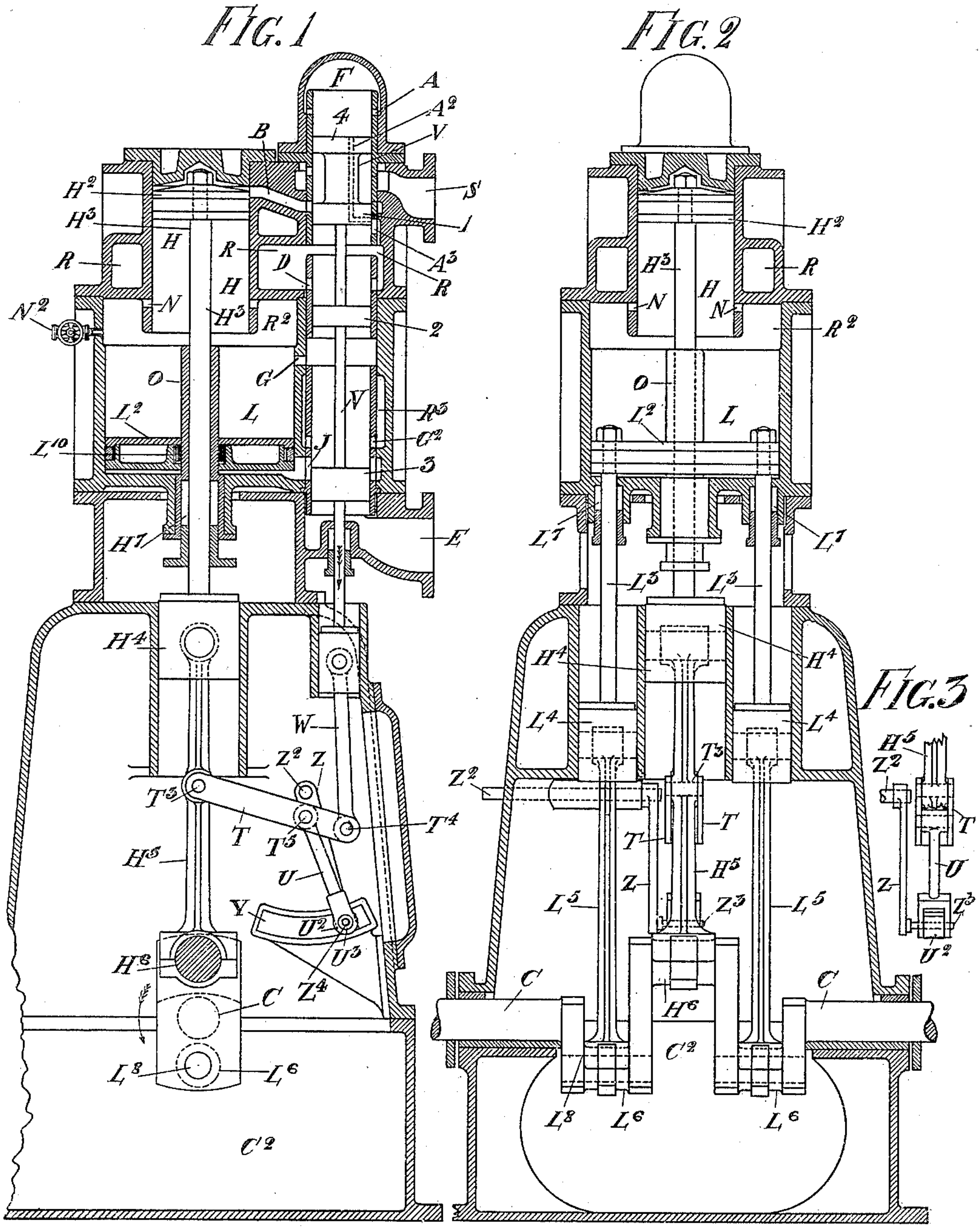
No. 649,956. Patented May 22, 1900.

A. F. SCOTT.

HIGH SPEED ENGINE.

(Application filed Nov. 5, 1897.)

(No Model.) 3 Sheets—Sheet 1.



