(No Model.) 2 Sheets—Sheet 1.

W. G. FLORENCE & J. H. BENNETT.

COMPOUND ROTARY STEAM ENGINE.

No. 525,341. Patented Sept. 4, 1894.

Fig. 1.

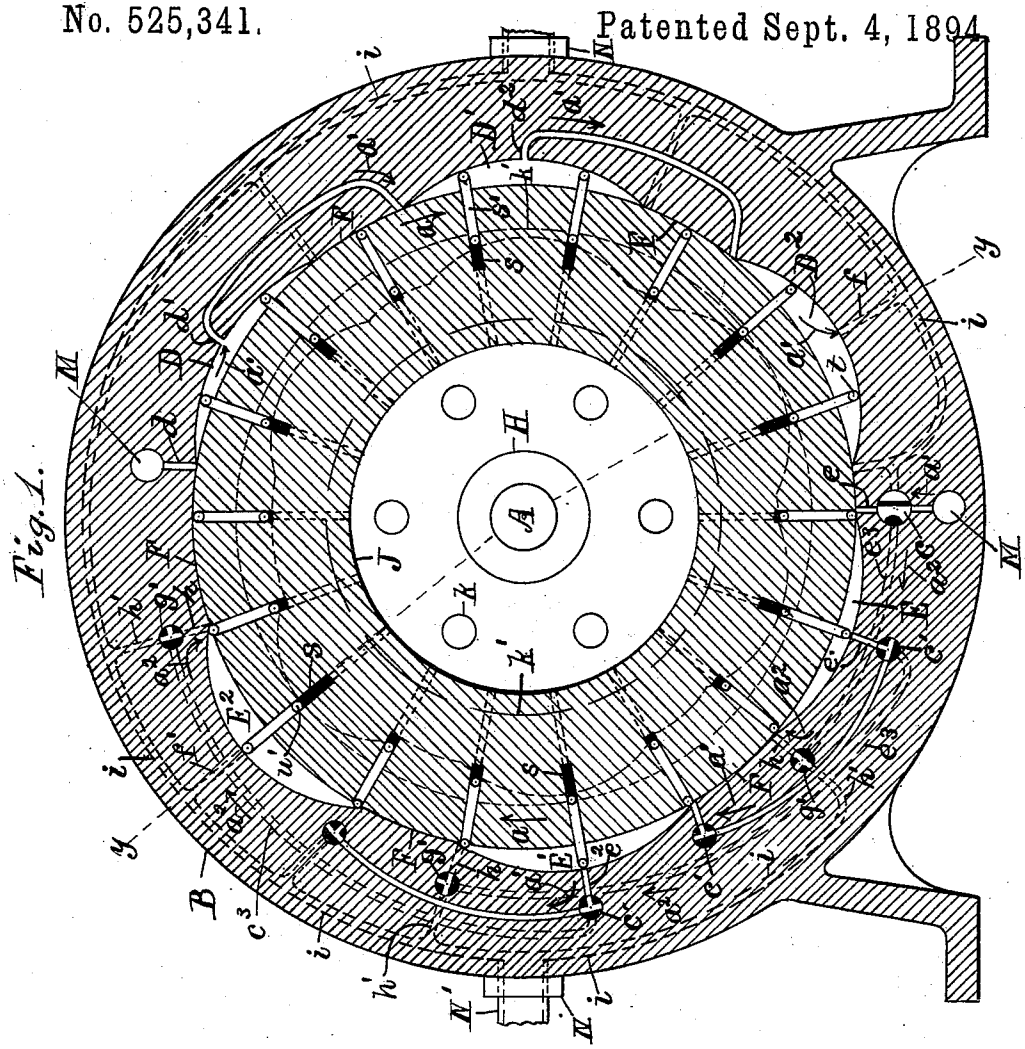
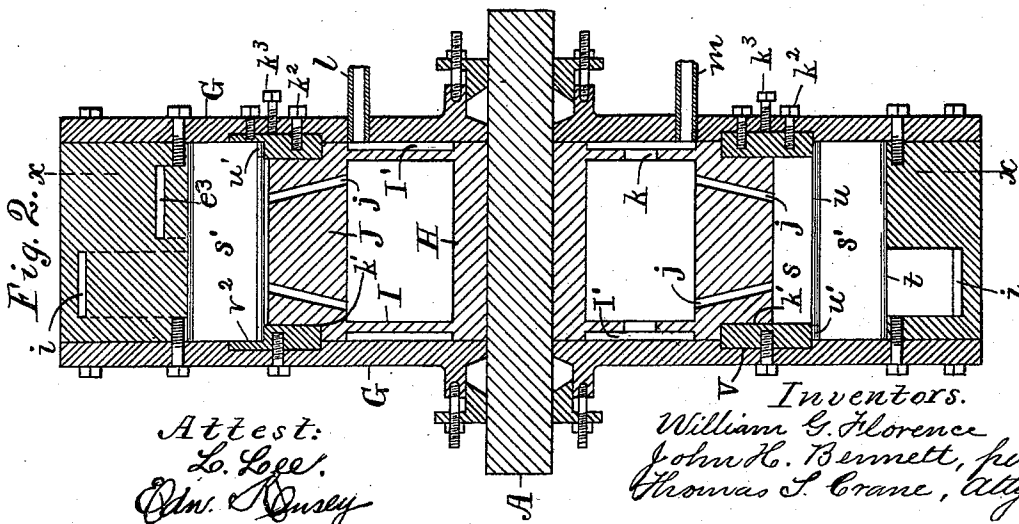


