

C. A. BALL.

STARTING GEAR FOR COMPOUND ENGINES.

No. 511,186.

Patented Dec. 19, 1893.

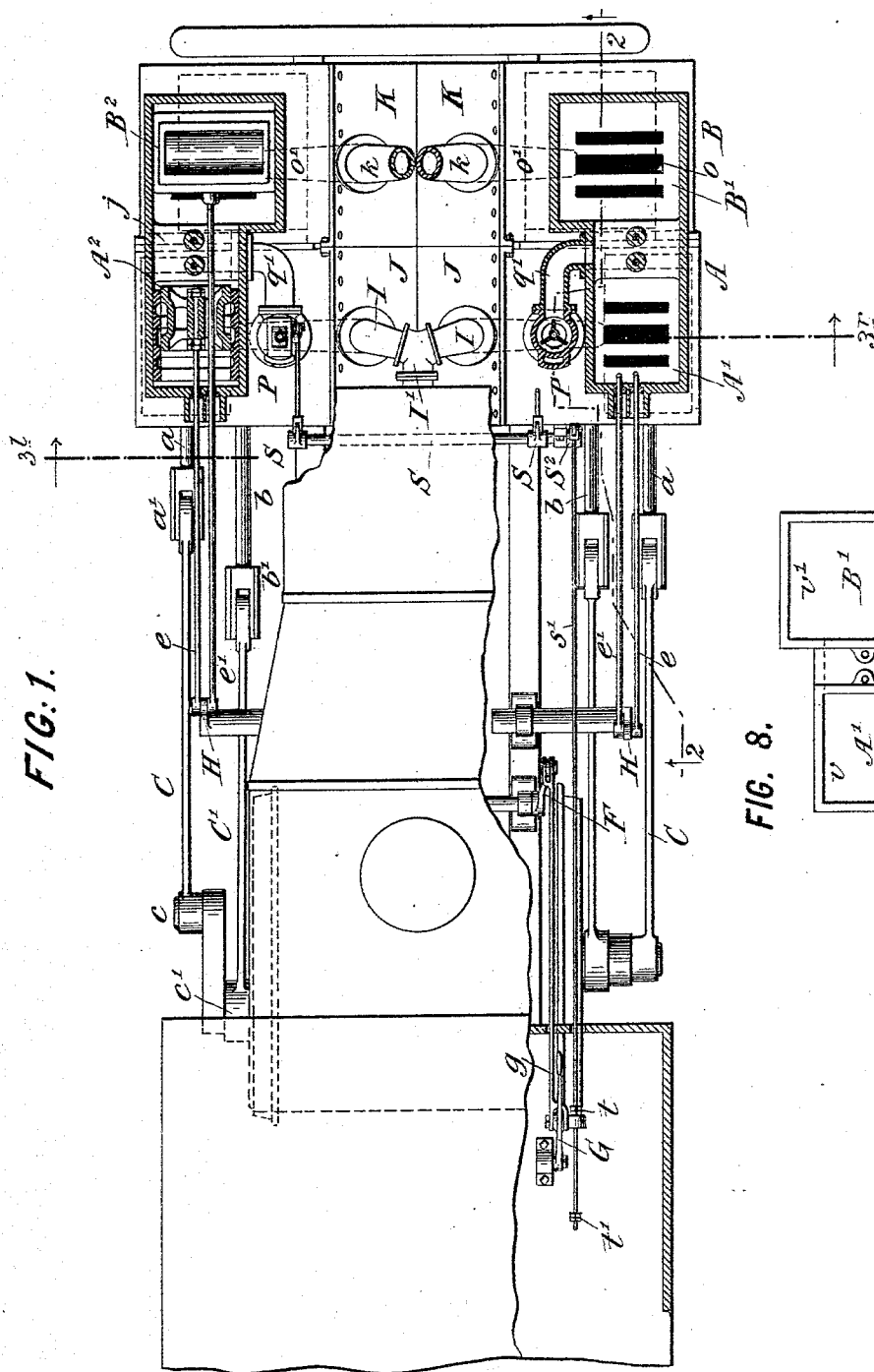


FIG. 1.

