United States Patent

[11] 3,559,764

[72] Inventor **Harry L. Wheeler, Jr.**
Fulton, Ga. (c/o DK Pneumatics Inc., 1090 Jefferson St. NW, P. O. Box 2427, Atlanta, Georgia, 30318)

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[22] Filed **June 5, 1968**
[45] Patented **Feb. 2, 1971**

[54] **SELECTIVE FILTER, REGULATOR AND LUBRICATOR COMPONENT ARRANGEMENT FOR AIR LINES**
22 Claims, 18 Drawing Figs.

[52] **U.S. Cl.** **184/55**
[51] **Int. Cl.** **F16n 7/34**
[50] **Field of Search** ..... 184/55, 55A, 56, 59 (Cursory); 210/

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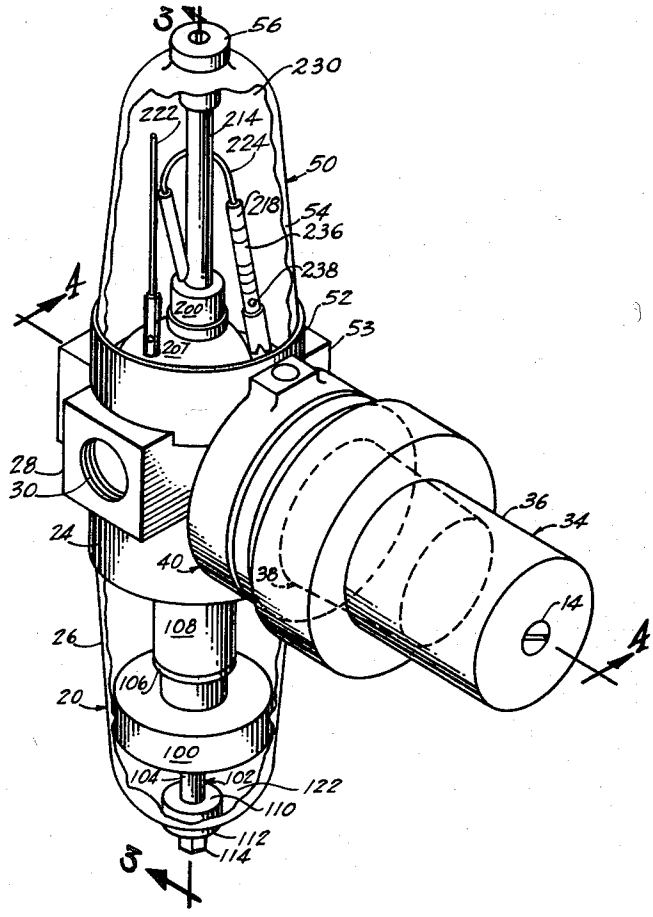
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Primary Examiner—Manuel A. Antonakas
Attorney—Patrick F. Henry

ABSTRACT: The air filter, the air regulator and the air lubricator, one or more of which are used in compressed air lines, such as those driving power tools, each having its own housing which may be selectively connected to one or more of the other housings to provide either a vertical or horizontal arrangement with respect to the air line axis with or without the use of fitting connections. The filter includes the metallic head containing inlet and outlet ports, a plastic chamber or bowl and a foraminous device therein to remove entrained impurities from the air and a collector to separate water from the air stream. The regulator includes a metallic casting with a valve means of controlling air flow responding to the diaphragm. The lubricator includes the metallic head containing inlet and outlet ports, a plastic chamber or bowl defining a reservoir and means to discharge oil vapor into the outlet port at a prescribed rate. By selective fitting of the housings together, communication is established through the inlets and outlets already provided therein and means is provided for securing the selected filter, or regulator or lubricator together. The respective housings interlock and nest together in different relationships to fit into existing spaces or to save space.

In the lubricator arrangement, the volume of the lubricator bowl, which may be plastic, metal or other suitable material, is used as oil reservoir and means is provided to inject a spray of oil into the air stream as it passes through the housing. When the individual respective filter and regulator or the filter lubricator and regulator housings are in intimate, combined pressure-tight relationship with the bowls for lubricator and filter, the entire assembly becomes a combined housing.



