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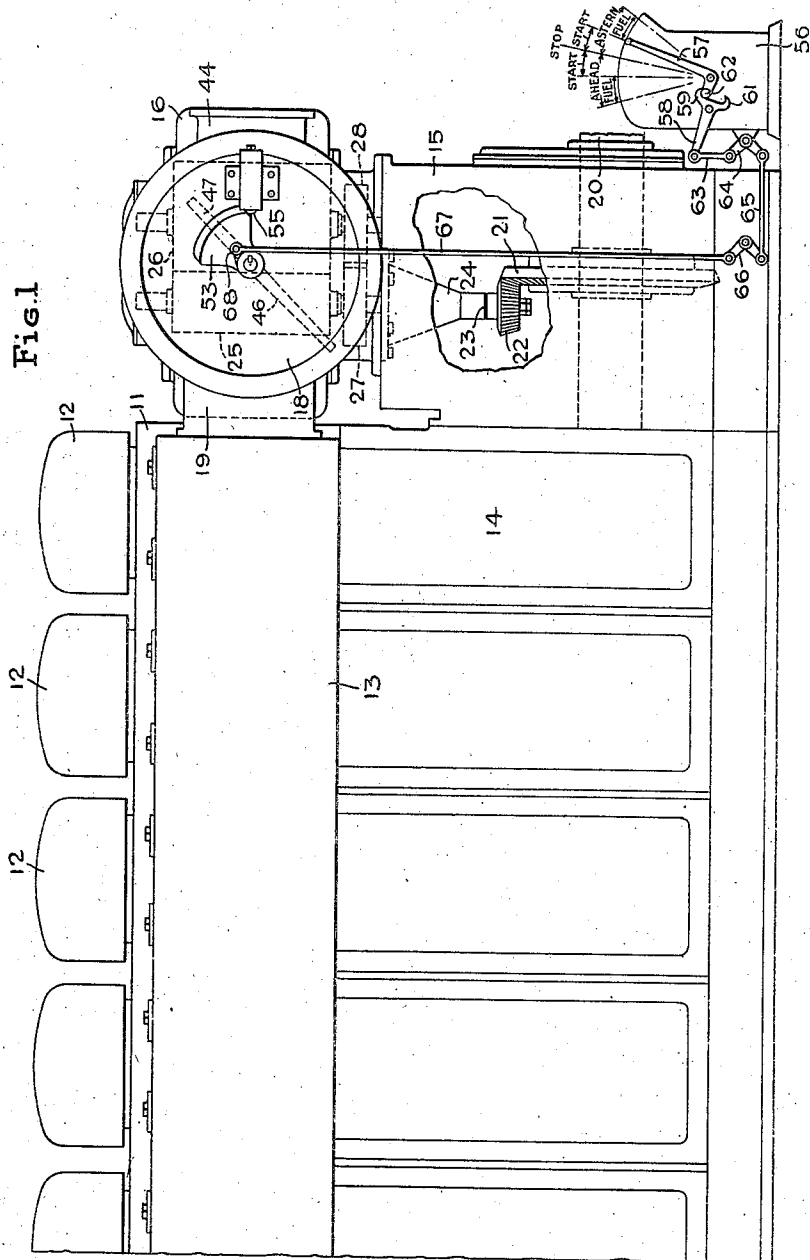
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2,394,237

