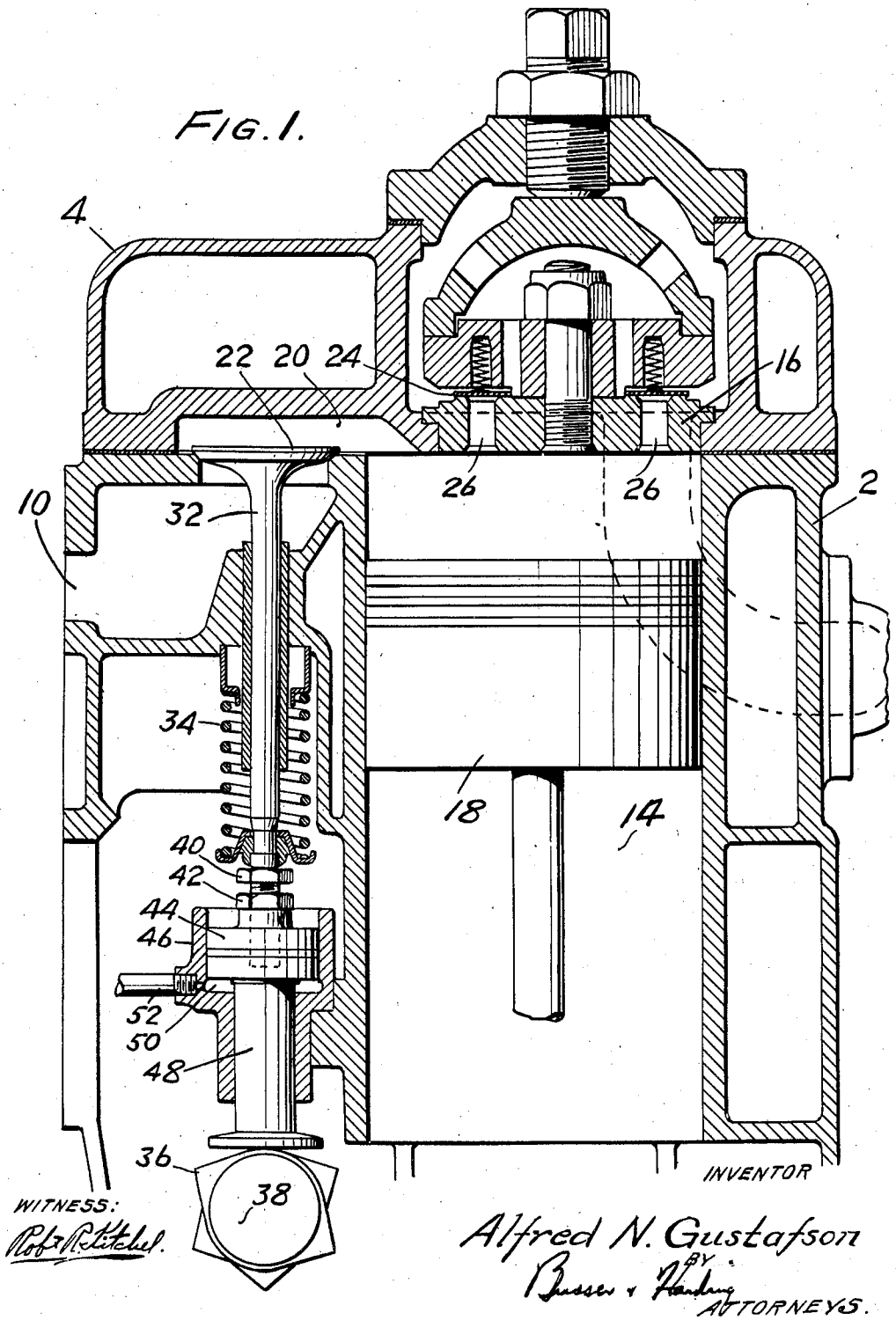
June 6, 1939. A. N. GUSTAFSON 2,160,860

COMPRESSOR

Filed Feb. 20, 1936 4 Sheets-Sheet 1

FIG. 1.



