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GAS COMPRESSOR SYSTEM

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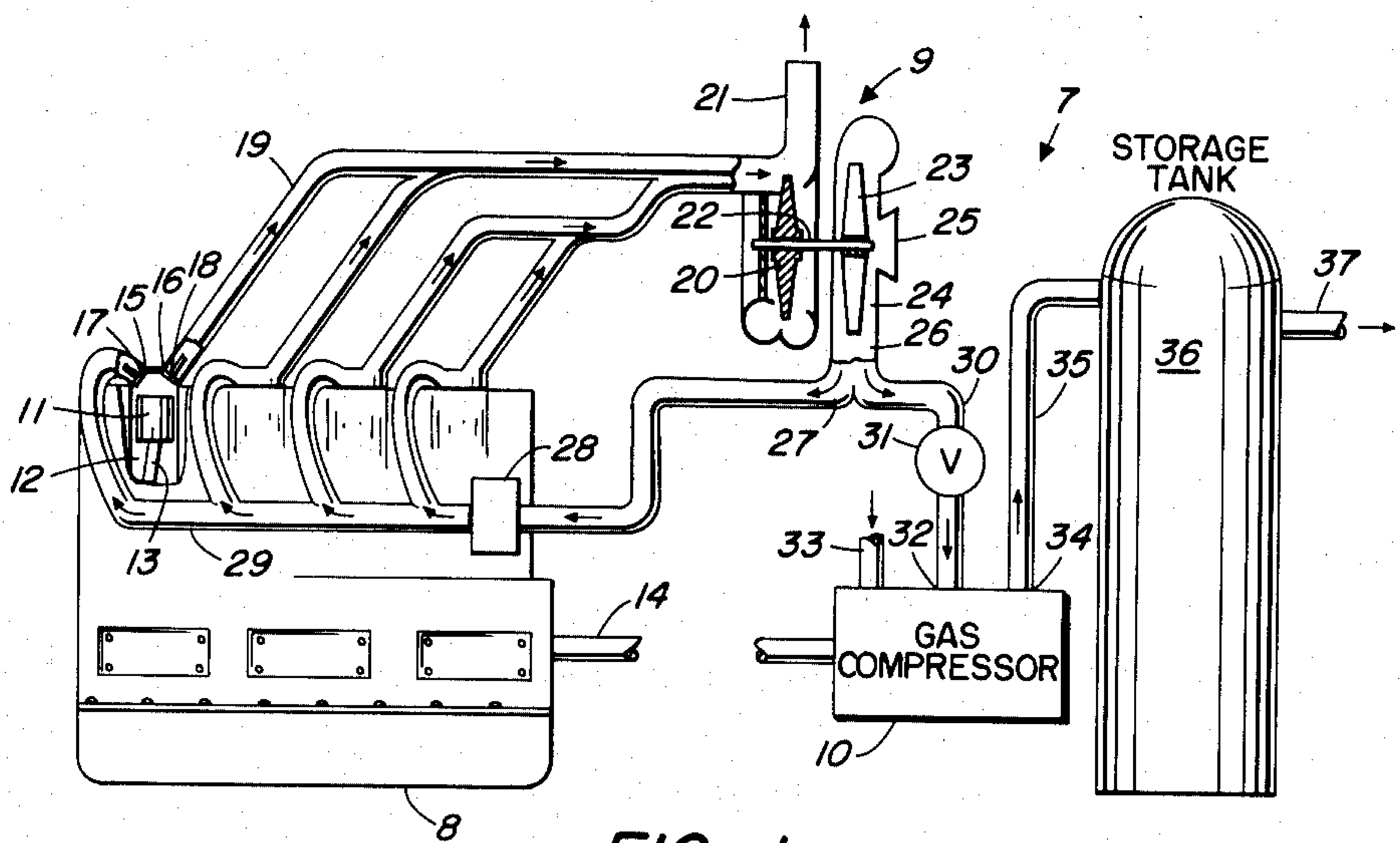