SCAVENGING REVERSIBLE INTERNAL-COMBUSTION ENGINE

Filed June 14, 1943

5 Sheets-Sheet 1



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SCAVENGING REVERSIBLE INTERNAL-COMBUSTION ENGINE

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Fig. 2

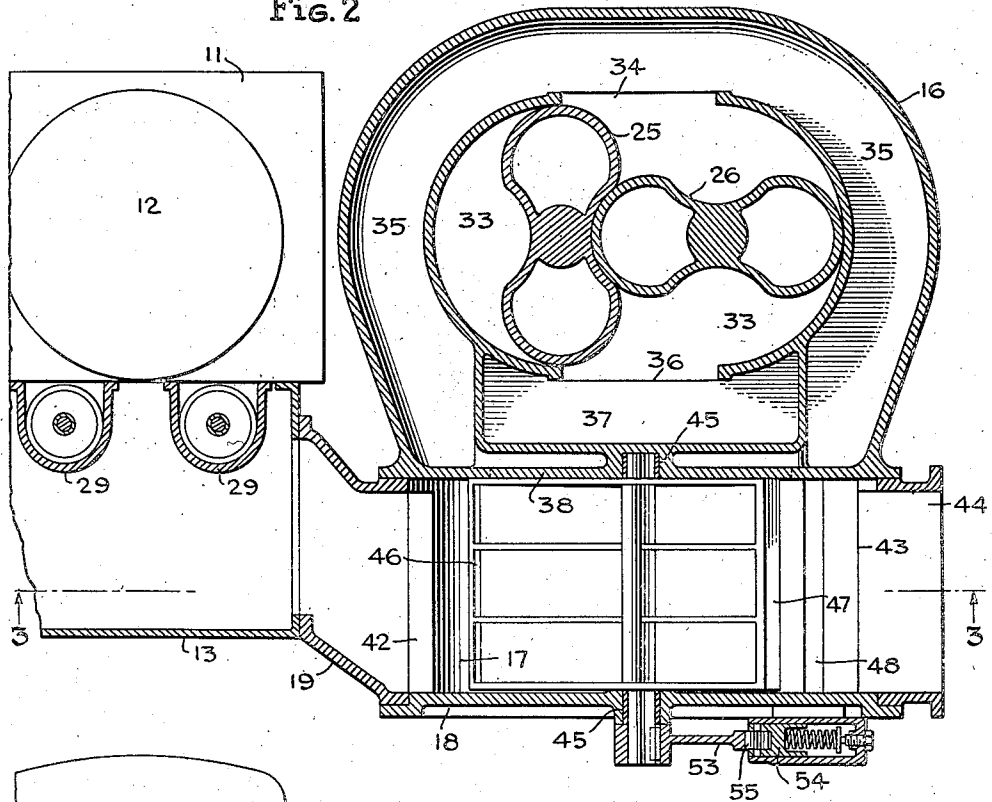
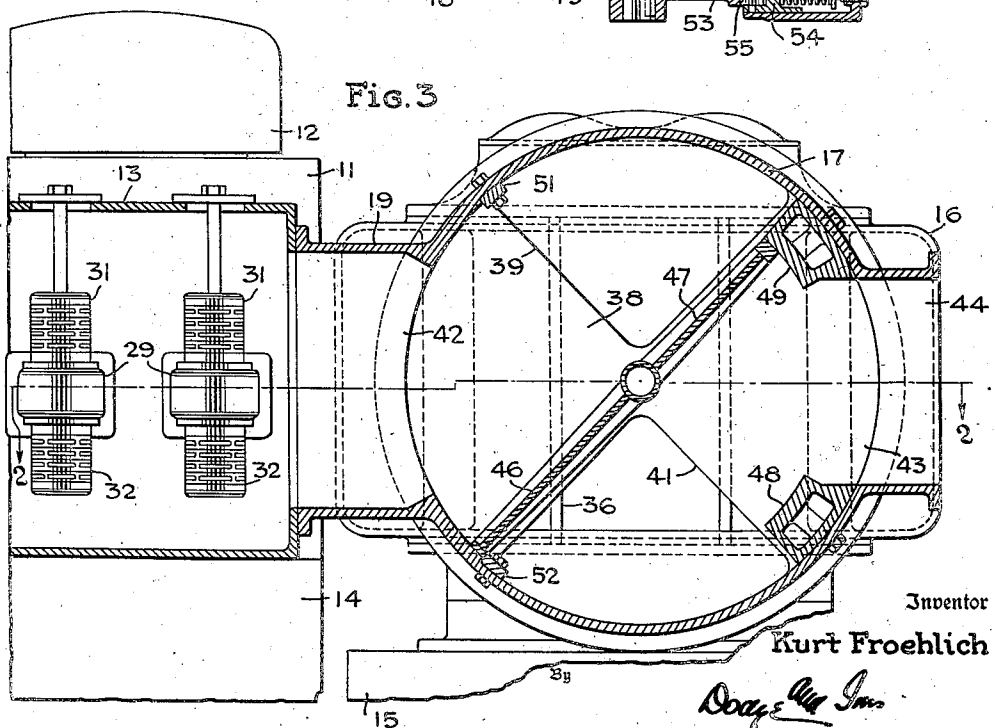


Fig. 3



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Fig. 4

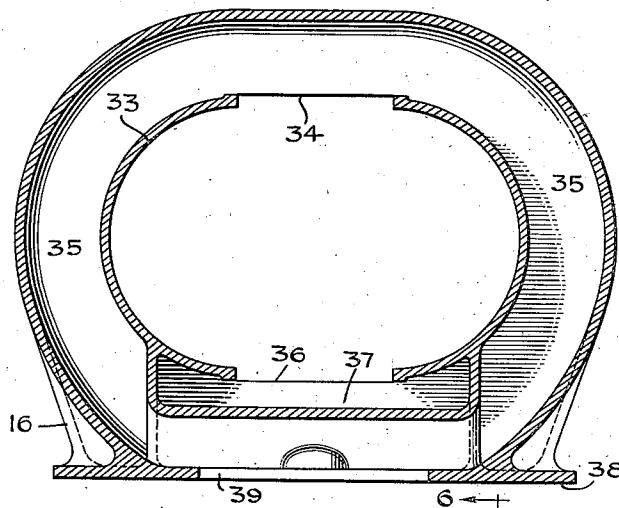


Fig. 5

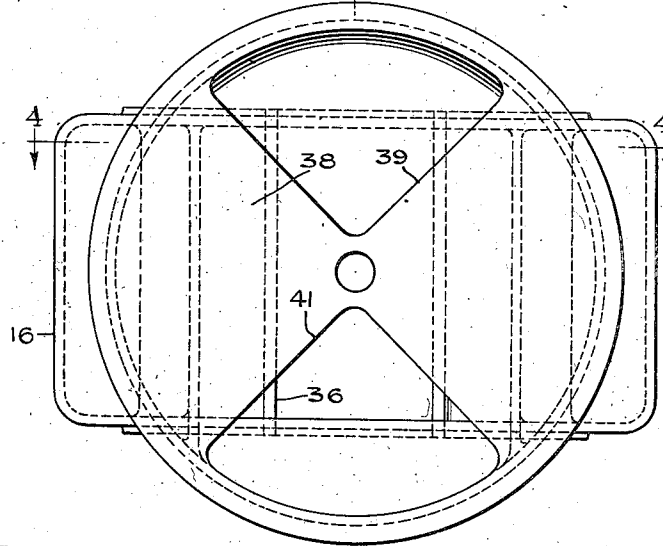
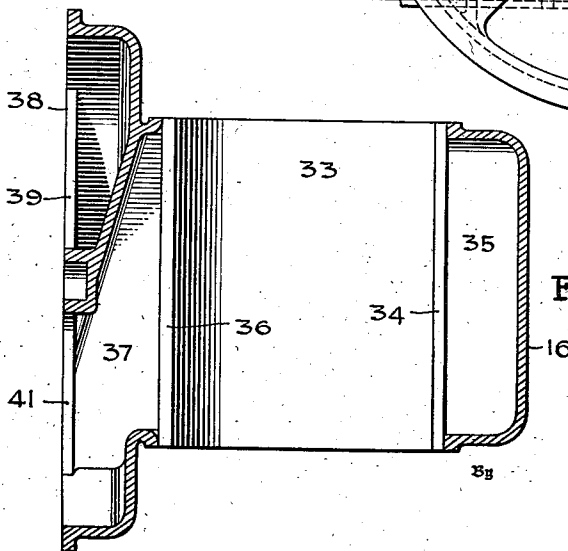