WITNESS:
Robt. R. Litchfield.

INVENTOR
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June 6, 1939. A. N. GUSTAFSON 2,160,860

COMPRESSOR

Filed Feb. 20, 1936 4 Sheets-Sheet 2

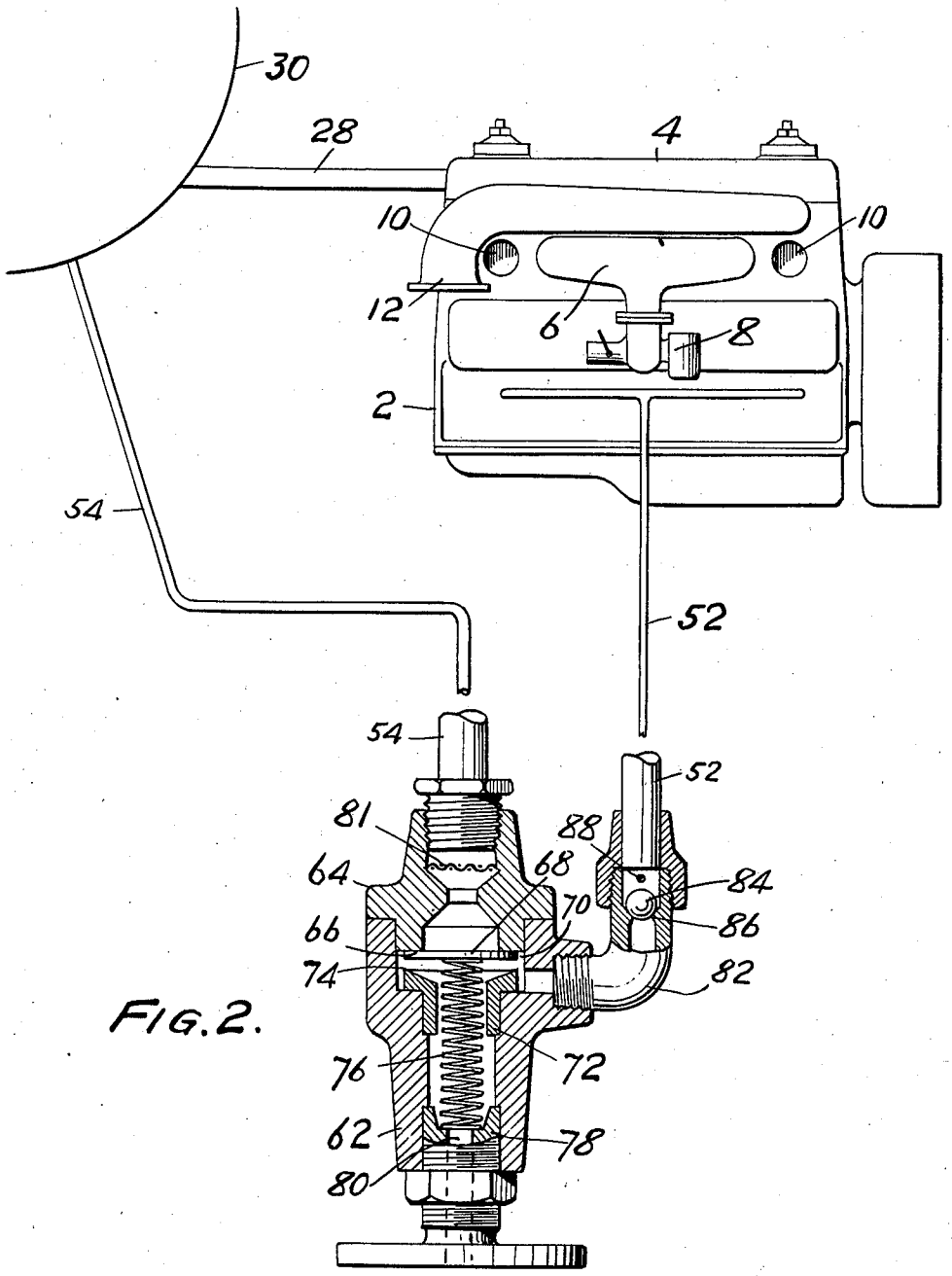


FIG. 2.

