Sept. 20, 1966 A. B. NEWTON 3,273,786

FLOW REGULATOR FOR PISTON-EQUIPPED CYLINDER

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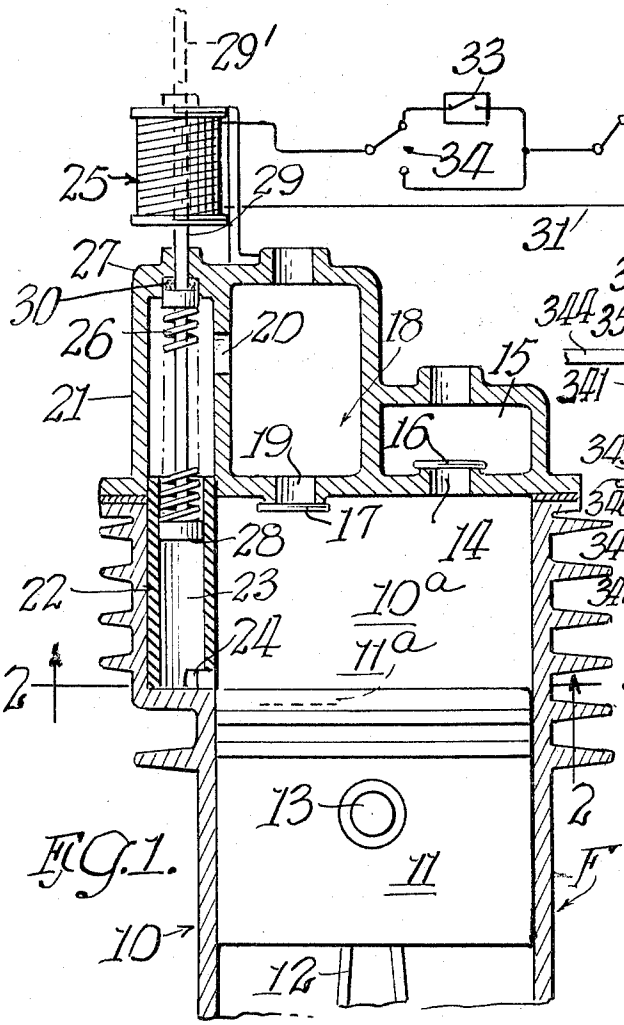


FIG. 1.

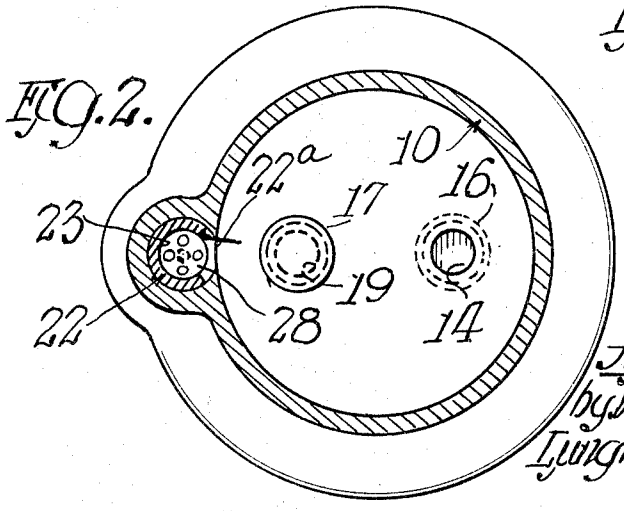


FIG. 2.

