No. 775,318. PATENTED NOV. 22, 1904.

G. W. SUTCLIFFE.

COMPOUND ENGINE.

APPLICATION FILED SEPT. 28, 1901.

NO MODEL. 2 SHEETS—SHEET 1.

Fig. 1.

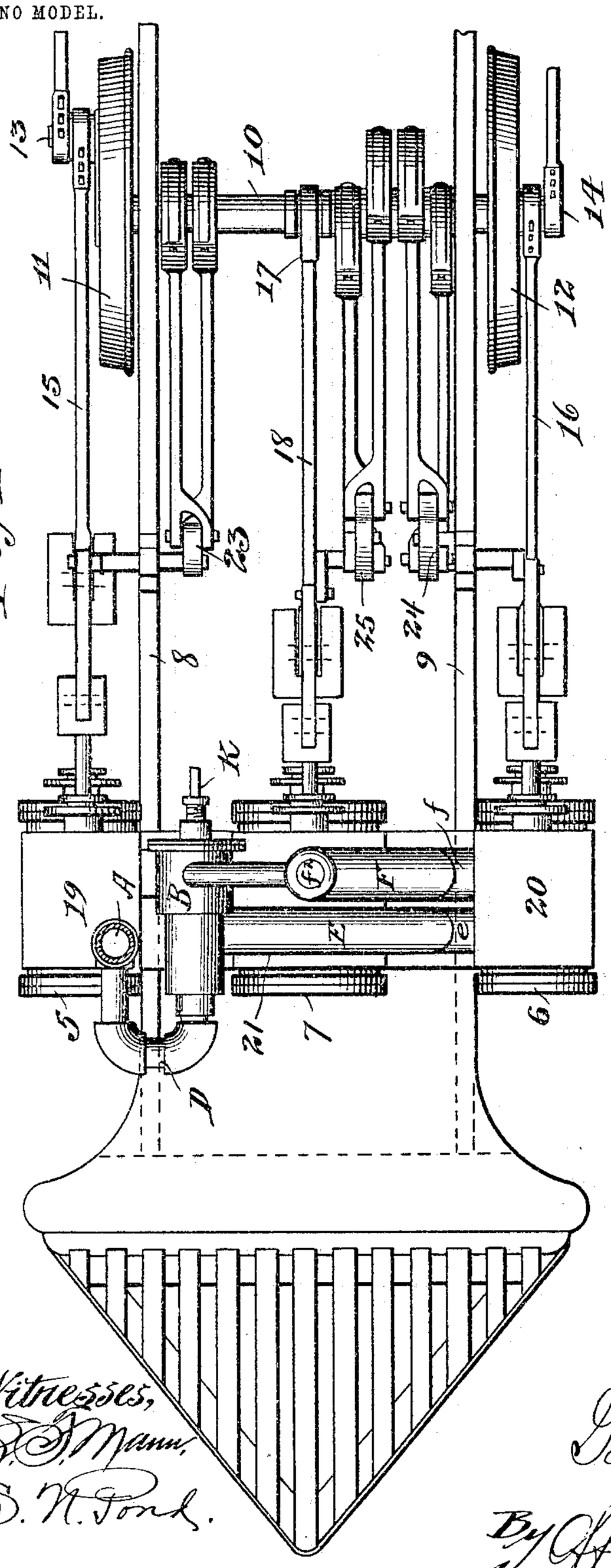
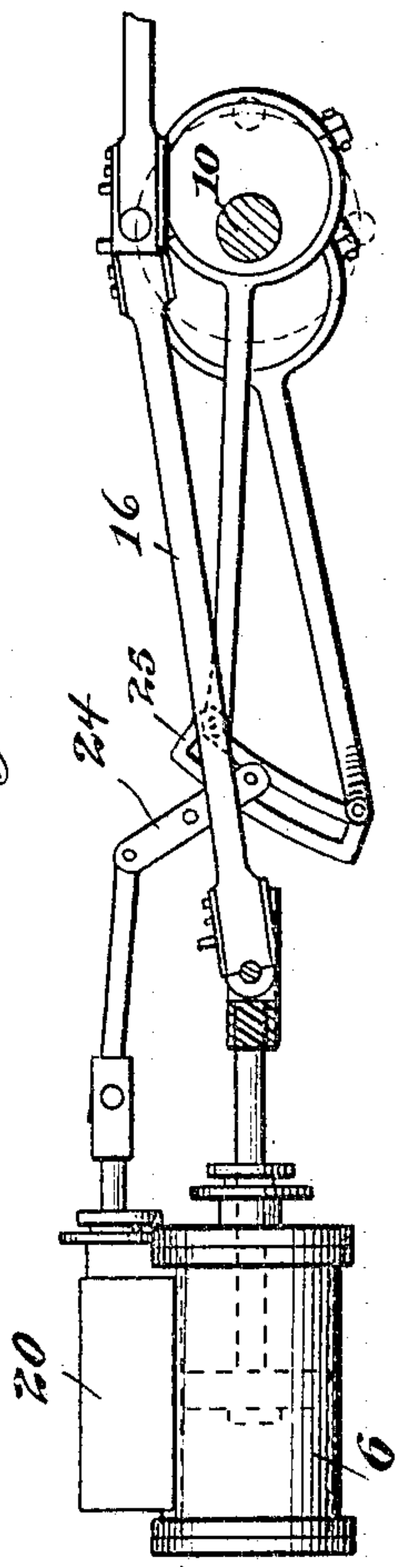


