

(No Model.)

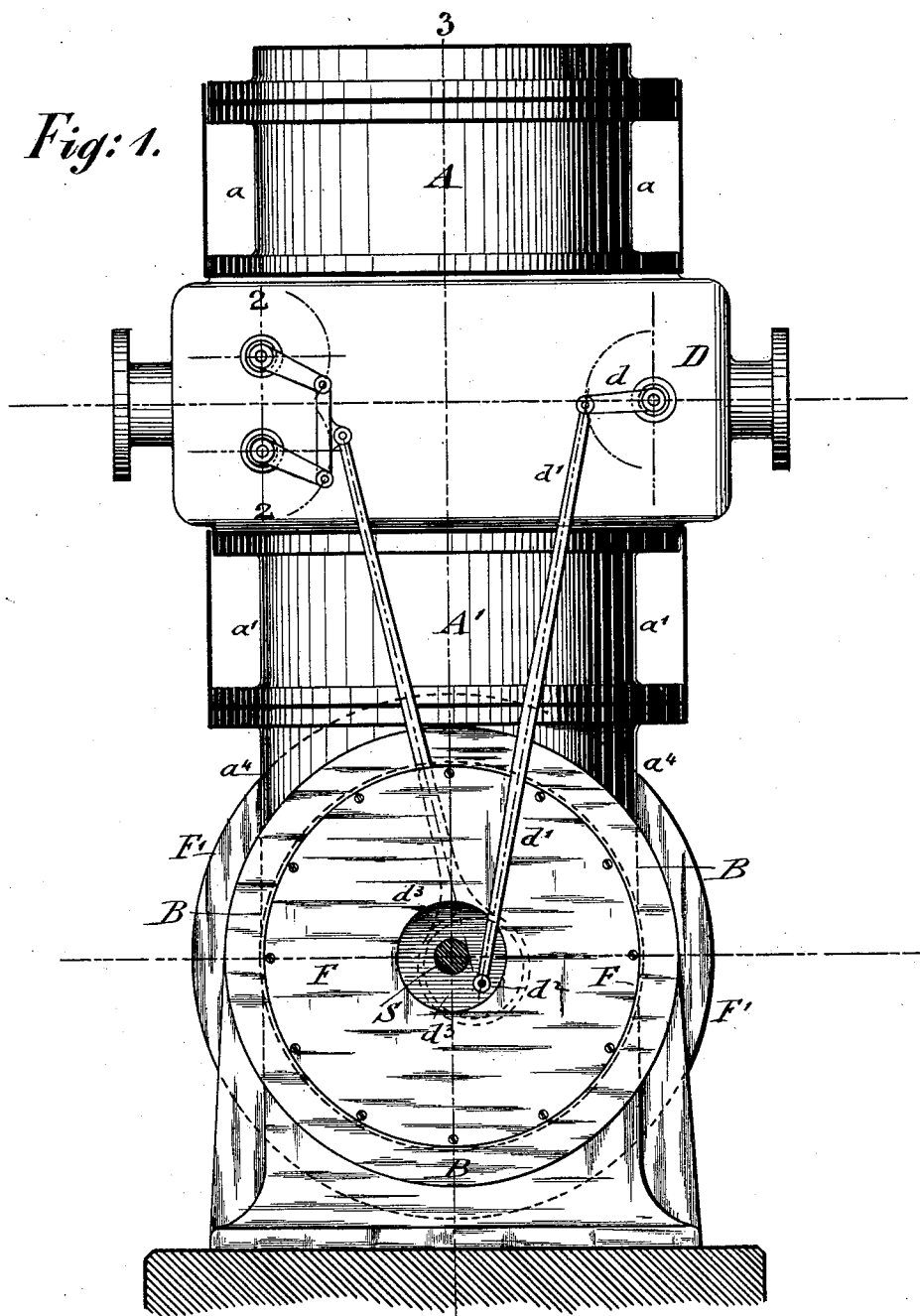
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R. BERG.
COMPOUND STEAM ENGINE.

No. 482,116.

Patented Sept. 6, 1892.

Fig: 1.



