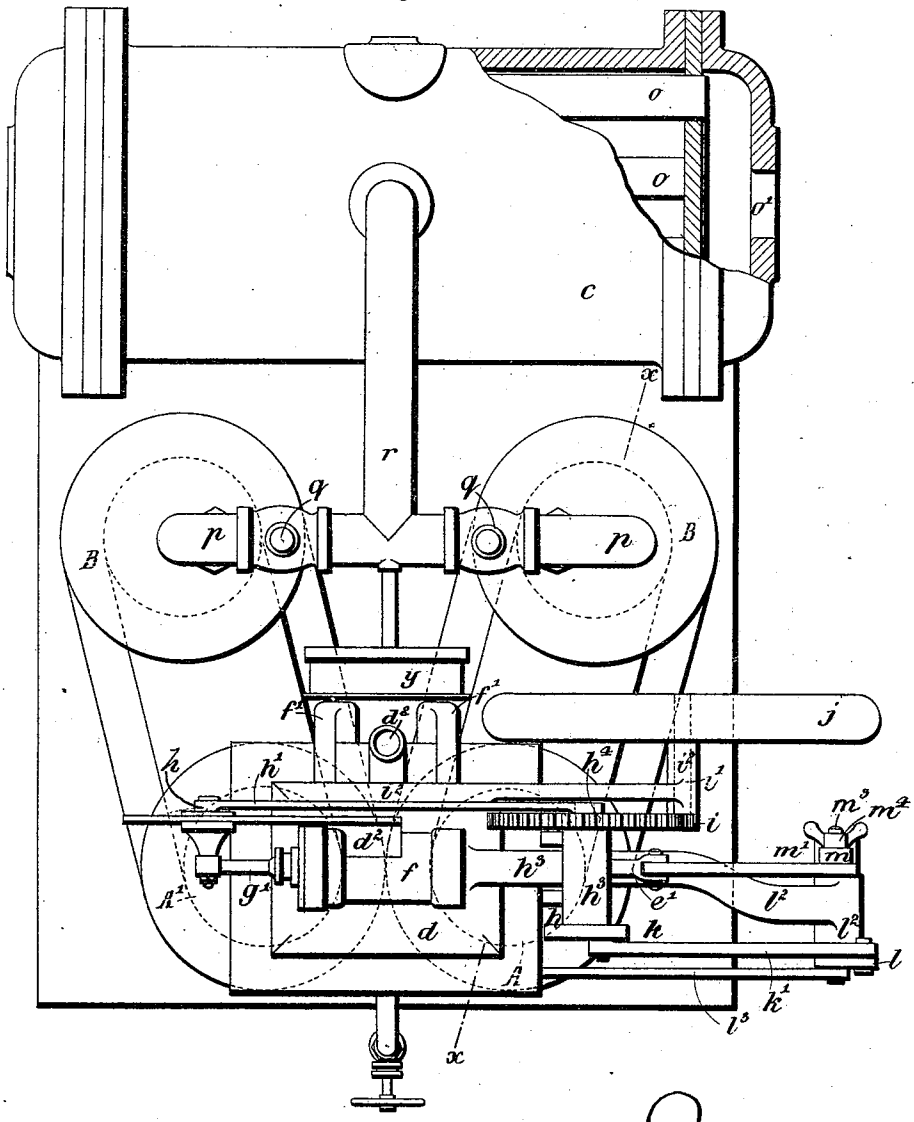
(No Model.) 6 Sheets—Sheet 1.

E. F. CLARKE.

APPARATUS FOR COMPRESSING AIR OR OTHER GASES.

No. 428,456. Patented May 20, 1890.

Fig. 1.



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(No Model.) 6 Sheets—Sheet 2.

