(No Model.)

4 Sheets—Sheet 1.

C. A. BALL.

COMPOUND LOCOMOTIVE ENGINE.

No. 521,254. Patented June 12, 1894.

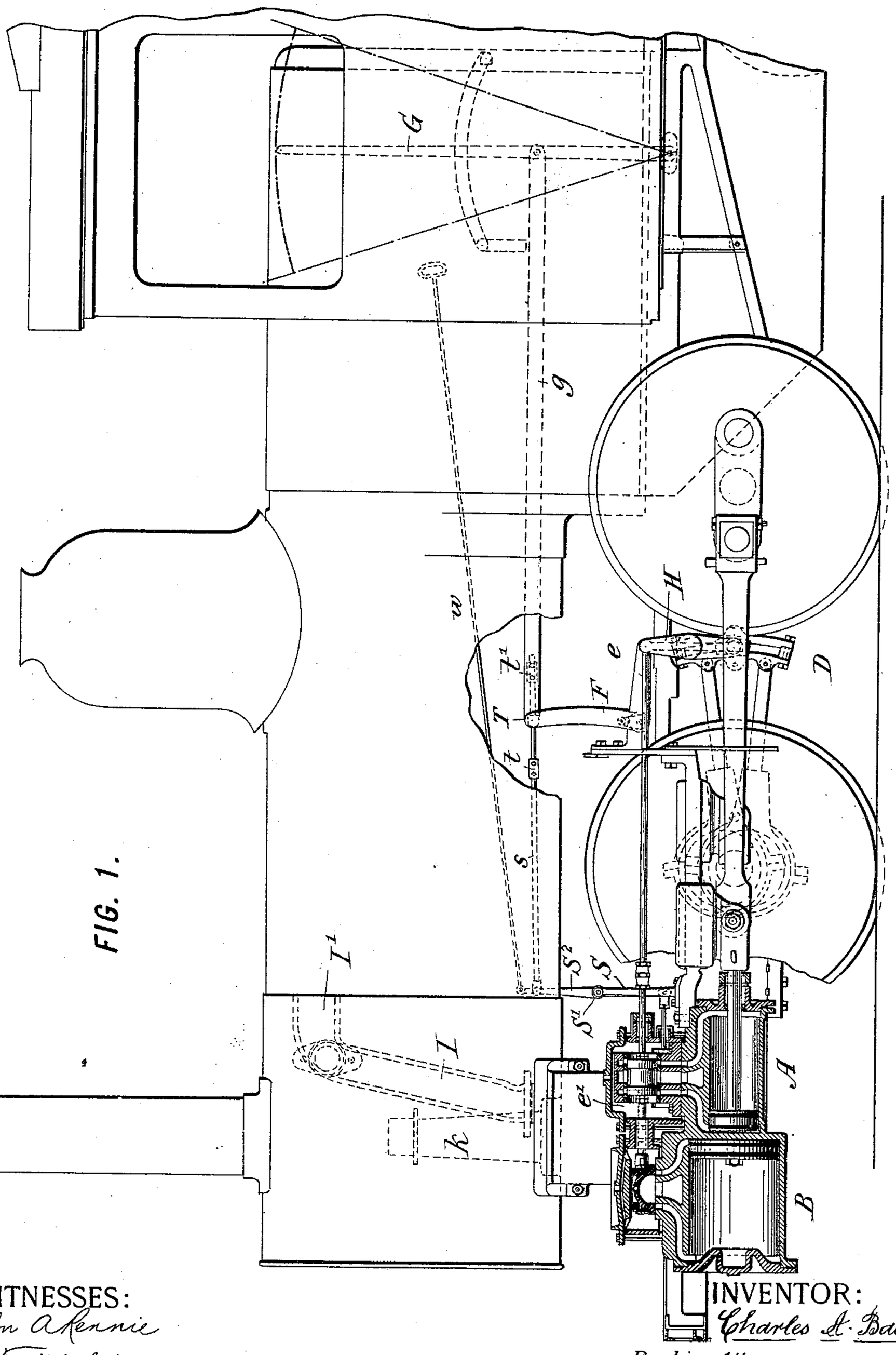

FIG. 1.

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(No Model.) 4 Sheets—Sheet 2.

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FIG. 2.