Witnesses:
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Inventor:
Arthur Forbes Scott, by
Harry P. Williams
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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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FIG. 11

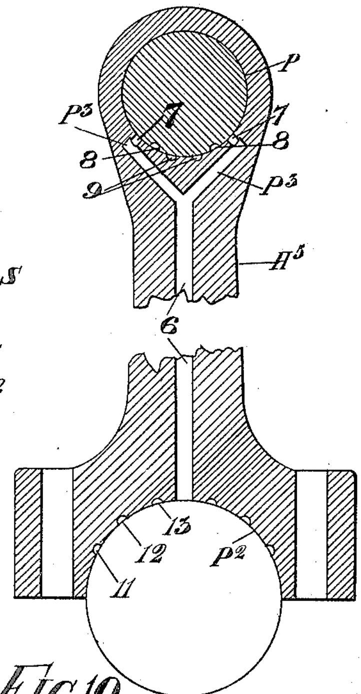


FIG. 12

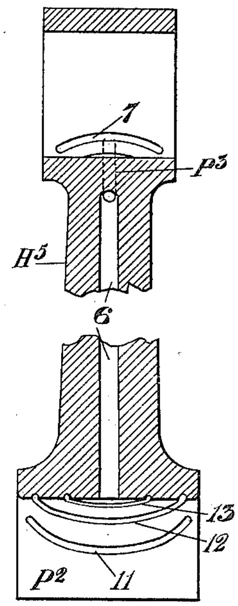


FIG. 4

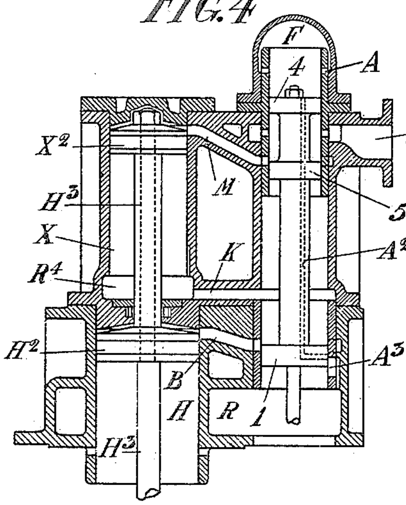


FIG. 9

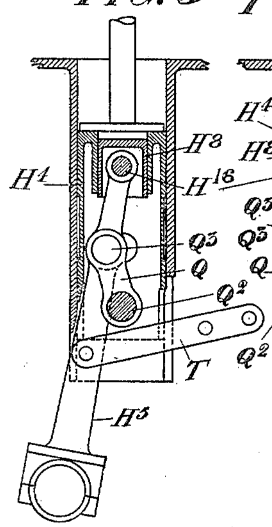


FIG. 10

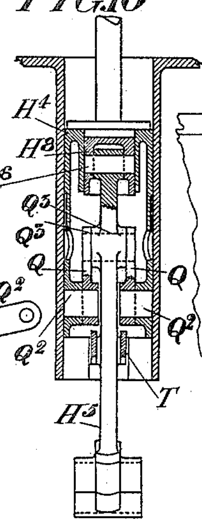


FIG. 15

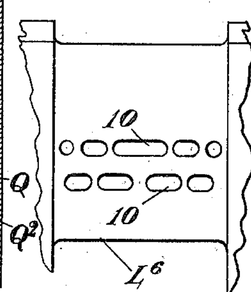


FIG. 13

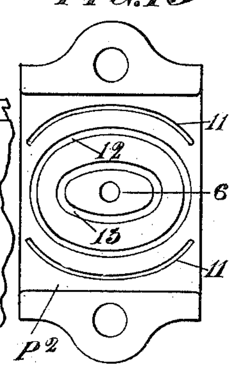
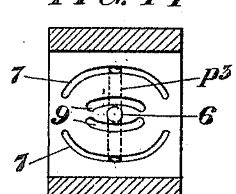