E. F. CLARKE.

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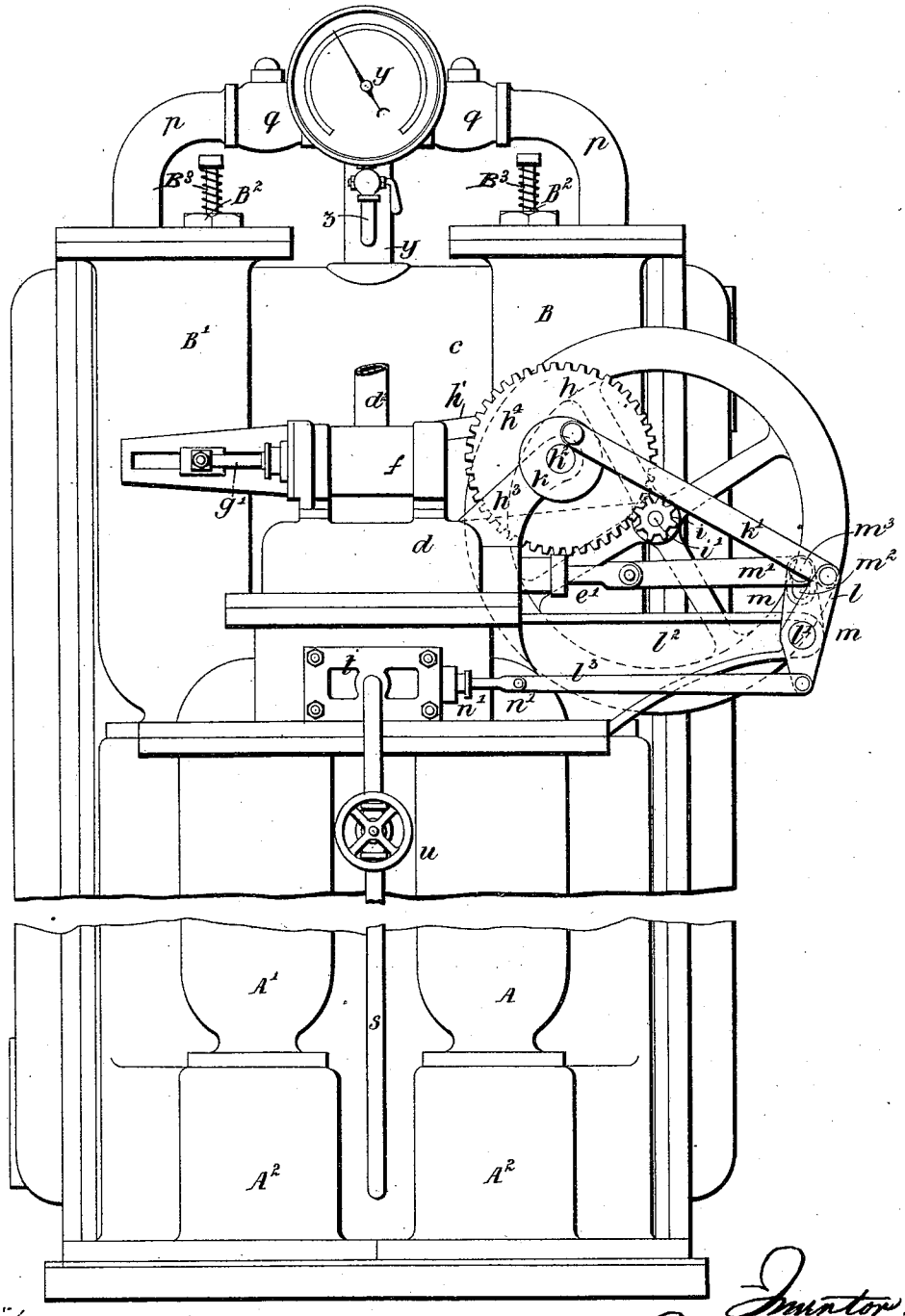
Fig. 2.