Fig. 2.



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NO MODEL. 2 SHEETS—SHEET 2.

Fig. 3.

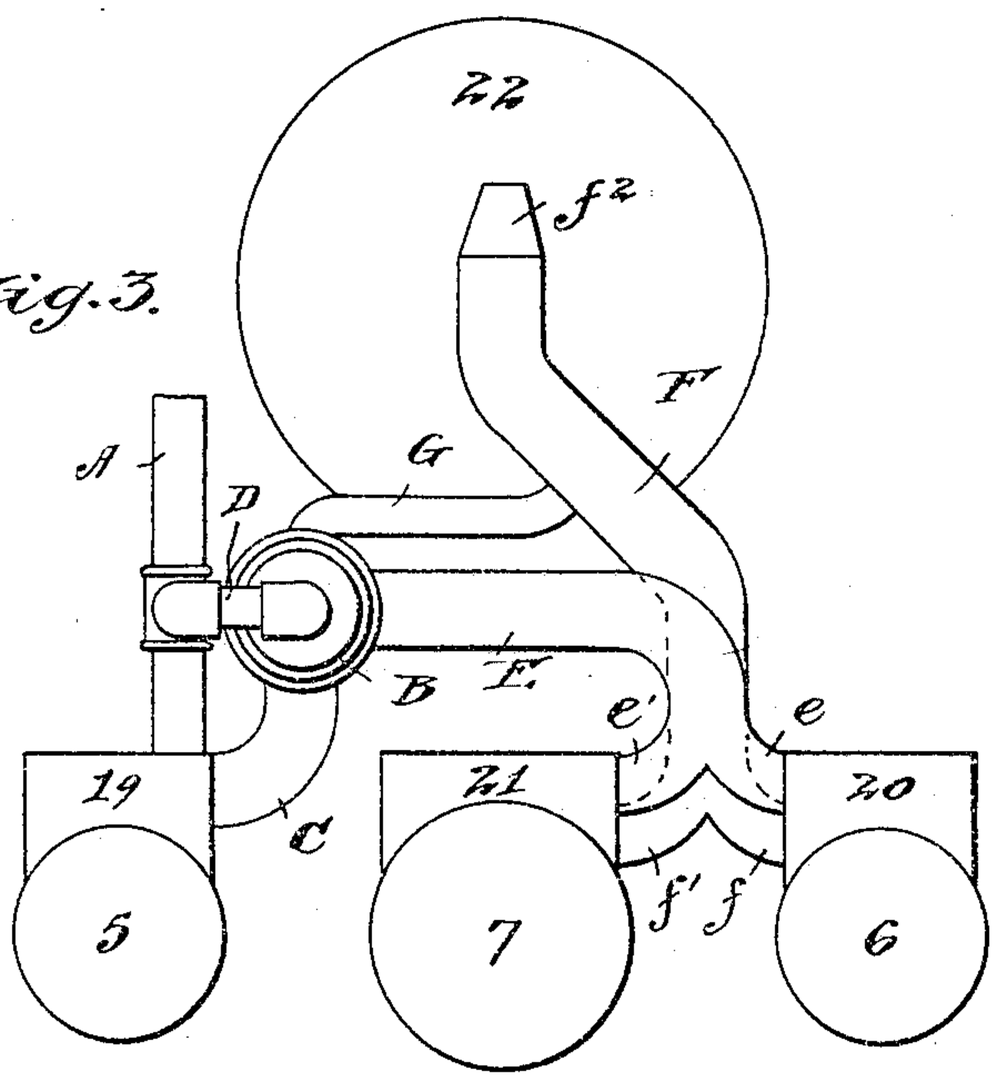


Fig. 4.

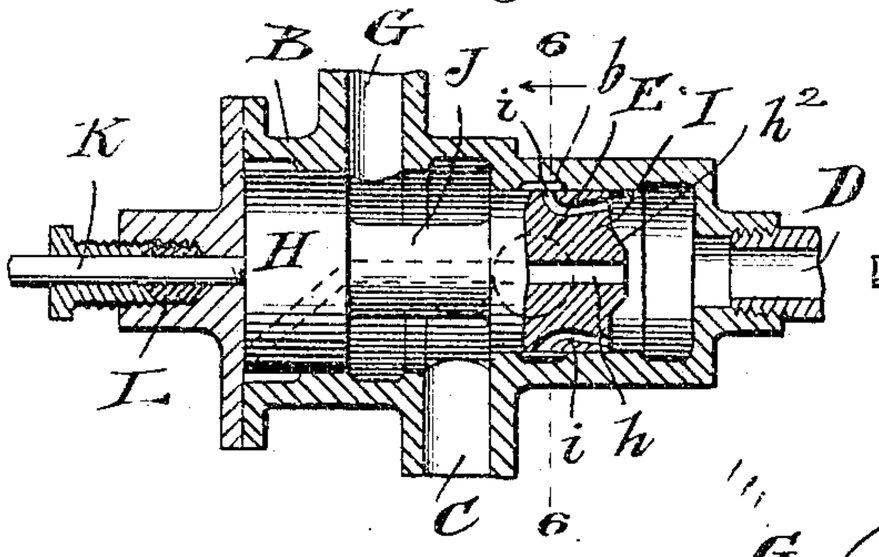


Fig. 5.