FIG. 14



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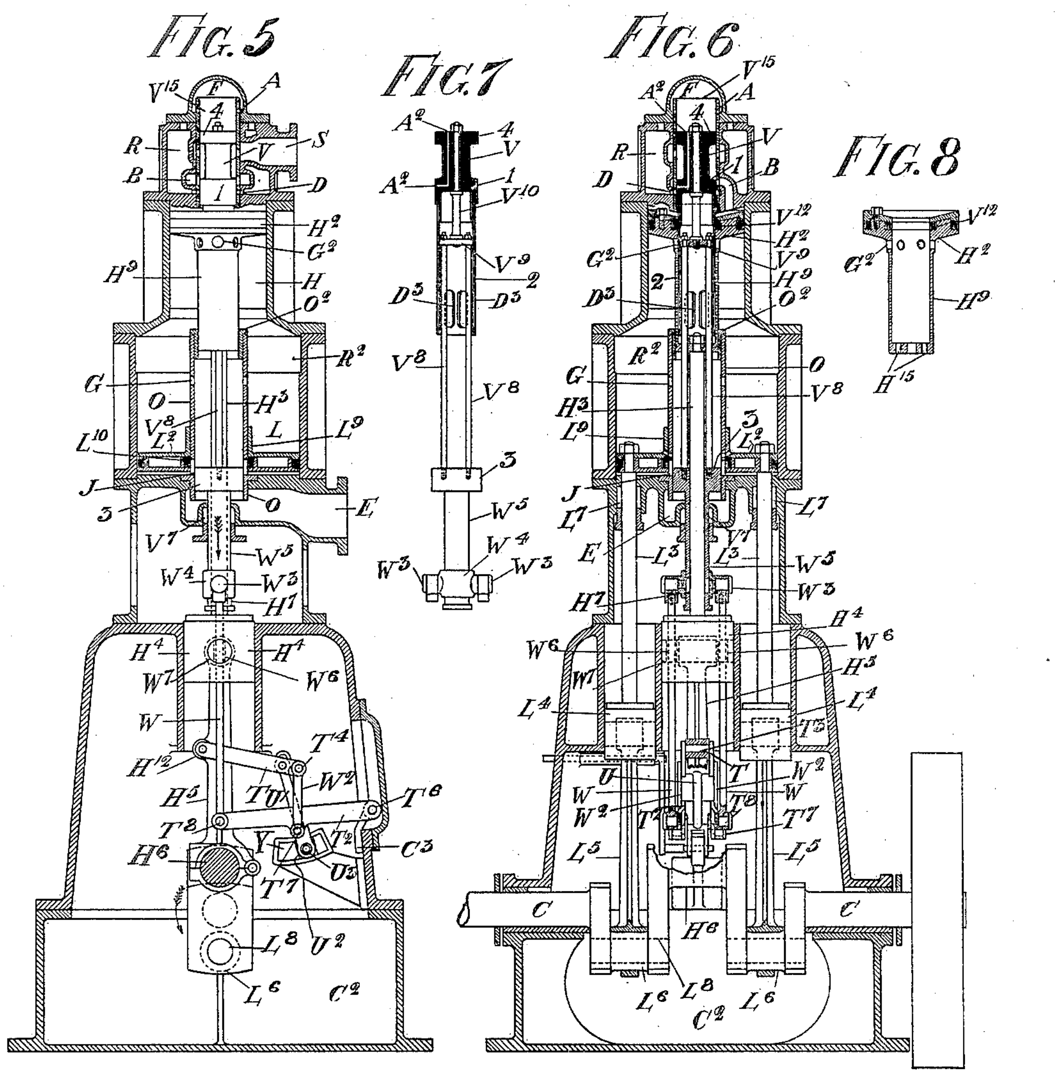

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Inventor:
Arthur Forbes Scott
by Harry R. Williams.
Atty.

UNITED STATES PATENT OFFICE.

ARTHUR FORBES SCOTT, OF BRADFORD, ENGLAND.

HIGH-SPEED ENGINE.

SPECIFICATION forming part of Letters Patent No. 649,956, dated May 22, 1900.

Application filed November 5, 1897. Serial No. 657,484. (No model.)

To all whom it may concern:

Be it known that I, ARTHUR FORBES SCOTT, M. I. M. E., a subject of the Queen of England, residing at Bradford, England, have invented certain new and useful Improvements in High-Speed Engines, of which the following is a specification.

This invention relates to improvements in high-speed steam-engines, the object and advantages of which improvements are set forth in the following specification.

In the accompanying drawings, Figure 1 represents a sectional elevation of my improved engine. Fig. 2 represents a similar view at right angles to Fig. 1. Figs. 5 and 6 are similar views of the engine fitted with a central valve. Figs. 3, 4, and 7 to 15 are views of details hereinafter referred to.

Similar letters and numerals of reference indicate corresponding parts in each of the figures.

The letters "h. p." represent the words "high pressure," and the letters "l. p." "low pressure."