WITNESS:

Robt. R. Kitchel

INVENTOR

Alfred N. Gustafson

BY

Burson & Harding

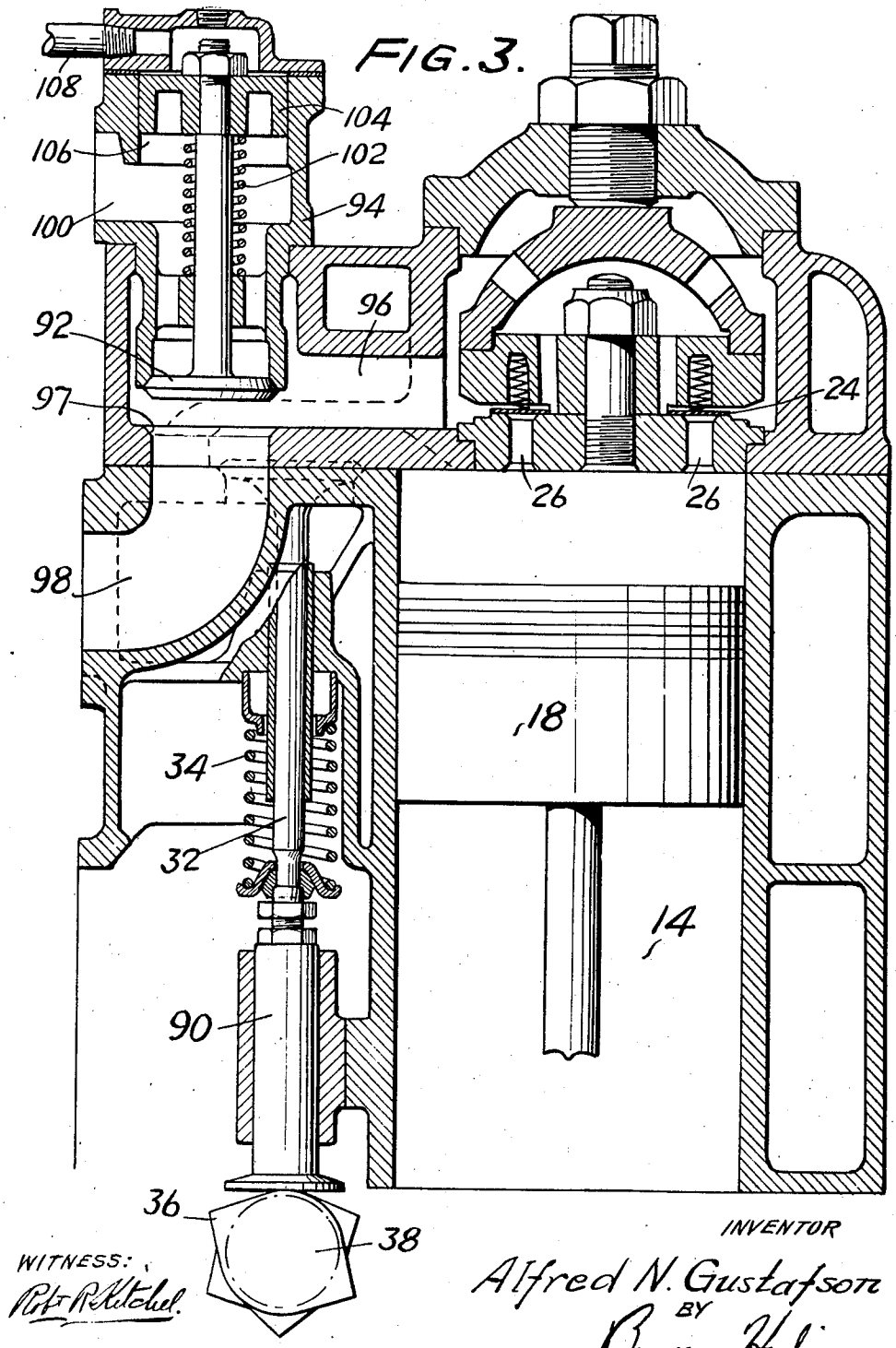
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June 6, 1939. A. N. GUSTAFSON 2,160,860

COMPRESSOR

Filed Feb. 20, 1936 4 Sheets-Sheet 3

FIG. 3.



