Nov. 18, 1969 R. E. BALL 3,478,689

CIRCULATING PUMP

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FIG. 1.

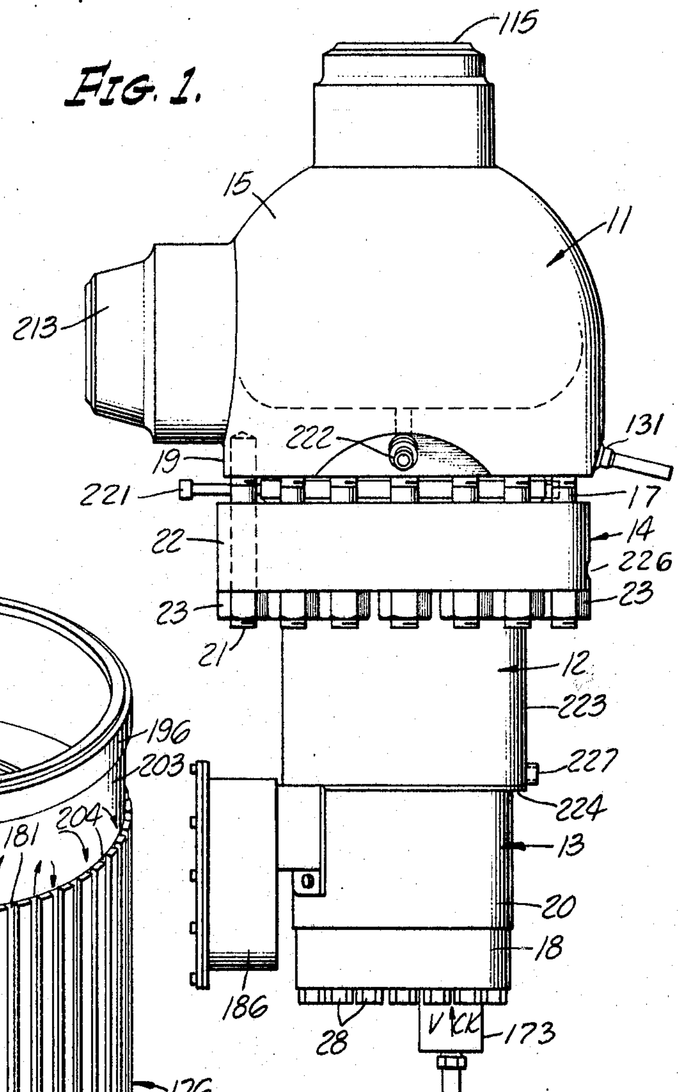
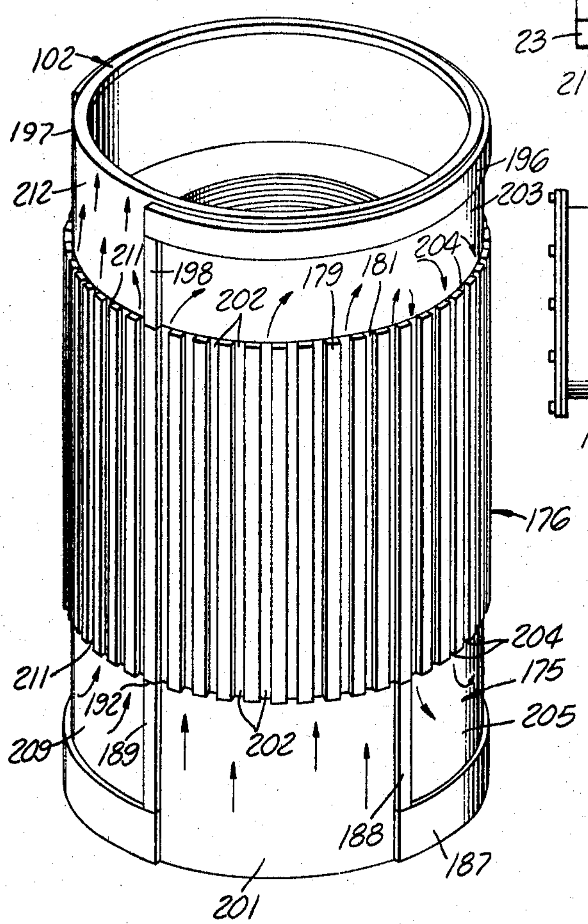


FIG. 6.



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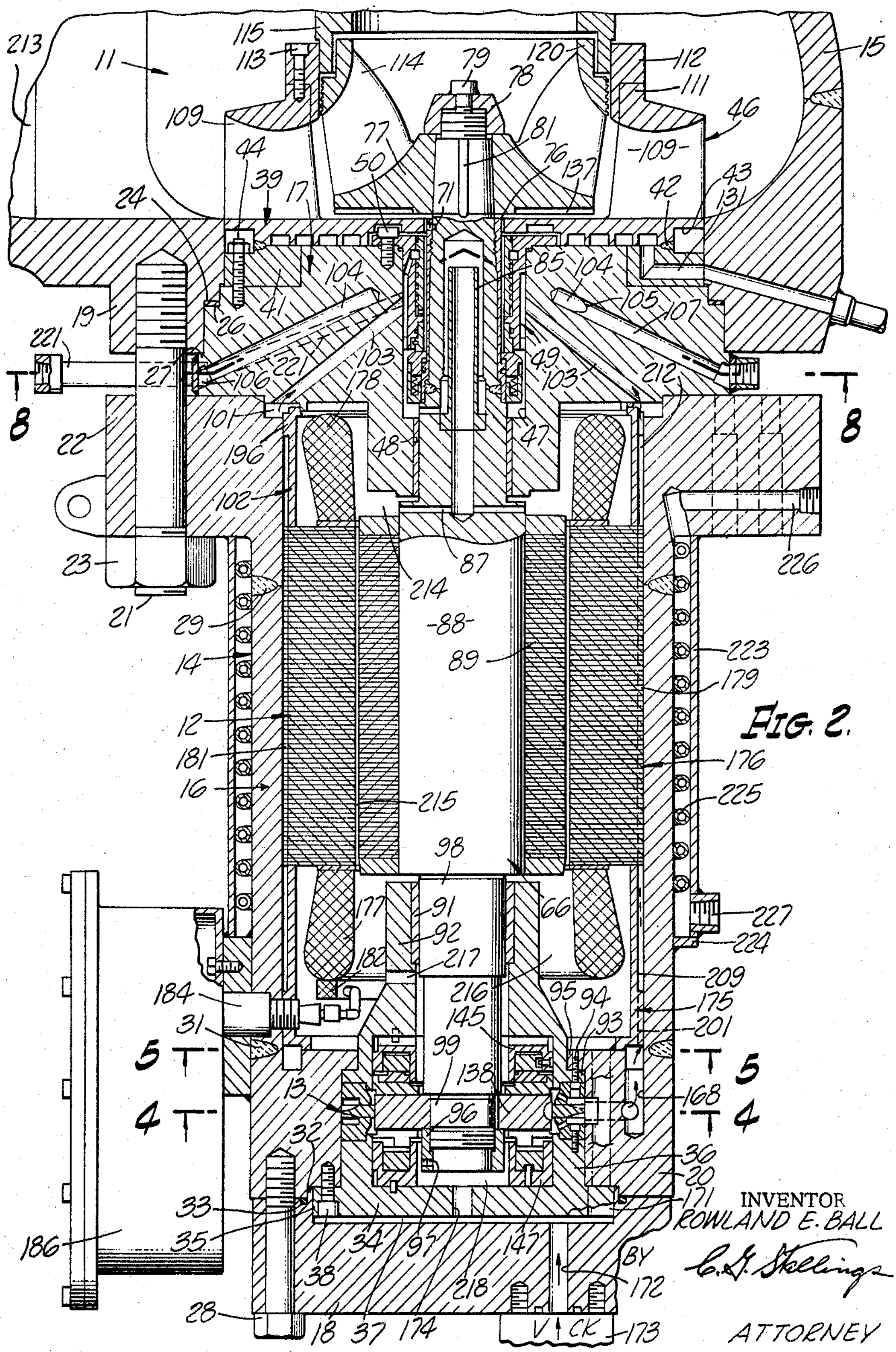

FIG. 2.