Fig. 6

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SCAVENGING REVERSIBLE INTERNAL-COMBUSTION ENGINE

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Fig. 7

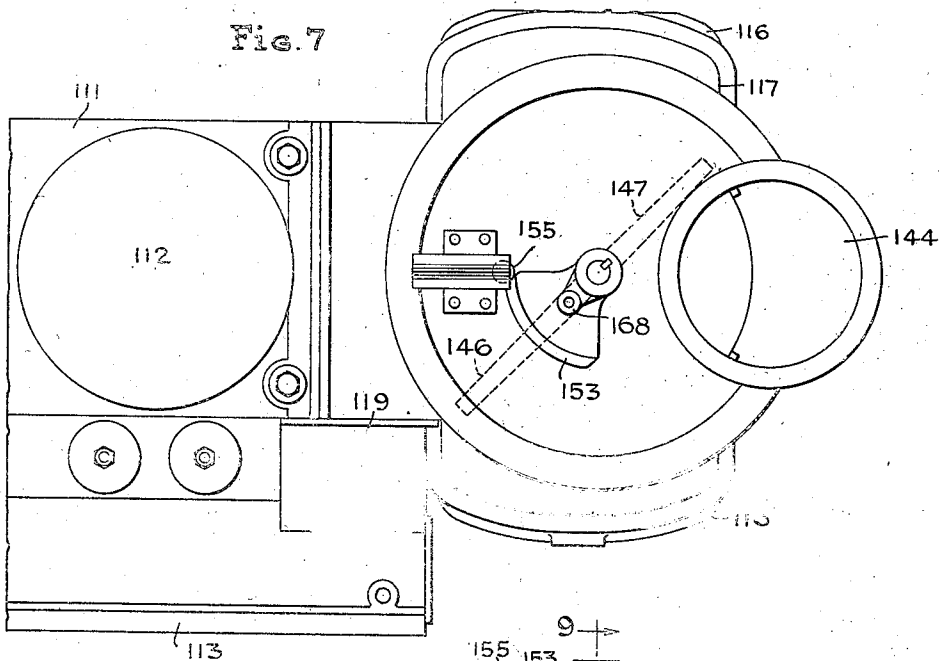
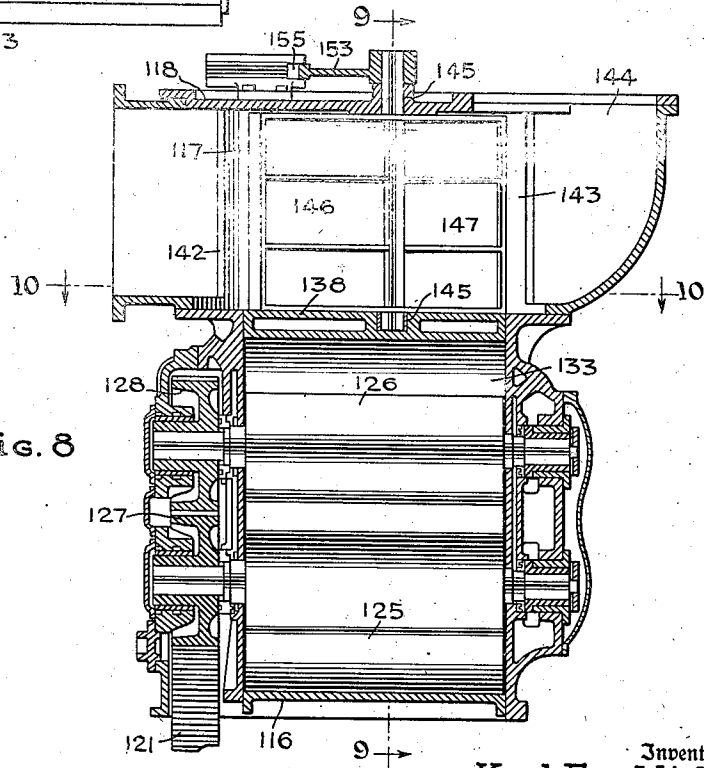