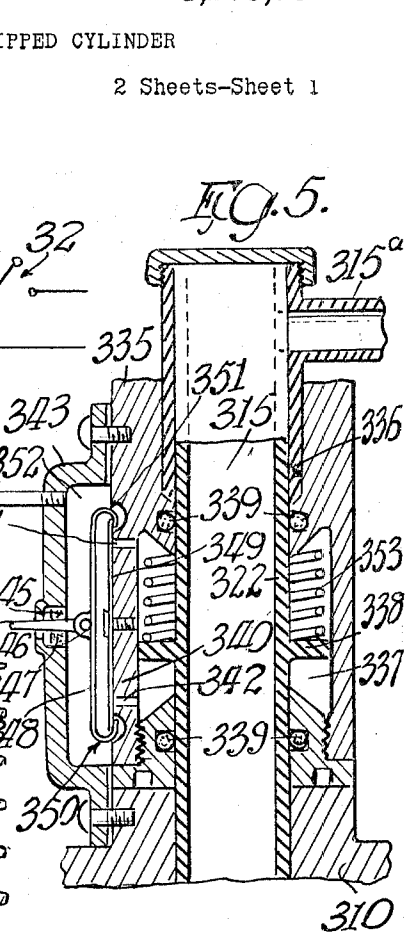


FIG. 5.

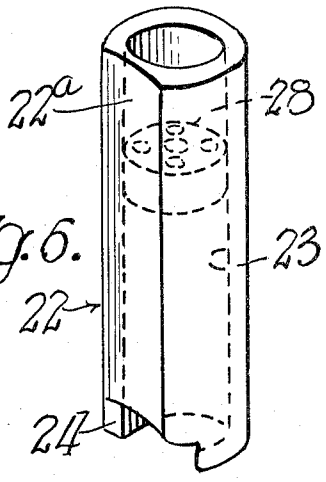


FIG. 6.

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FIG. 3.

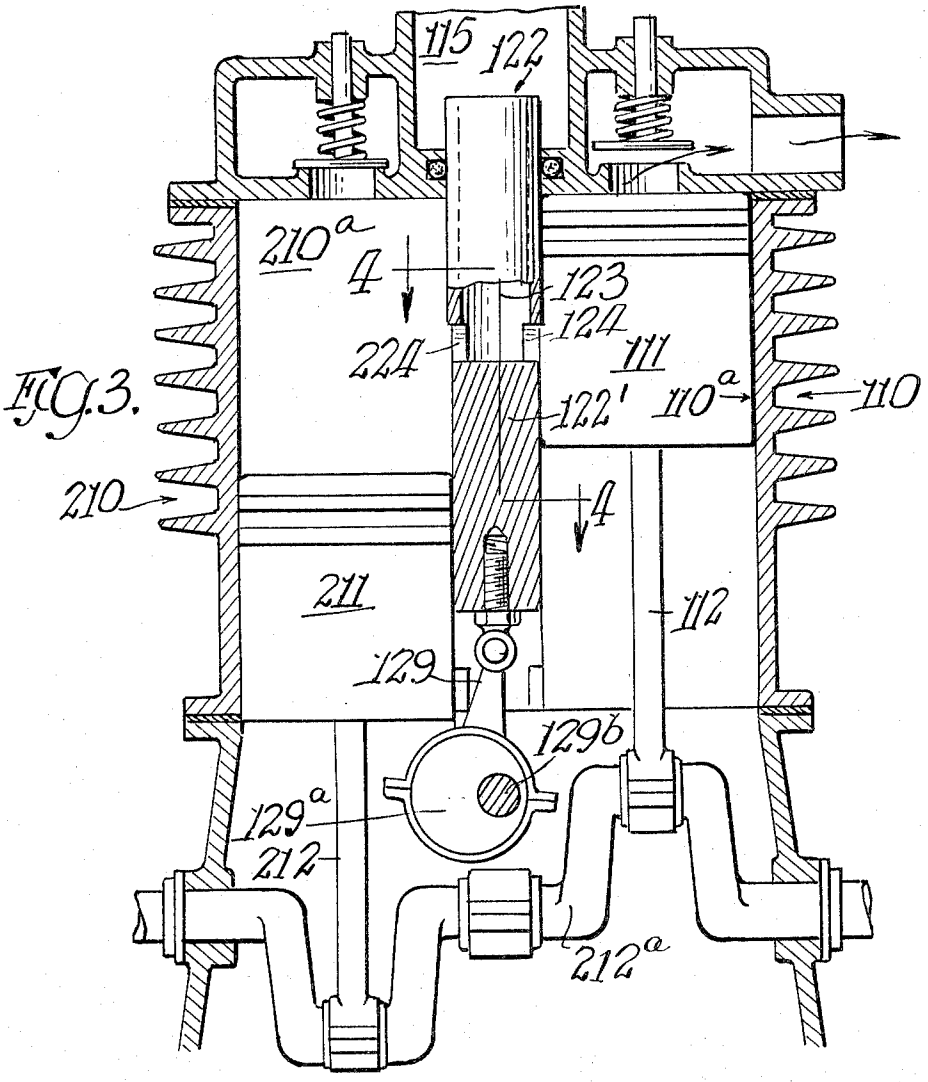
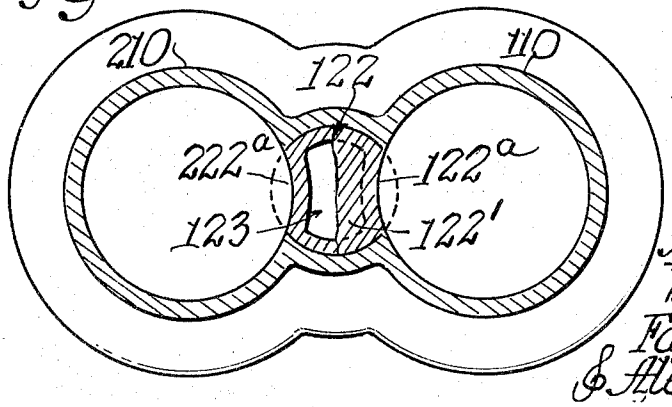


