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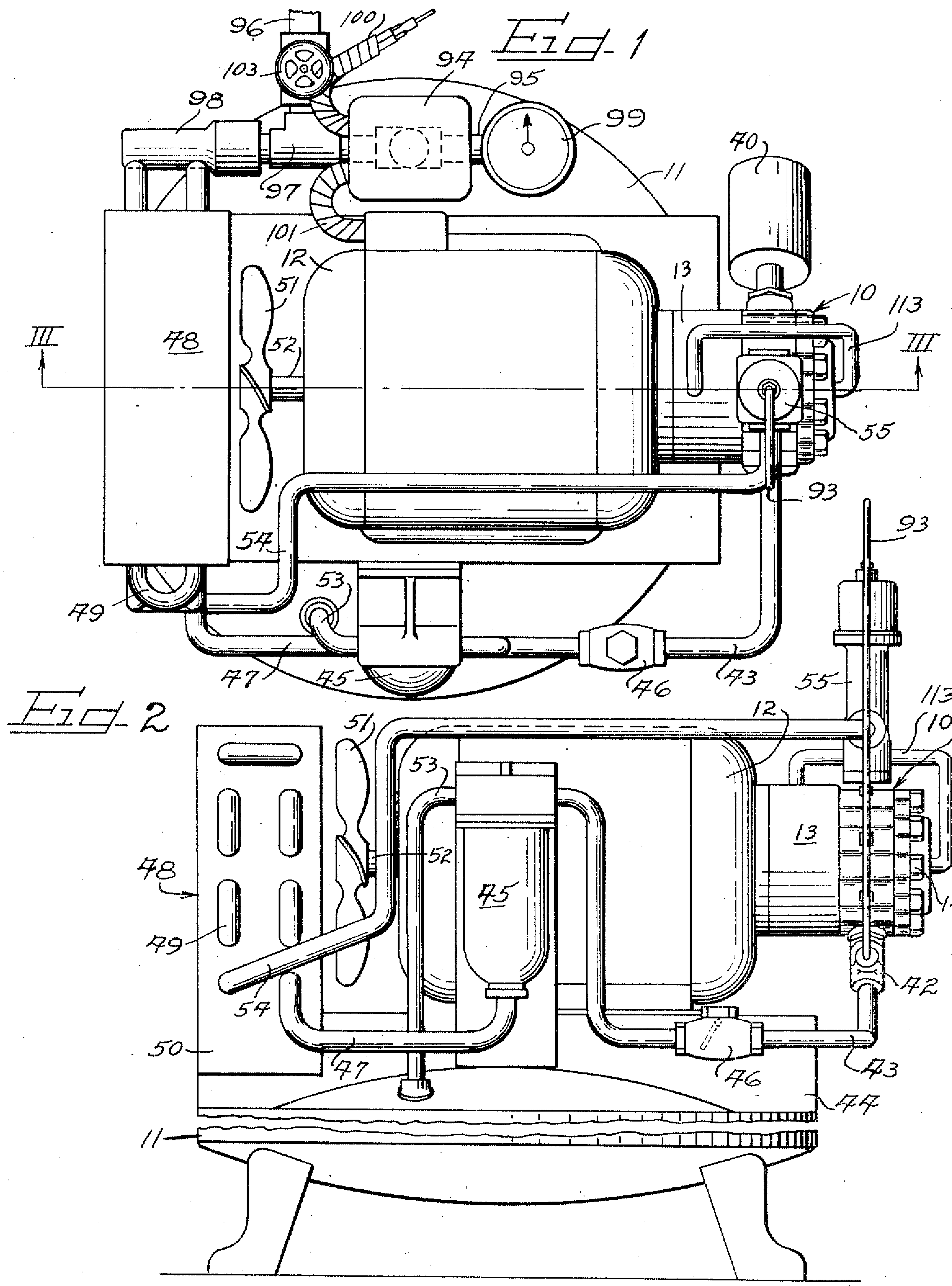

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Feb. 6, 1951 R. R. CURTIS ET AL 2,540,714

