N. G. HERRESHOFF.

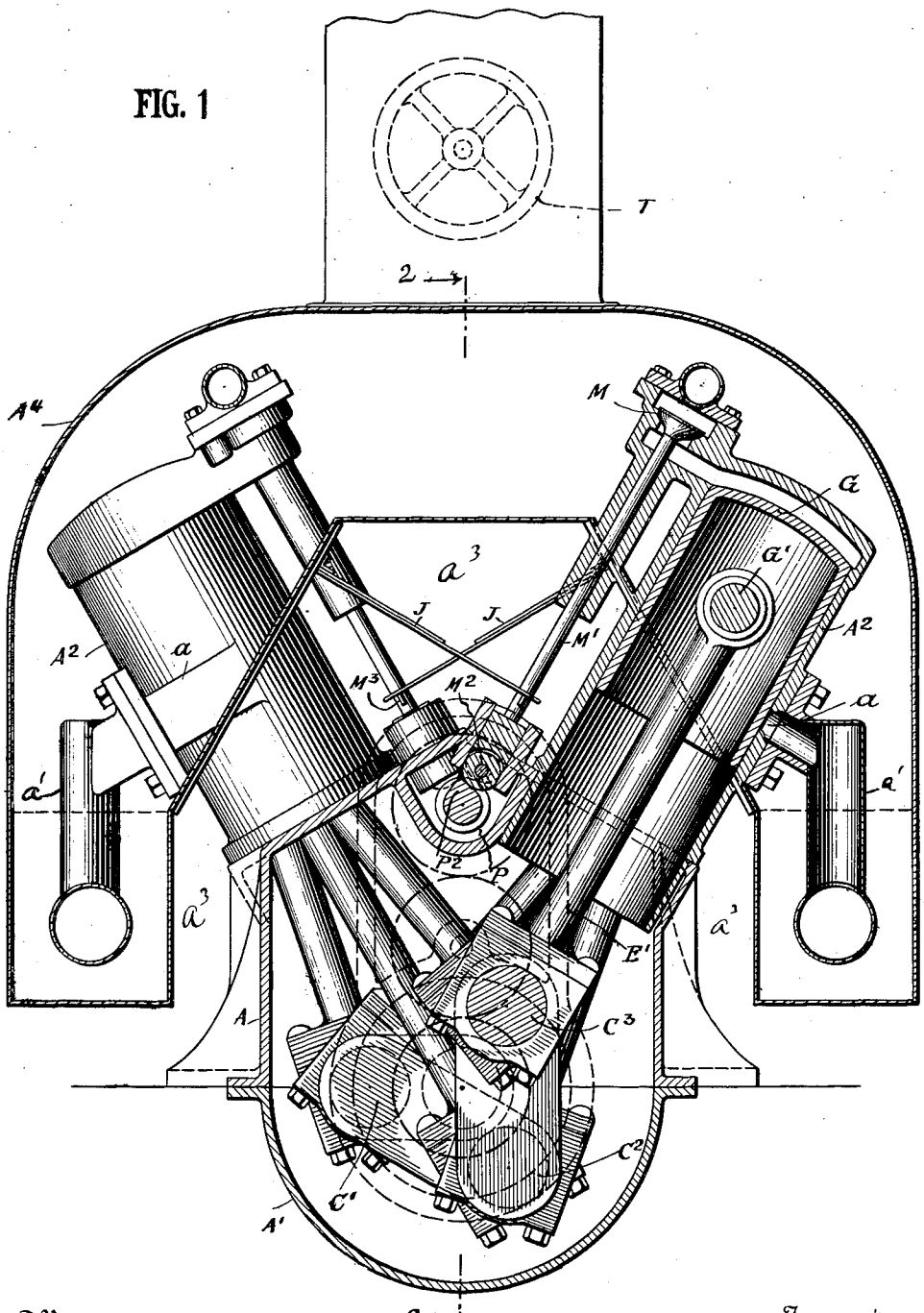
STEAM ENGINE.

APPLICATION FILED JULY 31, 1907. RENEWED DEC. 28, 1909.

986,982. **Patented Mar. 14, 1911.**

4 SHEETS—SHEET 1.

FIG. 1



Witnesses:
Max F. Doring.
A. E. W. Frazer.