Fig. 2.



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L. Lee.
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John H. Bennett, per
Thomas S. Crane, Atty.

(No Model.) 2 Sheets—Sheet 2.

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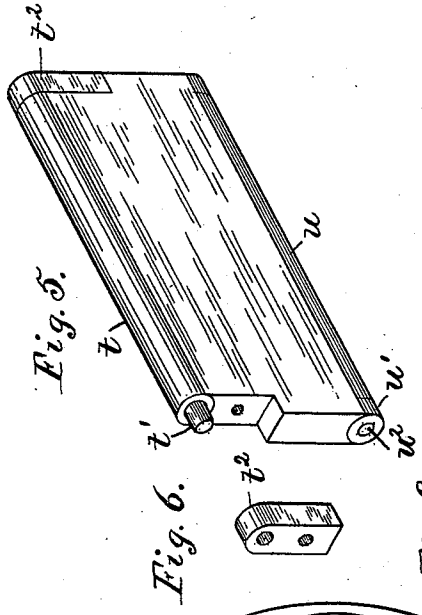

Fig. 5.

Fig. 6.

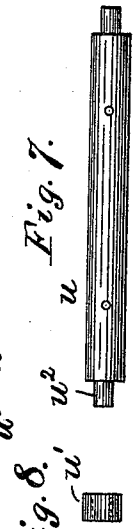

Fig. 7.

Fig. 8.

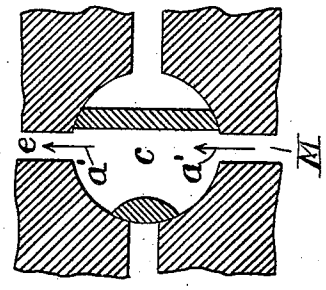

Fig. 9.

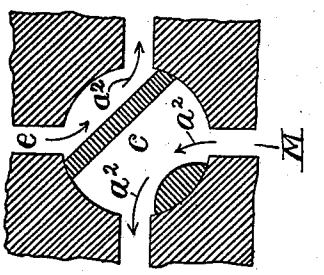

Fig. 10.

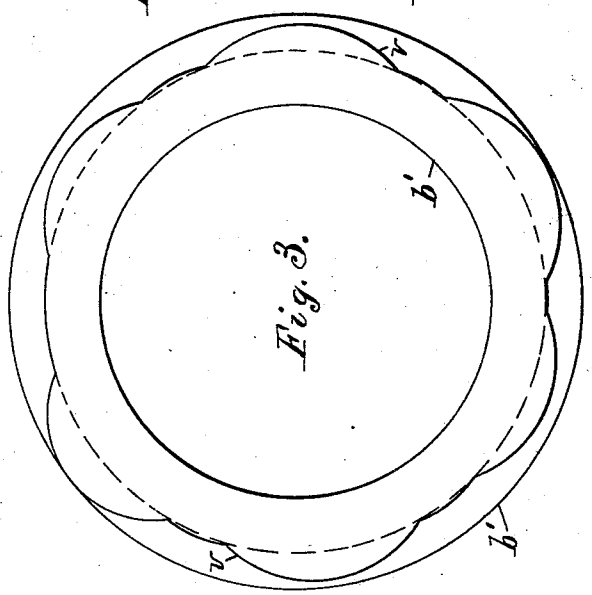

Fig. 3.

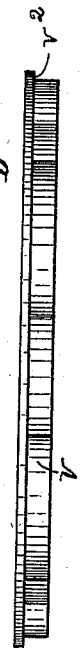

Fig. 4.