FIG 1

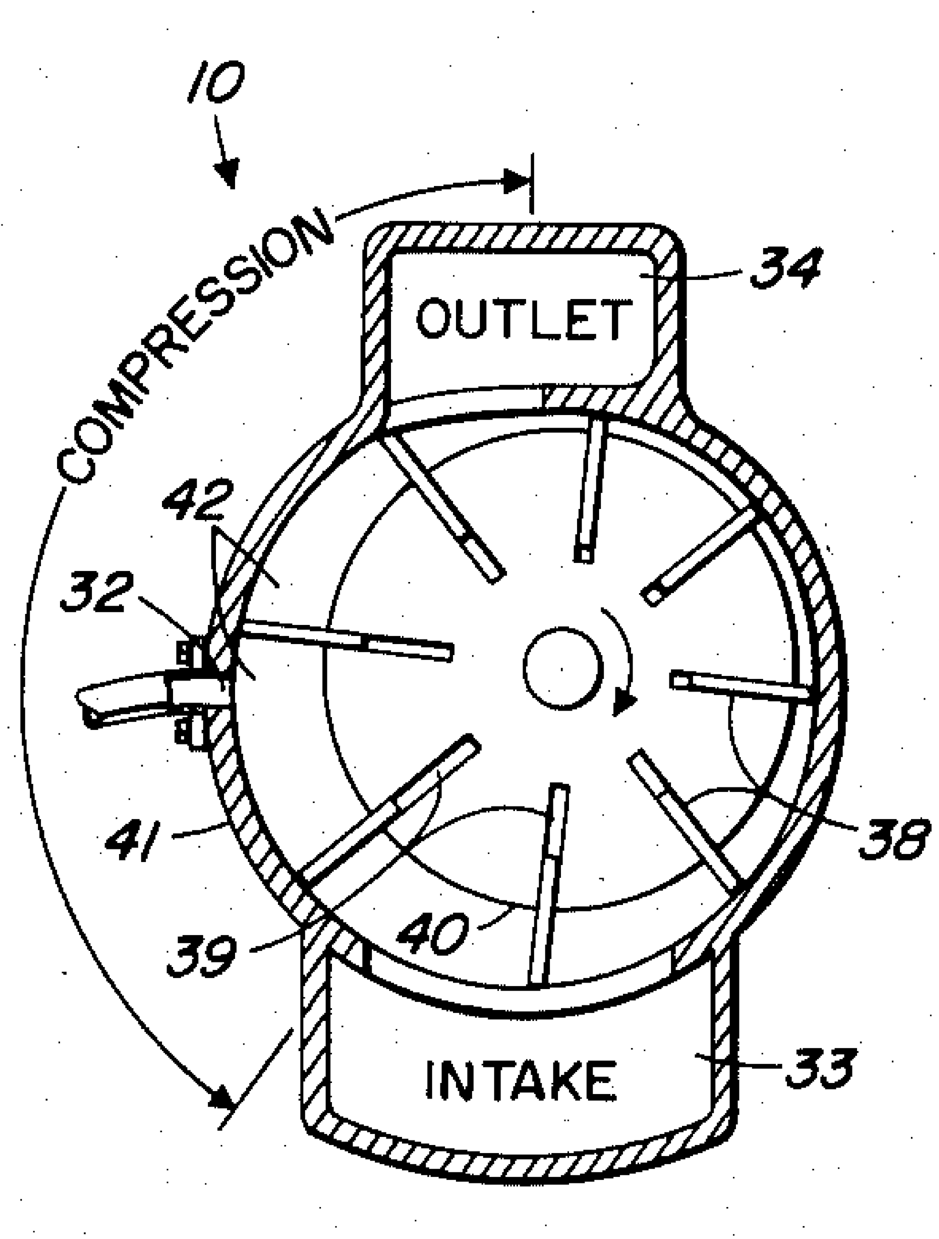

FIG 2

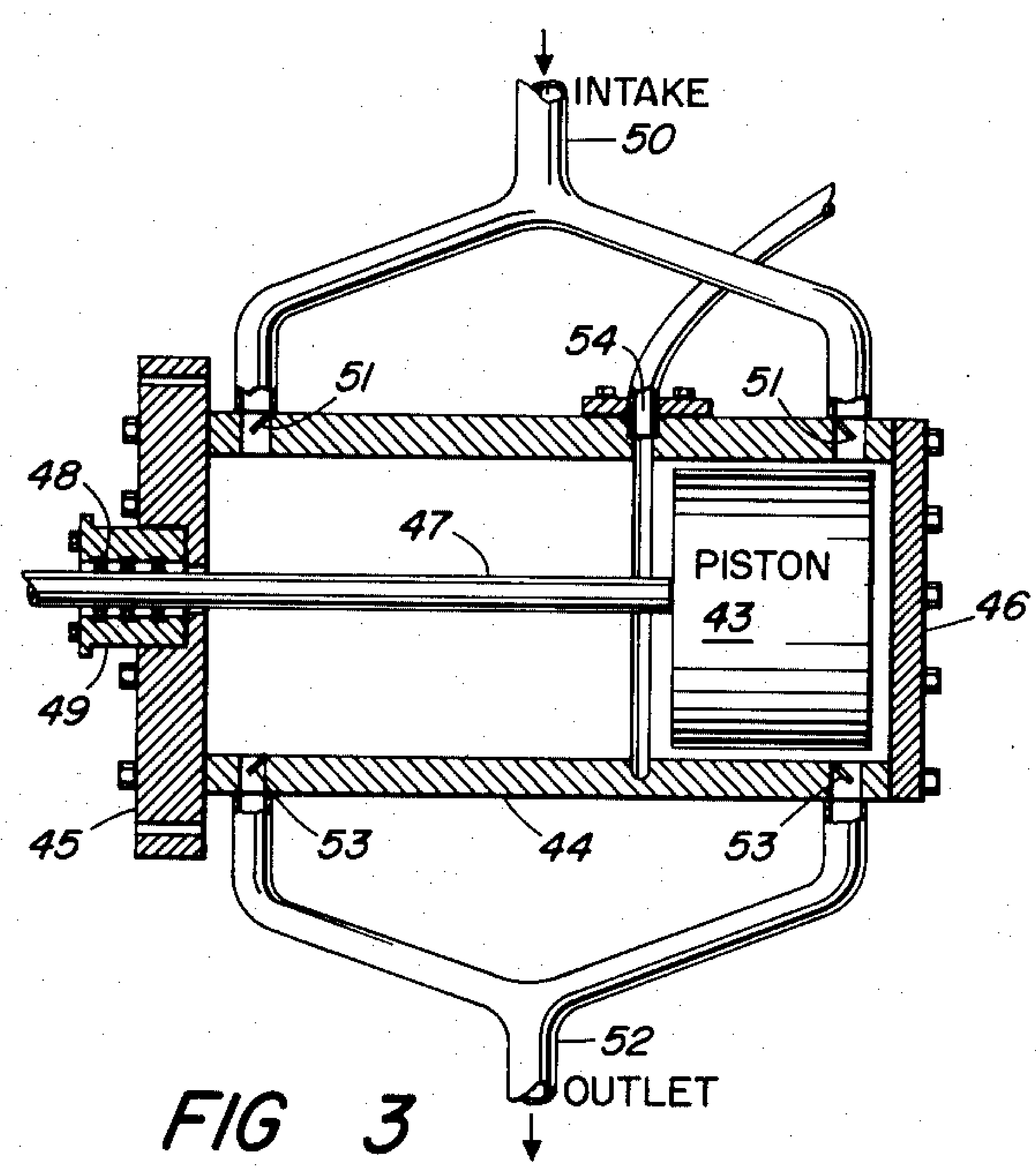

FIG 3

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GAS COMPRESSOR SYSTEM

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7 Claims. (Cl. 230—56)

This invention relates to a gas compressor system and is particularly directed to a system including a turbocharged internal combustion engine as a prime mover.

