No. 883,347. PATENTED MAR. 31, 1908.

E. W. ROBERTS.

COMPRESSOR.

APPLICATION FILED SEPT. 29, 1906.

2 SHEETS—SHEET 1.

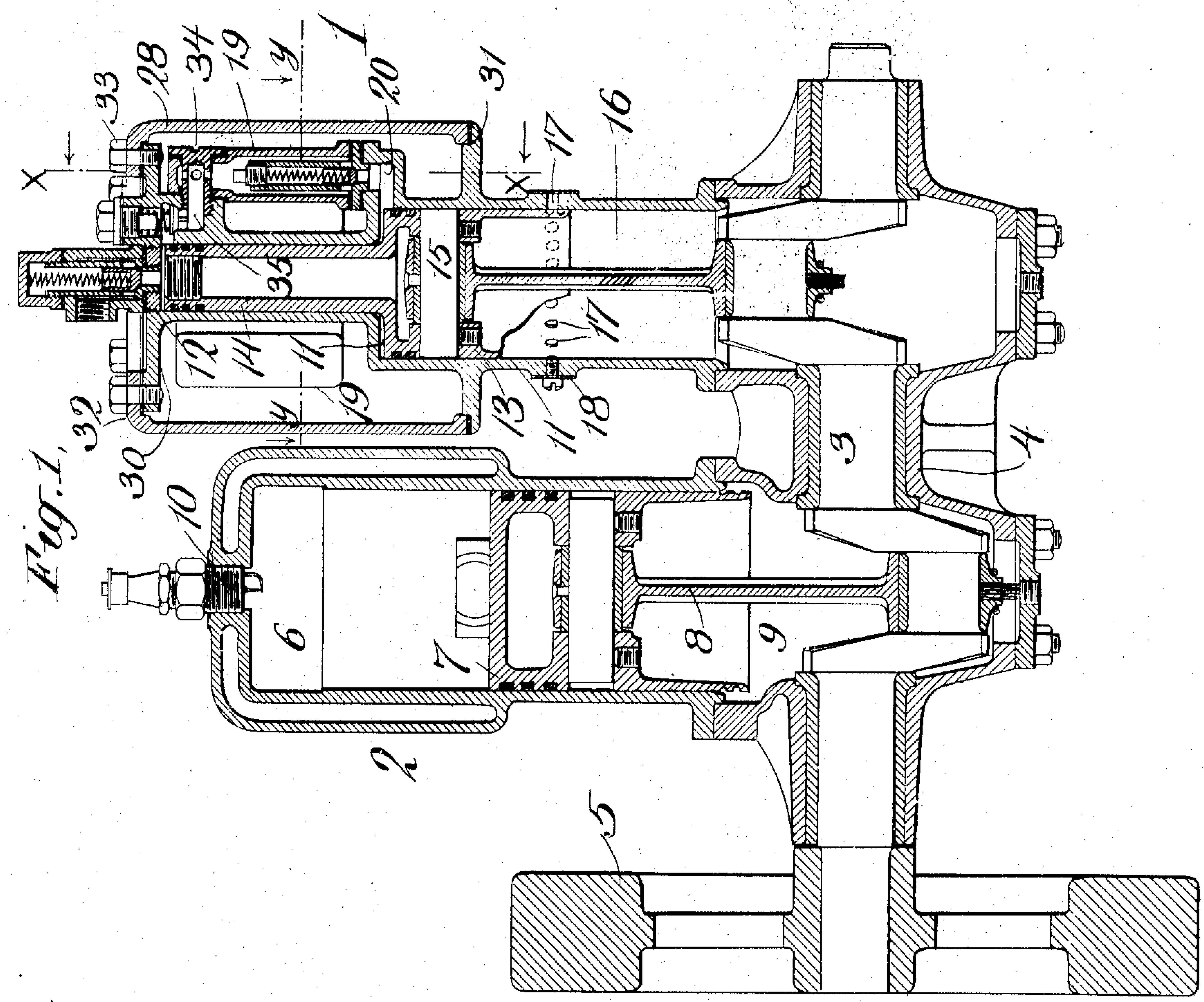

Fig. 1.

