Jan. 29, 1957 W. M. KAUFFMANN ET AL 2,779,155

TURBOCHARGING SYSTEM FOR INTERNAL COMBUSTION ENGINES

Filed Nov. 19, 1953. 2 Sheets-Sheet 1

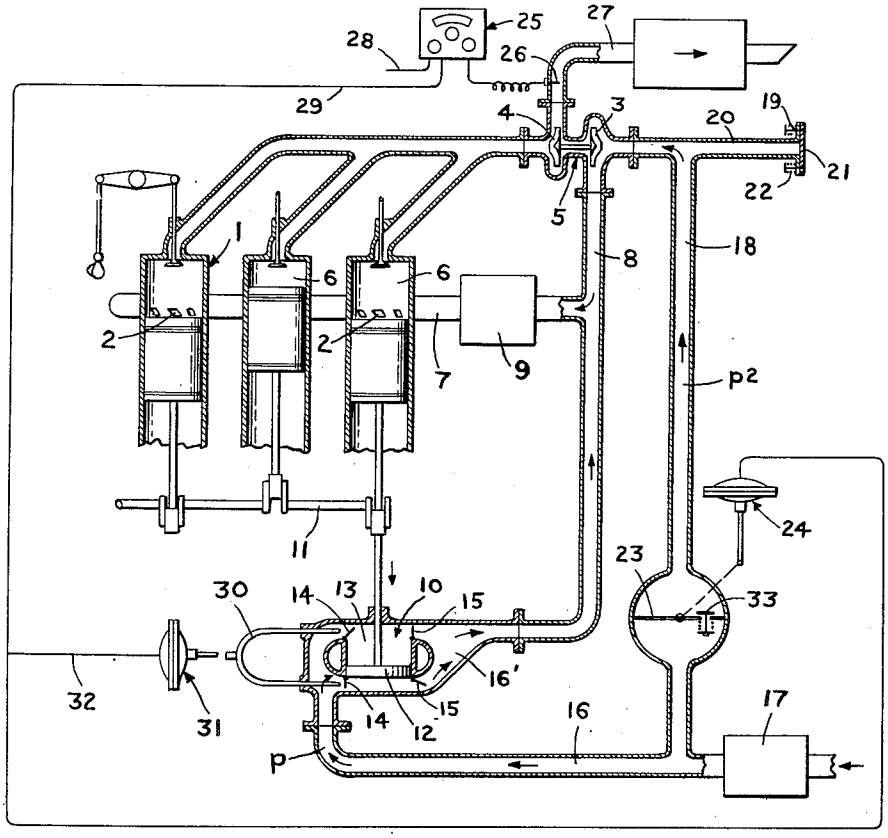

FIG. 1

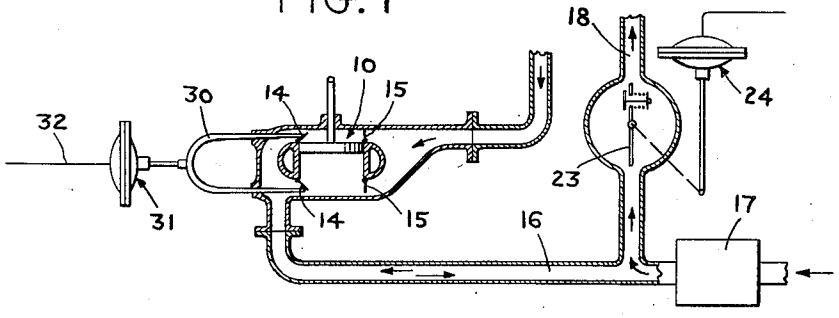

FIG. 2

WILLIAM M. KAUFFMANN
HAROLD W. WHITING
INVENTORS

BY Robert Meyer
Atty

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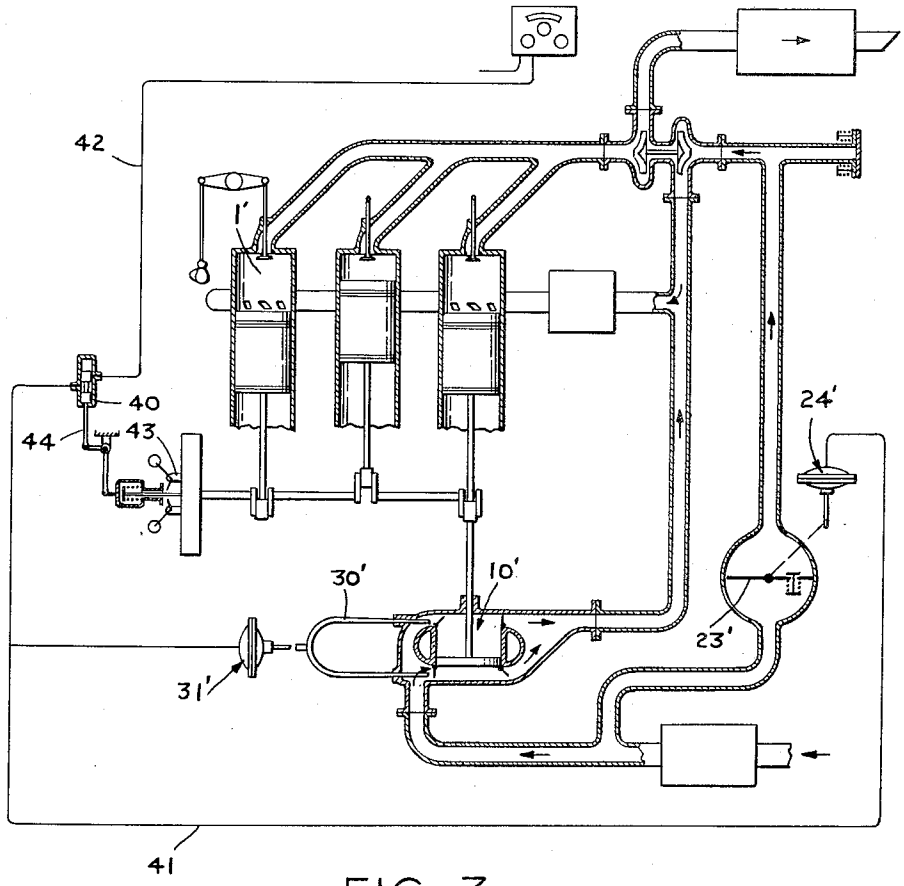

FIG. 3

WILLIAM M. KAUFFMANN
HAROLD W. WHITING
INVENTORS
BY

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TURBOCHARGING SYSTEM FOR INTERNAL COMBUSTION ENGINES

William M. Kauffmann, Hamburg, and Harold W. Whiting, Buffalo, N. Y., assignors to Worthington Corporation, Harrison, N. J., a corporation of Delaware

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3 Claims. (Cl. 60—13)

This invention relates to two-cycle internal combustion engines, and more particularly to a system and mechanism for turbocharging such engines.

In turbocharged engines, the air utilized for combustion and scavenging is compressed in a turbo-compressor driven by the exhaust gases of the engine. Such engines are, in most instances, started by air under pressure supplied from a suitable source, the engine being operated by such starting air until it "picks up" its normal operating conditions. While such an engine can be made to fire erratically while operating on starting air, there is not sufficient energy in the engine exhaust at such times to provide turbine speed of the turbo-compressor adequate to supply sufficient compressed air to support combustion in the engine and thus the engine will cease to fire when the starting air is cut off.