Fig. 8



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Fig. 9

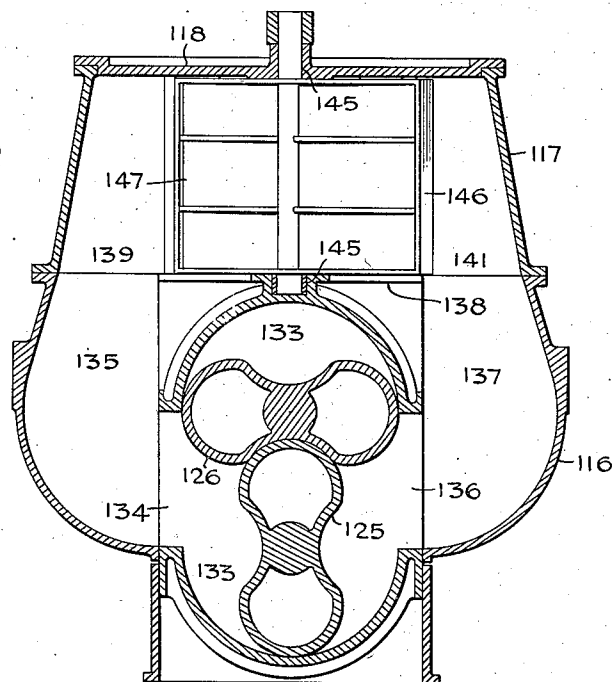
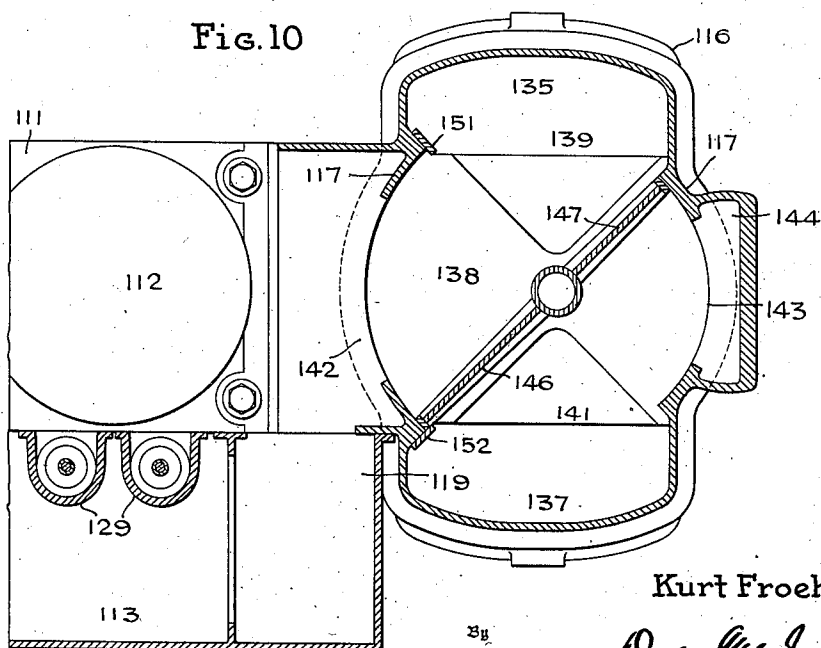


Fig.10



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UNITED STATES PATENT OFFICE

2,394,237

SCAVENGING REVERSIBLE INTERNAL-COMBUSTION ENGINE

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Application June 14, 1943, Serial No. 490,807

15 Claims. (Cl. 123—41)

This invention relates to the scavenging of reversible internal combustion engines, and particularly to automatic means for rendering an engine-driven scavenging blower indifferent to the direction of rotation of the engine.

Where scavenging air is furnished by an engine-driven positive displacement rotary blower, such as a Roots type blower, or by any other blower or pump not inherently indifferent to its direction of rotation, it is necessary either to reverse the blower drive when the engine is reversed, or to interchange the inlet and discharge connections of the blower as an incident to reversal of the engine.

In the prior art the mechanism which reverses the action of the blower is mechanically actuated from the reversing gear. This arrangement works very nicely if the engine is allowed to stop before the reversing gear is put into reverse position, but to stop the engine quickly it is the practice to "plug" the engine by moving the reverse gear into reverse starting position while the engine continues its motion. This causes the blower to evacuate the scavenging manifold, which is objectionable.

The present invention provides a valve which is not operated directly by the reversing gear but which responds to partial evacuation of a scavenging manifold to cause reversing. Thus in reversing, whether the engine is "plugged" or is allowed to stop before being set in reverse, response of the blower reversing device will not occur until the engine has actually started to turn reversely. Consequently the objectionable action of the prior art devices is avoided.

As illustrated in the accompanying drawings the valve will reverse automatically as soon as the engine crank shaft has turned reversely through a moderate angle, and will thereafter maintain its position until another reversal direction has occurred. No actuating connection between the valve and the engine reversing gear is required.

The valve is so arranged that development of a positive pressure in the manifold tends to maintain the unbalanced reversing valve in position, whereas depression of manifold pressure below atmospheric establishes a reversing tendency. This tendency cannot persist through the entire reversing motion. Hence use is made of some means, conveniently an impositive detent, which resists initial motion away from each limiting valve position and the ports are so dimensioned that the valve moves through a substantial angle before port interchange commences.

In this way, start of the shift is delayed until manifold pressure is reduced substantially. Thereupon the differential pressure becomes effective for a substantial angle of motion, so that the valve acquires sufficient momentum to cause it to move full stroke, once it starts. In this way the valve can be caused to reverse automatically when the crank shaft has turned reversely through a moderate angle. Such motion can be caused to occur, upon reverse rotation of the crank shaft through less than 60 degrees.

Two embodiments of the invention will be described, each of which offers a favorable location of the blower and valve, and each of which has the advantages of favorable flow paths for the air in both settings of the valve, and of simple driving trains from the engine crank shaft to the blower.

