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A. D. FERGUSON

2,137,752

COMPRESSOR

Filed May 2, 1935

Fig. 1.

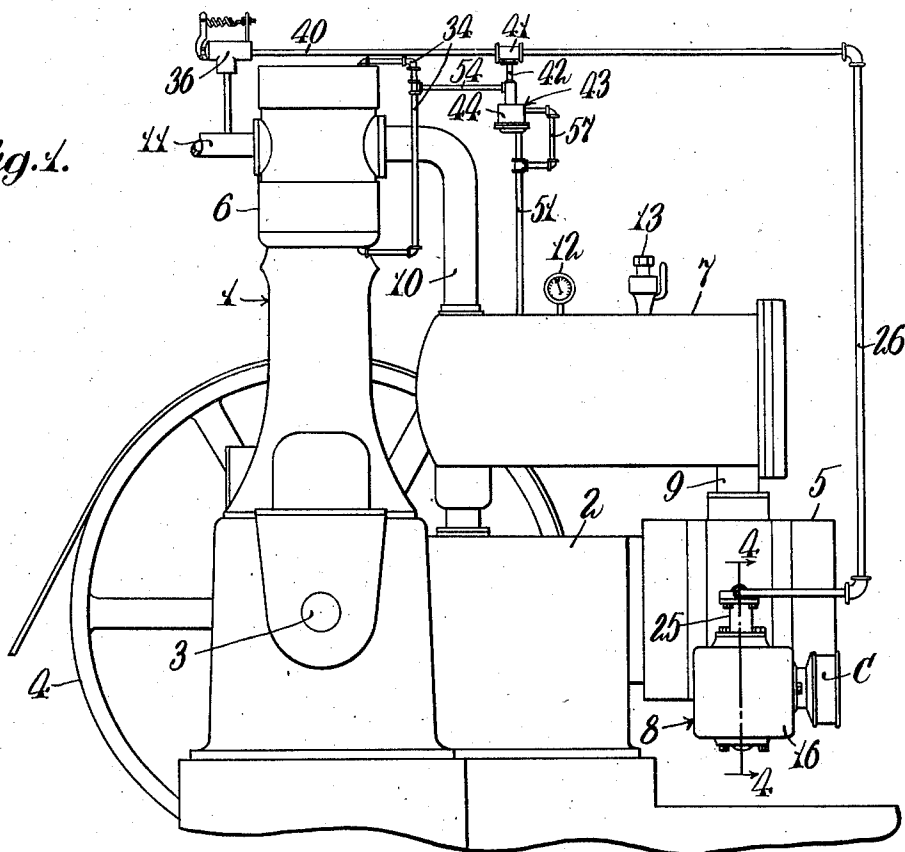


Fig. 2.

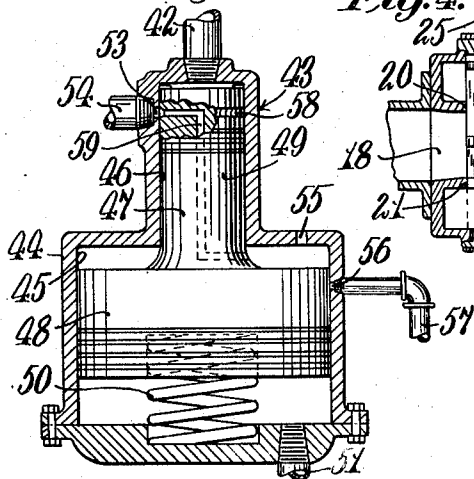


Fig. 4.

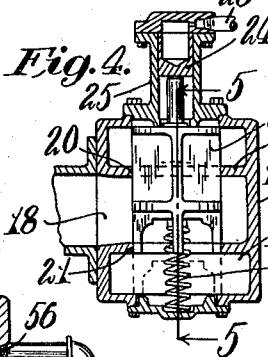


Fig. 3.

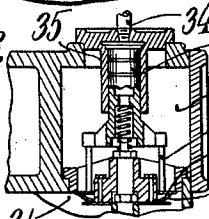
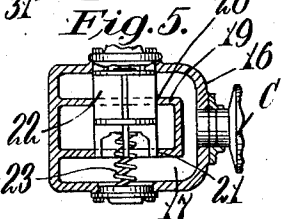


Fig. 5.