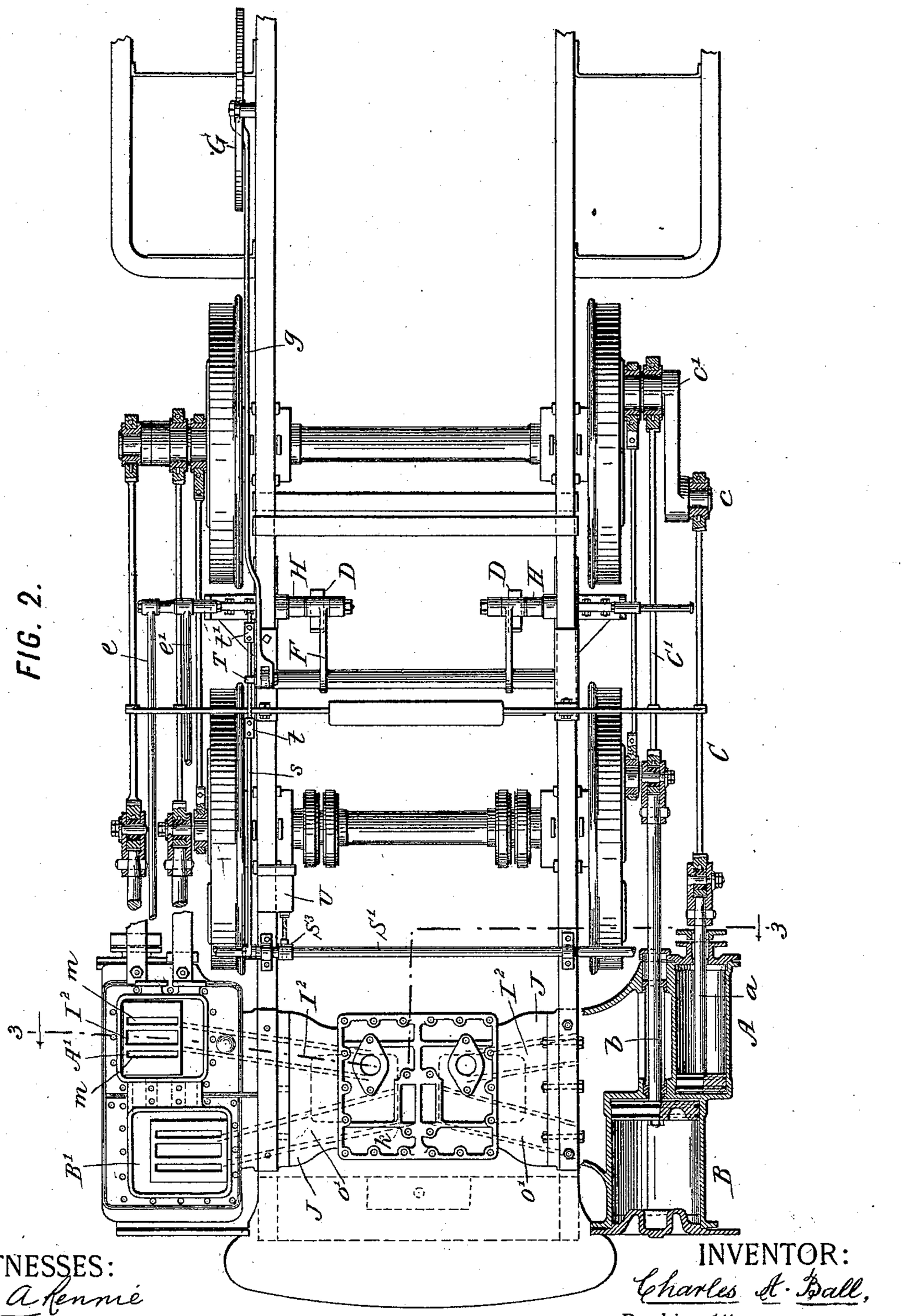

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FIG. 9.

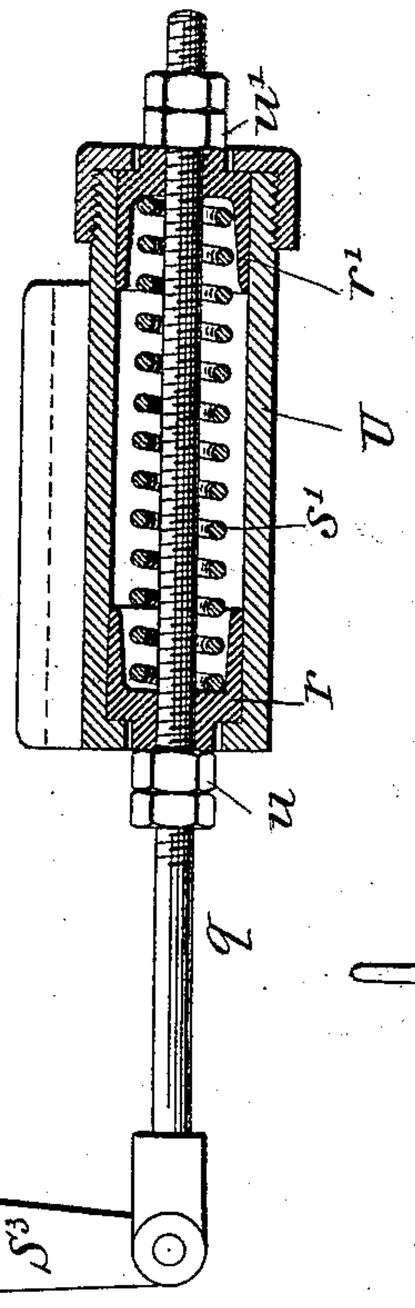


FIG. 8.