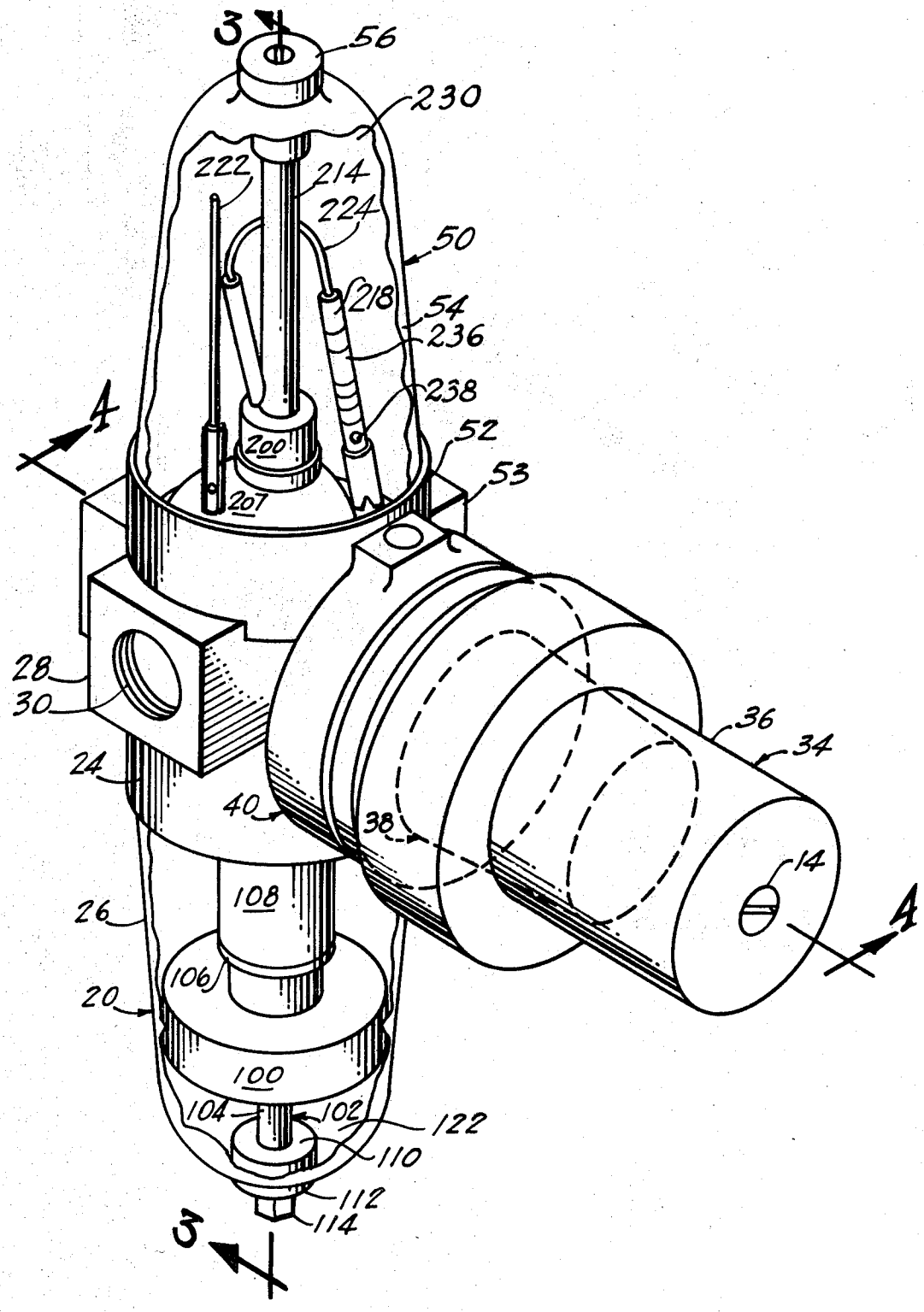


FIG. 1

INVENTOR
HARRY L. WHEELER, JR
BY Patrick J. Heaney
ATTORNEY

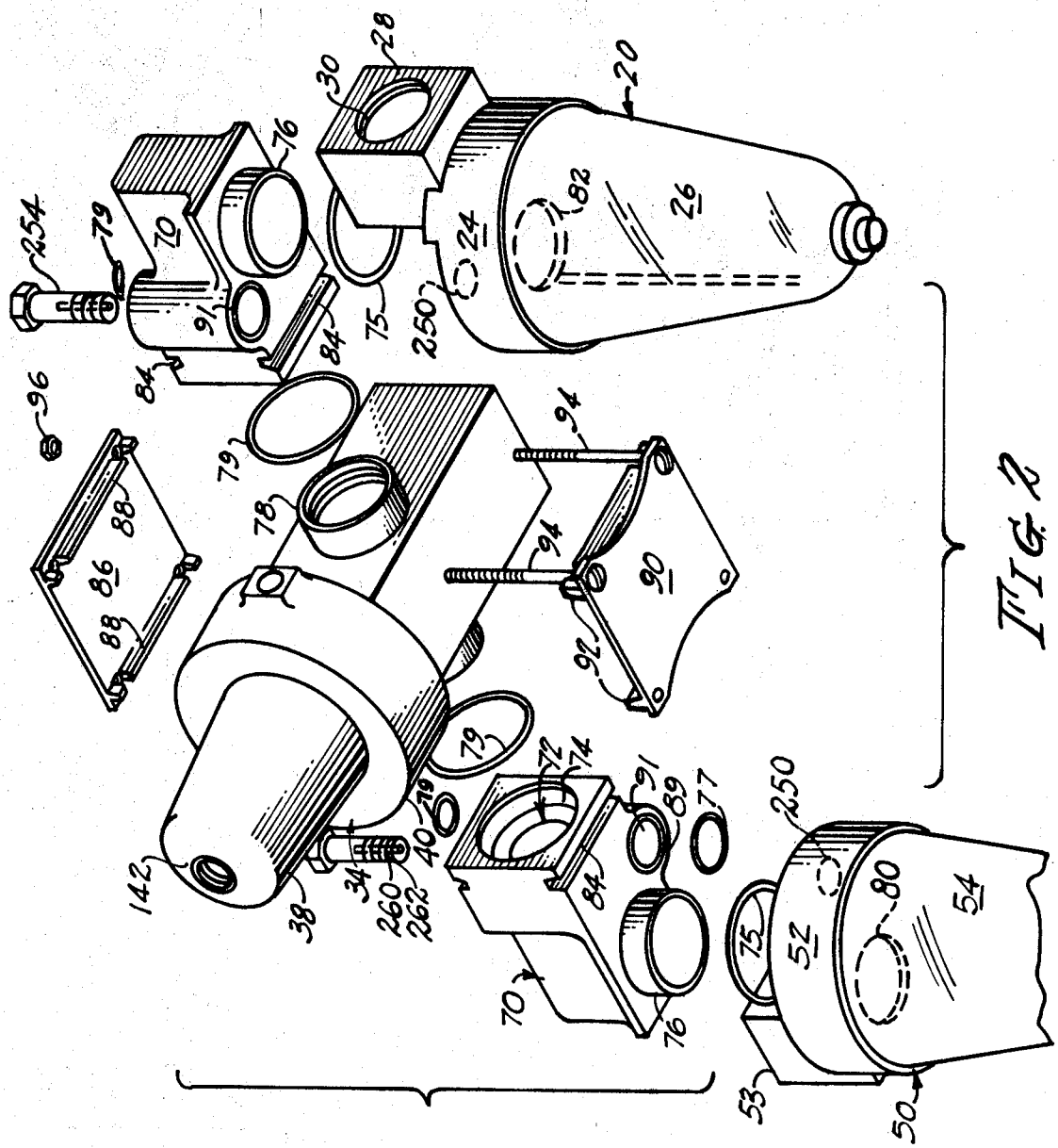


FIG. 2

INVENTOR
HARRY L. WHEELER, JR.
BY Robert J. Hennessy
ATTORNEY

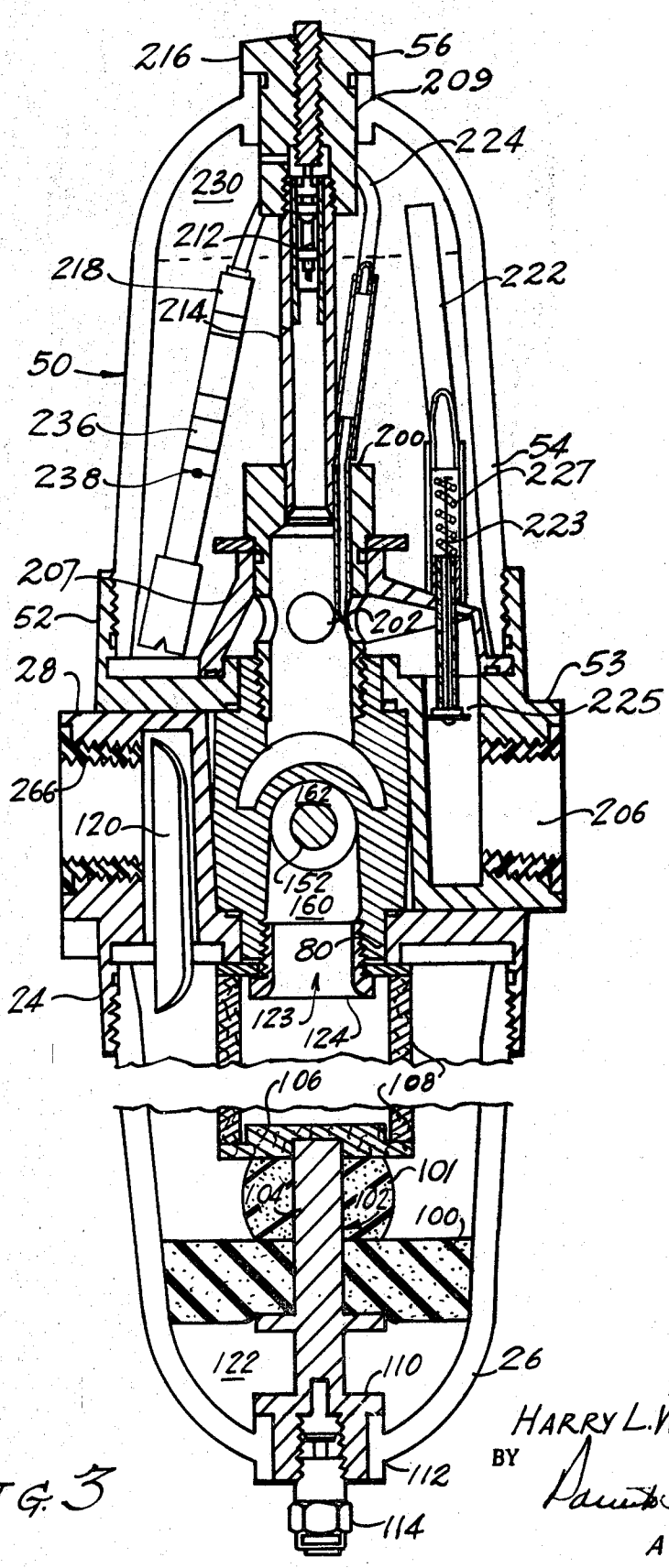


FIG. 3

INVENTOR.
HARRY L. WHEELER, JR.
BY
ATTORNEY

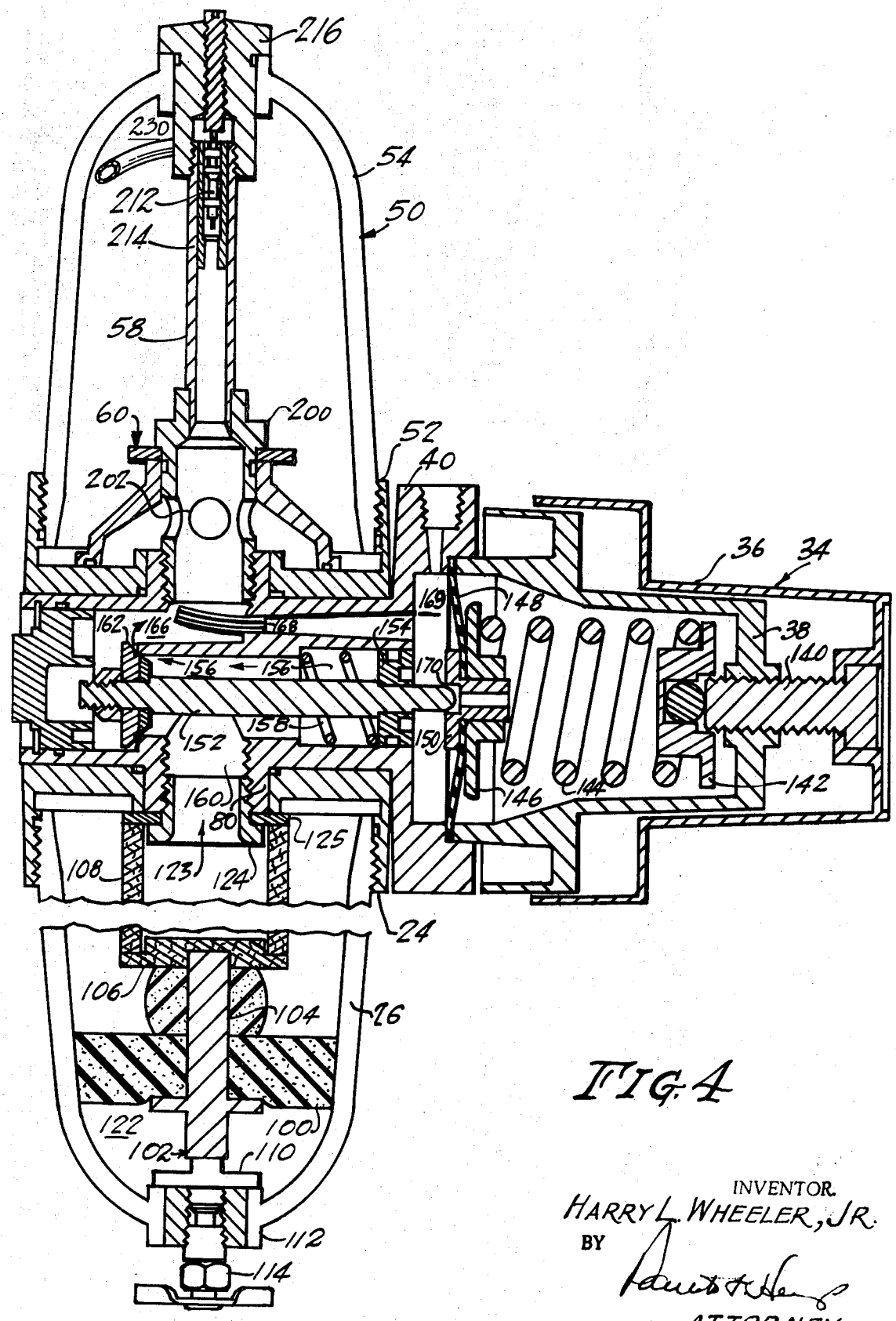


FIG. 4

INVENTOR.
HARRY L. WHEELER, JR.
BY
ATTORNEY

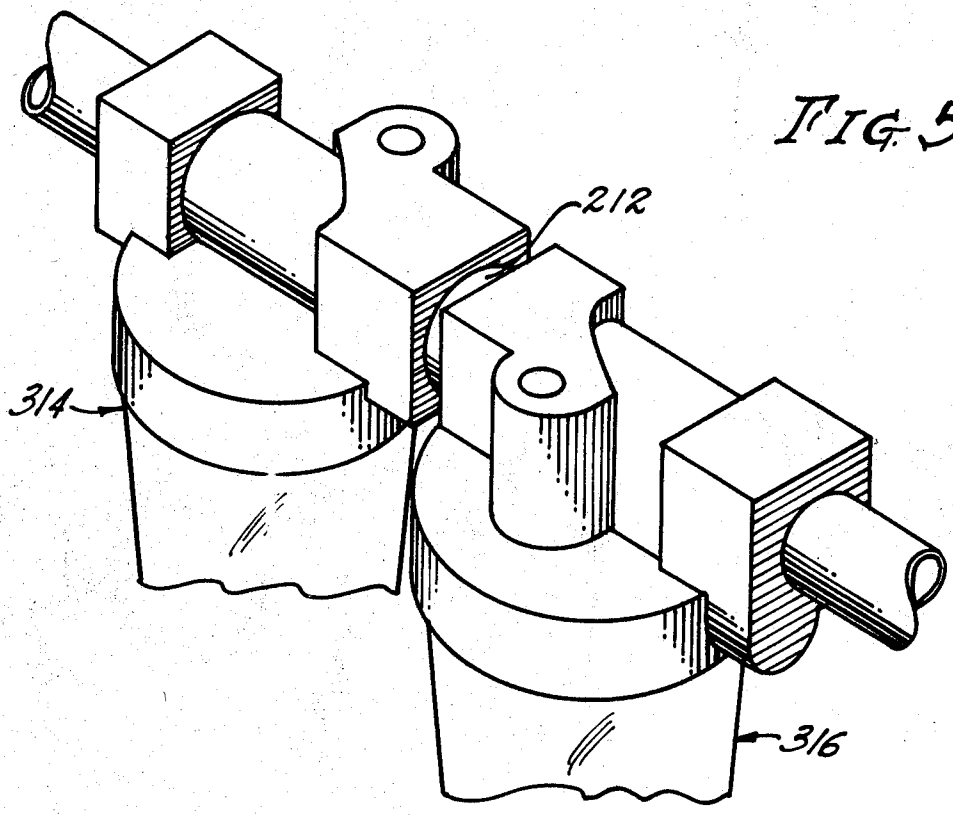


FIG. 5

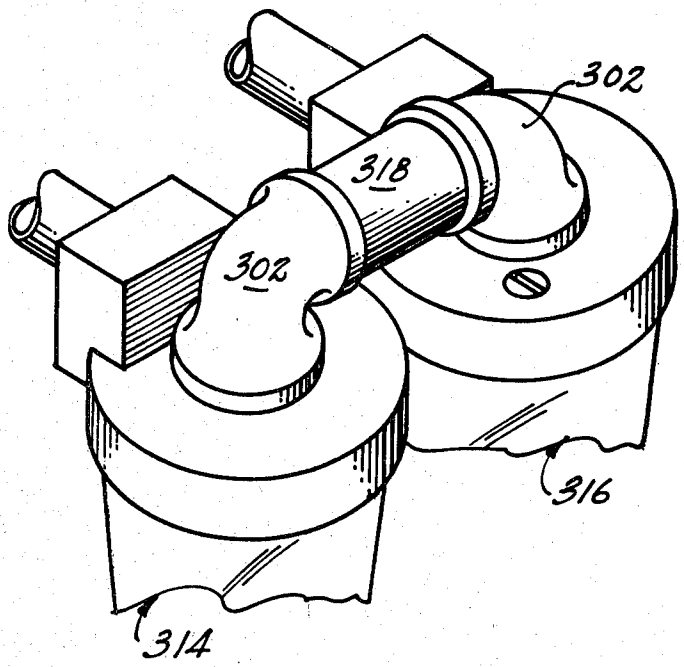


FIG. 6

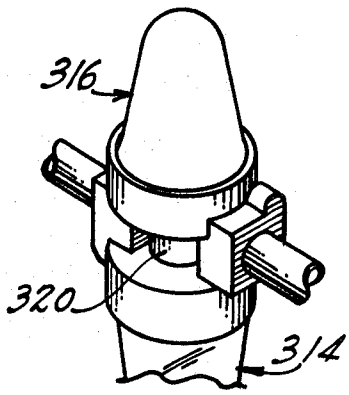


FIG. 7

INVENTOR
HARRY L. WHEELER JR.
BY
ATTORNEY

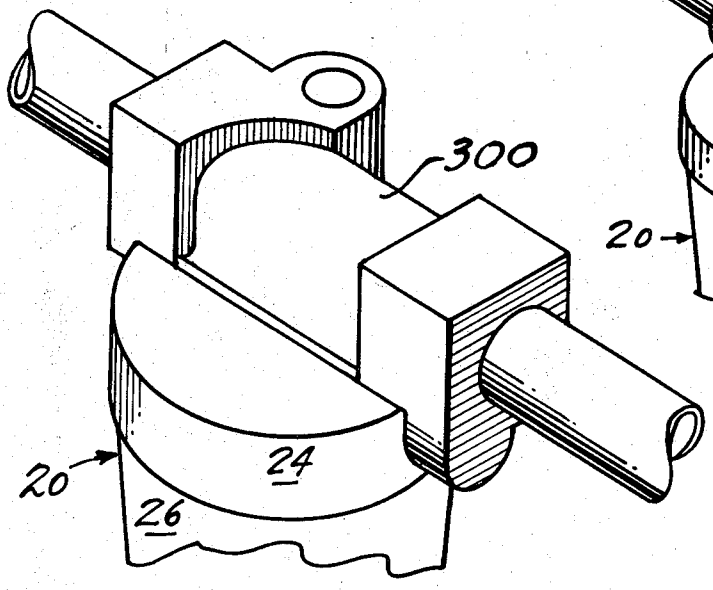