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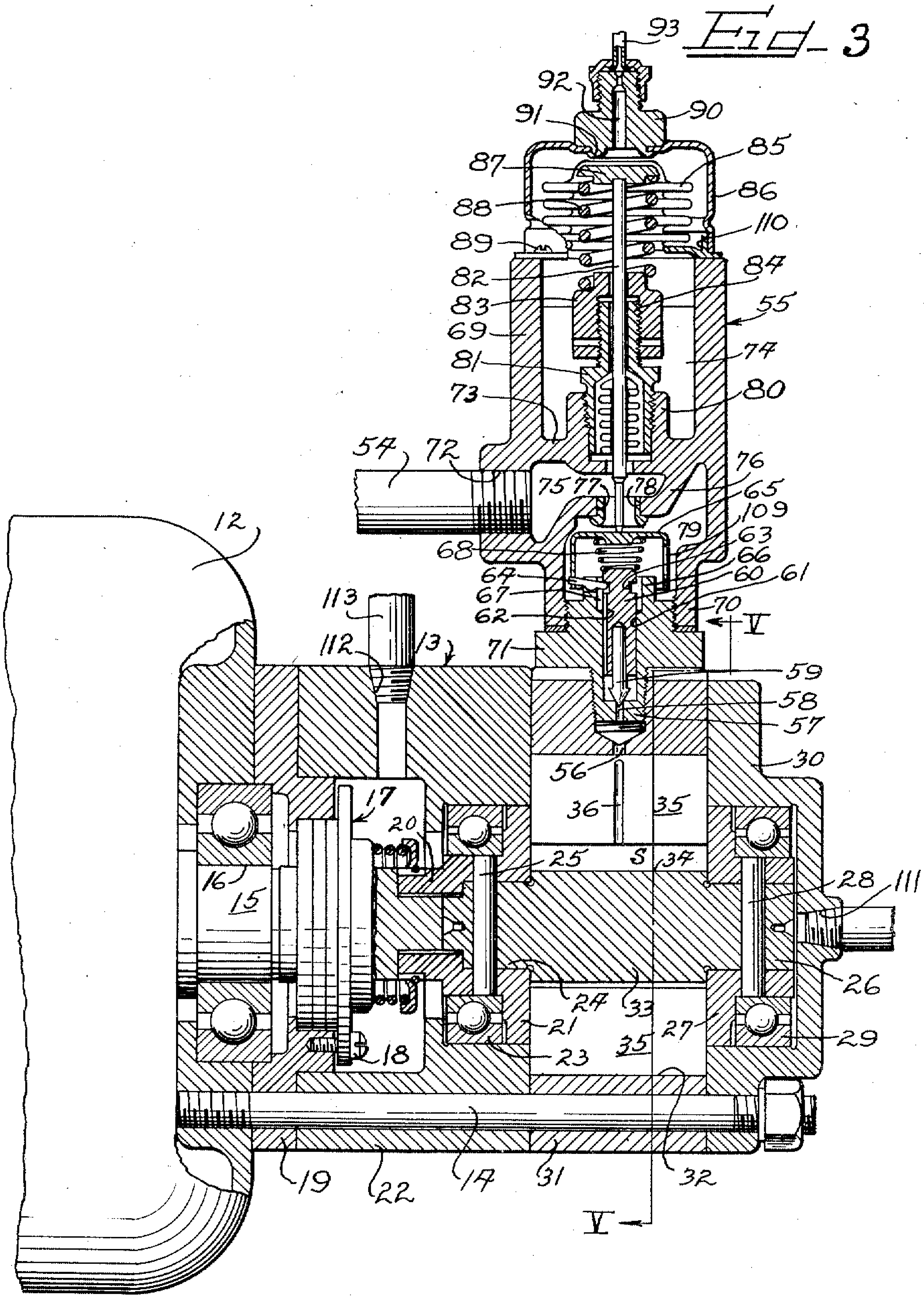

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Filed Jan. 22, 1945 3 Sheets-Sheet 3

