-piston valves for each, the valve for a cylinder of one pair having the steam-inlet pipe opening into the space between pistons and its exhaust connected with the space between pistons of the valve belonging to the second cylinder of the same pair, and the exhaust of said second valve being connected with the end spaces of the valves of both cylinders of the second pair, substantially as described.

In testimony that I claim the invention above set forth I affix my signature in presence of two witnesses.

NATHANIEL GREENE HERRESHOFF.

Witnesses:

JOHN B. HERRESHOFF,

C. W. YOUNG.