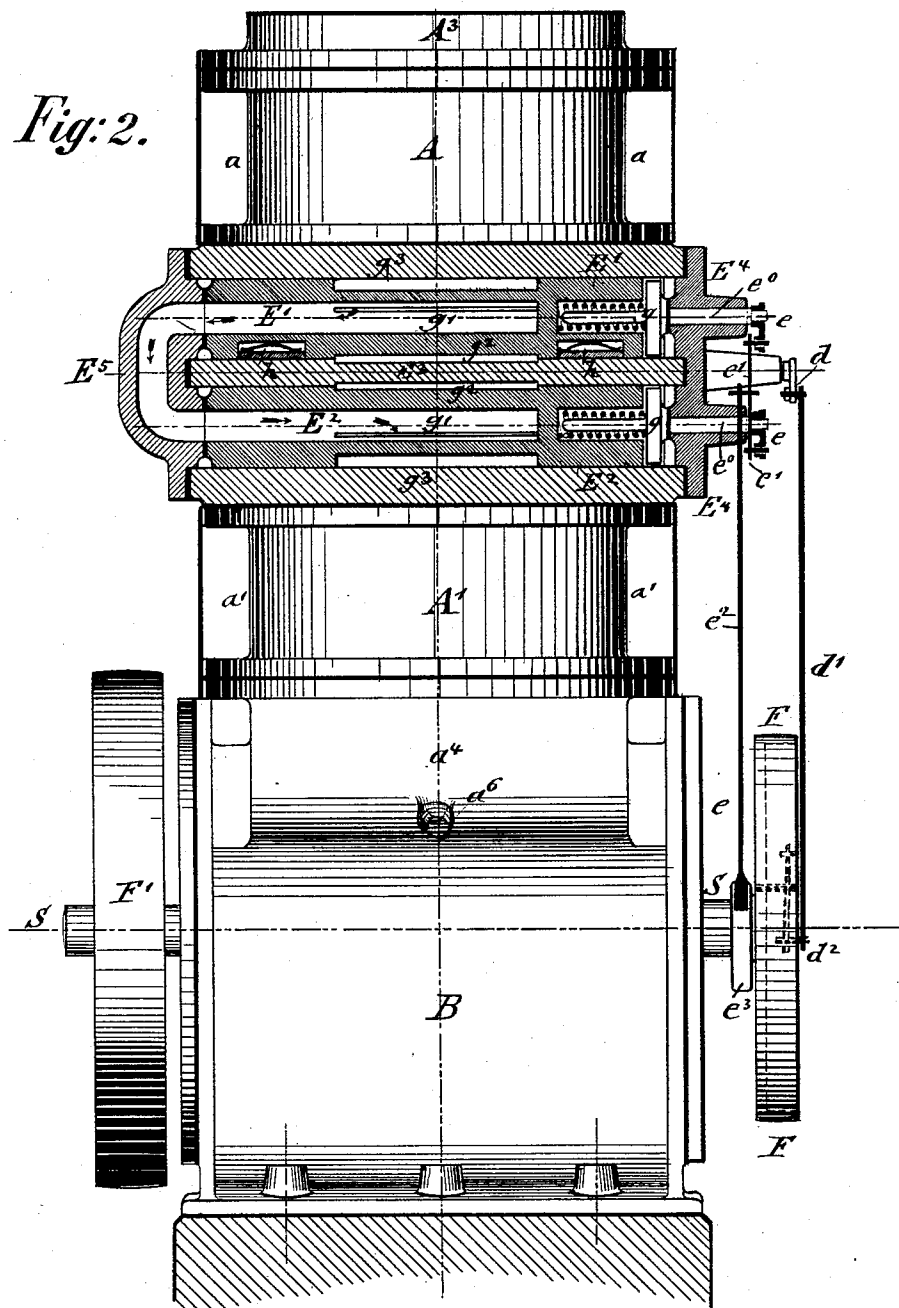
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4 Sheets—Sheet 2.

No. 482,116.

Patented Sept. 6, 1892.



