Feb. 18, 1941. A. N. GUSTAFSON 2,231,904

COMPRESSOR

Original Filed Feb. 20, 1936 2 Sheets-Sheet 1

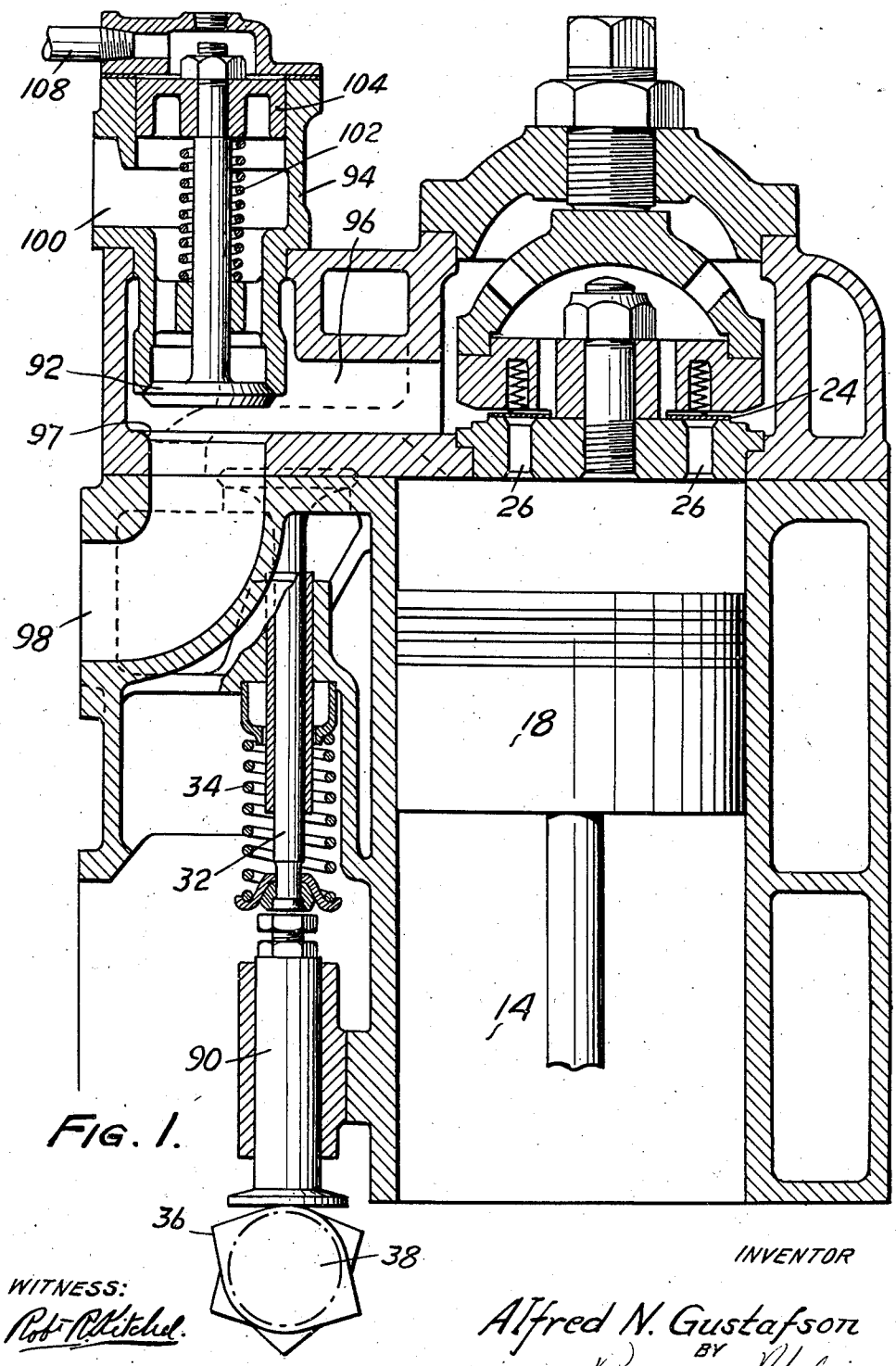


FIG. 1.

WITNESS:
Robt. A. Mitchell.