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UNITED STATES PATENT OFFICE

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COMPRESSOR

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24 Claims. (Cl. 230—26)

My invention relates to compressors, and more particularly to improved controlling means for effecting unloading, in the desired manner, of compound compressors.

5 It is a common practice in connection with compound compressors to provide a total-closure type, intake unloader for the low pressure cylinder and to unload the high pressure cylinder by holding open the inlet valves of the latter. With
10 a compressor so equipped, it is desirable to effect a small time delay between the closure of the compressor intake and the unloading of the high pressure cylinder, in order that the partially compressed fluid in the intercooler may be compressed
15 in the high pressure cylinder and discharge to the discharge line, thereby effecting a small, but desirable, economy. After complete unloading is effected, there is a tendency for the intercooler pressure gradually to build up, due to leakage
20 past the intake unloader valve and the absence, due to the holding open of the inlet valves of the high pressure cylinder, of continuous removal of air from the intercooler by the high pressure cylinder; and therefore there is likely to be a
25 periodic popping of the safety valve which is provided on the intercooler, a thing which is annoying, and at times definitely undesirable. It is therefore desirable to provide for a venting of the intercooler after complete unloading is effected, and to maintain the same vented throughout the
30 period of unloaded operation.

It is an object of my present invention to provide an improved compound compressor. It is another object of my invention to provide an
35 improved compound compressor having improved unloading means. It is a further object of my invention to provide an improved controlling means for effecting the unloading of a compound compressor which will accomplish the functions pointed out as desirable in the foregoing analysis.
40 It is a still further object of my invention to provide an improved unloading means for a compound compressor in which a single discharge pressure responsive pilot valve is used to control
45 fluid supply for unloading of both the high and low pressure cylinders, and on which appropriate devices are further provided for effecting a delayed unloading of the high pressure cylinder, and, thereafter, throughout the period of unloaded operation, a venting of the intercooler.
50 Other objects and advantages of the invention will hereinafter more fully appear.

In the accompanying drawing in which one illustrative embodiment which the invention may
55 assume in practice has been shown,

Fig. 1 is a side elevational view of a multi-stage compressor in which the illustrative embodiment of the invention is incorporated,

Fig. 2 is a vertical section on an enlarged scale through the secondary control device which governs the time of high pressure cylinder unloading and venting of the intercooler,

Fig. 3 is a detail sectional view through the unloading apparatus associated with an inlet valve of a high pressure cylinder,

Fig. 4 is a section on the line 4—4 of Fig. 1 through the intake closure unloading apparatus, and

Fig. 5 is a section with parts omitted on the plane of the line 5—5 of Fig. 4.

In the drawing, the compound compressor 1 has a frame 2, a driving shaft 3, a fly wheel 4, herein shown as belt driven, a low pressure cylinder 5, a high pressure cylinder 6, and an intercooler 7. The low pressure cylinder 5 takes in
20 air through an air cleaner C and through an unloading mechanism generally designated 8 and of the total intake closure type, and discharges the air which it compresses, through a connection 9 to the intercooler 7. The air from the intercooler is taken into the high pressure cylinder 6
25 through a connection 10, and after further compression is discharged through a discharge line 11. The intercooler is provided with a usual pressure gage 12 and a pop safety valve 13. The high
30 pressure cylinder 6 is provided with inlet-valve-opening, unloading mechanisms, of which one unit is shown in Fig. 3. The intake closure type unloading mechanism 8 includes a casing 16, providing a space 17 to which air passes initially.
35 The intake space of the low pressure cylinder 5 is connected with a space 18, which is partitioned off by the wall 19 having aligned openings 20 and 21, from the space 17. A double seat valve element 22, normally held in open position by a
40 spring 23, is movable by a piston 24, reciprocable in a cylinder 25, to close the openings 20 and 21, and thereby close communication between spaces 18 and 17 and effect unloading of the low pressure cylinder by total closure of the intake to the
45 latter. The cylinder 25 is placed in communication with a source of operating fluid and with exhaust through a connection 26. The high pressure cylinder is provided with inlet valves 28, normally held in closed position by springs 29
50 and controlling communication between spaces 30, connected through the passage 10 with the intercooler, and spaces 31 communicating directly with the cylinder proper. Plungers 32 are adapted to actuate fingers 33 to open and maintain
55

open the inlet valves of the high pressure cylinder, and connections 34 are arranged to effect communication, between a source of pressure fluid supply and a point of exhaust, under the control of apparatus later described, and cylinders 35, in which the plungers 32 are reciprocable.