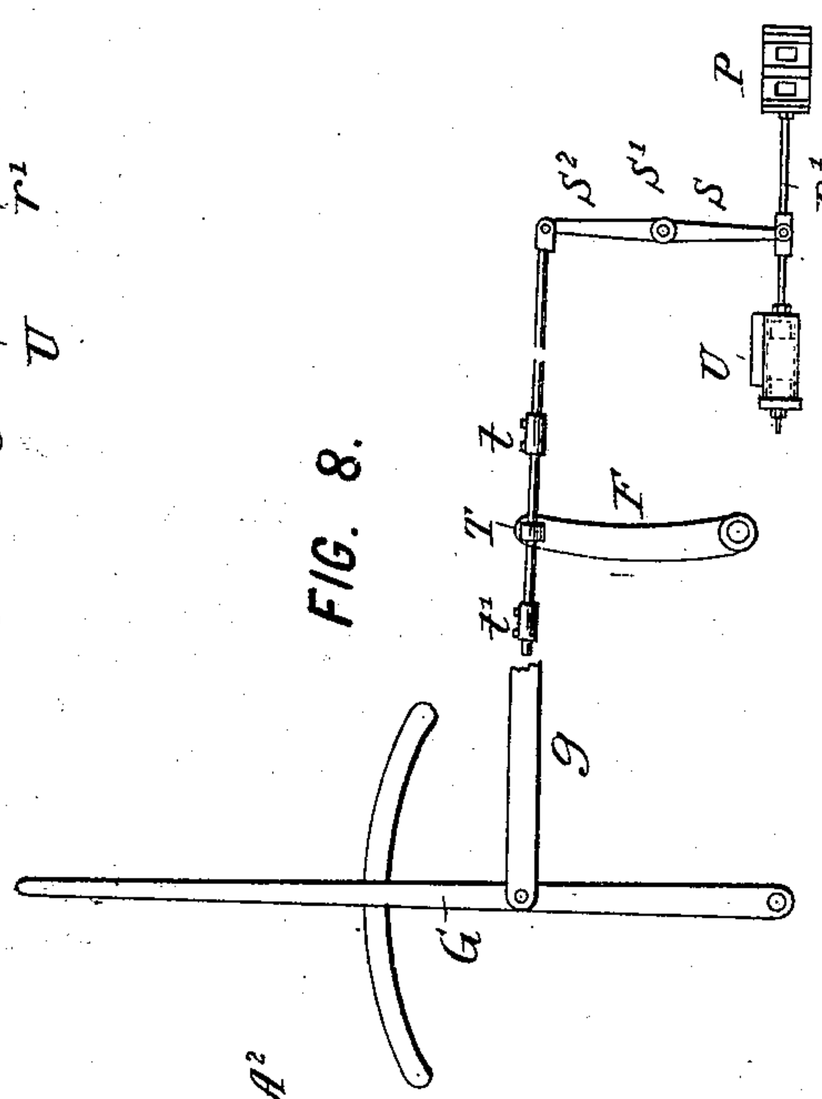
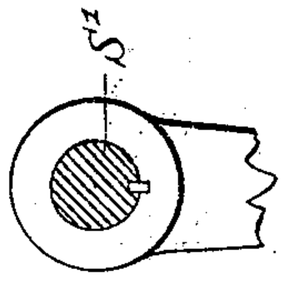
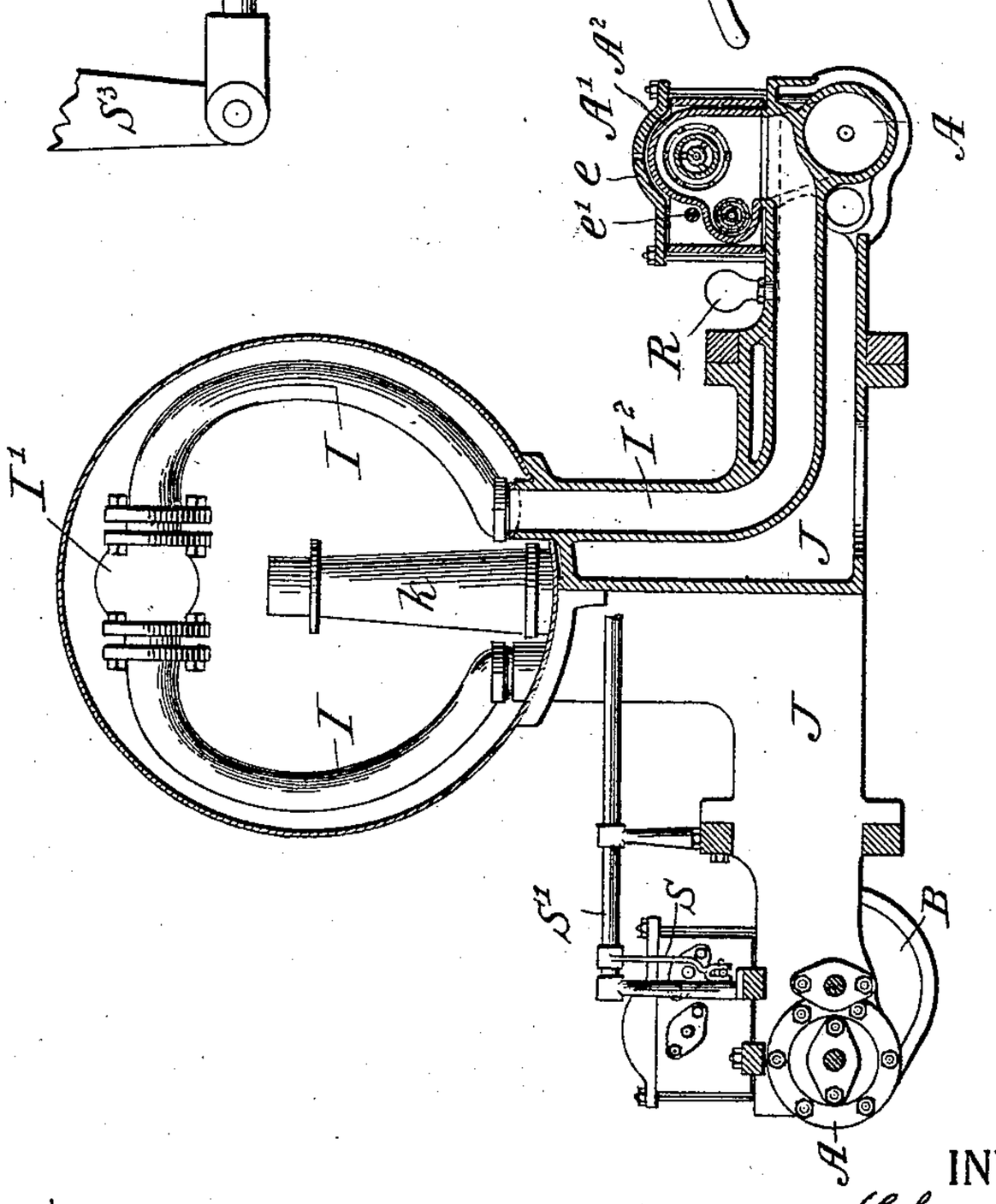


FIG. 3.





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(No Model.) 4 Sheets—Sheet 4.

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No. 521,254. Patented June 12, 1894.

FIG. 5.

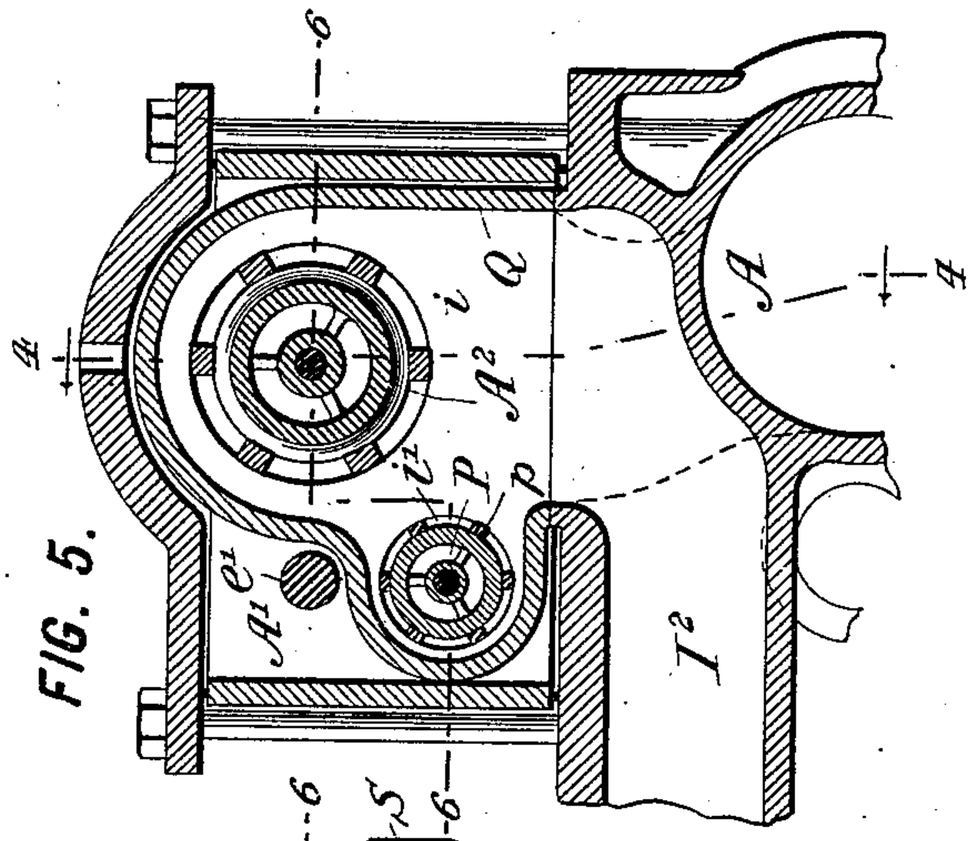


FIG. 7.

