L. J. CLAPP.

COMPRESSOR.

APPLICATION FILED OCT. 7, 1918.

1,435,135. Patented Nov. 7, 1922.

3 SHEETS—SHEET 1.

Fig. 1.

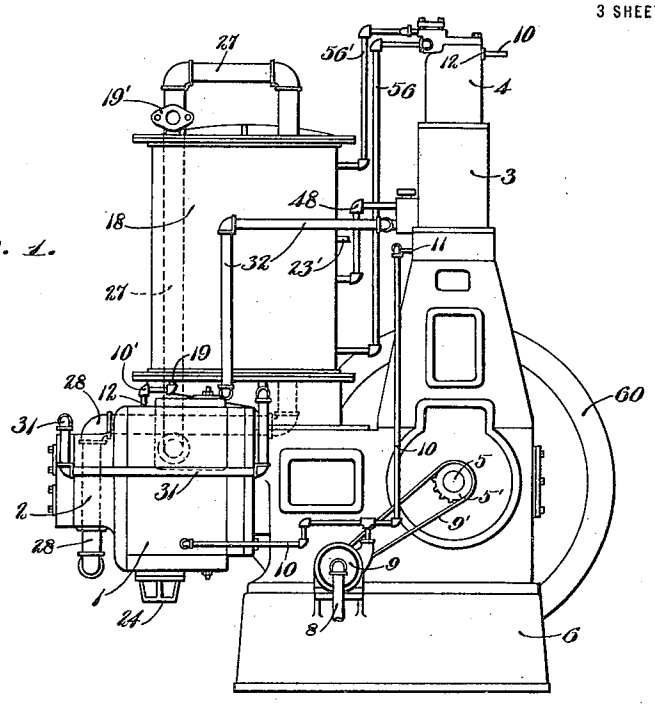
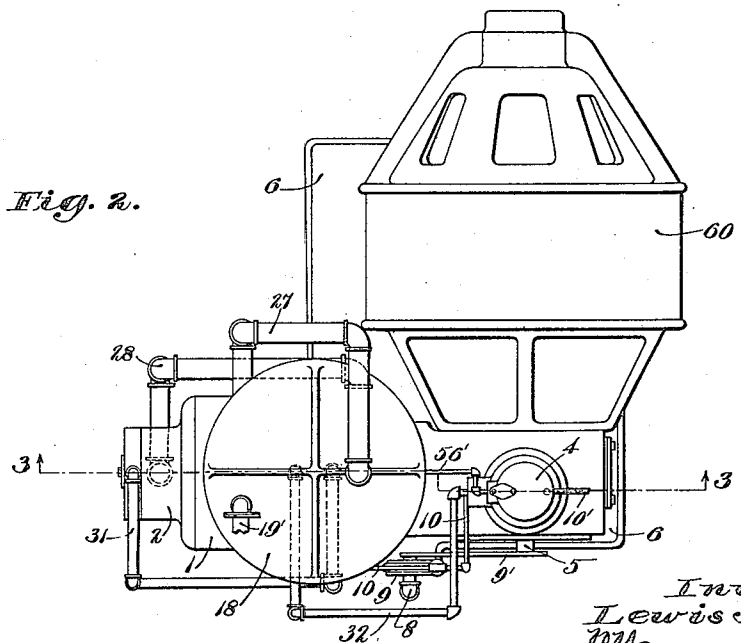


Fig. 2.



Inventor:
Lewis J. Clapp.
By Arthur L. Lahr.
Atty.

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3 SHEETS—SHEET 2.

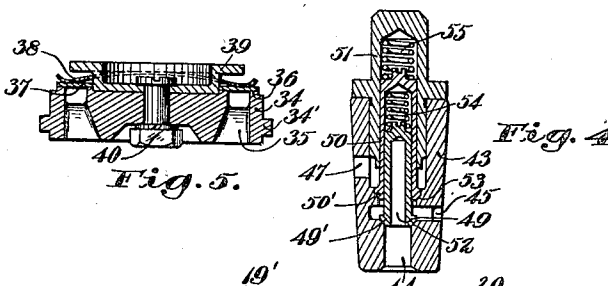


Fig. 5.

