(No Model.)

C. C. WORTHINGTON.

DUPLEX COMPOUND ENGINE.

No. 309,278. Patented Dec. 16, 1884.

Fig. 1.

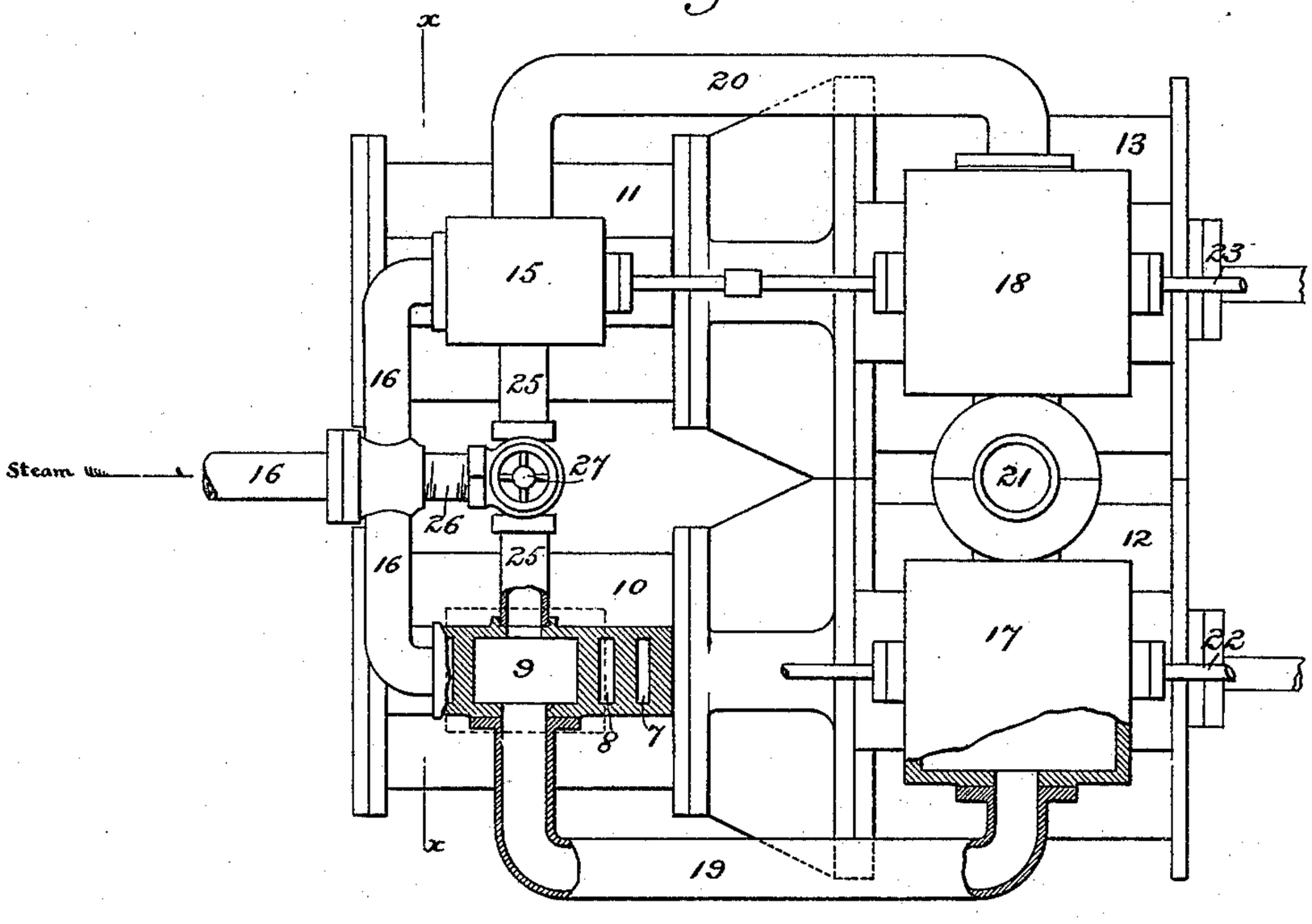


Fig. 2.