I mount the high-pressure cylinder H above the low-pressure cylinder L, and the low-pressure piston L^2 is attached to a pair of piston-rods L^3, which pass through packing L^7 and connect by cross-heads L^4 and connecting-rod L^5 with a pair of crank-pins L^6 on the crank-shaft C, which revolves in chamber C^2, containing lubricant in the lower part. The high-pressure piston H^2 is attached to rod H^3, which works through the sleeve O within the low-pressure cylinder L and passing through packing H^7 connects by the cross-head H^4 and connecting-rod H^5 with crank-pin H^6, which is opposite to the crank-pins L^6. The valve V is preferably worked, as described later, off the connecting-rod.

Referring to Figs. 1 and 2, the high-pressure cylinder H is fixed on the top of the low-pressure cylinder L, and the high-pressure piston H^2 is attached to the piston-rod H^3, which passes through the sleeve or liner O to the cross-head H^4, which is connected with the high-pressure crank-pin H^6 of the crank-shaft C by the connecting-rod H^5. The low-pressure piston L^2 contains packing-rings L^{10}, fitting the sleeve O. The valve V (preferably cylindrical) is divided into parts or rings 1, 2, 3, and 4. In the position shown when the crank moves in the direction indicated by the adjacent arrow the valve V descends and ring 1 admits steam from inlet S through port B to top of piston H^2 and ring 3 admits steam from receiver or inter-piston space R^2 and a receiver, partly shown at R^3, through ports G, G^2, and J to the under side of piston L^2. At certain points during the stroke the valve, rising, cuts off the supply to the top of the piston H^2 and under side of piston L^2 by rings 1 and 3, after which the steam expands above H^2 and below L^2 and is compressed above piston L^2 in the receiver-spaces R^2 and R^3, keeping piston L^2 in constant thrust. Toward the end of the stroke ring 1, rising above port B, admits steam from above piston H^2 to receiver R, and ring 2, rising above port D, admits steam from receiver R to receiver or inter-piston space R^2, and ring 3, rising above port J, admits steam from below piston L^2 to the exhaust E, and receiver R^3 is cut off from receiver R^2 by piston L^2 rising level with port G or by ring 3 closing port G^2. When piston H^2 uncovers the ports N at the bottom of cylinder H, steam also passes thereby from above to below the piston H^2. During the next stroke the low-pressure piston L^2 is propelled downward by the pressure in receiver R^2, and at a certain point the valve descending again the ring 2 closes port D, cutting off the receiver R from the receiver or inter-piston space R^2, when compression into receiver R begins above piston H^2, keeping the same in constant thrust, shortly after which ring 3 descends below port G^2, opening receiver R^3 to receiver R^2, and toward the end of the stroke ring 1 closes port B and cuts off the top side of piston H^2 from receiver R and ring 3 closes port J to the exhaust E, and afterward steam is again admitted above H^2, &c., as already described. Some advantages of this arrangement are as follows: The two pistons and cylinders being in line the engine takes up practically no more room than a single-acting tandem engine and yet has two impulses per revolution against one. The pistons working in opposite directions and concentrically or in the same line the motion is mainly balanced, tending to prevent vibration both in a vertical and horizontal direction. The expansion of the steam is in the three stages—above the high-pressure piston H^2, between the pistons, and finally below the low-pressure piston L^2, which conduces to economy, and the position of the cylinders facilitates drainage of the water downward. The pistons are held in constant thrust downward or toward the crank by the compression into the receivers, as described, thus preventing knock.

The advantages of the use of the receiver R^3 are that the amount of compression above the piston L^2 and the surface exposed to the incoming steam from the high-pressure cylinder can both be reduced by decreasing the size of the receiver R^2 and increasing the receiver R^3, as may be most suitable for the speed of engine.

When the speed of engine required is excessive, I simply abolish ports N and G and ring 2 of the valve, so that during the upstroke of the piston H^2 it exhausts and compresses into receiver R, and during the first part of the next stroke it passes from thence direct to the under side of the low-pressure piston L^2, the inter-piston space being filled with steam by leakage past the pistons, which may be supplemented and regulated by a small steam pipe and cock N^2, Fig. 1, so that at the beginning of the upstroke of each piston the pressure above is rather less than that below the same. The advantage of this particular arrangement is that the cranks are relieved of part of the work of lifting the pistons, which advantage by decreasing the friction would at an excessive speed more than compensate for the abolition of the inter-piston stage of expansion.