WITNESS:
Robt. R. Mitchell.

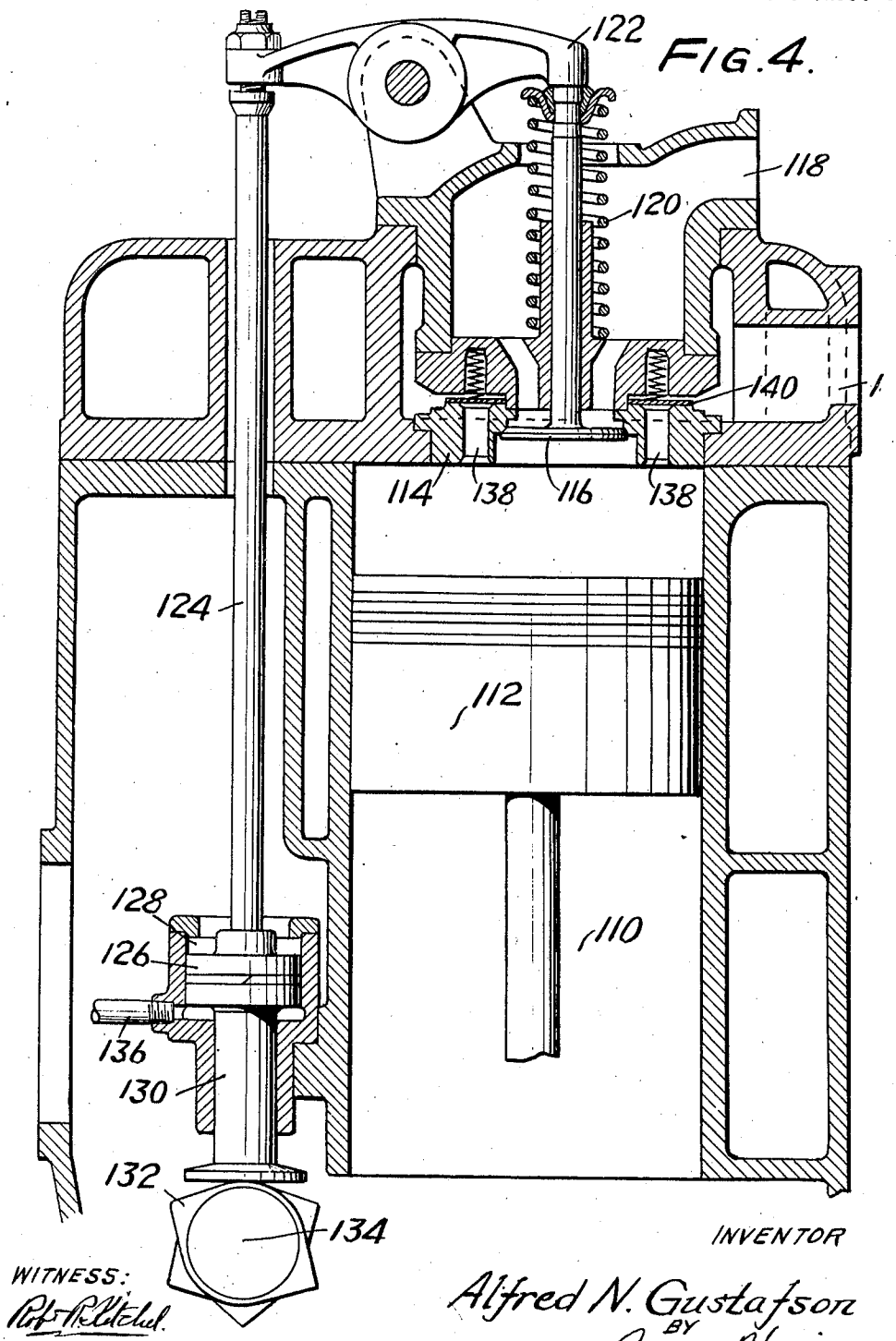
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June 6. 1939. A. N GUSTAFSON 2,160,860

COMPRESSOR

Filed Feb. 20, 1936 4 Sheets-Sheet 4

FIG. 4.