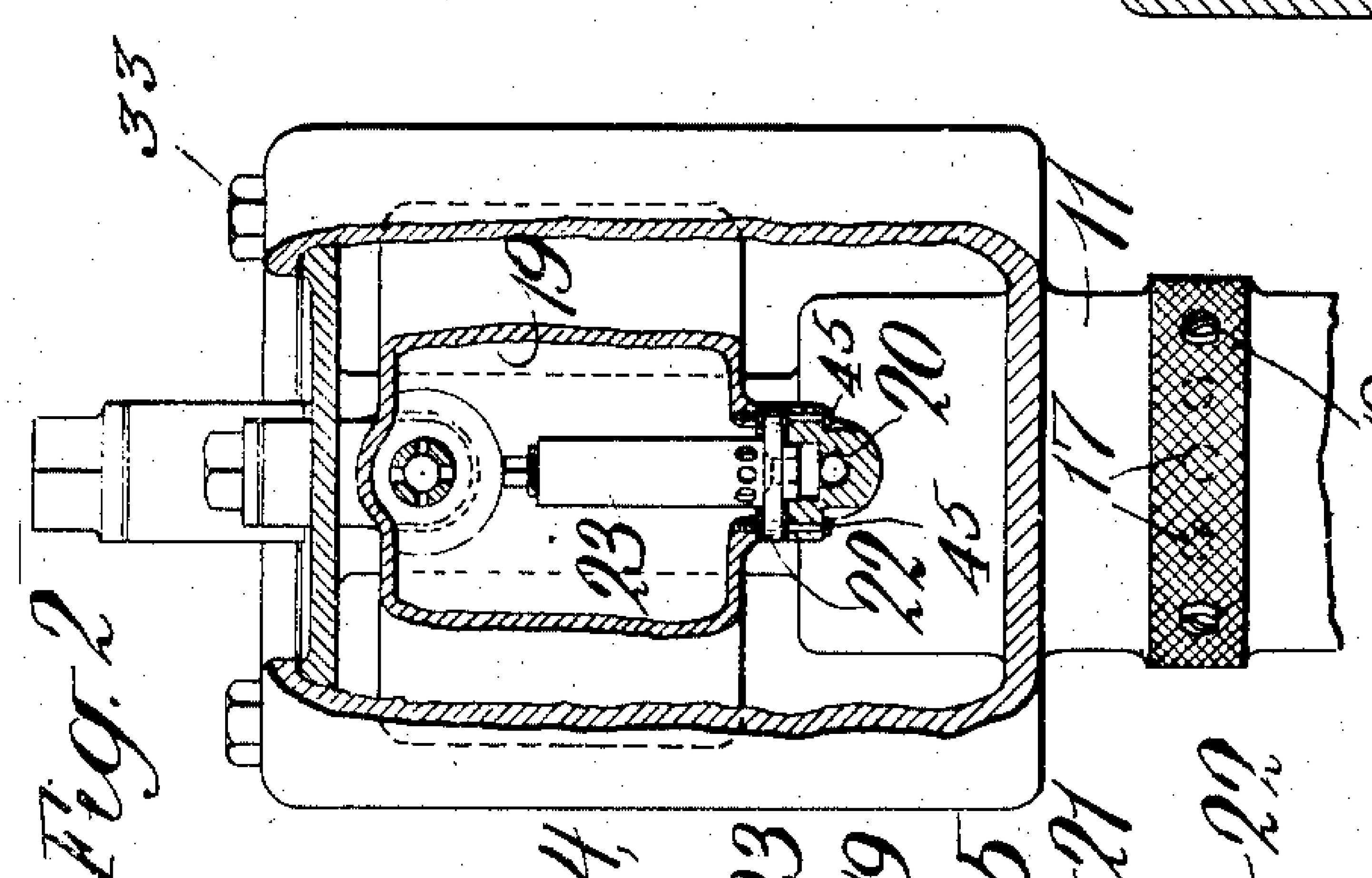

Fig. 2

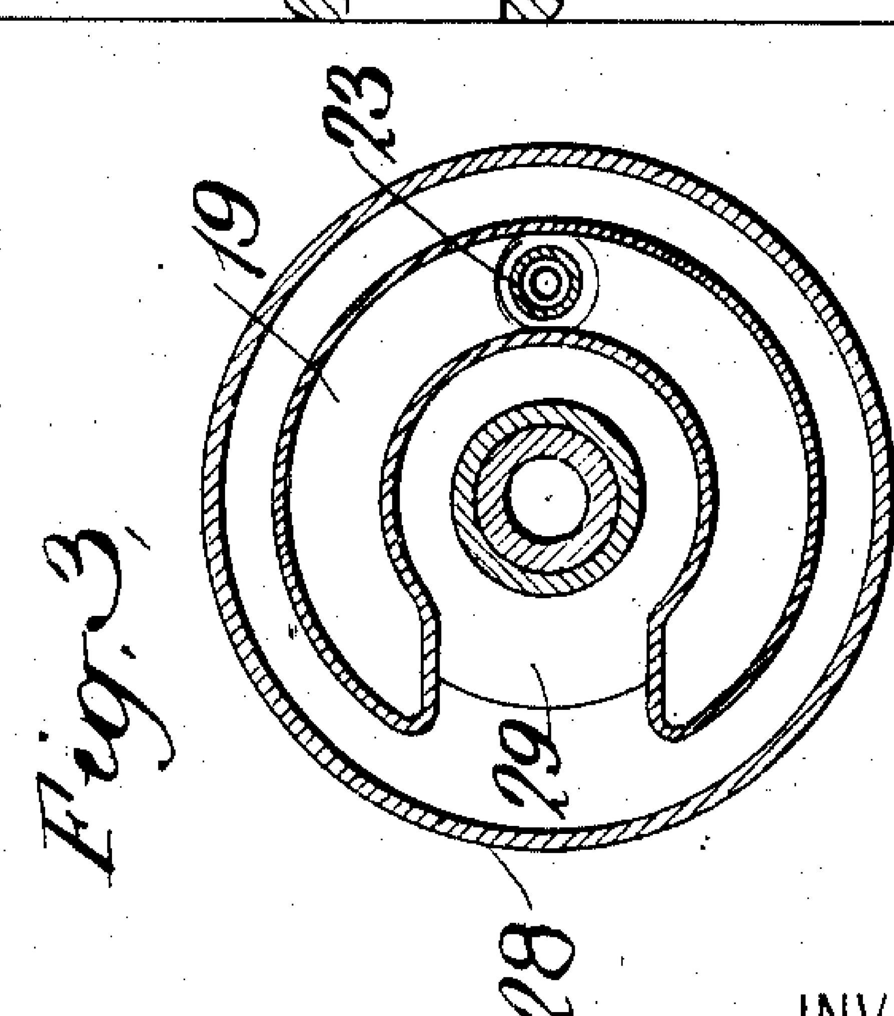