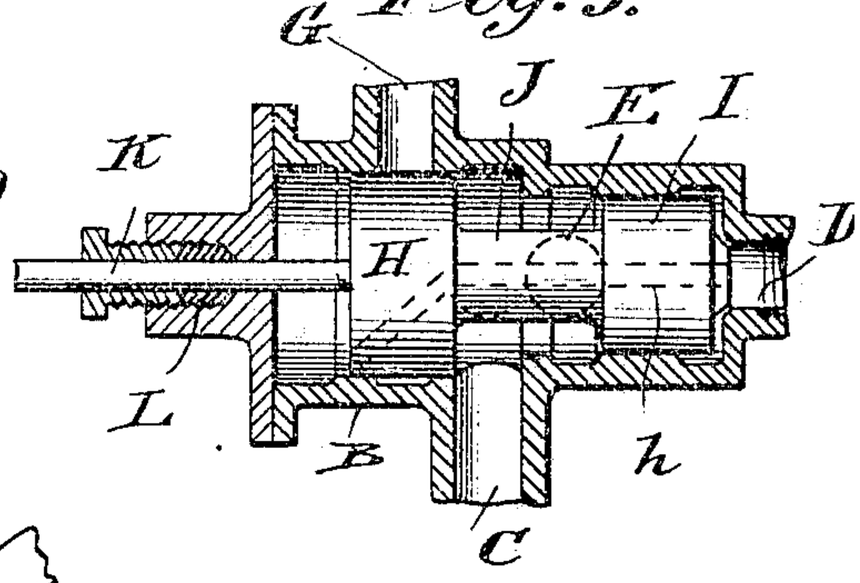
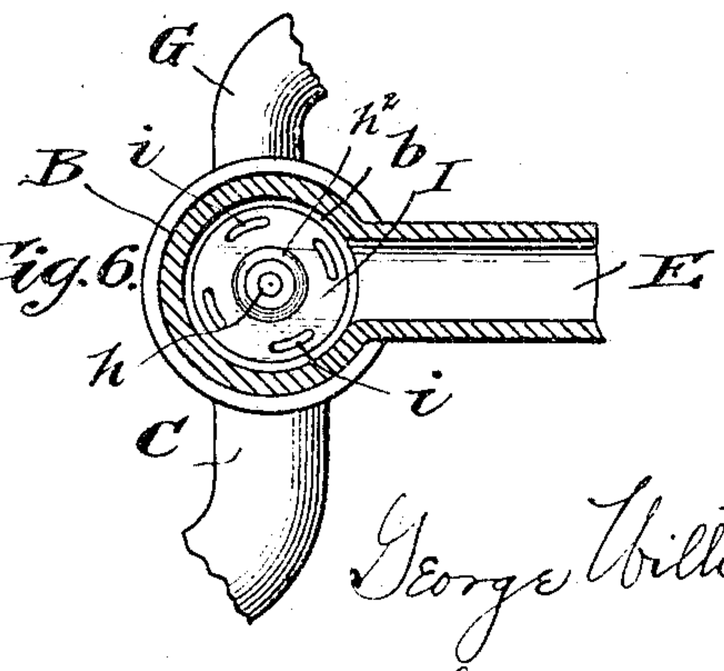


Fig. 6.



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F. D. Mann.
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No. 775,318. Patented November 22, 1904.

UNITED STATES PATENT OFFICE.

GEORGE W. SUTCLIFFE, OF MARPLE, ENGLAND, ASSIGNOR TO RACHEL SUTCLIFFE, OF MARPLE, ENGLAND, AND ARTHUR GEORGE SUTCLIFFE, OF CHICAGO, ILLINOIS.

COMPOUND ENGINE.

SPECIFICATION forming part of Letters Patent No. 775,318, dated November 22, 1904.

Application filed September 28, 1901. Serial No. 76,877. (No model.)

To all whom it may concern:

Be it known that I, GEORGE WILLIAM SUTCLIFFE, residing at Marple, in the county of Chester, England, have invented certain new and useful Improvements in Compound Engines, of which the following is a specification.

This invention relates to improvements in the construction of locomotive-engines, and refers more specifically to an engine of the compound type in which steam is expanded or utilized in two stages—*i. e.*, a high-pressure and a low-pressure stage.

The salient objects of the invention are to provide a construction in which such relation of the piston areas of the high and low pressure cylinders is provided as to secure the most effective and economical results, to provide a construction in which the low-pressure cylinders act in unison with each other and alternately with the high-pressure cylinder, and to provide in a construction of the character referred to an arrangement which enables the cylinders to be conveniently applied to locomotive-engines without substantially changing the forms of frame and truck construction now in ordinary use.