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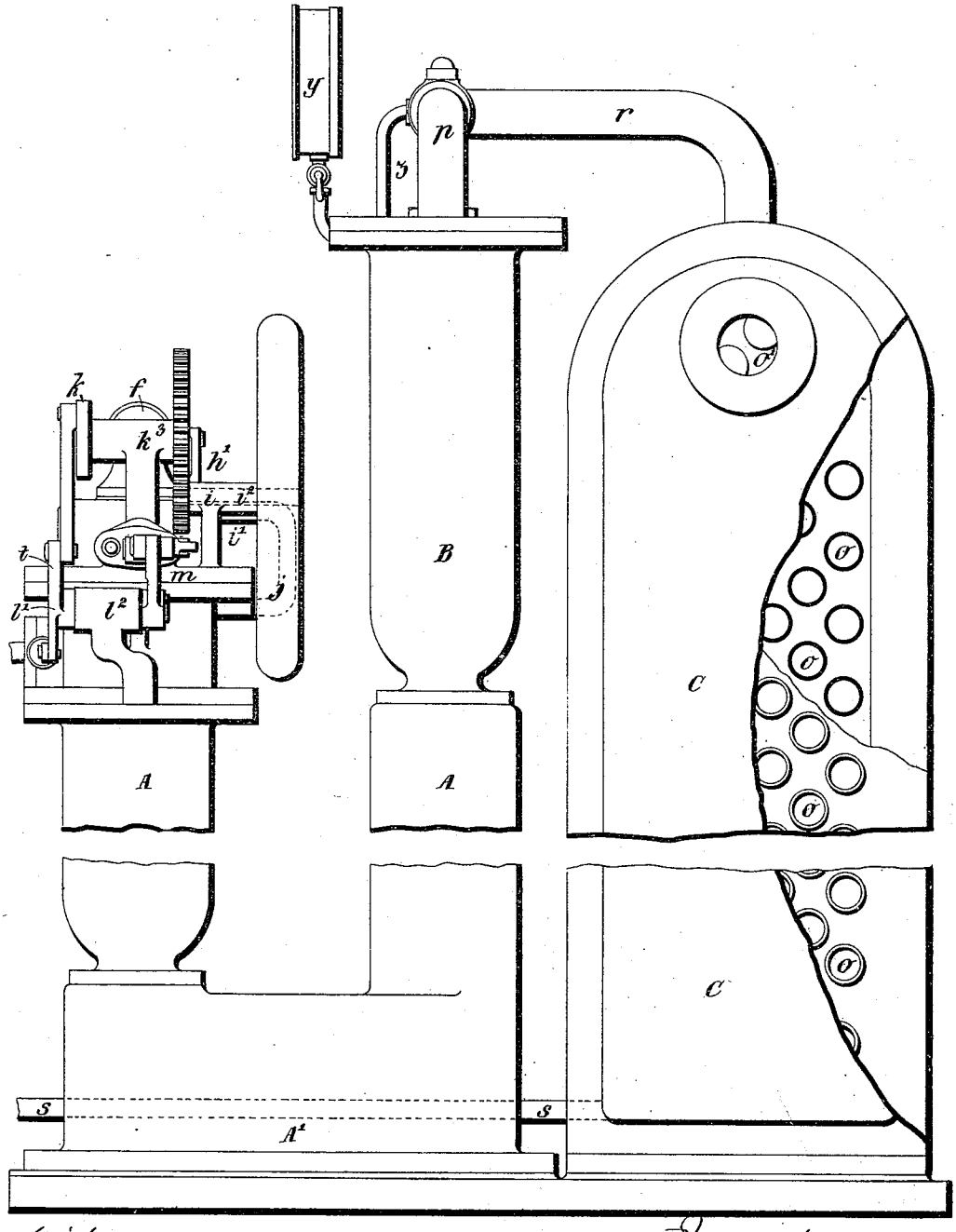
No. 428,456. Patented May 20, 1890.

Fig. 3.



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APPARATUS FOR COMPRESSING AIR OR OTHER GASES.