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Thomas S. Crane, atty.

UNITED STATES PATENT OFFICE.

WILLIAM G. FLORENCE AND JOHN H. BENNETT, OF NEWARK, NEW JERSEY.

COMPOUND ROTARY STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 525,341, dated September 4, 1894.

Application filed January 17, 1894. Serial No. 497,144. (No model.)

To all whom it may concern:

Be it known that we, WILLIAM G. FLORENCE and JOHN H. BENNETT, citizens of the United States, residing at Newark, Essex county, New Jersey, have invented certain new and useful Improvements in Compound Rotary Steam-Engines, fully described and represented in the following specification and the accompanying drawings, forming a part of the same.

The object of this invention is to furnish a means of securing triple expansion or other high ratios of expansion in a rotary steam engine, and the invention consists in the combination with a rotating drum having numerous radial sliding pistons, of a succession of chambers around the periphery of the drum into which such pistons move successively.

The invention also consists in specific means for introducing steam beneath the pistons to project them automatically, in means for packing the edges of the sliding pistons, and in means for reversing the motion of the drum when desired.

The invention will be understood by reference to the annexed drawings, in which—

Figure 1 is a vertical section on line *x*, *x*, in Fig. 2. Fig. 2 is a vertical section, where hatched, of the parts intersected by the line *y*, *y*, in Fig. 1. Fig. 3 is a side view and Fig. 4 an edge view of the cam ring detached from the cylinder head. Fig. 5 is a perspective view of one of the pistons upon a larger scale with one of the bearings for the roller detached. Fig. 6 is a perspective view of the detachable bearings for the outer roller. Fig. 7 is a side view of the detached inner roller, and Fig. 8 is a side view of one of the anti-friction wheels for the end of such roll. Figs. 9 and 10 are sections of the steam inlet cock.

The engine shaft A is shown concentric with a casing B which is formed about a shell or cylinder C containing two groups of chambers D, D′, D^2, and E, E′, E^2. Intermediate to the chambers the shell is formed with concentric curve F, and heads G are fitted to opposite ends of the shell and casing to close the chambers. The heads embrace opposite ends of the drum, which is formed with hub H, disks I, and rim J having radial slots *s*. Annular clearance spaces I′ are formed between the heads and the drum to diminish the frictional contact.

Piston slides *s′* are fitted movably to the slots and are forced outward by steam introduced to the bottom of each slot by holes *j*. The disks I are perforated in the sides with holes *k*, and a steam pipe *l* is supplied to the upper part of one of the spaces, from which the steam passes to the interior of the drum and to the other space through the holes *k*. The lower part of the space is drained by a drip pipe *m*.

The outer edges of the piston slides are provided with anti-friction rolls *t* fitted at opposite ends by pivots *t′* to bearings t^2, one of which is made detachable, as shown in Figs. 5 and 6, to insert the roll. The inner edge of each piston slide is grooved to admit a cylindrical rod *u* having anti-friction wheels *u′* fitted to pivots u^2 upon its opposite ends, to ride upon cam surfaces *v*. The cam surfaces are formed upon cam rings *v′* which are inserted in annular grooves V inside the heads G. The cam rings project inward from the heads, and the outer corners of the drum are formed with annular rabbeted seats *k′* to fit snugly against such rings; one of which is provided with set screws k^3 and clamp bolts k^2 to set it adjustably toward the rabbet in the drum. Such adjustment secures a steam tight joint between the interior of the drum and the heads. The periphery of each chamber is segmentally curved so that the piston slides gradually outward and inward in its movement through the chamber, and the chambers in each group are made deeper in succession from the first to the last; by which the capacities of the chambers are increased in a given ratio. A single inner corner of each cam ring is formed with recesses v^2 into which the ends of the piston slides *s′* are fitted, the inner edges of the recesses forming cams *v* of segmental shape parallel with the inner surfaces of the chambers D, D′, &c., E, E′, &c. The cam recesses are flush with the inner sides of the heads G. The wheels *u′* upon the inner corners of the piston slides fit the cams *v*, and serve to press the pistons positively outward whenever the steam pressure operating through the holes *j* is inoperative, which contingency may arise from the rusting or sticking of the piston slides when disused. The concentric curves F are fitted steam tight to the periphery of