A pilot valve 36, which may be of any suitable type, and which is herein illustrated as a so-called RC pilot valve, is arranged to control communication between the compressor discharge line 11 and a pipe 40, and between said pipe and the atmosphere, being operative automatically, in a well known manner, upon a rise of the pressure in the discharge line 11 to a predetermined value, to open communication between the pipe 40 and the discharge line, and so supply fluid from the discharge line to said pipe; and, upon a predetermined drop in pressure below said predetermined maximum, to interrupt the communication previously established and vent the pipe 40 to atmosphere. A tee 41 connects the pipe 40 with the connection 26, previously described; and accordingly, on opening of the pilot valve 36 to establish communication between the compressor discharge passage 11 and the pipe 40, compressor discharge pressure passes immediately through the connection 26 to act upon the top of the plunger 24 and to close the double beat valve 22, and thereby immediately unload the low pressure cylinder. From the T 41 another branch 42 passes to a valve mechanism generally designated 43. This last mentioned valve mechanism includes a casing 44 having a relatively large bore 45 and an aligned smaller bore 46. Within these bores a composite piston 47 is reciprocable. The piston 47 comprises a larger portion 48 fitting the bore 45 and a smaller portion 49 fitting the bore 46. A suitable spring 50 constantly tends to maintain the composite piston 47 in raised position. The space below the piston portion 48 is connected by a connection 51 to the air space in the intercooler, so that the lower end of the piston portion 48 is subjected to intercooler pressure. The upper end of the cylinder portion 46 communicates, through the connection 42 and the T 41, with the passage 40, so that the upper end of the piston portion 49 is subjected to the different pressures which prevail at different times in the passage 40. Upon a predetermined downward movement of the piston portion 49 in the bore 46, the top end of the piston portion 49 uncovers a lateral opening 53, which is connected through a pipe 54 with the connections 34 leading to the inlet valve opening plungers 32 for the high pressure cylinder. The upper end of the space within the larger cylinder bore 45 is vented to atmosphere through an opening 55, and upon downward movement of the piston portion 48 through a predetermined distance in cylinder 45, the upper end of the portion 48 uncovers the mouth of a passage 56 which is connected by a pipe 57 with the pipe 51 which opens into the air space of the intercooler. It will therefore be evident that upon predetermined downward movement of the composite piston structure 47, the intercooler air spaces will be connected through the pipe 51, branch connection 57, port 56, the interior of cylinder 45 and vent port 55 with the atmosphere, and also passage 40 will be connected through the upper portion of cylinder space 46, port 53, passage 54 and branches 34 with the inlet valve opening plungers associated with the high pressure cylinder inlet valves. Obviously, since establishment of communication between connection 42 and connec-

tion 54 effects unloading of the high pressure cylinder and therefore interrupts further pumping out of the intercooler, it is necessary that the intercooler be vented to atmosphere by the uncovering of the port 56 no later than, and preferably somewhat earlier than, connection is established between the space above the piston 49 in cylinder 46 and the passage 53. This can easily be insured by making the distance of composite piston movement necessary to uncover the passage mouth 56 slightly less than the distance of composite piston travel necessary to uncover the port 53.

It will be evident that the delay in downward movement of the composite piston structure 47 after unloading of the low pressure cylinder, can be controlled to effect substantially any desired reduction in intercooler pressure before high pressure cylinder unloading and venting of the intercooler takes place. Desirable results can be obtained for a compressor having, during running, an intercooler pressure of about thirty pounds and a high pressure discharge line pressure of perhaps 90 or 100 pounds, if high pressure cylinder unloading and intercooler venting are caused to take place when the intercooler pressure is reduced to about 10 pounds. Obviously, the stiffness of the spring 50 will enter into the design of the apparatus, and it will be noted that I have shown about a 9 to 1 area ratio between the bottom surface of the piston portion 48, subjected to intercooler pressure, and the top pressure area of the piston portion 49. This would involve the use of a spring 50 exerting a relatively light pressure, and be suitable for about a 100# discharge pressure.