Fig. 3.

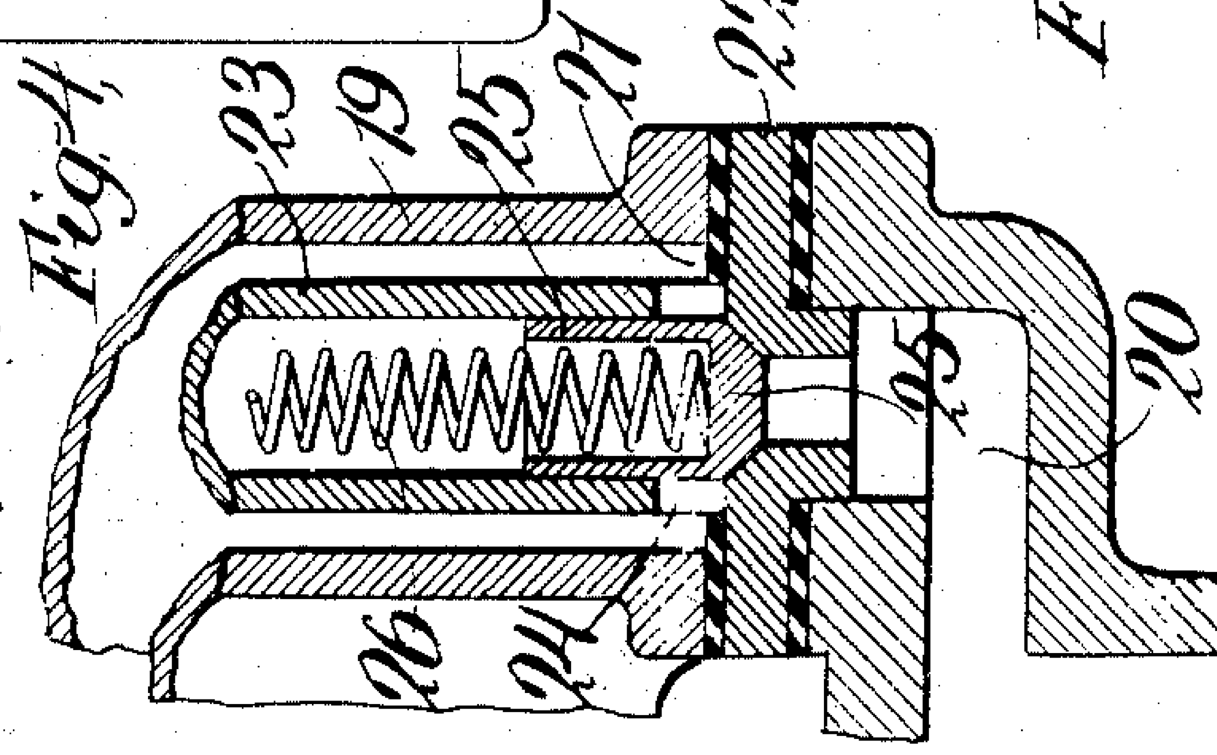

Fig. 4.

