REFRIGERANT COMPRESSOR

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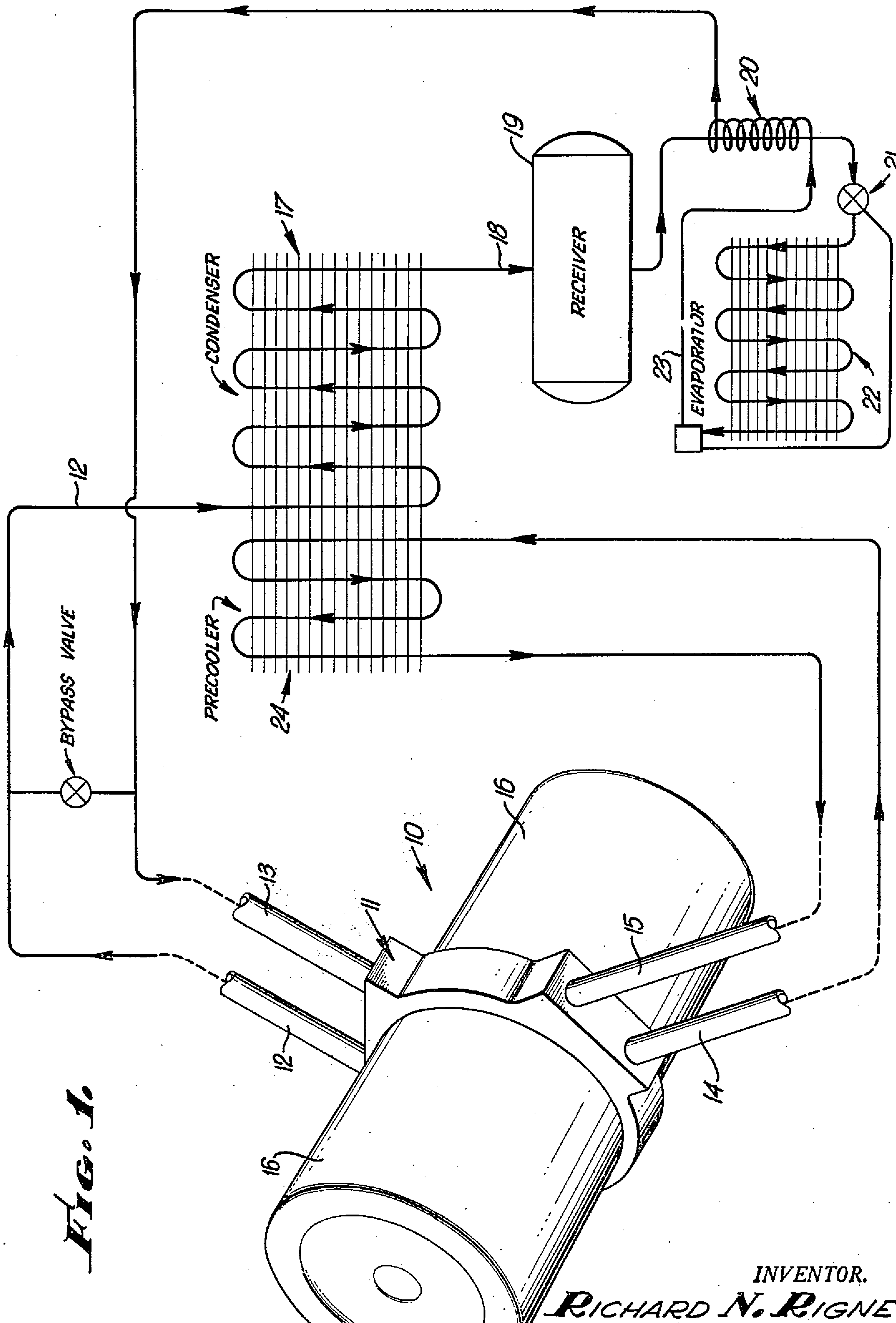

FIG. 1.

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3,064,449

REFRIGERANT COMPRESSOR

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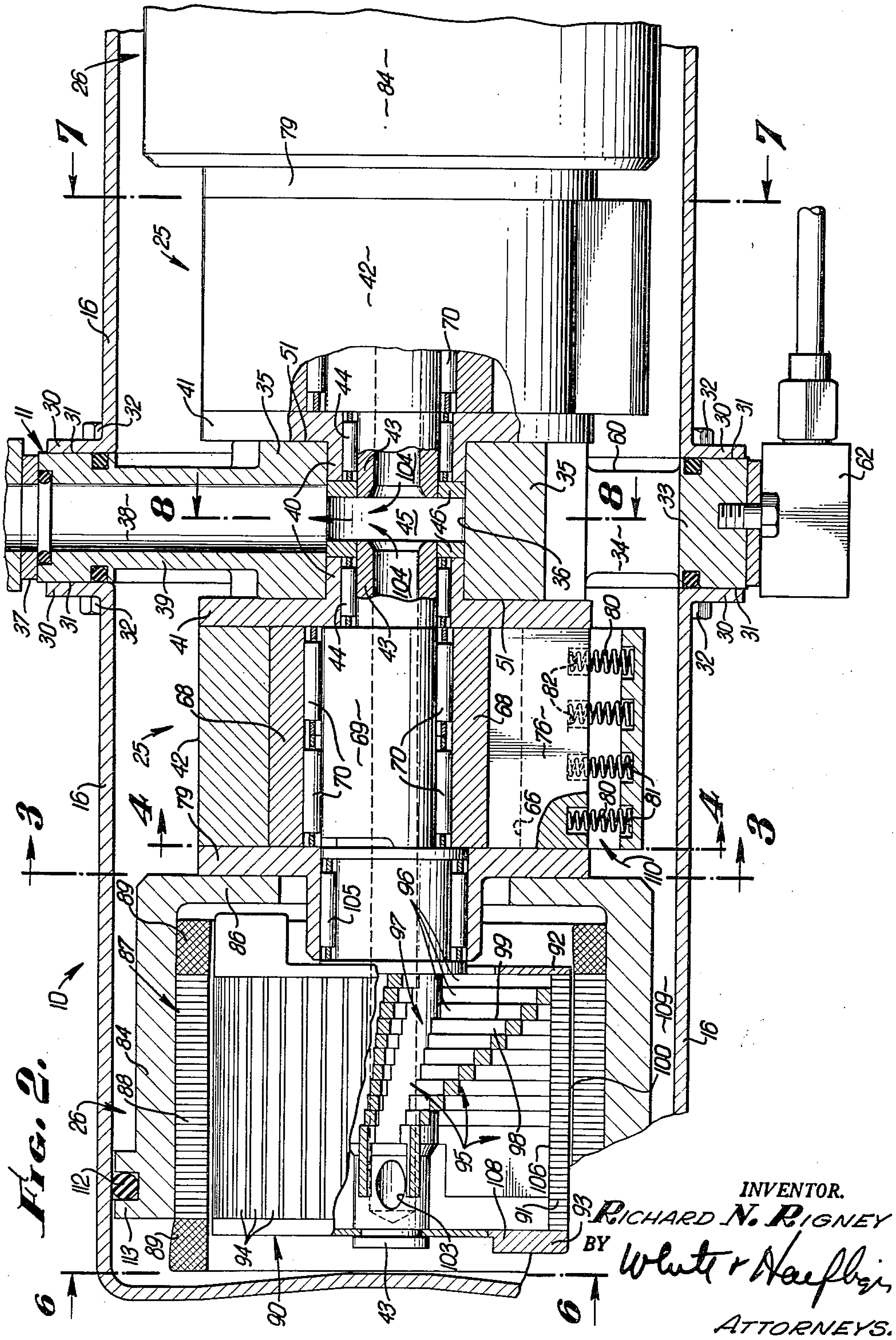

FIG. 2.