Because the upper end of the piston portion 49 might tend to entrap some air in the pipe 54 and branches 34, and above the plungers 32, suitable means is provided to effect connection of the port 53 to atmosphere when the composite piston member 47 is in topmost position. Various means for accomplishing this result may be used, but I prefer to provide a peripheral groove 58 in the piston portion 49 at such a position that it will be opposite the port 53 when the piston portion 49 is in top position, and to connect the groove 58 by means of a suitable passage 59 with the space in the bore 45 above the piston portion 48, and so to atmosphere through the port 55. As a result of this arrangement, 53 will be connected to atmosphere whenever the composite piston structure is in uppermost position, but this connection will be discontinued before the top of the piston portion 49, upon downward movement, establishes communication between the port 53 and the connection 42. Obviously, other means for the same purpose could be used, and if desired a bleed port could be placed in the connection 54 and make modification of the composite piston structure unnecessary.

The mode of operation of the apparatus described and illustrated will be readily understood from what has been said. During normal operation of the compressor, that is, with the pressure below the predetermined maximum desired, the pilot valve 36 will be in such position that the space above the plungers 32 will remain at atmospheric pressure. Communication between port 53 and passage 42 will be interrupted by the upper end of piston portion 49, and port 53 will be connected to atmosphere through groove 58, passage 59, cylinder bore 45 and passage 55.

Now starting with plungers 24 and 32 in raised position and with the composite piston 47 also in

raised position and held there by the intercooler pressure acting on the larger area at the bottom of the piston portion 48, it will be noted that when the predetermined desired maximum compressor discharge pressure is reached, the pilot valve 36

will connect the passage 40 with compressor discharge line 11, and fluid will flow directly to the line 26 and therethrough to the plunger 24 and close the compressor intake controlling valve 22. The low pressure cylinder will be immediately unloaded, and the air contained in that cylinder will be discharged to the intercooler and thereafter practically no more air (except leakage air) will be delivered to the intercooler. Air will also pass at once from the pipe 40 to the space in the top of cylinder portion 46, but until the intercooler pressure is substantially diminished, the composite piston 47 will not be moved downwardly, and therefore at first no air will pass through the pipe 54 and branches 34 to the plungers 32, and the high pressure cylinder will continue to pump, and will pump down the intercooler pressure. When the intercooler pressure has been sufficiently reduced, the discharge line pressure acting on the upper end of piston portion 49 will overcome the effect of the much-reduced intercooler pressure on the bottom of piston portion 48, and force down the composite piston 47, and vent the remaining intercooler pressure through line 51, 57, mouth 56, cylinder portion 45 and passage 55; and discharge line pressure then delivered through the passage 54 will unload the high pressure cylinder and the compressor will operate fully unloaded. It will be noted that venting of the intercooler will merely make more positive the maintenance in lower position of the composite piston structure 47. When the pilot valve 36, upon a predetermined fall in compressor discharge line pressure, vents the line 40, both the low pressure cylinder and the high pressure cylinder unloading-affecting plungers will be forthwith vented to the atmosphere through the pilot valve. The low pressure cylinder will immediately begin to pump into the intercooler, and the high pressure cylinder to pump out of the intercooler. The mouth 56 and the passage 55 have relatively small areas, and accordingly, there will be no serious retardation in the building up of intercooler pressure. When intercooler pressure builds up sufficiently, composite piston structure 47 will seal the mouth 56, close off opening 53, and move to top position. Any residual pressure in passage 54 will be bled off through groove 58, passage 59 and port 55.

From the foregoing description, it will be obvious that I have provided an improved apparatus for controlling a compound compressor, which automatically provides for the utilization of most of the pressure contained in the intercooler at the instant unloading commences, which prevents the building up of pressure in the intercooler during unloaded operation, which is effective to provide the desired results with extremely simple apparatus, and which requires only a single compressor discharge pressure responsive primary pilot valve, and whose parts are simple, rugged and free from all danger of derangement in normal use. The apparatus is obviously susceptible of modification without departing from the fundamental spirit of the invention.

While I have in this application specifically described one form which my invention may assume in practice, it will be understood that this form of the same is shown for purposes of illustration and that the invention may be modified and em-

bodied in various other forms without departing from its spirit or the scope of the appended claims.

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

1. In combination, a compressor having high and low pressure cylinders, means for unloading the low pressure cylinder, and automatically acting means controlled by variations in pressure, at a point beyond said unloading means, arising from the unloading of the low pressure cylinder for subsequently unloading the high pressure cylinder and venting the low pressure cylinder discharge freely to atmosphere at a point short of said high pressure cylinder.