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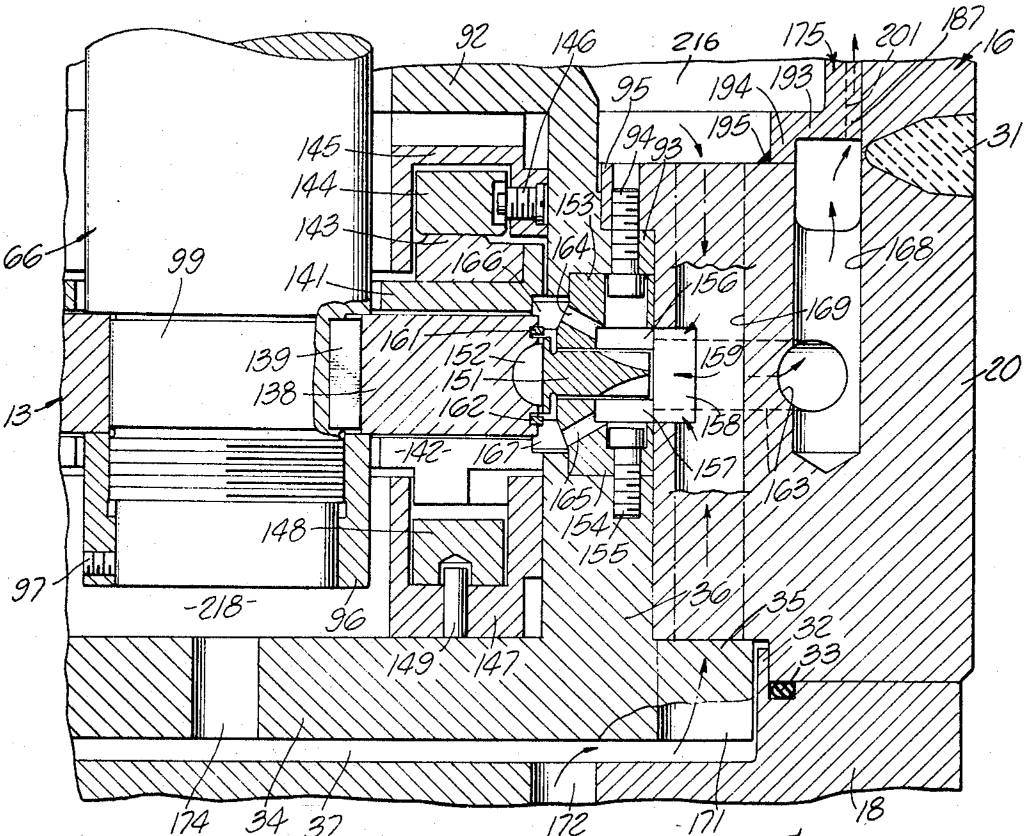
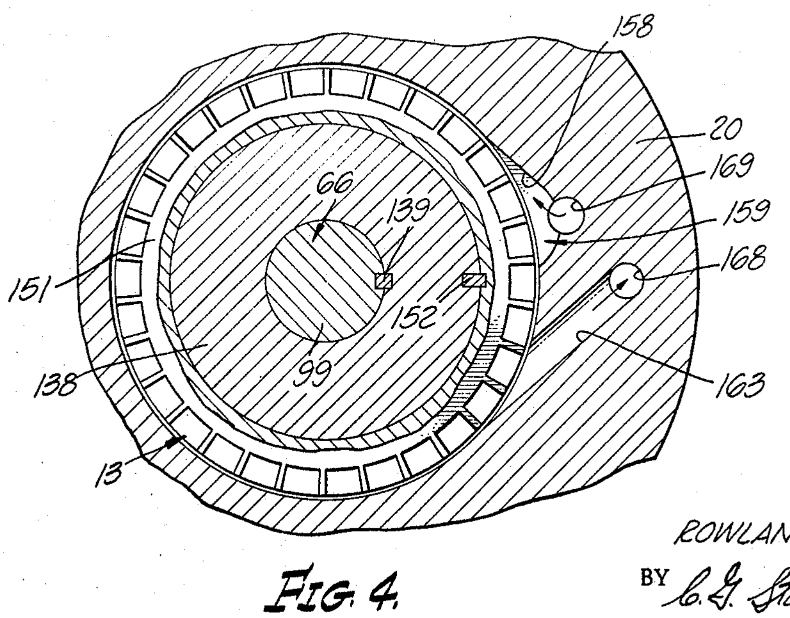


FIG. 3.



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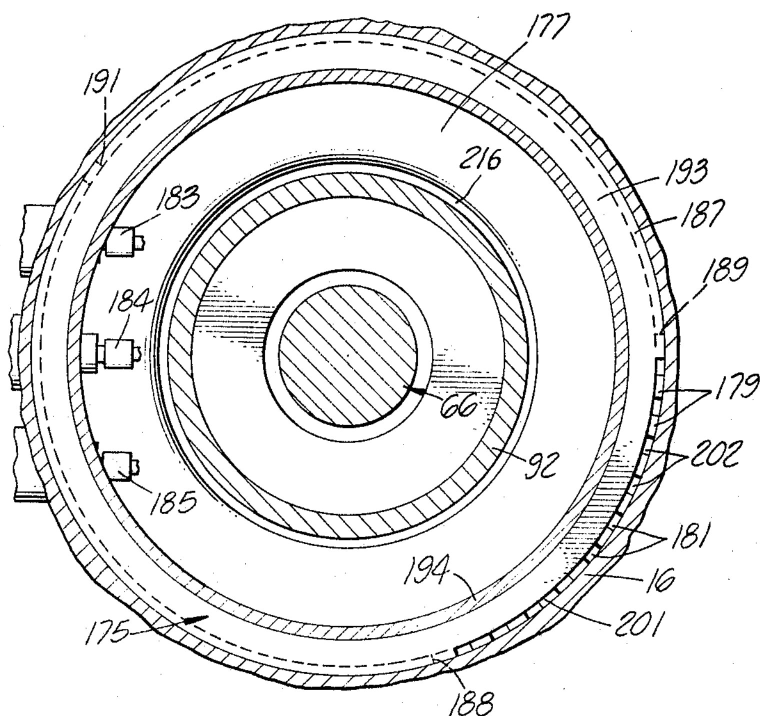

FIG. 5.

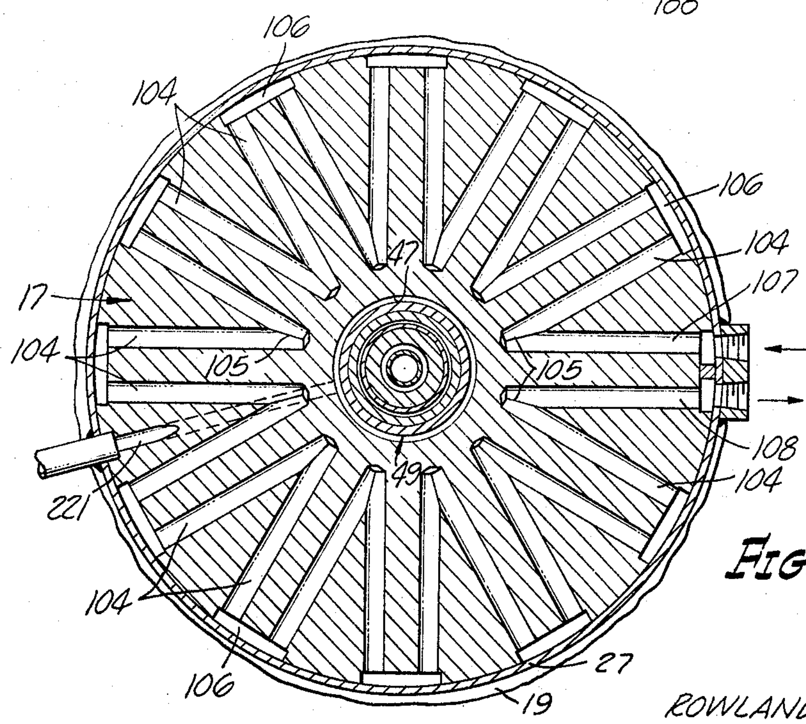

FIG. 8.

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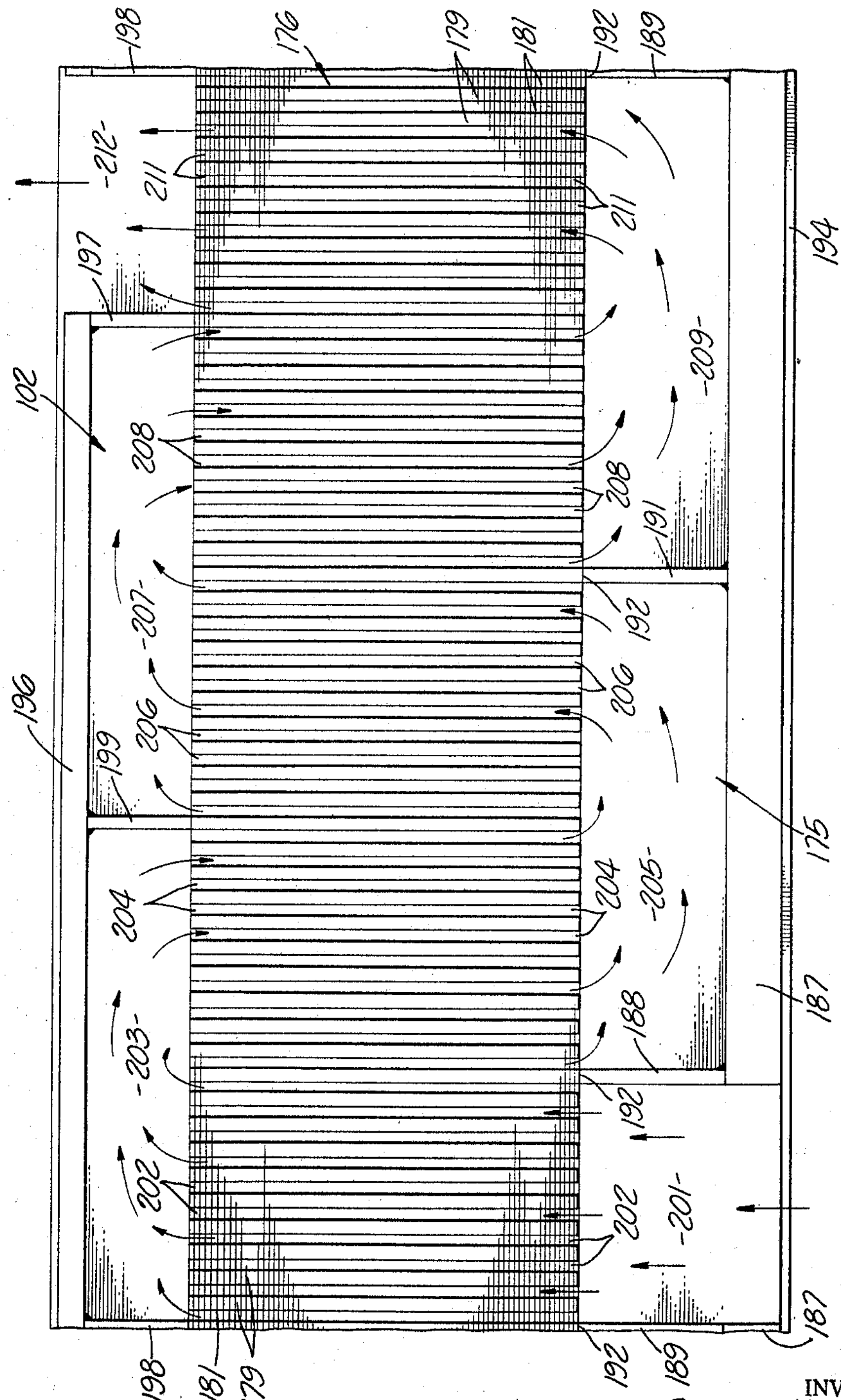