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COMPRESSOR

Original Filed Feb. 20, 1936 2 Sheets-Sheet 2

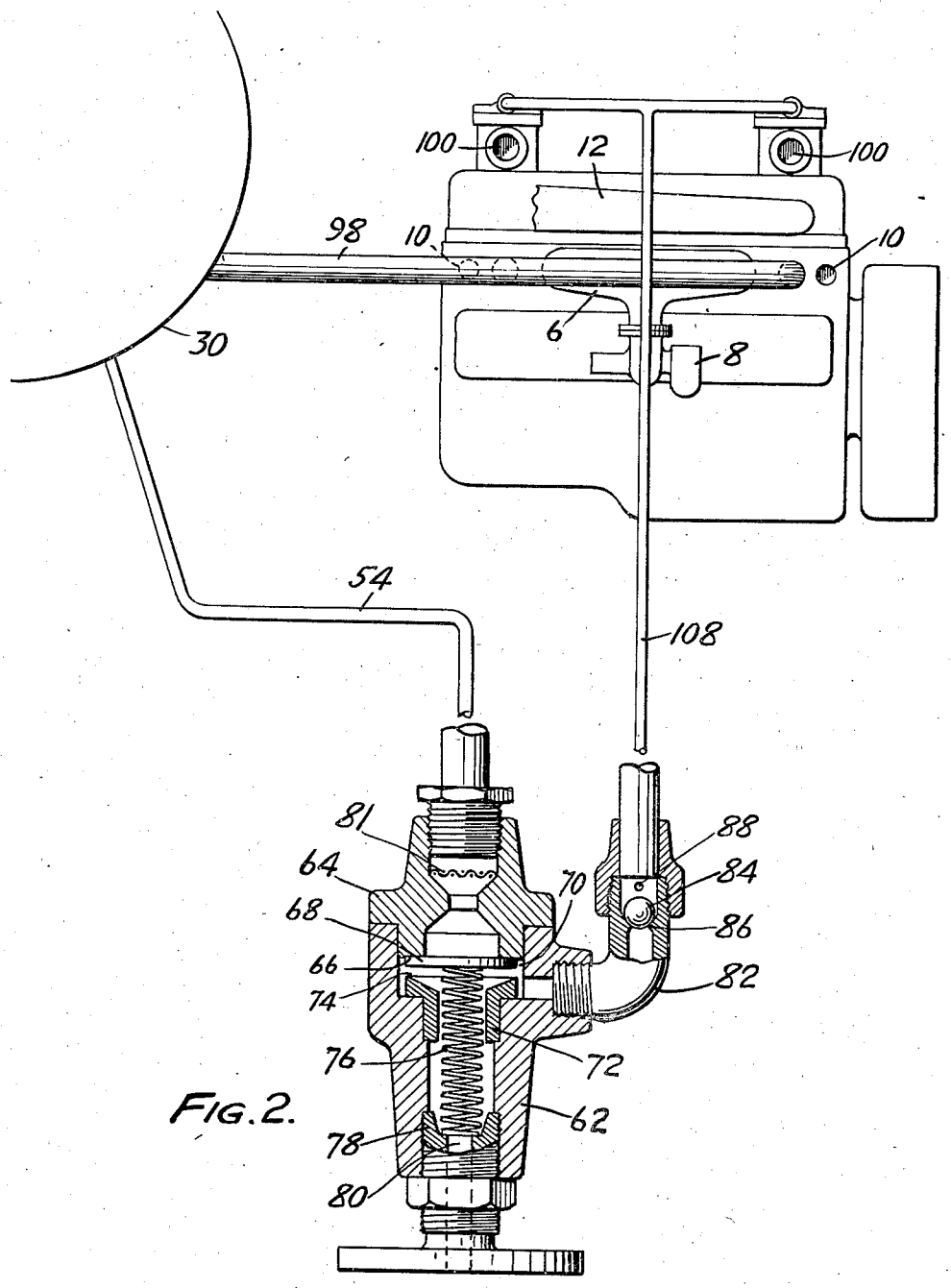


FIG. 2.

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WITNESS:

Robt. R. Ketchel

Patented Feb. 18, 1941 2,231,904

UNITED STATES PATENT OFFICE

2,231,904

COMPRESSOR

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Original application February 20, 1936, Serial No. 64,808. Divided and this application September 1, 1938, Serial No. 227,915

4 Claims. (Cl. 230—22)

This invention relates to a compressor and more particularly to a valve arrangement which is particularly effective in increasing the efficiency of a compressor and reducing its size for a given capacity.

This application is a division of my application Serial No. 64,808, filed February 20, 1936.