FIG. 4.



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United States Patent Office 3,273,786 Patented Sept. 20, 1966

3,273,786

FLOW REGULATOR FOR PISTON-EQUIPPED CYLINDER

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Filed Feb. 1, 1963, Ser. No. 255,491
4 Claims. (Cl. 230—23)

This invention is a continuation-in-part of my copending application, Serial No. 760,995, filed September 15, 1958, now patent No. 3,076,593.

This invention relates to a flow regulator for a piston-equipped cylinder, and, more particularly, to a flow regulator for the gas intake line for a compressor.

In certain applications of air conditioning, the compressor is operated irrespective of whether refrigeration is called for. One prime example is in automotive refrigeration. There, the compressor piston is directly coupled to the crankshaft and reciprocates whether refrigeration is needed or not. This operation is currently justified, since automobiles are overpowered and the power utilized in the refrigeration compressor does not seriously affect the engine performance. It would be desirable, however, to provide means which would regulate the amount of compression effected by the compressor as a function of the refrigeration load. It would further be desirable to provide means to reduce the capacity of the compressor during periods when little or no compression is required. These, then, form some of the objectives of this invention.

Another objective is to provide a novel flow regulator for a piston-equipped cylinder. Still another object is to provide means in the gas intake to a piston-equipped cylinder that regulates the flow of gas thereto. Yet another object is to provide means cooperating with the piston of a piston-equipped cylinder that regulates the degree of capacity or unloading of the cylinder and thereby correlates the compression developed by the cylinder to the load requirements.

A further object of the invention is to provide a novel structure of the character indicated in which a flow fitting or port member is sealingly and positionably mounted in the gas intake to a piston-equipped cylinder with the piston being movable into engagement with the fitting or port to close the same. A still further object is to provide in the apparatus described in the object immediately preceding, means for positioning the fitting or port member which is responsive to a thermal signal. A yet further object is to provide, in the apparatus just described, time delay means which postpones the imposition of all or part of the load on the compressor until it has started up. Other objects and advantages of this invention can be seen in the details of construction and operation set down in this specification.