FIG. 8

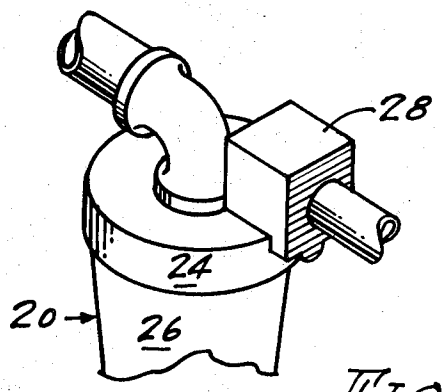


FIG. 9

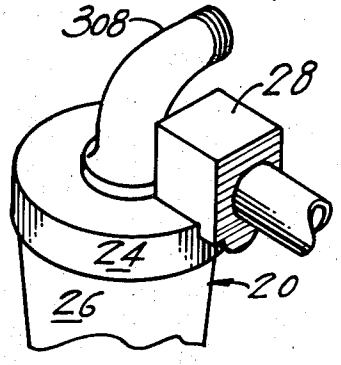


FIG. 10

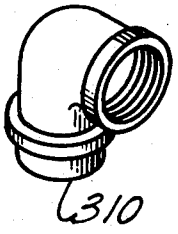


FIG. 11

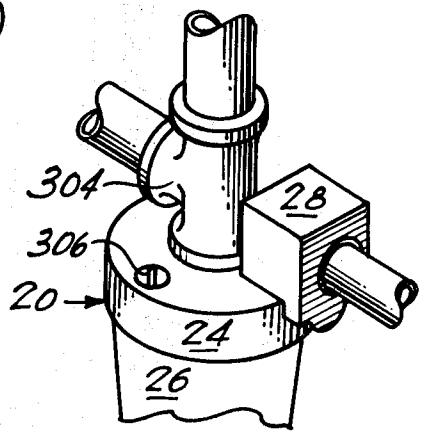


FIG. 12

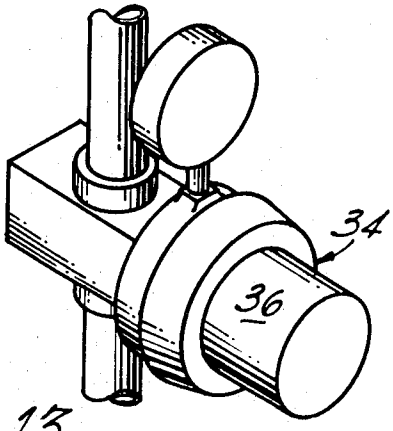


FIG. 13

INVENTOR
HARRY L. WHEELER, JR.
BY
ATTORNEY

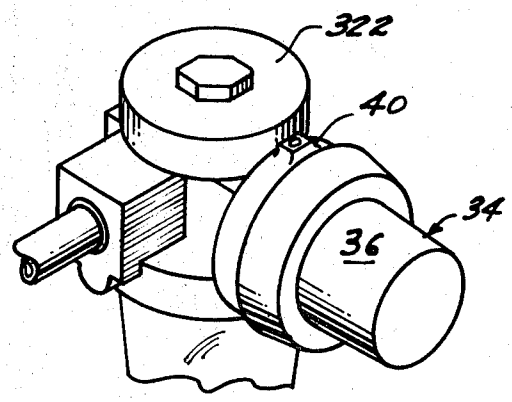


FIG 14

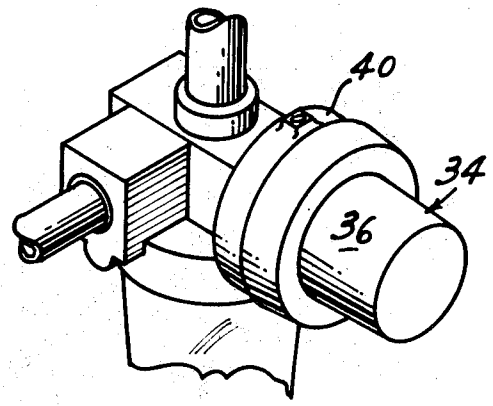


FIG. 15

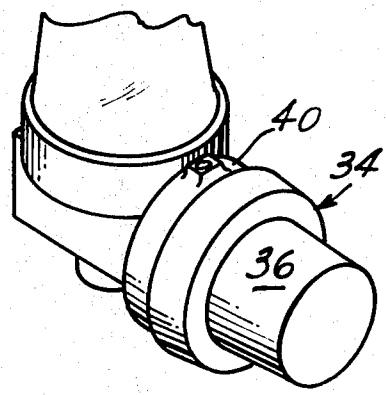


FIG 16

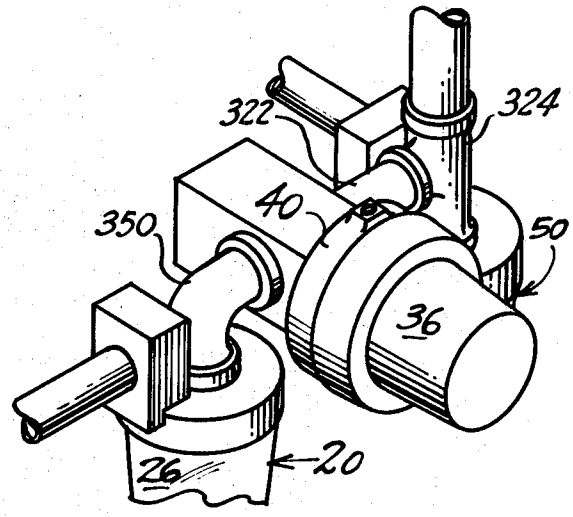


FIG. 17

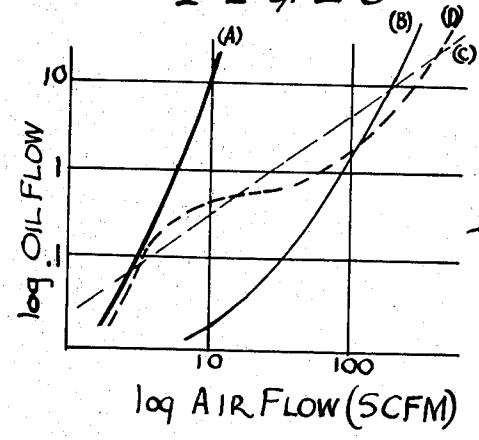


FIG. 18

INVENTOR
HARRY L. WHEELER JR
BY
ATTORNEY

SELECTIVE FILTER, REGULATOR AND LUBRICATOR COMPONENT ARRANGEMENT FOR AIR LINES

BACKGROUND OF THE INVENTION

1. Field of the Invention

The field of the invention may include the general categories of pressure regulators, lubricators, and filters and the subcategory of lubrication by air pressure although it should be understood that in the present device the air lubricator may be omitted in which event the general subject would be that of air filtering through a porous filter element and since the present device includes the versatility of one or more of the filter or lubricator or pressure regulator, the field will vary depending upon which components are being considered.