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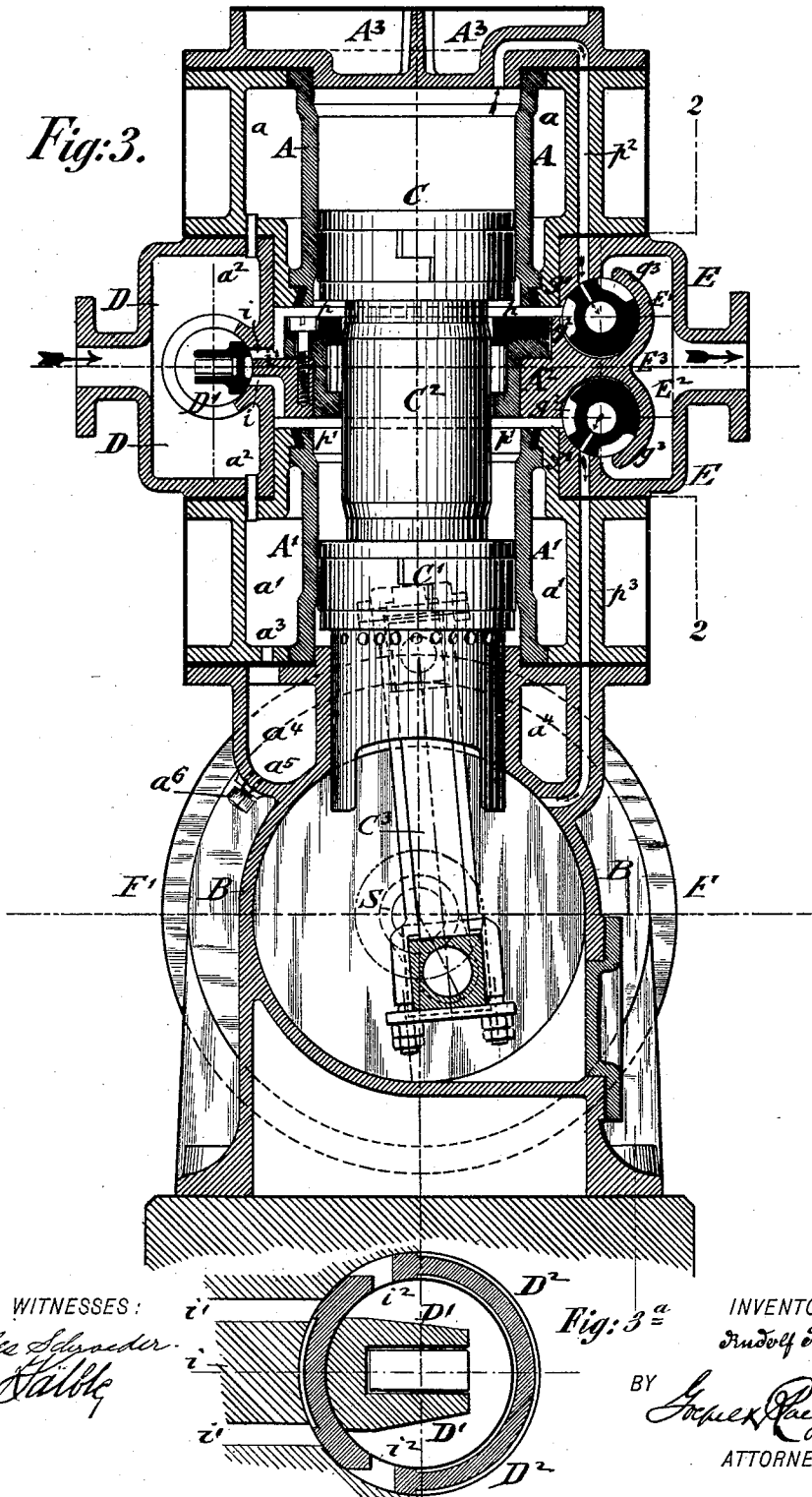
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Fig:3.



