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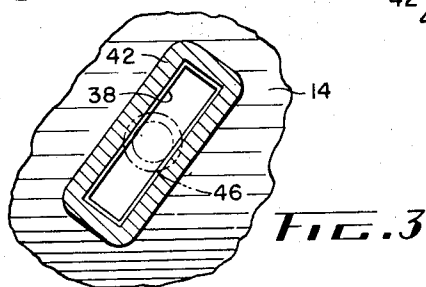
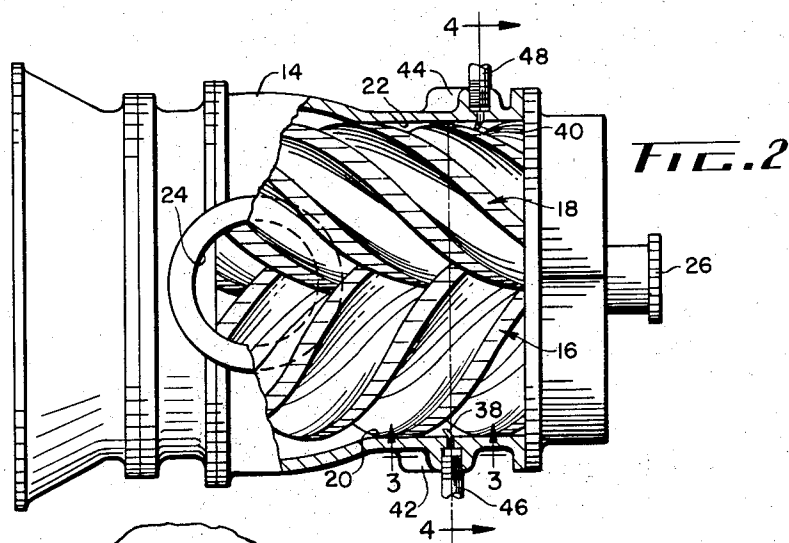
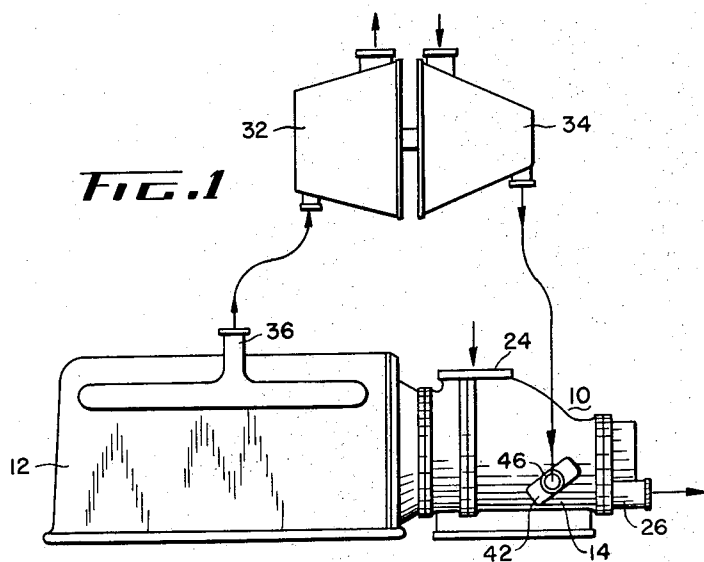
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3,141,604