I prefer to make the high-pressure crank H^6 of rather longer stroke than the low-pressure cranks L^6 and each of the latter lightened by having a hole L^8 through it, the advantages being that the cranks and motion of the pistons may be balanced without adding further weight to the crank or high-pressure piston, and the latter being smaller the pressure per square inch on the crank-pins or the distance apart of the main bearings may be reduced, while the surface exposed to cause initial condensation of steam is reduced with the smaller high-pressure piston. Also the crank is cheaper and less cumbersome than one made with balance-weights, especially when a crank bent from the bar is employed.

When more expansion of steam is required, I mount an extra high-pressure cylinder X on the cylinder H, which arrangement is shown separately in Fig. 4. This cylinder is, however, only used when there is a high steam-pressure available. Steam is admitted by the ring 5 from inlet S through port M to the top of the piston X^2. Toward the end of the stroke ring 5 rises above port M, and steam passes thence and through port K from the upper to the under side of the piston X^2 and is transferred thereto during most of the upstroke, and during the next downstroke it passes from below piston X^2 through ports K and B to the top of the piston H^2 until cut off, and compression in the space R^4 then takes place during the latter part of the stroke. The rest of the distribution is the same as already described in reference to Figs. 1 and 2.

In cases where the cost of extra gear in the valve-gear does not preclude its use, or for larger engines, and particularly when condensing and it is desired to reduce the port-space to a minimum, I construct the engine with a central valve, as shown in Figs. 5 and 6, and a separate sectional view of the valve is shown in Fig. 7. The valve is worked, preferably, from the connecting-rod, as described later, and rods W convey the motion to the pins W^3 on the gland-socket W^4, screwed on the hollow stem W^5 of the bottom ring 3 of the valve V. These rods W pass through clearance-holes W^6 in the gudgeon-pin W^7 and top of the cross-head H^4. The valve-ring 3 is connected with the upper portion of the valve by the rods V^8, coupled to the disks V^9 within the valve-trunk 2, and to this disk the valve-rings 1 and 4 and valve-trunk 2 are secured by a central rod V^{10}. The valve-trunk 2 takes the place of the ring 2 in Fig. 1. The lower portion of the high-pressure piston H^2 is in the form of a hollow trunk H^9, which works through the cover O^2 of the valve casing or liner O. A separate sectional view of the high-pressure piston and trunk is shown in Fig. 8. To the bottom of this trunk the high-pressure rod H^3 is attached, and this rod passes through the hollow stem W^5 and is attached to the high-pressure cross-head H^4. The rods V^8 pass through holes H^{15} in the bottom end of the high-pressure-piston trunk H^9, and inside the latter the valve-trunk 2 works, a packing-ring V^{12} being provided in the piston. The receiver R is fixed on the top of the high-pressure cylinder H and contains a valve-liner V^{15}, within which rings 4 and 1 work. The low-pressure piston L^2 is provided with a packing-ring L^{10}, surrounding the valve-liner O, and a pair of rods L^3, working through glands L^7, connect the piston with the cross-heads L^4, connected by the rods L^5 to crank-pins L^6. The high-pressure rod H^3 is packed at H^7 and the hollow stem W^4 of the valve V at V^7. In the position shown the valve is descending, and ring 1 admits steam from the inlet S through port B to the top side of the high-pressure piston H^2, and ring 3 admits steam from the receiver or inter-piston space R^2 through ports G and J to the under side of the low-pressure piston. As piston H^2 descends and piston L^2 ascends ring 1 cuts off the steam to the top side of H^2 and ring 3 to the bottom side of L^2 when compression begins above the latter; but the projection L^9 on the piston L^2, which more or less closely surrounds the liner O, covers the port G at a fixed point and closes it, (or nearly closes it,) so as to limit the lateness of cut-off to the under side of L^2. Toward the end of the stroke ring 1 rises above port D and connects receiver R with the top side of the piston H^2, and the slots D^3 in the valve-trunk 2 rise above piston H^2 and steam passes from above the piston through these slots D^3 and ports G^2 to the receiver R^2, while ring 3, rising above port J, places the under side of piston L^2 in communication with the exhaust E. During the next stroke the slots D^3 in the valve-trunk 2 descend below the piston H^2 and cut off the steam passing from the high-pressure cylinder to the receiver R^2, and then the steam remaining above H^2 is compressed in receiver R, while that between the pistons is expanding. Toward the end of this stroke ring 1 closes port D, cutting off the receiver R from the top side of the piston H^2, and steam is afterward admitted again by ring 1 to the top of the piston H^2 and by ring 3 from the top to the bottom of the piston L^2, as already described.