While certain aspects of the present invention are of general applicability to compressors of a reciprocating piston type, the invention is particularly directed to the type of compressor which may be regarded as constructed by a conversion of an internal combustion engine. The transformation of internal combustion engines into compressors constitutes a very economical method of producing high speed compressors. The engines are quite inexpensive because of quantity production and their running parts are so made as to be capable of operation at very high speeds. When large size compressors are produced by such transformation, all the cylinders of a multicylinder engine may be turned into compressor cylinders. On the other hand, where small compressor units are to be provided only some of the cylinders may be transformed, the remaining ones being left to function as engine cylinders so that a combination engine and compressor is provided. A satisfactory arrangement of this latter sort is illustrated in Schramm Patent No. 1,738,121, dated December 3, 1929. As shown in this patent, the two end cylinders of a four-cylinder engine have been transformed into compressor cylinders, while the two intermediate cylinders continue to function as engine cylinders. In cases where all of the cylinders are transformed, there is, of course, used a separate motor or engine for driving purposes.

In accordance with the practice heretofore used, there has been substituted a modified cylinder head in order that a greater compression ratio may be attained in the compression cylinders than would be permissible in engine cylinders, this substitution of head being also accomplished by elimination of the mechanically operated engine valves associated with the compressor cylinders and substitution of manifolds, etc., to produce the proper and necessary passages. Automatic valves responsive to air pressure have been provided in the substitute cylinder heads, all as shown in the Schramm patent referred to above.

One of the requirements, in addition to the transformations indicated above, is the provision of suitable unloading mechanism which will stop the compressor action when the pressure in the receiving tank attains a predetermined maximum. This is generally accomplished by holding open the intake valves of the compressor cylinders by means such as illustrated in my prior Patent No. 2,023,418, dated December 10, 1935, so that as the compressor piston continues to reciprocate air is alternately drawn into and forced outwardly through the permanently held valve. Unloading of this nature is quite simply accomplished where the valves are of automatic type.

Automatic intake valves, however, are not particularly satisfactory, inasmuch as, since they depend for their operation upon air pressure, their operation varies quite considerably, depending upon the pressure in the receiver. Consider, for example, the different conditions which exist when the receiver contains air at a low pressure and when it contains air at high pressure. There is always residual clearance in the cylinder when the piston is at its inner dead center. The pressure above the piston at this time depends upon the pressure of the receiver and is substantially equal to it. As the piston then recedes from its inner dead center position, an automatic intake valve will not open until expansion of the gas in the cylinder has taken place to such extent that the pressure is below atmospheric by an amount such that the difference in pressure will serve to open the intake valve against the relatively weak spring which acts upon it to normally hold it closed. It is obvious that the distance the piston must move before such opening takes place is very much affected by the pressure in the upper end of the cylinder when the piston is in its dead center position, which pressure is substantially equal to that of the receiver. The action of the intake valve accordingly varies very considerably with the receiver pressure and design can only be made to effect proper working under one particular condition. Desirably the intake valve should be open throughout substantially the entire intake stroke of the piston.

The use of a mechanically operated intake valve will, of course, insure that the intake valve will operate the same for all pressure conditions. Difficulties in unloading then arise. Proposals have been made to produce unloading by throttling the intake of air. This procedure, however, is objectionable because the vacuum drawn above the piston causes oil to pass into the upper portion of the cylinder where, as successive compression and expansion of the residual gas takes place, vaporization of the oil and consequent explosions may occur. There is also the grave danger of having so much oil accumulate that, because of the close clearances involved, the piston may eventually break the cylinder head.

It is the broad object of the present invention to provide a compressor combining the advantages of mechanically operated intake valves and automatic exhaust valves which, it may be remarked, have the great advantage of acting as automatic safety valves. In utilizing this com-

bination, the automatic exhaust valves can be considerably enlarged so as to take up most, if not all, of the end of the cylinders. The efficiency is thereby increased, since a very small movement of the exhaust valve is necessary to provide a sufficiently large passage for the free flow of the compressed air to the receiver.

It is a further object of the invention to provide improved unloading arrangements suitable for use in connection with mechanically operated intake valves.

The general objects mentioned above, together with subsidiary objects relating particularly to details of construction, will be apparent from the following description read in conjunction with the accompanying drawings, in which:

Figure 1 is an enlarged transverse section of a compressor of L-head type embodying the features of the invention; and

Figure 2 is a diagram showing the associations of various elements with the compressor of Figure 1, a conventional unloader valve being shown therein in enlarged longitudinal section.