The invention consists in the matters hereinafter described, and more particularly pointed out in the appended claims, and the same will be readily understood from the following description, reference being had to the accompanying drawings, in which—

Figure 1 is a plan view of so much of the truck-frame of a locomotive as will enable the invention to be understood, the supply-steam trunk being shown in horizontal section, taken in a plane above the plane of the cylinders. Fig. 2 is a side elevational view with certain parts in cross-section and others omitted and diagrammatically illustrating the relation of the crank connections of the high and low pressure cylinders. Fig. 3 is a front elevational view, in diagrammatic outline, illustrating the relative locations of the several cylinders and the boiler and their connecting-pipes. Figs. 4 and 5 are longitudinal sectional views of an intercepting-valve which I prefer to employ in order to render the engine simple or compound at will; and Fig. 6 is a detail cross-sectional view on the line 6 6 of Fig. 4, the ported valve-body appearing in end elevation.

It is found in practice that the low-pressure piston area should usually be about two and four-tenths as great as the high-pressure piston area, assuming the piston-strokes to be equal in the several cylinders in order to secure the most effective application of the steam. It is also essential that an engine should be so constructed as to be able to start promptly under load at all times and in all positions of the driving mechanism. For the latter reason it is important that the whole of the low-pressure piston area should be available for starting at all times when the high-pressure area is not available. Owing to the peculiarities of construction of locomotives as now generally constructed, a single low-pressure cylinder cannot be made of sufficient piston area to secure the proper relations between the area of the high and low pressure cylinders without serious objection.

In carrying out my invention I provide one high-pressure cylinder to first receive and apply the steam to drive the engine, which cylinder I place to one side of the main frame of the engine, as indicated at 5. I also provide two low-pressure cylinders of such size that their combined piston areas will bear to the piston area of the high-pressure cylinder substantially the relation hereinabove specified. One of these cylinders, which I designate by 6 and identify as the "outer" low-pressure cylinder, is placed upon the opposite side of the engine-frame from the high-pressure cylinder, while the other low-pressure cylinder, designated by 7 and identified as the "inner" low-pressure cylinder, is placed between the main side members 8 and 9 of the engine-frame.

The high-pressure cylinder 5 and the outer low-pressure cylinder 6 are in the present instance shown as arranged to impart rotation to a shaft 10, rotatably mounted in and be-

tween the side members 8 and 9 of the frame and here constituting the axle of the main driving-wheels 11 and 12, the outer faces of which are provided with wrist-pins 13 and 14, operatively connected with the pistons in cylinders 5 and 6 through pitmen 15 and 16, respectively, all as is usual in locomotive construction. It will be observed that two of the cylinders above mentioned—namely, cylinders 5 and 6—are arranged to act upon the wheels and axle driven thereby through cranks disposed a quadrant apart or at right angles to each other. Preferably the longitudinal axes of the cylinders 5 and 6 are disposed parallel, as herein shown. I may, however, arrange the cylinders out of parallel with each other, in which case the angle between the planes of the two cranks will be corrected to correspond, so that in either case the cranks of the two cylinders will pass the dead-points at four equal intervals of a complete revolution.

The inner low-pressure cylinder 7 is arranged to act upon a crank 17 through its piston and pitman 18, which crank 17 is formed or fitted upon the main axle 10 at a point intermediate of the length of the latter, as clearly indicated in the plan view, Fig. 1. This latter crank 17 is so disposed relatively to the crank of the low-pressure cylinder 6 as to be upon its outer dead-center point when the companion low-pressure cylinder is upon its inner dead-center point, and vice versa, or, in other words, the crank 17 is arranged diametrically opposite the crank 14, and in order that the two pistons of the cylinders 6 and 7 may act in unison in propelling the locomotive the valve-gear and steam-supply, hereinafter described, are so arranged as to drive the pistons of the two low-pressure cylinders in opposite directions during the same periods, so that the combined driving moment of both pistons acts effectively upon the main axle.