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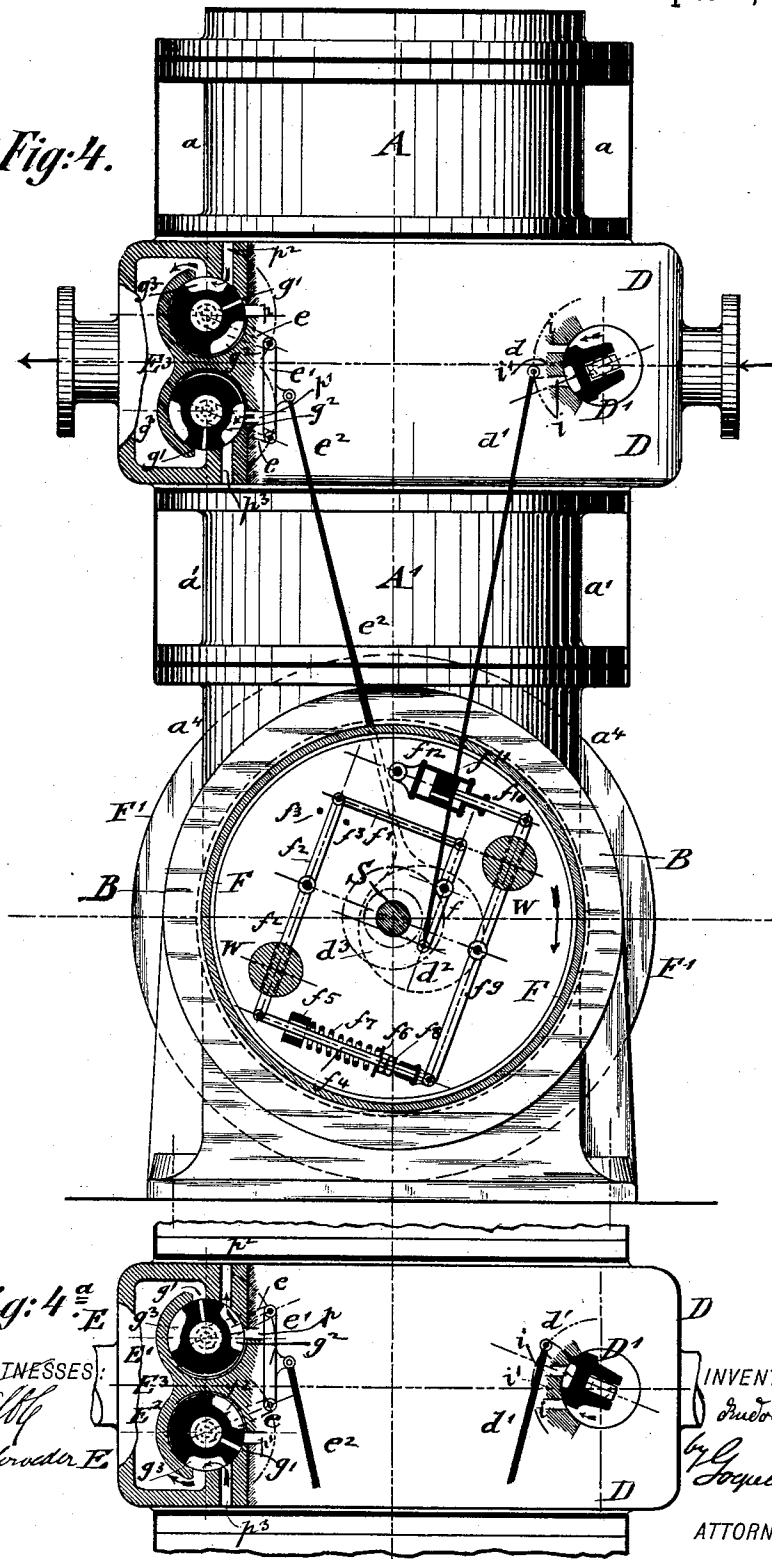
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Fig:4.



UNITED STATES PATENT OFFICE.

RUDOLF BERG, OF NEW YORK, N. Y.

COMPOUND STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 482,116, dated September 6, 1892.

Application filed March 17, 1892. Serial No. 425,352. (No model.)

To all whom it may concern:

Be it known that, I RUDOLF BERG, a citizen of the Empire of Germany, and a resident of New York city, in the county and State of New York, have invented certain new and useful Improvements in Compound Steam-Engines, of which the following is a specification.

This invention relates to improvements in compound steam-engines of that class in which two cylinders and pistons are arranged with each other and supplied with steam from a Corliss or other valve-gear in such manner that the steam is working twice at high pressure and twice at low pressure, and that the disposition of the parts is so arranged that a very simple, compact, and comparatively inexpensive compound engine is obtained.