As a secondary feature an interlock is provided between the unbalanced reversing valve and the control lever which is shiftable from a stop position in opposite directions through reverse starting ranges and then through fuel ranges. A gear of this general type is shown in the patent to Ramstad 2,243,883, June 3, 1941, and another in the patent to Froehlich and Grieshaber 2,304,161, December 8, 1942. The function of the interlock is to allow the controller to move from say forward position through the stop position and into the reverse starting position without interference but to prevent motion into the reverse fuel range until the unbalanced reversing valve which controls the blower has shifted to reverse position. This interlock is effective in both types of reversal so that it is impossible to operate the engine under fuel until the blower is functioning properly.

In the drawings:

Figure 1 is an elevation of an engine equipped with the invention and showing the location of the blower and valve relatively to the cylinders and the scavenging manifold. The drive train to the blower is indicated in dotted lines. In this view the protective interlock for the engine controller is shown.

Fig. 2 is a section through the blower, valve and manifold on the line 2—2 of Fig. 3.

Fig. 3 is a section on the line 3—3 of Fig. 2.

Fig. 4 is a horizontal section through the blower housing on the line 4—4 of Fig. 5.

Fig. 5 is an elevation of the blower housing showing the ported face with which the rotary valve coacts and upon which the valve housing is mounted.

Fig. 6 is a section on the line 6—6 of Fig. 5.

Fig. 7 is a plan view of a modified embodiment in which the blower axes are parallel with the crank shaft and the valve is mounted above the blower.

Fig. 8 is a vertical axial section through the valve and blower of Fig. 7.

Fig. 9 is a section on the line 9—9 of Fig. 8.

Fig. 10 is a section on the line 10—10 of Fig. 8.

The engines selected for illustration are of the two cycle port scavenged type with check valves (sometimes called Fiat valves) arranged to prevent flow from the cylinders through the scavenging ports to the scavenging manifold. Such valves are a familiar and desirable component of two cycle port scavenged engines and are important in connection with the invention because they make it possible to reduce manifold pressure below atmospheric pressure. Some such means is essential to operation of the device but means other than "Fiat valves" could be used.

In applying the invention to four cycle engines or any engine not of the port scavenged type with check valves in the scavenging path, some means must be supplied to prevent back flow from the atmosphere such as might occur through any open scavenging port or valve to the manifold.

In the present disclosure the Fiat valves typify any such means.

Simply as bearing on general proportions of parts in the drawings, and on statements of direction it may be stated that the engines selected for illustration have nine vertical cylinders in line.

First embodiment

The embodiment shown in Figures 1 to 6 will first be described. Figure 1 indicates the relationship of the blower and valve to the engine. Cylinders which are arranged in line are indicated at 11. These have heads 12. A portion of the scavenging air manifold is shown at 13, and 14 is a portion of the frame and enclosing structure housing the cranks and connecting rods. This frame structure has an extension 15 which supports the blower housing 16. To the blower housing is attached the cylindrical valve housing 17 for the reversing valve. This has a front cover 18. A connection 19 leads from housing 17 to manifold 13. The valve housing is thus nearly in line with the manifold.

The crank shaft 20 carries a bevel gear 21 which drives a pinion 22 on the lower end of blower drive shaft 23 which is sustained by the pendant bearing housing 24.

The two impellers 25, 26 shown in Fig. 2 are driven by shaft 23, impeller 25 being driven directly and impeller 26 by the gears 27, 28 shown in Fig. 1. Since the Roots type blower here shown is well known and involves no patentable novelty it is deemed unnecessary to go into further detail. Additional details of blower construction are shown in Fig. 8 to which reference can be made if desired.

Within the manifold 13 are the Fiat valves. There are two valve units per cylinder. Each unit comprises a bonnet 29 whose interior is in communication with the scavenging ports in the cylinder walls, an upper stack of check valves 31, and a similar lower stack of check valves 32. Each stack comprises a set of superposed annular slotted seats each controlled by an annular plate valve. The valves are light, the valve lift is small and the port areas are large in the aggregate. Thus the Fiat valves open rapidly, offer little resistance to flow from the manifold to the cylinder and close instantly against reverse flow. They are in extensive use in port scavenged engines.

The impellers 25, 26 of the blower turn in the usual oval chamber 33 within housing 16 and mesh with each other. The chamber 33 has a large port 34 which leads to the encircling passages 35, and at the opposite side a port 36 which leads to the downward extending passage 37. Figs. 4, 5 and 6 will make the arrangement clear. At the side toward the observer in Fig. 1 the housing 16 has a plate-like wall 38, to which the housing 17 of the reversing valve is attached. In the wall 38 are two diametrically opposed sector shaped ports 39 and 41. Port 39 is in direct communication with both the passages 35 and port 41 with passage 37. The ports 39 and 41 are the terminal connections of the blower which must be interchangeably connected with manifold 13.

Formed in the cylindrical wall of housing 17 are two opposed rectangular ports 42 and 43 which are displaced 90° from ports 39 and 41. Port 42 leads to connection 19 and hence to manifold 13, and port 43 leads from inlet air connection 44. The inlet connection may lead from the engine room or may be piped to any suitable air inlet.

Turning on trunnions which are journaled in bearings 45 in plate 38 and in cover 18 is an unbalanced reversing valve having blades 46 and 47 of unequal lengths. The blade 46 is the longer, and to compensate, masking seats 48, 49 are provided to coact with the shorter blade 47.