the drum between the slots *s*, and thus operate to retain the steam in the several chambers. The curves F are of uniform length between the several chambers in each group, but the groups are so disposed within the shell that the pistons in the chambers D, D′, D^2 may stand at the ends and middle of the chamber when the pistons in the chambers E, E′, E^2 are in an intermediate position. The shell is shown upon the left side of Fig. 1 provided with steam passages and cocks adjusted to drive the drum to the right, as indicated by the arrows *a*. A steam port *d* supplies live steam to the rear edge of the chamber D, and a similar port *e* supplies steam to the corresponding edge of the chamber E. Outlet passages *d′*, d^2, are shown extended from the middle of the chambers D and D′ to the first edge of the chambers D′ and D^2. Similar passages *e′* and e^2 connect the chambers E, E′, E^2. Three-way-cocks *c* and *c′* are shown applied to the passages *e*, *e′*, e^2, and adjusted to open such passages.

Exhaust passages *f*, *f′*, are extended from the middle of the chambers D^2 and E^2, and such passages would be connected with a condenser through a common passage *i*. With the three-way-cocks adjusted as shown in Fig. 1, the operation of the pistons in each group of chambers is similar, and being exerted upon opposite sides of the shaft A produces equal pressures at opposite sides of the drum. It will therefore be understood that the operation of the steam in the chambers D, D′, and D^2, is duplicated in the chambers E, E′ and E^2.

The live steam admitted at the port *d* presses upon the nearest piston slide in the chamber D and drives it forward. When such slide passes the exhaust port *d′* the supply of such live steam to such piston is cut off by the movement of the succeeding piston over the port *d*; and the steam already admitted between the two pistons is discharged by the passage *d′* into the rear edge of the chamber D′, and operates expansively upon the first piston moving therein. The chamber D′ being of greater cross section than the chamber D, the forward piston moving in such chamber presents a larger area than the piston in the chamber D, thus securing an effective pressure of the exhaust steam upon the forward piston. The chamber D^2 is in like manner deeper than the chamber D′, and the exhaust steam discharged through the passage d^2 into the rear edge of the chamber D^2 operates in a similar manner upon the piston therein. From the above description it will be seen that a triple expansion of the steam is secured in the three chambers D, D′ and D^2 by forming passages external to the chambers, and connecting the middle of each with the rear edge of the succeeding chamber. The pistons in the chambers are shown advanced from the rear edge of such chambers; and therefore intermediate to the ends of the chambers, thus exposing considerable area to the steam pressure at the time when the pistons in the chambers D, D′ and D^2 are coincident with their steam inlet ports, and thus inoperative. By such arrangement of the pistons in the two groups of chambers, an effective rotative force is exerted at all times upon the drum, and the engine presents no dead center. Where it is necessary to reverse the rotations of the drum, it may be effected by the provision of additional passages shown in dotted lines at the left side of Fig. 1; such passages being formed about the shell at the side of the other passages, as indicated in Fig. 2.

The passages e^3 connect the cocks *c* and *c′* with cocks *g′* having ports *h* leading to the forward end of each chamber.

The cocks *g′* are connected by passages *h′* with the condenser passage *i*, and the ports *h* are open to the condenser during the forward movement of the drum (indicated by the arrows *a*), thus producing an effective vacuum upon the forward side of each piston after it passes the middle of each chamber. The movement of the steam during such forward movement of the drum is indicated by the arrows *a′*, and the movement of the steam when the cocks are reversed is indicated by the arrows a^2. A cross section of one of the steam inlet cocks *c* is shown in Fig. 9 with the plug and its passages arranged to propel the drum forward, and connect the inner port *e* with the steam supply M; Fig. 10 shows the plug turned to throw the live steam into the opposite end of the first chamber E, and to connect the port *e* with the condenser. The cocks *c* and *g′* would be simultaneously reversed by any suitable means, and the steam would then operate in a reverse direction as indicated by the arrows a^2. The steam passages are shown, in Fig. 1 of the drawings, cast in the metal surrounding the shell C, with the plugs of the different cocks fitted to transverse apertures in the metal; but it is immaterial whether the passages be thus formed, or by means of threaded pipes connecting the ports with suitable cocks. It is obvious that the shell may be constructed with a single group of chambers, instead of two as shown in the drawings, and that the number of chambers, and the number of expansions to which the steam is subjected may also be varied at pleasure. The cocks required for reversing the direction of the steam in its movement through the successive chambers are shown only at the left side of the engine in Fig. 1, and are omitted upon the right side of the shell, as the passage of the steam through the ports connecting the successive chambers is much more clearly shown without exhibiting the cocks.