This invention will be described in conjunction with the accompanying drawing, in which—

FIG. 1 is a fragmentary elevational view, partly in section, of apparatus embodying the teachings of this invention;

FIG. 2 is a cross-sectional view, taken along the line 2—2 of FIG. 1;

FIG. 3 is a view similar to FIG. 1 but showing a plurality of cylinders in the inventive compressor;

FIG. 4 is a sectional view taken along the line 4—4 of FIG. 3;

FIG. 5 is a fragmentary sectional view of apparatus such as is seen in FIG. 3 and showing a modified form of controlling the positionable element for varying the degree of unloading in the inventive construction; and

FIG. 6 is a perspective view of the movable element of FIGS. 1 and 2.

In the illustration given in FIG. 1, the numeral **10** designates generally a cylinder provided as part of a frame F which has a piston slidably mounted therein and which

is reciprocated by a piston rod **12** coupled to piston **11** through a wrist pin **13** in a conventional fashion.

The cylinder **10** is equipped with an outlet port **14** communicating with an outlet manifold **15**, the manifold supporting an exhaust check valve **16**. The foregoing arrangement is well known, and therefore details have been omitted as unnecessary, i.e., spring mountings, etc. for check valves. An inlet check valve **17** is provided in conjunction with the inlet manifold **18**, each of the check valves **16** and **17** operating in conjunction with a suitable port as at **14** and **19**, respectively.

The inlet manifold **18** is equipped with a second flow port **20** which communicates with the interior of an integral supplemental housing generally designated **21**. Slidably positioned within the supplemental housing **21** is a flow fitting or element generally designated **22** and which functions in the invention to vary the degree of compressor loading. For this purpose, the element **22** is hollow as at **23** and is equipped with a notched-out bottom portion as at **24**, conforming as at **22***a* to the piston, i.e., being ground to the radius of the piston. Thus, the element **22** provides at least a portion of the cylinder wall.

From the foregoing, it will be seen that a path for the flow of refrigerant gas alternative to port **19** is provided via the port **20**, the hollow interior **23** of the element **22**, and the notched-out portion **24**, so as to communicate with the head space **10***a* in the cylinder **10**. In the position of element **22** shown in FIG. 1, the compressor is fully loaded, i.e., as the piston **11** rises, there is no return of the refrigerant gas to the intake manifold **18**. However, the compressor can be fully unloaded by elevating the element **22** so that during the entire upstroke of the piston **11**, there is provided a by-pass around the inlet check valve **17**. In this connection, it is noted that the upper surface of the piston **11** is relieved as at **11***a* to accommodate the inlet check valve **17**.

The position of the element **22** is regulated by means of a solenoid **25**. The solenoid acts against a coiled spring **26** interposed between the top wall **27** of the housing **21** and a spider **28** provided interiorly of the element **22**. Extending axially of the spring and into the solenoid **25**, is a rod **29**. Thus, as the solenoid is energized, the rod **29** is moved upwardly to the position designated **29′** (in dotted line) to move the element **22** to a position of unloading the cylinder **10**. A suitable seal as at **30** may be interposed where the rod **29** extends upwardly outwardly of the housing **21**.

For the purpose of energizing the solenoid **25**, an electrical circuit as at **31** may be employed which includes a switch **32** for manual operation, a time delay switch **33**, and a thermostatic switch **34**.

Operation

In the operation of the apparatus just described, and in conjunction with an automobile refrigeration system, the intake manifold **18** is connected to a condenser (not shown) while the outlet manifold **15** is connected to the usual expansion valve and evaporator (also not shown). In such a case, the piston **11** is energized from the engine crank shaft through the piston rod **12**. The manual and safety switch is provided as part of the ignition switch, while the thermostat **34** is responsive to the temperature within the passenger space of the automobile. When the automobile is started, switch **32** is closed, along with the time-delay switch **33**. If the thermostatic switch **34** is in the position shown, this will energize solenoid **25** to raise the fitting or element **22** to its upper limit of travel and thus have the compressor completely unloaded.