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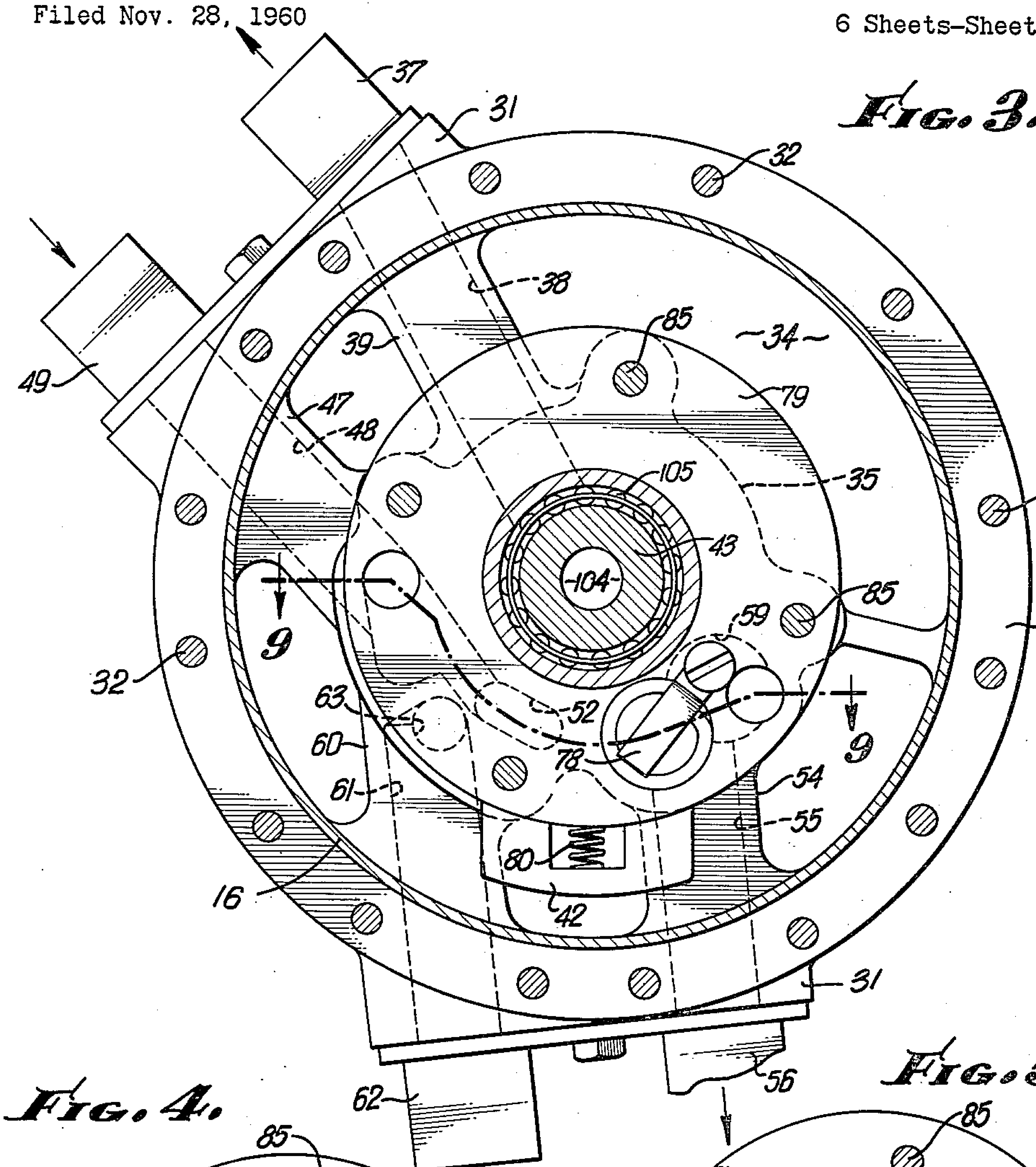

FIG. 3.

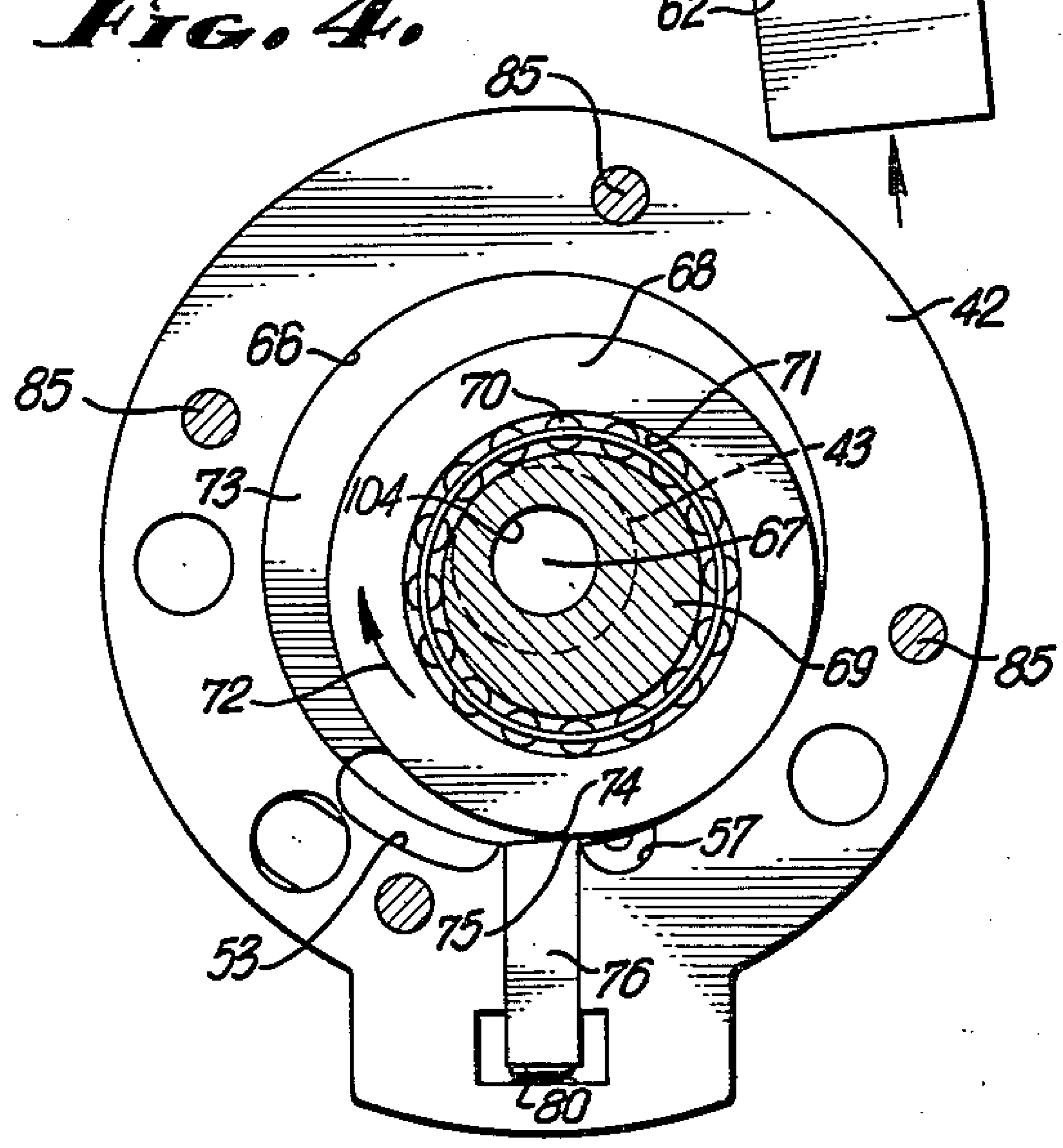

FIG. 4.