FIG. 8.

WITNESSES:
John A. Rennie
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INVENTOR:
Charles A. Ball,
By his Attorneys,
Arthur C. Fraser & Co.

(No Model.)

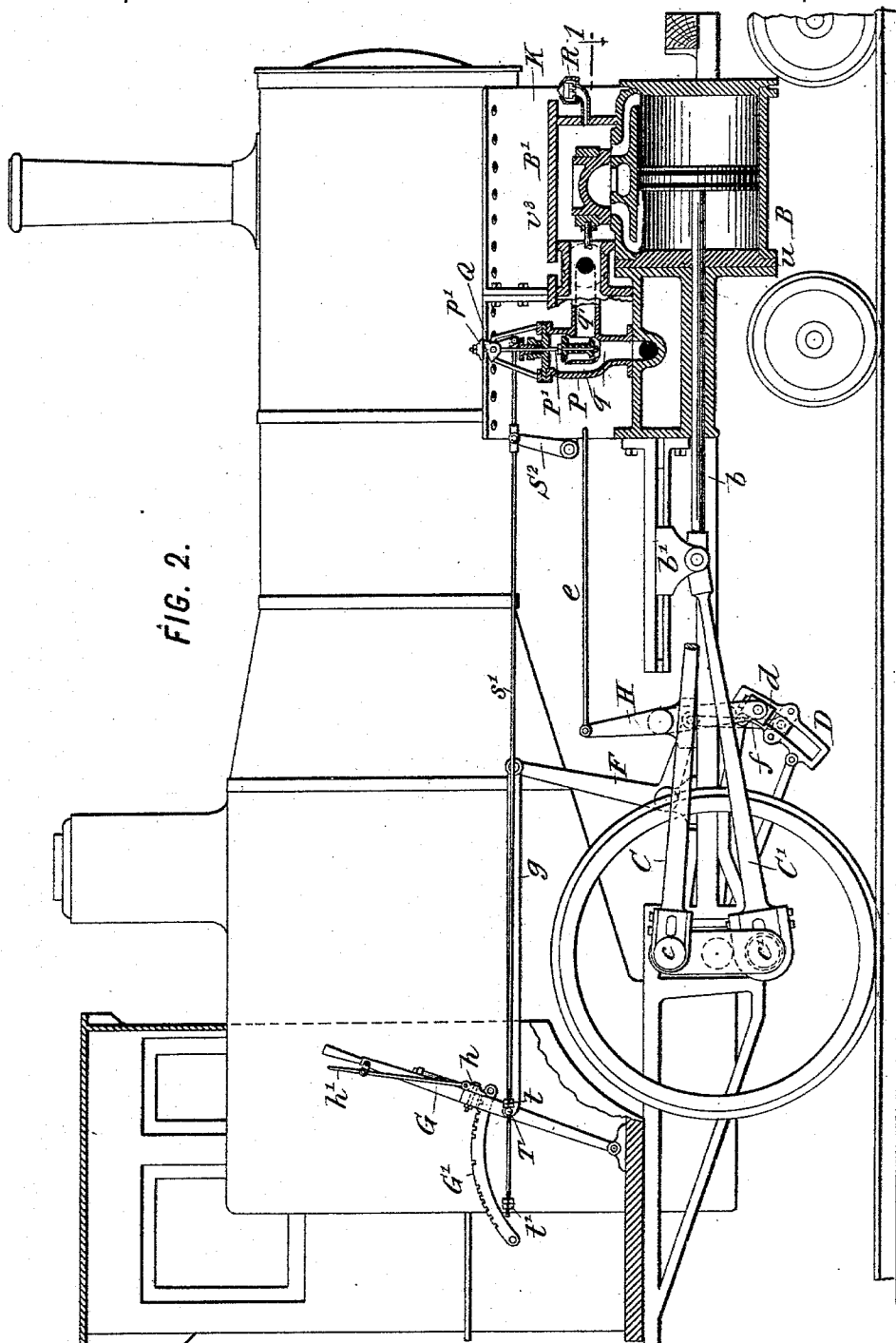
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FIG. 2.