The present invention embodies means to remedy these operating conditions by utilizing an air pump, such as the usual scavenge pump used with similar engines which do not employ turbo-compressors. The air pump is provided to supply pressure air to the engine during the starting period of sufficient quantity and pressure to support combustion when the starting air is cut off and until the engine reaches a desired load condition at which point of operation the energy in the engine exhaust will operate the turbo-compressor at conditions which will provide sufficient air to support combustion in the engine. At such times the pressure of air supplied by the turbocharger will increase above the normal air pressure supplied by the air pump. Means are provided which will, when the above condition is reached unload the air pump and permit it to operate idly and divert the incoming suction air to the turbo-compressor the discharge of which is delivered to the engine cylinders so that the engine continues operation with pressure air supplied by the turbo-compressor only.

With these and other objects in view, as may appear from the accompanying specification, the invention consists of various features of construction and combination of parts, which will be first described in connection with the accompanying drawings, showing a turbocharging system for internal combustion engines of a preferred form embodying the invention, and the features forming the invention will be specifically pointed out in the claims.

In the drawings:

Figure 1 is a diagrammatic view partly in section showing the turbocharging system of the present invention during the engine starting and light load operating conditions.

Figure 2 is a fragmentary diagrammatic view partly in section showing the air pump and companion mechanism during partial and full load operation of the engine when the air for scavenging and combustion is supplied wholly by the turbo-compressor.