Referring first to Figure 2, there is indicated therein a four-cylinder engine the two end cylinders of which have been converted into compressor cylinders by arrangement of parts as shown in Figure 1, intermediate cylinders being adapted to act as engine cylinders to furnish the drive. It will be obvious that the invention is also applicable to cases in which there is an individual compressor and motor or separate engine. The substituted cylinder head in the case illustrated may, as usual, be so arranged as to maintain conventional conditions at the ends of the cylinders; at the same time, however, providing close clearances in the compressor cylinders to secure maximum pressures and efficiency of operation. In the present case, a substitute intake manifold 6 is illustrated communicating only with the intake passages of the engine cylinders, the manifold being connected to a conventional carburetor 8. The intake passages 10 of the compressor cylinders may be opened directly to the atmosphere or, if desired, may be connected to suitable air filters to avoid accumulation of dirt in the compressor mechanism. The exhaust manifold 12 may still be used. The exhaust valves of the compressor cylinders are rendered inoperative by removing, for example, the intermediate follower elements located between them and their operating cams. Preferably, however, particularly where there is a complete transformation to a compressor, a substitute cylinder block is provided to eliminate the exhaust passages entirely.

Referring now to Figure 1, there is shown therein the unloading arrangement for the compressor. In this case the intake valve 32 is continuously operated through the pusher 90 by the cam 38, on the cam shaft. The passage 96 from the automatic discharge valve 24 normally communicates through 98 with the receiver 30. A valve 92 is arranged to alternatively seat on an upper seat carried by the lower end of a fitting 94 or upon a lower seat 97, in which latter position it will cut off communication between 96 and 98. A passage 100 furnishes communication between the atmosphere and the upper side of the valve 92. The valve 92 is normally urged into its upper seated position by a spring 102 and carries, at the upper end of its spindle, a piston 104 sliding in a cylinder 106 and arranged to be forced downwardly by air entering a tube 108 arranged to receive air at receiver pressure. The piston 104 is sufficiently large that upon communication of the upper end of the cylinder 106 with the receiver the valve 92 will be snapped downwardly against its lower seat 97 with the result that communication is established between the delivery side of the automatic delivery valve and the atmosphere. As the compressor continues to operate after this unloading takes place, the piston 18 will draw air inwardly past the continuously operated intake valve 32 and will force it outwardly through the delivery valve 24 to the atmosphere. Since the springs holding the delivery valve closed are very light, no appreciable amount of work is done in this action. At the same time there is no danger that oil will get above the piston.

Connection between the tank 30 and the tubes 108 occurs through a line 54 in which there is interposed a suitable snap valve of conventional type illustrated in detail in Figure 2.

The snap valve is of the type illustrated in my prior Patent No. 2,023,418, dated December 10, 1935. This valve comprises a casing 62 surmounted by a bonnet 64 connected to the tank 30. A disc 68 having plane faces is located within an upper cylindrical portion of the bore of casing 62 and is adapted for vertical movement between an annular plane seat 66 formed on bonnet 64 and an annular plane seat 74 formed on the upper end of a bushing 72. The disc and seats are finely ground to insure airtight contact between the disc faces and the respective seats. The disc fits the bore of the casing loosely whereby a slight clearance 70 is provided between its edge and the wall of the bore for leakage of air. A spring 76 extending through bushing 72 normally forces the disc against seat 66, its tension being adjustable by inward or outward movement of its abutment provided on a screw 78 threaded into the interior of the casing. A hole 80 extending axially through the screw furnishes communication between the interior of the casing below the disc and the atmosphere. A screen 81 prevents dirt particles from the tank 46 from entering the valve and causing faulty seating of the disc.

A fitting 82 communicates with the interior of the casing outside of and below seat 74. The fitting is connected to the air line 108 which communicates with the various spaces above the pistons 104. Within this fitting is a ball check valve resting on a seat 86 and retained in the fitting by cross pin 88.

In the operation of the device, so long as the pressure in the supply tank is below the predetermined maximum, the disc 68 will be held against its upper seat, and consequently the spaces above the pistons 104 will be open to the atmosphere through the ball check 84, which has a faulty fit upon its seat 86 so as to permit a slow leakage of air. Under such conditions the spring 102 maintains the valve 92 in its upper position so that the cylinders may supply compressed air to the tank 30 through the exhaust valves 24. When the pressure in the tank 30 reaches a predetermined amount, the disc 68 is snapped to its lower seat on which it is held by reason of the effective increase of area acted upon by the air at tank pressure. Air at the pressure of the tank then flows past the check valve 84 and depresses the pistons 104, moving the valves 92 to their lower seats so that air may be forced past the valves 24 directly to the atmosphere.