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FIG. 4.

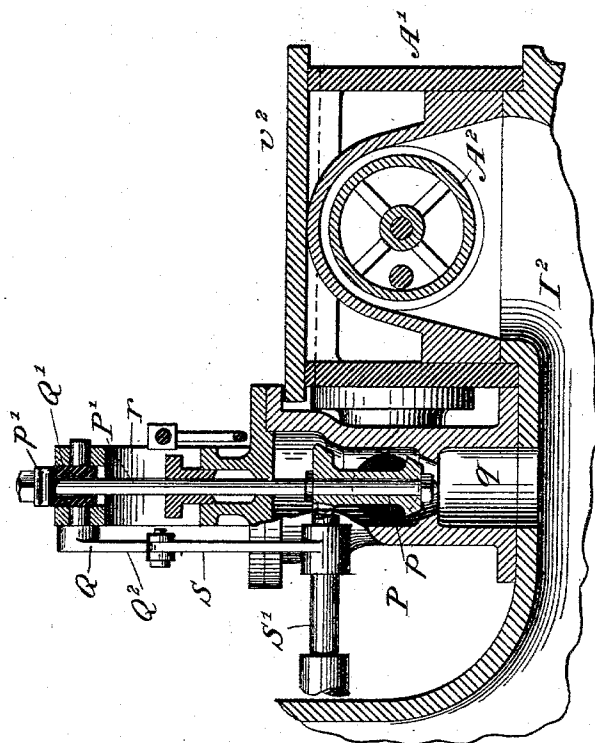
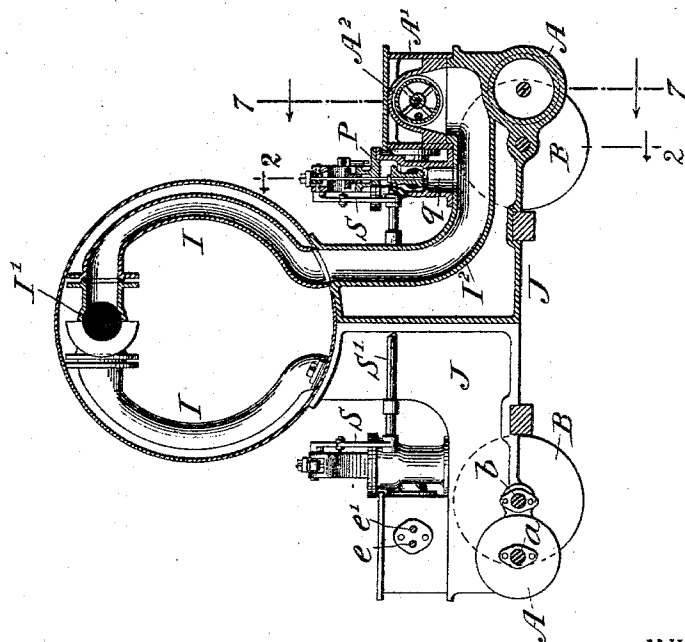


FIG. 3.