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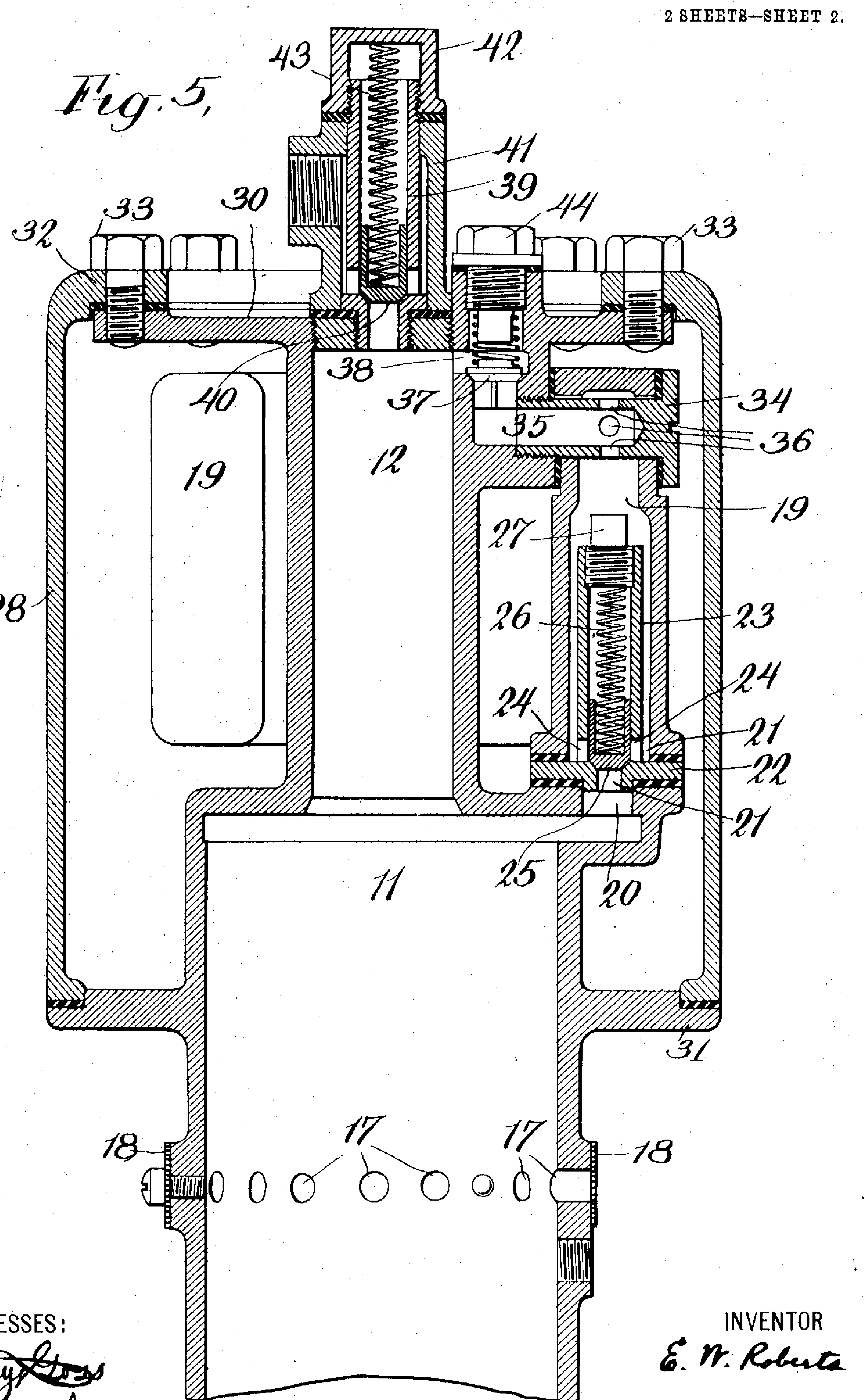

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COMPRESSOR.