FIG. 7

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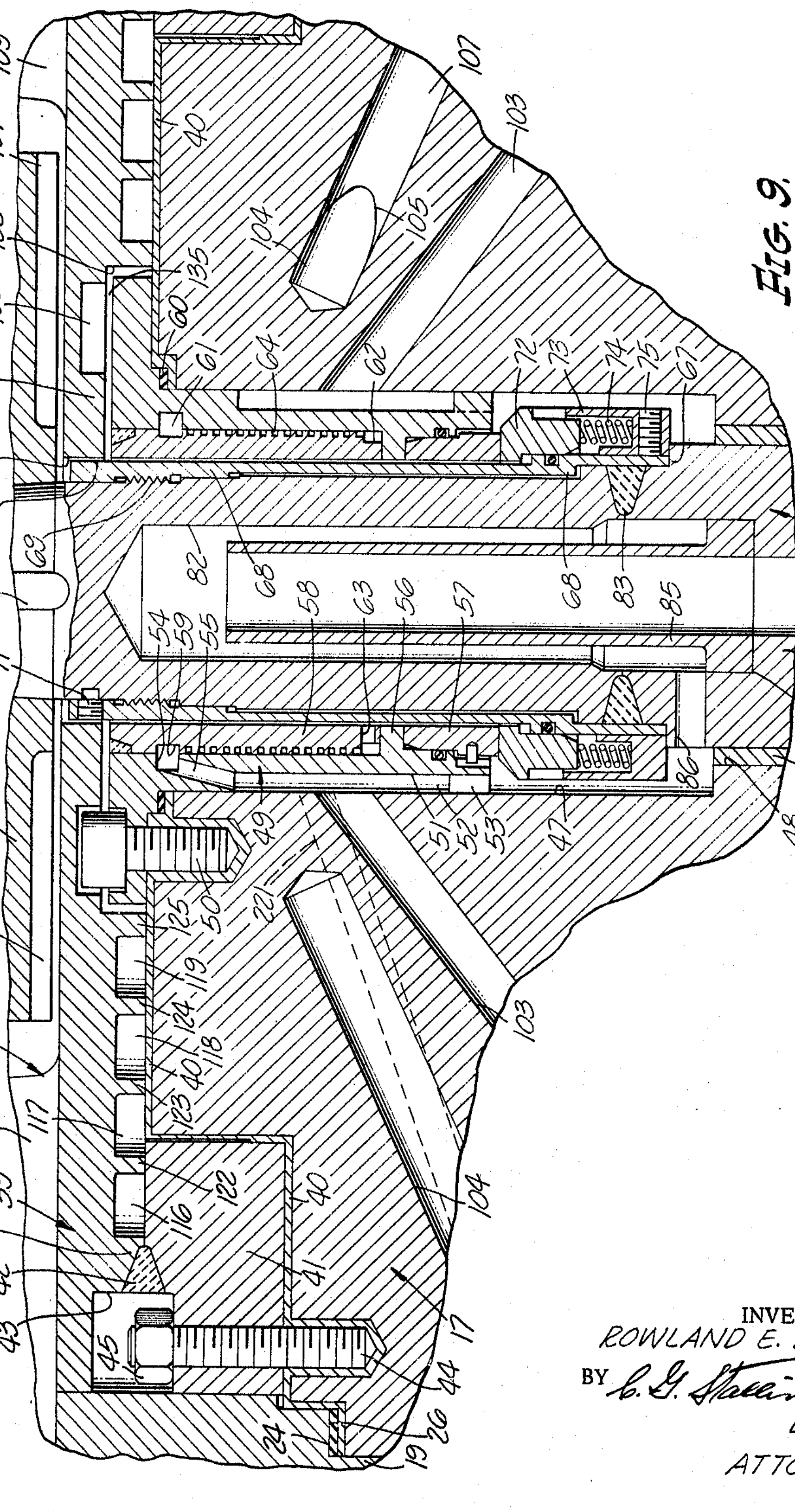

FIG. 9.

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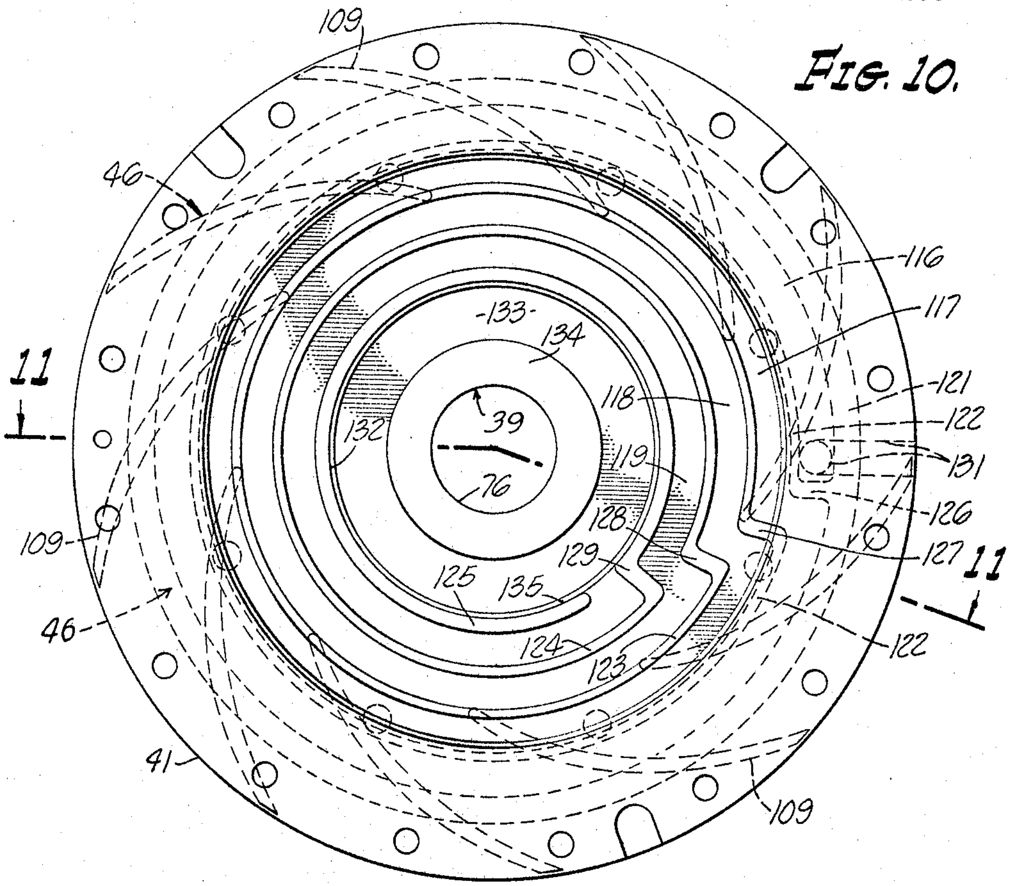
FIG. 10.



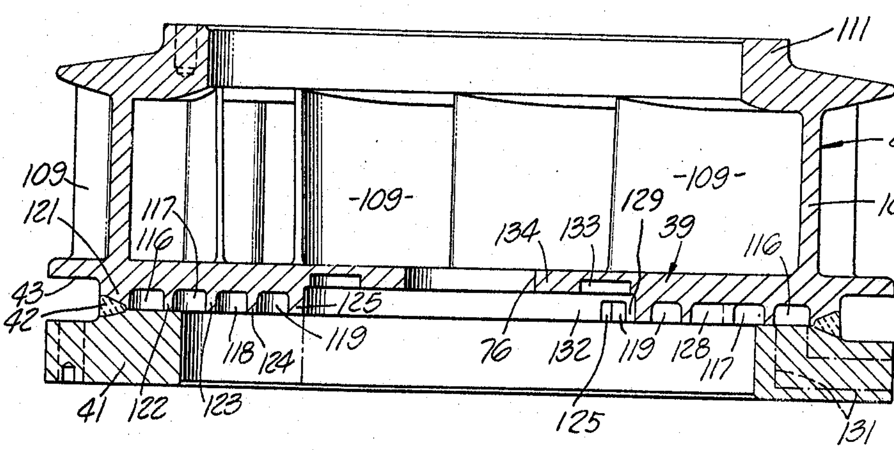


FIG. 11.

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United States Patent Office

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3,478,689
CIRCULATING PUMP

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Filed Aug. 2, 1967, Ser. No. 657,978
Int. Cl. F04d *13/06, 1/00;* H02k *9/16*
U.S. Cl. 103—87 8 Claims

ABSTRACT OF THE DISCLOSURE

The provision of a compact, unitary, combination of high pressure-high temperature hydrocarbon reactor circulating pump and an electric motor, with an improved cooling, heat repelling and heat dissipating arrangement for temperature regulation of the motor. There is also a unitary, combined thermal plate and pump diffuser removably attached to the pump cover body for facilitating assembly, service, repair, and replacement.

BACKGROUND OF THE INVENTION

This invention is primarily directed to reactor circulating pump assemblies for use in the pumping of high temperature fluids under extreme pressure conditions, such, for example, as are used in the distillation of hydrocarbons.

In the past, it has been difficult to provide a pump assembly for a high temperature-high pressure installation, including the power means which is usually an electric motor, in a compact unitary arrangement because of the difficulty of keeping the motor at a sufficiently low temperature to prevent damage due to the heat developed by the motor and that conducted to the motor from the fluid in the pump chamber. The practice has necessarily been to isolate the motor in a separate housing or at a considerable distance from the pump, thus making it a separate installation. It is desirous from both the standpoint of the pump manufacturer and the user, and especially from the standpoint of the former, to be in a position to warrant and service the entire installation as a unit, and to provide a compact, unitary assembly which can be shipped, installed, warranted and serviced as a unit. While this has not been too difficult where high temperatures and high pressures are not factors, heretofore, to applicant's knowledge, the combination of a pump and motor in such an installation has not been commercially feasible, and there exists none such that has been successful.

SUMMARY

It is an object of this invention to provide a compact combination pump and motor as a unit suitable for high temperature and high pressure use.

It is another object to provide such an arrangement wherein various improved means are combined to cool and to lubricate the motor and the shaft seal.

It is another object to provide such an arrangement wherein the cooling means for the assembly does not unduly impose on the heated fluid being pumped a cooling factor which seriously reduces the high temperature necessary for the fluid being pumped.