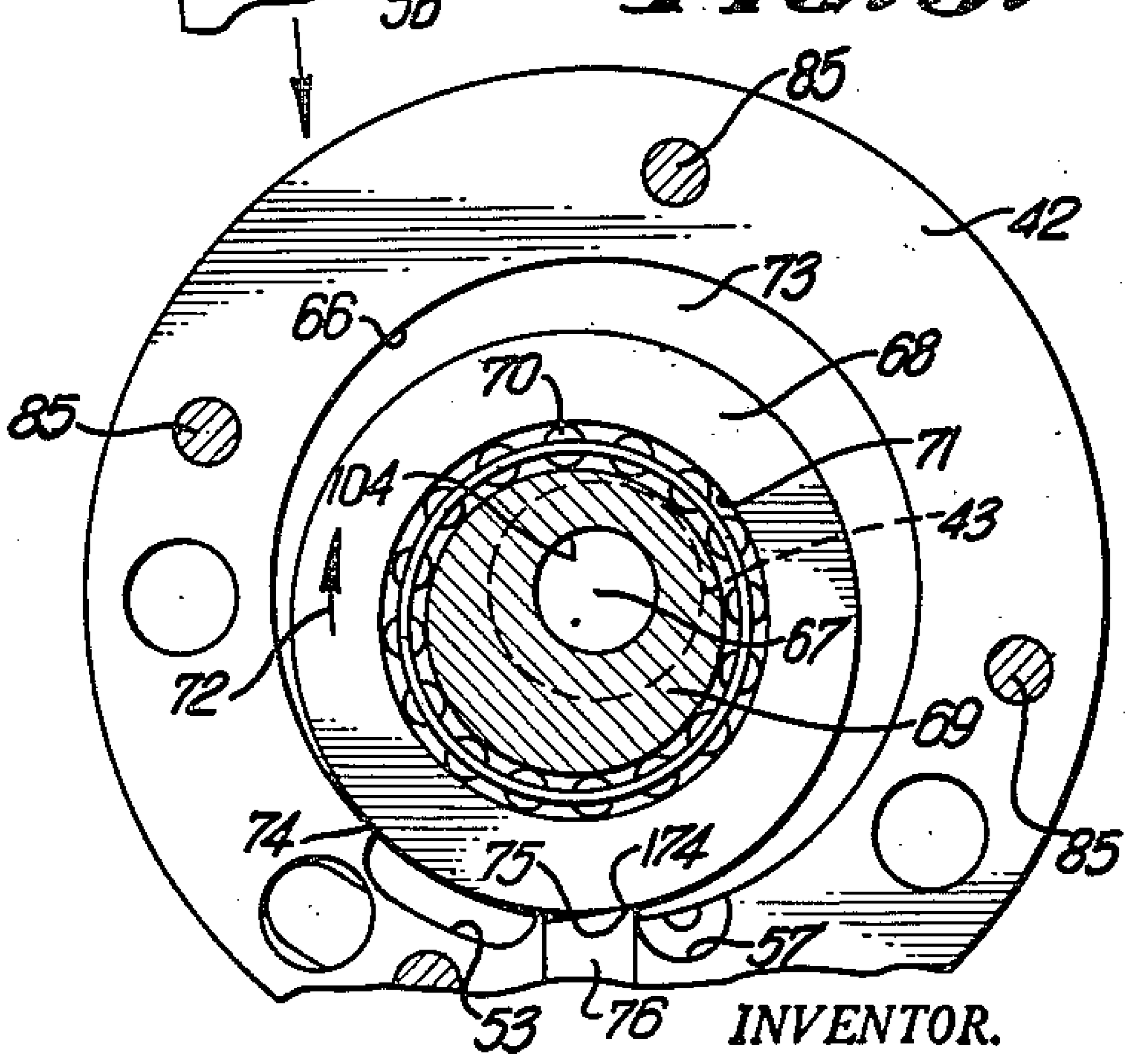

FIG. 5.

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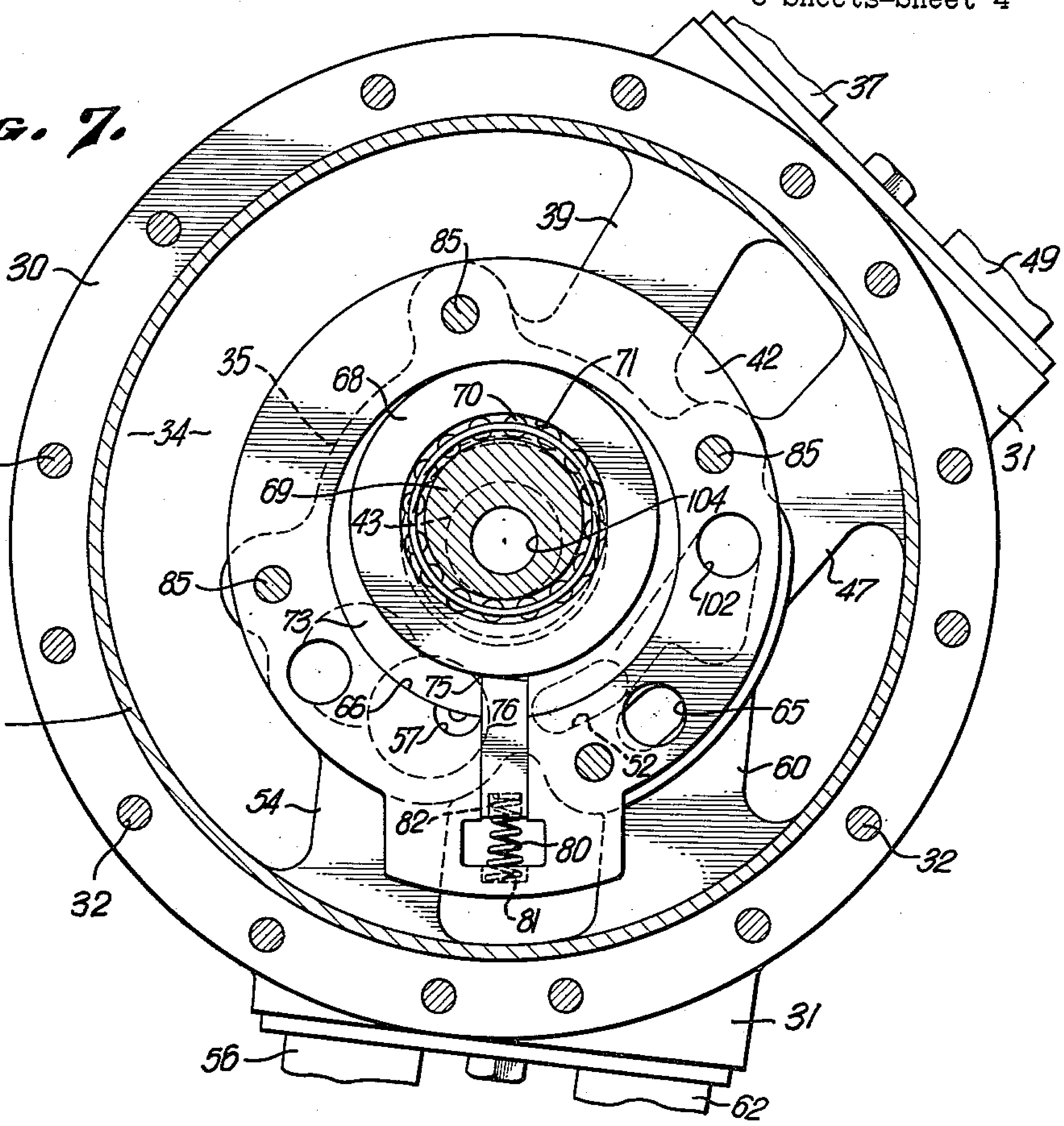
FIG. 7.