COMPRESSOR SUPERCHARGING SYSTEM

Filed Sept. 26, 1962

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

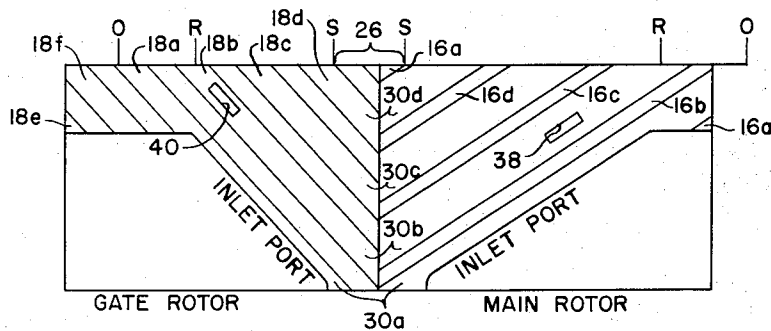
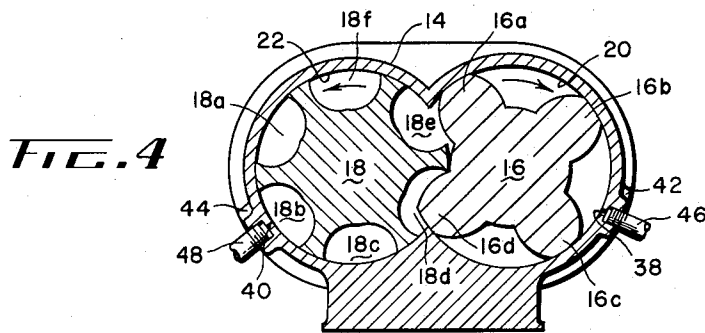


FIG. 5

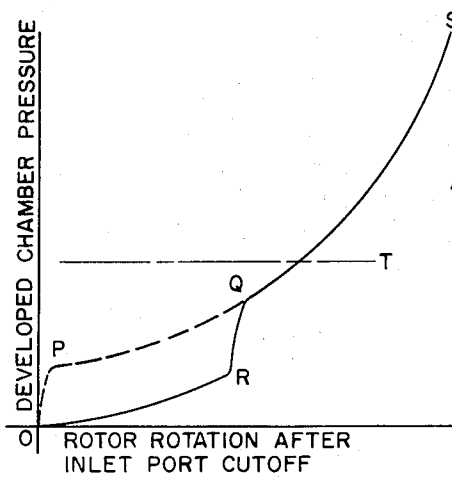


FIG. 6

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COMPRESSOR SUPERCHARGING SYSTEM
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This invention generally relates to compressors and, more particularly, to means for increasing the volumetric capacity of a compressor by supercharging the compressor working chambers after the chambers are cut off from the compressor inlet port.

In the art of supercharging compressors, means have been heretofore proposed for the increasing compressor volumetric capacity whereby the entire compressor intake is supercharged and communicated into the compressor inlet port. In the case of reciprocating piston-type compressors, it is known to introduce a pressurized charge of gas into a working chamber immediately after closure of the inlet port, but before internal pressure is developed within the working chamber. While these known systems for compressor supercharging effectively increase compressor volumetric capacity, both systems entail certain inherent energy losses due to expansion of the pressurized charging gas within the working chambers of the compressor. Thus the energy expended to raise the pressure of the charging gas is substantially lost since the gas is allowed to expand to a relatively much lower pressure after it is received in the working chamber. Moreover, additional work must be performed by the compressor to recompress the expanded charge after it is received in the working chamber.

Therefore, the general object of this invention is the provision of an improved compressor supercharging system which is more efficient than systems known heretofore.

Another general object of this invention is the provision of an improved compressor supercharging system which substantially reduces energy losses due to expansion of supercharging air within the compressor working chambers.

Yet another object is to provide an improved compressor adapted to receive a supplemental charge of air into the working chambers thereof after the chambers are cut off from the compressor inlet port, but not before the developed internal pressure of the working chambers reaches a predetermined level above compressor inlet pressure.

Still another object is to provide a system for supercharging a screw-type compressor whereby a pressurized charge of air is introduced into cutoff working chambers only after the developed internal chamber pressure approaches the pressure of the supercharging air, thereby minimizing energy losses due to expansion of the supercharging air.

A specific object is to provide a supercharging system of the aforescribed character wherein the supercharging air is provided by a turbocharger which is driven by exhaust gas from the compressor prime mover.

A more specific object is the provision of a supercharged compressor which is characterized by increased efficiency of operation and by simplicity and economy in construction.

These and other objects and advantages will appear upon considering the following detailed disclosure and appended claims, and upon considering in connection therewith the attached drawings in which:

FIG. 1 is a schematic representation of the components of an improved compressor supercharging system constructed in accordance with the present invention;

FIG. 2 is a top view of the compressor unit shown in

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FIG. 1 with a portion of the central casing member broken away;

FIG. 3 is an enlarged fragmentary sectional view taken substantially along lines 3—3 of FIG. 2 and showing the details of a charging port;

FIG. 4 is a transverse sectional view taken substantially along lines 4—4 of FIG. 2;

FIG. 5 is a diagrammatic development of the compressor housing and rotors indicating developed pressure values in the compression cells defined by the rotating rotors and the stationary housing; and

FIG. 6 is a diagram illustrating a work-saving feature of this invention.

