AIR COMPRESSOR CONTROL SYSTEM RESPONSIVE TO AIR FLOW

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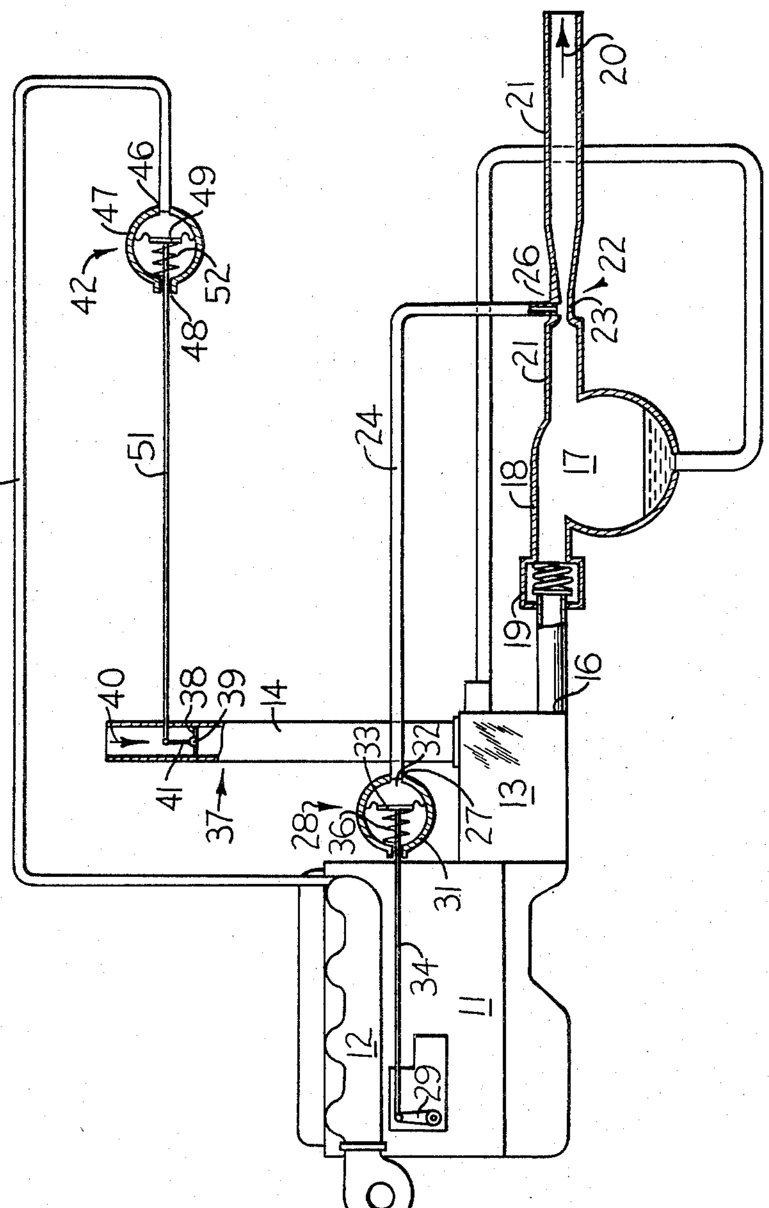

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AIR COMPRESSOR CONTROL SYSTEM RESPONSIVE TO AIR FLOW

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The present invention relates to air compressor systems and more particularly to means for providing a more rapid response of the prime mover to meet air output load demands.

Air compressor systems normally comprise a prime mover driving an air compressor and a receiver from which compressed air is supplied to air driven equipment. Turbocharged engines are commonly employed as the prime mover in industrial air compressor systems to provide increased power within a compact compressor system. A problem arises in the relation of the engine and turbocharger which is driven by the engine exhaust and in turn supplies intake air to the engine. When air is not being drawn from the receiver, it is desirable to permit the prime mover to operate at idling speed to conserve fuel and to minimize engine wear. When the system is called upon for output air, the engine must be accelerated to maintain the receiver air pressure at a satisfactory level to meet output demands. The problem with turbocharged engines is the inability of the turbocharger to provide sufficient air to the engine as necessary for acceleration when the engine is idling and placed under a load by the air compressor. This insufficient turbocharger air supply to the engine, being dependent upon engine exhaust energy transferred to the turbocharger, results in a "turbocharger lag" which limits rapidity of engine response to the compressor system load demands. A known method of regulating engine speed is by sensing pressure variations in the receiver as an indication of compressed air withdrawal from the system. However, due to the limited capacity of the receiver, the restricted engine response may permit receiver air pressure to reach too low a level for proper operation of the air driven equipment.

It is accordingly an object of the present invention to provide an air compressor system in which the prime mover has an improved response time to air requirement demands from the air driven equipment.