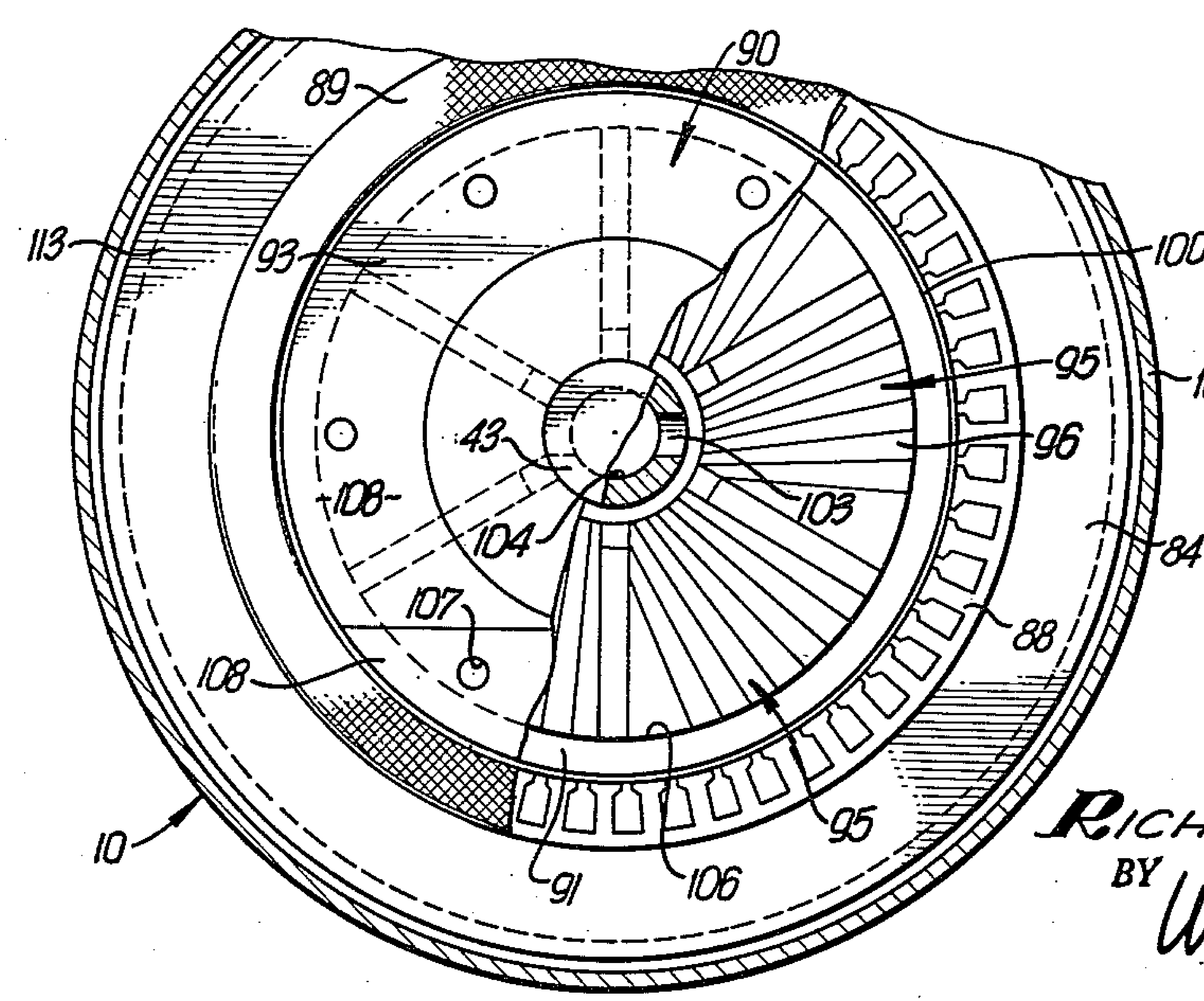


FIG. 6.

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FIG. 8.

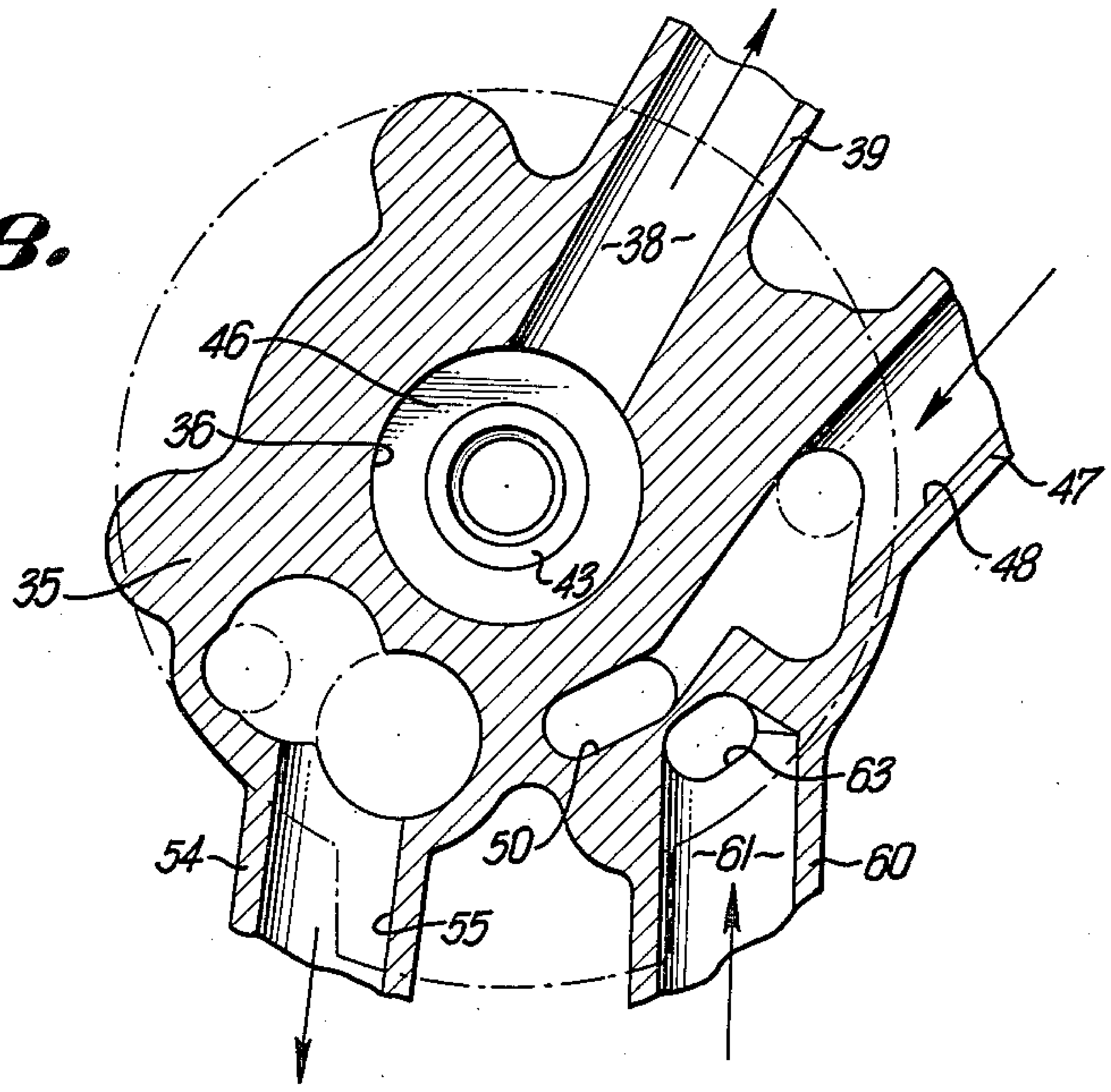
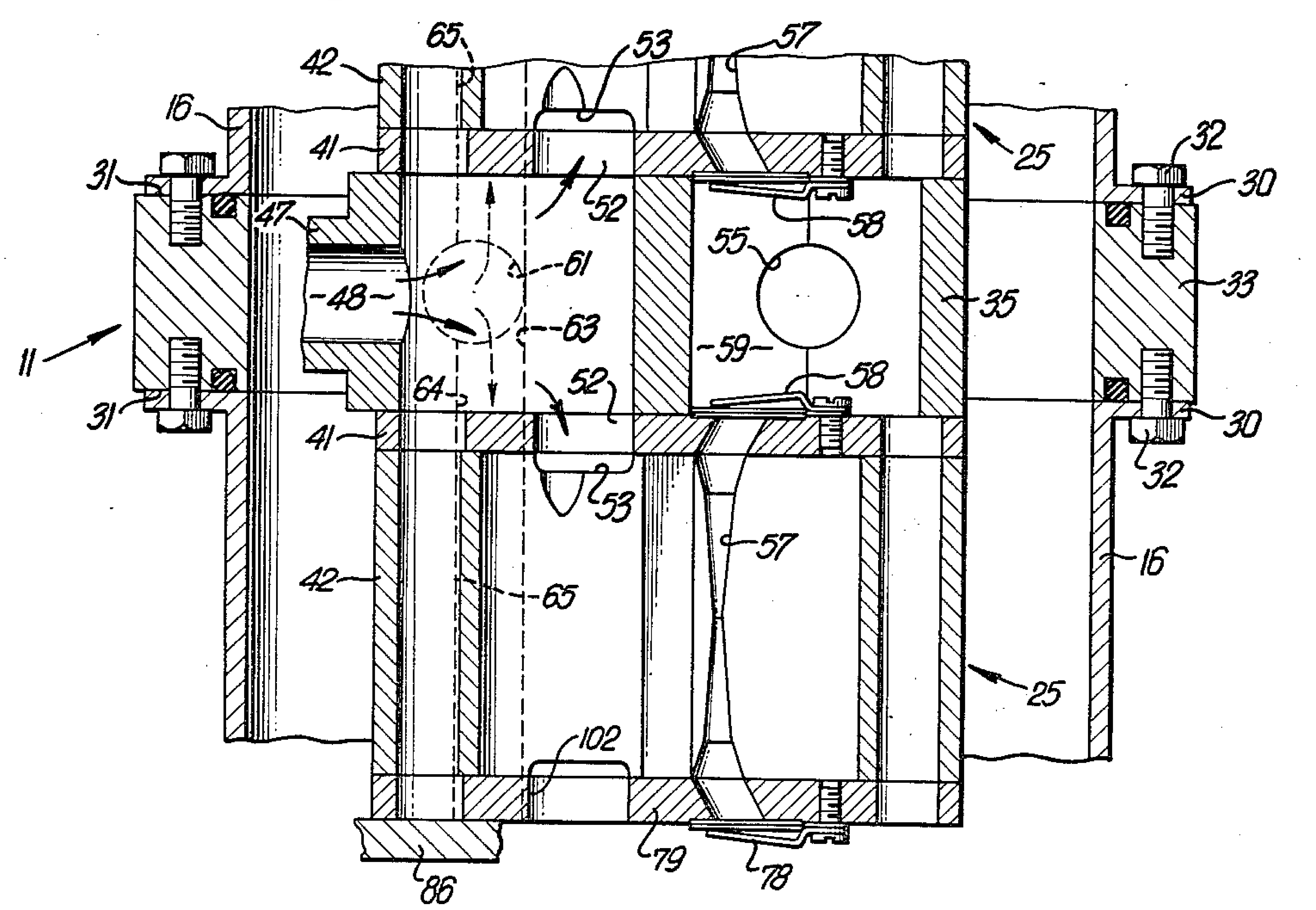