Referring to the accompanying drawings which illustrate one preferred embodiment of the present invention, the numeral 10 generally indicates a screw-type compressor which is drivingly coupled to the output of an internal combustion engine 12. The illustrative compressor device 10 essentially comprises a plural-part stationary casing 14 and a pair of complementary, meshing rotors 16 and 18 which are rotatively journaled within the casing 14. The casing 14 is provided with intersecting parallel bores 20 and 22 which are in open communication with a compressor inlet port 24 opening radially from one end of the casing and with a discharge port 26 opening axially at the other end of the casing.

As best shown in FIGS. 2 and 4, the compressor operating means, i.e. rotors 16 and 18, comprise complementary helical screw members which are journaled in the parallel bores 20 and 22. Rotor 16 is provided with four generally convex lobes 16a-d and is commonly referred to as the main rotor. Rotor 18 is provided with six generally concave grooves 18a-f and is commonly referred to as the gate rotor. Reduced diameter and shafts, not shown, of the rotors 16 and 18 are journaled by antifriction bearings mounted in the casing 14; and, a shaft extension, not shown, of the main rotor 16 is mechanically connected to the rotary output of the engine 12. Preferably, but not necessarily, the cooperating rotors are synchronized or timed to provide interrotor clearance.

In the illustrative air compressor, a plurality of working chambers or compression cells 30a-30d are defined by the mating main rotor lobes 16a-d and gate rotor grooves 18a-f as the rotors rotate in opposite directions and in approximate contact with the walls of the casing bores 20 and 22. As the rotors rotate, the working chambers sequentially open to their full volume and fill with air while in communication with the inlet port 24. After the individual chambers rotate out of communication with the inlet port 24 and due to entrance of the helical main rotor lobes 16a-d into mating gate rotor grooves 18a-f, the volume of air contained in the cells is progressively reduced by the shortening of the length of each cell from its inlet end to its discharge end; and, with a decrease in volume, the internal pressure in the chamber is progressively raised from inlet pressure to discharge pressure. Thus the compression chambers are axially displaced toward the discharge port 26 and brought into sequential registration therewith as the rotors revolve in mating relation. The operation of the compressor unit 10 will be more clearly understood by referring to FIG. 5 which is a diagrammatic development of the casing 14 and the main and gate rotors of an exemplary apparatus intended to compress air from inlet pressure O to discharge pressure S. With the main and gate rotors in the position shown in FIG. 5, a working chamber 30a is in radial and axial communication with the inlet port 24 and receives a full charge of air at inlet pressure. The chambers 30b, 30c, and 30d have rotated past the marginal edges of the inlet port and the

volumes of the respective chambers have been reduced due to the progressively greater entrance of the lobes 16*b-d* into the grooves 18*b-d*. It will be noted that the chamber 30*d* is in position to open to the discharge port 26 and that further rotor rotation will completely exhaust chamber 30*d* at a final discharge pressure S. It will also be noted that the developed chamber pressures increase as the chambers are displaced axially from the inlet port 24 to the discharge port 26.

According to the present invention, a charge of pressurized gas is introduced into the respective working chambers 30*a-30d* to increase the final volumetric discharge of gas from port 26. The charging gas may be supplied by any suitable source; however, the disclosed source comprises a well-known turbocharger device which conventionally includes a driving turbine 32 and a driven gas blower 34. The turbine section 32 may be driven conveniently by hot exhaust gas discharged from the engine exhaust manifold 36. The discharge pressure of blower 34 should be greater than the inlet pressure of compressor 10.