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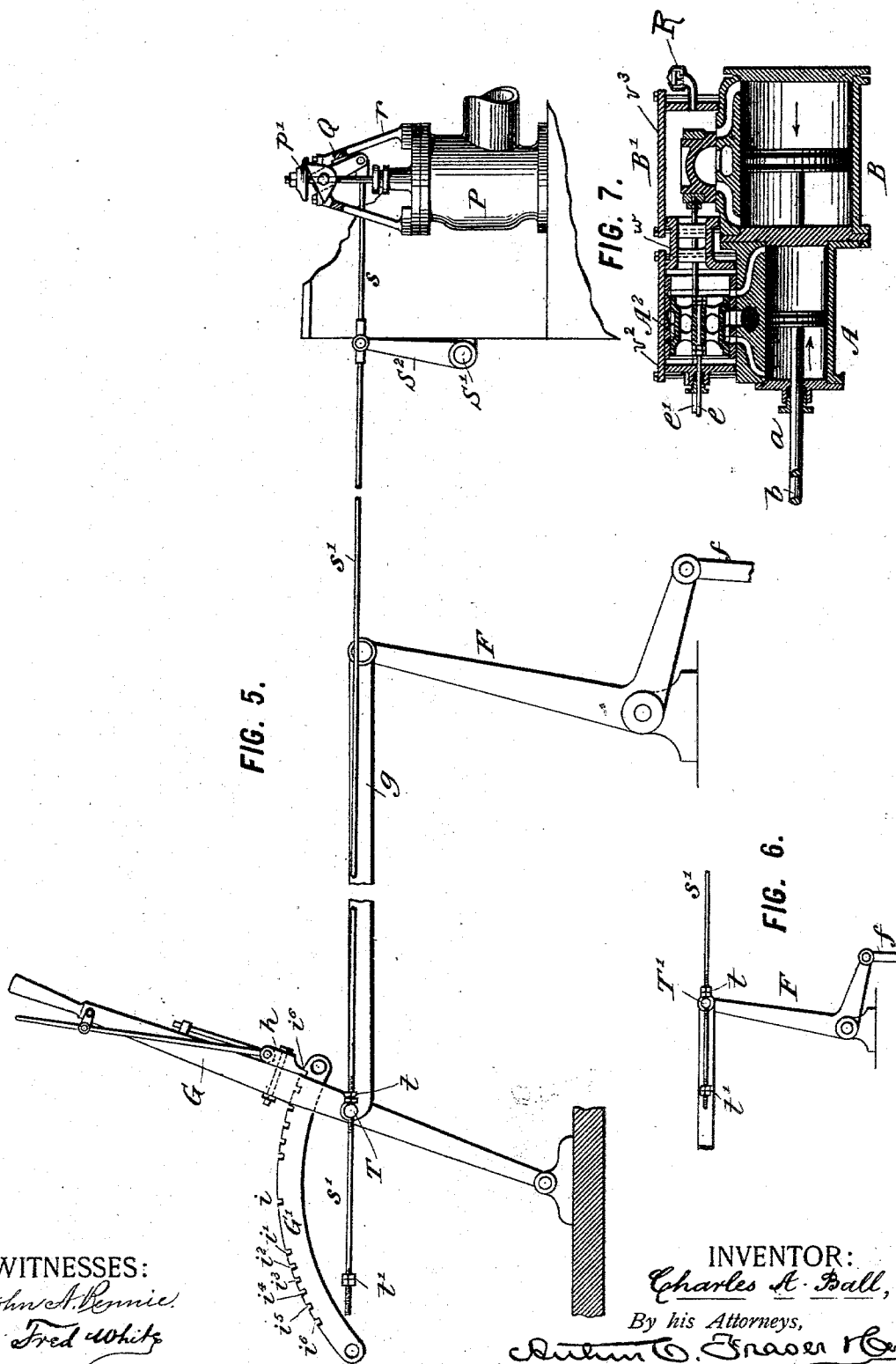
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CHARLES A. BALL, OF BROOKLYN, NEW YORK.

STARTING-GEAR FOR COMPOUND ENGINES.

SPECIFICATION forming part of Letters Patent No. 511,186, dated December 19, 1893.

Application filed January 16, 1893. Serial No. 458,442. (No model.)

To all whom it may concern:

Be it known that I, CHARLES A. BALL, a citizen of the United States, residing in Brooklyn, in the county of Kings and State of New York, have invented certain new and useful Improvements in Compound Engines, of which the following is a specification.

This invention relates to locomotive engines wherein the steam is operated under double expansion in high pressure and low pressure cylinders. A balanced compound locomotive engine is described and claimed in my Letters Patent No. 489,917, dated January 17, 1893.