The invention consists of a compound steam-engine with Corliss or other valve gear, in which a triple differential piston is guided in two cylinders arranged in line with each other and in which the high-pressure steam is supplied from the steam-chest by channels to the cylinders and pistons in such a manner that it acts alternately on the high and low pressure sides of the pistons, while oscillating valves in the exhaust-chest and connecting-channels serve to supply the steam to opposite ends of the cylinders and by transverse channels to the dead-spaces in the cylinders, so as to equalize the steam-pressure in the same.

The invention consists, secondly, of certain details of construction and novel combinations of parts, as will be fully described hereinafter, and finally pointed out in the claims.

In the accompanying drawings, Figure 1 represents a side elevation of my improved compound steam-engine. Fig. 2 is a front elevation, partly in section, on line 2 2, Fig. 1; and Fig. 3 is a vertical transverse section, partly in section, through the equalizing-valves on line 3 3, Fig. 1. Fig. 3^a is a modified construction of the steam-supply valve, and Figs. 4 and 4^a are sectional side elevations showing the different positions of the steam supply and exhaust valves.

Similar letters of reference indicate corresponding parts.

Referring to the drawings, A A' represent two steam-cylinders, which are arranged both

in line with each other and which are supported on a suitable base-frame B, in which a cylindrical oil-chamber is arranged for lubricating the driving-shaft S and its crank connection with the piston-rod C³ of a triple differential piston C' C², that is located in the steam-cylinders A A'. The steam-cylinders A A' are connected by an intermediate portion A², which is provided with a suitable packing that fits tightly to the middle or shank portion C² of the piston, so that the steam-cylinders are separated from each other and the steam is prevented from passing from one cylinder to the other. At the ends of the middle portion C² are arranged pistons C C', one for each steam-cylinder, which pistons are provided with any approved packing-rings, so as to fit tightly into their respective cylinders. The upper end of the upper cylinder A is closed by a suitable head A³, while the lower end of the lower cylinder A' has an opening that communicates with the oil-chamber in the base-frame of the steam-engine, as shown clearly in Fig. 3. The upper and lower steam-cylinders A A' are surrounded by annular steam-jackets a a', which are separated by the intermediate portion A², in which the middle smaller portion or shank of the pistons is guided, said steam-jackets being connected by channels a² with the steam-chest D, so that a supply of live steam is always kept up in said jackets. The water of condensation passes from the upper steam-jacket a through the upper channel a² into the steam-chest D, in which it is collected at the lower part of the same and dropped through the lower steam-supply channel a² to the lower steam-jacket a' and through an opening a³ in the bottom of the latter into an annular collecting-chamber a⁴, located alongside of the base-frame B, from which chamber the water of condensation is drawn off from time to time through a bottom opening a⁵, which is closed by a screw-plug a⁶ after the water of condensation is drawn off.

The steam-chest D is arranged at one side of the steam-cylinders A A', the exhaust-chest E being arranged at the opposite side of the same, both being located adjacent to the intermediate portion A², that separates the upper steam-cylinder and its steam-jacket from the lower steam-cylinder and its

jacket. In the valve-chest D is located an oscillating supply-valve D' and in the exhaust-chest E two oscillating valves E' E², that are operated on the principle of the Corliss valve-gear, the supply-valve D' being connected by a crank *d* and connecting-rod *d'* with a wrist-pin *d*² on a disk *d*³ at the outer end of the driving-shaft S, as shown in Fig. 1. The wrist-pin *d*² is also connected with a lever *f*, that is fulcrumed to the rear wall of a cylindrical governor-casing F, as shown in Fig. 4, the opposite end of said lever *f* being connected by an intermediate pivot-link *f'* with a second fulcrumed lever *f*², that oscillates between fixed pins *f*³ on the rear wall of the casing F. The opposite end of the lever *f*² is connected to a pivot-link *f*⁴, which is arranged at right angles to the fulcrumed lever *f*² and guided in a fixed keeper *f*⁵, between which and a shoulder *f*⁶ on the rod *f*⁴ is interposed a helical spring *f*⁷, the tension of which is adjusted by means of a nut and jam-nut *f*⁸, which retains the collar in the position to which it is adjusted. The helical spring *f*⁷ serves for the purpose of adjusting the engine to the required speed, the engine running at higher speed when the spring is set to high tension, while it will be run at lower speed when the spring is set to low tension. The opposite end of the connecting-rod *f*⁴ is pivoted to a third fulcrumed lever *f*⁹, which is arranged parallel with the lever *f*² and connected at its opposite end with the piston-rod *f*¹⁰ of a piston *f*¹¹, which is guided in a closed oscillating cylinder *f*¹², that is filled with oil at both sides of the piston *f*¹¹, the oil communicating through a small opening in the piston from one side of the piston to the other, so as to retard thereby the motion of the levers *f*² and *f*⁹ and prevent them from being too quickly oscillated by the adjustable weights W W, which are placed at diagonally-opposite points on the levers *f*² *f*⁹, the whole forming a sensitive and reliable centrifugal governor for my improved steam-engine.

