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VARIABLE CLEARANCE VOLUME AIR COMPRESSOR

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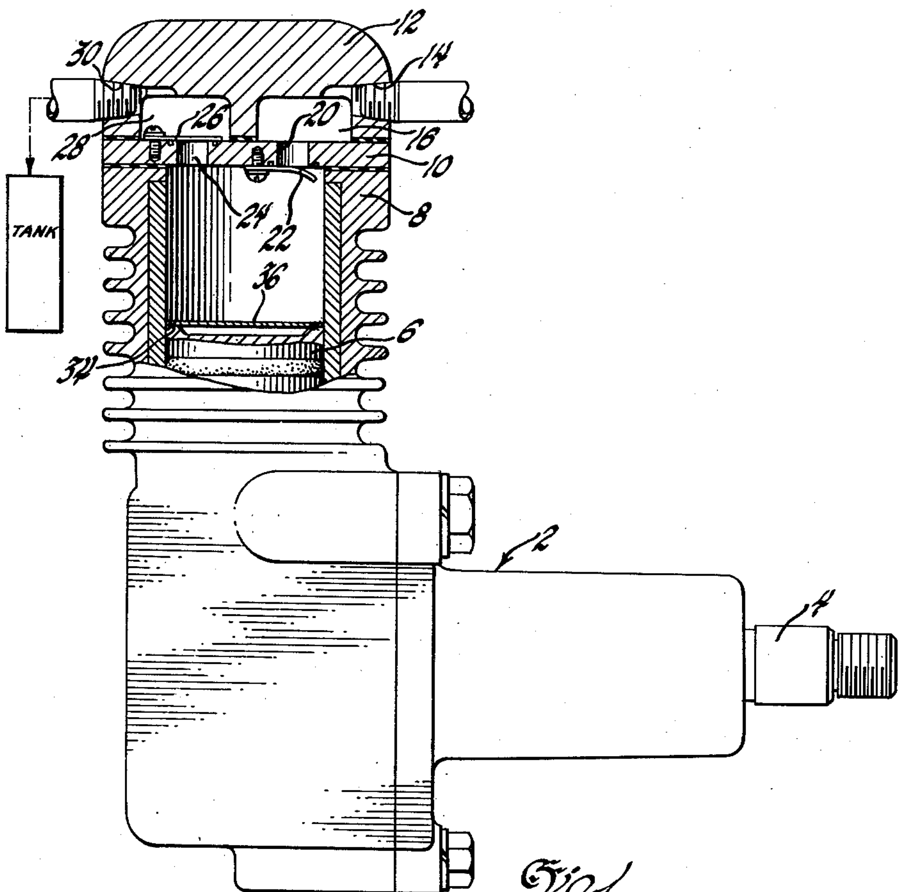

Fig.1

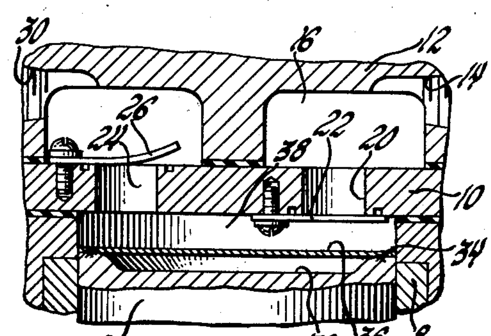

Fig.2

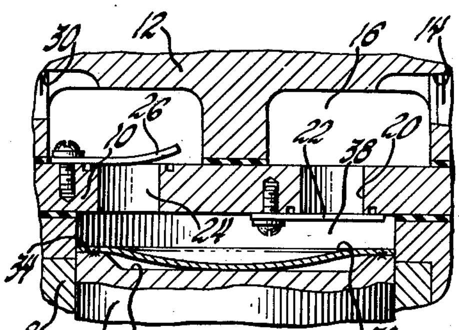

Fig.3

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VARIABLE CLEARANCE VOLUME AIR COMPRESSOR

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5 Claims. (Cl. 230—21)

The present invention relates to a novel means cooperating with an air compressor of the reciprocating piston and cylinder type to provide a variable clearance volume to vary the effective compression ratio of such a compressor.

Moreover, the present invention relates to fluid systems which include a high pressure air receiver in combination with an air compressor of the balanced head type, whereby the compressor may initially operate at a "stall pressure" in excess of the rated pressure capacity of the receiver followed by a progressive reduction in the "stall pressure" to a value at least as low as the rated reservoir capacity.

An obvious way to accomplish a decrease in effective compression ratio in the type of compressor herein defined is to increase the clearance volume thereof with respect to the swept stroke of the compressor piston. Heretofore, many elaborate devices have been designed to accomplish this purpose, all of which, to my knowledge, requiring the use of complicated valving and servo-mechanisms. It is now contemplated to provide a relatively simple means cooperating with the reciprocating piston and cylinder compressor to vary the volume of the clearance chamber of the compressor, thereby varying the effective compression ratio.