Figure 3 is a view similar to Figure 1 differing therefrom in that it shows a modified form of the control mechanism which controls unloading of the air pump and diversion of the incoming suction air to the turbo-compressor.

Referring more particularly to the drawings, 1 indicates a multicylinder two-cycle spark ignition gas engine in the combustion chambers of which a mixture of air and gas is fired by suitable sparking mechanism (not shown). The pressure air used in such engines enters the cylinders through the annular cylinder ports 2 and such air is used both for scavenging the cylinders and for supporting combustion.

The present invention relates to the turbocharging of such an engine, that is, to the supplying of the pressure air to the cylinders thereof by a compressor 3 operated by a turbine 4. The turbine 4 is operated by the energy of the exhaust gases leaving the cylinders of the engine 1 and consequently the turbine is interposed in exhaust outlet passages of the engine. The air compressed by the turbo-compressor unit 5 which constitutes the compressor 3 and turbine 4 is delivered to the cylinders 6 of the engine 1 through a suitable conduit system including the intake air manifold 7 and the conduit 8. In some engines and under some operating conditions the temperature of the air compressed by the turbo-charger 5 is greater than desired for efficient operation of the engine and in such instances an air cooler as shown at 9 is interposed between the conduit 8 and the air intake manifold 7.

As set out hereinabove, turbo-charged two-cycle internal combustion engines are subject to difficulties when starting and under light load operation due to the fact that the exhaust gas of the engine under such operating conditions does not have sufficient energy to provide turbine speed of the turbo-compressor adequate to supply sufficient air under the desired compression pressure to support combustion in the engine and consequently the engine will cease to fire at such times. To overcome this undesirable feature in such engines an air pump 10 of any suitable construction is provided which may be operated direct from the crank shaft 11 of the engine 1. In the drawings, the air pump 10 is shown as a reciprocating air compressor or pump but it is to be understood that a rotary blower or other suitable type of air pump which will meet the conditions of the present invention may be substituted for the reciprocating type of air pump or compressor shown.

The air pump or compressor 10 embodies, in the form shown, a reciprocating piston 12, cylinder 13 in which it reciprocates, inlet valves 14 and discharge valves 15. The discharge passage 16' of the air pump 10 opens into the conduit 8 and from the conduit 8 through the air cooler 9 into the air intake manifold 7. Air is supplied to the air pump 10 through a conduit 16 which may be connected to atmosphere or to an air reservoir or silencer as indicated at 17. A pipe or conduit 18 connects the inlet air source to the suction or inlet of the compressor 3. It may be desirable to provide a backfire cover structure in the inlet to the turbo-charger compressor or blower 3 as indicated at 19. Such a structure merely comprises a branch 20 to the conduit 18, the outlet of which is normally closed by a closure plate 21 held in closed position by a tension spring 22. When the backfire or reverse flow pressure in the extension 20 exceeds the tension pressure of the spring 22 the cover 21 will be unseated and allow such backfire pressure to exhaust to atmosphere.

A valve 23 is interposed in the conduit 18 for controlling the flow of the suction air to either the air pump 10 or to the turbo-compressor or blower 3. This valve 23 is operated by a pressure actuated diaphragm type valve operating structure 24 which is a well known structure and may be purchased upon the open market. The operation of the pressure operated valve actuating mechanism 24 is controlled by an automatic controller 25.

The automatic controller 25 is a mechanism which measures the value of a variable quantity or condition and operates to correct it to a selected value. Such control-

lers are well known and may be purchased upon the open market, being manufactured by The Bristol Company, Moore Products Company, and others. In the application of the controller 25 in the present invention it utilizes the temperature of the exhaust gases of the engine through a temperature sensitive element 26 (which is also well known and may be purchased upon the open market) mounted in the exhaust manifold 27 of the engine 1 outwardly of the turbine 4 of the turbo-compressor unit 5. Variations in the temperature of the exhaust gases of the engine are transmitted as pressure by and through the temperature sensitive element 26 to the controller 25 and acts as a control pressure which controls and regulates the delivery of pressure air from the pressure air supply conduit 28 through the conduit 29 to the pressure actuated mechanism 24.