In recent years, exhaust driven turbochargers have been developed to the point where they have the ability to provide more compressed air than the associated internal combustion engine can possibly utilize. This is due to various limiting engine characteristics, such as combustion noise, peak firing pressures, heat loading of the cylinder components, and long commercial life requirements, all of which limit the amount of compressed air that can be used by the internal combustion engine.

Although modern turbochargers have now acquired the capacity to produce an excess of compressed air over that which can be utilized by the associated internal combustion engine, this excess has heretofore been commonly discarded as a waste product. It is a feature of this invention to utilize this excess compressed air rather than discarding this potential source of energy, and more particularly, to utilize this excess compressed air to supercharge a gas compressor that is driven by the internal combustion engine, the exhaust gases of which drive the turbocharger.

While supercharging of a gas compressor may be accomplished by increasing the pressure of all of the gas fed to the compressor, it may also be accomplished by increasing the pressure of only a small portion of the gas supplied to the compression chamber sufficiently to bring the entire charge up to the desired supercharging pressure. It is this latter method which has been found to lend itself more favorably for use as a part of this invention.

Supercharging a gas compressor with the excess compressed gas from a turbocharger, as taught in this invention, has been found to have definite advantages, such as, for example, providing a system having higher operating efficiency, enabling the system to be more compact, and permitting higher discharge pressures from the compressor than heretofore had been realized.

It is therefore an object of this invention to provide a more efficient and compact gas compressor system capable of better performance than heretofore existing systems.

It is another object of this invention to provide a gas compressor system having an exhaust gas driven gas compressor capable of producing an excess of compressed gas over that needed to supercharge a prime mover, and means for utilizing said excess compressed gas to supercharge a second gas compressor driven by that same prime mover.

It is yet another object of this invention to provide an air compressor system having means for receiving a portion of its compressed air from an exhaust driven turbocharger associated with its prime mover, when the discharge pressure exceeds a predetermined value, to supercharge an air compressor driven by the internal combustion engine providing the exhaust gases to said turbocharger.

With these and other objects in view which will become apparent to one skilled in the art as the description proceeds, this invention resides in the novel construction, combination and arrangement of parts substantially as hereinafter described and more particularly defined by the appended claims, it being understood that such changes

in the precise embodiments of the herein disclosed invention may be included as come within the scope of the claims.

The acompanying drawing illustrates one complete example of the embodiment of the system of this invention, together with two embodiments of the compressor of said system, constructed according to the best mode so far devised for the practical application of the principles thereof, and in which:

FIGURE 1 shows diagrammatically the supercharged gas compressor system of this invention;

FIGURE 2 shows in section the vane type gas compressor which may be utilized as the gas compressor of the supercharging system of this invention; and

FIGURE 3 shows in section the reciprocating type gas compressor which may alternately be used as the gas compressor of the supercharging system of this invention.

Referring now to the drawing, in which the gas compressor is shown as an air compressor for purposes of illustrating the principles of this invention, the numeral **7** refers generally to the system itself. As shown in FIGURE 1, system **7** includes an internal combustion engine **8**, a turbocharger **9**, and a compressor **10**.

The internal combustion engine **8** (shown as a diesel engine in FIGURE 1) may be conventional and hence only those specific engine details needed to gain an understanding of this invention are illustrated herein. As is well known in the art, such an engine includes a plurality of pistons **11** (only one of which is shown in FIGURE 1), each of which is confined within a cylinder **12**. As is also conventional, movement of the piston **11** is transmitted through a piston rod **13** to a crank shaft **14**.

Each cylinder **12** of the internal combustion engine **8** has an intake port **15**, through which air is admitted to the combustion chamber, and an exhaust port **16**, through which exhaust gases are expelled from the cylinder. As is conventional, an intake valve **17** and an exhaust valve **18** are provided to open and close each port.

The exhaust port of the cylinder **12** is connected to an exhaust manifold **19** (all of the exhaust ports of the engine are connected to one or more exhaust manifolds). The exhaust manifold **19** is, in turn, connected to an exhaust gas driven turbocharger **9**.