Fig. 4.

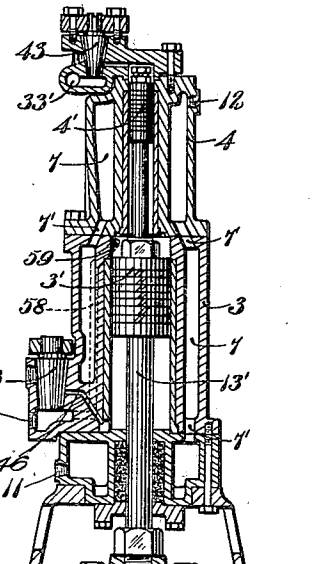


Fig. 3.

Inventor:
Lewis J. Clapp.
by Arthur L. Colvin
Atty

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3 SHEETS—SHEET 3.

Fig. 6.

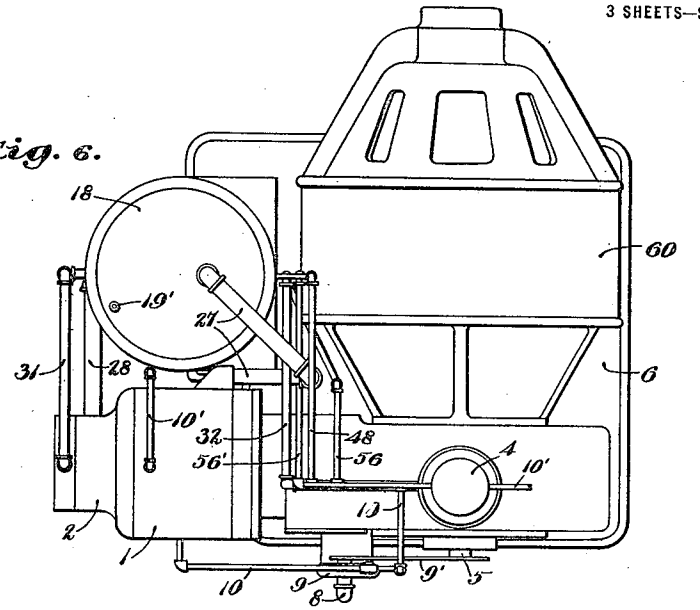
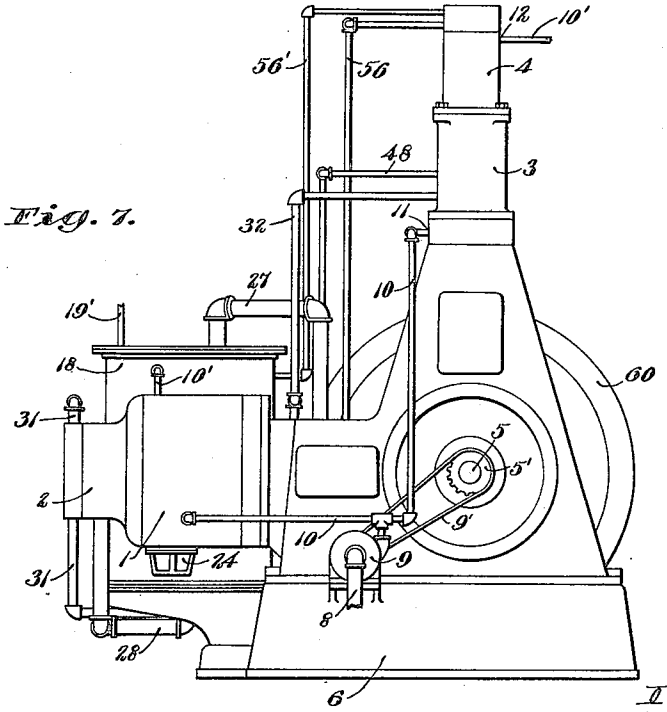


Fig. 7.