It will be understood that the heaviest work of a locomotive engine is usually performed at the moment of starting, a feature wherein locomotive engines differ materially from stationary engines. With the ordinary link motion or other equivalent valve gear, it is customary in starting a locomotive for the engineer to throw the reversing lever to its extreme position giving the valves the utmost throw, and consequently admitting steam at the full boiler pressure into the cylinder for almost the entire stroke of the piston, whereby the maximum power of the engine is utilized in starting. After headway is attained, the lever is usually drawn back a notch or two toward the middle in order to cause the valve gear to close the valve at an earlier point in the stroke, and consequently to use the steam expansively. This is the condition of normal running. In climbing steep grades, it is customary whenever the full power of the engine is required, to establish the same conditions as in starting.

In the operation of a compound locomotive, the mere movement of the reversing lever to its extreme position would not be sufficient to apply the full power of the engine for starting, because until after the first stroke is made no steam is admitted to the low pressure cylinder, since the steam taken into this cylinder is the exhaust from the high pressure cylinder, and this exhaust cannot take place until after the first stroke is made. As the high pressure cylinder is of smaller diameter than the cylinder of an ordinary single expansion locomotive, its power under high pressure is consequently less, from which it

would result that a compound locomotive, although exerting as much power as a single expansion locomotive in ordinary running, would have less power at the instant of starting. To overcome this difficulty, means have heretofore been applied to such locomotives for admitting high pressure steam from the boiler directly into the low pressure cylinder, in order thereby to increase the power by causing the steam to act against the greater area of the low pressure piston, which in a compound locomotive is larger than the piston of a single expansion engine. Thus high pressure steam is admitted to both sides of the high pressure piston, which becomes balanced and inactive, while the low pressure piston, being operated directly by high pressure steam, serves to start the engine with a power as much greater than that of an ordinary locomotive as the area of the low pressure piston exceeds that of the single piston of an ordinary locomotive.

My invention provides a further improvement in these means for effecting the starting of a compound locomotive and also provides certain improvements in the construction of the starting valve, and in its connection with the relief valve for enabling the engine to run freely while the steam is shut off, all of which will be fully hereinafter set forth.

In Figures 1 and 2 of the accompanying drawings, I have shown respectively a plan and side elevation of a locomotive constructed according to my invention. In both views certain parts are broken away, so that the views are partly sectional in order better to show the essential features of the invention. In both views the locomotive is reduced in length by the omission of the usual second pair of drivers and the proportional crowding forward of the cab, reversing lever, and rear end of the boiler, this being done in order better to show the essential parts of the invention, and making a larger scale available than if an accurately proportioned locomotive were shown. Fig. 3 is a transverse section through the forward end of the locomotive looking toward the front, the right-hand half being in section on the plane of the line 3^a in Fig. 1, and the left-hand half on the plane of the line 3^b. Fig. 4 is an enlarged view of a por-

tion of the apparatus shown in the right end of Fig. 3. Fig. 5 is a fragmentary side elevation partly in section showing the valve gear connections on a larger scale. Fig. 6 is a fragmentary view showing a part of Fig. 5 and illustrating a modified connection. Fig. 7 is a vertical longitudinal section through the centers of the high and low pressure cylinders and steam chests, its planes being denoted approximately by the lines 7—7 in Fig. 3. Fig. 8 is a plan of the steam chest casing or frame removed.

My improved locomotive in the construction shown in the drawings resembles the usual American type of locomotives, except in those particulars hereinafter described.

Instead of having a single cylinder on each side of the locomotive, there are two cylinders, a high pressure cylinder A, and a low pressure cylinder B, the latter being by preference arranged in front of the former, as shown in Figs. 1, 3 and 7, and with its center sufficiently nearer the middle line of the locomotive than that of the high pressure cylinder to enable the piston-rod *b* of the low pressure cylinder to pass alongside of the high pressure cylinder, as shown at the left in Fig. 3. The piston-rods *a b* of the two cylinders are fixed to cross-heads *a' b'* in the usual manner. To these cross-heads are coupled connecting rods C C' respectively, which engage with crank wrists or studs *c c'* respectively on the main or forward driving wheels.