It is another object of the invention to provide apparatus for sensing passage of air from the receiver and thereupon initiating engine acceleration prior to noticeable depreciation of receiver air pressure.

It is another object of the invention to provide apparatus which maintains application of compressor loading on the engine at a rate governed by acceleration of the prime mover.

It is still another object of the invention to provide apparatus adaptable to an air compressor system and which initiates prime mover acceleration prior to a substantial receiver air pressure drop and which maintains application of compressor loading on the engine at a rate governed by engine acceleration.

Further and more specific objects and advantages of the invention are made apparent in the following specification wherein a preferred form of the invention is described by reference to the accompanying drawing which is a schematic illustration of an air compressor system and means for controlling the turbocharged engine power source thereof.

Referring to the drawing, an air compressor system is comprised of a prime mover 11 having air inlet manifold 12, and connected by suitable gearing (not shown) to an air compressor 13. Compressor 13 has an air inlet

14 and a compressed air outlet port 16. Receiver 17 is hermetically communicated with compressor outlet port 16 by pipe 18 and is suitable for containing compressed air under high pressure. A check valve 19 is preferably disposed across pipe 18 to prevent reverse flow of air from receiver 17 to compressor 13. Receiver outlet tube 21 hermetically connects receiver 17 with any suitable external air driven equipment (not shown). Generally, air flow 20 is selectively drawn from outlet 21 by controls on said air driven equipment. The arrangement and interconnection of the above compressor system components is contemplated as being in accord with well known prior art practice.

To obtain maximum compressing power within a compact air compressor system, prime mover 11 is preferably a turbocharged engine. It is desirable to regulate the speed of engine 11 and thereby permit engine 11 to idle when air is not being drawn from the compressor system. However, it is necessary to rapidly accelerate engine 11 when compressed air is withdrawn from the system since the capacity of receiver 17 is limited and substantially constant pressure is usually necessary in outlet 21 to assure proper operation of the air driven equipment. To provide acceleration of engine 11 as soon as possible after air withdrawal is commenced, air flow sensor 22 is disposed within receiver outlet 21. Sensor 22 may comprise a pitot tube or orifice nozzle but preferably comprises a venturi tube 23 providing a constricted length within the channel of outlet 21. Venturi tube 23 is preferably disposed within a substantially straight portion of outlet 21 to maintain desirable air flow characteristics therethrough. A venturi sidearm 24 has a first end 26 hermetically communicating with outlet 21 within venturi constriction 23. The other end 27 of a venturi sidearm 24 communicates with prime mover control means 28 suitable for operating governor 29 of engine 11 and thus regulating the speed of engine 11 in response to air flow variations detected in outlet 21 by venturi sensor 22.

Preferably, governor 29 is of a lever control type wherein engine 11 speed is accelerated by moving lever 29 toward control means 28 and decelerating by moving lever 29 in the opposite direction. Control means 28 comprises a semi-spherical housing 31 having an opening 32 generally facing governor 29. Venturi sidearm end 27 hermetically penetrates housing 31 distal opening 32. Flexible diaphragm 33 extends across housing 31 to provide therewith a hermetic closure for venturi sidearm 24 and is in facing relation to governor lever 29. Governor actuating member 34 is a rod pivotally joining governor lever 29 with flexible diaphragm 33. Spring 36 is seated on housing 31 and acts upon rod 34 tending to move diaphragm 33 into venturi sidearm 24. The compression force of spring 36 and the length of governor rod 34 are selected according to the following criteria. When there is no air flow in outlet 21 and receiver 17 has operating compressed air pressure existing in outlet 21, and sidearm 24 which is exerted against diaphragm 33, spring 36 is sufficiently compressed to position governor 29 for proper idling speed of engine 11. When air is being withdrawn from outlet 21, the air flow 20 through venturi 23 causes partial evacuation of sidearm 24 and decreased pressure on diaphragm 33. The compression force of spring 36 is such that it flexes diaphragm 33 toward sidearm 24 and positions governor 29 to operate engine 11 at a proper speed to drive compressor 13 and supply adequate compressed air at the system outlet 21.