FIG. 9.



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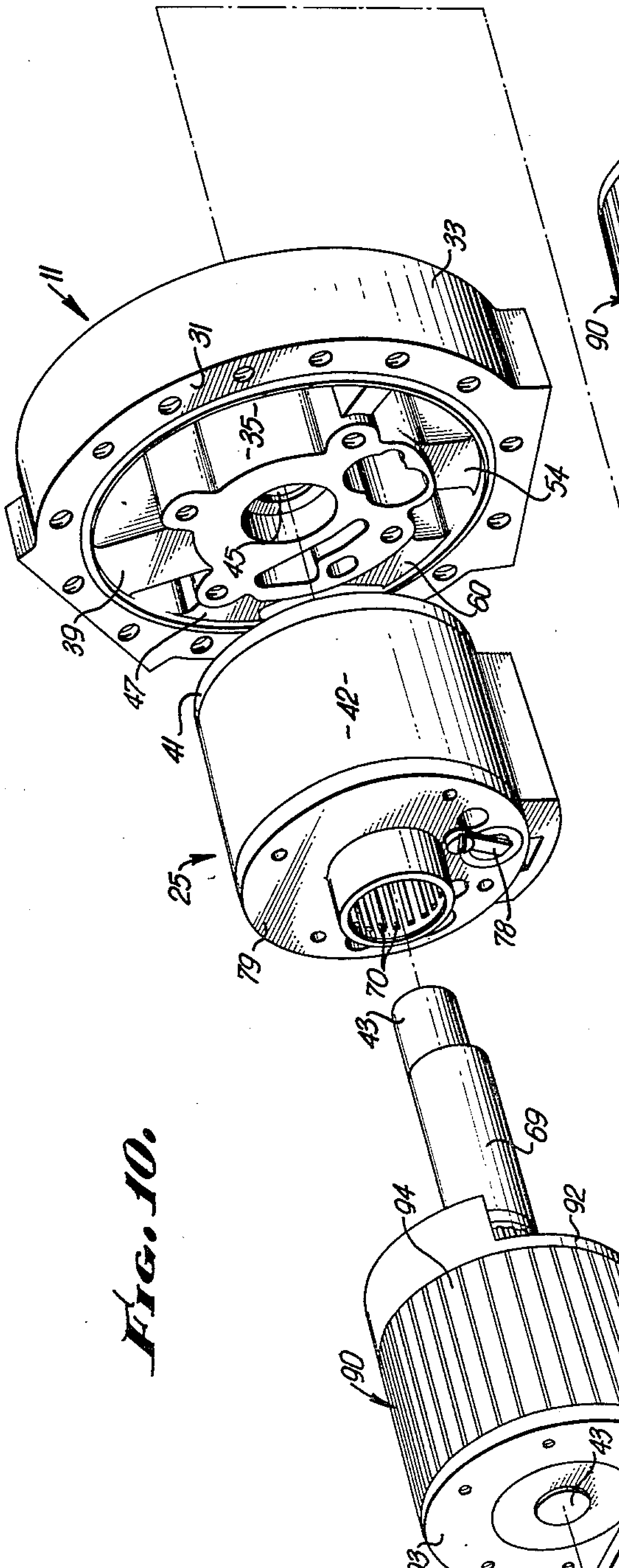

FIG. 10.

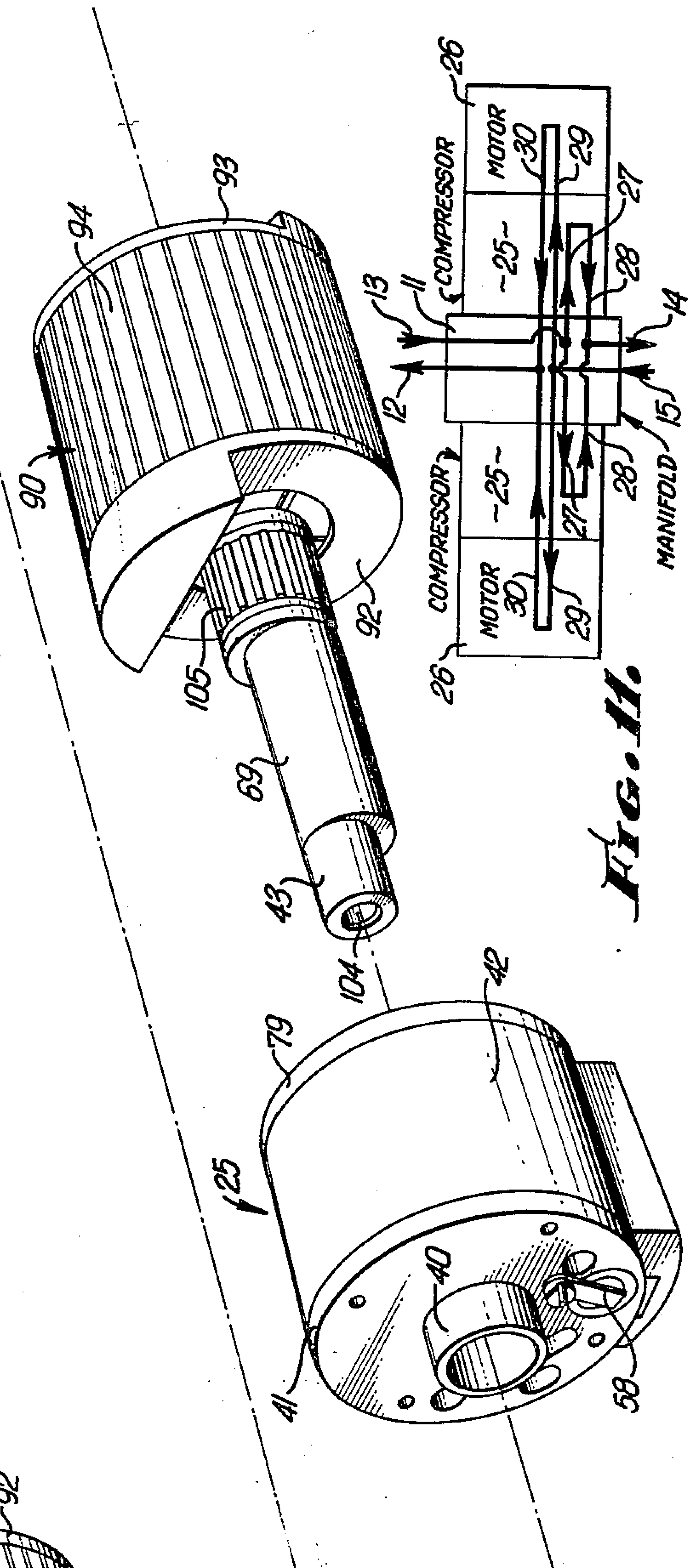

FIG. 11.