Inventor
Nathaniel G. Herreshoff
By his Attorney
Thomas Reed Stetson

N. G. HERRESHOFF.

STEAM ENGINE.

APPLICATION FILED JULY 31, 1907. RENEWED DEC. 28, 1909.

986,982. **Patented Mar. 14, 1911.**

4 SHEETS—SHEET 2.

FIG. 4

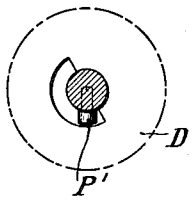


FIG. 2

Witnesses:
Max B. A. Doring
A. E. W. Frazer.

Inventor
Nathaniel G. Herreshoff
By his Attorney
Thomas Drew Stetson

N. G. HERRESHOFF.

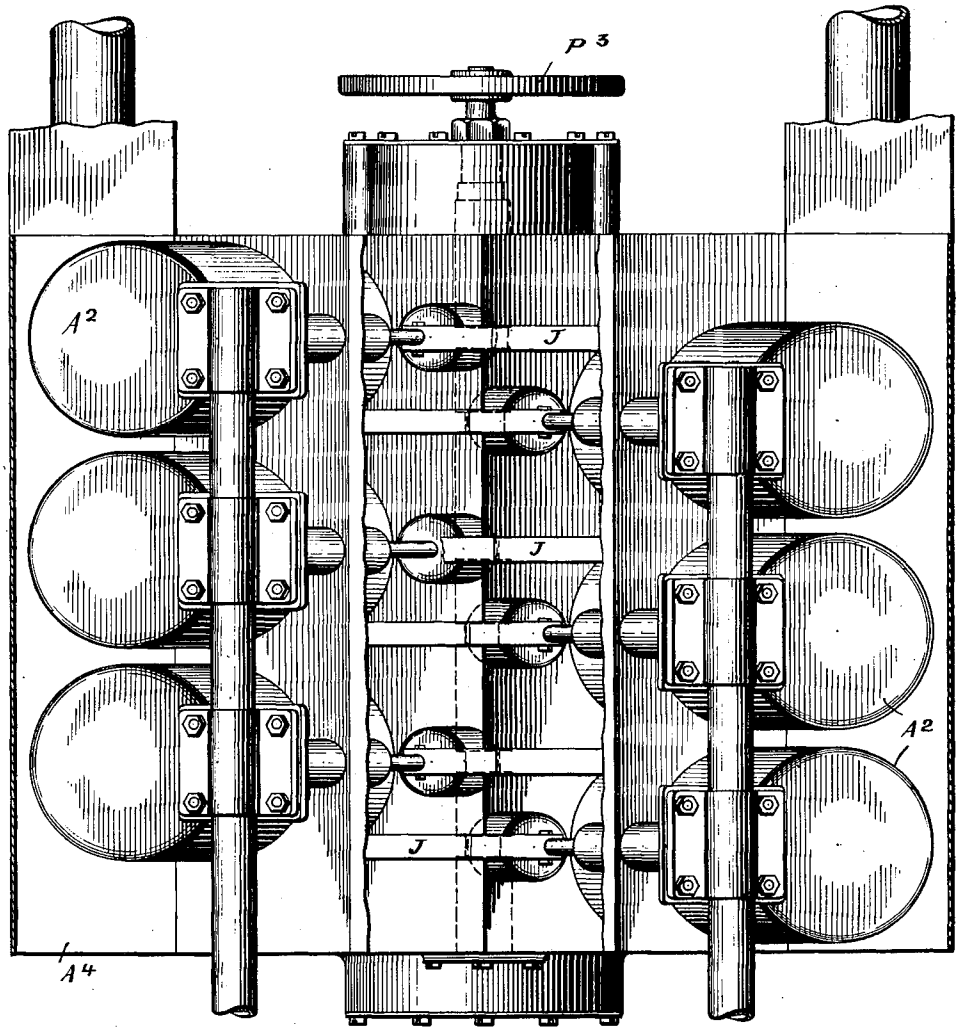
STEAM ENGINE.

APPLICATION FILED JULY 31, 1907. RENEWED DEC. 28, 1909.

986,982. **Patented Mar. 14, 1911.**

4 SHEETS—SHEET 3.

FIG. 3



Witnesses:
Max B. A Doring
A. E. W. Frazer.

