Sept. 17, 1935. G. E. A. HALLETT 2,014,932

ROOTS BLOWER

Filed March 17, 1933 2 Sheets-Sheet 1

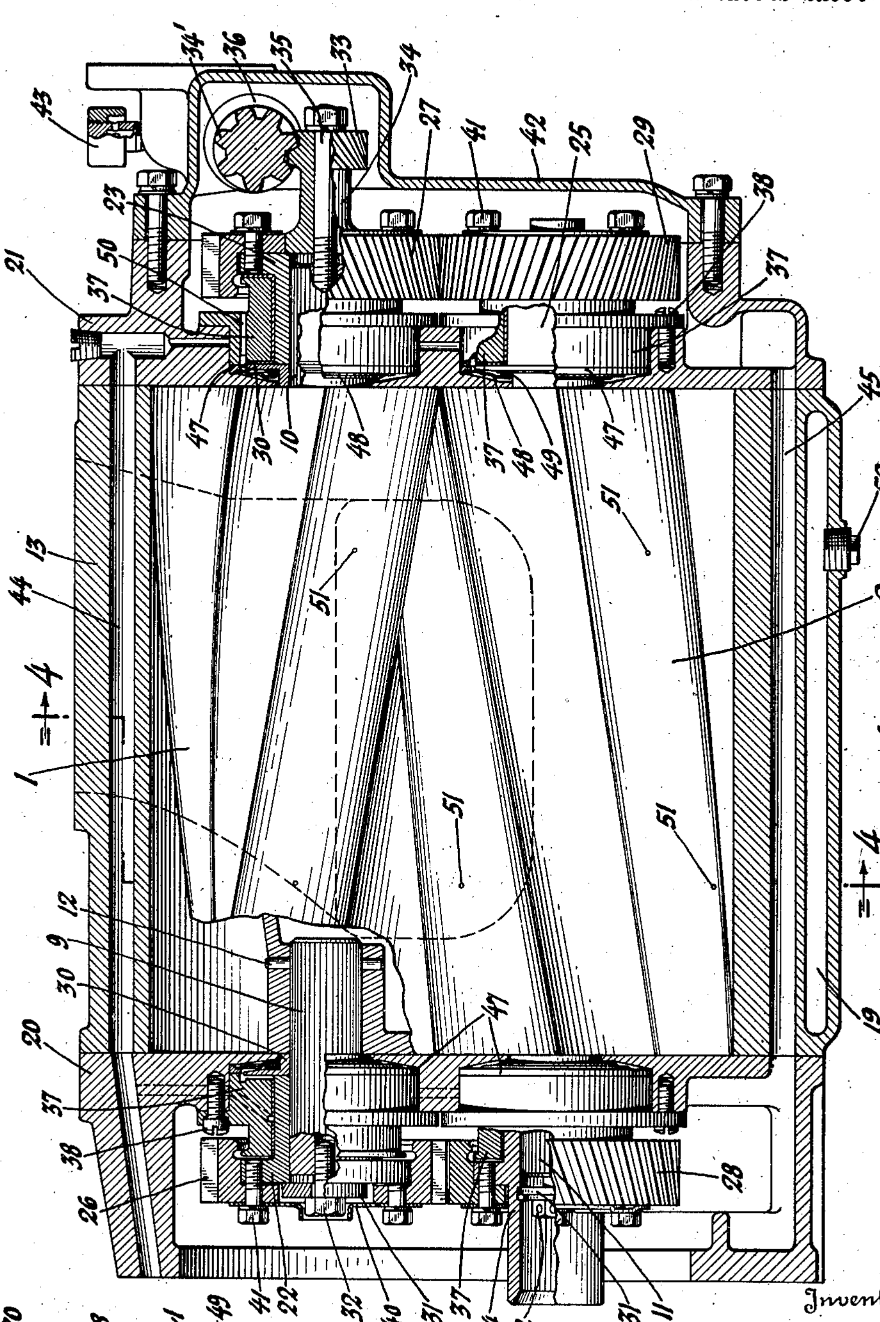

Fig. 1

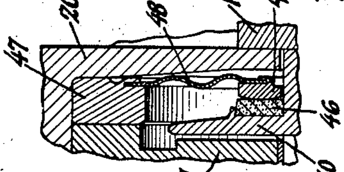