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3,064,449
REFRIGERANT COMPRESSOR

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Filed Nov. 28, 1960, Ser. No. 72,093
21 Claims. (Cl. 62—470)

This invention relates generally to refrigeration systems, and more particularly refrigerant compression in such systems, the invention being characterized in the provision of a novel and improved motor-driven compressor unit, as well as in the combination of such a unit in a refrigerant system.

It is a general object of the invention to provide a novel compressor and motor unit in which fluid lubricant is contained and becomes entrained in flowing refrigerant during compressor operation, the motor and compressor unit incorporating separator means operable to separate the lubricant from the compressed refrigerant prior to flow of the latter from the motor-compressor unit to condenser means in the system, thereby preventing excessive accumulation of lubricant in the refrigerant flowing to the condenser. It is also an important object of the invention to utilize the compressed refrigerant for cooling the electric motor driving the compressor, such cooling being accomplished in a particularly advantageous and novel manner through the incorporation of passages within the motor-rotor structure within which the compressed refrigerant is flowable in heat transfer relation with the motor-rotor structure, these passages presenting very little obstruction to the flow of compressed refrigerant. At the same time, the rotor structure forming the passages is operable to effect centrifugal separation of the fluid lubricant from the compressed refrigerant as the latter flows through the motor in cooling relation therewith, all as will be described.

The invention is also characterized in the combination of the elements making up the motor-driven compressor assembly, these elements including a manifold, an electric motor and rotary compressor means located between the motor and manifold and rotatable by the motor for compressing the refrigerant. This assembly contains passages for flowing circulating refrigerant through the manifold to the compressor means to be compressed thereby, these passages also acting to return the compressed refrigerant to the manifold to be circulated outside the assembly for cooling and to be returned in compressed and cooled state to the manifold. In addition, the assembly contains other passages for receiving the compressed and cooled refrigerant returned to the manifold from outside the assembly for flowing refrigerant through the manifold and compressor means to the motor in cooling relation therewith and for returning the refrigerant from the motor back through the compressor means to the manifold for circulation therefrom into the refrigerating system outside the assembly. As will be seen, maximum utilization of available space to provide for flow of the refrigerant within the assembly to accomplish these functions is made possible by locating the manifold, compressor means, and motor in relationships described and to be described.

These other features and objects of the invention, as well as the details of an illustrative embodiment, will be more fully understood from the following detailed description of the drawings in which:

FIG. 1 is a schematic showing of a refrigeration system incorporating the invention;

FIG. 2 is an enlarged elevation taken in section through the motor-driven compressor assembly;

FIG. 3 is a section taken on line 3—3 of FIG. 2;

FIG. 4 is a section taken on line 4—4 of FIG. 2;

FIG. 5 is a view like FIG. 4, showing elements of the compressor rotated with respect to the positions of these same elements shown in FIG. 4;

FIG. 6 is a section, partly broken away, taken on line 6—6 of FIG. 2;

FIG. 7 is a section taken on line 7—7 of FIG. 2;

FIG. 8 is a section taken on line 8—8 of FIG. 2;

FIG. 9 is a section taken on line 9—9 of FIG. 3;

FIG. 10 is an exploded perspective showing of the basic elements of the motor-driven compressor assembly shown in detail in FIG. 2; and,

FIG. 11 is a schematic showing of the circulation of refrigerant through the motor-driven compressor elements illustrated in block form.

Referring first to FIG. 1, a particular refrigeration system incorporating the invention is shown to include a motor-driven compressor assembly generally designated at **10**, the latter including a manifold **11** having connected therewith a refrigerant delivery or exhaust duct **12**, a refrigerant return or suction duct **13**, and other refrigerant outlet and inlet ducts **14** and **15**, the functions of which will be later described. The assembly **10** also is shown in FIG. 1 as incorporating a pair of housings **16**, which will be understood as joined to opposite faces of the manifold, so that the housings extend endwise oppositely from the manifold.

Tracing through the circulation of refrigerant within the system, the supply refrigerant, typically but not necessarily comprising Freon 12, passes through duct **12** to and is delivered at **18** to a receiver **19**. From the latter the liquified refrigerant passes through a heat exchanger **20**, an expansion valve **21** and then through an evaporator **22**. After passing through the latter, the refrigerant is returned at **23** through the heat exchanger **20** and then returned as suction gas through the duct **13** to the compressor assembly **10**.

It will also be observed in FIG. 1 that super-heated compressed Freon or refrigerant is circulated from the outlet duct **14** through a pre-cooler unit indicated at **24**, the purpose of which is to cool the Freon, removing its super-heat so that the cooled, compressed Freon may be circulated back through the inlet duct **15** into the assembly **10** for cooling the motor, as will be further described. Typically, but not necessarily, the superheated and compressed Freon discharged from the unit **10** through the duct **14** has a temperature around 230° F. and the cooled Freon is returned through the duct **15** at a temperature of around 170° F. After passing in cooling relation with the motor in the assembly **10**, the compressed Freon is exhausted to the system through duct **12** at a temperature of around 187° F. These temperatures are merely illustrative of typical operating conditions, and are not to be taken as limiting the operating temperatures of the present or equivalent systems or units.

Referring now to FIGURES 10 and 11 for a broad understanding of the arrangement and operation of the motor, compressor and manifold elements of the compressor assembly, it will be seen from FIG. 11 that a pair of compressor units **25** are located at opposite sides of the central manifold **11** and two electric motors **26** are placed or located endwise outwardly of the compressors **25**, the elements **11**, **25** and **26** thus being arranged in stacked series relation, the advantages of which will appear from the following description.

As broadly conceived, such advantages include the enablement of adequate cooling of the high output compressor and motor units by the compressed refrigerant, which is distributed or circulated to the compressor and motor units from the central manifold **11**. Thus, as schematically shown in FIG. 11, suction gas or refrigerant is supplied to the manifold **11**, as indicated at **13**, and is then distributed at **27** to the compressors **25**. Thereafter, the compressed and superheated refrigerant is returned back to the manifold **11** as indicated by the lines **28** for external circulation at **14** to the pre-cooler which is shown in FIG. 1 at **24**. The return flow of cooled compressed refrigerant is supplied at **15** to the manifold and is then led or conducted through the compressors **25** to the motors **26**, as indicated by the lines **29**. The circulating-compressed refrigerant is then returned at **30** back through the compressors **25**, typically through the tubular drive shafts therefor, to the central manifold **11**, from which the refrigerant was circulated at **12** to the external refrigeration system as previously described. Since the coolant comprises the refrigerant itself, and since the elements **11**, **25** and **26** are arranged as described, a very compact compressor assembly is provided with an extremely high output to weight ratio.

Now referring to FIG. 2, the assembly **10** is shown to include the opposite casings or housings **16** having flanges **30** bolted to the opposite faces **31** of manifold block **11**, the bolts being shown at **32**. Extending the description to FIGS. 3, 7, 8 and 10, the manifold chamber is shown to include a ring **33** forming a cavity **34** through which access of lubricant between opposite sides or faces of the manifold chamber may be had, the lubricant normally partly filling the interiors of the casings or housings **16** and the cavity **34** of the manifold chamber.

Located centrally within the chamber **34** is a block **35** containing a bore **36**, which is in communication with an outlet or exhaust refrigerant fitting **37** through a duct or passage **38**. The latter is formed by leg structure **39** integral with the body **35** and the manifold chamber ring **33**, as better shown in FIG. 3 and FIG. 7. The bore **36** also receives the tubular coaxial extents **40** of end plates **41** for the compressor bodies **42**, these bodies and end plates being part of the compressors **25**. The tubular extents **40** in turn receive the end extents of hollow shafts **43**, which are coaxially mounted by suitable roller bearings **44**, space **45** remaining between the ends of the shafts **43** and bearing retainers **46** to provide a path **45** for exhaust flow from within the shafts **43** through space **45** and the passage **38** to the exterior refrigerant system.