19, 20, and 21 designate the valve-chests of the three cylinders 5, 6, and 7, respectively, while 22, Fig. 3, may represent the boiler. In Fig. 3 I have diagrammatically illustrated a convenient system of distribution of the steam between the boiler and the several cylinders which may be employed, although such a system is illustrative merely and may be variously modified within the spirit and scope of my invention. A designates the steam-delivery pipe from the boiler, leading directly into the valve-chest 19 of the high-pressure cylinder 5. B designates the casing of an intercepting-valve which I prefer to employ for the purpose of effecting such a distribution of the steam to the cylinders as enables the engine to start up with full boiler-pressure in all three cylinders and subsequently automatically convert itself into a compound engine. The under side of the casing of this intercepting-valve is tapped by a pipe C, which constitutes the exhaust-pipe from the high-pressure cylinder. The forward end or head of the casing B is tapped by a short curved pipe D, which constitutes a direct live-steam connection from the steam-inlet pipe A to the interior of the intercepting-valve casing, at one end thereof. E is a delivery-pipe tapping one side of the casing B of the intercepting-valve and leading thence by branches e e' to the valve-chests 20 and 21 of the outer and inner low-pressure cylinders 6 and 7, respectively. F is the final exhaust or blast pipe which taps the valve-chests 20 and 21 by branches f and f', respectively, and terminates in a discharge-nozzle f^2, which in practice is located within the usual smoke-stack. G constitutes a connection between the upper side of the casing of the intercepting-valve and the blast-pipe F.

Referring to Figs. 4, 5, and 6, which illustrate the relative points of connection of the several pipes which tap the casing B of the intercepting-valve, it will be seen that the valve-body proper of the intercepting-valve comprises a pair of pistons H and I of unequal diameters and surface areas connected by a stem or shank J. It will be observed that the member H of the valve is adapted to control the passage of steam through the pipe G, while the companion member I of the valve-body is adapted to similarly control the admission of steam to the low-pressure cylinders through the pipe E. The inner wall of the casing B is annularly recessed through a limited extent intermediate its ends at b coincident with the point of junction of the pipe E therewith. This annular recess is adapted to coöperate with a series of small bores or steam passage-ways i, extending between the outer face of the piston-block I of the valve-body and points on its periphery which register with the annular recess b when the valve-body is at the end of its left-hand throw. The valve-body is further provided with a longitudinal bore h, extending entirely therethrough. The right-hand end of the valve-body is also formed as a stop-valve h^2, acting to open and close communication of the pipe D with the interior of the valve-casing.

The valve-chests 19, 20, and 21 of the several cylinders are preferably equipped with the usual steam-slide-valve mechanism, which is operated in properly-timed relation to admit and exhaust the steam from the cylinders through the usual eccentric-gear connections, (indicated at 23, 24, and 25, respectively,) which may be the usual well-known type and need not, therefore, be more particularly described. The body of the intercepting-valve is equipped with an actuating-stem K, extending rearwardly through a stuffing-box L, this stem being adapted to be connected with any suitable manual operating means, as a hand-lever, within convenient reach of the engine-driver.

The engine on starting is designed to work

separate, by which is meant that all of the several cylinders are supplied with high-pressure steam from the boiler, and to effect this the valve-body is shifted by hand to the left-hand position, as shown in Fig. 4. By this means direct communication between the high-pressure cylinder 5 and the low-pressure cylinders 6 and 7, which can take place only through the pipes C and E, is obviously closed by the piston-body I, and the live steam admitted to the high-pressure cylinder 5 directly through the pipe A is allowed to exhaust directly to the blast-pipe F through the pipes C and G, which are in free communication through the intercepting-valve. At the same time high-pressure steam from the boiler is allowed to pass through pipe D into the front end of the intercepting-valve casing, thence through the ports *i* and annular recess *h* into pipe E, and thence directly to the cylinders 6 and 7, the steam being exhausted directly from the latter cylinders through the branches *f* and *f'* and the blast-pipe F. It will thus be seen that in this position of the intercepting-valve all three of the cylinders are adapted to work at full boiler-pressure. Owing to the difference in area between the pistons H and I of the valve-body the latter is normally maintained in the described position until the pressure of steam between the pistons falls sufficiently far below the pressure of steam upon the left-hand side of the larger piston H, admitted through the bore *h*, to shift the valve into the position shown in Fig. 5, whereupon the engine will at once begin to work compound owing to the fact that high-pressure steam from the boiler is thus shut off from the cylinders 6 and 7 by the stop-valve h^2 closing the inlet-pipe D, while the shifting of the piston I throws the inlet-pipe E of the low-pressure cylinders into free communication with the exhaust-pipe C from the high-pressure cylinder, at the same time cutting off the direct exhaust of the latter to the blast-pipe through pipe G. The pressure of the steam acting through the bore *h* suffices to maintain the valve-body constantly in its right-hand position, and the engine will thus continuously run compound until the intercepting-valve is again manually shifted by the engineer.