To regulate the mass of air 40 entering compressor 13 through compressor inlet 14, movable valve means 37 is disposed across compressor inlet passage 14 to be varied between open and closed relation thereto. Preferably, valve means 37 comprises a circular pivoted valve plate

38 positionable to mate with and close off the air inlet passage defines by a tubular portion of compressor inlet 14. Valve plate 38 is rotatably mounted along a selected diameter 39 thereof to permit opening and closing of the valve plate 38. Valve plate arm 41 extends normally upward from said valve plate upon said selected diameter 39. Valve control means 42 is adapted to operate valve 37 in response to the speed of engine 11 and thereby prevent or minimize compressor 13 overloading upon engine 11. Preferably, valve control means 42 is similar to governor control 28 and comprises a conduit 43 having a first end 44 hermetically communicating with the interior of engine inlet manifold 12, and a second end 46 terminating generally adjacent valve means 42. Semi-spherical valve housing 47 has an opening 48 in facing relation to valve arm 41. A flexible diaphragm 49 extends across housing 47 to provide therewith a hermetic closure for conduit 43 and is in facing relation to valve arm 41. A valve actuator member 51 pivotally joins with the upper end of valve arm 41 and with the center of flexible diaphragm 49. Spring 52 is seated on housing 47 and compressively acts upon member 51 tending to move diaphragm 49 into conduit 43. The strength of spring 52, the length of member 51 and the location of control means 42 with respect to valve 37 are selected according to criteria in a similar manner as discussed with respect to governor control means 28 and governor 29. When engine 11 is operating at a desired air compressing speed, the resulting high pressure in inlet manifold 12 passes through conduit 43 and flexes diaphragm 49 toward valve 37. Valve member 51 positions valve plate 38 in an open position to admit adequate air for compression. As engine 11 decelerates, inlet manifold pressure and accordingly pressure in conduit 43 decreases. When engine 11 has decelerated to a desired idling speed, spring 52 acts upon diaphragm 49 and valve member 51 to rotate valve plate 38 to a closed position with respect to compressor inlet passage 14 to reduce and then terminate air flow 40 therethrough.

In operation, when there is no demand for air from receiver outlet 21, compressed air exists in receiver 17, outlet 21 and venturi sidearm 24 at a predetermined operating pressure level. Spring 36 is compressed by the pressure in sidearm 24 flexing diaphragm 33 toward governor 29. Rod 34 is thereby moved toward governor 29, positioning governor 29 to operate engine 11 at its desired idling speed. Air pressure in inlet manifold 12 and conduit 43 is low during idling of engine 11 and spring 52 is extended flexing diaphragm 49 toward conduit end 46. Valve member 51 is then actuated by diaphragm 49 to position valve plate 38 in closed relation across compressor inlet 14. At this point of operation, there is adequate air pressure in receiver 17 to be delivered on demand. Engine 11 is then operated at a desired idling speed to conserve fuel and minimize engine wear while compressor air inlet 14 is closed to reduce compressor loading on engine 11.

When compressed air is demanded from outlet 21, air flow 20 commences in outlet 21 prior to any substantial pressure reduction in receiver 17. The passage of air in outlet 21 causes a pressure drop across venturi constriction 23 and partial evacuation of venturi sidearm 24, decreasing the pressure against diaphragm 33. Spring 36 is permitted to expand and move diaphragm 33 toward sidearm 24. Rod 34 is acted upon by diaphragm 33 and, in turn, repositions governor 29 to operate engine 11 at an accelerated preselected operating speed. Acceleration of turbocharged engine 11 supplies increasing air pressure in intake manifold 12, conduit 43 and against diaphragm 49. This increased pressure tends to flex diaphragm 49 away from conduit end 46 with corresponding motion in member 51 and vale arm 41. Valve plate 39 is thereby rotated into an open position with respect to compressor inlet 14 at a rate relative to acceleration of engine 11. When engine 11 reaches a predetermined compressing speed, the pressure in inlet manifold 23, conduit 43 and exerted against diaphragm 49 is sufficient with respect to spring 52 to move flexible diaphragm, member 51 and arm 41 away from conduit end 46. Valve plate 38 is thereby positioned in a preselected open position admitting an appropriate mass of air for compressor system operation.

When air withdrawal from outlet 21 is terminated, the converse of the above steps occurs. Compressed air in receiver 17, outlet 21 and sidearm 24 builds up to the operating pressure. Diaphragm 33 and rod 34 are moved away from sidearm 24 and governor is returned to its original position to operate engine 11 at idling speed. As engine 11 decelerates to idling speed, air pressure in manifold 23 and conduit 43 decreases. Diaphragm 49, member 51 and arm 41 are moved toward conduit end 46 and valve plate 38 is rotated toward closure position such that, when engine 11 is operating at idling speed, valve 37 closes compressor inlet 14.

Thus, the above embodiment of the invention provides an air compressor system in which the problem of "turbocharger lag" is overcome by regulating engine speed in response to air flow variations in the receiver outlet and by initiating engine acceleration prior to any substantial pressure decrease in the receiver. Further, overloading of the accelerating engine by the compressor is prevented by employment of means for controlling the mass of air entering the compressor with respect to engine speed. It is to be noted that the invention permits employment of a standard turobcharged engine in an air compressor system where the engine turobcharger is unmodified, the engine idling speed need not be selected nearer the operating speed than is desirable for minimized fuel consumption and engine wear; further, an oversized engine is not required.