2. In combination, a compressor having high and low pressure cylinders, intake closure means for unloading the low pressure cylinder, and automatically acting means controlled by variations in pressure, at a point beyond said unloading means, arising from the unloading of the low pressure cylinder for subsequently unloading the high pressure cylinder and venting the low pressure cylinder discharge freely to atmosphere at a point short of the high pressure cylinder.

3. In combination, a compressor having high and low pressure cylinders, means for unloading the low pressure cylinder, and automatically acting means operated by terminal pressure and governed by variations in pressure, at a point beyond said unloading means, arising from the unloading of the low pressure cylinder for subsequently unloading the high pressure cylinder and venting the low pressure cylinder discharge freely to atmosphere.

4. In combination, a compressor having high and low pressure cylinders, intake closure means for unloading the low pressure cylinder, and automatically acting means operated by terminal pressure and governed by variations in pressure, at a point beyond said unloading means, arising from the unloading of the low pressure cylinder for subsequently unloading the high pressure cylinder and venting the low pressure cylinder discharge freely to atmosphere.

5. In combination, a compressor having high and low pressure cylinders and an intercooler, means for unloading the low pressure cylinder, and automatically acting means operated by terminal pressure and opposed in its movements by intercooler pressure and governed by variations in pressure arising from the unloading of the low pressure cylinder for subsequently unloading the high pressure cylinder and venting the intercooler freely to atmosphere.

6. In combination, a compressor having high and low pressure cylinders and an intercooler, intake closure means for unloading the low pressure cylinder, and automatically acting means operated by terminal pressure and opposed in its movements by intercooler pressure and governed by variations in pressure arising from the unloading of the low pressure cylinder for subsequently unloading the high pressure cylinder and venting the intercooler freely to atmosphere.

7. In combination, a compressor having high and low pressure cylinders and an intercooler, intake closure means for unloading the low pressure cylinder, inlet valve opening means for unloading the high pressure cylinder, and automatically acting means controlled by variations in pressure arising from the unloading of the low pressure cylinder for subsequently unloading the high pressure cylinder and venting the intercooler freely to atmosphere.