When the pressure in the tank falls to a predetermined minimum, the disc 66 would be

snapped against its upper seat by the spring 76 and held there by reason of the fact that the area on the upper side of the disc is now substantially reduced. When this occurs, the spaces above the pistons 104 are open to the atmosphere and the compressed air may flow therefrom, preferably slowly, past the ill fitting check 84. This check is desirable inasmuch as the slow upward movement of the pistons 104 would insure that the engine shaft will make an appreciable number of revolutions before the load is taken by the engine. In general an engine compressor unit of this character is furnished with a governor which is somewhat sluggish in operation and should be permitted to open the engine throttle before full load is imposed on the compressor. The delay provided by the slow movement of the valve 92 during compression strokes of the compressor pistons enables the governor to furnish sufficient mixture to the engine as the load is gradually increased to avoid any sudden shock. Of course, if the shock is immaterial, the check 84 may be eliminated, whereupon as soon as the valve 68 operates delivery of compressed air to the tank will take place.

It will be obvious that with the above arrangement the pressure in the cylinder remains constantly approximately atmospheric during an unloaded period, the deviations from atmospheric pressure being only the minor ones due to friction in the passages and the light pressure of the exhaust valve springs.

It will be clear that numerous changes in the embodiment of the invention may be made without departing from its scope.

What I claim and desire to protect by Letters Patent is:

1. In combination, a receiver for compressed gas, a compressor connected to said receiver to deliver gas thereto including a cylinder and reciprocating piston therein, an intake valve for the cylinder, means for mechanically actuating the intake valve, and an exhaust valve operated automatically by the gas compressed in the cylinder when its pressure exceeds that in the receiver, and means for unloading the compressor when the pressure in the receiver exceeds a predetermined amount, said last named means comprising a valve arrangement to engage alternatively either of two seats and adapted when engaging one seat to provide for passage of gas from the exhaust valve to the receiver and when engaging the other seat to open the discharge side of the exhaust valve to the atmosphere and cut off communication between the exhaust valve and the receiver so that the pressures in the cylinder remain approximately atmospheric during unloading periods, and means for effecting complete movements of said valve arrangement between said two seats when such movements begin.

2. In combination, a receiver for compressed gas, a compressor connected to said receiver to deliver gas thereto including a cylinder and reciprocating piston therein, an intake valve for the cylinder, means for mechanically actuating the intake valve, and an exhaust valve operated automatically by the gas compressed in the cylinder when its pressure exceeds that in the receiver, and means for unloading the compressor when the pressure in the receiver exceeds a predetermined amount, said last named means comprising a valve arrangement to engage alternatively either of two seats and adapted when engaging one seat to provide for passage of gas from the exhaust valve to the receiver and when engaging the other seat to open the discharge side of the exhaust valve to the atmosphere and cut off communication between the exhaust valve and the receiver so that the pressures in the cylinder remain approximately atmospheric during unloading periods, means for effecting complete movements of said valve arrangement between said two seats when such movements begin, and means for slowing down movement of the valve arrangement to position to provide passages of gas from the exhaust valve to the receiver so that load is applied gradually to the compressor.

3. In combination, a receiver for compressed gas, a compressor connected to said receiver to deliver gas thereto including a cylinder and reciprocating piston therein, an intake valve for the cylinder, means for mechanically actuating the intake valve, and an exhaust valve operated automatically by the gas compressed in the cylinder when its pressure exceeds that in the receiver, and means for unloading the compressor when the pressure in the receiver exceeds a predetermined amount, said last named means comprising a valve arrangement to engage alternatively either of two seats, the space within which the valve arrangement moves between the seats being continuously in communication with the discharge side of the exhaust valve, the side of one of the seats opposite the valve arrangement being continuously in communication with the atmosphere, and the side of the other of the seats opposite the valve arrangement being continuously in communication with the receiver, and means responsive to the receiver pressure for effecting movements of the valve arrangement from one seat to the other and preventing floating of the valve arrangement between the seats.

4. In combination, a receiver for compressed gas, a compressor connected to said receiver to deliver gas thereto including a cylinder and reciprocating piston therein, an intake valve for the cylinder, means for mechanically actuating the intake valve, and an exhaust valve operated automatically by the gas compressed in the cylinder when its pressure exceeds that in the receiver, and means for unloading the compressor when the pressure in the receiver exceeds a predetermined amount, said last named means comprising a valve arrangement to engage alternatively either of two seats, the space within which the valve arrangement moves between the seats being continuously in communication with the discharge side of the exhaust valve, the side of one of the seats opposite the valve arrangement being continuously in communication with the atmosphere, and the side of the other of the seats opposite the valve arrangement being continuously in communication with the receiver, and means responsive to the receiver pressure for effecting movements of the valve arrangement from one seat to the other and preventing floating of the valve arrangement between the seats, but said last means slowing down movements of the valve arrangement to position to provide passage of gas from the exhaust valve to the receiver so that load is applied gradually to the compressor.

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