On top of the cylinders A B are arranged steam chests or valve chests A' B', in which work the valves A² B² for the high pressure and low pressure cylinders respectively. These valves are driven by valve rods *e e'* respectively, which pass out through stuffing boxes at the rear ends of the chests, and are connected to a link motion or any other suitable valve gear. In the construction shown the two rods *e e'* are both jointed to the upper arm of the usual rock lever H of the valve gear, the lower arm of which is pivoted to the sliding block *d* of the link D, which link is connected as usual by eccentric rods to the two eccentrics. The link is raised or lowered to determine the direction of running of the engine and the point of cut-off, by being connected in the usual manner by a connecting bar *f* to an elbow-lever F on the "lift" or reversing shaft, which is connected by a bar *g* to the usual reversing lever or control-lever G in the cab. This lever carries a latch *h*, operated by a handle *h'* in the usual way, and entering notches in the fixed sector G' as usual, whereby the reversing lever when thrown to any position is held there. These parts are best shown in Fig. 5, where the reversing lever G is shown as thrown to its extreme position for starting, its latch *h* entering the final notch *i⁰* in the sector. In the construction here shown the notches *i¹* to *i⁴* are those used in normal running, while the notches *i⁵* and *i⁶* corresponding to an extreme

or normal movement of the valve gear, are those used in starting or in climbing heavy gradients.

Steam is taken from the boiler in the usual manner through a pipe I' (Figs. 1 and 3) which branches into two pipes I I leading to the smoke-box, and communicating with steam passages I² formed through the respective cylinder half-saddles J J, of each of which saddles one of the high pressure cylinders A forms a part in the construction shown. The steam passage I² leads as usual (see Fig. 3) to the steam-chest A' of the high pressure cylinder, opening in communication with the high pressure valve A². I have shown this valve as being a balanced or piston valve, and the low pressure valve B² as being an ordinary slide valve which may be balanced or not, but the employment of these particular types of valves is not essential, the use of any suitable kind of valve being admissible. In the construction shown, steam from the passage I² passing around and through the grooves of the valve A², is admitted into one of the cylinder ports *m m* leading to the high pressure cylinder (Fig. 7), while the exhaust therefrom escapes through the other port *m* into the interior of the steam chest A', and passing through the hollow piston valve A² flows through a neck or communicating passage *j* into the cavity of the steam chest B', and is controlled by the low pressure valve B², passing thence through one of the cylinder ports *n* into the low pressure cylinder, from which cylinder the exhaust escapes through the other port, through the D-valve, and through an exhaust port *o* (Fig. 7), from which it flows through the port *o'* (Fig. 1) into the exhaust nozzle *k*, which discharges beneath the stack in the usual manner. The operation thus described is that which takes place when the engine is running under normal conditions as a compound engine. The pistons in the two cylinders move simultaneously in opposite directions, exerting contrary thrusts against the cranks *c c'*, and being so proportioned in area relatively to the respective high and low steam pressures as to exert substantially equal thrusts in contrary directions against these cranks, whereby the engine is balanced.

For admitting high pressure steam into the low pressure cylinder in order to start the locomotive, a starting valve is provided which as a whole is lettered P. This valve might be variously constructed, the only thing essential being that it shall be normally closed but shall be capable of being opened to admit high pressure steam from the boiler to flow directly into the steam chest of the low pressure cylinder. In the construction shown there is a casing having an inlet port *q* communicating with the steam passage I², as shown in Figs. 3 and 4, and branching around, as shown in Fig. 2, to opposite sides of a double puppet valve *p*, which normally seats itself on conical seats in the casing. From the outlet

side of this valve a steam passage q' extends, as shown in Fig. 2, and enters the low pressure steam chest B' . In the construction shown this passage opens into the neck j , from which the steam flows into the low pressure steam chest. (See Fig. 1.) The movable valve or puppet p is fixed on a valve-rod P' , which passes out through a stuffing-box in the valve casing, in order that it may be operated to unseat the valve. The puppet valve p is a partially balanced valve consisting of two disks of unlike area receiving the high pressure steam above and below. The upper disk being the larger, the steam pressure tends to press the valve downward and consequently to close it and hold it against its seat.