Thus, no compression is provided and the refrigerant is merely drawn into the cylinder **10** through the port **19** and the passage made up of port **20**, hollow interior **23**, and notched portion **24**, and discharged through the same

passage. The cylinder **10** now acts as a compressor in a completely unloaded condition (i.e., with its capacity to pump reduced to zero). A short time after start-up, the time-delay switch **33** opens, breaking the supply of electrical current to the solenoid **25**, and the spring **26** forces the fitting **22** to the position shown. The compressor is then loaded. Under the operation just discussed, the thermostatic switch **34** is in the position in which refrigeration is called for. Should the switch be in the alternative position, corresponding to no demand for refrigeration, the solenoid **25** will be continuously energized and the cylinder **10** will remain in an unloaded condition.

This invention provides a number of advantages over prior art structures employed for the same purposes. The invention here, when employed in conjunction with a compressor, does more than merely "unload" the compressor, as was the case with prior art devices. Here, it is possible to reduce the capacity of the compressor cylinder. In a multi-cylinder compressor, it is possible to reduce the capacity of all cylinders an equal amount. In contrast to this, many conventional unloading means for cylinders permit only complete unloading, one by one. This results in unequal torque and damages some drive means. Such a conventional unloader is described in my prior Patent No. 2,761,616, issued September 4, 1956. In contrast to this, the invention here permits a smooth reduction of capacity. Furthermore, in conventional systems, it is usual to unload all but 20–30% of the cylinders in a multi-cylinder compressor, as to unload all of them would result in cessation of flow of gas and therefore of cylinder cooling. By keeping at least one or two cylinders cool by continuing their flow, it was hoped that the rest would be cool also. In the inventive device, at least a minimum flow can be provided for each cylinder through restricting the upward position of the element **22**, irrespective of the number of cylinders, thereby attaining cooling of each.

It is to be appreciated that the flow member **22** can be positioned intermediate two adjoining cylinders, thus varying the capacity of each—or a plurality of such members can be employed, each operating from a common shaft, so that each cylinder is "unload" to the same degree. In a form of invention where one port member as at **122** is slidably mounted in the intake **115** common to both cylinders **110** and **210**, a port member **122** is positioned by means of a connecting rod **129** connected to an eccentric **129***a*. For individual port members for each cylinder, the shaft **129***b* to which the eccentric **129***a* is attached can be arranged in parallel to the crankshaft **212***a* instead of transverse, as shown. In this manner, each of a number of positioning rods such as **129** can be simultaneously positioned. The crankshaft **212***a* is seen to be connected in conventional fashion to the pistons **111** and **211** by means of piston rods **112** and **212**, respectively.

The rod **129** is seen to be connected to a solid portion **122'** of the member **122**, the member **122** also having a hollow interior as at **123** and notched-out portions as at **124** and **224**, communicating, respectively, with the interior head spaces **110***a* and **210***a* of the cylinders **110** and **210**, respectively.

With the construction of FIG. 3, it will be seen that the sides of the pistons **111** and **211** contact the movable element **122** at all times in order to keep it in position and to cooperate with the upper lip of the pistons **111** and **211** as they move up and down.

The embodiment of FIGS. 3–4 permits positioning of the flow element **122**. This permits variation of the compressor loading. Normally, a refrigeration compressor, or, for that matter, most any compressor, operates at a fairly constant compression ratio and pressure level as load, speed, or both, vary. One of the features of the inventive construction is that for a given capacity, i.e., compression ratio and pressure level, the time for gas to enter the cylinder is fairly constant. For example, at 18 r.p.s. and a 60° portion of the stroke corresponding to the port or notch **124** being open, the time the port is open is 0.0093 of a second. At 90 r.p.s. with the port being open three-fourths of the stroke, i.e., 270°, the time the port is open is 0.0083 second.

As seen in FIG. 4, the element **122** has a pair of oppositely-disposed, arcuate side walls as at **122***a* and **222***a*, thereby providing portions of the cylinder walls. In the event it is desired to operate the construction of FIGS. 1 and 3 independently of the rods **29** and **129**, the construction in FIG. 5 can be employed.

In FIG. 5, the numeral **310** designates generally the upper portion of the cylinder units wherein a flow element **322** is mounted for positionable movement much the same as the element **122** in the showing in FIG. 3. The intake is designated by the numeral **315** and connects to a suction line as at **315***a*.