Any other approved construction of governor may be used, as I do not desire to confine myself to the special construction of the governor shown in the drawings.

The casing F of the governor is applied to one end of the driving-shaft, while a fly-wheel F' is applied to the opposite end of the same, the latter serving to carry the piston S as well as the governor over their dead-points.

The oscillating valves E' E² of the exhaust-chest E are coupled together by connecting the crank-arms *e e*, applied to their spindles by a pivoted connecting-piece *e'*, from which a connecting-rod *e*² extends in downward direction, which is strapped to an eccentric *e*³ on the driving-shaft S, as shown clearly in Figs. 1, 2, and 4. The eccentric *e*³ of the connecting-rod *e*² produces the oscillating motion of the exhaust-valves E' E² and imparts the required throw to the same, so as to set them in position for conducting the high-pressure

steam from the high-pressure sides of the pistons to the low-pressure sides of the same. The oscillating valves E' E² are guided in cylindrical casings E³, which are provided with outlet-openings, respectively, at their upper and lower ends, as shown clearly in Figs. 3, 4, and 4^a, through which the exhaust-steam is passed off into the exhaust-chest E and then to the atmosphere or to a condenser, as the case may be. The oscillating valves E' E² are made cylindrical in shape and provided with a longitudinal slit *g'* and with longitudinal recesses or cavities *g*² *g*³, which are arranged symmetrically at each side of the slit *g'*, as shown in the drawings. The spindles of the exhaust-valves E' E² are connected by means of T-pieces I, applied to the spindles inside of the cap-plate E⁴, with the valves E' E², said T-pieces engaging recesses in the ends of the exhaust-valves. The spindles O O are extended into sockets in the ends of the exhaust-valves, in which helical cushioning-springs are arranged, which serve for the purpose of pressing the opposite ends of the valves and the collar of the driving-spindle against the inner face of the cap E⁴ at one side of the exhaust-chest and against the inner face of the cored-out end piece E⁵, having a V-shaped channel by which the interior cavity of the upper exhaust-valve E' is connected with the interior cavity of the lower exhaust-valve E², as shown clearly in Fig. 2. The upper exhaust-valve E' is furthermore cushioned by means of band-springs *h*, which are arranged in recesses at the lower part of the same and interposed between the valve and suitable brasses, which latter bear on the casing E³, so that the upper exhaust-valve is pressed tightly against the ports of the upper cylinder and retained thereon. The lower exhaust-valve E² does not require any spring-cushioning, as the same fits tightly to its ports by gravity. The oscillating steam-supply valve D' is in the nature of a D-valve, and is provided with a D-shaped recess, so as to communicate with the high-pressure steam-ports *i i*, which are arranged at each side of a central partition or abutment *i'*, as shown in Fig. 3. The high-pressure steam-ports *i* communicate by suitable channels with ports *p p'* at the inner ends of the cylinders A A', so as to supply high-pressure steam to the annular spaces that are formed around the middle portion or shank C² of the pistons C C' and between the intermediate portion A², the side walls of the cylinders, and the inner faces of the pistons C C'. The interior spaces of the cylinders A A' are connected at their opposite sides with the recesses or cavities *g*² of the oscillating exhaust-valves E' E². The exhaust-valves E' E² are connected by vertical passages *p*² *p*³ with the upper and lower ends of the cylinders A A', said passages serving in connection with the radial slits *g'* and the interior passages of the exhaust-valves and the cored-out end piece E⁵ to produce a connection between the upper cylinder A and