In this connection, it is an object to provide an arrangement whereby the charging liquid for the pump contributes to, or is used as one of the cooling means employed for, the protection of the motor.

It is a further object of the invention to provide an improved lubricating and cooling arrangement for the motor and motor shaft seals; and it is a further purpose of the invention that the lubricating arrangement for the motor also serves to lubricate the seals and bearings for the motor shaft; also that a portion of the lubricant so used is combined with that portion of the charging fluid used for cooling purposes, and the combined fluids are discharged into the pump chamber fluid in a way to prevent the buildup of contaminants between the pump impeller and the thermal plate, which would cause blockage of circulation and wear or other damage to the assembly.

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It is an object to provide an improved auxiliary pump for the pump lubricant with improved lubrication and cooling of the bearing surfaces, motor, motor shaft and other parts.

It is an object of the invention to provide an improved pump cover body between the pump and motor wherein novel cooling means are provided, using motor lubricant, pump charging fluid, and other cooling fluid such as water, and providing a novel fluid circulation arrangement and means effectively blocking the flow of excessive heat from the pump chamber to the motor.

It is a purpose to provide an improved combination of a thermal plate and pump cover body wherein both are combined to form fluid passages for cooling liquid therebetween. In this connection, applicant proposes to disclose a novel arrangement of such fluid passages, as well as the fluid passages in the pump cover body.

It is an object in this connection to provide the pump cover body with a lamina of stainless steel on top thereof, thus preventing both corrosion of the pump cover body and excessive heat transfer between the pump and the motor.

It is a further object to provide an improved water jacket for the dissipation of heat conducted from the interior of the motor housing.

It is also a purpose to disclose a sinuous flow path means for lubricant and cooling liquid across the outer circumference of the motor stator, in which the cooling lubricant travels axially across the stator several times in its cooling circulation and in which an improved "wiping" action, removing heat from the motor and transferring it to the motor housing from which it is radiated to the water jacket, is obtained.

In connection with the above, it is an object to provide an improved arrangement for the lubrication and cooling of the seal and seal area by the fluid used to lubricate the motor.

Other objects, purposes, and advantages of the invention will be hereinafter described or will become apparent to those skilled in the art and the novel features of the invention will be defined in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of a pump, motor and auxiliary pump assembly, illustrating the combination of the present invention in its preferred operating position;

FIG. 2 is a longitudinal-sectional view showing the details of construction of the device of FIG. 1;

FIG. 3 is a fragmentary longitudinal-sectional enlargement showing details of the auxiliary pump illustrated in the lower portion of FIG. 2;

FIG. 4 is a fragmentary cross-sectional view taken on the line 4—4 of FIG. 2, looking upward in the direction indicated by the arrows;

FIG. 5 is a fragmentary cross-sectional view taken on line 5—5 of FIG. 2, looking upward in the direction indicated by the arrows;

FIG. 6 is a perspective view illustrating the arrangement of oil circulation channels on the stator and the spacer sleeves to provide a flow path for cooling the motor;

FIG. 7 is a development view illustrating by projecting on a plane the surface arrangement shown as cylindrical in form in perspective in FIG. 6;

FIG. 8 is a fragmentary cross-sectional view taken on the line 8—8 of FIG. 2, looking upward in the direction indicated by the arrows, and showing primarily details of passages and the flow path of one arrangement used in cooling the assembly;

FIG. 9 is a fragmentary longitudinal-sectional enlargement of the shaft seal arrangement, pump cover body, and thermal plate shown in the upper portion of FIG. 2;

FIG. 10 is a view showing the underside of the thermal plate which is positioned between the main pump impeller and the pump cover body, and illustrating in dotted lines integral diffuser vanes; and

FIG. 11 is a vertical cross-section taken on the line **11—11** of FIG. 10, looking in the direction of the arrows.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring more in detail to the construction shown in the drawings, and referring first primarily to FIGS. 1 and 2, there is here disclosed a pump and motor combination consisting of a main pump **11**, an electric motor **12**, and an auxiliary pump **13**, all located within a housing assembly **14**.

The main pump **11** is located within the pump case **15**, which forms the upper portion of the housing assembly **14**, and the motor **12** is housed within the motor shell **16**. Between the main pump **11** and the electric motor assembly **12** there is located the pump cover body **17**, which, among its other functions, forms a portion of the housing assembly **14** along with the motor shell **16** and pump case **15**. The housing assembly **14** is completed by a bottom flange **20** and the motor shell cover **18**, which closes the lower end of the housing assembly **14** and completes the enclosure of the motor and auxiliary pump assembly.

The pump case **15** has the depending flange **19** which is drilled and threaded to receive studs **21** spaced at intervals around its circumference.

The motor shell **16** at its upper end terminates in an outwardly extending motor shell flange **22**, which is provided with holes therethrough positioned to correspond with the position of the studs **21**, whereby the flange **22** receives a stud **21** through each hole. Each of the studs **21** is threaded on its depending end and receives a nut **23** by means of which the flange **22** of the motor shell **16** may be attached to the pump case **15**.

It will be noted that the flange **19** is provided with an undercut or shoulder **24** enlarging the internal circumference, as is obvious from FIG. 2, and is also provided with a second shoulder extending radially inward a slight distance. The land formed on the underside of shoulder **24** provides a seat complementary to the land formed on the top of the pump cover body **17**. A suitable seal means, such as spiral wound gasket **26**, is inserted between the land formed by the shoulder **24** and a corresponding land on the pump cover body, whereby leakage of fluid from the pump between the pump case **15** and the pump cover body **17** is prevented. The pump cover body is also provided with a radially outwardly extending flange, as shown at **27**, on which the bottom land of the flange **19** seats. Thus, when the nuts **23** are tightened, the pump cover body will be securely clamped between the flange **22** of the motor shell and the flange **19** of the pump case.

Referring to the motor shell cover **18** at the bottom of the housing assembly, it is attached to the bottom flange **20** of the motor shell **16** by means of circumferentially spaced cap screws **28** which extend through the cover **18** and are threaded into the bottom flange **20**, as will be clearly apparent from FIGS. 1 and 2.

The motor shell cover **18** has an upwardly extending flange **32** which forms a rim that fits into the undercut in the internal diameter of the bottom flange **20**. A seal, such as O-ring seal **33**, is provided to prevent leakage of fluid around the circumference of the motor shell cover **18** at its juncture with the bottom flange **20**.

The motor shell **16**, in practice, may be made up in segments which are welded together to facilitate assembly of the mechanisms therein, of which one segment comprises the bottom flange **20**. Such welds are indicated at **29** and **31**.

Attached to the bottom flange **20** and extending into the inner diameter of said bottom flange is the bearing housing cover **34**, which serves several functions as will be apparent hereinafter. This bearing housing cover **34** is disc-shaped and has an attaching flange **35** which extends radially outward and a vertically extending flange **36**. The bearing housing cover **34** is spaced from the motor shell cover **18** to form a fluid area **37**; and the bearing housing cover **34** is attached to the bottom flange **20** by any convenient means, such as cap screws **38**, located at spaced circumferential intervals around the attaching flange **35**.

Referring to the pump cover body **17** in the upper part of FIG. 2, and positioned between the pump case **15** and the motor shell flange **22** (see also FIGS. 9, 10 and 11), there is provided a thermal plate **39**. This thermal plate **39** has a depending diffuser ring **41** which, in the example shown, is separately constructed and welded to the thermal plate **39**, as shown by the weld **42**, to form an integral subassembly. The ring **41** and the thermal plate **39** seat within the inner circumference of the pump case **15**. This arrangement is clearly evident from FIGS. 2 and 9, in particular. The ring **41** and the thermal plate **39** have their outer circumference grooved, as shown by the groove **43**, at their juncture to provide an annular opening for the receipt of threaded studs **44** which extend into threaded holes provided therefor in the pump cover body **17**. At spaced circumferential intervals, the ring flange **41** is drilled to receive studs **44**; and a nut **45** for each stud **44** is threaded to the stud to draw the thermal plate **39** and its attached diffuser ring **41** into firm engagement with the pump cover body **17**, as will be apparent from FIGS. 2 and 9.

Further, as likewise will be apparent from FIGS. 2, 9 and 11, thermal plate **39** has, preferably integrally therewith, a pump diffuser **46**, whereby said thermal plate **39**, diffuser ring **41**, and pump diffuser **46** may be removed and replaced as a unit after removal of the pump case **15**, by removal of the nuts **45**, inserting the new or serviced unit in place, and replacing and tightening the nuts **45**. In this connection, it is also sometimes necessary to service the seal areas of a pump of this character, and ease and speed of obtaining access thereto by removal of the thermal plate **39** is a real advantage and saving. Additional details of this thermal plate diffuser assembly will be explained later, especially in connection with the pump cooling and fluid circulation.

As will be noted, particularly from FIG. 9, the upper surface of the pump cover body **17** has formed thereon or attached thereto by any convenient means, such as welding, electroplating, or the like, a lamina or layer of stainless steel **40**. This serves two purposes, the principal one of which is to prevent corrosion and deterioration of the upper surface of the pump cover body **17** due to the corrosive effect of fluid. In this connection, the pump cover body **17** is ordinarily constructed of carbon steel, and pump fluids contacting this surface would normally be crude oil or oil in the process of being refined and having a temperature on the order of 500° F., containing corrosive impurities of both a chemical and physical nature. Also, the thermal plate **39** is normally made of stainless steel.

The second purpose served by the stainless steel lamina **40** is that of enhancing the heat barrier effect, since it is well known that laminations form a poor conductor for heat transfer. A possible third benefit is the strengthening effect of the stainless steel on the carbon steel pump cover body.

As best evident in FIG. 9, the pump cover body **17** is bored from the top partway down, as shown at **47**, and is then counterbored on a reduced diameter, as shown at **48**, thereby forming a stepped longitudinally extending opening through the pump cover body in the center thereof. Extending into the bore **48** from the top is a flanged element, hereinafter termed "seal housing," 49, the seal housing being held in place by one or more cap screws 50 extending through the flanged portion thereof and into the pump cover body 17, as is obvious from the drawing. A ring seal 60 is provided between the flange of the seal housing 49 and the pump cover body 17 to inhibit fluid leakage.