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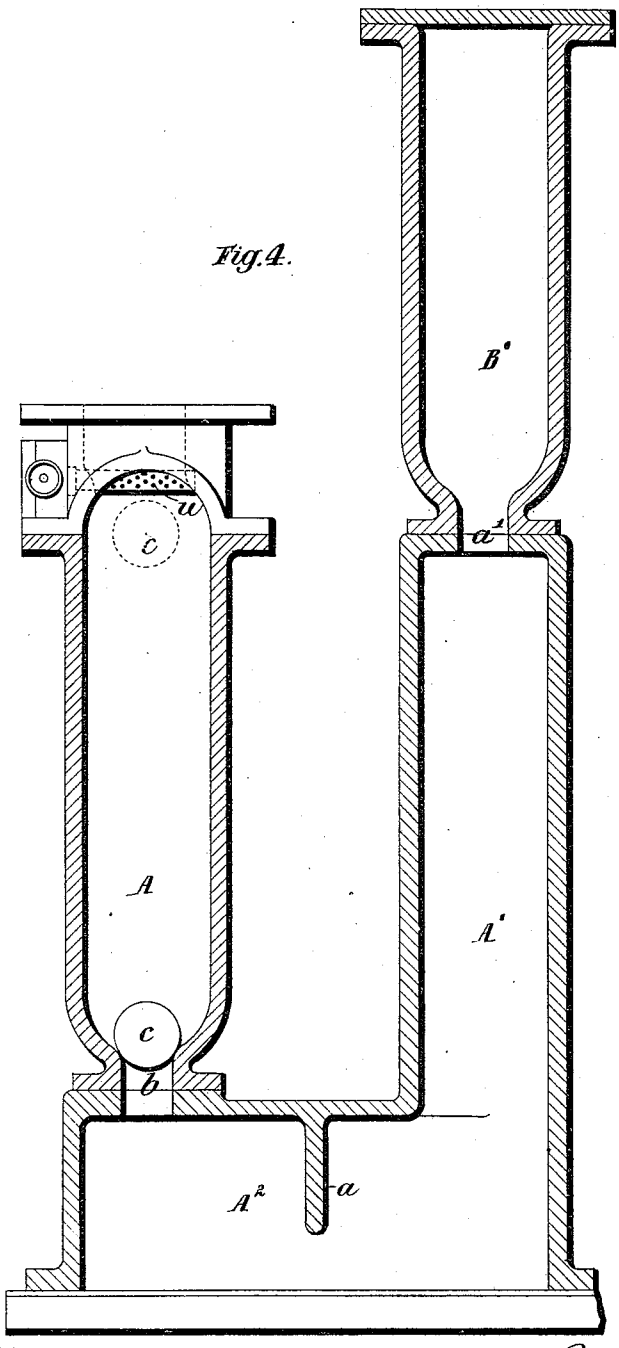
Fig. 4.



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E. F. CLARKE.

APPARATUS FOR COMPRESSING AIR OR OTHER GASES.

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Fig. 5.

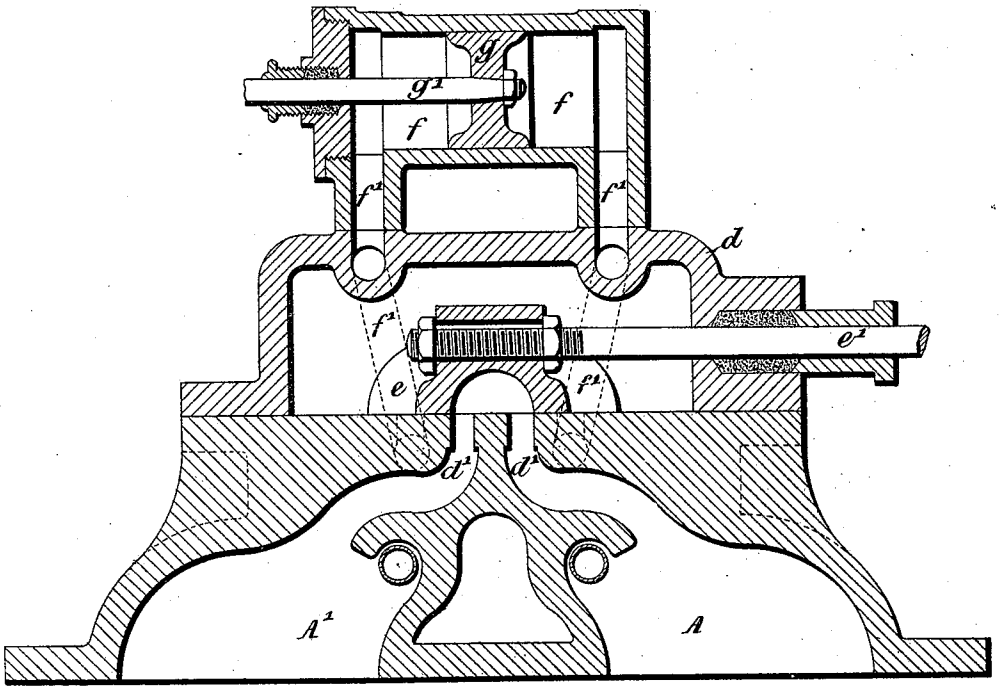
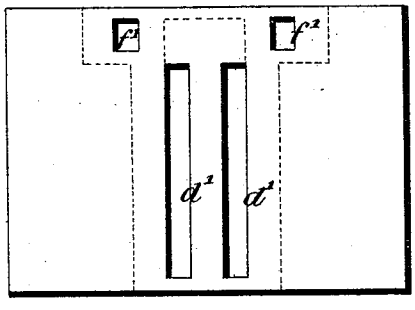