Some advantages of the central-valve construction are simple cylinder-castings, small clearance or port space, free exhaust at early cut-off, vibration caused by valve centralized, separate inlet and outlet ports for steam passing into and out of high-pressure cylinder, and small horizontal space occupied.

Referring to Figs. 1 and 2, the valve V is worked off the connecting-rod H^5 by a pair of levers T, pivoted at one end by the pin T^3 to H^5 and at the other end by a pin T^4 to the valve-rod W. An intermediate point is fulcrumed by the pin T^5 to one end of the radial link U, the other end of which is pivoted by the pin U^3 to the movable block U^2, fitting the slot Y. To move the block U^2 either toward or away from the center of the slot Y and give an earlier or later cut-off, respectively, the shaft Z^2 is provided. This shaft may be twisted by hand or governor and has an arm Z, carrying a stud Z^3, projecting into a hole Z^4 in the pin U^3. Fig. 3 shows a separate view of the parts hidden by the connecting-rod H^5 in Fig. 2. If the block U^2 is moved from the center of the slot to the left, the motion of the engine is reversed, and though the distribution is not quite so perfect as before it is suitable for occasional reversing of the motion. Besides the simplicity of this gear the main feature is that, applied to this engine, the radial link U is located on the lower or crank side of the levers T, resulting in the advantages that the different points of cut-off are all simultaneously altered, so that at different loads the turning effort on the crank-shaft during successive strokes tends to remain fairly equal, at the same time maintaining an efficient exhaust. The engine being single-acting, a constant lead may be given by the valve to the high-pressure piston at top stroke, while any variation in the lead at bottom stroke is corrected by the piston uncovering the port N. With a constant thrust on the valve by making the link U long enough so as not to exceed the angle of repose the block U^2 remains steady in the slot Y and yet is freely moved by the governor.

Referring to Figs. 5 and 6, the levers T are pivoted, as before, to a projection H^{12} on the connecting-rod H^5, and the motion is conveyed from the pin T^4 in the levers T by links W^2 to pins T^7 on the pair of levers T^2, fixed at one end to a pin T^6, pivoted in the bracket C^3 in the crank-chamber C^2, and the other ends are pivoted to the rods W by the pins T^8, which connect with the pins W^3 on the gland-socket W^4, fixed on the stem W^5 of the valve V. A special advantage of this gear as applied to the central valve is that the radial action of the short link W^2 tends to keep the exhaust longer open which is suited to the small clearance or port space existing in the central valve.

In order to maintain a fairly even and moderate pressure on the pins and bearings of the valve-gear at different loads, I mount an extra part or ring 4 on the valve V. The space between rings 4 and 1 being filled with steam at the top of the valve's travel, it passes thence through holes A to the space F above ring 4 with a certain fall of pressure. As the valve descends this steam expands, and at bottom stroke the hole A^2 (dotted) has passed between two of the openings of the port B and come opposite the hole A^3, communicating with the receiver R when a certain fall of pressure takes place, and the remaining steam is compressed above ring 4 during the upstroke and a fresh charge of steam then admitted through A, as before. When the points of cut-off in the cylinders are made earlier, the travel of the valve V is reduced, particularly in a downward direction. Consequently with the earlier cut-off the hole A^2 is connected with the hole A^3 (D in Figs. 5 and 6) and receiver R for a shorter length of time; but, on the other hand, the pressure in the receiver R is less with the earlier cut-off, the advantage of which is that the discharge from above the ring 4, and consequently the downward thrust on the valve-gear, tends to remain the same at different loads. In a similar manner with higher speeds the discharge may take place into receiver R^2 or port J through rings 2 or 3 and the space above ring 4 be reduced, if desired, so as to have a smaller pressure on ring 4 when at the bottom of its travel and a greater pressure when at top stroke.

As is well known, owing to the obliquity of the connecting-rod, the motion of the piston does not exactly coincide with the motion of the crank in the same line—that is to say, during the first part of the down or out stroke when the crank has made a quarter of a revolution the piston has traveled more than half its stroke, and consequently during the next quarter of the revolution it travels less than half its stroke, and also while making the up or in stroke the crank travels faster than the piston during the next quarter-revolution and slower during the last quarter of the revolution. To make the motion of the piston correspond to that of the crank and to check the vibration caused by the unequal motion of two pistons working in opposite directions, I introduce the compensating motion shown in Figs. 9 and 10 applied to the high-pressure cross-head H^4 and connecting-rod H^5. The cross-head is shown at half-stroke downward, and the upper end of the connecting-rod H^5 is attached to a slide or cross-head H^8 by a pin H^{16}. Links Q are pivoted to pins Q^2 Q^2, fixed in the main cross-head H^4, and at the other end to the pin Q^3 in the connecting-rod. As the rod swings from side to side it moves the main cross-head in relation to the pin H^9 in the top end of the rod and so tends to counteract the effect of the obliquity of the rod on the motion of the piston and to cause the vertical motion of the latter to coincide more nearly with the vertical motion of the crank-pin.