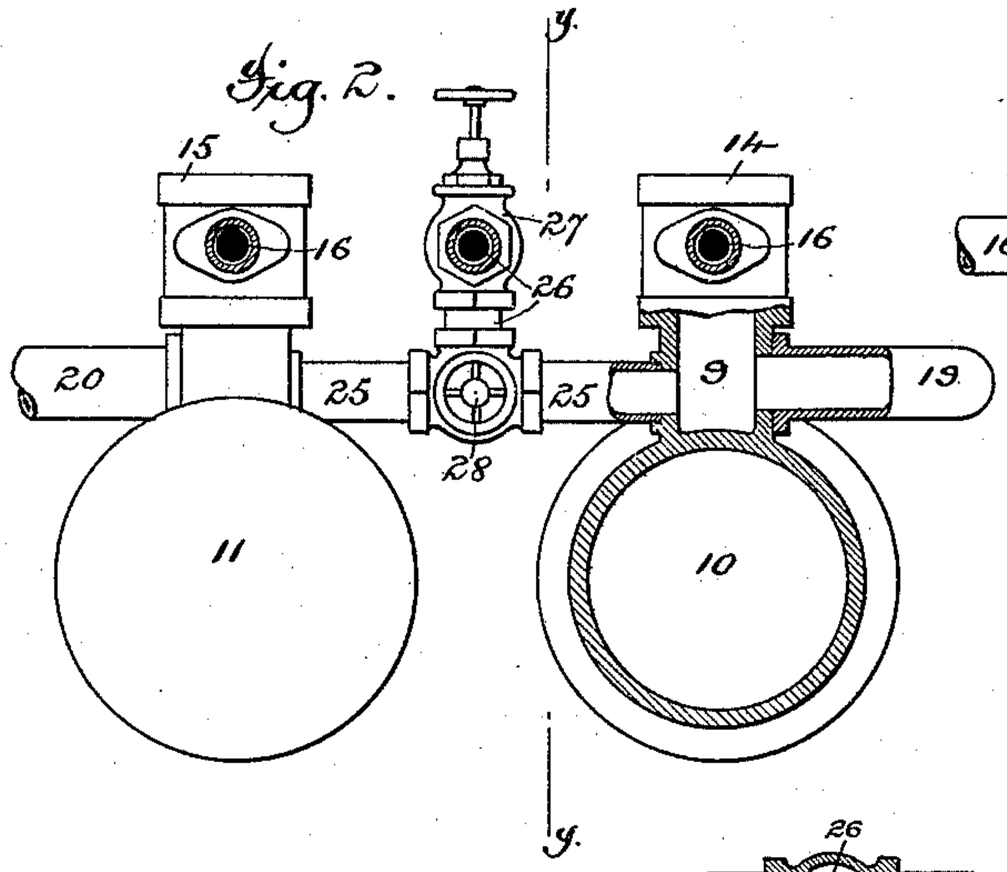
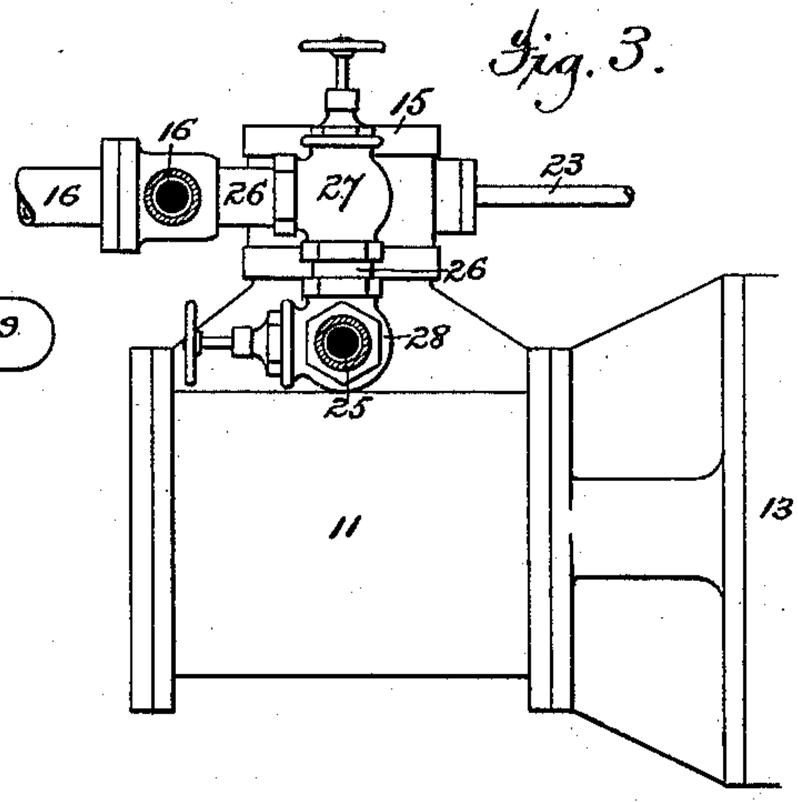