Inventor
Nathaniel G. Herreshoff
By his Attorney
Thomas Drew Stetson

N. G. HERRESHOFF.

STEAM ENGINE.

APPLICATION FILED JULY 31, 1907. RENEWED DEC. 28, 1909.

986,982. Patented Mar. 14, 1911.

4 SHEETS—SHEET 4.

Fig. 5.

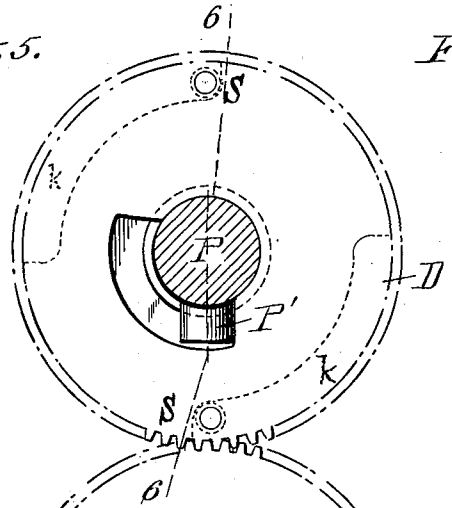


Fig. 6.

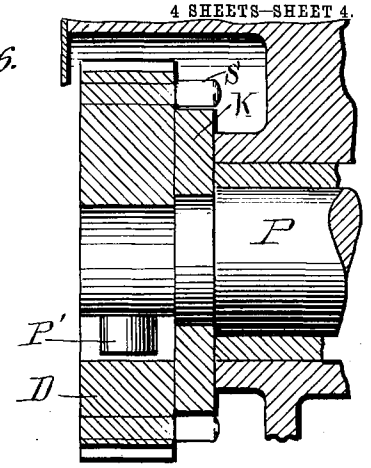


Fig. 7.

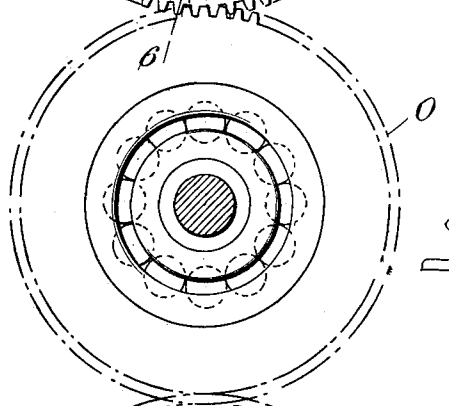
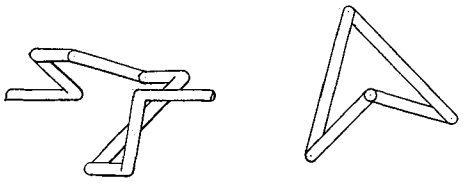


Fig. 8.



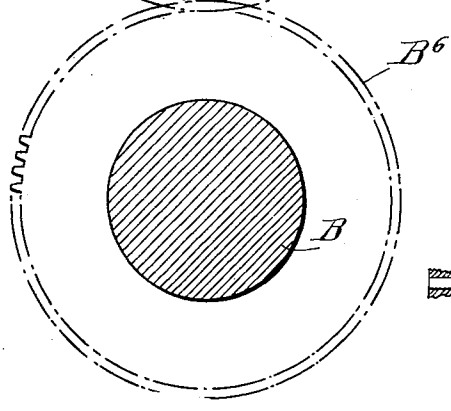


Fig. 9.

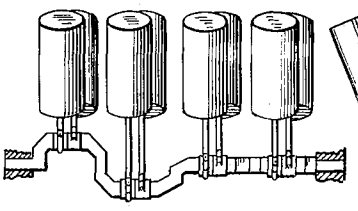
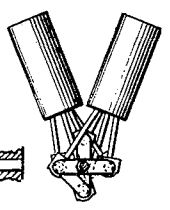


Fig. 10.



WITNESSES,
H. Crocheron
S. H. Stodder

INVENTOR
Nathaniel G. Herreshoff
BY
Thomas Drew Stetson
ATTORNEY

UNITED STATES PATENT OFFICE.

NATHANIEL GREENE HERRESHOFF, OF BRISTOL, RHODE ISLAND.

STEAM-ENGINE.

986,982. Specification of Letters Patent. Patented Mar. 14, 1911.