Also, integral with the manifold chamber is leg structure **47** forming a passage **48** through which suction refrigerant gas flows after entering the manifold fitting **49**. Such flow then passes at **48** to the inlet **50** within the body **35** of the manifold, as seen in FIG. 8. The inlet **50** communicates between opposite faces **51** of the block **35** and furthermore registers with inlets **52** in the end plates **41** and with inlets **53** in the compressor body **42**, as seen in FIGS. 4 and 5.

The manifold also includes leg structure **54** forming a passage **55** through which compressed and superheated refrigerant flows from the compressor chamber to the exterior fitting **56**, the latter communicating with duct **14**, as shown in FIG. 1. Compressed and superheated refrigerant leaves the discharge passage **57** within the compressor block, as seen in FIGS. 4, 5 and 9, and is delivered past a reed valve **58** into a passage **59** within the manifold and communicating with the passage **55**.

Finally, the manifold includes integral leg structure **60** forming a passage **61**, which communicates between the exterior fitting **62** and a passage **63** for receiving compressed and precooled refrigerant for delivery to the compressor and motor. Passage **63** is in registration with passages **64** and **65** within the compressor end plate **41** and the compressor body **42**.

Referring now to the compressor unit, as illustrated in FIGS. 4 and 5, the body **42** thereof forms a cylindrical bore **66** through which the shaft **43** extends axially, with respect to the axis **67**. A cylindrical piston **68** of smaller diameter than the bore **66** is arranged to rotate about the bore **66** and eccentrically with respect to the axis **67** as by mounting the piston upon an eccentric **69** carried by the shaft **43**, there being needle bearings **70** between the cylindrical surface of the eccentric and the bore **71** of the piston **68**. Such rolling contact of the piston with the bore **66** of the compressor body, all in response to shaft rotation in the direction of the arrow **72**, serves to draw suction refrigerant gas through the entrance port **53** into the clearance space **73** between the piston and the bore, which space is then progressively closed or reduced in volume between the rolling line of contact **74** of the piston **68** with bore **66**, and the line of engagement **174** between the piston surface and the lip **75** of a follower **76** spring urged into contact with the piston surface. It is clear from FIGS. 4 and 5 that the entrance ports **53** is at one side of the follower **76** and the discharge port **57** is at the opposite side of the follower. Also, communication between space **73** and inlet port **53** is interrupted once the line of contact **74** has moved past the port **53** in a clockwise sense. Accordingly, the pressure within the clearance space **73** and within the delivery port or passage **57** increases as the piston rolls around the bore **66** until such pressure increase is sufficient to open the reed valve **58**, as viewed in FIG. 9. At such time the compressed and super-heated refrigerant escapes through the manifold to the external line **14**, as viewed in FIG. 1 and FIG. 6, intermittent delivery occurring once per revolution of the shaft. Delivery pressure also escapes through a valve **78** at the opposite end of the compressor for return to passage **59**, valve **78** typically but not necessarily being mounted on end plate **79** of the compressor structure.

Returning to the description of the follower **76**, it is shown in FIGS. 2, 4 and 5 to be urged toward the piston **68** by a series of compression springs **80** the opposite ends of which are received within suitable openings **81** and **82** formed within the body **42** and the follower **76**.

Turning now to the description of the electric motors for rotating the compressors, reference to FIGS. 2, 6 and 10 will show each motor **26** to include a housing **84**, which is bolt-connected to the manifold block **35** by bolts shown at **85** passing through the compressor blocks from the motor housing flange **86**. Carried within each housing **84** is a stator assembly **87** that includes laminations **88** through which extent suitable windings, the end turns of which appear at **89**. Mounted for rotation within the stator annulus is a rotary assembly generally indicated at **90**, the rotor including annular laminations **91** and end rings **92** and **93**, all of which are included within the squirrel cage construction of the rotor, the squirrel cage bars of which appear externally at **94**.

The rotor annulus is made integral with the shaft **43** by means of support vanes **95** arranged in spiral convolutions, each vane convolution comprising a series of radial spokes **96** having polygonal cross-sections in planes normal to the spoke radii.

Accordingly, axially spiraling passages **97** are formed between the successive vane convolutions, and the spokes form radial protuberances projecting into these passages, as typified by the sides **98** and edges **99** of the vanes, all for the purpose of creating turbulant flow of pre-cooled compressed refrigerant passing through the passages **97**, thereby promoting heat transfer. The latter is necessary to cool the rotor structure, and it is furthermore found that the precooled refrigerant passes through the gap **100** formed betwen the rotor laminations and stator laminations **88** for cooling purposes.

Such pre-cooled refrigerant enters the passages **97** between the spiral convolutions **95** from an entrance chamber **101** which communicates with the passage **65** in the compressor body as shown in FIG. 9, through a corresponding passage **102** in the compressor end plate **79** as viewed in FIG. 9. The compressed refrigerant after passing through the passages **97** flows radially inwardly toward ports **103** in the tubular shaft **43** near the extreme end of the shaft and thereafter the refrigerant flows back through the shaft bore **104**, and thus through the motor and compressor to discharge at **45** and **38**, as previously described.

An additional and important function of the spiral vane convolutions **95** is to centrifuge outwardly the fluid lubricant which becomes entrained within the refrigerant flowing through the compressor. Such entrainment and distribution of the lubricant as a mist for lubricating the bearings, as for example those shown at **105, 70** and **44**, is of course desirable; however, separation of the lubricant from the compressed refrigerant just prior to delivery thereof to the external system is also desired in order not to affect adversely the operation of the latter system. Accordingly, adjacent spokes of the vanes form radial grooves for collecting and centrifugally impelling the lubricant outwardly against the inner bore **106** of the rotor laminations **91**, such throwout being opposite in direction to the inward flow of the refrigerant toward and into the ports **103**, thereby accomplishing separation of the refrigerant just prior to exit delivery thereof. Furthermore, the liquid lubricant so separated flows through holes or ports **107** appearing in FIG. 6 in the rotor end plate **108**, and the lubricant is thus returned to the sump **109** formed between the housing **84** and the casing **16**. The lubricant from the sump works its way back into the system of passages within the compressor and motor via the follower, as indicated by the arrows **110**, and it will be understood that other slight clearances allow return flow of lubricant into the circulating refrigerant. In this connection, FIG. 2 illustrates an annularly discontinuous O-ring **112** sealing off between a flange **113** on the motor housing **84** and casing **16**.

Briefly, referring now to the overall operation of the compressor assembly, the suction refrigerant enters the manifold through the fitting **49** and through passage **48** and entrance ports **50, 51** and **52** for delivery to the compressor piston. Rotation of the latter carries the refrigerant around the clearance passage **73** and discharges the refrigerant under pressure at **57** for exit delivery past valve **58** and into passages **59** and **55**. Thereafter, refrigerant circulates externally in the system through lines **14** and **15** for pre-cooling.

Upon return to the manifold the refrigerant enters through the inlet fitting **62**, FIG. 3, and through passage **61**, to the passage **63**, from whence the refrigerant flows endwise through the compressor passages **64, 65** and **102** for delivery to the passages **101** and **97** within the motor. Therein, the pre-cooled and compressed refrigerant cools the motor structure while lubricant is being separated from the refrigerant, whereupon the cleaned refrigerant exits through the ports **103** into the shaft bore **104** to flow back through the motor and compressor units to the manifold. Finally, the refrigerant is delivered through passages **45** and **38** for external circulation, as described in connection with FIG. 1 lines **12, 13, 18** and **23**.

I claim:

1. For combination in a refrigeration system in which refrigerant is cycled through condenser and evaporator means, an assembly including fluid lubricated motor driven compressor means operable to receive return flow of refrigenant from the evaporator means and to pressurize the refrigerant for supply to the condenser means, said assembly containing passage means in which fluid lubricant becomes entrained in flowing refrigerant during compressor operation, said assembly including separator means supporting motor rotor structure outwardly of the separator and inwardly of motor stator structure and being operable to clean the compressed refrigerant by centrifugally separating lubricant therefrom prior to compressed refrigerant flow to the condenser means, thereby to prevent excessive accumulation of lubricant in the refrigerant flowing to the condenser.