No. 883,347. Specification of Letters Patent. Patented March 31, 1908.

Application filed September 29, 1906. Serial No. 336,755.

To all whom it may concern:

Be it known that I, EDMUND W. ROBERTS, a citizen of the United States, residing at Clyde, in the county of Sandusky and State of Ohio, have invented certain new and useful Improvements in Compressors; and I do hereby declare the following to be a full, clear, and exact description of the same, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to air and gas compressors, and particularly to multi-stage compressors, and comprises novel arrangements of the low pressure and high pressure cylinders and pistons, intercooler, water jacket, and valves, as hereinafter more fully described and particularly pointed out in the claims.

The objects of my invention are to improve and simplify air and gas compressors, to adapt the same to run at high speeds while compressing to high pressures, to improve the arrangement of compression cylinders and intercooler and the means for cooling these parts, to improve the valves of such compressors, and generally to produce a simple and compact compressor, small in proportion to its capacity, capable of direct connection to a high speed motor and of operating at the speed of such motor, possessing few parts, and free from liability to derangement.

I will now proceed to describe my invention with reference to the accompanying drawing, showing one form of compressor embodying my invention, and will then point out the novel features in claims.

In the said drawing: Figure 1 shows a central vertical section of my improved compressor, and of the cylinder and piston and crank case of a driving motor therefor, the motor shown being a high speed two cycle explosion engine. Fig. 2 shows a vertical section through the water jacket, intercooler, and low pressure discharge valve on the line *x—x* of Fig. 1. Fig. 3 shows a horizontal section through the water jacket, intercooler, high pressure cylinder and piston and housing of the low pressure discharge valve, said section taken on the line *y—y* of Fig. 1. Fig. 4 shows a central vertical section of the low pressure discharge valve, housing, and associated parts. Fig. 5 shows a central vertical section of the compression cylinders and associated parts (the pistons omitted) on a larger scale than Fig. 1.

The machine shown in Fig. 1 comprises a compressor 1 and explosion motor 2, having in common a crank shaft 3, an engine bed 4, and fly-wheel 5. The explosion motor 2 comprises a water jacketed working cylinder 6, piston 7, connecting rod 8, closed crank case 9 and electric igniter 10—all these parts constructed and arranged as customary in the best type of high speed two cycle explosion engine practice; and since I claim no novelty, in this application, for any feature of construction of said explosion motor, nor do I limit myself to this or any particular type of motor for driving the compressor, I do not conceive that it is necessary to refer further to said motor, except to say that a motor such as shown is well adapted to work at speeds of from 600 to 1200 revolutions per minute and over.

The compressor shown is a two stage compressor, comprising a low pressure cylinder 11, a high pressure cylinder 12, and low pressure and high pressure pistons 13 and 14 respectively, said pistons being differential pistons connected as shown and having a common wrist pin 15 and connecting rod 16, the compression space of cylinder 11 being the annular space surrounding the lower end of the high pressure piston 14, and bounded by the head and sides of the low pressure cylinder 11 and the head of the low pressure piston 13.

Low pressure piston 13 serves as its own admission valve, the cylinder 11 having a plurality of admission ports 17 arranged to be uncovered by the piston near the lower end of its stroke, air then rushing in through these ports 17 to fill the low pressure cylinder. A screen 18 (see particularly Figs. 2 and 5) surrounds cylinder 11 and covers these ports 17, and serves to prevent the entry of large objects which might foul or interfere with the operation of the compressor, and also to muffle the suction. By avoiding the use of admission valves, such as are commonly used on compressors, I avoid altogether the noisy clashing and chattering of such valves against their seats, which is one disagreeable feature of ordinary air compressors.

For efficient operation of two-stage compressors, it is necessary that the air compressed by the low pressure cylinder shall be cooled before it is admitted to the high pressure cylinder; the cooling device for this purpose being commonly termed an intercooler. It is also necessary for effective operation of the compressor at high speed, that there shall be considerable storage space between the low pressure and high pressure cylinders. The intercooler I employ (which intercooler likewise provides necessary storage or receiving space intermediate the cylinders) comprises a hollow casting 19 of horseshoe shape, supported upon the head of the low pressure cylinder and surrounding the high pressure cylinder 12. The low pressure cylinder has at its upper end a discharge port 20, with which an orifice 21 (Fig. 4,) on the lower side of the intercooler, registers; and between the head of the low pressure cylinder and intercooler there is a removable valve seat 22 having a similar registering orifice. Within the intercooler is a cylindrical valve housing 23, integral with the valve seat 22, and having ports 24 at its sides, leading to the interior of the intercooler; and within said housing is a hollow valve plug 25 seating against the valve seat 22, and provided with a spring 26, the pressure of which may be regulated by a screw plug 27 screwing into the top of valve housing 23. Whenever, during the up stroke of the low pressure piston 13, the pressure in low pressure cylinder 11 exceeds the pressure holding said valve closed, said valve will open, admitting air from the low pressure cylinder into the intercooler 19. Said valve 25 closes automatically when the piston 16 ceases to ascend.