The limiting positions of the valve are determined by stops 51, 52 which are engaged by blade 46. These are so placed that the blade 46 must swing through a substantial angle away from each stop before the blade overtravels the proximate edge of port 42. When it does so, blade 47 will clear masking seat 48 or 49 as the case may be. During this range of motion the blower connections are not affected, but the valve acquires momentum sufficient to shift it full stroke.

Within this range of motion the valve is pressure-biased toward the adjacent stop 51 or 52 if pressure in manifold 13 is above atmospheric and away therefrom if it is below atmospheric. Depression of manifold pressure caused by initial reverse motion of the blower causes the valve to shift.

To delay shift of the valve until manifold pressure has been sufficiently reduced to cause full stroke-motion of the valve, an impositive detent, effective at each limit of motion is provided.

This comprises an arcuate cam 53 keyed to one of the trunnions on which the valve turns. A spring urged plunger 54 forces a roller 55 against the arcuate cam. At the limits of valve motion the roller engages the inclined terminal portions of the cam and thus yieldingly resists initial motion of the valve away from each terminal position.

The cam is so proportioned as to serve as a counterbalance so that the valve has no gravity bias. This is desirable particularly where the valve turns on a horizontal axis. It is desirable even if the valve be mounted on a vertical axis where the engine is used on locomotives or ships.

In Figure 1, 56 represents the control stand and 57 is the maneuvering lever. So far as is here material, the lever 57 has a midposition marked "stop" in which the starting mechanism which turns the engine over is inert. This starting mechanism might be of any type but in large Diesel engines commonly involves a distributing valve gear which admits compressed air to the various cylinders in timed relation to the position of the crank shaft.

Simply as an example of such connection it

may be stated that the lever 57 might be appropriately linked to the arm 104 shown in Figure 2 of the Ramstad patent above identified or to the arm 74 shown on Figure 2 of the Froehlich and Grieshaber patent above identified. These patents show examples of reversing gears in which a maneuvering lever such as the lever 57 is movable from a neutral position in opposite directions, first through a starting range and then through a fuel range. These two examples are of the air starting type, but the particular mechanism used to start the engine rotating is not material to the present invention.

If the lever 57 is moved into the ahead or astern starting range, the engine is turned over ahead or astern as the case may be. If the lever 57 is moved beyond the starting range into the fuel range either ahead or astern, the starting mechanism is rendered inactive and fuel is supplied to the engine at rates which increase with the displacement of the lever 57. The function of the interlock to be described is to prevent motion from either starting range into the corresponding fuel range until the blower reversing valve 46, 47 has shifted appropriately.

In Figure 1 this valve is shown in its forward position and lever 57 is shown arrested at the limit of the astern starting range as it would be set to plug the engine. It is there arrested by an interlock lever 58. This has an upper hook 59 which prevents entry into the astern fuel range and a lower hook 61 which when properly positioned, prevents entry of lever 57 into the forward fuel range.

In Figure 1 the hook 59 is shown engaging the lug 62 mounted on lever 57. If the lever 58 is turned counter-clockwise, hook 59 is retracted from the path of the lug 62 and hook 61 is projected into said path but in a position which will prevent entry of lever 57 into the forward fuel range. The lever 58 shifts between the positions just mentioned, in response to the shifting of the rotary valve 46, 47. The actuating connections are diagrammed as a link 63, bell crank 64, link 65, bell crank 66 and link 67. This last is connected to a crank pin 68 mounted on the cam disk 53. Thus the shift of the valve interchanges the hooks 59 and 61 making them functionally effective selectively.

No part of the control mechanism is illustrated other than the interlock, and the connections between the rotary valve and the interlock member are indicated in simple diagrammatic form and may be variously embodied.

Second embodiment

The second embodiment illustrated in Figures 7 to 10 is functionally identical with the first embodiment. The parts are differently arranged. To avoid repetitious description parts in the second embodiment corresponding to parts in the first are given the same numerals increased by 100, so that they can be readily identified.

The basic differences are that the blower is mounted with the axes of its impellers parallel with the crank shaft and the reversing valve is mounted above the blower. The axis of the unbalanced reversing valve is vertical instead of horizontal. This arrangement entails some differences of detail which will be briefly explained.

Instead of the bevel gear 21 a spur gear 121 is used and this gear 121 meshes directly with the pinion 127 on the lower impeller 125. The ports 134 and 135 at opposite sides of the oval blower chamber 133 communicate respectively with pas-

sages 135 and 137 which extend upward at opposite sides of the housing 116.

The circular housing 117 which encloses the reversing valve has four peripheral ports. Thus the ports 139 and 141 are opposed to each other and have V-shaped extensions in plate 138. The ports 142 and 143 are opposed to each other. This arrangement gives larger port areas and freer flow than is had in the first embodiment.

With the valve in the position of Figure 10 the inlet connection 144 is connected by way of ports 143 and 141 with the port 136 in the blower housing. Similarly the port 134 in the blower housing is connected by way of the ports 139 and 142 to passage 119 and thus to the scavenging manifold 113.

The impositive detent mechanism is essentially the same as that already described. The valve wings have a substantial angle of idle motion before they overrun the margins of the ports 142 and 143.

In Figure 7 the point of connection 158 for the interlock mechanism is indicated. No other parts of the interlock mechanism are illustrated since they would conform basically with what is fully illustrated in Figure 1.