WITNESS:

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BY

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Patented June 6, 1939

2,160,860

UNITED STATES PATENT OFFICE

2,160,860

COMPRESSOR

Alfred N. Gustafson, West Chester, Pa., assignor to Schramm, Incorporated, West Chester, Pa., a corporation of Pennsylvania

Application February 20, 1936, Serial No. 64,808

4 Claims. (Cl. 230—30)

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.

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 multi-cylinder 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 combination, 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. In the preferred form this arrangement involves permanently holding the mechanical intake valve open without affecting the continued operation of its operating means. The unloading mechanism is such that as soon as the unloading devices are rendered inoperative the intake valve immediately commences to operate in properly timed fashion.

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:

Fig. 1 is an enlarged transverse section of a compressor of L-head type embodying the features of the invention and illustrating the improved method of unloading by holding open the intake valve;

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

Fig. 3 is a transverse section similar to Fig. 1 but showing an alternative method of unloading; and

Fig. 4 is another transverse section of the same general nature as Fig. 1 showing the adaptation of the invention to a valve-in-head type of compressor.

Referring first to Fig. 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 Fig. 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 driven by a motor or separate engine. The substituted cylinder head 4 in the case illustrated may, as usual, be so arranged as to maintain conventional conditions at the ends of the engine 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.

Reference may now be made more specifically to Fig. 1, which shows details of one of the compressor cylinders. The exhaust valve which is rendered inoperative is not indicated, but would lie in line with the intake valve above the cam shaft 38. As indicated at 16, the cylinder 14 is provided with little clearance, the piston 18 being adapted to move quite close to the lower face 16 of the head to secure good volumetric efficiency. A passage 20 serves to provide for the inflow of air from the intake pasage 10 past the valve 22. The exhaust takes place through a conventional valve arrangement located in the head and comprising a ring-shaped valve member 24 held downwardly by light springs to normally close ports 26. The outlet passages from this valve mechanism communicate with a manifold connected, as indicated at 28, with a supply tank 30.

The stem 32 of valve 22 is held downwardly in the usual fashion by a spiral spring 34. In the engine there is located, between the lower end of the valve stem 32 and a cam, a push rod which serves for the actuation of the valve once in every two cycles if the engine is of the four-cycle type. To accomplish this result, the cam shaft 38 is conventionally driven at half the rotary speed of the crank shaft and would normally carry single-lobed cams properly angularly placed to attain desired timing. A cam shaft driven at one-half the speed of the crank shaft may be used after the conversion, but must then be provided with double-lobed cams 36 in order that the intake valve 22 may be opened through every out stroke of the piston 18.

In accordance with the present invention, the valve stem 32 is engaged by the head 40 of a screw which is locked by a lock nut 42 in a piston 44. The piston 44 is arranged for vertical movement in a cylinder 46 and may, in turn, be abutted by a cam follower, indicated at 48, suitably guided in a lower extension of the cylinder 46. The space 50 below the piston 44 is in communication with the tank 30 through a line 52 in which is interposed a suitable snap valve of conventional type, illustrated in detail in Fig. 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 disk 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 disk and seats are finely ground to insure air-tight contact between the disk faces and the respective seats. The disk 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 disk 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 disk and the atmosphere. A screen 81 prevents dirt

particles from the tank 46 from entering the valve and causing faulty seating of the disk.