Fig. 6.



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E. F. CLARKE.

APPARATUS FOR COMPRESSING AIR OR OTHER GASES.

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Fig. 9.

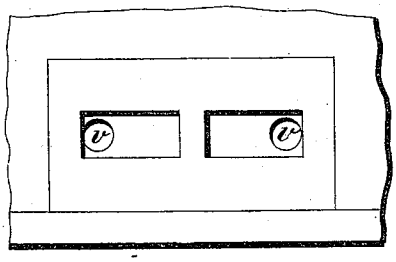


Fig. 8.

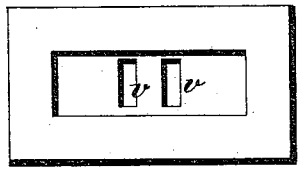
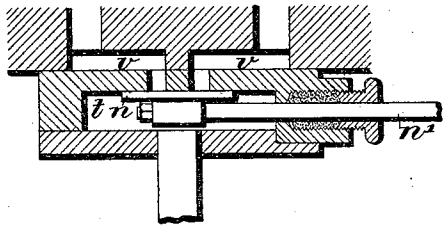


Fig. 7.



Witnesses:
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Edward Fuhrmann Clarke
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UNITED STATES PATENT OFFICE.

EDWARD FUHRMANN CLARKE, OF WALSALL, ENGLAND.

APPARATUS FOR COMPRESSING AIR OR OTHER GASES.

SPECIFICATION forming part of Letters Patent No. 428,456, dated May 20, 1890.

Application filed September 11, 1889. Serial No. 323,594. (No model.) Patented in England October 19, 1888, No. 15,060; in France March 7, 1889, No. 196,537; in Belgium March 9, 1889, No. 85,328; in Italy March 9, 1889, and in India May 1, 1889.

To all whom it may concern:

Be it known that I, EDWARD FUHRMANN CLARKE, engineer, a subject of the Queen of Great Britain, and a resident of Walsall, England, have invented certain new and useful Improvements in Apparatus for Compressing Air or other Gas, (for which I have obtained patents in Great Britain, No. 15,060, dated October 19, 1888; in France, No. 196,537, dated March 7, 1889; in Belgium, No. 85,328, dated March 9, 1889; in Italy March 9, 1889, and in India May 1, 1889,) of which the following is a specification, reference being had to the accompanying drawings.

My invention relates to machinery or apparatus for compressing air or other gas, and is designed to improve the construction of the same.

The main object of my said invention is to provide a novel machine or apparatus for compressing air or other gas by means of steam acting upon a column of water or other liquid interposed between such steam and the air or other gas to be compressed. For this purpose I provide cylinders or chambers containing water, which, when steam is admitted to the said cylinders above the water, will act as a piston for compressing the air or other gas which enters the apparatus through suitable admission-valves. Steam is admitted alternately into the said cylinders or chambers by means of a slide-valve (which may be an ordinary D-valve worked by a small steam cylinder and piston) or by any other suitable means. To prevent the complete ejection or discharge of the water upon which the steam acts into the vessel or receiver intended to contain the compressed air, should the slide-valve fail to cut-off the supply of steam soon enough, and to avoid excessive contact between the steam and the water, I sometimes employ a float-valve, whereby the passages for the water will be closed at the proper time and a floating body continually interposed between the steam and the water. The return of the water to its normal position in each cylinder or chamber is effected by the condensation of the steam which has been used. This condensation is caused by the injection of sprays or jets of water and the consequent formation of a vacuum or partial vacuum in each cylinder or chamber. Suitable floating valves or checks are sometimes also provided to regulate the return of the water.