Provided as an upward projection on the cylinder housing **310** is a casing **335** equipped with a bore **336** communicating with an annular chamber **337**. The positionable element **322** is equipped with an integral annular flange as at **338** which is positioned within the chamber **337**. The casing **335** is equipped with suitable seals as at **339** arranged to conform to the shape of the element **322** so as to seal the refrigerant gas coming from the suction line **315***a* from the chamber **337** which is filled with hydraulic fluid.

The chamber **337** is defined in part by the wall **340** equipped with flow ports **341** and **342**. Overlying this portion of the wall **340** is a supplemental casing **343** which is equipped with an oil inlet as at **344** and an aperture **345** through which a control knob **346** projects. Positioned about the control handle **346** is a flexible seal **347** secured to a valve actuator **348**. The actuator **348** is equipped with curved ends which extend under a valve plate **349** as at **350** and **351**.

Movement of the lever handle **346** upwardly in FIG. 5 results in raising the lower end of the valve plate **349** so that fluid is able to flow out of the upper end of chamber **337** into the supplemental casing chamber **352** and then through the port **342** into the lower portion of the chamber **337**. This permits the element **322** to be moved upwardly under the joint influence of gas pressure against the bottom as well as the frictional engagement thereof by the pistons. When the desired position of the element **322** has been achieved, the lever handle **346** is returned to neutral position, after which the lower end of the valve element **349** covers the port **342** and serves as a check valve.

Movement of the lever handle **346** downwardly results in the uncovering of the port **341**, i.e., preventing the valve element **349** from serving as a check valve so that fluid issuing from the chamber **337** through the port **342** into the supplemental casing chamber **352** is able to reenter the chamber **337** through the port **341**. This results in a downward movement of the element **322** under the influence of suction and the frictional engagement of the pistons with the element **322**. A light spring pressure may be applied by the spring **353** to provide the initial downward movement of the element **322** prior to the same becoming frictionally engaged with the pistons (not shown).

While, in the foregoing specification, a detailed description of the invention has been given for clearness of understanding, those skilled in the art will perceive many variations in the details herein given without departing from the spirit and scope of the invention.

I claim:

1. In a refrigeration apparatus, a pair of cylinders in side-by-side relation, each having side and top walls defining a compression chamber, a piston mounted in each of said cylinders for reciprocal movement defining intake and compression strokes, said cylinders being equipped with an opening in each of their side walls, means containing refrigerant fluid communicating with said openings, an element positioned between said cylinders and mounted in said openings for movement therein independ-

ent of the movement of said pistons, port means in said cylinders for introducing and removing refrigerant fluid, and means for positioning said element in said openings for changing the effective area of said openings and to provide fluid flow therethrough during selected initial portions of each of the pistons compression strokes up to and including substantially all of the pistons compression strokes.

2. In a device of the character described, a pair of adjacent cylinders each containing a piston for reciprocation therein, a crankshaft for driving said pistons in out-of-phase relationship, an opening in the common wall between said pair of cylinders, a movable element mounted within said opening and having its opposite sides shaped to fit closely to said pistons when adjacent thereto, means for positioning said element within said opening to vary the effective size of said opening, and means in said element for flowing fluid therethrough into said cylinders.

3. In a gas compressor, a frame providing a cylinder cavity and an outlet port for compressed refrigerant gas, an element movably mounted in said frame and having at least a segmental cylindrical wall to provide at least a portion of the wall defining said cylinder cavity, a piston mounted in said cylinder cavity for reciprocal movement defining intake and compression strokes, means for moving said piston and means for moving said element independent of said piston to change the effective area of said cavity, said element containing a flow passage for refrigerant gas communicating with said cylinder cavity.

4. The structure of claim 3 in which said means for moving said element includes a casing about said element and providing a hydraulic fluid chamber, a flange on said element projecting into said chamber to divide the same into two portions, a flow passage communicating said portions, and selectively operable check valve means in said flow passage.

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