Application filed July 31, 1907, Serial No. 386,439. Renewed December 28, 1909. Serial No. 535,361.

To all whom it may concern:

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

This invention is intended to meet the demand for engines of great power with little bulk or weight.

I have discovered that it is practicable by combining features before used separately to produce an engine eminently adapted for swift vessels and various other work developed by modern progress including flying machines.

The improvement may be used with the super-heated vapor of water or other fluids, but I will describe it as working with steam from any generator with means of superheating. I prefer that the pressure and temperature of the steam used be much higher than in ordinary engines.

The invention is more especially applicable where quick-acting, reversing engines of small size are required; I will describe it as applied on a motor boat, but it is also applicable in a motor carriage or car.

The cranks are formed in one with the shaft, the whole being forged or otherwise produced of sufficient thickness and strength to serve without bearings between the cranks, and extending the metal from each crank-pin to the next directly in straight lines. And I have discovered that it is practicable to make such cranks of the form, which we term "undercut" when applied to ordinary cranks so that each crank pin is longer and affords a wider bearing for the connection than would be otherwise practicable. I can employ many cranks. I will show and describe three. The six cylinders are matched together in pairs, steeply inclined like the sides of the letter V. I connect both the piston-rods of each pair to one crank-pin.

The following is a description of what I consider the best means of carrying out the invention.

The accompanying drawings form a part of this specification.

Figure 1 is a vertical section in the plane of the axis of one of the cylinders and of the accompanying valve and valve-stem, and an elevation of other parts. Fig. 2 is a longitudinal, vertical, section on the line 2—2 in Fig. 1. Fig. 3 is a plan view, with the upper portion of the top casing and the mid-width portion of the bottom casing removed. Fig. 4 is a cross-section of a detail on the line 4—4 in Fig. 2 proportioned to serve with a small number of cylinders. Figs. 5 and 6 are on a larger scale. Fig. 5 indicates the front elevation partly in section, though on a larger scale, of a part shown in Fig. 2 but proportioned to serve with a larger number of cylinders by allowing less lost motion in reversing. Fig. 6 is a vertical section of a portion corresponding to Fig. 2. It shows the forward end of the cam shaft and adjuncts. Fig. 7 is a perspective view showing a crank shaft and cranks more slender than are used in practice, to exhibit the relation of the parts. Fig. 8 is a corresponding end view. Fig. 9 is a side view partly in vertical section of an engine having eight cylinders. Fig. 10 is a corresponding end view partly in vertical cross-section, showing the relations when carried out with eight cylinders. In all these small diagrams the cylinders are shown wide apart and the cranks are more widened than is desirable in practice.

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

A is a fixed framing of cast-iron or other suitable material, certain portions being designated by supernumerals.

A^2 is a cylinder. Each cylinder is separately formed and the cylinders being alike, a description of one with its adjuncts will suffice for all.

A′ is a bottom casting, which can be removed for examination and repairs. After disconnecting by ordinary means, not shown, the entire engine with the casing A, A′, can be lifted out of its connection with the other parts, and turned on its side or inverted. The pan A′ which is at the bottom when in use can then be removed and easy access obtained.

B is an extension of the shaft, shown as integral with the cranked portion.

B′ is a portion of the metal extending from the center line of the shaft; C′ is a portion at right angles thereto, serving as the first crank-pin.

B^2 is a portion extending at right angles to C′.

C^2 is a second crank-pin.

B^3 is a portion of the metal extending from the latter crank-pin to the next and last crank-pin C^3, and B^4 is an extension of

the metal from C^3 inward to the shaft proper.

B^5 is a portion in line with the shaft B and resting in a stationary bearing corresponding thereto.

The bearings are shown as equipped with circumferential grooves each carrying a series of balls making anti-friction bearings.