My said invention, moreover, comprises other improvements hereinafter set forth.

In the accompanying drawings I have shown how my said invention may be conveniently and advantageously carried into practice.

Figure 1 is a plan. Fig. 2 is a front elevation; and Fig. 3 is a side elevation, partly in vertical section, showing one form of my improved apparatus. Fig. 4 is a vertical section on the line $x\,x$, Fig. 1, some of the parts being removed. Figs. 5 to 9 are various views drawn to an enlarged scale, showing details of construction hereinafter described.

Like letters indicate corresponding parts throughout the drawings.

A A′ are the steam and water cylinders or chambers.

B B′ are the air vessels or chambers.

C is the receiver for the compressed air.

The steam and water cylinders or chambers are each formed in two parts A A and A′ A′, respectively placed vertically one behind the other, and their lower extremities are connected through passages A^2.

$a\,a$ are checks provided in the said passages A^2 for preventing the escape of the steam from the cylinders or chambers A A′ to the air-vessels B B′, should the water in the said cylinders or chambers A A′ be forced down too low by the action of the said steam. The air vessels or chambers B B′ are provided with suitable inlet-valves B^2 (which are normally retained closed against external pressure by means of springs B^3) for admitting atmospheric air, and are placed upon the upper extremities of the rear cylinders or chambers A A′ and communicate with the latter through suitable passages a.

$b\,b$ are valve-seatings, on which the floating ball-valves c are adapted to rest should all the water be forced out of the front cylinders or chambers A A′ by the action of the steam thereon.

d is a steam-chest placed upon the upper

extremities of the front cylinders A A′. The said steam-chest d communicates with the cylinders or chambers A A′ through ports or passages d' and with a boiler or other source of steam-supply by means of a pipe d^2.

e is a slide-valve provided with a rod e' and arranged in connection with the ports or passages d'.

To operate the valve e, I prefer to employ an arrangement comprising a steam-cylinder f, which is supplied with steam from the steam-chest d through the steam ways or passages f', the alternate admission and exhaust of the said steam being regulated by the slide-valve e. g is a piston fitting steam-tight in the said cylinder f and adapted to be reciprocated by the steam admitted therein. The piston g is provided with a rod g', coupled to a disk-crank h by means of a connecting-rod h'. The disk-crank is keyed or otherwise secured upon a shaft h^2, carried in a suitable bearing in a bracket h^3, and the periphery of the said disk-crank h is provided with teeth h^4, and is arranged to gear with a pinion i. The pinion i is keyed or otherwise firmly attached to a shaft i', carried in suitable bearings in a bracket i^2.

j is a fly-wheel keyed or otherwise secured upon the shaft i'.

Upon the other extremity of the shaft h^2 is fixed a disk-crank k, coupled by means of a connecting-rod k' to one extremity of a lever l, fixed upon a rocking shaft l'. m is another lever fixed upon the said rocking shaft l', which is carried in bearings in a bracket l^2. The lever m is coupled by means of a connecting-rod m' to the slide-valve rod e'. I prefer to connect the rod m' to the lever m by means of a slot m^2 and a bolt m^3, provided with a thumb-nut or wing-nut m^4, so that the throw or travel of the valve e can be altered at will. In this manner, when starting the apparatus and the pressure of air in the receiver C to be overcome is slight, the throw or travel of the said valve e may be decreased and increased as the said pressure increases. The other extremity of the lever l is coupled by means of a rod l^3 to the rod n' of a slide n, which regulates the admission to the cylinders A A′ of spray or jets of water for condensing purposes, as hereinafter described. The slide-valve e is preferably so set with reference to the piston g that when either of the ports f' are about to be opened the piston is at the same end of its stroke.