In order to operate the starting valve, I provide by preference the following described mechanism:—On the upper end of the valve stem P' is fixed a cross-head p' . Shown best in Fig. 2. Beneath this cross-head works a double-armed lever or T-lever Q , the upper arms or head of which is adapted to act against the cross-head p' when the T-lever is tilted to either side of its normal or mid position. In the construction shown the valve stem P' intersects the pivotal axis of this lever, passing through a vertical slot in its cross-head Q' , as shown in Fig. 4. The lever Q is pivoted in a frame r mounted on the valve shell, or in any other suitable support, and its downwardly projecting arm Q^2 is applied on the outside of this support, as shown in Fig. 4. To the lower end of this arm is jointed a rod s , the opposite end of which is jointed to an arm S projecting from a rock shaft S' , which shaft extends transversely of the locomotive and has fixed to it the lever arms S for operating both the starting valves P and P' . It also has fixed to it at one end a third arm S^2 (Figs. 1, 2 and 5) to the end of which is jointed a tappet-rod s' which extends back along the locomotive and preferably enters the cab. This rod is provided with tappets t or t' , consisting in the construction shown of nuts screwed upon it and set tightly in place. Against these tappets operate shoulders or projections connected with or carried by the reversing gear. Preferably these shoulders are constructed as a single stud T projecting from the reversing lever G , as shown best in Fig. 5, the tappet-rod s' passing through this stud so as to be guided thereby, and the tappets t or t' being so set or adjusted as to come in contact with the stud T when the reversing lever is thrown to the farthest position from the center that it occupies in normal running, in order that upon any displacement of the lever beyond such position, the stud T shall move against and displace the corresponding tappet t or t' , thereby moving the rod s' endwise in one direction or the other, and consequently through the arm S^2 , rock shaft S' , arms S and rods s , tilting the T-levers Q in one direction or the other, and consequently lifting the cross-head p' and valve stem P' so as to open both the starting valves P and P' . These valves are opened more or

less according to the extent to which the reversing lever G is thrown beyond the extreme normal position. Since in the running of any ordinary locomotive the engineer in order to start the locomotive throws the reversing lever beyond the normal running position, that is, beyond one of the notches i^1 , he automatically and unconsciously by this movement converts the locomotive from a balanced compound engine into an unbalanced high pressure engine of abnormal power, the large diameter of the low pressure piston being utilized to receive the action of high pressure steam, and thereby exerting a heavy thrust for starting the load. The high pressure steam by being thus admitted to fill the inlet and exhaust sides of the high pressure cylinder, puts the piston thereof *in equilibrio*, and thereby renders it ineffective. The result described is that effected if the reversing lever be thrown to its extreme position, that is to say, to either notch i^6 . If it be thrown a less distance but still beyond that of normal running, as for example to either notch i^3 , the effect produced is less in degree; that is to say, the starting valves are only partly opened, thereby increasing the pressure exerted against the low pressure piston to an extent less than that of the full pressure of the boiler. In this case the pressures on opposite sides of the high pressure piston may not be entirely balanced, so that this piston may still exert some thrust, while the thrust of the low pressure piston is not increased as much as when the valve is fully opened. The tappet-rod need not necessarily be connected with the reversing lever G , as its connection may be made with any other suitable part of the valve gear to like effect. For example, in Fig. 6, lever F is shown as provided at its upper end with a stud T' taking the place of the stud T in the construction shown in Fig. 5, in order to act against the tappets t or t' on the rod s' .

To provide for the unobstructed running of the engine when steam is turned off, as for example in descending a grade, the low pressure steam chest is provided with a relief valve R , consisting of a check-valve adapted to admit air in case a suction is formed in the steam chest. It is understood that when the engine continues running after steam is shut off, its pistons act as pumps to create a vacuum in the steam passages II^2 , and in the steam chests. In an ordinary locomotive this vacuum is relieved by admitting air to the steam chest through a relief valve consisting of an inwardly opening check-valve. In my improved compound locomotive, I provide not only for thus relieving the vacuum in the low pressure steam chest, but I equally relieve it in the steam inlet to the high pressure cylinder. This result is accomplished by the construction of the starting valve P as a puppet valve, its puppet disks being only partially balanced, so that while a steam pressure in the steam passage tends to seat the valve, a vacuum therein tends to unseat it. When the engine is coast-

ing free with steam shut off, the pumping action of the high pressure cylinder creates a vacuum in the high pressure steam inlet passages which lifts the puppet valve *p*, causing an inflow of air from the low pressure valve chest B', which itself is supplied with air admitted through the relief valve R.