2. Description of the Prior Art

Prior art devices customarily include separate elements for pressure regulation, filtering and lubricating such as the air filtering and moisture separating device shown in the U.S. Pat. No. to Semon 2,467,408 which might be combined with the device for lubricating fluid pressure operative means in Semon U.S. Pat. No. 2,571,770 by the use of various pipe fittings which involves some amount of assembly and consumes space and it might be preferred in a given situation to use a combined Compressed Air Treatment Device of the sort similar to that shown in Walters U.S. Pat. No. 2,459,398 wherein a single housing combines a filter device with a lubricating device thereby avoiding the separate housings and fittings mentioned previously. A similar arrangement to the combined type shown in Walters is found in Earle U.S. Pat. No. 2,730,269 which relates everything having to do with the filtering, the pressure regulation and the lubrication, to one single integral casing which is provided with the inlets and outlets therein but which requires that the various inlets and outlets not to be used must be deactivated and the stream directed accordingly. In the Earle device the internal construction of the single casing is important to the overall functioning and association of all the different elements and necessarily this requires some amount of manufacture and fabrication and care in the provision of the various communicating passageways and the deactivation thereof of for selective use of only one or two of the three different elements. The Earle device does not lend itself to the sale to a customer who might use only the lubricator or only the regulator due to the internal construction of the casing. On the other hand, the instant invention is a very worthwhile compromise between the putting together by fittings or the like of the three different elements, or being restricted to two elements in one common housing or having to purchase a base unit casing which accommodates all three. At the same time each element of Applicant's device is in itself a separate unit capable of being used alone or simply in combination with any of the other two units but also easily combinable into a merged and neatly assembled housing.

SUMMARY OF THE INVENTION

A filter, regulator or lubricator component selectively combined for compressed air lines comprising three separate housings or bases selectively combinable by interlocking without external connections as two or three elements. Also, adapter means may be used to change the relative position of the components. Two elements arranged without adapters may be disassembled and recombined in a different relative position with a third element. In any arrangement when the elements are in pressure relationship there is a compact package without external fittings.

The lubricator of the present device provides a means for proportioning the oil that is discharged into the air stream to match the volume of the air flowing through the lubricator. In one form this is accomplished by means of a suction tube and valve one end of which projects into an outlet port and the other end of the suction tube projects into the oil reservoir in an air space above the surface of the oil. Also, the lubricator may be filled while the pneumatic system in which it is installed is fully pressurized and operating. This is accomplished by means of a valve arrangement acting in response to applied pressure differential.

In addition to the special relationship of the three elements for selective attachment directly to each other the elements may also be put together with pipe nipples and fittings in one of several different relationships.

BRIEF DESCRIPTION OF THE DRAWINGS

Other and further objects and advantages of my invention will be apparent upon reading the following specification taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a perspective view of an assembled arrangement of filter, regulator and lubricator elements in vertical arrangement.

FIG. 2 is a disassembled assembly view showing the elements in FIG. 1 disassembled and in the process of being reassembled with bowls of the two elements side by side instead of opposite sides as shown in FIG. 1.

FIG. 3 is a cross-sectional view taken substantially along lines 3–3 in FIG. 1.

FIG. 4 is a cross-sectional view taken substantially along lines 4–4 in FIG. 1.

FIG. 5 is a perspective view of a filter-lubricator combination in a row in series.

FIG. 6 is a perspective view of a filter-lubricator arrangement side by side.

FIG. 7 is a perspective view of a filter-lubricator arrangement on opposite sides.

FIG. 8 is a perspective view of one of the elements used by itself with an adapter.

FIG. 9 is a perspective view of the element in FIG. 8 without the adapter.

FIG. 10 is the element in FIG. 9 with the pipe elbow turned for attachment in a different manner.

FIG. 11 is a perspective view of a modified pipe fitting.

FIG. 12 is a perspective view of the elements in FIGS. 8 and 9 with a T-fitting.

FIG. 13 is a perspective view of the pressure regulator used by itself in the air line.

FIG. 14 is a perspective view of a filter-regulator assembly using a capped lubricator base to obtain colinear inlet and outlet ports.

FIG. 15 is a perspective view of a filter-regulator assembly with the outlet at right angles to the inlet.

FIG. 16 is a perspective view of a lubricator-regulator.

FIG. 17 is a perspective view of a filter-regulator-lubricator, having one inlet and two outlets for lubricated and unlubricated air respectively.

FIG. 18 is a graphic representation of the function and action of the lubricator oil flow.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference of FIG. 1, one form of the present composite filter, pressure regulator and lubricator comprises a filter component designated generally by reference numeral 20 and including a die cast head or base 24 and a filter bowl 26 which is threaded into the base. Base 24 includes an offset portion 28 with a threaded opening 30 therein.

The pressure regulator designated generally by reference numeral 34 comprises a handle cover 36 and an internal regulating valve arrangement designated by reference numeral 38 which is mounted on a base or die cast head 40 sometimes referred to as the housing or casing.

The lubricator component is designated generally by reference numeral 50 and comprises a die cast head or base 52 with an offset portion 53 having an inlet therein and base 52 has threaded removably thereinto a bowl 54 having a nut-knob 56 threaded onto a sleeve 58 supported inside the bowl 54 on an assembly 60 assembled with base 52.

The various components 20, 34, and 50 are attached together in another relationship shown in FIG. 2 wherein the

adapters which are identical are designated generally by reference numeral **70** and are three-dimensional castings, bases or housings each having a bore **72** therein with a female inlet **74** and a male outlet boss **76**. Male boss members **78** on the pressure regulator **34** match with and are inserted into the respective female inlets **74** in the adapters **70**. The central openings in the bases of the filter **20** and the lubricator **50** lead through their respective bases **24, 52** internally in said bases **24, 52** through outlets **80, 82** which are inserted onto the male outlets **76** on the adapters **70**. Each adapter **70** has an end portion at the bore **72** provided with opposed notches **84** which are part of an assembly retaining means comprising a top plate **86** with projecting edges **88** that fit in the notches in the adapter **70** on opposite sides of the pressure regulator **34** and a plate **90** on the other side is positioned with projections **92** fitting into the slots **84** and plate **90** is secured to plate **86** by means of four screws **94** and nuts **96**. In the FIG. **2** assembly, the respective bowls **26, 54** are arranged side by side rather than one on top of the other as shown in FIG. **3**. This allows some amount of versatility in the installation of the device depending upon the space and other factors.

FILTER 20

The details of filter **20** comprises a base **24** previously mentioned having the inlets **30** and the outlets **80** and the bowl **26** which is threaded into the cylindrical portion of the base **24**. A foraminous filter element **108** is supported on a central post **104** nonseparably attached to filter bowl **26**. The upper end of element **108** bears against a washer **125**. The lower end is centered and sealed by disc **106**, and is held in position by a compressure force applied thru the post **104** as the bowl **26** is screwed into head **28**. A passage **110** on post **104** and a valve member **114** provide means for emptying accumulated fluid and contamination from the bottom of bowl **26**. A flange **102** on post **104** supports two porous collectors **100** and **101**. The space below the element **100** is sometimes referred to as a sump and is used to contain collected contaminant which is mostly water. The pressure envelope formed by the bowl **26** and the base **24** is sometimes referred to as a filter housing. A deflector **120** is mounted in the passageway from the opening **30** in the base **24** and the incoming air strikes the deflector **120** which turns the incoming air downward and imparts a strong whirling motion. This transition should take place very smoothly since the creation of turbulence tends to shatter the water droplets being carried with the air. Centrifugal action forces the suspended or entrained water droplets out against the wall of the filter bowl **26** and the spiraling air moves downward carrying the water with it until the nonabsorbent, porous, foraminous filter element **100** disperses the water and contaminants therein immediately and transmits it to the sump **122** where it is collected for removal through the drain **114**. The air returns upward thru the center of the downward moving vortex and passes out of the filter assembly through the filter element **108**. The collector **100** replaces the conventional device which in one form is a conically shaped baffle in the same general location. The purpose of the collector **100** is to help create a quite zone in the sump **122** where the water may accumulate since it has been found that some of the baffles used in this place tend to shatter large water droplets at high rates of airflow resulting in the formation of smaller droplets which are carried upward in the air stream through the filter element and an into the pneumatic system which is undesirable. The porous collector **100** acts to some extent as a gas-liquid separator and the porous structure should be characterized by a high degree of interconnection, a very low resistance to the percolation of water therethrough and a substantial resistance to the passage of gas as a result of tortuosity and the resistance to wetting. The collector **100** is preferably nonabsorbent to some degree. While natural sponges meet some of the requirements sponges tend to wet easily and thus tend to retain water and resist percolation whereas synthetic nylon sponges reduce interconnection but wet easily. Polymer foams such as styrene are totally lacking in interconnection and therefore are impermeable but urethane ester foams of proper port size are well suited because the urethane surface resists wetting. The pores must be large enough to permit the free passages of water and water-oil emulsions that characterize pneumatic systems. According to the previous described arrangement, the collector **100** is relatively impermeable to air and therefore any water once collected in the sump **122** almost cannot be scavenged back into the system by sudden increases or surgings in an air flow as is the case when a solid conical baffle is used. Furthermore, the use of the collector **100** has another advantage in that there is a good deal of scale and rust carried with the air and when this material strikes the diaphragm **100** the majority of it will tend to embed itself in the porous structure thereof. If a conventional conical baffle were used, there is a good chance that most of the contamination would be carried upward and would accumulate on the outside of the filter element and after a period of time this would block the filter element and prevent the passage of further air flow. Such plugging effect necessitates frequent recleaning of filters in the air line service whereas the present arrangement should extend the life of the filter element substantially and provide also a definite economic advantage. The diaphragm **100** is a more efficient method of water removal and less water will get into the pneumatic system to be carried to the air tools and cylinders and therefore the life of the device that is using the air should be extended sufficiently to create an economic advantage. A still further advantage of the collector **100** is that if the amount of moisture in the air is small, that absorbed by the diaphragm during periods of high humidity will reevaporate during periods of low humidity thus saving maintenance.