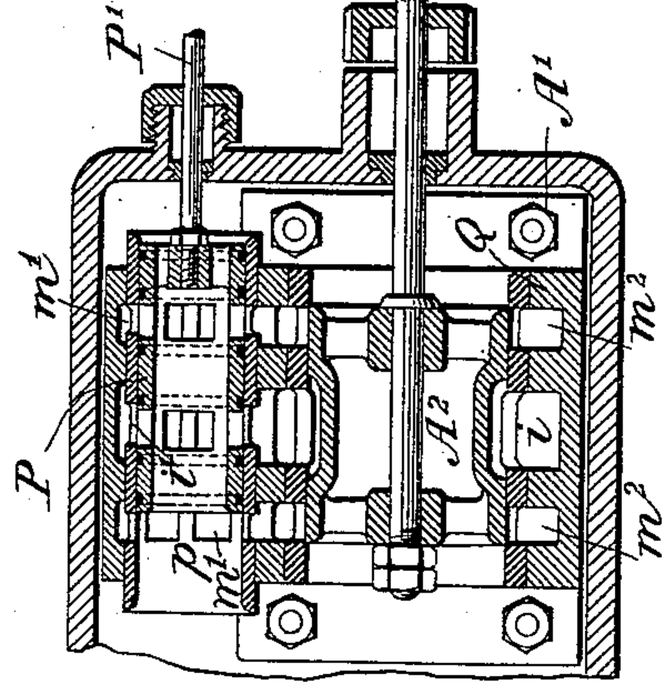


FIG. 4.

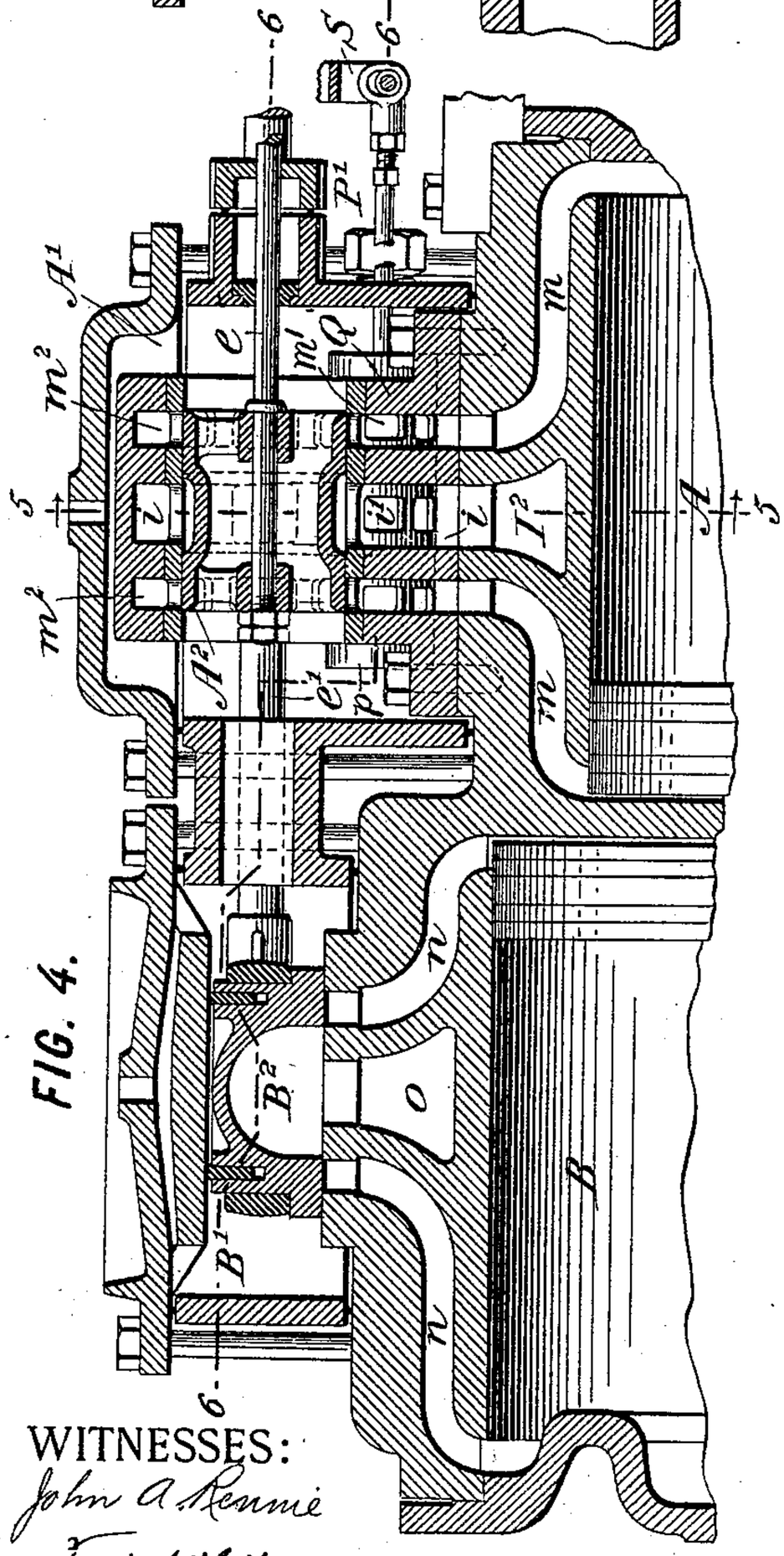
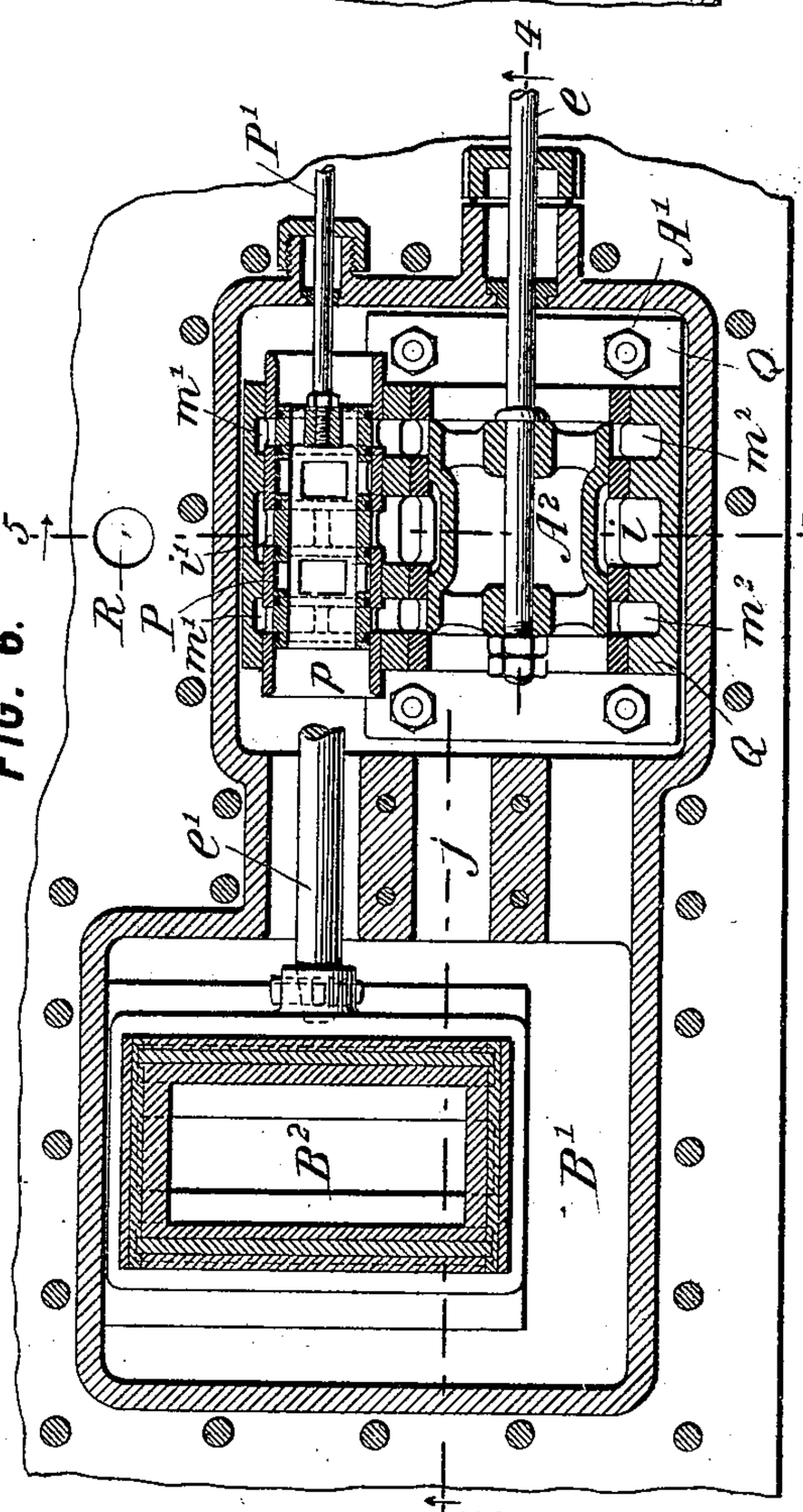