Fig. 3.



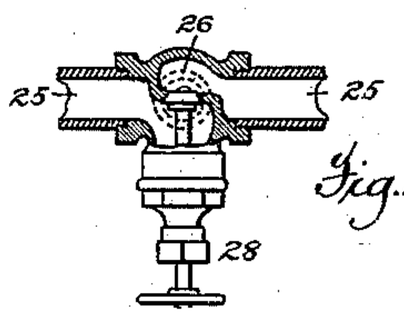


Fig. 4.

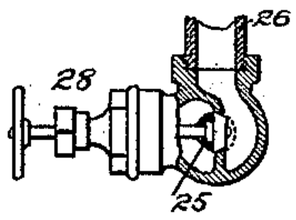


Fig. 5.

Attest:

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UNITED STATES PATENT OFFICE.

CHARLES C. WORTHINGTON, OF IRVINGTON, NEW YORK.

DUPLEX COMPOUND ENGINE.

SPECIFICATION forming part of Letters Patent No. 309,278, dated December 16, 1884.

Application filed March 8, 1884. (No model.)

To all whom it may concern:

Be it known that I, CHARLES C. WORTHINGTON, a citizen of the United States, residing in the city of Irvington, county of Westchester, and State of New York, have invented certain new and useful Improvements in Duplex Compound Engines, fully described and represented in the following specification, and the accompanying drawings, forming a part of the same.

This invention relates, generally, to what are known as "duplex engines;" but more particularly to that class of these engines in which each of the engines or sides of the duplex engine is provided with compound cylinders—that is to say, two cylinders of different sizes, the first or smaller of which receives steam direct from the boiler, and uses it at full pressure throughout the whole or nearly the whole stroke, while the second or larger cylinder receives the steam from the exhaust of the first, and uses it expansively. The engines of this class possess many advantages, and have gone into very extensive use, particularly for pumping and other like purposes when it is desirable that the engine should act directly upon the load. The especial adaptation of this class of engines for such uses is due to the fact that by thus combining two engines into a duplex engine a practically uniform and regular discharge of water can be secured, while, by reason of the compound cylinders, the economy due to the use of the steam expansively is obtained, and at the same time a practically uniform propulsion power is maintained throughout the entire stroke without the use of a fly-wheel or other heavy moving part. In order to secure the most economical results with an engine of this class, it is desirable that the size of the engine should be so graduated with relation to the work to be performed that when operating under its ordinary running conditions the full power of the engine will be but little in excess of the resistance offered by the constant load. It frequently happens, however, in operating these engines that for various reasons it is desirable that the engine should be able to temporarily perform an amount of labor considerably in excess of that which it is ordinarily called upon to perform, and consequently it is highly desirable that the engine should be capacitated to meet these temporary demands, even though to do it the steam must be temporarily used in an uneconomical manner.