For cooling the upper end of the low pressure cylinder, the high pressure cylinder, and the intercooler 19, I provide a single water jacket 28 surrounding all these parts. By employing a single jacket for the purpose, I avoid an unnecessary number of jackets, pipes, joints, etc. Since the water circulates around both sides of the intercooler and completely around the high pressure cylinder as well as around that portion of the low pressure cylinder in which any considerable heat is generated the radiated surface in contact with the water is very large in proportion to the size of the parts and the volume of the water jacket. Except for convenience in manufacture and assembling, the intercooler 19 might be a chamber completely encircling the high pressure cylinder and formed integrally with the low pressure and high pressure cylinders. I have found in practice that it is very difficult to obtain perfect castings when forming the low pressure and high pressure cylinders, and annular intercooler, in one casting; and it is inconvenient to assemble and connect with the low pressure and high pressure cylinders, an annular intercooler completely surrounding the high pressure cylinder. But by making the intercooler annular, but of horseshoe shape, the gap 29 between the horns of the horseshoe being wider than the external diameter of high pressure cylinder 12, it is easy to put the intercooler in place or to remove the same, the water jacket having first been removed.

One important feature of my invention resides in the means of securing the water jacket to the single casting comprising the low pressure and high pressure cylinders. As shown particularly in Figs. 1, 2 and 5, the high pressure cylinder has at its top a wide flange 30, and the water jacket 28, which at its lower end forms a joint with flange 31 of the low pressure cylinder, has a flange 32 fitting over flange 30 of the high pressure cylinder, and bolts 33 screwing into flange 30 holds the water jacket in place; the single set of bolts 33, constituting one set of attaching devices, producing the pressure necessary to close both jacket joints, *i. e.*, the joints at both flanges, 30 and 31.

Another important feature of my invention resides in the means for securing the intercooler to the cylinder casing. For securing the intercooler to the head of the low pressure cylinder I employ bolts 45 passing through flanges of the cylinder head and of the intercooler, as shown in Fig. 2. A horizontal screw 34 (Figs. 1 and, 5) passing through the intercooler into the high pressure portion of the main cylinder casting, secures the intercooler to said cylinder casting. This screw 34 has in it a central passage 35 connected by ports 36 with the interior of the intercooler, and leading to the high-pressure admission valve 37, which is a spring-actuated valve, as shown, having a port 38 leading to the upper end of the high-pressure cylinder. Said high-pressure cylinder has a spring-actuated discharge valve set into its head, and comprising a valve housing 39 screwing into the end of the high pressure cylinder, cupped valve plug 40, bushing 41 surrounding the housing 39 and provided with an outlet screw threaded for the attachment of a delivery pipe, screw-threaded head 42, and spring 43. Valve plugs 25 and 40 are made hollow, as shown, in order that they may be as light as possible. I find that at the high speed at which this compressor runs, unless these valves be exceedingly light they will hammer the seats to such extent as to seriously deform the same. By making the valves hollow as shown, however, the inertia of the valves becomes so small that no deformation either of the valves or of their seats results. It will be seen that the construction of the discharge valve described is such that when the screw head 42 is unscrewed somewhat, the bushing 41, forming the exterior valve chamber, may be turned to any desired position, thus permitting the compressor to deliver in any desired direction; and then by screwing up the cap 42 again, a tight joint is formed between said cap and said bushing and between said bushing and the head of the cylinder.

I find that the speed at which the compressor works is materially affected by the type of valves employed. I find that housed check valves for the discharge valves of the low-stage cylinder 11 and high-stage cylinder 12, having cupped valve plugs, such as 25 and 40 shown, and, for an admission valve to the high-stage cylinder, an open check valve, such as 37, shown, give the best results and permit a materially higher speed of operation than if a different arrangement of valves be employed. This is doubtless because the housed valves are very quick in opening and the valve plugs may be made very light, while the open check valve is very quick in closing. A removable screw-plug 44 affords access to valve 37.