REGULATOR 34

The air enters the regulator **34** through the port **123** in the fitting **124** positioned in the base **24** inside the filter **108** and as seen in FIG. **4** as well as other FIGS. the cylindrical housing **38** is covered by the handle cover **36** which is held in place by an internal screw **140** which engages a collar **142** inside the housing **38** and which is resting in one end of a coil spring **144** having the other end pressed against a disc **146** attached with a flexible diaphragm **148** having a diaphragm collar **150** in which there is a recess containing an O-ring **151** and there is a valve stem **152** which has a small piston **154** operating in a plenum chamber **156** defined inside of the base **40** and in which chamber **156** there is a closing spring **158**. Shaft **152** operates across a plenum chamber **156** leading from the inlet **123** and shaft **152** carries a valve **162** seated in the end of the chamber **156**. Air enters the regulator through the inlet **123** thru entrance **160** and into the chamber **156** and since there is no load on spring **144** and since the area of the valve **162** is smaller than the piston **154** the pressure in the plenum chamber **156** forces the valve **162** closed. This is called the differential closing force. A further closing force is provided by the smaller spring **158** in case the air pressure present in the chamber or passageway **156** is not sufficient to actuate the valve **162** against friction. If a load is applied to the spring **144** by rotation of the handle cover **36** to move the screw **140** against the collar **142** then the valve **162** will be opened and air will then flow through the valve **162** as indicated by the arrows and into the outlet plenum **166**. Pressure in the outlet plenum **166** is transmitted through a small eductor tube **168** and passes to the diaphragm chamber **169** which forces the diaphragm **148** to the right in FIG. **4** compressing spring **144** to the right and as the pressure continues to rise the spring **144** is compressed sufficiently to allow the valve **162** aided by the differential closing force to shut off the flow. If there is no leakage or demand for air then the valve **162** will remain closed.

If for any reason the pressure in the outlet plenum **166** increases above the preset valve pressure established by the main spring **144**, the diaphragm **148** will move to the right in

FIG. 4 against the spring **144** and away from the valve stem **152** and it will open the relief valve **170** thereby allowing the excess pressure to escape through a hole in the cover **38**. If on the other hand it is desired to increase the pressure permitted by the regulator, then the rotation of the handle-cover **36** which is also a handle and the resulting further compression of the spring **144** as mentioned previously will force open the valve **162** allowing the air to again flow into the outlet plenum **166**. If air is demanded, the pressure in the outlet plenum **156** will drop, the diaphragm **148** will have moved to the left in FIG. **4** and the valve **162** will open under the force of the spring **144**. The valve **162** will stay open until the pressure in the diaphragm chamber **169** again is sufficient to force the spring **144** to the right in FIG. **4** and close the valve. The eductor tube **168** functions as follows: assume that the spring **144** has just been adjusted so that a certain air pressure is delivered to the system with no flow. Then when flow is initiated, the pressure in the chamber **169** will drop, valve **162** will open and the movement of the valve to the left in FIG. **4** will allow the spring **144** to lengthen and exert less force and therefore when equilibrium between the air pressure and the chamber **169** and the spring **144** is again established it will be at a lower level than was originally set. By placing the mouth of the eductor tube **168** in the area of low pressure at the exit passage **174** of the outlet plenum **166**, then the pressure in the diaphragm chamber **169** is dropped below the level of the average pressure of the air in the outlet plenum **166** and will therefore reach equilibrium with spring **158** while the pressure in the outlet plenum **166** is still close to the no-flow valve pressure. Accurate design and fabrication and positioning of the eductor tube **168** should result in an almost flat pressure-airflow relationship.

LUBRICATOR 50

The lubricator **50** is connected to the regulator **34** by means of an assembly nipple **200** and air flows through the nipple **200** and through the ports **202** and into the air chamber housing and out through the lubricator outlet port **206**. Oil is stored in reservoir which is defined by the bowl **54**, the lubricator base **52** and the air chamber housing **207**, as the air passes thru the holes in assembly nipple **200** it picks up the oil which is discharged from pickup tube **218**. The high velocity and the turbulence in this zone shatters the oil droplets which are leaving the end of the tube **128** and creates a fog or mist or oil. The static pressure of the incoming air stream is transmitted up a sleeve **214** to a pressurizing valve **212** inside of sleeve **214** which is controlled with an adjustment knob **216** threadedly engaging the sleeve **214** and passing thru a cylindrical opening **209** in the bowl **54**. If the adjustment knob **216** is set to open the valve **212**, then the pressure will force oil up through the oil pickup tube **218**. A small bleed hole **224** is provided at the top of the tube **218** to prevent syphoning when there is no air flow or when the valve **212** has been closed. The closing of the valve **212** equalizes the pressure in the oil reservoir and the pressure in the outlet port **206** so that there is no pressure differential to force oil through the tube **218**. Since there is no obstruction in the lubricator airflow passage, air may pass through the lubricator in the reverse direction without difficulty. Therefore, the instant lubricator may be located at an air cylinder to provide direct lubrication instead of upstream of the control valve which is usually at some distance from the cylinder.

One of the problems which must be solved in all lubricators is that of proportioning the oil discharged into airstream to match the volume of the air flowing through the lubricator. In the absence of modifying means, the pressure differential which forces oil thru oil pickup tube **218** is a highly nonlinear function of air pressure and air velocity that is strongly influenced by the geometry of the assembly nipple **200** and the position of the point of termination of oil pickup tube **218**. Test results indicate a relationship of the type: $q = KQ^n$. Where q is the oil flow rate in ounces per hour, K, a constant of proportionality, Q, the airflow rate in cubic feet per minute and n, an exponent which varies from 1.4 to over 3 depending on the specific factors previously mentioned. Thus, an example, if the airflow rate were doubled the oil flow would increase from two and one-half to as much or more than eight times. Furthermore with this setup there would be no way to establish a desired rate for the oil flow.

In order to solve these two problems the lubricator described herein is provided with a suction tube **222** which projects into general zone of the outlet port **206**. The pressure at the end of this tube **222** is less than the pressure on the end of the oil pickup tube **218**. The upper end of tube **222** projects into the oil reservoir and into the air space **230** above the surface of the oil. Suction tube **222** also contains a valve means **223** which is sensitive to the airflow rate passing out of air chamber **207**. This valve **223** consists of a rubber-covered flat plate **225**, which bears against the end of tube **222** attached to a compression spring **227** by a small wire. A small orifice in the upper end of tube **222** limits the amount of air which is drawn there thru. At very low airflows the valve plate **225**, which is larger than tube **222** seals off the end of suction tube **22**. Pressure is generated in air space **230** by air entering the reservoir thru valve **212**.