Fig. 4

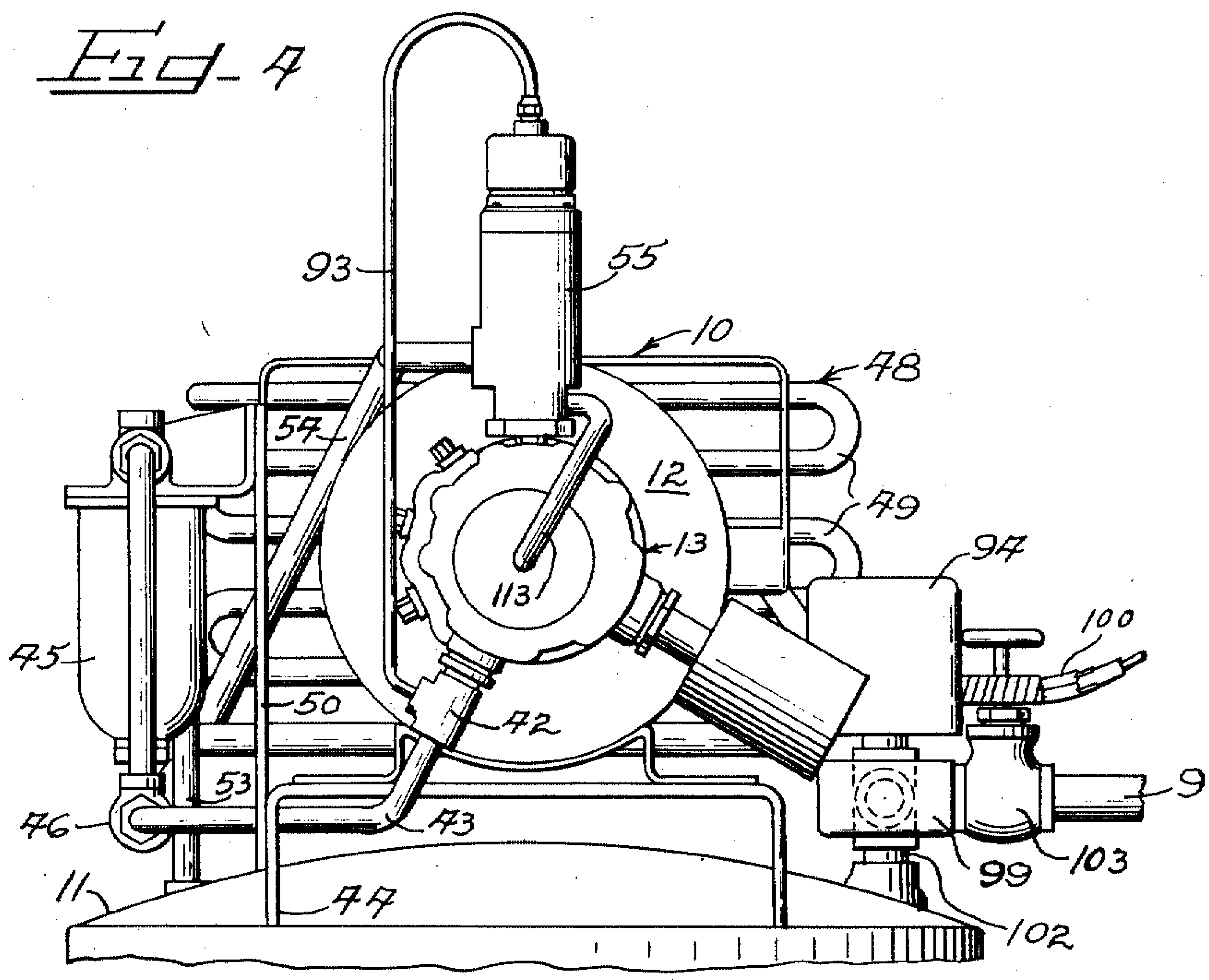


Fig. 5

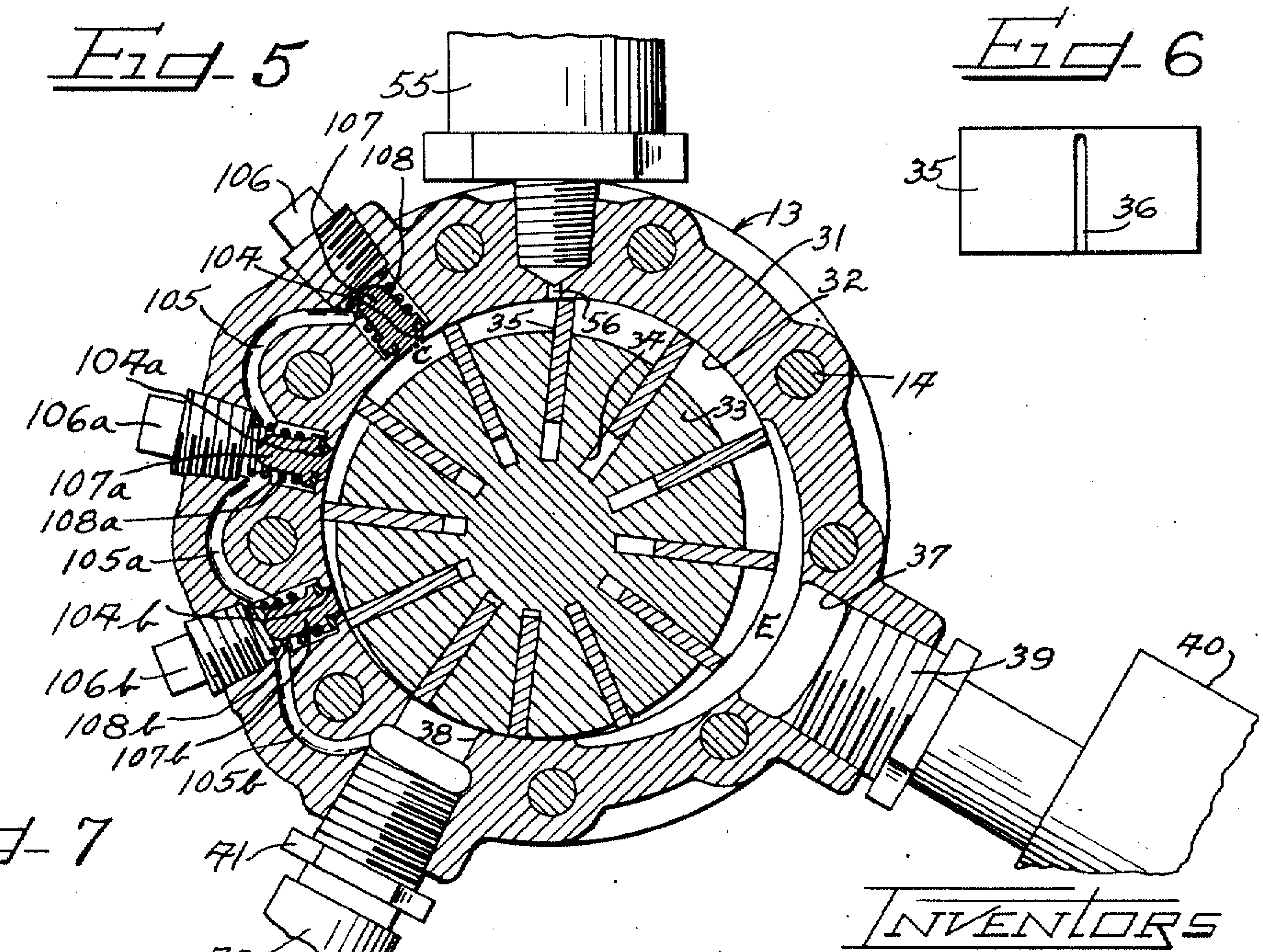
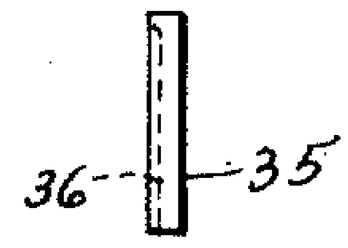


Fig. 6

Fig. 7



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UNITED STATES PATENT OFFICE

2,540,714

PUMP

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1 Claim. (Cl. 230—207)

1

This invention relates to a pump, and more particularly to high pressure air compressor adapted to be installed, for instance, in garages, service stations and the like for providing a source of compressed air.

The air compressor assembly of our present invention includes a rotary pump of the radially extensible, multi-vane type. To facilitate the manufacture of the pump rotor, the hub portion of the rotor is provided with radially extending slots the full length thereof, instead of being provided with slots terminating short of the ends of the rotor hub, as previously. This novel feature permits the slots to be milled out more easily since the milling cutter can travel the full length of the hub portion of the rotor in each pass. End plates secured to the stub shafts of the rotor are provided on either side of the hub for sliding clearance with the lateral edges of the vanes. This makes for a simpler construction than heretofore.

Another feature of the rotor construction is the provision of slots or grooves in at least one face of the vane for substantially the full length thereof, whereby the pressures at the bottom of the slots beneath the bases of the vanes tend to be equalized with the higher of the pneumatic pressures adjacent the working faces of the vanes. In this way pneumatic radial thrust on the vanes is approximately balanced. We have also found that by making the vanes of carbon, their low mass minimizes wear on the bore.

Another feature of our pump assembly is the provision of a lubricating system for the introduction of a lubricant into the pump bore at a point of relatively low pressure therein. The lubricating system includes a line from the discharge port of the pump for the compressed air and entrained lubricant, a lubricant separator in the discharge line, a line for carrying off the separated lubricant from the separator to a cooling device for lowering the temperature of the separated oil and a connection from the cooling device to a metering valve assembly.