The air pump structure 10 embodies any suitable type of unloading mechanism which is shown generically in the drawings as a reciprocating element 30 which acts on the suction or inlet valves 14 of the air pump to hold these valves open under predetermined conditions so that when the suction valves are held open air merely churns back and forth through the suction or inlet valves and is not compressed and thus the air pump runs idly. The suction valve operating unloading device 30 is shown as operated by a pressure actuated element 31. This element 31 is shown as a diaphragm actuated mechanism of the same construction as the structure 24 and it is connected to the pipe or conduit 29 as clearly shown at 32 in the drawings.

The valve 23 which is a butterfly valve is fitted with a spring-loaded inward opening valve 33 which, when the valve 23 is closed will be unseated if the pressure $p2$ in the suction inlet to the turbo-compressor 3 becomes less than p, that is, compressor suction against pump suction pressure.

During the starting and light load operation of the engine 1 the valve 23 is closed due to the fact that the temperature in the exhaust manifold 27 is not sufficient to operate the controller 25 to open the valve 23 and operate the air pump unloader mechanism 30 and thus the incoming suction air will during such times of operation be diverted or directed to the suction of the air pump 10. This pump will compress the air and deliver it to the respective cylinders of the engine 1 to provide sufficient air to support combustion in the cylinder. However, as the engine picks up speed and load the energy in its exhaust gases increases until the temperature of the exhaust gases in the manifold is sufficient to cause operation of the controller 25. At this time, the controller 25 is operated to admit pressure air into the pressure actuated devices 24 and 31. The pressure operated device 24 then opens the valve 23 into a full open position as shown in Figure 2 of the drawings and the pressure operated device 31 operates the compresor unloading mechanism 30 to unseat the suction or inlet valves 14 of the air pump 10 and thus the inlet suction air will be diverted to the suction of the compressor or blower 3 of the turbo-compressor unit due to the higher suction pull thereon and such incoming air as passes to the air pump 10 will be merely pumped back and forth therein thus permitting the air pump 10 to operate idly during the operation of the engine.

The structure shown in Figure 3 of the drawings is identical to the structures shown in Figures 1 and 2 of the drawings differing therefrom only in the control mechanism for controlling the delivery of pressure air to the pressure operated mechanism 24' which operates the valve 23' and the presure operated mechanism 31' which operates the unloading mechanism 30' of the air pump 10'. In this modified form of construction a reciprocating piston type valve structure 40 is connected in the pressure air line 41 to the elements 24' and 31' and to a suitable source of supply of pressure air (not shown). The valve structure 40 which may be of any approved type of reciprocating piston type valve is connected to the governor 43 of the engine 1' by suitable articulated linkage 44 so that when the engine reaches a predetermined speed during operation it will operate through the governor 43, the valve 40 to admit pressure air to the elements 24' and 31' for opening the valve 23' and unloading the air pump 10'.

It will be understood that the invention is not to be limited to the specific construction or arangement of parts shown, but that they may be widely modified within the invention defined by the claims.

What is claimed is:

1. In a turbo-charging system for internal combustion engines, in combination, an internal combustion engine, means for supplying scavening and combustion air to the engine including a turbo-compressor operated by the engine exhaust, an air pump operated by the engine, conduit means for delivering suction air to said turbo-compressor and said air pump, a valve in said conduit means for controlling delivery of suction air to said turbo-compressor, means for unloading the air pump when full suction air is delivered to the turbo-compressor, actuating means operatively associated with said valve and unloading means, and control means acting on said actuating means and responsive to the temperature of the engine exhaust.

2. In a turbo-charging system for internal combustion engines, in combination, an internal combustion engine, means for supplying scavening and combustion air to the engine including a turbo-compressor operated by the engine exhaust, an air pump operated by the engine, conduit means for delivering suction air to said turbo-compressor and said air pump, a valve in said conduit means for controlling delivery of suction air to said turbo-compressor, means for unloading said air pump when full suction air is delivered to the turbo-compressor, actuating means operatively associated with said valve and unloading means, and pressure control means acting on said actuating means and responsive to the temperature of the engine exhaust.

3. In a turbo-charging system for internal combustion engines, in combination, an internal combustion engine, means for supplying scavenging and combustion air to the engine including a turbo-compressor operated by the engine exhaust, an air pump operated by the engine, conduit means for delivering suction air to said turbo-compressor and said air pump, a valve in said conduit means for controlling delivery of suction air to said turbo-compressor, means for unloading said air pump when full suction air is delivered to the turbo-compressor, actuating means operatively associated with said valve and unloading means, and pressure control means acting on said actuating means and responsive to the speed of the engine.

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