With respect to another aspect of this invention, it is intended to provide an air compressor of the reciprocating piston and cylinder type particularly adaptable for use with an air suspension system. Air suspension systems of the type to which reference is herein made, typically include a plurality of air springs supporting the sprung mass of the vehicle on ground engaging wheels, a source of fluid pressure, means for conducting this pressure to the air springs and, somewhere in the system and usually between the fluid pressure source and the springs, a high pressure tank or receiver. In such a system it is, of course, desirable to supply air under pressure to the air springs as rapidly as possible to bring the vehicle to the desired standing or trim height. Moreover, because of the limited space available on the vehicle for mounting a compressor to supply this fluid pressure, it is desirable to provide a relatively small compressor which, nevertheless, will be effective to inflate the air springs rapidly. However, with an air compressor of any given size, an additional time delay in inflating the springs is presented if, as is the usual practice, the compressor functions to first fill the high pressure receiver or storage tank from which the springs are supplied.

Pursuant to the general features of this invention in which the compressor is intended for use in an air suspension system of the type described, it is desirable that the compressor operate on the balanced head or controlled compression ratio principle; that is, a compression ratio is selected which will provide a predetermined desired capacity or rate of delivery. Moreover, to protect the high pressure tank, the compressor will have a "stall pressure" roughly equivalent to the desired cut-off pressure

of a high pressure tank or receiver. For the purpose of this application, "stall pressure" may be defined as the compression ratio times atmospheric pressure, without considering valve efficiency or thermal effects. Accordingly, in the case stated, when the pressure in the high pressure tank equals the "stall pressure" of the compressor, the latter stalls or stops compressing air; that is, the air in the compressor cylinder compressed by the piston on each compression stroke is not displaced into the high pressure tank, but merely expands back to normal volume on the return stroke of the piston. Thus, the power required to drive the compressor on the compression stroke is returned to the compressor by expansion of the compressed air against the piston on return stroke, so that the total power consumption of the compressor operating at "stall pressure," ignoring the losses aforementioned, is substantially zero.

For the reasons aforementioned, it is desirable that the compressor of the air suspension system be capable of a high rate of delivery of air to the high pressure tank thereby minimizing delay in bringing the vehicle to the desired standing height. Naturally, large compressors could be used to accomplish this purpose but, as aforementioned, space is not readily available for them. Thus, it is desirable to use a relatively small compressor but still have the advantage of rapidly bringing the vehicle to standing height. Moreover, the compression ratio of this smaller compressor must not be so large as to result in a "stall pressure" which will exceed the rated pressure capacity of the high pressure receiver or tank.

According to the present invention there is provided, in combination with the high pressure receiver of an air suspension or other fluid system, an air compressor of the reciprocating piston and cylinder type which has a design compression ratio resulting in a "stall pressure" in excess of the rated pressure capacity of the high pressure tank. However, a movable member is provided in cooperation with the piston and cylinder to define a variable volume clearance chamber, which member is progressively responsive to increasing pressure in the high pressure tank to increase the clearance volume of the compressor, thereby decreasing the effective compression ratio and the "stall pressure." The movable member of this invention is so designed as to provide an air compressor which will initially supply air rapidly to a high pressure receiver but, as the pressure in the latter increases, progressively reduce the "stall pressure" of the compressor to a point substantially equal to or below the rated pressure capacity of this tank.

It is, therefore, an object of this invention to provide an air compressor of the reciprocating piston and cylinder type in combination with a movable member responsive to increases in compressor exhaust pressure to vary the effective compression ratio of the compressor.

It is another object of this invention to provide a compressor of the type described with a movable member responsive to increase in exhaust pressure to reduce the "stall pressure" of the compressor.

It is still another object of this invention to provide a compressor of the type described with a depression in the piston head thereof, a flexible member or diaphragm overlying such depression and forming with the cylinder a variable volume clearance chamber, which member will deflect into the depression to decrease effective compression ratio and "stall pressure" in response to an increase in the exhaust pressure of the compressor.

Moreover, it is a principal feature and object of this invention to provide a balanced head or controlled compression ratio compressor of the type aforedescribed in combination with a fluid system such as an air suspension which includes a high pressure storage tank of a rated capacity less than the design "stall pressure" of the compressor, the compression ratio and "stall pressure" of the compressor being reduced as the tank pressure approaches its rated value whereby the compressor can operate initially at a "stall pressure" in excess of rated tank pressure capacity without damaging the latter.

These and other features, objects and advantages of this invention will appear more fully hereinafter as the description of the invention proceeds, and in which reference is made to the following drawing in which:

Figure 1 is a side elevation partly broken away of the compressor of this invention;

Figure 2 is a fragmentary enlarged view of the compression ratio varying means of this invention at a time when the pressure in the receiver is at a relatively low value;

Figure 3 is another enlarged view of the compression ratio controlling means of this invention at a time when it is operating in response to relatively high receiver and compressor exhaust pressures.