The faces of the parts B′, B^2, B^3 and B^4 which are presented toward their respective connecting-rods, are undercut, thus making the crank-pins C′, C^2 and C^3 longer than the spaces between the main portions of the stout adjacent parts B′, B^2, etc. As shown, there are six connecting-rods, six cylinders, and six pistons, all alike, coupled in pairs to the respective crank-pins. Describing only one, E′ is a connecting-rod, taking hold of half the length of the corresponding crank-pin C^3 and connecting to a pin G′ in the trunk-piston G. The construction is intended to make the bearing afforded by the brasses sufficiently extended to allow the engine to work with its full force for an indefinite period with the efficient lubrication which I provide. The exteriors of the pistons, and the interiors of the cylinders are finished truly, and my experiments indicate that the parts will work together for a long period without abrasion or appreciable leakage. There is no movable part termed an "exhaust-valve," unless the piston shall, itself, be given that name. The exhaust-port *a* extends a considerable portion of the distance around the cylinder, the metal being, of course, bridged across at short distances to maintain the strength. This port is in the lower side of the cylinder.

P′ is a pin set in the cam-shaft P. It plays in a recess which extends about half way around in the interior of the loosely mounted gear-wheel D, which latter is thus free to revolve to a limited extent,—something less than half of a revolution,—on the cam-shaft.

S, S are pins permanently set at opposite points in the loose gear wheel D and extending parallel to the axis into the plane of the disk K. At opposite points in the circumference of the latter wheel are shallow recesses *k*, *k*, each deep enough to receive the corresponding pin S and of the width required to allow the wheel D to turn freely to the extent prescribed. There are thus shown two means for connecting the wheel D having a limited looseness with the shaft P. I can use both of these two means of engagement, one being the pin P′ set in the shaft P and playing in an approximately segmental recess in the wheel D, and the other being the two pins S set in such wheel D and playing in the two broad spaces *k* in the circumference in the wheel K, which latter is fast on P. The effect of either or both is to communicate motion reliably from the engine to the cam shaft P and to allow thus sufficient lost motion to insure that the position of the cams relatively to the valves will be right for revolving in either direction.

M is the induction-valve,—one for each cylinder. These are the only valves, strictly so-called, except the necessary stop-valves, in the entire engine. When a valve M is opened, the steam comes from above through the steam-pipe, and flows downward through the valve-seat and impels the piston with force until the valve is allowed to close by the retreat of the cam, after which it continues to impel by its expansion until near the end of the stroke when its surplus above atmosphere escapes through the port *a* and the connected thin metal pipe *a*′. It will be understood that the source of power of the engine lies in the excess of the favorable action thus initiated and continued on the upper side of the piston, during its descent, over the resistance due to the compression which the piston meets during its upstroke. The valve M is a single puppet of liberal area controlled by the aid of the valve-stem M′. A high degree of compression of the exhaust steam under the valve aids in raising it. This is very important when working with high pressure or high speed or both. The valve stem is actuated by a block containing an anti-friction roller M^2 on its lower end which is subjected to the action of the cam P^2 in the cam-shaft P. This latter shaft is supported in stationary bearings and rotated by the aid of a nicely cut gear-wheel D which receives the action of an intermediate gear-wheel O, which latter receives its motion from the gear-wheel B^6 keyed to the main shaft B. The only exhaust which is obtained is the expansion of the steam contained in the cylinder when the piston approaches and passes the lower center and commences to rise again. The liberal opening provided by my extended port *a* allows the steam pressure to descend, theoretically, to atmospheric pressure, while the piston is at its lowest point. During the rising motion of the piston the thin steam remaining in the cylinder above the piston is compressed. The clearance, by which term I include all the space above the piston, when the piston is in its highest position, is so little that the pressure will be raised by the compression nearly up to the high pressure of the boiler. Reversing is effected at will by the force of the hand of the attendant. This effect is due to a just sufficient amount of lost motion in the connection of the gear-wheel D to the cam-shaft.

On the overhanging end of the cam-shaft P, nearest the engineer, is fixed a hand-wheel P^3. This is important in reversing. To reverse the engine the steam is tempo-

rarily shut off by an ordinary stop-valve, not shown, and the engineer turns the wheel P^3 forward, relatively to its previous direction of rotation, as far as it will go by hand, either directly or through the agency of a chain or belt from a hand-wheel placed in convenient position. Now, on properly turning the stop-valve to admit steam again to the cylinders the shaft B commences to revolve in the opposite direction to that which before obtained, and thenceforward it turns in such direction with the same efficiency and economy as before. The engine has been reversed.