The receiver C is provided with tubes o and a water-inlet o' for the circulation of water for cooling purposes.

p p are pipes provided with check or retention valves q. The pipes p are connected to the upper ends of the air-vessels B B′ and communicate with the receiver C by means of a pipe r. The said air-vessels B B′ are made of less capacity than the front portions of the steam and water cylinders or chambers A A′, so that when steam is admitted into the latter a portion of the water will be discharged from the said air-vessels immediately after the air into the air-receiver C. The water which is thus delivered into the receiver C, with the compressed air from the vessels B B′, is utilized for condensing purposes.

s is a pipe communicating at one extremity with the lower part of the receiver C and at its other extremity with the recess in the casing or chamber t, in which is placed the valve n.

u is a stop-valve for regulating or cutting off altogether the said condensing-water. The condensing-water is delivered alternately to the cylinders or chambers A A′ by the action of the valve n through the ports or ways v, and is turned into spray by means of perforations w. The valve n has a sufficient stroke or travel to fully open both the ports v.

y is a pressure-gage attached to the pipe r by means of a siphon-pipe z.

The operation of my apparatus is as follows—that is to say, the receiver C is filled with water to a level above the top of the cylinders or chambers A A′. The said cylinders or chambers A A′ are also filled with water, the valves c floating on the surface of the water at the upper extremities of the said cylinders or chambers. The main slide-valve e is then placed in a central position and steam is admitted into the steam-chest d. The said main slide-valve e is then moved to the right and steam is admitted into the cylinder or chamber A′, forcing down the water contained in the front portion of the said cylinder or chamber and causing it to rise in the rear portion thereof and pass into the air vessel or chamber B′. The water, being interposed between the steam and the air to be compressed, acts like a piston in preventing contact between or mixing of the air and steam. The rising of the water in the vessel B′ causes the compression of the air contained in the latter and ejecting it, and also a small quantity of water through the pipe p past the check or retention valve q and through the pipe r into the receiver C. The floating ball-valve c descends with the water in the front portion of the cylinder or chamber A′, and should the said water be forced down too low rests upon its seating b and prevents further ejection of the said water. The main slide-valve e, having completed its stroke to the right, returns and closes the cylinder or chamber A′ to the steam and opens communication between the said cylinder or chamber A′ and the cylinder or chamber A through the cavity in the said main slide-valve e. The high-pressure steam in the cylinder or chamber A′ then passes into the cylinder or chamber A, forcing down the water contained therein until the diminishing steam-pressure and the increasing air-pressure re-establish an equilibrium. The main slide-valve e, still traveling to the left, then closes the communication between the cylinder or chamber A′ and the cylinder or chamber A and opens the latter to the steam-chest d, the high-pressure steam from which completes

the operation of ejecting the air and a small quantity of water from the air vessel or chamber B through the pipe *p* past the check or retention valve *q* and through the pipe *r* to the receiver C. The valve *n*, admitting the condensing-water to the cylinders or chambers A A′, is, as above described, worked off the extremity of the lever *l* of the rocking shaft *l′*, opposite to the lever *m*, which works the main slide-valve *e*, and consequently the said valve *n* moves in an opposite direction. Thus it will be seen that when the main slide-valve *e* opens the cylinder or chamber A to the steam the valve *n* will open the cylinder or chamber A′ to the injection-water, and vice versa. The injection-water is forced from the receiver C by the air-pressure therein. This injection-water causes condensation to take place, thus producing a vacuum or partial vacuum and permitting the water to return to its normal position in the cylinder or chamber A. In some cases suitable valves are provided to act as checks, and thus prevent this action from taking place too suddenly. The return of the said water causes the admission-valve B^2 to open under the atmospheric pressure and admit air to the interior of the said vessel or receptacle B′ from the exterior. When the said chamber or receptacle B′ is again full of air, the valve B^2 closes under the action of the spring B^3. This action takes place alternately in the said cylinders or chambers A A′ and air-vessels B B′. The air-vessels B B being of smaller dimensions than the front portions of the steam cylinders or chambers A A′, as hereinbefore mentioned, a certain proportion of the water is ejected with the air into the receiver C at each operation. This water is returned into the steam cylinders or chambers in the form of injection-sprays, thus maintaining the proper amount of water therein and preventing the overheating of the said water. By making the said air-vessels of smaller dimensions than the front portions of the said steam-cylinders I provide for ejecting or delivering all the air contained in the said vessels B B′ at each operation, thus securing a better vacuum therein on the return of the water to its normal position in the cylinders or chambers A A′, and thereby avoiding back-pressure that might be caused by the expansion of any compressed air remaining in the said vessels B B′. The main slide-valve *e* during its travel admits steam through the ports or ways *f′* alternately to either extremity of the small steam-cylinder *f*. By reason of the relative positions of the crank-disks *h* and *k* with regard to each other the crank *h* is on its dead-center when the main slide-valve *e* commences to open one of the ports *f′* to the steam. The said main slide-valve at the same time commences to open the other port *f′* to the exhaust through the cavity of the said main slide-valve *e* and one of the ports *d′* to the cylinder or chamber A or A′, in which there is a vacuum or partial vacuum, and into which the exhaust-steam from the small cylinder *f* passes. I thus provide for working the small steam cylinder or engine *f* as a condensing-engine, thereby greatly increasing its efficiency and economy in work. The said small steam cylinder or engine *f*, through the medium of the piston *g*, piston-rod *g′*, connecting-rod *h′*, toothed crank-disk *h*, crank-disk *k*, connecting-rod *k′*, lever *l*, rocking shaft *l′*, lever *m*, connecting-rods *m′* l^3, and valve-rods *e′* and *n′*, works the main slide-valve *e* and the injection-valve *n*, as will be readily understood. The fly-wheel *j* is rotated by means of the toothed crank-disk *h* and the pinion *i* at a considerable speed, owing to the relative proportions of the said disk *h* to the pinion *i*.