FIG. 6.



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UNITED STATES PATENT OFFICE.

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COMPOUND LOCOMOTIVE-ENGINE.

SPECIFICATION forming part of Letters Patent No. 521,254, dated June 12, 1894.

Application filed July 3, 1893. Serial No. 479,540. (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 Locomotive-Engines, of which the following is a specification.

This invention relates to locomotive engines wherein the steam is operated under double expansion and 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. Inasmuch as the heaviest work of a locomotive engine is usually performed at the moment of starting it is practically necessary to provide means in connection with a compound locomotive, for admitting high pressure steam directly to the low pressure cylinder in order to start the engine under load, the means usually provided for this purpose consisting of a valve for opening communication between the live steam passage and the valve chest of the low pressure cylinder. This valve called the starting valve, or supplemental valve, has heretofore been constructed as a puppet valve, and has usually been located exterior to the steam chest and so as to control the flow of steam through a branch steam passage.

My present invention provides an improved construction having reference to the location, mounting and functions of the supplemental or starting valve. Instead of constructing it as a puppet valve I construct it as a piston valve moving over ports in a cylindrical seat or bushing. Instead of locating it exterior to the valve chest to control a branch steam pipe, I arrange it within the valve chest where it is in communication through suitable ports with the live steam passage and with the valve chest.

Heretofore in compound locomotives the starting valve had the sole function of admitting high pressure steam to the low pressure valve chest. When this valve is opened the high pressure cylinder becomes inoperative since high pressure steam is admitted to opposite ends thereof thereby putting its piston in equilibrium, so that the locomotive is propelled solely by the low pressure piston, the power of which is greater than that of an ordinary single expansion engine in proportion as its area is greater. But with the ordinary construction when the engine is operating under these conditions, the high pressure cylinder is not merely inoperative but actually serves to partially obstruct the operation of the locomotive by reason of the compression of the steam therein during the latter portion of each stroke of the piston due to the outflow of steam being cut off by the movement of the high pressure valve the lap of which covers and closes the port, usually for about the last eighth of the stroke of the piston. An important feature of my present invention consists in such construction of the supplemental or starting valve as will prevent this compression by opening a communicating passage between the opposite ends of the high pressure cylinder independent of the passage through the usual cylinder ports and valve.

According to my invention I so construct the one valve that it serves when opened both to admit high pressure steam to the low pressure valve chest and to throw the opposite ends of the high pressure cylinder into communication with one another. This communication is most readily and simply effected by opening the main cylinder ports of the high pressure cylinder directly into the valve chest which supplies steam to the low pressure valve.

Having thus given a general idea of the nature and principles of my invention, I will proceed to describe one embodiment thereof in the construction of a compound locomotive engine, the same being to the best of my present knowledge the preferred construction in which my invention may be embodied.

Referring to the accompanying drawings,—Figure 1 is a side elevation of the forward or engine part of a locomotive, the particular type of locomotive here shown being a rapid transit or elevated railway locomotive. The cylinders and valve chest are shown in vertical section and certain parts of the locomotive are broken away to more clearly illustrate other parts beyond them. Fig. 2 is a plan of the same locomotive with the boiler removed, the view being partly in horizontal

section through the axes of the cylinders Fig. 3 is a transverse section in two different planes denoted by the line 3—3 in Fig. 2. Fig. 4 is a fragmentary longitudinal mid section through the valve chests, on a larger scale. Fig. 5 is a fragmentary transverse section on the same scale cut in the plane of the lines 5—5 in Figs. 4 and 6. Fig. 6 is a horizontal section through the valve chests in the plane of the lines 6—6 in Figs. 4 and 5, and showing the starting valve closed. Fig. 7 is a duplicate of the right hand half of Fig. 6 except that the starting valve is shown open. Fig. 8 is a fragmentary elevation viewed from the opposite side of the locomotive from that shown in Fig. 1, showing the valve gear for operating the starting valve. Fig. 9 illustrates a detail of this valve gear on a larger scale.