Fig. 5

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ROOTS BLOWER

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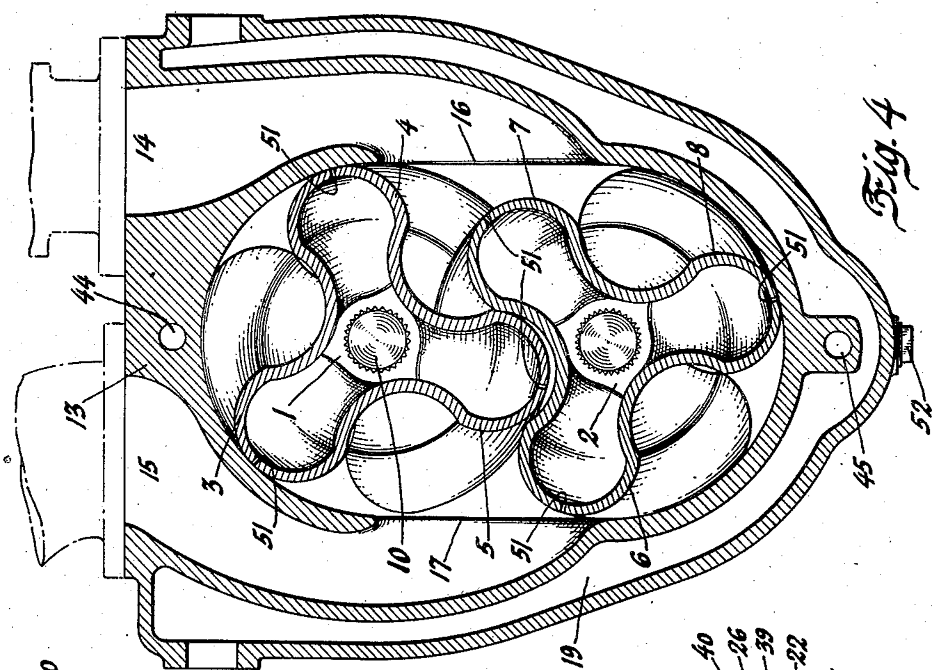