The seal housing 49 has a reduced outer diameter, as shown at 51, extending a substantial part of the distance between the ends of the seal housing to form a fluid chamber 52 between the seal housing 49 and the bore 47.

At its bottom end, the seal housing 49 has an outer diameter extending to the bore 47, but is provided with a series of fluid passages, such as serrations, notches or flats 53, whereby fluid in the fluid chamber 52 is in communication with the bore 47 below the end of the seal housing 49.

Near its upper end, the internal diameter of the seal housing 49 is grooved or undercut, as shown at 54. A hole 55 is drilled from the chamber 52 into the undercut 54, whereby fluid communication is established between said chamber and said undercut. The seal housing 49 has formed on its internal diameter intermediate the ends a ring flange 56 which serves as a stop for axial movement of the fixed or nonrotating seal face 57 in an upward direction.

A grooved sleeve 58 is inserted into the seal housing 49 and is attached thereto in fluid tight relation near its top in any convenient manner, such as by welding. The grooved sleeve 58 is undercut radially inwardly on its outer diameter, as shown at 59, which undercut is complementary to and mates with the undercut 54 in the seal housing to form an annular chamber 61. At its lower end, the sleeve 58 is provided with a reduced diameter to provide an annular chamber 62 between the outer circumference of the end portion of said sleeve and the inner circumference of the seal housing 49; and, as indicated at 63, a hole or opening is provided, which may be in the form of a radial slot cross the bottom land of said sleeve 58, placing the chamber 62 in fluid communication with the interior of the sleeve 58. The outer circumference of the sleeve 58 has a spiral groove 64 which extends from the chamber 62 to the chamber 61 and serves as a pressure reducing cell. In this way, fluid under pressure in the chamber 61 is caused to leak at reduced pressure into the chamber 62 and through th eslot 63, all as will be described later.

Referring to the counterbore 48, there is provided a radial sleeve bearing 65 into which extends a drive shaft 66. The bearing 65 serves to support such shaft 66 at the pump end of the assembly. This shaft 66, above the bearing 65, is reduced in diameter to provide a stop 67 for a rotary sleeve 68 which surrounds the shaft 66 and is attached thereto by any convenient means, such as by threading thereto as shown at 69. Also, the sleeve is provided with a set screw 71 which holds the sleeve 68 against rotation with respect to the shaft 66. Mounted on the sleeve 68 is rotary seal face 72, spring retainer 73, and springs 74, all attached to the rotary sleeve 68 and thus drivingly attached to the shaft 66 by means of the set screw 75, sleeve 68, and set screw 71.

The details of the seal assembly, except to the extent necessary to show the features of operation of the present disclosure are not described herein, as the seal forms the subject matter of a separate application for United States patent by Fernando G. Marrujo and Winfred J. Wiese, Ser. No. 644,214, for Mechanical Seal Assembly, filed June 7, 1967, now United States Letters Patent No. 3,447,809, issued June 3, 1969; and although this is a preferred form of seal, other seal arrangement would serve the purpose. The disclosure of the foregoing Marrujo et al. patent is incorporated herein by reference, the Marrujo et al. patent and this application being commonly owned.

It will be well to mention that the drive shaft 66 extends from the interior of the pump case 15 longitudinally through the entire housing assembly 14, terminating within the bearing housing cover 34. Further details with respect to the assembly and lower bearing support for the drive shaft 66 will be described later.

At its upper end, as will be apparent from FIGS. 2 and 9, the drive shaft 66 extends through a central shaft opening 76 in the thermal plate 39 and has mounted thereon the impeller 77 of the main pump 11, said impeller being retained in place by the threaded collar 78 which is threaded onto the end of the shaft 66, and a cap screw 79 threaded into the end of the shaft 66 and passing through the collar 78. A key 81, positioned in a key slot on the shaft 66 and a matching key slot in the hub of the impeller 77, drivingly connects the impeller 77 to the shaft 66.

The drive shaft 66, at its upper end, is drilled or formed with a longitudinally extending bore 82 terminating below the top. In actual practice, this drive shaft may be formed in sections and welded as shown at 83. The bore 82 has an enlarged diameter in the area extending from just above the weld 83 downward to a point 84, into which is inserted a flanged sleeve 85.

The drive shaft 66 has a hole 86 drilled axially from the outer circumference of shaft 66 into the bore 82 to form a passage for fluid from the bore 47 in the pump cover body 17 into the bore 82 in the shaft 66. The flanged sleeve 85 extends upwardly to the vicinity of the top of the bore 82, and fluid entering through the hole 86 from the bore 47 to the bore 82 is deflected upwardly around the upper end of the flanged sleeve 85 and flows downward through the interior of the sleeve 85, again entering the bore 82 below the bottom of the flanged sleeve 85.

The drive shaft bore 82 is continued downward for a distance which reaches a position below the bottom of said pump cover body 17; and, at a position adjacent its bottom, said bore 82 is provided with passages 87 which, in the embodiment shown here, consist of a hole drilled axially through the shaft 66 providing two passages leading from the bore 82, whereby fluid in said bore 82 may escape into the motor shell 16.

The shaft 66 is enlarged as shown at 88, and mounted thereon is the rotor 89 which is formed on and drivingly connected with the shaft 66. Beneath the enlargement 88 the shaft 66 is reduced in diameter as shown at 98 and is mounted in a sleeve bearing 91, as is clearly apparent in FIG. 2. The sleeve bearing 91, in turn, is fitted within the inner diameter of a bearing housing sleeve 92 which has an annular flange 93 near its bottom perforated at spaced intervals around its circumference to receive the cap screws 94, whereby said bearing housing sleeve 92 is attached to an inwardly extending annular flange 95 on the bottom flange 20 which forms an integral part of the housing assembly 14. Thus, the sleeve bearing 91 for the shaft is supported through the bearing housing sleeve 92 and housing assembly 14. This firmly holds the shaft 66 in place at its lower end. The shaft 66 is further reduced in diameter, as shown at 99, and extends through the auxiliary pump 13. At its bottom end, the drive shaft 66 is provided with a thrust disc nut 96 which is threaded onto said drive shaft and which is held against rotation with respect to said shaft 66 by the set screw 97.

Referring again to the pump cover body 17, and referring to FIGS. 2, 8 and 9, extending at an angle from a fluid chamber 101 formed by a counterbore in the top internal diameter of the motor shell 16, the bottom surface of the pump cover body 17 and an upper stator spacer sleeve 102, are the fluid passages 103 extending to the pump cover body bore fluid chamber 52. In actual practice, four of the fluid passages 103 connect the chamber 101 to the chamber 52. It may be noted that oil for cooling and lubrication flows upwardly through said passages **103** for lubricating the seal and for other purposes. This will be clarified later in the description.

Also, as will be clear from FIG. 8, what may be referred to as a pump cover body water conduit circuit is provided, comprising a series of holes **104** drilled at circumferentially spaced intervals from the circumference generally toward the center of the pump cover body, preferably at an upward angle. Each of these holes intersects another of the holes as shown at **105** (FIG. 8), the arrangement being such that the holes may be said to be in pairs, so that each pair of holes connects into the contiguous pair at their inner ends. Also, except for the inlet and discharge holes, each pair of holes is connected by a fluid passage **106** at its radially outer ends. One hole of the series is tapped to receive a fluid conduit (not shown) and forms an inlet **107** whereby fluid, usually cold water, is introduced into the circuit; and another hole is tapped to receive a drain connection and forms an outlet **108** for discharge of fluid from the circuit. Thus, fluid, such as cold water, is introduced through the inlet **107**, travels to what may be termed the radially inner end of the inlet hole **107** to the intersection **105**, and then back radially outward through the first connecting hole **104**, through the fluid passage **106**, into the next circumferentially spaced hole **104** and so on, through the entire circumferential arrangement to the discharge **108**. By this means, cooling water is enabled to travel through the pump case body in what may be termed a zigzag manner and in such a way as to exert maximum cooling effect and efficiently dissipate substantially all of the heat from the pump cover body before it can reach the motor. This is extremely important since the temperature in the main pump may be on the order of 850° F., which temperature must be reduced before it reaches the electric motor so that the latter will be maintained at, for example, 110° F. to 150° F., to prevent damage to the motor windings, which must ordinarily not exceed 150° C.

Referring next primarily to FIGS. 10 and 11, and reference still being had to FIGS. 2 and 9, the construction of the thermal plate **39** with its integral diffuser **46** is considered unique and important, both from a service standpoint and as an improved heat barrier, in the construction of a pump motor combination, such as that disclosed herein, whereby the motor assembly **12** may be located in the same housing assembly **14** and in close relationship to the pump assembly **11** for the pumping of extremely hot, corosive fluids, while aiding in maintaining the temperature of the motor **12** within safe limits to prevent damage thereto. This thermal plate **39** has, as mentioned previously, the integral pump diffuser **46** which is preferably formed integrally therewith. The diffuser **46** in the arrangement indicated has a series of vertical curved vanes **109** spaced around the circumference and an annular integral ring **111**, which ring surrounds the inlet port **115** for the main pump **11**. The diffuser vanes **109** form the fluid flow path of liquid discharged from the main pump impeller **77**. As is apparent from FIG. 2, a wear ring **112** fits over the annular ring **111** and is attached thereto by a series of cap screws **113**. The wear ring **112** extends downward into the internal circumference of the annular ring **111** and receives an inlet conduit **115** by means of which the fluid to be pumped reaches the main impeller **77**. The impeller blades **114** of the main impeller are joined to an impeller ring **120** at their upper edges, in the well known manner.

On its underside, the thermal plate **39** is provided with a series of what may be termed partially annular concentric grooves, **116**, **117**, **118** and **119**, formed by the outer depending rim flange **121**, and the depending spaced ridges **122**, **123**, **124** and **125**, which ridges are concentric with the rim flange **121** but extend circumferentially to a short distance less than a full 360°. At the end of each ridges (except the innermost, **125**) a barrier or fluid diverter is provided extending radially inwardly across the adjacent, radially inward groove. In the arrangement

of FIG. 10, the groove **116** has the barrier **126** which extends radially inwardly from the rim flange **121** to the ridge **122**; the groove **117** has the barrier **127** which extends from the ridge **122** to the ridge **123**; the groove **118** has the barrier **128** which extends from the ridge **123** to the ridge **124**; and the groove **119** has the barrier **129** which extends from the ridge **124** to the ridge **125**.