Inventor.

Lewis J. Clapp.

by Chadwick & Calvert

Atty.

Patented Nov. 7, 1922. 1,435,135

UNITED STATES PATENT OFFICE.

LEWIS JOSEPH CLAPP, OF CLAREMONT, NEW HAMPSHIRE, ASSIGNOR TO SULLIVAN MACHINERY COMPANY, A CORPORATION OF MASSACHUSETTS.

COMPRESSOR.

Application filed October 7, 1918. Serial No. 257,134.

To all whom it may concern:

Be it known that I, LEWIS J. CLAPP, a citizen of the United States, residing at Claremont, in the county of Sullivan and State of New Hampshire, have invented certain new and useful Improvements in Compressors, of which the following is a full, clear, and exact specification.

This invention relates to compressors, and particularly to the type of multi-stage compressor used on warships for forcing air under a high pressure, usually about three thousand pounds, to a torpedo tube for discharging a torpedo, the principal objects of the present invention being to provide a compressor which will produce this high compression, which will occupy a minimum of floor space, which will have a low center of gravity, and whose operation is accompanied by a minimum vibration. These and other objects and advantges of my improved construction will, however, hereinafter more fully appear.

In the accompanying drawings I have shown, for purposes of illustration, certain specific embodiments which my invention may assume in practice.

In these drawings,—

Fig. 1 is a side elevation of the complete apparatus.

Fig. 2 is a plan view thereof.

Fig. 3 is a sectional view on the line 3—3, Fig. 2, with parts omitted.

Fig. 4 is a longitudinal sectional view of one of the combined inlet and exhaust valves of the high pressure stages.

Fig. 5 is a sectional view of one of the inlet and exhaust valves used in the low pressure stages.

Fig. 6 is a plan view of a modified form of my compressor.

Fig. 7 is a side elevation thereof.

Referring to the drawings, I have there shown for the purpose of illustrating the principal features of the invention, a four stage compressor having two horizontal low pressure stages 1 and 2, and two high pressure stages 3 and 4 preferably vertically disposed over a crank shaft 5 in the same vertical plane with the stages 1 and 2 in such a manner that the whole forms a single unit mounted on a relatively small base 6.

Each of the compressor stages or cylinders is provided with a water jacket 7, the water jackets being connected in pairs by ducts 7′ cored in the cylinder walls in such a manner that the four jackets constitute two cooling units, one for each pair of compressor cylinders. It is thus seen that I have simplified the cooling system so that but one inlet 11 and one outlet 12 is required for each cooling unit. This construction is particularly adapted for use in the restricted space available in warships and especially the smaller craft, as submarines, when it is essential that the length and size of external piping be reduced to a minimum. The cooling medium is supplied to the jackets through an intake pipe 8 and distributing pipes 10, and is returned to a cooling tank or radiator (not shown) through pipes 10′, the flow being positively maintained during the operation of the compressor by a pump 9 driven by a chain 9′ which passes over a sprocket wheel 5′, mounted on one end of the crank shaft 5.

The pistons 1′, 2′, 3′, and 4′ of the several cylinders are preferably mounted in pairs in the low and high pressure stages, and in the form of my improvement shown herein, these pairs are mounted on piston rods 13, 13′, the latter being actuated through wrist pins 14, 14′ and pitmen 15, 15′ by a single wrist pin 16 on the crank shaft 5. A single counterweight 17 is so attached to the crank shaft that it counterbalances the inertia forces of the piston in all the cylinders, for, by placing the cylinders at an angle of 90° to each other, the two horizontal positions of the weight correspond to the two extreme horizontal positions of the pistons 1′, 2′, while the two vertical positions of the weight correspond to the extreme vertical position of the pistons 3′, 4′. In Fig. 3 the pistons 3′, 4′ are shown at about their highest point, while the counterweight 17 is about to pass through its lowest possible position, it being clear that the counterweight and pistons produce equal and opposite strains on the crank shaft, the driving force of the shaft being absorbed by the operation of compressing the air.