Fig. 4

Fig. 3

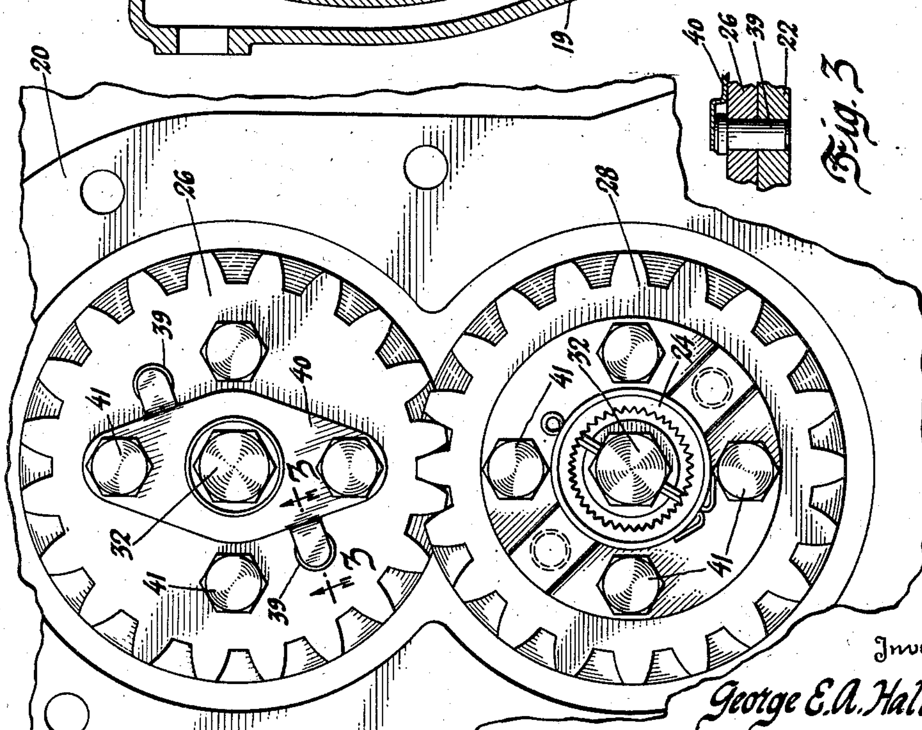

Fig. 2

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UNITED STATES PATENT OFFICE

2,014,932

ROOTS BLOWER

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Application March 17, 1933, Serial No. 661,338

4 Claims. (Cl. 230—141)

This invention relates to a blower or supercharger of the well known Roots type having intermeshing teeth or lobes which take in a volume of fluid between the tooth spaces and carry it round between the teeth and a closely encircling housing, to be squeezed out as the teeth come into meshing relationship on the delivery side. Such blowers can be made to combine to a degree, the advantages of positive displacement and capacity for high speed operation without lubrication of the parts swept by the air or other fluid which is being delivered by the blower. In order to eliminate rubbing friction, the rotors of blowers of this type have been so dimensioned as to provide a small clearance between themselves and between themselves and their housing and have been driven in proper registry with one another by gearing so that the rotor lobes or teeth are relieved of any driving duty and the small clearance of a few thousandths of an inch insures that the surfaces of the rotors themselves do not touch either each other or their housing at any point in their operation. Although hereinafter the rotors will be referred to as forming a "seal" between themselves and their housing against the flow of fluid between each other or between themselves and their housing, it will be understood that there is a small clearance and that the rotors and the housing do not actually touch each other at any point in their operation.

As ordinarily designed, these blowers are quite suitable for low outlet pressures at constant speed and where a continuous discharge characteristic is not essential.

It is the object of the invention to improve the design and structure of a Roots type blower in order that it may work efficiently at higher outlet pressures throughout a greater speed range and have more nearly continuous discharge characteristics.

It is a further object of the invention to so design such a blower that it will be quieter in operation with mechanical and pneumatic noises reduced to a minimum.

Generally, it is the object of the invention to make a Roots type blower more suited to the requirements for scavenging, charging or supercharging an internal combustion engine.

The above and other objects are attained in the manner hereafter described.

It has been found that for a reasonably large and unrestricted port area together with the largest displacement volume for a blower of given dimensions a three lobe rotor is best. That is, it has been found that a continuous discharge characteristic together with maximum volumetric displacement, and with provision for sufficiently large and unrestricted inlet and outlet port areas to give high volumetric efficiency, is best attained in a blower of this type with a three-lobed rotor.

With straight toothed rotors, each having three lobes at 120° as above, there will be cyclic discharge fluctuations or pulsations every

$$\frac{360^\circ}{6}=60^\circ$$

of rotation of the rotors, or six pulsations per revolution of the blower. The magnitude of the discharge fluctuations or pulsations is reduced as the number of lobes and the number of pulsations is increased but the displacement per unit of space occupied is also reduced. A three lobe rotor best effects a compromise between the requirements of maximum displacement for a blower of given dimensions and a maximum frequency of pulsations of lesser magnitude.