A fitting 82 communicates with the interior of the casing outside of and below seat 54. The fitting is connected to the air line 52 which communicates with the various cylinders 46. Within this fitting is a ball check valve 84 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 disk 66 will be held against its upper seat and consequently the cylinder 46 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 34 presses the follower 48 in continuous contact with the operating cam 36 and, as a consequence, the inlet valve is opened by the cam during the intake strokes and closed during the exhaust strokes, so that compressed air is forced through the valve 24 into the tank 30. When the pressure in the tank 46 reaches a predetermined amount, the disk 66 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 raises the piston 44, opening and holding open the intake valve 22 so that, as the compressor continues to operate, air is drawn inwardly and forced outwardly idly past the intake valve. By this arrangement the intake valve is held wide open with the result that there is little resistance to flow of the air and consequently no substantial waste of energy due to the continued operation of the compressor pistons.

When the pressure in the tank falls to a predetermined minimum, the disk 66 will 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 disk is now substantially reduced. When this occurs, the cylinder 46 is opened 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 piston 44 will move downwardly slowly with the result that for an appreciable number of revolutions of the engine shaft the valve 22 will not be completely closed. 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 closing of the valve 22 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 66 operates, the inlet valve 22 will be again under the control of the cam 36.

Referring now to Fig. 3, there is shown therein a compressor similar to that of Fig. 1 but in which the unloading is accomplished in a somewhat different fashion. In this case the intake valve 32 is continuously operated through the pusher 90 by the cam 36 on the cam shaft. The passage 96 from the automatic discharge valve 24 normally communicates through 98 with the receiver. 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 in 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 corresponding in its connections with the tube 52; in other words, 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.

In Fig. 4 there is shown substantially the same operative arrangement as in Fig. 1, applied to a valve-in-head type of compressor. In this case the cylinder is indicated at 110 and the piston at 112. In the cylinder head there is fitted a member 114 which provides a seat for the valve 116 normally urged upwardly by a spring 120 and opened at the proper times by a rocker arm 122 acted upon by a push rod 124 connected to a piston 126 reciprocating in cylinder 128. The piston 126 is acted upon by a plunger 130 which forms a follower for the cam 132 carried by the cam shaft 134. The tube 136 corresponds to the tube 52 and communicates with an unloading arrangement such as indicated in detail in Fig. 2. It will be obvious that the unloading takes place in substantially the same fashion as in Fig. 1, the unloading resulting in the maintenance of valve 116 in open position so that air is idly drawn into and forced out through the passage 118. In this arrangement the delivery or discharge valve 140 in the form of a ring may be arranged annularly to the valve 116, there being provided an annular series of holes 138 communicating with the cylinder. The compressed air is forced outwardly through one or more passages 142 to the receiver.

In all of the unloading arrangements illustrated, it will be obvious that during an unloaded period the pressure in the cylinder remains constantly approximately atmospheric, the deviations being only the minor ones due to friction in the passages and, in the case of the modification of Fig. 3, 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 cyl-

inder 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 means maintaining the intake valve open during an unloaded period.

2. A compressor including a cylinder, a piston therein, a valve controlling an intake port, a spring urging said valve to closed position, a cam having a fixed axis driven in timed relationship with the piston to open said valve, and means for holding said valve open upon attainment of predetermined pressures of compressed gas delivered by the compressor irrespective of the operation of said cam.

3. A compressor including a cylinder, a piston therein, a valve controlling an intake port, a spring urging said valve to closed position, a cam having a fixed axis driven in timed relationship with the piston to open said valve, and pneumatically actuated means for holding said valve open upon attainment of predetermined pressures of compressed gas delivered by the compressor irrespective of the operation of said cam.

4. A compressor including a cylinder, a piston therein, a valve controlling an intake port, a spring urging said valve to closed position, a cam driven in timed relationship with the piston to open said valve, intermediate devices between the cam and valve through which the cam operates said valve, the intermediate devices including a piston, and means for moving the piston to hold the valve open upon attainment of predetermined pressures of compressed gas delivered by the compressor irrespective of the operation of said cam.

ALFRED N. GUSTAFSON.