Although the invention has been described above with particular reference to a single embodiment, the scope of the invention is not limited thereto. For example, the receiver outlet air flow sensor-governor control means and the compressor inlet valve control means are particularly described with reference to a compressor system having a turobcharged engine for overcoming the problem of "turbocharger lag." These two control elements may also be employed in compressor systems employing other prime movers, e.g., a standard combustion engine. The governor control means may then be adapted to be similarly responsive to the prime mover exhaust manifold pressure as a measure of the prime mover speed. More rapid response of the prime mover to air demands, in such a configuration, is similarly desirable since it may be employed to provide greater constancy of the compressed air pressure or may even permit reduction of the size of the receiver with the same compressed air pressure limits. As a further example, the invention is described above with the two immediately above-noted elements as integral parts of an air compressor system. Although such a description may be considered as contemplating only construction of the compressor system with these elements, it is also possible to utilize the control elements of the invention for incorporation with existing air compressor systems.

I claim:

1. In an air compressor system, the combination comprising:

- a prime mover having a speed governor means;
- a compressor disposed to be driven by said prime mover;
- a receiver disposed to receive and store compressed air from said compressor;
- a receiver outlet disposed with respect to said receiver to provide a passage by which compressed air is intermittently drawn from said receiver as desired, said intermittent withdrawal of compressed air from said outlet passage causing air flow variations in said outlet;
- control means operatively disposed between said receiver outlet and said speed governor means and op-

erative to control said speed governor means in response to air flow variations in said outlet an air inlet through which air flows to said compressor; and means disposed in said air inlet to control air flow therethrough responsive to changes in speed of said prime mover.

2. The air compressor system of claim 1 wherein the last mentioned means comprises:

valve means movably mounted in said inlet and control means operatively connected between said valve means and said engine.

3. The air compressor system of claim 2 wherein:

said prime mover is a turbocharged engine having an inlet manifold which receives air from a turbocharger, and wherein said air flow sensor means comprises:

a venturi tube disposed within said receiver outlet to define a restriction in said receiver outlet passage intercepting air flow from said receiver through said outlet; and

a venturi sidearm tube communicating the restricted outlet passage with said governor control means whereby pressure in said venturi sidearm fluctuates in response to variations in air flow through said outlet passage, and said governor control means operates said governor in response to pressure fluctuations in said venturi sidearm.

4. The air compressor system of claim 3 wherein air pressure in said inlet manifold is generally proportional to engine speed and said speed governor control means comprises:

a flexible diaphragm hermetically disposed across said venturi sidearm tube;

a governor actuating member connecting flexible diaphragm with said engine governor and spring means yieldably acting upon said governor actuating member tending to cause flexure of said diaphragm into said venturi sidearm tube and positioning of said governor to accelerate said engine;

and said inlet valve control means comprises:

a conduit having a first end in communication with said engine inlet manifold and a second end;

a flexible valve control diaphragm hermetically disposed across said second conduit end;

a valve actuating member connecting said flexible valve control diaphragm with said inlet valve; and

valve control spring means acting on said valve member and tending to cause flexure of said valve control diaphragm into said conduit and closure of said inlet valve.

5. In a turbocharged air compressor system, the combination comprising:

a variable speed turbocharged engine having an inlet manifold by which to receive air from a turbocharger, said inlet manifold having variable air pressure generally proportional to said engine speed;

a compressor coupled to be driven by said engine and having an air inlet communicating directly with the atmosphere;

valve means disposed in said air inlet to control air flow therethrough; and

detecting means communicating with said inlet manifold and detecting pressure variations therein, said detecting means further disposed to control said valve means to regulate air flow through said compressor air inlet in response to detected pressure variations in said inlet manifold.

6. Control apparatus adaptable to an air compressor system having a variable speed turbocharged engine with an inlet manifold, said manifold having variable air pressure generally proportional to said engine speed, a governor disposed to control said engine speed, a compressed air receiver and receiver outlet means by which compressed air may be intermittently drawn from said receiver as demanded for external requirements, air flow in said outlet varying according to said intermittent air demands, a compressor driven by said engine and having an air inlet, a valve disposed in said compressor air inlet to regulate air flow therethrough, said control apparatus providing minimized response of said engine speed to said external air demands and controlling compressor loading on the engine, the combination comprising:

means adaptable to communicate with said receiver outlet to detect said air flow variations in said receiver outlet, said air flow detecting means further adaptable to operate said speed governor in response to said detected air flow variations; and

valve control means adaptable to communicate with said inlet manifold to detect air pressure variations in said inlet manifold, said valve control means further adaptable to be connected with said valve to regulate air flow through said air inlet in response to said pressure variations detected in said inlet manifold.

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