In the practical construction of this compound locomotive, I mount the four cylinders on four separate half-saddles formed integrally therewith. The half-saddles J J have the high pressure cylinders A cast integrally with them as already stated, while the half-saddles K K mounted in front of these (see Fig. 1) have the low pressure cylinders B B cast integrally with them. Between the respective cylinders A B, is introduced a single cylinder head *u*, consisting of a plate having bosses on opposite sides entering the respective cylinders, and bolted to and between them. The upper sides of the saddles over the cylinders are planed off flat, as shown in Fig. 7, both to form seats for the low pressure slide valves, and to provide a steam tight joint for the bottoms of the steam chests. To construct the steam chests I make a casting, best shown in Fig. 8, consisting of two rectangular boxes *v v'* respectively, formed without top or bottom, and connected together by a neck *w* in the manner shown best in Fig. 7. This neck consists of a tubular portion constituting the steam passage for admitting the exhaust steam from the high pressure cylinder, which flows into the steam chest A' to pass into the steam chest B'. The steam chests are closed by caps or top plates *v² v³* placed over the respective boxes *v v'*, and fastened by bolts passing down through the top plates and box casting into the cylinder-castings. The low pressure valve-rod *e'* passes freely through the high pressure steam chest A', through an opening in the high pressure valve, and through an opening in the neck *w* to reach the low pressure valve.

The construction thus described affords simple and effective means for providing the two steam chests compactly with the minimum number of parts essential to ready accessibility of the valves, and with the least difficulty in fitting the respective packed surfaces together with the requisite accuracy and tightness.

I claim—

1. The combination with compound engine cylinders, valves and reversing valve-gear, of a starting valve adapted to admit high-pressure steam into the low-pressure cylinder, and a mechanical connection between said valve and the reversing gear for operating said

valve, the same consisting of a tappet rod connected to the valve and having tappets arranged to be displaced by shoulders carried by said reversing gear when the latter is in a position beyond that of normal running.

2. The combination with compound engine cylinders, valves and reversing valve-gear, of a starting valve P adapted to admit high-pressure steam into the low-pressure cylinder, having a normal tendency to close, and means for operating said valve consisting of a tappet rod *s'* connected to the valve and having tappets *t t'* arranged to be displaced by shoulders carried by said reversing gear when the latter is in a position beyond that of normal running, and a double-armed lever Q connected to said rod and engaging the valve-stem to open the valve upon the displacement of said rod in either direction.

3. The combination with compound engine cylinders, valves and reversing valve-gear, of a starting valve P adapted to admit high-pressure steam into the low-pressure cylinder, constructed as a puppet valve *p* closing with the steam pressure, a valve-stem P' having a cross-head *p'*, a double-armed rock lever Q adapted upon oscillation in either direction to displace said cross-head and open the valve, and mechanical tappet connections between said lever and the reversing gear adapted when the latter is moved to a position beyond that of normal running to displace said lever Q and force open the starting valve.

4. The combination with compound engine cylinders, valves and reversing valve-gear, of a starting valve adapted to admit high-pressure steam into the low-pressure cylinder, constructed as an unbalanced puppet valve having a normal tendency to close under the steam pressure, a mechanical connection between said valve and the reversing gear for forcing said valve open when said gear is moved to its extreme position, and a relief-valve adapted to admit air to the low-pressure steam-chest when the steam is shut off and the engine continues running, whereby at such time the vacuum created by the pumping action of the high-pressure piston unseats said unbalanced valve and draws air from the low-pressure chest through it into the high-pressure cylinder.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

CHARLES A. BALL.

Witnesses:

GEORGE H. FRASER,
CHARLES K. FRASER.