The volumetric displacement will vary with the lobe or tooth contour and while a cycloidal tooth form would give the maximum volumetric displacement together with a seal preventing any flow between the rotors themselves and their housing, it cannot do so except by taking away necessary stock at the boss required for strength. Since, however, the rotors are geared together independently of themselves and a cycloidal lobe contour for driving is no longer a requirement, it is sufficient that there should at all times be a seal preventing any flow of fluid between the rotors, and since this sealing can be effected by a following edge when the leading edge of the tooth has ceased to make a seal there is a considerable part of the tooth contour performing no useful function. Advantage is taken of this fact to modify the tooth profile so that adequate strength at the boss is provided together with only a minor reduction of the swept volume. It has been found that a tooth tip having a contour which is a true arc of a circle best effects the required compromise.

In order to reduce or eliminate the noises of pneumatic origin which are due to the pulsations or disturbances in the air stream inherent in the usual form of Roots type blower with straight lobes or teeth and port edges parallel thereto giving sharp cut off and sharp opening, some means of approaching a more continuous and constant discharge is required.

According to the invention this is attained by making the rotors of spiral or helical form around their own axes throughout their length.

In this way the discharge variations, which with three lobed rotors occur in cycles of 60° of rotor revolution, will be smoothed out and the helical angle given to the rotors will eliminate both sharp cut off and sharp opening of the entire rotor length and the sudden back flow into the low pressure chambers which goes therewith and at the same time reduce the extent or degree of fluctuations in the cyclic pulsations.

It has been found that these results are best attained when the helical angle is such that the projection of one end of the rotor in a plane at right angles to the axis of the rotor is displaced angularly relatively to the other end of the rotor a number of degrees equal to half the angle between adjacent teeth on the rotor, i. e. the "helical angle" should be a function of the number of teeth on the rotors and equal to 360° divided by twice the number of teeth on each rotor. With three lobes at 120° on each rotor this "helical angle" will be 60° and a seal of 180° around the housing will be required for each rotor.

One dimension of the port areas must be divided equally above and below the transverse geometrical center line of the blower for equal displacement from each rotor and for maximum port areas with a seal of 180° this dimension will be equal to the distance between rotor centers for each port if the housing seals for each rotor are divided symmetrically 90° on either side of the line of centers of the rotors in a plane at right angles to the rotor axes. The number of degrees required for housing seal in a plane at right angles to the rotor axes is the number of degrees between lobes plus the number of degrees of angular displacement of one end of the rotor relatively to the other end and if this total is greater than 180° the housing can not have two sides defined by the common tangents to the two rotor tip circles.

It will thus be seen that a three lobed rotor with one end angularly displaced 60° relatively to the other best fulfills the conflicting requirements for a blower of given dimensions, of maximum displacement, maximum number of pulsations of minimum magnitude per revolution, and continuity of discharge with gradual intake, exhaust, back flow and cut off, contributing to a smoother and more constant output.

A blower built in accordance with the invention and capable of operating at speeds up to 9,000 R. P. M. with a capacity of 900 cubic feet per minute and pressures up to 14 or 17 lbs. per square inch above atmospheric pressure may have a temperature difference between inlet and outlet which are only 4" or 5" apart, in the neighborhood of 300° F. The intake air, particularly if mixed with gasoline, may be 15° F. below atmospheric temperature while the heat of compression may raise this temperature to 350° F. at the outlet. The housing is water jacketed for the purpose of reducing this temperature difference, but it is not practicable so to cool the rotors. For this reason it has been found expedient to make the rotors and the housing of materials of different coefficient of expansion such that although the housing is cooled it will expand approximately the same amount as the uncooled rotors. For instance, cast iron may be used for the rotors and aluminum for the housing.

The water jacketing of the housing is insufficient to equalize the temperature difference between inlet and outlet to keep the aluminum housing from unequal expansion out of shape. The hotter outlet side expands, giving more clearance between itself and the rotors and the inlet side buckles in towards the rotors. In order always to maintain the necessary clearance between rotors and housing within the desirable maximum and minimum limitations, and in order that these clearances may be approximately equal and as small as possible, particularly on the outlet or pressure side to reduce back flow between the rotors and their housing for the average operating conditions of speed and pressure and hence of temperature difference, the housing is preferably bored eccentric to the line of centers of the rotor shafts, so as to allow more clearance on the intake side when the housing has an even temperature throughout and there may be a slight excess of clearance on the outlet side when the temperature difference is a maximum.