It will be observed that when the engine is reversed, the steam passes from the chamber D to D′, and from the chamber D′ to D^2, but enters each chamber at the opposite end; the construction thus securing the expansion of the steam in the same ratio and in the same order throughout the succession of

chambers. Where the drum is intended to rotate in one direction only, the engine would be constructed as shown at the right side of Fig. 1, without any reversing cocks; but where the drum is intended to rotate in opposite directions the cocks would be applied to all the chambers upon both sides of the engine. The steam is shown admitted to the engine upon opposite sides by transverse passages M, which would be supplied with pipes extended outward through the heads G. The exhaust passage *i* extends around the greater part of the cylinder within the casing B, and may be connected with the condenser by any suitable means, as by the discharge nozzles N and pipes N'. The entire engine may be surrounded by a steam jacket to prevent radiation if desired. The admission of steam to the bottoms of the piston slides *s'* operates to press the slides elastically outward at all times, and thus greatly reduces the work imposed upon the cam surfaces *v*.

The arrangement of the anti-friction wheels *u'* upon the pivot u^2 of the rod *u* which is attached to the inner edge of each slide, enables the wheels to turn much more freely than if the rod were arranged like the rolls *t*, and thus diminishes the friction upon the cam surfaces. All of such sliding and rolling surfaces would be lubricated by supplying oil to the inlet steam pipe *l*.

Having thus set forth the nature of the invention, what is claimed herein is—

1. In a compound rotary engine, the combination, with a rotating drum having a series of radial sliding pistons, of a succession of corresponding chambers in a shell around the periphery of the drum into and out of which the pistons move successively, with external passages connecting the chambers in series, and thus leading the same steam in succession through the series of chambers, substantially as herein set forth.

2. In a compound rotary engine, the combination, with a rotating drum having a series of radial sliding pistons, of a succession of corresponding chambers in a shell around the periphery of the drum into and out of which the pistons move successively, with external passages connecting the chambers in series, and means for reversing the flow of the steam through such passages to reverse the movement of the drum, substantially as herein set forth.

3. In a compound rotary engine, the combination, with a rotating drum having a series of radial sliding pistons, of a succession of corresponding chambers in a shell around the periphery of the drum into and out of which the pistons move successively, with external passages connecting the chambers in series, and three-way-cocks inserted in such passages, and reversing passages for leading the steam reversely into the chambers, substantially as herein set forth.

4. In a compound rotary engine, the combination, with a rotating drum having a series of radial sliding pistons, of a shell having within its periphery two series of segmentally curved chambers, a steam inlet to the first chamber of each series, a steam outlet from the last chamber of each series, and passages connecting the chambers of each series in succession, as herein set forth.

5. In a triple expansion rotary engine, the combination, with a drum having eighteen radial sliding pistons, of a shell formed with six segmentally curved chambers arranged in two groups, with the pistons at the ends of the chamber in one group, when in the intermediate position in the other group, heads embracing the drum and closing the ends of the chambers, opposite steam inlets to the first chamber of each group, opposite steam outlets from the last chamber of each group, and passages connecting the passages at each group in series, as and for the purpose set forth.

6. In a triple expansion rotary engine, the combination, with a drum having eighteen radial sliding pistons, of a shell formed with six segmental chambers arranged in two groups, with the pistons at the end of the chamber in one group, when in the intermediate position in the other group, heads embracing the drum and closing the ends of the chambers, opposite steam inlets to the first chamber of each group, opposite steam outlets from the last chamber of each group, passages connecting the chambers of each group in each series, and a casing covering all of such passages and forming a steam jacket over the same, substantially as herein set forth.

7. In a rotary steam engine, the combination, with a rotating drum having a series of radial sliding pistons, of a succession of corresponding chambers in a shell around the periphery of the drum, heads at opposite sides of the drum closing the ends of the chambers, a clearance space I' at the sides of the drum, a pipe admitting steam to such clearance space, and apertures leading the steam therefrom to the inner edges of the sliding pistons, as herein set forth.

8. In a rotary steam engine, the combination, with a rotating drum having a series of radial sliding pistons, of a succession of corresponding chambers in a shell around the periphery of the drum, heads at opposite sides of the drum closing the ends of the chambers, clearance spaces at opposite sides of the drum adjacent to the heads, a pipe admitting steam to one of such spaces and apertures through the drum leading the steam to the opposite space, as herein set forth.

In testimony whereof we have hereunto set our hands in the presence of two subscribing witnesses.

WILLIAM G. FLORENCE.
JOHN H. BENNETT.

Witnesses:
JOHN C. CORY,
THOMAS S. CRANE.