As indicated, suitable packing material is provided between the water jacket 28 and the cylinder flanges upon which it sets, and also between the valve seat 22 and the adjacent parts, between the screw 34 and the adjacent parts, and between the head of the high pressure cylinder and its discharge valve.

This compressor as shown, is designed to work at speeds in excess of 500 revolutions per minute and to compress to pressures of 400 pounds per square inch and over. By giving the compression cylinders different proportions I may of course, adapt the compressor to compress to either higher or lower pressures efficiently. Relatively high speed of this compressor is permissible, and relatively high compression pressure is obtainable, because of the design of the compression cylinders, pistons, connecting rods, etc., which in form, construction and proportions approximate corresponding parts of high speed explosion engines, and because of the very small clearance of the cylinders, the relatively large storage capacity afforded by the annular intercooler, and the quick action of the automatic valves employed.

What I claim is:—

1. A multi-stage compressor comprising in combination compression cylinders of different stages, and an intercooler comprising a hollow annulus connected to both said cylinders and surrounding one of them.

2. A multi-stage compressor comprising in combination compression cylinders of different stages, and an intercooler connected to both said cylinders and surrounding one of them and having the form of a hollow annulus, there being space for the circulation of cooling fluid on both sides of such annulus.

3. A multi-stage compressor comprising in combination compression cylinders of different stages, and an intercooler comprising a hollow annulus connected to both said cylinders and arranged substantially concentrically with respect to one of them.

4. A multi-stage compressor comprising in combination compression cylinders of different stages and an intercooler removably connected to both said cylinders and having the form of a hollow horseshoe, the gap between its horns adapted to permit lateral removal of said intercooler.

5. A multi-stage compressor comprising in combination compression cylinders of different stages, an intercooler comprising a hollow annulus connected to both said cylinders and surrounding one of them, and a jacket surrounding both said cylinders and said intercooler and adapted to contain cooling fluid.

6. A multi-stage compressor comprising in combination compression cylinders of different stages, an intercooler comprising a hollow annulus connected to both said cylinders, and a jacket surrounding both said cylinders and said intercooler and adapted to contain cooling fluid; said chamber located entirely within said jacket.

7. A multi-stage compressor comprising in combination compression cylinders of different stages arranged in tandem, an intercooler constituting the receiver between said cylinders connected to both said cylinders and surrounding the higher-stage cylinder, and a jacket surrounding both said cylinders and said intercooler and adapted to contain cooling fluid; said intercooler located entirely within said jacket.

8. A multi-stage compressor comprising in combination compression cylinders of different stages and of different diameters arranged in tandem, an intercooler constituting the receiver between said cylinders connected to both said cylinders and surrounding the one of smaller diameter, and a jacket surrounding both said cylinders and said intercooler and adapted to contain cooling fluid; said intercooler located entirely within said jacket.

9. A multi-stage compressor comprising in combination compression cylinders of different stages and of different diameters arranged in tandem, an intercooler connected to both said cylinders and surrounding the one of smaller diameter, said intercooler having the form of a hollow horseshoe, the gap between its horns permitting lateral removal of said intercooler from the cylinder surrounded by it.

10. A multi-stage compressor comprising in combination low-stage and high-stage cylinders comprised in a single structure, a jacket surrounding said cylinder structure and adapted to contain cooling fluid, and an intercooler within said jacket, said intercooler constituting the receiver between said cylinders and provided at one side with valved

means directly connecting said intercooler with the low stage cylinder, and provided at the other end with valved means directly connecting said intercooler with the high stage cylinder.

11. A multi-stage compressor comprising in combination low-stage and high-stage cylinders of different diameters comprised in a single structure, a jacket surrounding said cylinder structure and adapted to contain cooling fluid, and an intercooler within said jacket and surrounding the cylinder of smaller diameter, said intercooler constituting the receiver between said cylinders and provided at one side with valved means directly connecting said intercooler with the low stage cylinder, and provided at the other end with valved means directly connecting said intercooler with the high stage cylinder.

12. A multi-stage compressor comprising in combination cylinders of different diameters comprised in a single structure, a laterally removable intercooler surrounding the smaller cylinder and having the form of a hollow horseshoe, the gap between its horns permitting its lateral removal, and a longitudinally-removable jacket surrounding said intercooler and the cylinder surrounded by it, and adapted to contain cooling fluid.

13. A multi-stage compressor comprising in combination low-stage and high-stage cylinders, an intercooler surrounding one of them and laterally removable with respect thereto, said intercooler connected to the low-stage cylinder, and fastening means securing said intercooler to the high-stage cylinder having within it a passage connecting the interior of said intercooler with said high-stage cylinder.