In order to reduce mechanical noise, the rotors are synchronously driven through helical gears at each end of the rotors. The helical angle of the gear at one end of each rotor is opposed to that at the other end in order to balance end thrust. The use of such gears at each end of the rotors prevents torsional displacement or twist of one end of each rotor relative to the other end and it maintains the rotor ends in registry independently of the rotors themselves.

The accompanying drawings show a Roots type blower constructed in accordance with the invention.

In the drawings:

Figure 1 is a part cut away, part sectional elevation of the blower.

Figure 2 is an enlarged end elevation showing the mounting of the driving gears.

Figure 3 is a section on line 3—3 of Figure 2.

Figure 4 is a section on line 4—4 of Figure 1.

Figure 5 is an enlarged part detail sectional view of the sealing rings between the rotating spindles of the rotors and the housing to prevent the escape of fluid out from the blower and the leakage of lubricating oil for the gears and the bearings into the blower.

The rotors 1 and 2 each with three lobes, or teeth, 3, 4, 5 and 6, 7, 8 of right and left hand spiral form respectively, the projection of one end of each rotor in a plane at right angles to the axis of the rotor being displaced 60° angularly relatively to the other end, are provided with splined stub shafts such as 9, 10, 11, splined in the rotor hubs and pinned against endwise movement relative to the rotors as by a pin 12.

The rotor housing 13 closely encircles 180° of each rotor and follows the two tangents common to both rotor tip circles. It is provided with intake and output ducts 14 and 15 leading to inlet and outlet ports 16 and 17, extending a distance equal in length to the distance between centers of the rotors, divided equally above and below the transverse geometrical center line of the blower along each of the tangents common to the two rotor tip circles. A water cooling space 19 around the blower is provided. End plates 20 and 21 form the end closures for the rotor housing 13.

Splined on the rotor shafts are gear hubs 22, 23, 24, and 25 for the right and left hand spiral gears 26 and 27 of the rotor 1 and the left and right hand spiral gears 28 and 29 of the rotor 2.

On the rotor shafts between the rotor hubs and gear hubs are end thrust collars 30 forming part of an oil seal later to be described. The end thrust collars 30 and the gear hubs 22, 24, and 25 are clamped up tightly against the rotor hubs by retaining rings 31 and studs 32 screwed into the ends of the rotor shafts. A spiral gear 33 with its hub 34 and stud 35 forms a similar clamping means for the gear hub 23 and its end thrust collar 30. The gear 33 forms a convenient drive for a gear 34' which, in the example illustrated, drives through the medium of the cam 36 a gasoline pump not shown.

The splined hub 24 for the gear 28 of the rotor 2 is elongated and adapted to take the drive for the blower through the medium of a splined quill or driving shaft, not shown.

Bearings 37 held in the end plates 20 and 21 by studs 38 carry the gear hubs and hence the rotors.

The spiral gears 26, 27, 28, and 29, are each dowelled to their hubs, with the rotors in proper phase relationship by dowels 39 retained in position by a plate 40 secured by two of four cap screws 41 which hold each gear firmly on its hub.

An end cover plate 42 encloses the gears 27 and 29 and is provided with an air vent 43. No such end cover plate for the gears 26 and 28 is shown as in the present example this end of the blower bolts up to the crankcase of an internal combustion engine with the blower gear chamber in communication with the engine crank chamber.

A lubricating oil passage 44 through the end plate 20 housing 13 and end plate 21 supplies oil to the bearings and the gears while the gear chambers at each end of the rotors are connected together by an oil passage 45.