The metering valve assembly includes a metering needle controlling a passage for the lubricant back into the interior of the pump, and resilient means for holding the valve closed for all pressures below a predetermined pressure, such as, for instance, 75 lbs./sq. in. Tubing from the discharge side of the pump establishes communication with the interior of the metering valve assembly on the other side of a Sylphon that seals off the main interior of the metering valve assembly. The arrangement is such that fluid pressure on the Sylphon serves to open the metering

2

needle when the pressure is greater than that for which the valve is set. For all lower pressures, the resilient means referred to serves to cause the metering valve to close. Thus, this valve is shut before the compressor chamber pressure drops down to atmospheric pressure, thereby preventing flooding of the compressor chamber when the compressor shuts off.

In order to prevent the setting up of a back pressure when the compressor is not operating, a check valve is positioned in the discharge line between the pump and the oil separator and the point of connection for the tubing back to the metering valve assembly is ahead of the check valve. Consequently, when the compressor shuts off, pressure drops at the discharge side of the pump, the Sylphon expands to its normal position and the resilient means previously referred to act to close the metering valve pin. Thus, lubricant is admitted into the bore of the pump only when the pump is operated and then only when the discharge pressure is above a predetermined level.

It is therefore an important object of this invention to provide a pump assembly of novel and improved construction embodying features that enable it to be manufactured at relatively low cost and that materially increase its operating efficiency.

It is a further important object of this invention to provide a high pressure air compressor of the radially extensible, multi-vane type in which the slots for the vanes extend the full length of the rotor hub and end plates secured to the rotor shaft serve to confine the lateral edges of the vanes while providing a sliding clearance therebetween.

It is a further important object of this invention to provide an air compressor, pump or the like, having a lubricating system of improved efficiency that operates automatically during operation of the compressor to inject lubricant into the pumping chamber whenever the pressure on the discharge side of the compressor rises above a predetermined pressure.

It is a further important object of this invention to provide a rotary pump of the vane type in which the vanes are formed of carbon, or other suitable material of relatively low density, to minimize wear on the bore, and in which slots are provided in one of the faces of each of the vanes to roughly equalize the pneumatic radial thrust on the vanes by introducing into the space at the base of each of the vanes the higher of the pneumatic pressures adjacent the outer vane surfaces in the pumping chamber.

Other and further important objects of this invention will be apparent from the disclosures in the specification and the accompanying drawings.

On the drawings:

Figure 1 is a top plan view of an installation of an air compressor embodying the principles of our invention.

Figure 2 is a broken front elevational view of the same.

Figure 3 is an enlarged sectional view taken substantially along the line III—III of Figure 1, with parts in elevation.

Figure 4 is a fragmentary side elevational view looking toward the pumping end of the apparatus.

Figure 5 is a fragmentary sectional view taken substantially along the line V—V of Figure 3.

Figure 6 is a plan view of a pump vane, or blade.

Figure 7 is an end view of the vane of Figure 6.

As shown on the drawings:

The reference numeral **10** indicates generally an air compressor of our invention mounted upon a receiver **11** by means of supporting brackets **44**. Said air compressor includes a motor **12**, to one end of which is fastened a rotary compressor **13**. The rotary compressor **13** is secured to the motor housing by means of bolts **14**.

The rotary compressor is driven from the motor **12** through the motor shaft **15** (Fig. 3) supported at its extending end in a bearing race **16** mounted in the motor housing. Said shaft **15** extends through a seal **17** that is attached by means of screws **18** to an apertured plate **19**. The seal **17** is of the rubber diaphragm type, the details of which need not be specifically described here as suitable seal constructions of this type are well known. The driving end of the motor shaft **15** engages the tongued end **20** of driven member **21** that also serves as an end plate for the rotor vanes. A cylindrical housing **22** encloses the driving connection and provides an annular shoulder for a bearing race **23**.

Said end plate **21** is secured to the inner end **24** of a rotor stub shaft by means of a pin **25** that extends transversely through these two members. Said end plate **21** thus rotates with the rotor shaft in the bearing race **23**. The other rotor stub shaft **26** carries a similar end plate **27** secured to said stub shaft by means of a transversely extending pin **28**. A bearing race **29** supports said end plate **27** and shaft end **26** for rotation. The bearing race **29** is housed within an end cap **30**.

The pump casing, indicated generally by the reference numeral **31** is positioned between said end cap **30** and the cylindrical housing **22** and the whole assembly is held together and mounted on the motor housing **12** by means of the through bolts **14**. In order to equalize pressures at each end of the rotor and balance any end thrust, a connection is provided between the chambers at opposite ends of the rotor **33**. This is accomplished by providing a threaded hole **111** in the end cap **30** (Fig. 3) and a threaded hole **112** extending through the wall of the housing **22**, and by connecting the two holes by tubing **113**. Since the housing assembly for the rotor is substantially fluid tight, the tubing **113** effects an equalization of fluid pressures on opposite ends of the rotor and thus effects a balance of any end thrust.