The strong casing A which incloses the cranks and the cam-shafting and gearing is bolted upon the keelsons, not shown, and receives and holds the lower ends of the cylinders. It serves as the bed-plate or foundation framing for the engine. The lower portion A′, is an inverted cap, detachably secured by bolts, not shown. A^4 is another casing of lighter construction. It conveys the gaseous products of combustion from the steam generator, not shown, and utilizes their heat in warming the engine. It envelops in the hot bath thus obtained, the upper portions,—the working portions,—of the cylinders and of the valves and valve-stems, leaving the cranks and the shaft unaffected. The hot casing A is approximately arch-shaped and envelops the higher part of the cylinder, the valve boxes and the steam pipes, and extends down each side enveloping the exhaust pipe a' for a litttle distance horizontally. (See Fig. 3.)

J are springs secured to the fixed framework and acting each on a cross-pin M^3 in the corresponding valve-stem. The duty of these springs is to hasten the closing of the valves.

I attach importance to the arrangement of the pairs of cylinders so that the two which connect to one crank are not directly opposite, but one is in advance of the other so that the crank boxes are side by side on the one crank pin because it allows them to transmit force in direct lines and avoids making offsets in the connecting rods and valve stems.

T is a hand-wheel, controlling a large, light valve, mounted in the manner long practiced with dampers,—it is in fact, a damper which may at will be caused to control the flow of the hot gaseous products of combustion. It may allow those gases to flow actively through the upper portion of the casing and warm the cylinders as above described or to shut off the flow of such gases, other means, not shown, being provided for their escape. Such valve and the provision for controlling it, may be dispensed with under all ordinary conditions.

It will be seen that there are two separate casings A, A′ and A^4, the lowermost A stout and cold serving to defend the cranks and valve motions from injuring or being injured and allowing for lubrication by holding a liberal stock of suitable oil, and also as a bed for the engines, and the uppermost A^4 thin and arch formed carried on the cylinders and valve guides, out of contact with the cold envelop A but so connected by the cylinders and valve guides as to be removable therewith when required for examinations or repairs, with connections for flowing the hot gases through it. The considerable space a^3 with liberal ventilation between these casings retards the flow of heat from the hot to the cold chamber, and I attach importance to the fact that this hot upper casing A extends down and envelops the exhaust pipe a' so as to maintain the high temperature of the escaping steam, and make it more efficient for any useful purpose as blowing the fire or warming distant portions of the vessel.

I attach importance to the oppositely inclined positions of the cylinders because such arrangement is compact while allowing access and facility for attention to any one as required; to the eduction ports on the lower sides because it effectually drains out water or oil; to the lower casing A A′ because it keeps the cranks cool and well supported, and when the engine is lifted and turned over, easily accessible; to the hot casing A^4 and its connections because it warms the main portions of the several cylinders; to the hand wheel T and its connections because it allows the hot gases to be excluded to avoid over-heating when the engine is stopped; to the reversing gear because of its efficiency and convenience, and to the provision of two valve motions to be used both at once if required because it gives great security against derangement.

I claim as my invention:

1. In a steam engine having plural cylinders arranged in pairs with the members standing inclined from each other, a shaft having corresponding multiple cranks with the two pistons of each pair connected to one crank pin; so inclosed in casings as to produce two chambers, one chamber inclosing the effective parts of the cylinders and the valves and valve stems, filled with the hot products of combustion, a space between serving to retard conduction, and a second chamber arranged below inclosing the cranks and shaft and the lower ends of the cylinders and connecting rods well defended from the heat.

2. A steam engine having plural sets of cylinders in pairs inclined apart, in combination with a shaft having corresponding cranks and having two pistons connected to each crank-pin, with the cranks undercut, allowing broad bearings for the connecting

rods, the cranks working in a strong and relatively cool casing A A′ and with the main portions of the several cylinders bathed in the hot products of combustion, and with provisions for shutting off such heating means when required.

3. A steam engine comprising plural sets of cylinders inclined in pairs, with the exhaust passage on the under side of each inclined cylinder controlled directly by the movements of the piston therein, in combination with a shaft having a corresponding number of cranks about equally spaced, and casings providing two chambers at different levels, the uppermost heated by the products of combustion and the lowermost protecting the main bearings from heat and serving the additional function of a bed casting.

Signed at Bristol, Rhode Island, this 6th day of July, 1907.

NATHANIEL GREENE HERRESHOFF.

Witnesses:
NEWELL B. SHELDON,
F. P. BRIGHTMAN.