2. For combination in a refrigeration system in which refrigerant is cycled through condenser and evaporator means, an assembly including a motor and fluid lubricated compressor means operable by the motor to receive return flow of refrigerant from the evaporator means and to pressurize refrigerant for supply to the condenser means, said assembly containing passage means in which fluid lubricant becomes entrained in flowing refrigerant during compressor operation, said passage means including motor driven rotary passage extent within which the refrigerant has turbulent flow proximate the motor to absorb heat produced by operation of said motor, and separator means operable to clean the compressed refrigerant by centrifugally separating lubricant therefrom prior to compressed refrigerant flow to the condenser means, thereby to prevent excessive accumulation of lubricant in the refrigerant flowing to the condenser.

3. The invention as defined in the claim 2 in which said assembly has first inlet and outlet ports communicating with the compressor for passing said return flow of refrigerant to the compressor and for passing the compressed and superheated refrigerant stream to said condenser means to precool the compressed refrigerant stream, and said assembly has second inlet and outlet ports for passing said precooled refrigerant stream to said passage means and separator means and for passing the cleaned refrigerant to the condenser and evaporator means.

4. For combination in a refrigeration system in which refrigerant is cycled through condenser and evaporator means, an assembly including an electric motor and fluid lubricated rotary piston compressor means operable by the motor to receive return flow of refrigerant from the evaporator means and to pressurize refrigerant for supply to the condenser means, said assembly including a shaft for driving the compressor rotary piston in response to motor operation, said assembly containing passages in which fluid lubricant becomes entrained in flowing refrigerant during compressor operation, said passages including motor driven rotary passage extent within which the refrigerant in gaseous state has turbulent flow proximate the motor to absorb heat produced by operation of said motor, said assembly including separator means mounted in said shaft and operable in response to shaft rotation to clean the compressed refrigerant by centrifuging entrained lubricant therefrom outwardly away from the shaft prior to compressed refrigerant flow to the condenser means, thereby to prevent excessive accumulation of lubricant in the refrigerant flowing to the condenser, said shaft having an inlet and a hollow interior for receiving clean compressed refrigerant flowing from said separator means to said compressor means.

5. The invention, as defined in claim 4, in which the motor rotor and stator are spaced radially outwardly from said shaft and said separator means extends intermediate the shaft and motor rotor, whereby lubricant is centrifuged outwardly toward the motor rotor.

6. The invention as defined in claim 5, in which said separator means comprises vanes carried by the shaft and circularly spaced thereabout, said vanes being integral with the motor rotor to receive heat by conduction therefrom.

7. The invention as defined in claim 6, in which said vanes have protuberances exposed at the vane sides for creating turbulance in the gaseous refrigerant from which lubricant is centrifuged in response to vane rotation, thereby to promote heat transfer from the vanes to the refrigerant.

8. The invention as defined in claim 5 in which said assembly includes a manifold and said compressor includes a chamber receiving the rotary piston, said manifold and separator means being at axially opposite ends of said chamber, said manifold and chamber containing refrigerant intake and discharge ports communicating with the compressor piston.

9. The invention as defined in claim 8 in which said intake and discharge ports are adapted respectively to pass the return flow of refrigerant to the compressor and to pass the compressed and superheated refrigerant stream to the condenser means to pre-cool the refrigerant stream,

and in which the manifold and compressor chamber have other intake and discharge ports for passing the precooled refrigerant stream to said passages and separator means and for passing the cleaned refrigerant from the interior of said shaft to the condenser and evaporator means.

10. The invention, as defined in claim 8, in which the compressor chamber has a cylindrical bore through which said shaft extends axially, said piston having a cylindrical periphery and being mounted eccentrically on said shaft to rotate eccentrically about the shaft axis in rolling contact with the chamber bore in response to shaft rotation, said intake and discharge ports opening into said bore at circularly spaced locations and in which said compressor includes a spring urged follower projecting through said bore between said locations and engaging the piston periphery to seal off between the intake and discharge ports.

11. The invention, as defined in claim 10, in which the chamber contains a radial slot receiving the follower to move radially in response to piston rotation, said follower having a pressure shoulder facing away from the piston and being in communication with said discharge port.

12. The invention as defined in claim 4 in which said assembly includes a housing enclosing said compressor and motor, said housing containing liquid lubricant in a reservoir outside the motor and compressor, and to which lubricant entrainment is returnable after separation thereof from the refrigerant.

13. For combination in a refrigeration system in which refrigerant is cycled through condenser and evaporator means, an assembly including a manifold, a pair of electric motors and a pair of fluid lubricated rotary piston compressors, the compressors being at opposite sides of the manifold and between the manifold and said motors, the compressors being operable by the motors to receive return flow of refrigerant from the evaporator means and to pressurize refrigerant for supply to the condenser means, said assembly including shaft means for driving the compressor rotary piston in response to motor operation, said assembly containing passages in which fluid lubricant becomes entrained in flowing refrigerant during compressor operation, and in which the refrigerant in gaseous state absorbs heat produced by operation of said motors, and separator means mounted on said shaft and operable in response to shaft rotation to clean the compressed refrigerant by centrifuging entrained lubricant therefrom outwardly away from the shaft means prior to compressed refrigerant flow to the compressor means, thereby to prevent excessive accumulation of lubricant in the refrigerant flowing to the condenser means, said shaft means having inlets and a hollow interior for receiving clean compressed lubricant flowing from said separator means to the manifold and then to the compressor and evaporator means.

14. The invention as defined in claim 13 in which each motor rotor and stator is spaced radially outwardly from a shaft and the separator means includes vanes extending intermediate the shaft and each motor rotor, whereby lubricant is centrifuged outwardly toward the motor rotors.

15. The invention as defined in claim 14 in which said separator vanes are carried by the shaft and are integral with the motor rotors to receive heat by conduction therefrom.

16. The invention as defined in claim 13 in which said assembly includes housing means enclosing said compressors and motors, said housing means containing liquid lubricant reservoirs outside the motors and compressors, and means forming passages through which lubricant is returnable to said reservoirs after lubricant separation from the refrigerant.

17. For combination in a system for transferring heat by circulation of fluid subject to heating and cooling, an assembly including manifold means, motor means, and rotary compressor means driven by said motor means for compressing the transfer fluid, said assembly containing passages for flowing circulating fluid through the manifold and compressor means to said motor means in cooling relation therewith and for returning the fluid from said motor means back through said compressor means to the manifold means to be circulated therefrom and in said system, said passages including motor driven rotary passage extent within which the fluid has turbulent flow proximate the motor to absorb heat produced by operation of the motor.

18. The invention as defined in claim 17, including fluid lubricant contained by said assembly, and in which said assembly includes separator means in the path of transfer fluid circulation for separating lubricant from the heat transfer fluid.

19. For combination in a refrigerant circulating system, an assembly including a manifold, an electric motor, and rotary compressor means between the motor and manifold and rotatable by the motor for compressing the refrigerant, said assembly containing first passages for flowing circulating refrigerant through the manifold to the compressor means to be compressed thereby and for returning the compressed refrigerant to the manifold to be circulated outside said assembly for cooling and to be returned in compressed and cooled state to the manifold, said assembly containing other passages for receiving the refrigerant returned to the manifold from outside said assembly, for flowing the refrigerant through the manifold and compressor means and the motor in cooling relation therewith and for returning the refrigerant from said motor back through said compressor means to the manifold to be circulated therefrom into said system outside said assembly, said other passages including motor driven rotary passage extent within which the refrigerant has turbulent flow proximate the motor to absorb heat produced by operation of the motor.

20. The invention as defined in claim 19 including fluid lubricant contained by said assembly, and in which said assembly includes rotary separator means driven by said motor in the path of refrigerant circulation for separating fluid lubricant from the circulatory refrigerant.

21. The invention as defined in claim 20 including means connected in series communication with said first passages for receiving and cooling the compressed refrigerant to a temperature lower than the motor operating temperature prior to return of the compressed refrigerant to said other passages.

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