The general construction of the compound engine is substantially the same as that shown in my said patent. Let A designate the high pressure cylinder and B the low pressure cylinder, the latter being by preference arranged in front of the former, and with its center sufficiently near the center line of the locomotive to enable the piston rod *b* of the low pressure cylinder to pass alongside of the high pressure cylinder, as shown in the lower side of Fig. 2. The piston rods *a b* of the two cylinders are fixed to cross heads in the usual manner, and to these cross heads are coupled connecting rods C C′ respectively, which engage with crank wrists or studs *c c′* respectively on the main driving wheels.

On top of the cylinders A B are arranged valve chests A′ B′, in which work the valves A^2 B^2 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 end of the chests, and are connected to a link motion, or any other suitable valve gear. In the construction shown the two rods 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 of the link D, which link is connected as usual by eccentric rods to the two eccentrics (see Fig. 1). The link is raised or lowered to determine the direction of running and the point of cut off, by being connected in the usual manner by a connecting bar 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.

Steam is taken from the boiler in the usual manner through a pipe I′ (Fig. 1), which branches into two pipes I I (Figs. 1, and 3) leading through the smoke box and communicating with steam passages I^2 I^2 (Fig. 2,—one being shown in section in Fig. 3) formed through the respective cylinder half saddles J J, of each of which saddles the two cylinders A B on the same side form integral parts in the construction shown. Each steam passage I^2 leads as usual (see Fig. 3) to the steam chest A′ of the high pressure cylinder, opening in communication with the high pressure valve A^2. In the preferred construction shown this valve is a balanced piston valve, and the low pressure valve B^2 is an ordinary slide valve, preferably balanced, but the construction of the valves may be greatly varied within the scope of my invention. In the construction shown, steam from the passage I^2 enters through a communicating port *i* into and around the middle groove of the valve A^2, and when this valve is carried to either side by the valve gear the steam enters one of the cylinder ports *m* leading to the high pressure cylinder, while the exhaust therefrom escapes through the other port *m* into the interior of the valve chest A′ (Fig. 4) from which it flows through a neck or communicating passage *j* into the cavity of the valve chest B′, where it is controlled by the low pressure valve B^2, which directs it through one of the cylinder ports *n* of the low pressure cylinder, the exhaust from which escapes through the other port *n*, through the valve B^2, and thence through an exhaust port *o* (Fig. 4) and exhaust passage *o′* (Fig. 2) into the exhaust nozzle *k* (Fig. 1) 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 condition as a compound engine. The pistons of the two cylinders move simultaneously in opposite directions, and exert contrary and equal thrusts against the crank wrists *t t′*.

For admitting high pressure steam into the low pressure cylinder in order to start the locomotive, a supplemental valve or starting valve P is provided. This valve is of novel construction and arrangement, being placed wholly within the valve chest or chests and communicating through an internally constructed port with the live steam passage I^2. The valve P is constructed preferably as a hollow piston, being in fact an elongated tube which is suitably connected to the valve rod P′, which passes out through a stuffing box in the valve chest A′. The valve P slides in a cylindrical bushing *p* constituting the valve seat or cage. This bushing is open at both ends to the interior of the valve chest, and the valve P is also open at both ends. In the bushing *p* are formed ports or openings *i′* communicating with the live steam passage I^2 and *m′ m′* communicating with the respective cylinder ports *m m*. According to the preferred construction the respective port communications are effected through the medium of an inner shell Q, technically called the "cage" which is fastened in place within the valve chest A′ and through which are formed the steam port *i* already referred to, leading to the middle of the high pressure valve A^2, and ports m^2 m^2 extending between the ports *m* of the cylinder and the communicating ports in the bushing of the high pressure valve. The transverse section through

the middle port *i* is clearly shown in Fig. 5, the other ports being of the same shape. Such an inner shell is not in itself new, having been before used in connection with a piston valve for effecting the port communications between its bushing and the steam ports cored in the cylinder casting; but by a modification of the shape of this inner shell I adapt it to serve also as a support for the supplemental valve bushing *p* and for effecting the requisite port communications between the latter and the ports I^2, *m* and *m*. To this end I form the inner shell Q with an enlargement or bulge on one side sufficient to surround the bushing *p* at a little distance, as clearly shown in Fig. 5. The supplemental valve P is thus located to one side of the main steam valve A^2 so that it does not obstruct the main passages *i* and m^2 leading to and from this valve. At the same time the bulge or enlargement in the inner casing is formed so low down as to come beneath the low pressure valve rod *e'*, so that this rod has free passage through the valve chest A' outside of the inner shell Q, as clearly shown in Fig. 5. By this construction of the inner shell the intervening ports or steam passages *i*, m^2 m^2 are extended to one side and carried into communication with the corresponding ports *i'* *m'* *m'* in the supplemental valve bushing *p*. The valve P is preferably of the construction shown in Figs. 6 and 7, so that when in its mid position as shown in Fig. 6, its solid portions close the respective ports in the bushing, and preferably the valve is provided with packing rings which in this position stand on opposite sides of the port openings and prevent any leakage of steam between them and the interior of the valve or valve chest. The valve is movable to either side from this mid-position to open it, and when so moved, as shown for example in Fig. 7, one of its ends uncovers one series of ports *m'* while the other series of ports *m'* and *i'* are uncovered by port openings *p'* *p'* formed through the valve T, so that steam may pass through these openings into the interior of the valve and thence communicate with the valve chests A' and B'. It will be understood that these two valve chests are essentially one, being connected through the communicating neck or passages *j*, so that the same steam pressure exists in both.