Figs. 11 to 15 show an improved method of lubrication applied to one of the connecting-rods. Figs. 11 and 12 represent vertical sections of the rod, with the middle portion broken away to show the ends on a larger scale. Fig. 13 is a diametrical view of the bottom bearing, and Fig. 14 is a diametrical section of the top bearing. Fig. 15 is a view of one of the cranks. From the center of the crank-pin bearing P^2, I take a hole or pipe 6, with branches P^3 at the upper end connected with grooves 7, formed in the gudgeon-pin bearing P of the rod. The grooves may be about forty-five degrees from the rod center, the exact position depending on the relative bearing-surfaces of the crank and gudgeon pins; but I cut the grooves at a point where the oil-film pressure is the same or a trifle less than in the center of the crank-pin bearing. Retaining-grooves 9 are cut nearer the center of the brass, and distributing-grooves 8 are cut in the gudgeon-pin. The pressure on the oil in the bearing P^2 forces it up the passage 6 and conveys it by the branches P^3 to the grooves 7. Then as the rod moves from side to side the grooves 8 take oil from the outside grooves 7 to the inside grooves 9, where the film-pressure is greater. In the crank-pin I make short disconnected distributing flats or grooves 10 and similar grooves in the bearings, or in the bearing the grooves 11, 12, and 13 may be used. As the film-pressure is greatest at about the center and falls away toward the edges of the brass, both lengthwise and sidewise, I cut the grooves in a curved form, following a certain line of uniform film-pressure in each groove, which pressure is greatest in the central groove 13 and least in the outside groove 11. As the pressure is greatest slightly to one side in the direction of rotation, the grooves may be formed somewhat on that side; but for a reversing-shaft I form them centrally and divide the grooves on these lines of pressure into two or more portions, as shown in the outside grooves 11. The flats or grooves 10 on the crank-pin, which may be shorter at the edges than in the center, carry around the oil to grooves 11, 12, and 13 without letting down the film-pressure much as they pass. I employ similar grooves and flats in the main bearings and shaft, and for the pins and bearings of the valve-gear I use grooves similar to those in the gudgeon-pin and its bearing.

As the pressure of the oil film in a bearing varies at different points, the advantage of my lubricating arrangements lies in carrying into and retaining a supply of oil without letting down the pressures natural to the different points to any extent, on the ground that letting down the natural pressure of any point must increase the maximum pressure in order to keep the average pressure the same, and that as I reduce the maximum pressure I tend to reduce the friction. There is also a more constant supply and retention of the oil tending to the same result.

I claim as my invention—

1. A compound engine having a low-pressure cylinder and a high-pressure cylinder communicating with each other, a piston in the low-pressure cylinder and connected with a pair of cranks, a piston in the high-pressure cylinder and connected with one crank set oppositely of the main shaft to the pair of cranks, receiving-chambers, a valve-chamber, passages from the valve-chamber to the cylinders and receiving-chambers, and a valve located in the valve-chamber and connected with the pistons in such manner that steam is first admitted to the side of the high-pressure piston remote from the cranks, and finally to the side of the low-pressure piston adjacent to the cranks, while during the latter parts of their return strokes the low-pressure piston compresses steam in the inter-piston space or receiving-chamber, and the high-pressure piston in another receiving-chamber, in order to keep the connecting-rod bearings constantly thrusting against the crank-pins, substantially as specified.

2. A compound engine having a high-pressure cylinder and a low-pressure cylinder communicating with each other, pistons movable in said cylinders, a main shaft with one central crank and a pair of cranks set oppositely to and one on each side of the other crank, connections between the pistons and the cranks, receiving-chambers, a valve-chamber, passages from the valve-chamber to the cylinders and receiving-chambers, and a valve located in the valve-chamber and connected with the pistons in such manner that steam is first admitted to the side of the high-pressure piston remote from the cranks, and finally to the side of the low-pressure piston adjacent to the cranks, while during the latter parts of their return strokes the low-pressure piston compresses steam in the inter-piston space or receiving-chamber, and the high-pressure piston in another receiving-chamber, in order to keep the connecting-rod bearings constantly thrusting against the crank-pins, substantially as specified.