The turbocharger **9** is also conventional, and, as indicated in FIGURE 1, includes a rotor **20** that is rotated by the exhaust gases from the engine **8**, the gases then being discharged through a turbine discharge port **21**. The rotor **20** is connected by means of a shaft **22** to an air impeller **23** of the compressor portion **24** of the turbocharger. The compressor portion **24** has an inlet **25** for receiving air and discharges compressed air through a discharge port, or outlet, **26**.

The compressed air from the turbocharger **9** is coupled through a conduit, or piping, **27** to an intercooler **28**, where the temperature of the intake air is reduced and then through an intake manifold **29** to the intake ports **15** of the engine **8**.

The compressor outlet **26** also has opening therefrom a second passage **30** (which passage may also be connected to the conduit **27**, if desired, instead of opening directly into the outlet **26**). This passage, or second conduit, has a valve **31** therein that is sensitive to the pressure level of the compressed air from the turbocharger **9**. The valve **31** maintains the passage **30** closed until the discharge pressure level exceeds a predetermined value dictated by the needs of the internal combustion engine **8**.

The passage **30** is connected to a supercharging inlet port **32** of the gas compressor **10**. The compressor **10** is connected with the crank shaft **14** of the engine **8** so that the engine drives the compressor. Air is introduced to the compressor at (or slightly below) atmospheric pressure, through an inlet 33, and a relatively smaller amount of compressed air is introduced through the supercharging inlet port 32 to bring the entire input charge to the desired supercharging pressure. The input charge is compressed by compressor 10 and then discharged from the compressor through an outlet 34. As shown in FIGURE 1, the outlet 34 discharges to a storage tank 36. The stored compressed air may then be taken from the storage tank for utilization purposes through a second conduit 37.

The performance characteristics of nearly any type of gas compressors will be improved by use as a part of the system of this invention. Two such types are shown in FIGURES 2 and 3 to explain the principles of this invention. The invention is not meant to be limited to these two types of compressors, however, and a screw type, for example, could also be utilized as a part of the combination. Since gas compressors are well known in basic form to those skilled in the art, only those portions necessary for a complete explanation of the system of this invention have been shown and described in FIGURES 2 and 3.

A gas compressor of the vane type is shown schematically in FIGURE 2. This compressor has a series of radially positioned vanes 38 which are received in a series of notches 39 cut in the cylindrical wall of a cylinder 40. The notches 39 are parallel to the axis of the cylinder and, when the cylinder is rotated (the cylinder is connected with the crank shaft 14 of the engine 8 for this purpose), the vanes are thrown outwardly from the notches by centrifugal force.

The cylinder and vanes are confined with a housing 41, which housing is substantially cylindrical and has, of course, a radius larger than that of the cylinder 40. The housing 41 is closed at both ends (not shown) and the cylinder 40 is mounted within the housing so as not to be coaxial with the cylindrical portion of said housing. As shown in FIGURE 2, one side of the cylinder 40 is contiguous to the inner side of the cylindrical portion of housing 41, while the diametrically opposite side of the cylinder is spaced from the housing.

Since a space of varying volume is therefore left between the housing and the cylinder 40, and since the vanes are thrown outwardly when the cylinder 40 is rotated, each section (defined by adjacent vanes, the housing and the cylinder) comprises a compression chamber 42. As clearly shown in FIGURE 2, the volume of each chamber 42 first enlarges and then decreases to substantially zero volume as the cylinder is rotated, the vanes being cammed inwardly by the housing as the volume of the space between the housing and the cylinder decreases.

Each compression chamber is opened to inlet 33 as its volume nearly reaches its maximum, as shown in FIGURE 2. The air introduced into the chamber through the inlet 33, is of course, trapped between adjacent vanes and carried to the point where compressed air is introduced into the chamber through the supercharging intake port 32. It is to be noted that at least one vane is always between the inlet and the supercharging inlet port, as is also the case between the supercharging inlet port and the discharge outlet 34.