When the diffuser ring **41** is attached, as pointed out earlier, to the thermal plate **39**, it forms a bottom closure for groove **116** and thus completes a fluid passage; and when the pump cover body **17** is attached, it forms a bottom closure for the remaining grooves **117**, **118** and **119**, to make them into fluid passages. Since the ridges **122**, **123**, **124**, **125** terminate short of a full circle, each passage **116**, **117**, **118** thus opens into the next radially inward passage **117**, **118**, **119**, so that a flow path for fluid, spiral-like in arrangement, is created. Although the above indicated grooves **116**, **117**, **118**, **119** are more easily manufactured, and are believed to be more efficient, actually a series of spiral grooves or possibly other shapes would serve the purpose. The series of passages including grooves **116**, **117**, **118** and **119**, the hereinafter described inlet **131**, concentric channel **133**, fluid chamber **135**, and annular space **136**, may be herein collectively referred to as the "thermal plate cooling system." The passage described as groove **116** has a fluid inlet provided by the right-angle inlet bore **131** through the diffuser ring **41**. This bore **131** is preferably connected to the source of fluid used to charge the main pump **11**. As contemplated here, this will comprise crude oil, possibly at as much as 500° F. temperature.

The underside of the thermal plate **39** has an enlarged, upwardly extending bore **132** concentric with the shaft opening **76** and extending upwardly a distance somewhat above the upper extent of the grooves **116–119**, and the top of the bore **132** has an upwardly extending concentric channel **133**. The radially inner side of the channel **133** comprises the outer periphery of the depending ring flange **134** which extends in width from the channel **133** to the shaft opening **76**.

As will be obvious from FIGS. 2 and 9, particularly the latter, when the thermal plate **39** is in place, the heads of cap screws **50**, which fasten the flange of the seal housing **49** to the pump cover body **17**, extend into the channel **133**. Further, the flange of the seal housing **49** is spaced a short distance from the bottom of the bore **132** and also is located radially inward from the side of said bore **132**, whereby the fluid chamber **135** is created which leads through the channel **133**, across the top of the flange of the seal housing **49**, across the top of the grooved sleeve **58**, and discharges into the annular space **136** between the sleeve **68** and the grooved sleeve **58**. At the intersection of said fluid chamber **135** with the annular space **136**, fluid is caused to flow through the shaft opening **76** where it is discharged between the impeller **77** and the thermal plate **39**. It will be picked up by vanes **137** on the bottom of the impeller **77** and mixed into the fluid in the main pump **11** from where it is discharged into the diffuser **46**. It should be noted that fluid from the groove **119** enters the fluid chamber **135**, past the end of the ridge **125** which terminates short of the barrier **129**, as above described. Thus, fluid entering the inlet bore **131** is picked up by the groove **116**, proceeds into grooves **117**, **118** and **119**, is discharged into the fluid chamber **35**, flows through the channel **133**, across the top of the flange of the seal housing **49** and grooved sleeve **58** beneath the bottom of the ring flange **134**, into the annular space **136**, upwardly around the shaft **66** through the shaft opening **76**, and outwardly beneath the impeller **77** where it is picked up and discharged by the vanes **137** on the bottom of said impeller. At the discharge of the fluid from the chamber **135** into the annular space **136**, fluid from said annular space is mixed with a relatively small amount of seal lubricating fluid from charged beneath the impeller **77**. Since the fluid entering the motor lubrication system, and the mixture is dis- the inlet 131 is usually fluid taken from the source for the main pump inlet 16, it may have physical (such as "fines" from a catalyst) and chemical impurities. It is desirable that there be a flushing action created which includes some motor oil to keep the lubricant passages clear and prevent the building up of harmful deposits beneath the main impeller 77 which could cause blockage and/or consequent wear to that impeller and the thermal plate 39. The temperature of the fluid entering through inlet 131 may, as mentioned above, be on the order of 500° F., and, in the example shown herein, it is contemplated that the flow would be possibly 25 gallons per minute. Such fluid flowing through the grooves 116, 117, 118, 119, as above-mentioned, will thus normally be several hundred degrees lower in temperature than the fluid in the main pump chamber 15 and thus will cause a considerable cooling before the heat from the main pump chamber reaches the pump cover body 17.

Referring next to the auxiliary pump construction and various lubricating passages, and referring particularly to FIGS. 3 and 4, with occasional reference to FIG. 2, the drive shaft 66 has attached thereto at the reduced shaft diameter 99 a thrust disc 138 which, in the example shown here, is attached to the shaft by means of the key 139. Thus, the thrust disc 138 rotates with the shaft 66.

On each side of the thrust disc 138 is located a thrust bearing shoe, here shown as the upper and lower thrust bearing shoes 141 and 142, respectively. These shoes are preferably segmental in form and loosely inserted so that they may tilt for proper alignment and to compensate for distortion, etc. These shoes are free to "float," but do not rotate with the shaft 66. As shown in connection with shoe 141, each shoe has a button 143, which is also true (but not shown) for the shoe 142. These buttons 143 are loosely fastened to their respective shoes 141 and 142 by any convenient means (not shown), and the button for each shoe engages a corresponding leveling plate, of which the leveling plate 144 is shown. These leveling plates are positioned in an annular ring 145 and held loosely therein by means of a screw 146 which extends through the ring 145 and into an aperture provided on the outer surface of the leveling plate. A similar arrangement applies, although not shown, to annular ring 147. This construction will be clear from FIG. 3.

The leveling plates 144 are alternated in the annular rings 145 and 147 with rocker plates 148, one of which is shown in the ring 147, which rocker plates 148 are each loosely attached to the respective rings 147 and 145 by means of dowel pins 149. By this means, the parts comprise a rather loose, self-adjustable assembly in which the shoes 141 and 142 are free to tilt, and wherein the lubricating fluid between the thrust disc 138 and the shoes 141 and 142 builds up, by what may be termed a wedging action, a lubricating and self-adjusting support between said parts which is relatively free of friction. It is noted that because of the segmental construction of the shoes 141, 142 and associated parts, oil for lubrication and cooling can flow therearound with facility.

The thrust disc 138, upper and lower thrust bearing shoes 141 and 142, buttons 143, leveling plates 144 plates 148, and rings 145 and 147 comprise a form of Kingsbury-type thrust bearing (see United States Letters Patent No. 1,378,544, issued May 17, 1921), which is well known and has been commercially available. The description herein is primarily in order that the fluid flow forming a feature of this invention may be clearly evident when hereafter described.

Mounted on the thrust disc 138 is a ring-type impeller 151. This impeller is drivingly attached to the thrust disc 138 by means of a Woodruff key 152. A pump ring 153 is attached to the bearing housing sleeve 92 by any convenient means (not shown), and the pump ring 154 is attached to the bearing housing cover 34 by means of one or more screws 155. These pump rings form the side walls of the impeller chamber and, as will be apparent from FIGS. 3 and 4, are each undercut as shown at 156 and 157 to form with a mating groove 158 in the bottom flange 20 an inlet chamber 159 for fluid to be pumped. It is noted that the thrust disc 138 is grooved circumferentially on either side of the impeller 151, and retainer rings 161 and 162 hold the impeller against sidewise movement of a sufficient amount to cause it to bind on either pump ring 153 or 154.

The pump is provided with a discharge chamber 163, shown partly in dotted lines in FIG. 3 and in full lines in FIG. 4. From the chamber 163, on each side of the impeller 151, there is provided a fluid passage in the form of a hole 164 drilled through the pump ring 153 and a hole 165 drilled through the pump ring 154 between the discharge chamber 163 and the annular fluid chambers 166 and 167, respectively. By this means, fluid from the pump discharge chamber 163 enters the annular chambers 166 and 167. The principal portion of the discharged fluid from the pump passes outward from 163 and enters a conduit 168 formed by drilling downwardly from the upper surface of the bottom flange 20 to intersect said discharge chamber 163.

The bottom flange 20 also has a port 169 drilled from its upper surface through the flange and intersecting the inlet chamber 159. The bearing housing cover 34 has a mating hole 171 drilled in its outer flange and positioned to mate with the port 169 of the bottom flange, whereby fluid from the fluid area 37 may flow into the pump inlet 159 and also fluid from the motor chamber at the top of the bottom flange 20 may flow into said pump inlet 159.

The motor shell cover 18 has a fluid opening 172 therethrough leading into the fluid area 37, whereby a supply of lubricant fluid may be constantly furnished to the interior of the housing assembly 14.

As will be apparent from FIG. 2, the fluid opening 172 in the motor shell cover 18 connects to a source of lubricating oil for replacing fluid lost from the circuit so there is a constant supply for lubricating and cooling the motor assembly, seal, etc.; and a check valve 173 (indicated only diagrammatically) is preferably provided to control the flow of such oil into the housing assembly 14 and to prevent its flow from the fluid area 37 in a reverse direction.

The bearing housing cover 34 has its bottom perforated by means of a drilled hole or the like 174, thus placing the interior of the bearing housing cover in fluid communication with the fluid area 37.

It will be noted from FIG. 3 particularly, that the conduit 168 from the discharge of the auxiliary pump impeller 151 is in fluid communication with the exterior of the lower spacer sleeve 175, as will be described hereafter.

Referring to FIGS. 5, 6 and 7, the construction of the stator 176, the upper stator spacer sleeve 102 and the lower stator spacer sleeve 175 are illustrated more in detail, reference also being had to FIG. 2 to illustrate their installation in the motor assembly. As shown in the latter figure, the stator 176 has end windings 177 and 178, the windings 177 being located at the lower end of the stator and the windings 178 being located at the upper end of the stator.