Operation

Suppose, for example, that the engine is operating forward and that the valve 46, 47 is in the position indicated in dotted lines in Figure 1. During forward operation the maneuvering lever 57 would be some where in the ahead fuel range. The engineer desires to stop and reverse the engine. He may move the handle 57 to stop position and wait until the engine stops, or he may move the handle to the position illustrated in Figure 1, in which it has reached the limit of the astern starting range and thus operates to plug the engine and start it turning reversely. The hook 59 prevents the maneuvering lever 57 from moving beyond this position into the astern fuel range. However, as explained below, when the engine starts to turn in the reverse direction, the valve 46, 47 will automatically shift to astern position and by its shift will retract the hook 59 and protrude the hook 61. Thereupon the operator may move the maneuvering lever into the astern fuel range. The protrusion of the hook 61 establishes a similar safeguard for the next reversal, so that during such reversal the operator may move the handle 57 through the starting range but not beyond that range until the blower connections have been reversed.

The automatic shift of the valve 46, 47 will now be described in detail.

In the case of either embodiment, if the engine is stopped and then put in motion in the reverse direction, the blower will first operate to draw air from the scavenging manifold. The Fiat valves will prevent the entrance of air through any open scavenging port and consequently the pressure in the scavenging manifold will be reduced.

The action of the detent is such that when pressure in the manifold has been reduced moderately the unbalanced valve will overpower the detent and start to move. Through the first few degrees of motion the port connections are not changed. Sufficient momentum will be gathered through this range of motion to cause the valve to swing full stroke. As it approaches the opposite limit of motion, the development of positive pressure in the scavenging manifold by the continued operation of the blower will force the

valve to its other limit of motion and retain it there.

Consequently, the reversing valve operates automatically as an incident to reversal but requires no mechanical connection with the reversing gear. Because it is in static balance (the detent arm serving as a counterweight) the valve is indifferent to gravity effects, and to any motion which it may encounter when used on a ship or locomotive.

An examination of the drawings will indicate that the blower and valve are located in line with the cylinders and that the flow paths from the blower through the valve to the scavenging manifold and from the air intake to the blower are simple, direct and of adequate cross sectional area.

While two embodiments of the invention have been described in considerable detail, they are intended to illustrate the principle of the invention without implying any necessary limitation to the specific structure so described.

What is claimed is:

1. The combination of a reversing internal combustion engine having a scavenging manifold; a blower driven by the engine and acting to propel air in opposite directions between the terminal connections of the blower according as the engine operates in one or the other direction; and means responsive to a pressure differential between said manifold and blower, abnormal in direction, and created by operation of the blower, to interchange said terminal connections as to communication with said scavenging manifold.

2. The combination of a reversing internal combustion engine having a scavenging manifold; a blower driven by the engine and acting to propel air in opposite directions between the terminal connections of the blower according as the engine operates in one or the other direction; and an unbalanced valve having two positions in which respectively it interchanges said terminal connections as to communication with the manifold and with an air supply, said unbalanced valve being arranged to shift in response to a pressure differential between said manifold and blower, abnormal in direction, acting on the valve and developed by operation of the blower.

3. The combination of a reversing internal combustion engine having a scavenging manifold; means for preventing back flow through the manifold; a blower driven by the engine and acting to propel air in opposite directions between the terminal connections of the blower according as the engine turns in one or the other direction; valve means shiftable between two limiting positions in which respectively it interchanges said terminal connections, connecting a selected one with the manifold and the other with the atmosphere; and means effective in each limiting position of the valve, and responsive to a definite reduction of manifold pressure below atmospheric pressure, to impart a reversing impulse to the valve.

4. The combination of a reversing internal combustion engine having a scavenging manifold; means for preventing back flow through the manifold; a blower driven by the engine and acting to propel air in opposite directions between the terminal connections of the blower according as the engine turns in one or the other direction; valve means shiftable between two limiting positions in which respectively it interchanges said terminal connections, connecting a selected one

with the manifold and the other with the atmosphere; and pressure operated means effective through a limited range of valve motion measured from each limiting position, and responsive to a definite reduction of manifold pressure below atmospheric pressure to impart reversing momentum to the valve.

5. The combination of a reversing internal combustion engine having a scavenging manifold; means for preventing back flow from the engine to the manifold; a blower driven by the engine and acting to propel air in opposite directions between the terminal flow connections of the blower according as the engine runs in one or the other direction; an unbalanced multi-way valve shiftable between two limiting positions in which respectively it interchanges said terminal connections, connecting a selected one with the manifold and the other with atmosphere, said valve being pressure-biased toward or away from each limiting position when near the same according as manifold pressure is above or below atmospheric pressure, said valve having near each of said positions a range of idle motion in which it does not affect the communications controlled by it; and impositive means serving to retain said valve in each limiting position.

6. The combination of a reversing internal combustion engine having a scavenging manifold; means for preventing back flow from the engine to the manifold; a blower driven by the engine and acting to propel air in opposite directions between the terminal flow connections of the blower according as the engine runs in one or the other direction; an unbalanced rotary blade valve shiftable between two limiting positions in which respectively it interchanges said terminal connection, connecting a selected one with the manifold and the other with atmosphere, the unbalanced character of said valve serving to bias said valve toward or away from respective limiting positions when near the same according as manifold pressure is then above or below atmospheric pressure; masking means coacting with the blades of said valve to afford a range of idle motion near each limiting position; and impositive means serving to exert a retaining tendency on the valve in each limiting position.