It is the object of the present invention to provide means by which this result can be accomplished; and to this end the invention consists in providing connections by which the steam can, when desired, be admitted directly from the boiler to the exhaust-ports of the smaller cylinders, so as to pass to and act upon the pistons of the larger cylinders at its initial or boiler pressure throughout their entire stroke, instead of expansively and at a reduced pressure. It will readily be seen that when the steam is thus admitted to the larger cylinders at its initial or boiler pressure the pressure of the steam upon both sides of the pistons of the smaller cylinders will be equal, so that said smaller pistons will be constantly in equilibrium and will consequently perform no work; but it will also be observed that the relative areas of the smaller and larger pistons are such that the increased pressure thus applied to the larger pistons will very much more than compensate for the loss of the smaller pistons, so that when the engine is operating in this manner it will develop a much greater power than when operating in the ordinary manner, although to develop this increased power it will sacrifice the economy due to the use of the steam expansively.

In the accompanying drawings, Figure 1 is a plan view partly in section of an ordinary duplex compound engine embodying the invention. Fig. 2 is a vertical section taken upon the line *x x* of Fig. 1, one of the smaller cylinders being shown in elevation. Fig. 3 is a vertical section taken upon the line *y y* of Fig. 2; and Figs. 4 and 5 are details, to be hereinafter referred to.

Referring to said drawings, it is to be understood that the engine therein shown consists of two cylinders, 10 11, which receive steam direct from the boiler, and in which the steam acts at its full pressure throughout the whole or nearly the whole stroke of the pistons, and two larger cylinders, 12 13, into which the steam passes from the exhaust of the first cylinders, and in which it acts expansively, after which it is exhausted into a condenser or into the open air, the whole forming an ordinary duplex compound engine. The

cylinders 10 11 are provided with the usual steam-chests, 14 15, into which the steam is admitted through a pipe, 16, direct from the boiler, and the cylinders 12 13 are also provided with similar steam-chests, 17 18, which are connected by pipes 19 20 with the exhaust-ports of the first cylinders, the exhaust-ports of these last cylinders being provided with a pipe, 21, leading to a condenser (not shown) or to the open air.

The induction and exhaust ports 7 8 9 of the several cylinders are of the usual construction, and are controlled by valves of the common form, the rods 22 23 of which are provided with the usual connections, by which the valves of each side of the engine are operated by the main piston-rod of the opposite side, as in the well-known duplex pumping-engine manufactured by Henry R. Worthington.

In order to secure a steady and uniform action it has been found desirable in this class of engines to so adjust the valve-operating mechanism that just before the pistons of each side of the engine complete their stroke in either direction the valve mechanism will be operated so as to start the pistons of the opsite side of the engine upon their stroke in the same direction.

Although by means of compound cylinders arranged as just described the steam can be used expansively and yet each side of the engine be caused to develop a comparatively uniform propulsive power throughout its entire stroke, yet it has been found in practice that owing to condensation, loss by expansion and other causes, even with cylinders so arranged, the power developed at the beginning of the stroke will be somewhat in excess of that developed at the end of the stroke, thereby causing a more or less spasmodic action of the engine. To correct this action these engines are commonly provided with what is known as a "cross-exhaust," which consists of a pipe, as 25, arranged to connect the exhaust-ports 9 of the two smaller cylinders. By reason of this connection it will be seen that the steam exhausted from both the cylinders 10 11 is allowed to circulate freely between the steam-chests 17 18 of the expanding-cylinders 12 13. It will also be seen that by reason of the relative movements of the pistons and valves of the two sides of the engine as just described as the pistons of each side of the engine are nearing the end of their stroke, and consequently losing power, the exhaust-port of the smaller cylinder of the opposite side will be opened so as to admit a fresh quantity of steam into the pipes 19 20 25 and steam-chests 17 18, and thereby raise the pressure in said pipes and chests and give an additional impulse to the pistons at the end of their stroke.