As best shown in FIGS. 2-4, a pair of charging ports 38 and 40 are disposed on opposite sides of the central section of the compressor casing 14. The ports 38 and 40 preferably, but not necessarily, comprise elongated slots which open to the interior bores 20 and 22, respectively, from elongated supply manifolds 42 and 44, which may be cast integrally with the casing 14. The ports 38 and 40 slopingly extend along the curved wall of casing 14 and are shaped so that the longitudinal marginal edges of the ports are disposed in substantial alignment with the helical crest edges of the rotors 16 and 18. This port disposition and configuration permits full opening of the ports as the trailing edges of the crest surfaces of the rotors sequentially pass over the leading edge of the port openings. It is intended that the ports 38 and 40 communicate with respective working chambers successively; therefore, the width of the ports 38 and 40 should substantially correspond to the crest surface width of the rotor coating therewith in order to prevent gas leakage between adjacent working chambers. Furthermore, the port area should be sufficiently large to avoid any appreciable throttling of the flow of supercharging gas therethrough. The supply manifolds 42 and 44 may be provided with threaded openings for receiving threaded ends of conduits 46 and 48 which communicate charging gas from a source such as blower 34.

An important feature of this invention resides in locating the charging ports 38 and 40 longitudinally with respect to the casing 14 so that the ports open to successive working chambers 30*a-30d* after the chambers are filled with the normal supply of gas from the inlet port 24 and after the chambers are cut off from the inlet port due to rotor rotation. Moreover, it is intended that the additional supply of charging gas flowing through ports 38 and 40 be communicated to the working chambers only after the developed working chamber pressure reaches a predetermined level as will be hereinafter more fully described. The means for accomplishing such delayed charging will be more fully understood by referring to FIG. 5 which diagrammatically indicates the preferred location of the charging ports 38 and 40 with respect to the inlet port 24 and the axially movable working chambers 30*a-30d*. It will be noted that the charging ports 38 and 40 open into working chamber 30*b* which is cut off from the periphery of the inlet port due to the meshing of the main rotor lobe 16*b* and the gate rotor groove 18*b*. The rotor lobe 16*b* has entered the mating groove 18*b* sufficiently to develop a pressure R within the working chamber 30*b*. It will be appreciated that the proximity of the charging ports with respect to the discharge end of the compressor casing 14 will determine the level of developed pressure within that working chamber which is in communication with the ports. Thus shifting the charging ports axially toward the compressor discharge

port will communicate the ports with a working chamber having a higher developed pressure.

The charging ports should be located to open to a working chamber which displays a developed pressure approaching as nearly as is practical the pressure of the charging gas supplied by the blower 34. However, in selecting the charging port location for a given compressor, the charging pressure available from the source of supercharging air must necessarily be somewhat greater than the developed chamber pressure existing at the selected port location in order that the charging air will flow into the chamber during the charging period. The minimum differential pressure required between the charging pressure and the developed chamber pressure at the point of introduction of the charge will depend on the final pressure reached in the chamber during the charging period and on unavoidable gas pressure losses incurred in the ports and in the conduit connecting the ports to the source of charging gas.

The principal advantage afforded by the improved supercharging system described above is graphically demonstrated in FIG. 6 which contrasts the operation of the herein disclosed system against the operation of a system wherein a working chamber is charged immediately at inlet port cutoff. In the graph, developed working chamber pressure is plotted against rotor rotation after inlet port cutoff. The full line OR represents the normal increase in working chamber pressure as the meshing rotors 16 and 18 rotate past cutoff and decrease the volume of the working chamber. According to the present invention, at a developed pressure R a charge of gas is introduced into the working chamber to raise the chamber pressure very rapidly along the line RQ. Since the increase in pressure during the charging phase is not instantaneous due to the inertia of the charging gas, the line segment RQ is somewhat sloped rather than vertical. After the chamber pressure is increased by charging to point Q, further rotor rotation causes the chamber pressure to rise in the usual manner to a final discharge pressure S along line QS. If an identical charge of gas were introduced into the working chamber immediately at cutoff, represented at point O, the chamber pressure would quickly increase along the broken line OP and would thereafter increase in a normal manner along line PQS to a final discharge pressure S.