The bore **32** (Figs. 3 and 5) is eccentric with respect to the axis of the rotor. The contour of the bore may suitably be built up of Archimedes and parabolic types of spirals joined together to provide compression and extension zones. The compression zone, indicated at C may have twice

the angular length of the extension zone, indicated at E, allowing for very gradual compression. It will be understood, of course, that these proportions may be changed at will. The combination of spirals employed permits the total angular displacement to be divided in any way desired. In addition, the maximum extension is relatively small in proportion to the diameter of bore or rotor, and the consequent gradual angularity of the Archimedes spirals and the low acceleration of the parabolic spirals cause smooth, small-vibration action.

The rotor **33** is provided with radially extending slots **34** that extend the full length of the rotor. By reason of this construction, the slots **34** can be more readily milled out than would be the case if the slots terminated short of the ends of the rotor. As shown, there are twelve such radially extending slots, but there may be more or fewer than that number. A vane **35** is mounted in each of the slots **34**. As shown in Figures 6 and 7, each of the vanes **35** is rectangular in shape and is provided along one of its broad faces with a slot or recess **36** that extends substantially the full height of the vane. The purpose of the slot **36** is to permit the pressure in the radially extending slot **34** at the base of each vane to be roughly equalized with the higher of pneumatic pressures at the two sides of the outer free ends of the vanes, and thus roughly balance pneumatic radial thrust on the vanes. The vanes themselves are preferably made of carbon or other relatively low density material so as to minimize bore wear. A relatively large number of vanes is used so that there is no great difference in pneumatic pressure on either side of each vane.

The pump housing **31** is provided with an intake port **37** opening into the extension zone E, and a discharge port **38**. The intake port **37** is connected by a nipple **39** to an air filter **40**. A nipple **41** threaded into the discharge port **38** is connected through a T **42** to piping **43**.

As best shown in Figures 1, 2 and 4, the piping **43** is connected to an oil separator **45**, which may be of any suitable construction for the separation of the lubricant from the compressed air. A check valve **46** is inserted in the piping **43** ahead of the oil separator **45**, the purpose of the check valve being to prevent back pressure from the tank **11** passing into the compressor when the latter is not operating.

From the oil separator **45** piping **47** leads to a cooler, indicated generally by the reference numeral **48**. Said cooler **48** includes a number of horizontally disposed coils of piping **49** supported by means of vertical plates **50**. A fan **51** is mounted upon the rear extended end **52** of the motor shaft to provide air circulation through and over the coils **49** to aid in cooling the oil passing therethrough. A pipe **53** leading from the top of the oil separator **45** serves to conduct the compressed air from said separator into the top of the tank **11**.

The cooled oil from the cooler **48** is led through a pipe **54** to an oil metering valve assembly indicated generally by the reference numeral **55**. Said oil metering valve assembly **55** is mounted directly on top of the bore casing **31**. Said casing **31** is provided with a small diameter passage **56** (Fig. 3) extending into the pumping chamber. Above the small passage **56** the bore housing is counterbored and threaded to receive the lower threaded end **57** of the member **71** forming part of said metering valve assembly.

Said lower end **57** is provided with an axial passage **58** of small diameter and adapted to be controlled by means of a metering needle **59**. Said metering needle is fixed in the lower end of a stem **60** that is slidable in the vertical bore **61** provided for the purpose. Said stem **60** has a longitudinally extending slot **62** for permitting the passage of the lubricant therealong into the space beneath said stem **60**.

The upper end of the stem **60** is provided with an annular groove **63** into which fit the inner ends of a plurality of levers **64**. An inverted cup-shaped cap **65** is positioned above said stem **60** with its lower open end spaced from the annular wall **66** that surrounds said stem so as to permit the flow of lubricant into the well **67** provided by said annular wall **66**. The cap **65** is also provided with openings **109**. A light spring **68** is placed within said inverted cup-like cap **65** to rest upon the upper end of said stem **60**. The outer ends of the levers **64** extend through slots provided for the purpose in the lower end of the cap **65**, so that when the cap moves downwardly, the levers are rocked to lift the stem **60**.

The housing **69** of said metering valve assembly **55** is cylindrical in shape and provided with a lower reduced end **70** that is internally threaded for threading upon the passaged member **71**. Said housing **69** has a threaded opening **72** for receiving the end of the piping **54** which conducts the lubricant to the interior of said housing. Said housing is provided with an integral transversely extending wall **73** that divides the interior of the housing into an upper chamber **74** and an intermediate chamber **75**. An integrally formed second wall portion **76** has an aperture **77** in which is positioned a sleeve **78** providing a passageway from said chamber **75** to a lower chamber **79**.