Although I have hereinbefore described the slide-valve *e* as being in the first instance moved to the right, it is obvious that the said slide-valve may be first moved to the left, in which case the operation of the cylinders or chambers A A′ and the air vessels or chambers B B′ is reversed—that is to say, the steam is first admitted into the cylinder or chamber A and the air compressed in the vessel or chamber B.

To prevent the receiver C from becoming too full of water, I sometimes lead a pipe from the pipe *r* or from the lower portion of the receiver C to the feed-pump of the boiler supplying the steam, or provide other suitable means for disposing of a portion of the water ejected into the said receiver from the cylinders or chambers A A′.

It is obvious that I can construct my apparatus of any suitable materials and form the same of any convenient shape or dimensions, and that my said apparatus can be employed either by itself or in conjunction with other machines for any purpose or purposes for which compressed air can be employed. Moreover, I have hereinbefore described a convenient method of carrying my said invention into practice. It is obvious that I can somewhat modify the construction of my apparatus without departing from the nature of my said invention. For instance, instead of two cylinders or chambers, I can employ any other suitable number of cylinders or chambers, and I can, if desired, dispense with the small steam cylinder or engine and provide other suitable means for actuating the main slide-valve for admitting steam and injection-water to the said cylinders or chambers. I can, moreover, obtain the water necessary for condensation from any other suitable source of supply instead of from the compressed-air receiver, as hereinbefore described.

What I claim is—

1. In an air-compressing apparatus, the combination of the steam and water cylinders A A′, connected at their lower ends by horizontal passages A^2, each having at one end a contracted passage and valve-seat *b*, communicating with the bottom of the forward cylinders, the float-valves *c*, located in said forward cylinders, the air-vessels B B′, located

above the rear cylinders and communicating therewith through contracted passages a', the main slide-valve e and injection slide-valve n, located above the forward cylinders for alternately admitting steam into the same and injecting water therein, and the compressed-air receiver C, communicating with the air-vessels B B', substantially as described.

2. In an air-compressing apparatus, the combination, with the steam and water cylinders A A' and the compressed-air receiver C, of the air-vessels B B', located above the rear cylinders and of less capacity than the steam-space of the forward cylinders, and the valved pipes p and connecting-pipe r, through which said air-vessels communicate with the compressed-air receiver, substantially as described.

3. In an air-compressing apparatus, the combination of the steam and water cylinders A A', the horizontal passages A^2, communicating with the lower ends of said cylinders, the float-valves c, the air-vessels B B', located above and communicating with the rear cylinders, the compressed-air receiver C, communicating with said air-vessels, the main slide-valve e and injection-valve n, located above the forward cylinders, and the engine-cylinder f, having a piston and connections for actuating said slide-valves, substantially as described.

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

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