The stator 176 is composed of a series of laminations in the usual manner which are notched about their peripheries with aligned notches to provide stator ridges 179 extending transversely across the stator assembly and the stator grooves 181 between the stator ridges 179. As is clearly apparent from FIG. 6, there is thereby created a series of alternate channels and ridges; and when the stator is press-fitted into the motor shell 16 there is thus formed a series of passages or fluid flow paths axially on the outer circumference of the stator. As mentioned, the stator 176 is, in production, ordinarily press-fitted or shrink-fitted into the motor shell 16 so that the outer lands of the stator ridges 179 engage the motor shell 16 and hold the stator firmly in place and properly aligned and provide such fluid flow paths whereby heat from the motor will be dissipated by fluid in said axial flow path across the stator which, in turn, conducts heat through the motor shell **16**.

The electrical conduit **182** for the electrical terminal connections (not shown) to the end windings **177** contains the wiring to the terminal studs or lead-in connections **183, 184** and **185** (see FIG. 5) collected for protection thereof and these, in turn, as shown in FIG. 2, lead to the junction box **186**. Since the electrical connections are unimportant for this disclosure, no further reference need be made thereto. It may b state that, as contemplated, the electric motor **12** is a three-phase 440 volt motor.

Referring again to FIGS. 2, 3, 5, 6 and 7, the sleeve **175** has, on the radially outer surface thereof, a raised base land **187** which extends, in the example shown, four-fifths of the circumference at the base, leaving one-fifth of its outer surface without the base land. One end of said base land **187** is provided with an upwardly extending raised land or ridge **188**, and the other end is provided with a similar ridge **189**. Intermediate the ridge **188** and the ridge **189** is another upwardly extending ridge **191**. In each instance, these ridges **188, 189** and **191** extend from the base land **187** to the top of the spacer sleeve. Further, each of these ridges is preferably the same circumferential width as the stator ridges **179** of the stator **176** and are positioned, when the spacer sleeve **175** is in place, to mate with a stator ridge **179** as shown at **192**.

The spacer sleeve **175** (see FIG. 3) at its bottom has an inwardly extending flange portion **193** which, in turn, has an annular depending ring flange **194**. The spacer sleeve **175** is, as was the case with the stator **176** shrink-fitted into the motor shell **16** with the base land **187** and ridges **188, 189** and **191** engaging the inner circumference of the motor shell **16**. The spacer sleeve **175** is attached to the bottom flange **20** by any convenient means, such as by the weld **195**.

The upper stator spacer sleeve **102** is similarly constructed insofar as its outer circumference is concerned to the spacer sleeve **175**, with the top land **196** extending four-fifths of the circumference and forming a rim around the top for said four-fiifths of the distance. The raised ridges **197, 198** and **199** extend from the top land **196**, the ridge **197** extending downwardly from one end of said land and the ridge **198** from the other end of said land.

As is evident, the top land **196** does not extend between the ridges **197** and **198**, whereas, as mentioned above, the base land **187** does not extend between the ridges **188** and **189**. Accordingly, fluid entering the space, herein designated as space **201**, between the lower spacer sleeve **175** and the motor shell **16**, between the ridges **188** and **189**, is conducted through the passages, here designated **202** (that is, over the stator grooves **181**, between the stator ridges **179**), and into the conduit space **203** which extends from the raised ridge **198** to the raised ridge **199** across the top of the stator. Such fluid will then be directed in a reverse path through similar stator passages **204** into the bottom conduit space **205** which extends from the ridge **188** to the ridge **191** across the bottom edge of the stator. From there the fluid will again reverse its path and flow through the stator passages **206** into the second top conduit space **207** which extends from the raised ridge **199** to the ridge **197**. From the second top conduit space **207** the fluid will flow through the stator passages **208** into the second bottom conduit space **209** which extends from the raised ridge **191** to the raised ridge **189**. From the second bottom conduit space **209** the fluid will flow through the stator passages **211** into the discharge space **212** which extends between the raised ridges **197** and **198**. The series of stator passages **202, 204, 206, 208** and **211** in the example shown consists of ten passages for each series although, of course, the number may be varied. It is obvious that fluid entering the space **201** will thus travel in zigzag fashion in what may be called a sinuous flow pattern in completing its trip around the complete circumference of the stator, traveling axially across the stator in the example shown five times, thereby efficiently performing its cooling function. The stator **176** and top and bottom sleeve **102, 175** in assembly may thus be referred to as comprising a "sinuous stator cooling fluid flow path."

As will be clear from FIGS. 2 and 3, the entrance space **201** is open to fluid from the auxiliary pump flowing from the conduit **168**. In the example shown, this fluid is maintained at a pressure exceeding that existing at the main pump impeller **77**, preferably the differential being about 250 p.s.i. Thus, the pressure in the motor cavities **214** and **216** may be approximately 2,750 p.s.i., while that in the main impeller suction area would be about 2,500 p.s.i.

At its upper end (see FIGS. 2 and 9), the discharge space **212** opens into the fluid chamber **101** which, in turn, supplies fluid to the fluid passages **103** from where it enters the fluid chamber **52**, a portion serving to lubricate the seal faces **57, 72** and a second portion passing through the hole **55** into annular chamber **61** and through the pressure and flow reducing spiral groove **64** and slot **63** into annular space **136** where it mixes with the leakage across the seal faces **57** and **72**, then is mixed with fluid from the passage **135** and is discharged through the shaft opening **76** beneath the main impeller **77**, picked up by the vanes **137** on the bottom thereof, mixed with the main pump discharge and leaves the assembly by way of the pump outlet **213**. In the example shown, perhaps two gallons per minute of lubricating fluid is mixed with the fluid from passage **135**.

The remainder of the fluid from the fluid chamber **52** passes over the seal and through the hole **86** into the bore **82** in the drive shaft **66**, passes through the flanged sleeve **85** and out the passages **87** into the upper motor cavity **214**, through the clearance space **215** between the rotor and the stator and into the lower motor cavity **216** below the motor. From the lower motor cavity **216** where it performs the function of lubricating the sleeve bearing **91**, the fluid enters the port **169** (see FIG. 3) and returns to the inlet chamber **159** of the auxiliary pump **13** to be recycle.

It is also noted that the auxiliary pump **13** creates a pair of ancillary fluid circuits to supply lubrication and fluid primarily to the Kingsbury-type bearing assembly. As described heretofore, the pump rings **153** and **154** have outlet ports **164** and **165**, respectively. The port **164** conducts fluid from the discharge chamber **163** into the fluid chamber **166** from where the fluid flows around the elements of the Kingsbury-type bearing assembly and between the upper thrust bearing shoe **141** and the thrust disc **138**, into the space formed by the clearance between the upper thrust bearing shoe **141** and the drive shaft **66**, along the internal diameter of the bearing housing sleeve **92** and out the port **217** into the lower motor cavity **216**, from where it flows through the port **169** into the inlet chamber **159** to the auxiliary impeller **151**. Likewise, fluid from the discharge chamber **163** flows through the hole **165** in the pump ring **154** into the fluid chamber **167** and from there through the Kingsbury-type bearing elements and also across the bottom face of the trust disc **138**, into the annular space **218** below the drive shaft **66** and inside of the bearing housing cover **34**. From the annular space **218** the fluid flows through the hole **174** from where it enters the fluid area **37**. In the fluid area **37** it comingles with freshly supplied fluid through the fluid opening **172**, enters the mating hole **171**, passes through the port **169** into the inlet chamber **159** of the auxiliary pump where it is again picked up by the impeller **151**.

Thus these two circuits, which may be described as the ancillary lubricating circuits, constantly supply fluid to the Kingsbury-type bearing elements and other auxiliary pump parts. It is noted that the sleeve bearing **91** also receive lubrication from the first-mentioned ancillary fluid circuit, as well as from the fluid present in the lower motor cavity **216**.

In connection with the initial supply of lubricating fluid to the auxiliary pump **13** and thus to the fluid circuits for the motor **12** and seal as above described, there is preferably provided an air-bleed **221** which, as is indicated in dotted lines in FIGS. 2, 8 and 9, extends into the fluid chamber **52** whereby the system may be initially filled without entrapped air being a problem. Of course, any relatively small amount of air will work its way through the groove **64** and out through the shaft opening **76**.

For the purpose of removing fluid from the main pump **11** when it is desired to disassemble the system, or for other reasons, there is provided a drain **222**. This drain is shown only in FIG. 1, as it is not important for the disclosure herein.

To assist in removing heat from the motor area and maintaining the desired temperature, an improved heat exchange arrangement is provided. As evident from FIG. 2, this comprises a heat exchange shell **223** surrounding the exterior of the motor shell **16** and spaced therefrom, and attached at its upper end by any suitable means, such as welding, to the bottom of the motor shell flange **22**. At its bottom end, the shell is attached to a weld ring **224** which is welded or otherwise attached to the motor shell **16**. The heat exchange shell **223** is spaced from the motor shell **16**, and there is located in said space a spiral tube **225**. At its bottom end, the spiral tube **225** is opened to the interior of the water jacket thus formed, and at its top end is similarly opened. Thus, both the entrance and exit of the spiral tube are within the water jacket, and any fluid flowing through said tube is derived from fluid entering the water jacket. It is noted that the convolutions of the spiral tube **225** are preferably spaced so that water may flow upward in the areas between said tube convolutions, whereby such water or other fluid travels in a spiral path around and around the motor shell **16**.

At its upper end, the water exits through a discharge port **226** formed by drilling a substantially vertical hole in said flange **22** for a short distance above said water jacket and drilling a radial hole intersecting said vertical hole. The water jacket has an inlet **227** whereby water under pressure can be introduced into the interior. It is noted that this water jacket is of an unusual nature in that two flow paths, one through the tube and one around the convolutions of the tube, are created, both of which have a common inlet **227** and a common discharge **226**. This assists in obtaining a more thorough contact and movement of the water with respect to the motor shell **16**, whereby heat is more effectively removed from the motor area. The water jacket is ordinarily attached to a source of water under pressure, such as a city water main, and cold water is thus passed through the water jacket and over the motor shell **16**. Since the fluid flow of the lubricating and cooling fluid in the motor **12** is initially channeled against the shell **16** by reason of the sinuous stator cooling fluid flow path as above described, said lubricating and cooling fluid is constantly cooled by the water jacket fluid circulation.