8. In combination, a compressor having high and low pressure cylinders and an intercooler, intake closure means for unloading the low pressure cylinder, inlet valve opening means for unloading the high pressure cylinder, and automatically acting means operated by terminal pressure and responsive to variations in pressure arising from the unloading of the low pressure cylinder for subsequently unloading the high pressure cylinder and venting the intercooler freely to atmosphere.
9. In combination, a compressor having high and low pressure cylinders and an intercooler, intake closure means for unloading the low pressure cylinder, inlet valve opening means for unloading the high pressure cylinder, and automatically acting means controlled by variations in pressure in the intercooler arising from the unloading of the low pressure cylinder for subsequently unloading the high pressure cylinder and venting the intercooler freely to atmosphere.
10. In combination, a compressor having high and low pressure cylinders and an intercooler, intake closure means for unloading the low pressure cylinder, inlet valve opening means for unloading the high pressure cylinder, and automatically acting means operated by terminal pressure and responsive to variations in pressure in the intercooler arising from the unloading of the low pressure cylinder for subsequently unloading the high pressure cylinder and just prior thereto venting the intercooler to atmosphere.
11. In a controlling apparatus of the type defined and adapted to effect supply of pressure to a high pressure cylinder unloading means and to vent an intercooler, a casing providing aligned cylinder bores of different diameters, a composite piston having portions fitting said bores, intercooler vent means controlled by the larger piston portion, high pressure cylinder unloading means, a supply port for said high pressure cylinder unloading means controlled by the smaller piston portion, means for subjecting the smaller piston portion to a pressure to be controlled, and means for applying an opposing pressure on the larger piston portion.
12. In a controlling apparatus of the type defined and adapted to effect supply of pressure to a high pressure cylinder unloading means and to vent an intercooler, a casing providing aligned cylinder bores of different diameters, a composite piston having portions fitting said bores, intercooler vent means controlled by the larger piston portion, high pressure cylinder unloading means, a supply port for said high pressure cylinder unloading means controlled by the smaller piston portion, means for subjecting the smaller piston portion to the compressor discharge pressure to be controlled, and means for applying as an opposing pressure intercooler pressure on the larger piston portion.
13. In a controlling apparatus of the type defined, a casing providing aligned cylinder bores of different diameters, a composite piston having portions fitting said bores, a port controlled by the larger piston portion, a port controlled by the smaller piston portion, means for subjecting the smaller piston portion to a pressure to be controlled, and means for applying an opposing, lower, related pressure on the larger piston portion.
14. In a controlling apparatus of the type defined, a casing providing aligned cylinder bores of different diameters, the larger bore vented at its top, a composite piston having portions fitting said bores, a port controlled by the larger piston portion, a port controlled by the smaller piston portion, means for subjecting the smaller piston portion to a pressure to be controlled, and means for applying an opposing, lower, related pressure on the larger piston portion and conducting the last named pressure to the first mentioned port.
15. In combination, a compressor having high and low pressure cylinders and an intercooler, means for unloading the low pressure cylinder, and automatically acting means controlled by variations in pressure arising from the unloading of the low pressure cylinder for subsequently venting the inter-cooler to atmosphere and then unloading the high pressure cylinder.
16. In combination, a compressor having high and low pressure cylinders and an intercooler, intake closure means for unloading the low pressure cylinder, and automatically acting means controlled by variations in pressure arising from the unloading of the low pressure cylinder for subsequently venting the intercooler to atmosphere and then unloading the high pressure cylinder.
17. In a controlling apparatus of the type defined and adapted to effect supply of pressure to a high pressure cylinder unloading means and to vent an intercooler, pressure responsive valve means movable in one direction to effect intercooler venting and to admit pressure to effect high pressure cylinder unloading, and in an opposite direction to stop intercooler venting and effect high pressure cylinder re-loading, and controlling means for said valve means having opposed surfaces of unequal areas, the smaller subjected to high pressure cylinder discharge pressure and the larger to intercooler pressure.
18. In a controlling apparatus of the type defined and adapted to effect supply of pressure to a high pressure cylinder unloading means and to vent an intercooler, pressure responsive valve means movable in one direction to effect intercooler venting and to admit pressure to effect high pressure cylinder unloading in the order named, and in an opposite direction to stop intercooler venting and effect high pressure cylinder re-loading, and controlling means for said valve means having opposed surfaces of unequal areas, the smaller subjected to high pressure cylinder discharge pressure and the larger to intercooler pressure.
19. In a controlling apparatus of the type defined and adapted to effect supply of pressure to a high pressure cylinder unloading means and to vent an intercooler, pressure responsive valve means movable in one direction to effect intercooler venting and to admit pressure to effect high pressure cylinder unloading, and in an opposite direction to stop intercooler venting and effect high pressure cylinder re-loading, and controlling means for said valve means having opposed surfaces of unequal areas, the smaller subjected to a pressure to be controlled and the larger to a related lower pressure.
20. In a controlling apparatus of the type defined and adapted to effect supply of pressure to a high pressure cylinder unloading means and to vent an intercooler, pressure responsive valve means movable in one direction to effect intercooler venting and to admit pressure to effect high pressure cylinder unloading in the order named, and in an opposite direction to stop intercooler venting and effect high pressure cylinder re-loading, and controlling means for said valve

means having opposed surfaces of unequal areas, the smaller subjected to a pressure to be controlled and the larger to a related lower pressure.

21. In combination, a compressor having high and low pressure cylinders, and means for regulating the output of said compressor in accordance with compressor discharge pressure variations, first unloading said low pressure cylinder, and thereafter unloading said high pressure cylinder and venting the low pressure cylinder discharge freely to atmosphere, and effecting reloading of the low and high pressure cylinders simultaneously upon reduction of compressor discharge pressure to the desired minimum, said means including means automatically controlled by variations in pressure at a point beyond the low pres-

sure unloading means for effecting delayed unloading of said high pressure cylinder and venting of the low pressure cylinder discharge.

22. The combination defined in claim 21 in which means for effecting unloading of the low pressure cylinder is provided in the form of intake closure means.

23. The combination defined in claim 21 in which the means for effecting delayed unloading of the high pressure cylinder is controlled by intercooler pressure.

24. The combination defined in claim 21 in which the means for effecting delayed unloading of the high pressure cylinder is operated by compressor discharge pressure.

ALEXANDER D. FERGUSON.