14. A multi-stage compressor comprising in combination low-stage and high-stage cylinders, and an intercooler surrounding one of them and laterally removable with respect thereto, said intercooler provided with means mechanically securing it to such cylinder and comprising a fastening piece having within it a passage connecting the interior of such intercooler with such cylinder; said intercooler also connected to the other cylinder.

15. A multi-stage compressor comprising in combination low-stage and high-stage cylinders, an intercooler surrounding one of them and laterally removable with respect thereto, and a fastening member for securing said intercooler to that cylinder which it surrounds, passing through the intercooler and secured to the wall of such cylinder and having within it a passage connecting the interior of the intercooler with the high-stage cylinder; said intercooler also connected to the low-stage cylinder.

16. A multi-stage compressor comprising in combination, low-stage and high-stage cylinders, an intercooler surrounding one of them and laterally removable with respect thereto, said intercooler connected to the low-stage cylinder, a discharge valve for such low-stage cylinder located within the intercooler, an admission valve for the high-stage cylinder, and a fastening member securing said intercooler to the cylinder which it surrounds and having within it a passage leading from the interior of the intercooler to the said admission valve of the high-stage cylinder.

17. A multi-stage compressor comprising in combination, low-stage and high-stage cylinders, an intercooler connected to both cylinders, a housed check valve between the low-stage cylinder and said intercooler, an open check valve between the intercooler and the high-stage cylinder, and a housed discharge valve for the high-stage cylinder.

18. A compressor comprising in combination, a compression cylinder, a receiving chamber, a valve housing therein having a flange and a valve seat, means for securing said housing and cylinder together, and a valve within said housing.

19. A compressor comprising in combination, a compression cylinder, a receiving chamber, a valve housing therein having a flange and a valve seat, means for securing said housing and cylinder together, a valve within said housing, a spring therefor also within said housing, and a screw closure for the end of the housing.

20. A multi-stage compressor comprising in combination, compression cylinders, an intercooler connected to both, a valve housing for the discharge valve of one of said cylinders located within the intercooler and having a flange and the valve seat, a valve in such housing, and means for securing said housing and the corresponding cylinder together.

21. A multi-stage compressor comprising in combination, low-stage and high-stage cylinders and an intercooler therefor, and a single jacket surrounding the high stage cylinder, the intercooler, and the compression space of the low-stage cylinder, said latter cylinder provided with an admission port outside the jacket.

22. A multi-stage compressor comprising in combination, high-stage and low-stage cylinders arranged in tandem, an intercooler therefor, and a single jacket surrounding the high-stage cylinder, the intercooler and the upper portion of the low-stage cylinder, said latter cylinder having an admission port beneath the jacket.

23. A compressor comprising in combination, a cylinder structure having lateral flanges, a receiving chamber between said flanges, and a jacket surrounding said cylinder structure and receiving chamber, and seating upon said flanges.

24. A compressor comprising in combination, a cylinder structure having lateral

flanges, a receiving chamber between said flanges, a jacket surrounding said cylinder structure and receiving chamber, and seating upon said flanges, and a single set of fastening devices pressing said jacket toward and holding it against both said flanges.

25. A compressor comprising in combination, a compression cylinder and a discharge valve therefor comprising a housing secured to said cylinder, a valve within said housing, a rotatable bushing surrounding said housing, and provided with means adapting it for connection to a discharge conduit, and means closing the end of said bushing and the end of said housing and holding said bushing in place.

26. A compressor comprising in combination, a compression cylinder and a discharge valve therefor comprising a housing secured thereto, a valve within said housing, a rotatable bushing surrounding said housing, and provided with means adapting it for connection to a discharge conduit, and a screw cap closing the end of said bushing and the end of said housing and holding said bushing in place.

27. In a multi-stage compressor, the combination of low-stage and high-stage cylinders arranged in tandem, an annular intercooler surrounding said high-stage cylinder and connected to both cylinders, and suitable valves comprising an admission valve for the high-stage cylinder, said admission valve being an open check valve located in a passage connecting the intercooler and said high-stage cylinder, said passage having an extension leading through the head of such cylinder to the outside, and a plug normally closing such extension but adapted upon removal to afford access to said valve plug.

In testimony whereof I affix my signature, in the presence of two witnesses.

EDMUND W. ROBERTS.

Witnesses:
H. M. MARBLE,
MAY I. TRIMBLE.