the lower cylinder A', so as to produce an equalizing of the steam-pressure in the same after each stroke. In a similar manner is the steam-pressure at the inner ends of the steam-cylinders A A' at each stroke of the piston equalized by the ports $p p'$ and the cavity in the steam-supply valve D', as shown in Fig. 3, so that the injurious influences of the dead-spaces in the cylinders at the end of each stroke is neutralized. As soon as the equalization of the high-pressure steam in the steam-spaces formed around the shank of the piston at the inner ends of the cylinders and the equalization of the low-pressure steam at the upper and lower ends of the cylinder is produced the supply-valve is oscillated so as to admit high-pressure steam to the inner end of the upper cylinder. Simultaneously the exhaust-valves are oscillated so as to assume the position shown in Fig. 4, in which position the upper exhaust-valve E' serves to discharge the low-pressure steam from the upper cylinder A to the atmosphere, while the high-pressure steam that has just acted on the lower piston C is conducted from the high-pressure-steam space of the lower cylinder A' through the channel p^3 to the low-pressure side of the lower piston C'. As high-pressure steam is thus supplied to the high-pressure side of the upper piston C and low-pressure steam to the low-pressure side of the lower piston C' both steam-pressures act together and produce the lifting of the pistons C C' until the oscillating supply-valve D' as well as the exhaust-valves arrive again at their intermediate or neutral positions between the ports, as shown in Fig. 3, so that the equalization of pressure in the dead-spaces at the high and low pressure sides of the pistons can take place with the next turn of the crank. The steam-supply valve D' is next shifted into the position shown in Fig. 4^a, so as to supply high-pressure steam to the lower cylinder A', while the lower exhaust-valve is set to exhaust and the upper valve in such a position that the high-pressure steam can pass from the high-pressure side of the upper piston to the low-pressure side of the upper cylinder and act expansively with low pressure on the upper side of the same, while the low-pressure steam in the lower cylinder A' is exhausted through the lower channel p^3 and the recess g^3 to the atmosphere. The alternating play of the oscillating steam supply and exhaust valves D' E' E² is continued and thereby the piston C C' acted upon simultaneously by high-pressure steam on the high-pressure side of one piston and by low-pressure steam on the low-pressure side of the other piston, and so on alternately on the upper and lower pistons C C', so that the power of the steam is fully utilized by the compound action before the steam is exhausted. In the intermediate or neutral position of the steam supply and exhaust valves the equalizing of the steam-pressure takes place in the high-pressure and low-pressure dead-

spaces of the cylinders, so that the injurious and retarding influence of the same is obviated.

The governor produces by its centrifugal weights and intermediate lever mechanism the equalizing of the speed of the engine as the connecting-rod changes the throw of the supply-valve, so as to supply a greater or smaller quantity of steam to the cylinders. When the engine is running at higher speed, the throw of the valve is reduced and thereby a smaller quantity of high-pressure steam applied to the engine, while when the speed of the engine is slackened the throw of the supply-valve is increased and thereby a larger quantity of high-pressure steam supplied to the cylinders. In place of the supply-valve, which is regulated for the different degrees of expansion by the varying degrees of throw imparted to the valve, it may be advisable to use the double supply-valve, (shown in Fig. 4^a), in which an exterior oscillating cylinder D², provided with ports p^2 , is used, which exterior cylinder has a uniform throw and which is operated by a trap connection with the eccentric of the exhaust-valves, while the interior expansion-valve D' is adjusted in its relative position to the exterior cylinder and to the different degrees of expansion by the governor in the manner before described. This arrangement corresponds to some extent to the constructions used in steam-engines with straight slide-valves, only that in the present case the valve is adapted for a rotary reciprocating motion instead of a rectilinear reciprocating motion of the valve.