7. The combination of a reversing engine having a crank shaft, a plurality of cylinders in line, and a scavenging manifold extending along said line of cylinders; a rotary blower mounted in line with said cylinders and connected to be driven by said crank shaft, said blower being of a type which propels air in opposite directions between terminal connections according as it is driven in one or the other direction; a reversing valve device mounted as a unit with said blower controlling the terminal connections thereof and having an air intake port and a port leading to the end of said manifold, said valve device including a flow directing member shiftable between two positions to interchange said ports as to communication with the terminal connections of the blower; and means responsive to manifold pressure and serving to retain said flow directing member in either of said positions if manifold pressure be then above atmospheric pressure, and to propel said valve toward the other of said positions if manifold pressure be reduced below atmospheric pressure.

8. The combination defined in claim 7 in which the valve device is mounted on the side of the blower and approximately in line with the end of the manifold.

9. The combination of a reversing engine having a crank shaft, a plurality of cylinders in line, and a scavenging manifold extending along said line of cylinders; a rotary blower mounted in line with said cylinders and connected to be driven by said crank shaft, said blower being of a type which propels air in opposite directions between terminal connections according as it is driven in one or the other direction; a reversing valve device mounted on the blower substantially in line with said manifold, said device controlling said terminal connections and including a housing having an air intake port and a port leading to the end of said manifold, and a flow directing member shiftable between two positions to interchange said ports as to communication with the terminal connections of the blower; and means for shifting said flow directing member between said positions as an incident to reversal of the direction of rotation of the engine.

10. The combination of a reversible internal combustion engine having a scavenging manifold; means for preventing back flow from the engine to the manifold; a blower driven by the engine and acting to propel air in opposite directions between the terminal connections of the blower according as the engine runs in one or the other direction; valve means shiftable between two limiting positions in which respectively it interchanges said terminal connections, connecting a selected one with the manifold and the other with the atmosphere; actuating means associated with the valve means, responsive to the pressure differential between the manifold and atmosphere and effective when the valve means are near either limiting position to urge the valve means toward such position if manifold pressure predominates and away therefrom if atmospheric pressure predominates, there being a range of idle motion near each of said limiting positions, in which the actuating means moves while the blower connections are not affected by the valve means; and impositive means serving in said limiting positions to resist motion of the actuating means therefrom until a substantial pressure differential has been established.

11. The combination of a reversing internal combustion engine having cylinders, a scavenging manifold and scavenging ports leading therefrom to the cylinders; check valve means permitting flow from the manifold through said ports to the cylinders but inhibiting reverse flow; a blower driven by the engine and acting to propel air in opposite directions between the terminal connections of the blower according as the engine runs in one or the other direction; valve means shiftable between two limiting positions in which respectively it interchanges said terminal connections, connecting a selected one with the manifold and the other with the atmosphere; actuating means associated with the valve means, responsive to the pressure differential between the manifold and atmosphere and effective when the valve means are near either limiting position to urge the valve means toward such position if manifold pressure predominates and away therefrom if atmospheric pressure predominates, there being a range of idle motion near each of said limiting positions, in which the actuating means moves while the blower connections are not affected by the valve means; and impositive means serving in said limiting positions to resist motion of the actuating means therefrom until a substantial pressure differential has been established.

12. The combination of a reversing internal combustion engine having a scavenging manifold; a controller for said engine shiftable through a mid-position in which the engine is stopped and through starting ranges on each side of said stop position in which the engine is caused to turn in opposite directions, said controller being shiftable to fuel ranges beyond said starting ranges in which fuel is supplied to the engine for forward and reverse running respectively; a scavenging blower driven by the engine and acting to propel air in opposite directions between the terminal connections of the blower according as the engine operates in one or the other directions; means responsive to a pressure differential, abnormal in direction, and created by operation of the blower to interchange said terminal connections as to communication with said scavenging manifold; and an interlock device connected with the last named means and serving to prevent the controller from being reversed beyond the starting range until an appropriate interchange has occurred.

13. The combination of a reversing internal combustion engine having a scavenging manifold; a controller for said engine shiftable through a mid-position in which the engine is stopped and through starting ranges on each side of said stop position in which the engine is caused to turn in opposite directions, said controller being shiftable to fuel ranges beyond said starting ranges in which fuel is supplied to the engine for forward and reverse running respectively, a scavenging blower driven by the engine and acting to propel air in opposite directions between the terminal connections of the blower according as the engine operates in one or the other direction; an unbalanced valve having two positions in which respectively it interchanges said terminal connections as to communication with the manifold and with an air supply, said unbalanced valve being arranged to shift in response to a pressure differential, abnormal in direction, acting on the valve and developed by operation of the blower; and an interlock device connected with said unbalanced valve and serving to prevent the controller from being reversed beyond the starting range until the unbalanced valve has shifted.

14. The combination of a reversible internal combustion engine having a scavenging manifold; a controller operable to start said engine in either direction by motion through starting ranges, said controller being movable beyond said starting ranges into fuel ranges in which fuel is supplied to operate the engine; a scavenging blower of the type in which flow reverses upon reversal of the direction of rotation, said blower being driven by the engine; interchange means operable by the initial rotation of the engine in either direction to cause said blower to deliver air to said manifold; and an interlock actuated by said interchange means and inhibiting reversal of said controller beyond said starting range until said interchange means have functioned.

15. The combination of a reversible internal combustion engine having a scavenging manifold; a scavenging blower of the type in which flow reverses upon reversal of the direction of rotation, said blower being driven by the engine; and interchange means responsive to reduction of manifold pressure, and operable by the initial rotation of the blower in either direction to cause said blower to deliver air to said manifold.