After the compressed air is introduced into the compression chamber, further rotation of cylinder 40 compresses the air since the volume of the space is decreased, as shown in FIGURE 2. After compression, the air is then discharged from the compressor through the outlet 34.

An alternate type of compressor, the reciprocating type, is shown in FIGURE 3. As shown therein, a piston 43 is mounted for reciprocal movement within a cylinder 44. The cylinder 44 is closed at both ends by means of plates 45 and 46. Plate 45 has an opening therein through which extends a piston rod 47, which piston rod is supported by a bearing 48 in a sleeve 49 attached to the plate 45. The piston rod 47 has a driving connection at one end to the crank shaft 14 of the engine 8 and at the other end to the piston 43.

As shown in FIGURE 3, the cylinder 44 has an inlet 50 near each end, and each has a one-way valve 51 therein to permit air to be introduced to the compression chamber but blocking discharge of compressed air therethrough. In like manner, the cylinder 44 also has an outlet 52 near each end, and each has a one-way valve 53 permitting only discharge from the chamber through the outlet.

The cylinder 44 also has a supercharging inlet port 54 opening into the cylinder near the middle thereof. Since the piston 43 is of substantial width (as shown in FIGURE 3), the supercharging inlet port 54 is blocked at the beginning of the piston stroke in each direction. This allows the air at (or just below) atmospheric pressure to be introduced into the chamber through the inlet 50. When the piston 43 is then moved a sufficient distance to open the supercharging inlet port 54, compressed air from the turbocharger 9 is introduced into the chamber. The air is then compressed during the return stroke of the piston 43 and discharged through the outlet 52.

The system of this invention operates to supercharge the associated gas compressor only after a predetermined turbocharger discharge level has been attained. This pressure level is subject, of course, to the particular needs of the prime mover since it is intended that only the excess compressed air, over that which can be utilized by the prime mover, be diverted to supercharge the gas compressor.

It has been found that when supercharging the gas compressor to 5 p.s.i.g. (pounds per square inch gauge), the valve 31, used to block the passage of air to the compressor at lower pressures, may be opened at 2.5 p.s.i.g. It has also been found that when supercharging the gas compressor to 5 p.s.i.g., a satisfactory division of the flow of compressed air from the turbocharger is two-thirds to the engine and one-third to the compressor. With this ratio, a higher operating efficiency is realized, and it has been found that, utilizing the system of this invention, 15% less fuel is required for compressing a given quantity of air between 0 and 100 p.s.i.g. pressure. Another measure of increased output is evident from the finding that with a screw-type compressor and with 5 p.s.i.g. supercharge, the discharge pressure will be raised from 100 p.s.i.g. to 139 p.s.i.g. maintaining the same compression ration as is required for the 100 p.s.i.g. discharge.

Although an air compressor has been specifically shown and described herein, this invention is not meant to be limited to this particular type of supercharging gas system since the principles of this invention can be utilized equally well, as would be obvious to one skilled in the art, for compression of gases other than air.

What is claimed as my invention is:

1. An air compressor system, comprising: an internal combustion engine having a drive shaft and intake and exhaust manifolds; an exhaust driven turbocharger connected to the exhaust manifold of said internal combustion engine, said turbocharger having an outlet providing compressed air; conduit means for connecting the outlet of said turbocharger with the intake manifold of said internal combustion engine to supercharge the same; and an air compressor connected with the drive shaft of said internal combustion engine, said air compressor having an inlet port for receiving air near atmospheric pressure, a supercharging port connected with said conduit to receive compressed air from said turbocharger after said air near atmospheric pressure has been introduced, and an outlet port for discharging air after compression.

2. The air compressor system of claim 1 further characterized by valve means between said turbocharger and said compressor to block passage of compressed air to said air compressor until the discharge pressure from the turbocharger exceeds a predetermined value.

3. The air compressor system of claim 1 wherein said system is constructed so that when said compressor is supercharged to 5 p.s.i.g., said air compressor receives about one-third of said turbocharger output while said

internal combustion engine receives about two-thirds of said turbocharger output.