The crank 13 of the high-pressure cylinder 5 is preferably arranged half-way between the cranks 14 and 17 of the low-pressure cylinders, as illustrated diagrammatically in Fig. 2, for the evident purpose of enabling the engine to start promptly in any and all rest positions of the driving mechanisms. It will be noted that the cylinders as thus arranged may be very nearly of the same diameter and of precisely the same length, one of the two low-pressure cylinders being larger in diameter than the high-pressure cylinder in order to afford the desired piston area. If preferred, both low-pressure cylinders may obviously be of slightly-larger diameter than the high-pressure cylinder. It will be further noted that the arrangement is such that it may be applied to locomotives as now generally constructed without extended reconstruction of the parts and without in any wise increasing the size of the engine or so placing the cylinders as to substantially interfere with other parts. It will further be noted that the arrangement described provides for the approximate mutual balancing of the two low-pressure pistons and other connected reciprocating and revolving parts.

While I have herein shown and described a preferred embodiment of my invention, it will be understood that the cylinders are not necessarily arranged to act upon the same axle so long as the driving moment of the pistons is imparted in a manner equivalent to that described. I do not, therefore, wish to be limited to the precise construction and arrangement shown except to the extent that the same are made the subject of specific claims.

I claim as my invention—

1. In a locomotive, the combination with the source of steam-supply, of a high-pressure cylinder and a pair of low-pressure cylinders arranged to simultaneously receive the exhaust-steam directly from the high-pressure cylinder, and operative connections between the pistons of said cylinders and the propelling-wheels, the driving-cranks actuated by the low-pressure pistons being arranged in diametrically opposite relation, and the driving-crank actuated by the high-pressure cylinder being arranged at right angles to the plane of the cranks of said low-pressure cylinders.

2. In a locomotive, the combination with the source of steam-supply, of a high-pressure cylinder arranged outside one of the side members of the main frame of the locomotive, a low-pressure cylinder arranged outside the main frame at the opposite side of the locomotive and a second low-pressure cylinder arranged between said side members of the locomotive-frame, interconnections whereby the exhaust from the high-pressure cylinder discharges directly into both low-pressure cylinders simultaneously but at opposite ends of said low-pressure cylinders and driving connections between the pistons of said several cylinders and the propelling-wheels of the locomotive.

3. In a locomotive, the combination with the source of steam-supply, of a high-pressure cylinder arranged outside one of the side members of the main frame of the locomotive, a low-pressure cylinder arranged outside the main frame at the opposite side of the locomotive and a second low-pressure cylinder arranged between said side members of the locomotive-frame, interconnections whereby the exhaust from the high-pressure cylinder dis-

charges directly into both low-pressure cylinders simultaneously but at opposite ends of said low-pressure cylinders, a main drive-axle provided at each end and at a point intermediate its length with pitman-wrists, and operative connections between the pistons of the respective cylinders and corresponding crank-wrists, the said two low-pressure cylinders being arranged in diametrically opposite relation and the crank-wrist of the high-pressure cylinder being arranged at right angles to the other crank-wrists, substantially as described.

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