Referring now to the drawings, and Figure 1 in particular, an air compressor **2** of the reciprocating piston and cylinder type has a drive shaft **4** suitably connected to a source of power at one end, while its other end is connected through a crank to the piston **6** reciprocating in cylinder **8**. A cylinder head **10** and manifold **12** are suitably fixed to the upper end of the cylinder **8** of the air compressor. An air inlet port **14** communicates with an inlet chamber **16** through which air may pass through the port **20** as controlled by the flap valve **22**. The exhaust from the compressor will pass from the port **24** past the flap valve **26** into the exhaust chamber **28** from which it flows through the port **30** to a high pressure tank or other portion of a fluid system. With the compressor adapted for use with an air suspension system, the port **30** may be connected by suitable conduits to a high pressure storage or receiver tank, not shown. On the other hand, the air inlet port **14** may be in communication with atmosphere or, alternatively, with a low pressure tank or receiver.

Referring now more particularly to Figures 2 and 3, a preferably annular depression **32** is formed in the head of the compressor piston and is surrounded by the annular shoulder **34** formed at the peripheral edge of the piston head face. An annular flexible metal diaphragm **36** has its peripheral edge seated on the shoulder **34** as shown in Figures 2 and 3. In Figure 2, the piston is reaching the end of its compression stroke under a low exhaust pressure condition in which the compression ratio is not varied, while Figure 3 depicts a condition of higher exhaust pressure causing the member **36** to deflect into the depression **32** to increase the clearance volume **38** resulting in a decrease in effective compression ratio and compressor "stall pressure."

The operation of the compressor in a fluid system will be as follows, it being assumed that the exhaust port **30** is connected to a high pressure tank or receiver. For the purpose of this illustration, let it also be assumed that the high pressure receiver is at substantially atmospheric pressure when the compressor begins to operate. At this time, the diaphragm **36** will be disposed as shown in the Figure 2 position. As the compressor operates, it will compress air and deliver it through the port **24** to the high pressure tank or receiver gradually building up the pressure in the latter. As the pressure in the high pressure tank increases, the flexible member **36** will be progressively depressed into depression **32** as shown in Figure 3. As the flexible member is so depressed, it is obvious that the clearance volume **38** will be increased thereby decreasing effective compression ratio and, accordingly, the "stall pressure" of the compressor. Thus, it will be seen that the compression ratio of the compressor with the member **36** distended over the depression in the piston head as shown in Figure 2 will be greater than when the flexible member is displaced into the depression due to the increase in compressor exhaust pressure. This condition is shown in Figure 3 and corresponds to a decreased effective compression ratio and, naturally, a decrease in the "stall pressure" of the compressor.

The advantages attendant to incorporation of the compressor of this invention in any given fluid system including a tank to be supplied with air under pressure will be obvious. In such a system, the compressor may be relatively small and have a relatively high compression ratio and "stall pressure" relative to the rated pressure capacity of the high pressure tank to rapidly bring the latter up to pressure. However, as tank and compressor exhaust pressures increase, the diaphragm yields progressively on the compression stroke to gradually reduce the effective compression ratio until "stall pressure" has been reduced to approximate the maximum pressure capacity of the tank. Thereafter, the operation is the same as in any conventional controlled compression ratio or balanced head compressor.

It will therefore be readily appreciated that the structure of the present invention provides a relatively simple means for varying the compression ratio of a reciprocating type of compressor, and one which is particularly effective and useful when used in conjunction with a balanced head type of compressor in a fluid system such as an air suspension mechanism.

I claim:

1. An air compressor comprising a reciprocating piston and cylinder, air inlet and exhaust ports communicating with said cylinder, a depression formed in the head of said piston, a flexible member seated over said piston head depression and forming with said cylinder a variable clearance volume, said member being progressively yieldable into said depression to increase said volume as the exhaust pressure of said compressor increases.

2. A balanced head air compressor comprising a reciprocating piston and cylinder, said piston having a depression formed in its head, a flexible member seated over said depression and forming with said cylinder a variable clearance volume, said flexible member being progressively yieldable into said depression to variably increase said clearance volume in response to increased exhaust pressures to reduce the stall pressure of said compressor.

3. In combination, a high pressure receiver, an air compressor of the balanced head type comprising a reciprocating piston and cylinder, said compressor having a compression ratio and stall pressure in which the latter is in excess of the pressure capacity of said receiver, a depression formed in the face of said piston between the latter and said cylinder, a flexible member overlying said depression and forming with said cylinder a variable clearance volume, said flexible member being progressively yieldable into said depression in response to increasing pressure in said receiver to reduce the effective compression ratio of said compressor, whereby the stall pressure of the latter is progressively reduced to a value substantially equal to the rated pressure capacity of said receiver.

4. A balanced head air compressor comprising a reciprocating piston and cylinder, said piston having a central depression surrounded by an annular shoulder in its head, and a flexible diaphragm overlying said depression and having its periphery secured to said shoulder to form with said cylinder a variable clearance volume, said diaphragm being progressively yieldable into said depression to variably increase said clearance volume in response to increased exhaust pressures.

5. An air compressor comprising a cylinder having a fixed cylinder head, a piston including a piston head reciprocably disposed within said cylinder, air inlet and exhaust ports communicating with said cylinder, a depression formed in one of said heads, a flexible member seated over said depression and forming with said cylinder a variable clearance volume, said member being progressively yieldable into said depression to increase

said volume as the exhaust pressure of said compressor increases.

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