4. A system for compressing air, comprising: an internal combustion engine having a combustion air intake and a rotating power output shaft, an air compressor having a chamber therein, said compressor chamber having an atmospheric inlet port adjacent one end of said cylinder, a discharge port at the other end of said chamber and a superatmospheric inlet port opened to said cylinder chamber between said atmospheric inlet and discharge ports, movable means dividing said compressor chamber into an expansible and collapsible chamber which expands when in communication with said inlet port, is thereafter communicated with said superatmospheric port, and is thereafter collapsed while in communication with said discharge port, said movable means being driven by said shaft of said internal combustion engine to cyclically expand and collapse said expansible and collapsible chamber, a turbocharger including a turbine driven by exhaust gases from said internal combustion engine and a rotary compressor driven by said turbine for producing sufficient compressed air to supercharge said internal combustion engine at a predetermined optimum pressure, a manifold having a first branch delivering one part of the air at superatmospheric pressure from said rotary compressor to said combustion air intake and a second branch delivering a second part of the air from said rotary compressor to said superatmospheric inlet port of said compressor chamber, and whereby said expansible and collapsible compressor chamber is topped with superatmospheric pressure before being communicated to said discharge port.

5. A system for compressing air, comprising: an internal combustion engine having a combustion air intake and a rotating power output shaft, an air compressor having a chamber therein, said compressor chamber having an atmospheric inlet port adjacent one end of said cylinder, a discharge port at the other end of said chamber and a superatmospheric inlet port opened to said cylinder chamber between said atmospheric inlet and discharge ports, movable means dividing said compressor chamber into an expansible and collapsible chamber which expands when in communication with said inlet port, is thereafter communicated with said superatmospheric port, and is thereafter collapsed while in communication with said discharge port, said movable means being driven by said shaft of said internal combustion engine to cyclically expand and collapse said expansible and collapsible chamber, a turbocharger including a turbine driven by exhaust gases from said internal combustion engine and a rotary compressor driven by said turbine for producing sufficient compressed air to supercharge said internal combustion engine at a predetermined optimum pressure, a manifold having a first branch delivering one part of the air at superatmospheric pressure from said rotary compressor to said combustion air intake and a second branch delivering a second part of the air from said rotary compressor to said superatmospheric inlet port of said compressor chamber, and valve means in said second branch of said manifold effective to only allow air from said rotary compressor in excess of that required to supercharge said internal combustion engine to said predetermined pressure to flow to said superatmospheric inlet port of said compressor chamber, and whereby said expansible and collapsible compressor chamber is topped with superatmospheric pressure before being communicated to said discharge port.

6. The system of claim 4 wherein said air compressor receives about one-third of said turbocharger output while said internal combustion engine receives about two-thirds of said turbocharger output.

7. A system for compressing air, comprising: an internal combustion engine having a combustion air intake and a rotating power output shaft, a reciprocating compressor having a cylinder chamber and piston therein which starts an intake stroke when said piston is adjacent one end of said cylinder and terminates its intake stroke when adjacent the other end of said cylinder, said piston being reciprocated in said cylinder by a rotatable power input shaft connected to said shaft of said internal combustion engine, said cylinder chamber having an atmospheric inlet port adjacent said one end of said cylinder and a superatmospheric inlet port opened to said cylinder chamber when said piston is adjacent said other end of said cylinder chamber, a turbocharger including a turbine driven by exhaust gases from said internal combustion engine and a rotary compressor driven by said turbine for producing compressed air to supercharge said internal combustion engine at a predetermined optimum pressure, a manifold having a first branch delivering air at superatmospheric pressure from said rotary compressor to said combustion air intake and a second branch delivering air to said superatmospheric inlet port of said reciprocating compressor, and back pressure valve means in said second branch of said manifold effective to maintain the pressure in said first conduit at said predetermined pressure and only open to allow flow through said second branch when the discharge from said rotary compressor exceeds said predetermined pressure.

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