The wall **73** is provided with an upstanding, internally threaded annular portion **80** into which is threaded the lower end of a guide member **81**. The guide member **81** is provided with an axially extending bore through which extends a rod **82** that rests at its lower end upon the cap **65**. An adjusting nut **83** is threaded upon the upper reduced end **84** of said guide member **81**. The upper end of the casing **69** is closed by a Sylphon **85**, the lower flanged end of which is secured to said upper end of the housing by screws **89**. The rod **82** extends into the Sylphon **85** and is secured at its upper end in a disc **87** that is fitted inside the upper end of the Sylphon. A coiled spring **88** surrounds the upper end of the plunger **82** and is held under compression between said adjustment nut **83** and the disc **87**.

A cap **86** frictionally engages an upstanding flange **110** formed on the lower end of the Sylphon **85**. Said cap **86** has a passaged fitting **90** formed with a lower annular shoulder **91** against which the top of the Sylphon **85** normally bears. Said fitting **90** has an axial passage **92** to which is connected one end of a small diameter tube **93**.

The tube **93** (Figs. 1, 2 and 4) is connected into the T **42** on the discharge side of the compressor. Consequently, whenever the compressor is running, the pressure at the discharge port **41** is transmitted through the tube **93** and the passage **92** to the inside of the cap **86** above the Sylphon **85**.

The adjusting nut **83** will ordinarily be set for a predetermined pressure, such as 75 lbs. per sq. in., so that when the pressure on the top of the Sylphon exceeds that amount, the Sylphon will

be contracted and cause the rod **82** to press downwardly upon the cup-like cap **65**. Downward movement of said cap **65** causes the levers **64** to elevate the stem **60** and the attached needle **59** to open the passage **58**.

Whenever the passage **58** is opened in this way, oil is caused to flow from pipe **54** through the chambers **75** and **79**, along the groove **62** and through the passageways **58** and **56** into the pump bore. The oil serves there to lubricate the moving parts of the compressor. Since the passageway **56** is on the low pressure side of the pump, the oil need not be under any substantial pressure head in order to make it flow into the pump bore.

As illustrated in Figures 1 and 4, a pressure operated switch **94** serves to start and stop the compressor. Said switch is connected by a nipple **102** in the main airline **96** from the receiver **11**. A safety valve **98** is connected in said line by a T **97**. A pressure gauge **99** is positioned in the branch pipe **95**. A cable **100** connects the switch **94** to a source of electrical energy and a second cable **101** connects the switch to the motor. The pressure responsive switch **94** is in communication with the interior of the tank **11** through the nipple **102** and operates to start up the motor **12** whenever the pressure within the tank drops below a predetermined point. A valve **103** is located in the supply line **96** for the purpose of shutting off the tank when not in use.

As shown in Figure 5, the pump housing **31** has a plurality of interconnected discharge ports **104**, **104*a*** and **104*b*** on the pressure side of the rotor. Said auxiliary discharge ports **104**, **104*a*** and **104*b***, are interconnected by passages **105**, **105*a*** and **105*b*** to each other and to the main discharge port **38**. Plugs **106**, **106*a*** and **106*b*** are threaded in said auxiliary discharge ports. Normally these ports are closed by spring pressed check, or by-pass valves **107**, **107*a*** and **107*b*** under the action of the corresponding springs **108**, **108*a*** and **108*b***.

Said springs are of only sufficient compressive strength to hold the valves shut until the pressure builds up to above a predetermined point, whereupon the valves open and the compressed air is caused to flow through the auxiliary discharge ports and their connecting passages into the main discharge port. The purpose of this is to save power when the compressor is being operated to bring the pressure in the receiver **11** up to the predetermined point. For instance, if the pressure in the receiver is to be maintained between the limits of 120 to 150 lbs. per sq. in., so long as the pressure in the receiver is below that range, the auxiliary discharge port valves **107**, **107*a*** and **107*b*** remain open so that the compressor does not have to compress the air to its final stage which would not be reached until the rotor vanes pass the main discharge port **38**. The by-pass valves **107**, **107*a*** and **107*b*** are not relief valves but check valves and the retaining springs **108**, **108*a*** and **108*b*** are very weak. When the pressure in the receiver **11** is up to its lower limit, say of 120 lbs. per sq. in., the by-pass valves close so as to get the full compression of which the pump is capable.