The supplemental valves P P may be operated in any suitable manner, either by being provided with a separate operating handle, or by being automatically connected with the main valve gear in the manner described and claimed in my application for patent filed January 16, 1893, Serial No. 458,442. In the construction shown (see Fig. 8) the valves P are connected by their rods P' to arms S S projecting from a rock shaft S' having an upper arm S^3 which is connected by a tappet rod *s* with some suitable part of the valve gear, preferably the link lifter F, through a suitable tappet construction. As shown, tappet blocks *t t'* are fixed on the rod *s* at suitable distances on opposite sides of block T mounted on the lever F and through which the rod *s* freely passes. The tappets are set far enough apart so that they are not struck by the block T in any position to which the valve gear is thrown by the reversing lever G in ordinary running, but upon carrying this lever beyond the normal position and to its extreme position to either side the block T strikes one or other of the tappets and consequently through the intervening parts, moves the valve P in one direction or the other from its mid position, thereby opening it. For restoring the valve P upon its release by the tappet mechanism, and to normally hold the valve P firmly in its mid position, a double acting spring device U is provided. The preferred construction of this is shown in detail in Fig. 9. To either arm S or to any other conveniently located arm attached to the cross-shaft S' (a separate arm S^3 being preferably provided) is coupled a rod *q* which passes freely through two pistons or disks *r r'* between which is a spring *s'* tending to press them apart, while they are normally held seated against shoulders or stops formed at opposite ends of the cylindrical casing U. The rod *q* has shoulders formed preferably as nuts *u u'* engaging the opposite or outer sides of the pistons *r r'*. As these shoulders normally engage the opposite sides of the respective pistons, while the latter are in engagement with the stop shoulders on the cylinder, the whole tension of the spring is exerted to hold the arm S^3 and consequently the valve P in mid position. When the valves are thrown to either side by the tappet mechanism the rod *q* forces one of the pistons *r r'* toward the other and thereby compresses the spring *s'*, and upon the release of the tappet mechanism the spring by reacting against the stationary piston presses the displaced one back to place and thereby forces the rod *q* and through the intervening mechanism the valves P back to the mid position.

By my improved construction of the starting valve not only is it much more conveniently and safely located and its connection with the live steam passage more readily made, but the important advantage is introduced of wholly freeing the high pressure piston from any retarding influence save that of friction during the time that the starting valve is open, there being no compression of steam in the high pressure cylinder toward the end of the stroke of its piston notwithstanding that the lap of the high pressure valve by which such compression has heretofore been caused remains unaltered, but on the contrary free communication is afforded between the opposite ends of the high pressure cylinder so that steam may flow from either end through the cylinder port *m*, the communicating passage m^2 and port *m'* into the valve P and back through the other port

m', passage m^2 and cylinder port m to the opposite end of the cylinder. This communication remains constantly open during the time that the valve P is in its open position, although the need for this communication exists only during the last eighth or thereabout of each stroke. During the remainder of the stroke there is free communication through the action of the main high pressure valve A^2. While the starting valve P is open the live steam at boiler pressure flows from the steam passage I^2 through the communicating passage or port i and port i' and the corresponding valve port p' to the interior of the valve P and thence to the interior of the valve chest A′ and through the neck j to the valve chest B′. The communicating ports i' p' need not have sufficient area to carry the entire supply of steam for operating the low pressure cylinder, since steam is also supplied thereto at high pressure through the high pressure valve and cylinder.

It may sometimes be desirable, especially in climbing heavy grades, to increase the power of the engine without materially impairing its balance and without throwing the reverse lever to its extreme position. I therefore provide means for enabling more or less high pressure steam to be admitted to the low pressure valve while the engine is running under cut off. To do this it is only necessary to open or partially open the valve P without displacing the main valve gear from its normal position in running under cut off. For this purpose I provide, as shown in Fig. 1, an operating rod w jointed to the lever arm S^2 and extending thence back into the cab and terminating in a handle within reach of the engineer by means of which he can at any time pull open the starting valve enough to admit live steam temporarily in greater or less volume direct to the low pressure valve.

A practical advantage of the construction of the separate cage or inner shell Q carrying the bushings or seats for the valves A^2 and P is that by providing for each locomotive a duplicate set of these inner shells and valves the one set can be easily and quickly substituted for the other by opening the valve chest and disconnecting the valve rods in case the valves get out of order, so that the valves can be repaired or new bushings fitted while the locomotive continues in use. By placing the supplemental valve in the valve-chest its lubrication is easily provided for since it is not exposed to excessive heat, as is the case when such valves are placed in the saddle or smoke box.

In order to supply the vacuum which tends to form when an engine continues running after steam is shut off, as occurs for example in descending a grade, it is customary to provide locomotives with relief valves opening into the valve chests of the respective cylinders, such valves consisting of check valves opening inwardly, so that when a vacuum occurs air is drawn in from outside and is pumped through the cylinders in lieu of steam and discharged through the exhaust nozzle. With my improved construction I apply this relief valve lettered R on top of the cylinder casting to one side of the valve chest A′ where it will admit air into the steam passage I^2, as shown in Figs. 3 and 6. It is understood that in cutting off steam the reversing gear should be thrown entirely over while the engine continues running in order to open the supplemental valve P. It then results that the air drawn in through the relief valve R flows partly to the high pressure valve A^2 from which it is pumped through the high pressure cylinder and exhausted to the low pressure valve, and partly to the valve P by which it is admitted directly into the valve chest to supply the suction created by the low pressure cylinder. Should the engineer fail to throw his reversing gear to its extreme position the low pressure cylinder will run under the retardation of the vacuum caused by the rarefying of the air exhausted from the high pressure cylinder to the increased volume demanded by the low pressure cylinder.

It will be obvious to any skilled mechanic that the practical details pertaining to my present invention may be greatly varied without departing from the essential principles of operation introduced by my invention. For this reason I do not desire to limit myself to the particular construction of the supplemental valve, nor to the particular means for operating it, although I desire to make specific claims to these specific constructions.

With reference to my broader or more generic claims, it is to be understood that any substantially equivalent valve construction known in the art may be substituted for the specific construction shown.

Of the many valve constructions known to steam engineers, comprising plug valves, piston valves, rotary valves, puppet valves, &c., I have selected as being the best adapted to the purpose and most practical, a tubular piston valve working longitudinally in a tubular ported bushing constituting essentially the valve seat. This is to be understood as being one example or embodiment of my invention, and not as being the only means by which it may be carried into effect. The construction shown constitutes the preferred means, being as I believe the best construction by which the essential principles of my invention may be reduced to operative mechanism.

I am aware that a starting valve for compound locomotives has been made which has the effect of affording a restricted passage through which a limited amount of steam may wire-draw from the inlet-port of the high-pressure cylinder to the exhaust-port thereof and thus to the steam-chest supplying steam to the low-pressure cylinder, in order that enough steam may thus leak past the high-pressure cylinder at starting to supply the

low-pressure cylinder, and render the latter active at the first stroke in order to gain power enough to start the engine and train. Thus the engine at the first stroke operates under the same dynamic conditions as a compound engine, although the steam supplied to the low-pressure cylinder is live-steam at reduced pressure, instead of steam exhausted at a similar reduced pressure from the high-pressure cylinder. In such an engine both cylinders are utilized in starting, and the high-pressure piston is not placed in equilibrium. By my improvement the communicating passage opened by the starting valve is of such large area as to establish a free communication between opposite ends of the high-pressure cylinder thus putting its piston in equilibrium so that it becomes powerless, and turning the entire boiler pressure into the low-pressure cylinder so that its piston acts as a single high-pressure piston of abnormally large area, and exerts a thrust for starting the train that is much greater than the combined thrusts of both pistons when the engine is working as a compound engine. My locomotive has thus a greater starting power than one constructed according to the system referred to.