Oil will be forced thru pickup tube **218**. At low airflow the rate of oil flow is determined solely by the resistance of the oil feed system and the pressure in sleeve **214**. As air flow increases the dynamic head of the airstream forces the plate **225** away from the end of tube **222**. Thus, under moderate to high airflow conditions a portion of the air entering the reservoir thru valve **212** is drawn off thru tube **222** thus lowering the pressure available to force oil into the tube **218**. The rate of oil flow can be controlled by varying the amount of air entering the reservoir from sleeve **214** by means of valve **212** which is actuated by knob **216**. As the air velocity is increased the valve **223** opens further and at the same time the difference in pressure between tubes **218** and **222** increases. However the opening of valve **223** action increases the rate of air removal and relatively retards the oil flow. If the valve **212** is closed, the difference in pressure between tubes **218** and **222** will force the oil in the tube **218** to back up and return to the reservoir through the bleed hole thus providing a positive shutoff. By properly locating the lower end of the tube **222** and by sizing the upper end to limit the amount of air which can be drawn away from the reservoir and by establishing proper valves for the tension of spring **227** and the size of valve plate **225**, the pressure in the oil reservoir can be maintained over a limited airflow range at a level more or less directly proportional to the volume of the air going through the air chamber cover **207**. That is, if the volume of the air is doubled the flow of oil will also approximately double. The function and action of the suction tube **222** and valve **223** are best described by reference to FIG. **18** which presents the analytical situation graphically. Log-log coordinates are used for convenience since slopes thereon represent exponential values. Curve C represents the desired situation where oil flow and air flow are directly proportional curve A represents the case where there is no suction tube and the oil flow is governed primarily by the air pressure in the reservoir. The slope of this curve is typical and the valve may vary widely. Curve B is typical of an open suction tube (no valve) but with limiting orifice in the upper end. Curve D is typical of that which can be achieved by introduction of valve means **223** into the suction tube while curve D can only approximate curve C and must be paralleled to curves A and B at its lower and upper ends respectively it is close enough for all practical purposes. The slope of curve D can be varied by appropriate adjustment of the valve, spring and orifice.

In order to obtain some measure of the amount of oil which is being discharged into the pneumatic system a small flow meter **236** of the tapered tube type is provided at the intake end of the oil pickup tube **218**. The float in the oil flow meter **236** is a small ball **238** which, with the tapered tube, acts as a check valve to prevent reverse flow. It may be desirable under

certain circumstances to provide additional one-way valves in tube **236**.

To be commercially practical any lubricator should be capable of being filled while the pneumatic system in which it is installed is fully pressurized and operating. This is accomplished in the instant system in the following manner: unscrew the adjustment knobs **216** several turns to totally close off the pressurizing valve **212**. Then unscrew the knob **216** another turn which further allows the pressure trapped in the lubricator to escape through a passage defined by the knob **216** and the end port **209**. This pressure loss will create a pressure differential across the check valve ball **238** in the oil pickup tube **218** and valve **223** in the suction tube **222** and both valves will close. The lubricator reservoir is now fully isolated from the pressure system. The knob **216** may be removed and the reservoir is filled and when the knob **216** which acts as a cap is replaced, the replacement opens the valve **212** and as soon as the pressure in the reservoir exceeds the pressure in the discharge outlet **206** the two valves will open and oil flow will be reestablished. The same relationship is true whether in the vertical one on top of the other arrangement in FIG. **3** or the side-by-side arrangement which is assembled in FIG. **2**.

Sometimes the unit herein is referred to as F-R-L (Filter, Regulator and Lubricator). The vertical assembly described above can be converted to a horizontal assembly as described below. Reference is first made to FIGS. **3** and **4**. Adjustment knob **216**, lubricator bowl **54** and filter bowl **26** along with element **108** and related components are removed from the assembly. Chase nipple **124** is unscrewed and removed along with washer **125**. This releases the filter head **20** from the F-R-L assembly.

Assembly nipple **200** is now unscrewed and removed along with washer **229** with assembly **60**. Lubricator **50** will now separate from the regulator body **40**. The three functional sections of the F-R-L are now separate. Reassembly of the three components in the horizontal mode is made as follows: (Reference is made to FIG. **2**). Seal rings **79** are pressed over regulator bosses **78**. Adapters **70** are slid over bosses **78** and seated firmly against regulator body **40**. Seal rings **79** seat against regulator body **40** and fit into a recess in adapter **70**.

Lower and upper bridge plates **90** and **86** have two ridges **88, 92** the interior opposed faces of which slope out at an angle of 60° to the plate. These ridges are pressed into grooves **84** on the upper and lower faces of adapters **70**. The side of these grooves closest to the regulator are also sloped at an angle of 60° to the plane of the adapter. Dimensional control is such that when clamp screws **94** which straddle regulator body **40** and adapters **70** are tightened, the two adapters **70** are wedged against the regulator body simultaneously compressing seals **79**. This method of joining has proven capable of withstanding an internal pressure of 1,000 p.s.i. without leakage or deformation.

Before reassembly, a tapped hole **250** approximately one-half inch in diameter is made in bases (head castings) **24** and **52**. The center for these holes is already located in the castings.

To reassemble the filter slip seal ring **75** over adapter boss **76** and seal ring **77** into a groove **89** in a hole **91**. Slide center port **82** of base **24** over boss **76**. Line up hole **91** in adapter with threaded hole **250** in base **24**. Reinstall washer **125** and chase nipple **124** in threaded hole in boss **76** and tighten. Please seal ring **79** over a plug bolt **254** and slip through hole **91** and thread into hole **250** and tighten. Guide filter element **108** already in bowl **26** over chase nipple **124** and screw bowl **26** into head.

Assembly of the lubricator is made in the same manner except that assembly nipple **200**, washer **229** and modified air chamber assembly are used in place of chase nipple **24** and washer **125** to hold the head in place. A vented plug bolt **260** with vent **262** is used in place of a plug **264**. Replace the bowl **54** and adjustment knob **216**. This modified air chamber differs from air chamber **207** only in the configuration of tubes **218** and **222**. Tube **218** is shortened and hangs down into the bottom of the oil reservoir. Flow meter **236** is much shorter and only need project through air chamber housing **38** into the air space **230** above the oil. All action and control remains the same except for refilling.

To refill the inverted reservoir valve **212** is shut off by rotation of knob **216**. Plug **260** which contains a vent bleed passage **262** is unscrewed several turns. This permits the reservoir pressure to bleed off past a seal **264**. The plug is then removed and oil replaced in the reservoir through the passage thus opened.

It is believed that the method used to proportion the flow of oil from the lubricator is more effective than many systems currently in use.

An innovation in this F-R-L unit is the use of plastic port inserts **266**. In F-R-L's currently marketed the inlet and outlet ports are threaded for a specific pipe size, i.e. one-fourth, three-eights, one-half, etc. thus a distributor must carry a stock of each size. The external ports **206, 30** of the present filter and lubricator heads are tapped with three-fourths NPS thread which may be used with ¾-inch pipe. If smaller pipe sizes are required, a series of moulded plastic inserts **266** are available. The present port inserts are not necessarily conventional pipe bushings. This difference is demonstrated in FIG. **3**. These port inserts are completely inside of the three-fourth NPS female thread in the die cast head or base **24, 52** of the filter **20**, lubricator **50** or adapter **70**. As the connecting pipe is screwed into tapered thread, the insert expands to seal against threads in head. Insert travel is limited by a shoulder. Overtorquing will strip the bushing, not the head. The connecting male thread, then, is in the same relationship to the filter or lubricator head as though there were no insert. With usual pipe bushing, the connecting line is frequently completely outside the ports and with sufficient vibration or torque, the bushing fails in the zone noted in FIG. **3**. Use of these inserts insures a conformity between male and female threads, eliminates the need of pipe sealants, provides freedom from corrosion due to galvanic action and offers some degree of isolation from vibration. Deformation of the insert distributes stresses uniformly around the ports, thus reducing the probability of breaking the casting through pipe mislignment or overtorquing. These joints may be easily disassembled even after long periods of service without danger of stripping corrosion weakened threads. If the incoming pipe is inadvertently cross threaded, only the replaceable bushing, not the expensive head casting is damaged.

The elements of the instant F-R-L are unique in the variety of ways in which they may be combined. First, each of the basic element is a separate entity in itself. The filter, regulator and lubricator may be used independently of any of the other elements as shown in FIGS. **5** thru **13**.