In order to permit the steam to pass directly from the boiler to the cylinders 12 13 when it is desired to temporarily increase the capacity of the engine as before explained the pipe 16 is provided with a branch, 26, which communicates with the cross-exhaust pipe 25, and thus affords means by which the steam may, when desired, be allowed to pass directly from the boiler to the exhaust-ports 9 of the cylinders 10 11, and thence through the pipes 19 20 to the steam-chests 17 18 and the cylinders 12 13. The branch pipe 26 is provided with an ordinary throttle-valve, 27, by which the communication between the pipes 16 25 may be shut off when the engine is operating in the ordinary manner, and the pipe 25 is provided with a valve, 28, which may be constructed and arranged in any suitable manner—as, for example, as shown in Figs. 4 and 5, which are, respectively, a horizontal and vertical section of the valve shown in Figs. 2 and 3—so as to close the cross-exhaust when desired.

The operation of the engine thus organized is as follows: If the engine is to perform only the ordinary labor for which it is intended, the valve 27 will be closed, so as to shut off communication between the pipes 16 25. The throttle-valve of the pipe 16 being then opened, the steam will pass from the boiler to the steam-chests 14 15, and will enter the cylinders 10 11, in which it will act at the full boiler-pressure throughout the whole, or nearly the whole, stroke of the pistons, after which, as the pistons in said cylinders commence their return-stroke, the steam already in the cylinders will pass through the pipes 19 20 and enter the steam-chests 17 18, from which it will pass to the cylinders 12 13, where it will act expansively upon the pistons of said cylinders so as to augment the power exerted by the steam acting directly upon the small pistons of the cylinders 10 11, and so the operation is repeated, the steam which enters the cylinders 10 11 at each stroke being exhausted into the steam-chests 17 18 at the next stroke. After acting expansively in the cylinders 12 13 the steam is exhausted through the pipe 21 into the condenser or into the open air.

The relative size of the cylinders 10 11 and 12 13 may be varied from that shown in the drawings, the proportions therein shown being only an approximation of the true proportions for the purpose of illustrating the principle and operation of the invention. These cylinders will, however, be so proportioned that the steam, acting upon the pistons of the two cylinders as just described, will exert a substantially uniform propulsive power throughout the entire stroke of the engine, and in order to secure the greatest economy in the use of the steam the pistons of the cylinders 12 13 will be of at least twice the area of the pistons of the cylinders 10 11. From this it will be seen that if the steam is allowed to enter the larger cylinders at its full or boiler pressure these cylinders alone will develop a much greater power than all four of the cylinders will develop when acting in the regular way, as already described, although in doing it the economy of using the

steam expansively will be sacrificed. Whenever, therefore, it becomes desirable for any reason to temporarily increase the capacity of the engine, the valves 27 28 will be opened, so that the steam will pass directly from the pipe 16 through the pipes 26 25 to the exhaust-ports 9 of the cylinders 10 11, and thence through the pipes 19 20 to the steam-chests 17 18, thus causing the steam to be supplied at its full or boiler pressure to both the cylinders 10 11 and 12 13. When this is done, the pressure upon both sides of the pistons of the cylinders 10 11 will of course be the same, so that said pistons will always be in equilibrium and will consequently develop no power; but the increased pressure upon the larger pistons of the cylinders 12 13 will very much more than compensate for this and thus have the effect of actually increasing the power of the engine.

I am aware that it is not new to provide a duplex engine with a cross-exhaust, and also that it is not new, broadly speaking, to admit steam directly from the boiler to the expanding-cylinders of a duplex compound engine. It is, however, so far as I am aware, new to utilize the cross-exhaust for this purpose.

What I therefore claim is—

1. The combination, with the two sides of a duplex compound engine and the cross-exhaust thereof, of connections by which steam can be admitted directly from the boiler to said cross-exhaust, substantially as described.

2. The combination, with the pipe 16 leading from the boiler, and the cross-exhaust pipe 25, of the pipe 26, connecting the two and provided with a valve, 27, substantially as described.

3. The combination, with the pipe 16, leading from the boiler, and the cross-exhaust pipe 25, provided with a valve, 28, of the pipe 26, connecting the two and provided with a valve, 27, substantially as described.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

CHAS. C. WORTHINGTON.

Witnesses:

STILLMAN H. STORY,

JACOB BRANDT.