I claim as my invention the following-defined novel features, substantially as hereinbefore specified, namely:

1. In a compound engine, the combination with the high and low pressure cylinders and valves, of a supplemental valve and ports controlled thereby communicating with the opposite ends of the high pressure cylinder, the valve and ports relatively constructed and arranged and of such large area as when the valve is open to establish free communication between the opposite ends of the high pressure cylinder, whereby to put the high pressure piston in equilibrum and admit high pressure steam to the low pressure cylinder.

2. In a compound engine, the combination with the high and low pressure cylinders and valves, of a supplemental valve and ports controlled thereby communicating with the opposite ends of the high pressure cylinder, and the live steam passage, and the valve and ports relatively constructed and arranged when the valve is open to establish communication between said ports respectively and the live steam passage, and thereby to put the high pressure piston in substantial equilibrium with the full live steam pressure on opposite sides thereof.

3. In a compound engine, the combination with the high and low pressure cylinders and valves, of a supplemental valve and ports controlled thereby communicating with the live steam passage, the low pressure valve, and the opposite ends of the high pressure cylinder, the valve and ports relatively constructed and arranged when the valve is open to admit live steam directly to the low pressure valve and establish communication between the opposite ends of the high pressure cylinder.

4. In a compound engine, the combination with the high and low pressure cylinders and valves, of a supplemental valve and ports controlled thereby communicating with the live steam passage, the low pressure valve, and the opposite ends of the high pressure cylinder, the valve and ports relatively constructed and arranged when the valve is open to establish communication between said ports respectively, and thereby admit live steam to the low pressure valve, and to both sides of the high-pressure piston, and put the latter in substantial equilibrium.

5. In a locomotive engine, the combination with the cylinder, valve, and valve-chest, of a supplemental valve inclosed in the valve-chest, consisting of a hollow movable valve working in a seat, said seat having ports communicating with the opposite ends of the cylinder, and the valve constructed in its open position to establish communication between said ports, whereby to put the piston moving in said cylinder in substantial equilibrium.

6. In a locomotive engine, the combination with the cylinder, valve, and valve-chest, of a supplemental valve inclosed in the valve-chest, consisting of a hollow movable valve working in a seat, said seat having ports or openings communicating with the interior of the valve-chest and with the opposite ends of the cylinder, and the valve constructed in its open position to open communication between said ports respectively, whereby the opposite ends of the cylinder are connected with each other and with the interior of the valve chest.

7. In a compound engine, the combination with the cylinders, valves and valve chest, of a supplemental valve inclosed in the valve chest and movable in a seat, said seat having a port communicating with the live steam passage, whereby when the valve is moved to its open position the said port is opened to the valve chest and whereby the supplemental valve is readily accessible and removable by opening the valve-chest, and is protected from excessive heat.

8. In a compound engine, the combination with the cylinders, valves and valve chest, of a supplemental valve inclosed in the valve chest, consisting of a movable cylinder having ports communicating with the valve chest, and a valve seat therefor having ports communicating respectively with the live steam passage and the opposite ends of the high pressure cylinder.

9. In a locomotive engine, the combination with a cylinder and live steam passage and valve chest and valve, of an inner shell in said chest having ports communicating between the cylinder ports and valve ports, and a supplemental valve working through said inner shell and adapted to establish communication between the ports thereof communi-

cating with the cylinder ports whereby to throw the opposite ends of the cylinder into communication with one another.

10. In a locomotive engine, the combination with the cylinder, live steam passage and valve chest and valve, of an inner shell in said chest having ports communicating between the cylinder ports and valve ports, and formed with a sidewise extension to receive a supplemental valve, and a supplemental valve working therein and adapted to establish communication between the ports thereof communicating with the cylinder ports, whereby the supplemental valve is arranged to one side of the main steam passages communicating between the main valve and cylinder.

11. In a compound engine, the combination with the cylinders, valves and valve chest of a supplemental valve inclosed in the valve chest and an inner shell in said chest inclosing the high pressure valve and said supplemental valve and formed with ports communicating between the cylinder ports and live steam passage on the one hand, and the ports controlled by the respective valves on the other hand.

12. In a compound engine, the combination with the cylinders, valves and valve chest, of an inner shell Q within said chest having ports m^2 m^2 communicating with the cylinder ports and the port i communicating with the live steam passage and inclosing the high pressure valve, and the supplemental valve P formed as a movable piston working through said shell and having ports for communicating with the ports therein whereby in one position to close communication therewith, and in another position to open communication therewith and thereby admit live steam into said chest and establish communication between the high pressure cylinder ports.

13. In a compound engine, the combination with the cylinders, valves and valve chest, of a supplemental valve P inclosed in the valve chest, a bushing p therefor formed with ports, and an inner shell Q in said chest inclosing the high pressure valve and said supplemental valve and formed with ports communicating between the cylinder ports and live steam passage on one hand and the ports controlled by the high pressure valve and the ports in said bushing p controlled by said valve P on the other hand.

14: In a compound engine, the combination with the cylinders, valves and valve chest, of a supplemental valve P inclosed in the valve chest and constructed as a tubular piston movable longitudinally parallel with the main valve and having a rod P′ passing out through the stuffing box in the end of the chest, and ports controlled by said supplemental valve communicating with the live steam passage for admitting high pressure steam to the low pressure valve.

15. In a compound engine, the combination with the cylinders, valves and valve chest, the low pressure valve rod e' being extended through the valve chest alongside of and exterior to the high pressure valve, of a supplemental valve P arranged beneath the low pressure valve rod, and an inner shell Q within the valve chest inclosing the high pressure valve and said supplemental valve and formed with a sidewise extension beneath the low pressure valve rod for surrounding said supplemental valve, whereby the low pressure valve rod is extended exterior to said inner shell.

16. In a compound locomotive engine, the combination with the cylinders, valve chests, valves and valve gear, of supplemental or starting valves P inclosed in the respective valve chests and means for operating them consisting of a cross shaft S′ having arms S connecting with the valve rods of said valves, and an arm S^2, a tappet rod s connected therewith and having tappets engaged by some part of the valve gear and arranged to be displaced when the reversing gear is put to its extreme position in either direction, and a spring centering device U for restoring the valves after displacement to their mid position connected to said shaft.

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

CHARLES A. BALL.

Witnesses:
ARTHUR C. FRASER,
GEORGE H. FRASER.