In the form of my invention illustrated in Figs. 1, 2, and 3, I have provided a light sheet metal cooling tank 18 mounted on the low pressure cylinders, the tank being provided with a fluid (preferably water) inlet 19 and an outlet 19′, it being understood that the tank may be supplied with water either in series with one or both of the water jackets 7 (see Fig. 1), or by a different circulating system. Concentrically disposed in

the cooling tank 18 are four helical coils 20, 21, 22, and 23, the first three coils in the order named serving as intercoolers between the several stages taken in their order of compression, while the last named coil serves to cool the fluid after it has been finally compressed and before it passes to the air receiver or torpedo tube (not shown), it being clear from the disposition of the several pipes leading to and from the cooling coils that the air always flows downward through the coils so as to carry the oil and water which condenses in these coils to sumps, one of which is shown at 18′ at the outlet end of the coil 20.

The air to be compressed is admitted through a screened intake 24, passes through an intake valve 25 into the low pressure cylinder 1 on the suction stroke therein, and on the compression stroke is forced out through a discharge valve 26 and pipe 27 to the largest helical cooling coil 20. From the lower end of this coil the air is conducted through a short pipe 28 to the cylinder 2, the air passing in through an inlet valve 29 and out through an outlet valve 30, the action being identical to that in the cylinder 1. The pipe 31 conducts the air from the second stage compressor cylinder to the vertical intake pipe of the helical cooling coil 21, as is clearly shown in Fig. 1. The flow from this point is through a pipe 32 to an inlet 33 of the third stage cylinder 3, from this cylinder through a pipe 48 to the coil 22, from the coil 22 through a pipe 56 to the intake 33′ of the highest stage cylinder 4, and from this cylinder to the coil 23 through a pipe 56′. The air as finally compressed and cooled, is conducted from the coil 23 by a pipe 23′ to a receiver or supply line (not shown).

In the modification shown in Figs. 6 and 7, the different parts and their connections are the same as those just described, except that the intercooler has been placed beside the low pressure cylinders instead of on them, so as to lower the center of gravity of the machine. As these compressors are adapted to be used on torpedo boats and submarines, it is evident that the lowering of the position of a tank containing several hundred pounds of water and metal is quite beneficial.

In order that this apparatus may be placed in a minimum of space, the pipes and their points of connection with the cooling coils and cylinders have been so placed that the majority of the pipes are relatively short and do not project from the side of the machine (note especially Fig. 6). For example, the ends of the coils 22 and 23 are attached to the tank on the side thereof adjacent the high pressure cylinders, and the pipes 32, 48, 56, and 56′ are so disposed relative thereto that the cylinders 3 and 4 may be taken apart for inspection without removing the pipes, it only being necessary to disconnect the pipes from the cylinders.

In order that this apparatus may be especially adapted for use on the smaller warships, such as submarines, the low pressure stages or cylinders have been provided with the same type of valve for the inlets and outlets, it being apparent that this construction conserves the restricted storage space provided on the smaller ships, by necessitating the carrying of fewer spare parts which are interchangeable with the parts on any of these four valves. This valve is clearly shown in Fig. 5, and includes a bridge 34 cored out, as shown at 35, for the passage of the air, an annular seat 36 being formed on one side thereof. An annular steel valve 37 rests on and is held against this seat by a disk spring 38, the latter being held under compression by a guide 39 and bolt 40. An annular flange 34′ is formed on the bridge and is adapted to contact with a seat or shoulder on the intake or the exhaust passage of both cylinders, it being understood that the position of the valve in the intake passages is the reverse of the position of that in the exhaust passages of these cylinders. It should also be noted that these valves are so placed in the cylinders 1 and 2 that it is not necessary to remove the water jackets nor to in any way dismantle these cylinders in order to inspect these valves or replace them, the engineer having only to remove a plug or cap 25′, and a bolt 41 (note cylinder 2) or a bolt 41 and yoke 42 (note cylinder 1), in order to remove bodily the valve, this construction being of particular advantage in adjusting the valve bridge against the seat formed on the cylinder, for, if the flange 34 or its cooperating shoulder should become pitted, or should leakage occur due to the use of an improper lubricant or other cause, the corresponding surfaces may be reground, and the flange adjusted to its seat through a movement of the bolt 41.