FIG. **8** depicts either a lubricator or regulator adapted for independent use, (the two units are externally similar except that the inlet and outlet ports are reversed). An adapter **300** is mounted in precisely the same manner as adapter **70**, FIG. **2**. The sole distinction between adapters **70** and **300** is that the latter has three-fourths NPS threads machined into the externally exposed port. The same function may be served by a modified standard 300 pound pipe L **302** (Jigg). While it does not provide as attractive an appearance, the pipe L makes it possible to establish virtually any desired angular relationship between inlet and outlet ports. This freedom simplifies installation and alignment problems. Nor, is one confined to the horizontal plane. FIG. **12** shows a pipe T **304** as the inlet connection for a lubricator. Incoming air enters thru the horizontal leg of the T. Unlubricated air is taken off from the vertical leg to service (for example) a fluidic control circuit. The remainder of the air passes thru the lubricator and onto an actuating cylinder controlled, perhaps, by the fluidic circuit. The concept of bringing flow into and dividing flow off from a common connection, where that connection is an integral part of the F-R-L assembly is novel. Such a practice simplifies utilization and installation and, in addition represents a significant cost saving. Other custom designed manifolds or tie

points can easily be made by any one familiar with pneumatics. A fill port **306** must be provided for refilling the oil reservoir.

A street L **308**, a 45° L virtually any other standard heavy duty fitting may also be used. FIG. **10** depicts a street L filter inlet port connection oriented at right angles to the outlet.

The modification required to prepare a fitting for use as a port connection is shown in FIG. **11**. A boss **310** identical in dimension with the boss **76** on adapter **70** is machined on one end of the fitting. The fitting need only be large enough in external dimension to provide a sealing surface for a seal ring **79**. 300 pound to 3,000 pound fittings have been used. The thread connection at the machined end must be ½inch NPT to match the regulator thread.

The regulator, FIG. **13**, needs no port connection since ½ inch NPT threads are machined into the ports.

A frequently used combination of two elements of the F-R-L system is the filter-lubricator combination. This is commonly used where pressure regulation is not required, or is done on a system basis. FIG. **5** shows a cojoined filter **314** and lubricator **316**. Each is a separate unit as described previously. Units **314** and **316** are joined by a ¾-inch NPT close nipple **212**.

FIG. **6** shows the same two elements joined using two modified pipe L's **302**, and a short nipple **318**. A distinct advantage of this combination is the freedom of orientation of the inlet and outlet ports. FIG. **6** shows both ports facing to the rear for front panel mounting.

The filter and lubricator elements may also be disposed vertically as shown in FIG. **7**. A coupling or T **320** may be used as the cojoining member. This arrangement reduces installation space requirements.

Many applications require either filter and regulator or lubricator and regulator. FIG. **14** shows a filter-regulator combination. The assembly is the same as that shown in FIG. **1**, except that bowl **26** or **50** or **54** and the internal mechanism of the lubricator **50** have been replaced by a cap **322** which threads into the bowl recess in place of bowl **26**. FIG. **6** simplifies this installation by eliminating parts and using the threaded outlet port of the regulator **34**.

The position of the lubricator may be substituted for that of the filter in the foregoing examples, or used in its normal position as shown in FIG. **16**. The regulator and either of the other two elements may also be joined by appropriate pipe connections.

Two arrangements of the complete F-R-L assembly have already been discussed (cf, FIGS. **1** and **2**). The three elements may also be simply joined using pipe fittings in place of adapters **140**. Such a method offers considerable freedom of port orientation. FIG. **7** demonstrates the versatility of the F-R-L assembly disclosed here. Filter and regulator are joined by a street L **350**. Regulator and lubricator are joined by a nipple **322** and a T **324** in a manner similar to that shown in FIG. **6**. Inlet and outlet ports are at right angles. It should be noted that unlike some presently marketed F-R-L units flow may be either left to right or right to left.

While I have shown and described a preferred embodiment of the invention together with several suggested modifications thereof, this is by way of illustration only and does not constitute any sort of limitation on the scope of my invention since various alterations, changes, deviations, eliminations, substitutions, additions, variations and departures may be made in the forms shown and described without departing from the scope of my invention as defined by interpretation of the appended claims.

I claim:

1. In a selective combination of two or three of the following:

a. An air filter element, an air pressure regulator element and an air lubricator element for use in compressed air lines;

b. Each of said air filter element, air pressure regulator element and air lubricator element having a separate, independent base complete with inlet and outlet ports and a closed chamber, such as a glass or plastic bowl, with a passage therein from said inlet to said outlet ports respectively through said closed chamber through which air under pressure is moved to be filtered, lubricated or regulated as appropriate to the particular element and its respective function, and each of said bases having a three-dimensional configuration arranged so that said bases may be brought together in connected engaged relationship with said outlet port in closed communication with a respective inlet port in the other to which it is connected and with which it is mounted as a combination;

c. At least two of said three bases being formed with an offset portion having said inlet port and said outlet ports therein in other than in a straight line and the exterior of said two bases being offset in two dimensions to fit and interlock with the third element to bring said respective inlet and outlet ports of said respective elements in communication, and said third element having the inlet and outlet ports in its base substantially opposed; and

d. said one of said two bases with an offset portion being combinable with the base having inlet and outlet ports, and with or without the other base with the offset portion, whereby selectively as desired the lubricator, filter and pressure regulator may be combined into one combination with two or three together so that there is a complete passageway from the inlet of one base receiving air through a pressure line or the like and said air passing through that said element on to the next element combined and connected therewith and through that element to the outside or other conduit with or without the said third element which may be combined selectively therewith.

2. The arrangement claimed in claim **1**, wherein there is an adapter means for combining all three elements, all of said bases and said adapter means being secured together in a detachable and removable assembly with air moving through said elements.

3. The arrangement claimed in claim **2**, wherein said adapter means includes separate three-dimensional adapters, each of said adapters having an inlet on one side and an outlet spaced therefrom and said element bases interconnecting with said adapters.

4. The arrangement claimed in claim **1**, wherein said element bases have the inlet at an angle through said base with respect to said outlet.

5. The device in claim **3**, said adapters being three-dimensional and elongated and having an opening at one end fitted to and cooperating with one of the inlet and outlet openings in said element and said other opening on said adapter fitted to another of said inlet and outlet of the elements.

6. The device in claim **5**, wherein each of said elements has a circular bowl retaining portion and an offset three-dimensional portion which is fitted to one end of said adapter with said inlets and outlets in communication, and means removably securing said adapters and said elements together.

7. The arrangement in claim **1**, wherein said bases are housings which may be combined in either a vertical or horizontal relationship.

8. The arrangement in claim **1**, wherein said outlet of one element is operably connected to the inlet of another by positioning one to the other without internal or external connections therebetween.

9. The arrangement in claim **8**, wherein one of said inlets and outlets has a connecting means which fits to said other internally by close association between same.

10. The arrangement in claim **1**, wherein said bases have offset portions matching with complementary images on said other base to cause operable relationship between said inlets and said outlets.

11. The arrangement in claim **10**, wherein said internal inlets and said outlets are operably associated by combining said selected respective bases and there is a means for retaining said bases in assembled relationship.

12. The arrangement in claim 10, wherein said means comprises a pressure-tightening means.

13. The arrangement in claim 7, wherein said inlets in said housings extend in one direction and the outlets are at an angle thereto whereby said elements may be assembled into a stacked relationship without external connecting means wherein the inlets and outlets are colinear.

14. The arrangement in claim 2, wherein said adapter is used with only one element such as the lubricator or regulator and there is a means on said adapter to connect said air line.

15. The arrangement in claim 1, wherein only one of said elements is used with a pipe "L" to provide one of any number of different angles between inlet and outlet.

16. The arrangement in claim 1, wherein one of said elements is used alone with a pipe "T" so that if the element is a lubricator unlubricated air can be taken off from one leg of the "T" for service to a control circuit and the other air passes through the element.

17. The arrangement in claim 1, wherein only one element is used and a street el attaches thereto.

18. The arrangement in claim 1, wherein said element is provided with a fitting having a boss thereon insertable into an inlet or outlet port without threads.

19. The arrangement in claim 1, wherein the filter element and lubricator elements are combined without adapters by using a close nipple.

20. The arrangement in claim 1, wherein said elements are joined in pairs by means of two modified pipe "L's" and a short nipple therebetween.

21. The arrangement in claim 1, wherein said elements are used in pairs and the assembly is capped by a cap which threads into one bowl recess.

22. The arrangement in claim 1, wherein said three elements are connected by using pipe fitting rather than adapters, for freedom of port orientation, the filter and regulator are joined by a street "L" and the regulator and lubricator are joined by a nipple and "T" in a manner to place inlet and outlet ports at right angles.