3. A compound engine having the high-pressure cylinder fixed on the top of and com-

municating with the low-pressure cylinder, pistons movable in the cylinders and working on oppositely-set cranks, receiving-chambers, a valve-chamber, passages from the valve-chamber to the cylinders and receiving-chambers, and a valve located in the valve-chamber and connected with the pistons in such manner that steam is first admitted to the side of the high-pressure piston remote from the cranks, and finally to the side of the low-pressure piston adjacent to the cranks, while during the latter parts of their return strokes the low-pressure piston compresses steam in the inter-piston space or receiving-chamber and the high-pressure piston in another receiving-chamber, in order to keep the connecting-rod bearings constantly thrusting against the crank-pins, substantially as specified.

4. A compound engine having three cylinders with a piston movable in each cylinder, two of said pistons being fixed to the same rod and acting upon a crank set oppositely to the crank upon which the other piston acts, receiving-chambers communicating with the intermediate and low-pressure cylinders upon the side of the pistons distant from the crank-shaft for the purpose of keeping the connecting-rod bearings constantly thrusting against the crank-pins, a valve-chamber, passages from the valve-chamber to the cylinders and receiving-chambers, and a valve located in the valve-chamber and connected with the pistons for directing the flow of steam from piston to piston and receiving-chamber, substantially as specified.

5. A compound engine having a high-pressure cylinder and a low-pressure cylinder communicating with each other, pistons movable in said cylinders, a main shaft with one central crank and a pair of cranks set oppositely to and one on each side of the other crank, connections between the pistons and the cranks, receiving-chambers, a valve-chamber coaxial with the pistons, passages from the valve-chamber to the cylinders and receiving-chambers, and a valve located in the central valve-chamber and connected with the pistons in such manner that steam is first admitted to the side of the high-pressure piston remote from the cranks and finally to the side of the low-pressure piston adjacent to the cranks, while during the latter parts of their return strokes the low-pressure piston compresses steam in the inter-piston space or receiving-chamber and the high-pressure piston in another chamber, in order to keep the connecting-rod bearings constantly thrusting against the crank-pins, substantially as specified.

6. A compound engine having a high-pressure cylinder and a low-pressure cylinder communicating with each other, pistons movable in said cylinders, a main shaft with one central crank and a pair of cranks set oppositely to and one on each side of the other crank, connections between the pistons and the cranks, one piston-rod passing through the other piston, receiving-chambers, a valve-chamber coaxial with the pistons, passages from the valve-chamber to the cylinders and receiving-chambers, a fixed sleeve in the high-pressure cylinder, a sleeve fixed to the low-pressure cylinder, and a central valve with a part working in the sleeve in the high-pressure cylinder, a part within an opening in the high-pressure piston, and a part within the sleeve fixed to the low-pressure cylinder, substantially as specified.

7. In combination with the high and low pressure cylinders of an engine, a valve-chamber, receiving-chambers communicating with the valve-chamber, ports from the valve-chamber to the cylinders, and a valve so arranged that at one end of its travel steam is admitted into a receiving-chamber and at another part of its travel steam is permitted to escape from the receiving-chamber into another receiving-chamber or part of the engine in which the pressure is less than the initial pressure, the whole being arranged so that at early cut-off the travel of the valve being shorter, the time of discharge into the last-mentioned receiver is less than at late cut-off, and as the pressure in the receiver is less than at late cut-off the strain on the pins of the valve-gear tends to be equalized at different loads on the engine, substantially as specified.

8. In combination with the high and low pressure cylinders of an engine, a valve-chamber, a receiving-chamber, ports connecting the valve-chamber and the receiving-chamber and the cylinders, and a valve movable in the valve-chamber and so arranged that shortly after cut-off during one stroke the receiving-chamber is connected with one side of the piston and remains connected with the same until the end of the next or return stroke, when it is disconnected therefrom before the admission of fresh steam, the piston compressing into the receiver during the return stroke in order to keep the bearings in constant thrust, substantially as specified.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

ARTHUR FORBES SCOTT.

Witnesses:
DAVID NOWELL,
SAMUEL A. DRACUP.