In order to seal the rotor bearings against leakage of fluid out from the blower and against leakage of oil from the bearings into the blower, each bearing 37 is provided with a seal between the rotating end thrust collars 30 of the rotors and the stationary end plate, as shown more clearly in Figure 5. Referring to this figure, the thrust collar 30 has a carbon insert ring 46. Clamped between the bearing 37 and the end plate 20 is a ring 47. This ring 47 subtends a corrugated diaphragm 48 of phosphor bronze which carries an inner steel ring 49. This inner ring is displaced approximately $\frac{1}{32}''$ by the end thrust collar 30 on assembly, thus putting the diaphragm in a condition such that it exerts a pressure on the carbon ring through the inner steel ring 49. The seal is thus formed between the stationary inner steel ring and the rotating carbon insert ring. This arrangement has been found adequate and is in a measure self lubricating. Since the pressure in any part of the blower is always atmospheric or over, any leakage outward will press the sealing surfaces 46 and 49 more tightly together by pressure on the diaphragm 48.

An oil bleed 50 is drilled in each bearing 37 in order to lead any oil which leaks between the bearing 37 and the thrust collar back to the gear chamber.

The lobes of the rotors are cored out hollow as shown in Figure 4, and before assembly are balanced by removing material as required from the inside of the lobes, sufficient stock being provided for this purpose. Since the blower may be required to handle not only air, but fluid vapor, or gasoline, for instance, which may condense in the hollow rotors and put them out of balance, small drain holes 51 are drilled in each lobe as indicated.

52 is a drain plug for the blower water jacket.

I claim:

1. A Roots type blower having means adapted to provide a continuous discharge characteristic together with maximum volumetric displacement and with provision for sufficiently large and unrestricted inlet and outlet port areas to give high volumetric efficiency, said means comprising intermeshing three-lobed rotors of helical form such that one end of each rotor is displaced angularly relative to the other end, by an amount substantially equal to half the angle between adjacent lobes thereon, a housing for the rotors cooperating with each rotor so as to provide only a small clearance and an effective seal between itself and each rotor for an angle of the sweep of each rotor equal substantially to one and one-half times the angle between adjacent lobes on each rotor and not more than 180°, whereby a total area equal to at least the distance between centers of the rotors multiplied by the length of the rotors is available in the housing for each of the inlet and outlet port openings on opposite sides of the meshing zone of the gears, and gearing for driving and maintaining the rotors in registry independently of themselves such that in the operation of the blower a small clearance and an effective seal is at all times maintained between the rotors.

2. A Roots blower according to claim 1 and having opposed helical gears at each end of the rotors, whereby the rotors are driven and maintained in registry independently of themselves by preventing torsional displacement between the ends of each rotor and whereby end thrust of the helical gears is neutralized and end thrust of the rotors is counteracted.

3. A blower according to claim 1 and having means for cooling the housing and for reducing the temperature differential between the inlet and outlet of the blower, the material of said housing having a coefficient of expansion sufficiently higher than that of the rotor material so as to provide for approximately similar average expansion of the rotors and cooled housing under operating conditions.

4. In a positive displacement type of blower, in combination, two intermeshing three-lobed rotors of helical form, the projection of one end of each rotor in a plane at right angles to the axis of the rotor being angularly displaced 60° relatively to the other, a housing surrounding the rotors and forming circumferential sealing portions of 180° around each rotor, the housing being divided symmetrically about the lines of center of the rotor axes on either side thereof in a plane transverse to the rotor axes and having ports in the housing extending a distance substantially equal in length to the distance between centers of the rotors, divided equally above and below the transverse geometrical center line of the blower along each of the tangents common to the circumferential sealing portions, whereby a continuous discharge characteristic together with maximum volumetric displacement and sufficiently large and unrestricted inlet and outlet port areas to give high volumetric efficiency is obtained while providing an effective seal between the rotors and housing.

GEORGE E. A. HALLETT.