Assuming that charging gas is available at a source pressure T and that the charging gas to be introduced will raise the chamber pressure from point O to point P or from point R to point Q, depending upon the point at which charging is begun, the graph shows that delaying the introduction of the charging gas as hereinbefore described will provide less drop in pressure of the charging gas as it is introduced into the working chamber, thereby conserving a measure of the energy supplied to the charging gas by the blower 34. Thus the charging gas, if introduced at point O or cutoff, will expand and drop in pressure from T to O while the same charge will expand and drop in pressure only from T to R if it is introduced when the developed chamber pressure reaches point R along the compression curve OR. Moreover, the work performed by the blower on the charging gas is substantially entirely wasted by charging at cutoff while the herein disclosed charging system efficiently utilizes a significant portion of the work done by the blower. To illustrate this work-saving feature of the present invention in another manner, the work performed by the compressor in raising the gas pressure from the inlet pressure O to the discharge pressure S may be conveniently represented by the areas below the compression curves ORQS and OPQS, respectively. The work saved by delaying the introduction of the charging gas in accordance with the present invention is graphically indicated by the area defined by points OPQR. Since the improved supercharging system makes more effective use of the energy of the charging gas, the horsepower input to

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the compressor 10 from the engine 12 may be reduced, thereby affording a saving in the cost of operation of an engine-compressor apparatus.

While the present supercharging system has been shown and described as having particular utility when employed with screw-type compressors, it will be appreciated that the invention is not limited to any particular type of compressor. Moreover, the above description and drawings comprehend only a general and preferred embodiment of the improved screw-type compressor and various changes in the construction, proportion, and arrangement of various parts may be made without sacrificing any of the enumerated advantages of the invention.

Having fully disclosed the invention, I claim:

1. A gas compressor supercharging system comprising:

(a) first gas compressor means providing a source of charging gas having a predetermined pressure above atmospheric pressure

(b) second gas compressor means having
(1) casing means provided with spaced inlet and discharge ports

(2) operating means cooperable with said casing to provide a working chamber wherein a volume of gas is supplied through said inlet port and is compressed, after said inlet port is cut off, to develop a progressively increasing internal pressure in response to displacement of said working chamber from said inlet port to said discharge port

(3) charging port means opening through said casing means to said working chamber as the latter is displaced to register with said charging port means

(4) said charging port means being located with respect to said working chamber to open thereto before the internal developed pressure therein is equal to the pressure of said charging gas thereby to provide a gas pressure differential between said source and said working chamber which is effective to induce flow of charging gas into said working chamber

(5) said charging port means being located with respect to said working chamber to minimize said gas pressure differential whereby expansion of charging gas within said working chamber is minimized

(c) means communicating said charging gas from said source to said charging port means.

2. The invention defined in claim 1 together with motive means drivably connected to said operating means; and, wherein said source of charging gas comprises another compressor means operated by said motive means.

3. The invention defined in claim 2 wherein said motive means comprises an internal combustion engine providing exhaust gas; and said another compressor means includes turbine means driven by said exhaust gas.

4. A gas compressor supercharging system comprising:

(a) first compressor means providing a source of charging gas at a predetermined pressure

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(b) second compressor means comprising:

(1) casing means having axially spaced inlet and discharge ports

(2) a pair of rotors rotatably journaled in said casing means and having complementary helical lobes and grooves cooperable with said casing to define plural working chambers

(3) said rotors meshing to displace said working chambers successively and axially from said inlet port to said discharge port thereby to effect a decrease in the working chamber volume and an increase in the working chamber internal pressure

(4) charging port means opening through said casing means intermediate said inlet and discharge ports to register with respective working chambers as the latter are axially displaced as aforesaid

(5) said charging port means being located to register with respective working chambers as aforesaid before the internal pressure therein becomes equal to the pressure of said source of charging gas thereby to provide a gas pressure differential between said source and said working chamber effective to induce flow of charging gas into said working chamber

(6) said charging port means being located to minimize said gas pressure differential whereby expansion of charging gas within said working chamber is minimized

(c) means communicating said charging gas from said source to said charging port means.

5. The invention defined in claim 4 wherein said lobes and grooves have crest surfaces separating adjacent working chambers; and the width of said charging port means is the same or less than the width of said crest surfaces thereby preventing gas communication between adjacent working chambers as said crest surfaces pass over said charging port means.

6. The invention defined in claim 5 wherein said charging port means are provided with marginal edges disposed in substantial alignment with the edges of said crest surfaces.

7. The invention defined in claim 5 wherein said rotors comprise a main rotor and a gate rotor; and said charging port means comprise a first charging port opening to said main rotor and a second charging port opening to said gate rotor.

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