A combined intake and exhaust valve 43 is used on each of the intakes 33 and 33′, but for the sake of illustration I will describe this valve and its operation only in connection with the cylinder 3 and the passages connected therewith, the valve being shown in section in Fig. 4. The intake passages for this cylinder include ports 44 and 45, in the valve 43, and a passage 46 cored in the cylinder wall. The outlet passages include the passage 46, port 45, and a third port 47 also carried by the valve 43. The valve control means consists of three concentric sleeves 49, 50, and 51, the first two being movable and carrying at their lower extremities valve heads 49′ and 50′, respectively, adapted to rest on the valve seats 52 and 53 to control the flow through the ports

44 and 47, the last named sleeve being held in a fixed relation to the valve 43. A light coiled spring 54 and a relatively heavy coiled spring 55 are inserted between the sleeves 49 and 50 and 51, respectively, to normally hold the sleeves 49 and 50 in their lowest positions against the seats 52 and 53.

During a suction stroke in the cylinder 3, the sleeve 49 is forced upwardly against the tension of the spring 54, while the spring 55 retains the sleeve 50 against the valve seat 53, to permit an inflow of air from the pipe 32. During a compression stroke, the sleeve 49 is forced against its seat by the spring 54 and air pressure, and the sleeve 50 is moved upward to permit an outflow of compressed air to the pipe 48. By this construction it is possible to remove the combined inlet and exhaust valve of either cylinder, 3 or 4, as a unit without detaching any of the pipes or dissembling any part of the cylinders.

Any suitable motor 60 may be used for driving the compressor, but in the preferred embodiment herein shown, the motor is an electric motor mounted on the same base as the compressor, thereby avoiding the difficulty of alining the parts when installing the machine, it being further noted that in this construction the rotor of the motor serves as a flywheel, thus conserving the space and weight that the ordinary flywheel demands. Attention is also directed to the fact that, because of the angular placing of the cylinders and the counterbalancing action of the single counterweight 17, a very small flywheel will serve to produce an even turning movement quite free from vibration.

A breather space 57 is provided in the head of the cylinder 1 and communicates with the intake 24 to prevent the compression of air between the pistons during the normal action of the compressor. A second breather passage or set of passages 58 (see Fig. 3) connects an opening 59 in the upper end of the cylinder 3 with the intake 33 for the same purpose.

By placing the two series of cylinders at an angle of 90° to each other I obtain a marked improvement in the operation of the compressor, for when one set of pistons is at one end of their path the other set is substantially midway of their path, so that the impulses, due to the heavy loads developed in the last half of each piston stroke when the compression in each cylinder is at or near a maximum, occur alternately at regular intervals. Since the work done by the different pistons is virtually the same, and since the pistons are operated in alternating, equal periods, or in a split phase relation, the load on the compressor motor is constant. By split phase, I mean that the phase of operation of one series of cylinders is made to overlap the phase of operation of the other series of cylinders in such a manner that the corresponding points of the phases occur periodically or at equal intervals. Since the work done by the different stages or cylinders is approximately the same, the cylinders may be interchanged where the question as to the resulting height of the center of gravity is not important; for example, the second and fourth stages may be alined to form one series and the first and third stages alined to form the second series.

It is thus seen that I have devised a simple and compact multi-stage compressor which, because of the mounting of the pitmen and the counterweight, is quite free from vibration, which occupies a minimum of floor space, and which, because of the low horizontal placement of the large cylinders, has a low center of gravity.