The operation of the system will now be described in greater detail. In starting up, assuming that the receiver is under only atmospheric pressure, the end of the cable **100** is plugged into a suitable source of electrical current, whereupon the pressure actuated switch **94** closes to energize the motor **12**. The motor thereupon starts up the pump. As soon as the pressure builds up on the discharge side of the pump, air and entrained oil will be discharged through the line **43**, and past the check valve **46** into the oil separator **45**. Air is there separated and conducted into the top of the receiver **11** through the pipe **53**. The separated oil passes out through the bottom of the separator **45**, through the discharge line **47** into the cooler **48**. The fan **51** serves to draw air over and through the coils **49** and thus increase the rate of cooling of the oil passing therethrough. The cooled oil is led from the cooler through the piping **54** into the metering valve assembly **55**.

Until the pressure in the receiver builds up to the predetermined point, such for instance as 75 lbs. per sq. in., the spring **88** will hold the Sylphon against the annular shoulder **91** to close the passageway **92**. The metering needle **59** during this time will be in closed position, closing the passageways **58** and **56** into the bore of the pump. As soon, however, as the pressure is sufficient to overbalance the compressive action of the spring **88**, the Sylphon will be contracted to open the lower end of the passage **92**. Movement of the Sylphon is transmitted through rod **82** to the cap **65**. Upon depression of the cap **65**, the outer ends of the levers **64** will be depressed and the inner ends of said levers will be elevated to raise the stem **60** and the attached needle **59**, thereby opening the passages **58** and **56** into the bore of the pump. So long as these passages remain open, oil from the return pipe **54** passes through the chambers **75** and **79** and through the openings **109** into the interior of said cap **65**. From there, the oil finds its way along the groove **62** into the passages **58** and **56** and thence into the bore of the pump. As previously explained, the passage **56** is at a point in the pump bore where the pressure is relatively low, so that the oil flows freely whenever the passageways are opened by the needle **59**.

Until the pressure in the receiver is built up to the range for which the pressure switch is set, air is discharged from the pump through the auxiliary discharge ports **106**, **106*a*** and **106*b*** and through their interconnecting passageways **105**, **105*a*** and **105*b*** to the main discharge port **38**. This, as previously explained, reduces the load placed upon the compressor during the initial stage of bringing the receiver up to pressure.

The check valve **46** in the discharge line **43** serves to prevent back pressure from the receiver **11** finding its way into the pump when the pump is not operating. With the check valve **46** operating to cut off back pressure, the pressure in the pump bore drops rapidly as soon as the pump ceases to run, with the result that the pressure in the line **93** also drops and permits the spring **86** to expand the Sylphon and thus close off the passage **92**. The light spring **68** serves to hold the metering needle **59** in closed position.

The slot **36** in each of the vanes **35** serves to introduce the higher of the two pneumatic pressures adjacent the working ends of the vanes into the space below the vanes indicated at S in Figure 3. In this way pneumatic radial thrust is roughly balanced on each of the vanes. Centrifugal force alone is relied upon

to hold the vanes in their extended position against the wall **32** of the bore. The lubricant injected into the bore by the metering needle **59** serves to lubricate the wall of the bore and also to lubricate between the lateral edges of the blades and the end plates **21** and **27**. The end plates serve as guides for the lateral edges of the vanes, there being only sufficient clearance to permit sliding movement over the inner faces of said end plates.

The bore of the compressor is of such contour as to give a rapid throw-out of the vanes to full extension, followed by a gradual retraction after passing the inlet port. This gives a gradual compression without building up an abrupt load on the vanes.

It will, of course, be understood that various details of construction may be varied through a wide range without departing from the principles of this invention and it is, therefore, not the purpose to limit the patent granted hereon otherwise than necessitated by the scope of the appended claim.

We claim as our invention:

In a vane type pump assembly including a pump housing having a mixed air and oil discharge port on the high pressure side of the pump, an oil intake on the low pressure side of the pump, and means for recovering and returning oil from the air-oil discharge mixture to said oil intake, a valve for metering the oil returned to said pump through said intake comprising a valve housing having a connection opening therein in communication with the discharge port of the pump, a spring-pressed bellows in said valve housing biased toward covering said connection opening, a valve stem having a needle controlling said oil intake, means including a spring normally acting upon said valve stem to bias said needle toward intake-closing position, and a force-transmitting member operatively connecting said bellows and said means to move said valve stem against the bias of the spring acting thereon to cause said needle to open said intake when pressure at the connection opening against said bellows over-balances the force of the spring biasing said bellows and uncovers said opening.

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