My improved compound engine (shown in the drawings) is arranged as a vertical engine; but it is obvious that the same may be arranged with equal facility as a horizontal engine, either with oscillating Corliss valves or with ordinary slide-valves, as desired. I desire it to be distinctly understood that the underlying principle in the construction of my compound engine relates, mainly, to the distribution of the steam so that the same passes alternately from the high-pressure side of one piston to the low-pressure side of the same piston, while the other piston receives high-pressure steam on the high-pressure side and exhausts simultaneously on the low-pressure side of the same piston. This takes place alternately in the upper and lower cylinders, whatever be the special construction of the valves or whether the same are arranged for expansion or not.

In the neutral positions of the supply and exhaust valves the equalization of pressure in the dead-spaces of the cylinders takes place, which is another important feature of my invention and which takes place whether oscillating or slide valves are used or whether the engine is arranged on the vertical or horizontal type. In the latter case both cylinders have to be closed by heads, the head nearest to the driving-shaft being provided with a stuffing-box, which is not required in the vertical

type of engine in which the lower cylinder communicates with the oil-chamber in which the crank and crank-pin of the piston-rod is rotated.

5 The advantages of my improved compound engine are, first, that only three valves—one supply-valve and two exhaust-valves—are required; secondly, that by the equalizing of the pressure in the dead-spaces of the cylinder-
10 sections the retarding influence of the same on the pistons is obviated and a considerable saving of steam obtained; thirdly, that by the compact arrangement of the cylinders and pistons the compound action is obtained with
15 moving parts of comparatively small size, and, lastly, that by the improved construction of the automatically-working governor the throw of the steam supply and exhaust valves is regulated and a uniform running speed ob-
20 tained.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. The combination of two cylinders ar-
25 ranged axially in line with each other, an intermediate separating portion or web between said cylinders, two pistons, one in each cylinder, connected by an intermediate portion or shank guided in the separating-web of the
30 cylinders, a steam-supply valve communicating with ports at the lower ends of the cylinders, and exhaust-valves also communicating by ports with the inner ends of the cylinders and provided with cavities communicating
35 alternately with channels leading to the outer ends of the cylinders and with the exhaust-pipe, substantially as set forth.

2. The combination of two cylinders ar-
40 ranged in line with each other, an intermediate separating portion or web between said cylinders, two pistons, one in each cylinder and connected by an intermediate portion or shank that is guided in the separating portion, a steam-supply valve, two exhaust-valves
45 having longitudinal cavities communicating with the high and low pressure sides of the cylinders, steam-ports connecting the high-pressure spaces of the cylinders with the supply and exhaust valves, and channels con-
50 necting the low-pressure ends of the cylinders with the exhaust-valves, whereby the

high-pressure steam is conducted from the high-pressure side of one piston to the low-pressure side of the other piston, substantially as set forth.

3. The combination of two steam-cylinders
55 arranged axially in line with each other, an intermediate separating portion or web between said cylinders, two pistons, one in each cylinder, an intermediate portion or shank
60 connecting said pistons, said shank being guided in the separating portion of the cylinders, a supply-valve for the live steam, two exhaust-valves provided with central cavities, radial slits, and recesses at each side of said
65 slits, a bent tube connecting the ends of the exhaust-valves, ports for connecting the steam-supply valve with the high-pressure sides of the cylinders and with the exhaust-
70 valves, and channels by which the exhaust-valves are connected with the low-pressure sides of the cylinders, substantially as set forth.

4. The combination of two cylinders ar-
75 ranged in line with each other, an intermediate separating portion between said cylinders, a steam-piston for each cylinder, a connecting portion or shank for said pistons guided in the intermediate separating portion, a steam-supply valve, and steam-exhaust
80 valves which are coupled together and strapped to an eccentric on the driving-shaft, substantially as set forth.

5. The combination of two cylinders ar-
85 ranged vertically in line with each other and provided with steam-jackets, a steam-chest, a steam-supply valve in said steam-chest, channels connecting the steam-chest with the steam-jackets, a reservoir for the water of con-
90 densation, located below the lower cylinder, and a channel connecting the steam-jacket of the lower cylinder with the reservoir, said reservoir being provided with a plugged discharge opening for the water of condensation,
95 substantially as set forth.

In testimony that I claim the foregoing as my invention I have signed my name in presence of two subscribing witnesses.

RUDOLF BERG.

Witnesses:

PAUL GOEPEL,
CHARLES SCHROEDER.