While I have herein shown and described for the purpose of illustration one specific form of the invention, it is to be understood that the same has been shown for illustrative purposes only and that extensive deviations may be made from the disclosed form thereof without departing from the spirit of the invention.

What I claim as new and desire to secure by Letters Patent is:

1. In a compressor, in combination, a pair of coaxially arranged cylinders communicating at their adjacent ends, a pair of pistons therein, a common piston rod for said pistons, a second pair of coaxially arranged cylinders communicating at their adjacent ends and provided with pistons having a common piston rod, said first and second mentioned pairs of cylinders being arranged with their axes at an angle, inlet and exhaust valves arranged in said cylinders at the remote ends thereof, and means including a single counterbalancing means for causing reciprocation of said pistons.

2. In a compressor, in combination, a plurality of series of compressor cylinders arranged at an angle to each other, pistons in said cylinders, common rods for the pistons of each series, and a single crank arranged at the vertex of said angle, each of the cylinders of a series being arranged at the same side of the crank, and said single crank actuating said several piston rods.

3. In combination, a low and an intermediate pressure compressor cylinder arranged in horizontal position, a second intermediate and a high pressure cylinder arranged at right angles to said first mentioned cylinder, pistons in said cylinders, and a crank arranged at the intersection of the axes of said cylinders and cooperating with the pistons thereof.

4. In combination, a plurality of series of alined compressor cylinders comprising a pair of cylinders arranged in horizontal po-

sition, a pair of cylinders arranged in vertical position, a crank shaft arranged at the intersection of the axes of said cylinders extended, and pistons in said cylinders actuated by said crank shaft.

5. In a compressor, in combination, a series of coaxially arranged cylinders, a second series of cylinders coaxially arranged with respect to each other but disposed with their axis at an angle to the axis of said first named cylinders, pistons in said cylinders, driving means therefor, and an intercooler located in the angle between said cylinders.

6. In a compressor, in combination, a pair of horizontally arranged cylinders, a pair of vertically arranged cylinders, a piston in each of said cylinders, a separate piston rod for each of said pairs of cylinders, a single crank located at the intersection of the axes of said piston rods, and an intercooler having cooling elements interposed between each pair of cylinders and arranged in the angle formed by said pairs of cylinders.

7. In a multistage compressor, in combination, a pair of compressor cylinders constituting different stages arranged in horizontal alinement, a piston in each of said cylinders, a common piston rod for said pistons, a second pair of cylinders constituting other stages of the compressor, a piston in each of said second mentioned cylinders, a common piston rod therefor, a crank located at the intersection of the axes of said rods extended, connecting rods between said crank and said piston rods, and an intercooler located in the angle between said cylinders.

8. In a compressor, in combination, two pairs of coaxial cylinders communicating with each other at their adjacent ends and constituting different stages, said pairs being arranged at an angle to each other, pistons in each of said cylinders, valve means for said cylinders at the remote ends thereof, single piston rods connecting the pistons of each pair of cylinders for simultaneous action, and common driving means for said piston rods, the spaces between each pair of pistons being vented to the intake of the lower stage member thereof.

9. In combination, a plurality of series of compressor cylinders, each of said series comprising a pair of coaxially arranged cylinders communicating with each other at their adjacent ends and provided at their opposite ends with inlet and discharge valves, pistons in said cylinders, and a vent for the space between said pistons, said series of cylinders being arranged at right angles to each other and said pistons being actuated by a common crank shaft located at the apex of said angle.

In testimony whereof I affix my signature.

LEWIS JOSEPH CLAPP.

Certificate of Correction.

It is hereby certified that in Letters Patent No. 1,435,135, granted November 7, 1922, upon the application of Lewis Joseph Clapp, of Claremont, New Hampshire, for an improvement in "Compressors," errors appear in the printed specification requiring correction as follows: Page 3, line 5, after the numeral "50" insert a comma; same page and line, before the numeral "51" insert the numeral and word *50 and;* and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 5th day of December, A. D., 1922.

[SEAL.] KARL FENNING,

Acting Commissioner of Patents.