OPERATION

To recapitulate the more important aspects of the assembly, especially with respect to the improved means for servicing certain critical parts, and also to emphasize the cooling and heat control features, it is noted that the pump case **15** is essentially a pressure vessel and that the reactor vessel to which the pump is connected may, by proper design, have provision for receiving the main impeller **77**, and diffuser **46**, with provision for attaching by means of studs similar to the studs **21**, or otherwise, the remainder of the assembly. However, for the purposes of this description, it is assumed that the arrangement in such event would be the equivalent of the pump case **15**.

Although the assembly herein described may be filled with lubricating fluid before the pump cover body **17** is placed in position, provision has been made for a supply of lubricant under pressure through the check valve **173**, in which event the filling would be expedited by bleeding off the excess air through the air-bleed **221**. Any remaining entrapped air above the radially inner end of the air-bleed **221** would normally find its way out of the assembly through the shaft opening **76**.

The inlet bore **131** is preferably attached to the source (not shown) of charging liquid to be pumped. Due to the desirability in this type of pump that the liquid entering the inlet bore **131** be relatively hot, such liquid can be obtained by providing a bypass from the source of liquid used in charging the main pump **11**. It is believed that a disclosure of such bypass is unnecessary here for the reason that it is a relatively simple matter to provide such a bypass, it being understood that such a liquid is from the charging source for the main pump **11** and after it is mixed with fluids from the seals and pressure reducing spiral **64** in the space **136**, will be at a pressure slightly above that in the main pump chamber beneath the impeller **77** when discharged through the shaft opening **76**. The pressure at **76** beneath the impeller **77** will be less than that existing in the main pump chamber for the reason that the bottom vanes **137** exhaust the fluid from the area of the shaft opening **76**. In the normal course and for the type of use disclosed herein, fluid entering the inlet bore **131** would be at a fairly high temperature, for example 500° F., and at a pressure about that of the main pump suction pressure—that is, for example, 2,500 pounds per square inch.

Since the temperature normally existing in the main pump **11** is somewhat higher than the temperature of the fluid entering the inlet bore **131**—the former being perhaps 750° F., and the latter 500° F.—the fluid flowing through the inlet bore **131** and from there through the passages **116**, **117**, **118** and **119** will have a tempering effect on any heat conducted into the thermal plate **39**. On the other hand, such fluid escapes through the shaft opening **76** into the main pump chamber underneath the impeller **77** after having previously been mixed with the comparatively small amount of lubricant leaking through the seal, that is, across the faces of the fixed seal face **57** and rotary seal face **72**. Such fluid, because it is fairly high in temperature even after the mixing occurs, does not unduly lower the temperature in the pump chamber, a condition which would be intolerable. This flow of fluid through the shaft opening **76** may be on the order of, for example, 25 gallons per minute and is sufficient to flush out any impurities, such as fines, which would otherwise tend to pile up under the main impeller **77** and block the flow of the fluid from the passages **116**, etc., and also, perhaps more important, interfere with the flow of lubricant across the seal faces, with consequent damage to the seals. The fluid escaping through the shaft opening **76** is picked up by the impeller blades **137** and carried into the liquid being pumped by the main pump **11**. It is noted that this just above-described fluid flow does materially reduce heat escaping by conduction through the thermal plate **39**, and the shape of the flow path due to the novel arrangement of the passages **116**, **117**, **118**, **119**, **135** and **133** does cause a very effective surface contact with the thermal plate **39**, whereby the areas below the thermal plate receive very little conducted heat from the pump chamber.

Effectively assisting the retardation of heat conduction is the stainless steel lamina **40** which forms the bottom of the channels or grooves **117**, **118** and **119**, and which extends across the top of the pump cover body **17**. Such stainless steel has the property of deflecting heat, prevents corrosion of the top of the pump cover body **17**, and adds an insulating means due to its laminated characteristic. Thus it is noted that relatively hot fluid enters the inlet bore **131**, travels through the channels **116**, **117**, **118** and

119, and into the fluid chamber 135 and concentric channels 133, in what may be termed a generally spiral path, into the annular space 136, there mixes with any lubricant present due to leakage across the seal faces of lubricating fluid, and is discharged into the main pump chamber through the shaft opening 76. This circulation forms what may be referred to as the circulation for the "thermal plate cooling system."

The pump cover body 17, in turn, has provision for both circulation of a cooling fluid such as cold water in a zigzag course, radially and circumferentially, and also provision for the passage of the motor lubricant from the motor lubricant circulating system to the seal areas, from where it is returned through the motor drive shaft 66 back to the motor housing. Such zigzag cooling passages and motor lubricant passages may be collectively referred to as the pump cover body fluid means, it being understood that the latter mentioned motor lubricant passages form a portion also of the motor cooling and seal lubricating system.

With respect to what may be referred to as the pump cover body water circulating means, as described above, the inlet 107 is connected to a cold water source, such as a city water system. Of course, an independent source of any cooling fluid would serve the purpose, but for this description the reference will be to a cold water source. The inlet 107, as described above, extends in a generally radial direction inward to where it intersects the hole 104 at the intersection 105, and the water then flows radially outward into the fluid passage 106 and then in a generally radially inwardly direction through the adjacent hole 104, and continues similarly in a zigzag fashion around and through the pump cover body 17 to the fluid outlet 108 where it is discharged in any convenient manner. It is contemplated that this zigzag water flow arrangement will remove most of the heat entering the pump cover body 17 and will reduce the temperature to below that which would be harmful to the motor 12.

The fluid passages 103 for the lubricating oil from the motor lubricating system to the seals will be tempered by the pump cover body 17 temperature, removing any heat above that of the lubricating oil or, if the lubricating oil is warmer than the pump cover body 17 at the position of the fluid passages 103, will release the excess heat into the pump cover body where at least a portion of it is removed by the water circulation system above described.

The motor and seal lubrication system has previously been described in connection with separate portions of the assembly. It is noted that lubricating fluid is introduced into the system through check valve 173 and fluid opening 172 under pressure greater than the suction pressure of the main pump 11, for example, 250 p.s.i. over the suction pressure of the main pump, and this check valve prevents any reverse flow of the lubricating fluid. From the fluid opening 172 the lubricant flows into the fluid area 37, through the mating hole 171 into the inlet chamber 159 of the auxiliary pump assembly 13. Here it is picked up by the impeller 151 and carried into the discharge chamber 163 where it is split into three circuits, two of them 164, 165 for lubricating the Kingsbury-type bearing assembly and shaft bearing (from where the fluid finds its way back into the auxiliary pump inlet 159), but the main discharge going to the conduit 168. Here the fluid enters the space 201 of the lower spacer sleeve 175 and accelerates through the passages 202 (because of restrictions) of the stator 176 where it picks up any motor heat and conducts heat to the motor shell 16 which is cooled by the water jacket.

From the passages 202 the lubricant enters the conduit space 203 where it is diverted into the passages 204, making a second pass axilially across the stator 176. From the passages 204 the lubricant is discharged into the bottom conduit space 205 where it is again diverted axially across the stator through the passages 206. The lubricant is discharged from the passages 206 into the second top conduit space 207 and is again diverted axially across the stator through the passages 208 and into the second bottom conduit space 209. From the space 209 the lubricant passes through the stator passages 211 into the discharge space 212, having made five axial passes across the stator, picking up motor heat and conducting at least some of said heat through the motor shell 16.

The discharge space 212 discharges into the annular fluid chamber 101 from where the fluid is conducted by the fluid passages 103 (in the example given here, four in number) into the fluid chamber 52 of the pump cover body 17. From the fluid chamber 52 a restricted amount of the lubricant flows through the hole 55 into the annular chamber 61, through the spiral groove 64 into a second annular chamber 62. From there it goes through the slot 63 into the annular space 136 where it mixes with fluid from the above-described "thermal plate cooling system" from the fluid chamber 135 and is discharged beneath the main pump impeller 77 through the shaft opening 76. The remainder of the fluid flows over the seals, a minute portion going across the seal faces for lubricating and cooling them, but the main portion being discharged through the hole 86 into the shaft bore 82 from where it flows through the flanged sleeve 85 into passages 87 which, in turn, conduct the fluid into the upper motor cavity 214.

From the upper motor cavity 214 the fluid passes between the stator 176 and the rotor 89 in the clearance space 215 and into the lower motor cavity 216. From the lower motor cavity 216 the fluid is returned to the auxiliary pump 13 through the inlet chamber 159 from where it starts its circuit again.

It will thus be seen that the motor lubrication system, which is also the seal lubrication system, very efficiently cools and lubricates the motor area and seals. Fluid lost through the shaft opening 76 is replaced by fluid through the check valve 173 and, in the example given, amounts to two or more gallons per minute.

The water cooling jacket for the motor shell 16 is attached to a suitable source of water or other cooling fluid (not shown) by means of the inlet 227, and the water flows around the coils 225 through the outlet 226. Also, the coils are open at each end in the water jacket and will pick up water for flow through the coils from that present in the water jacket, thus giving a spiral effect to the water flow and furnishing a double path, very efficient arrangement which will remove a major portion of the heat from the motor area and retain the motor 12 at not to exceed its maximum operating temperature.

There has thus been described a combination cooling system involving the "thermal plate cooling system," the zigzag water cooling system in the pump cover 17, the motor and seal cooling and lubricating system, and the water jacket system for cooling the motor shell 16. These systems are interrelated and coordinated to maintain the temperature of the motor 12 at its proper level, to lubricate and cool the seals, and, at the same time, deter the flow of heat from the main pump 11 to the motor while not seriously reducing the heat in the main pump chamber.

It may be noted that the pump and motor assembly herein is provided with a very efficient and advantageous means for servicing and assembly. The motor shell 16, motor shaft 66, pump cover body 17, thermal plate 39 and its integral pump diffuser 46, and impeller 77 may be removed from the pump case 15 by removal of the nuts 23. The impeller may be removed by removal of the cap screw 79 and threaded collar 78. When this has been done, the thermal plate 39 is removed by removing the nuts 45; and removal of the thermal plate automatically removes its integral pump diffuser 46, allowing full access for service thereto. A replacement thermal plate—the thermal plate and integral pump diffuser are subject to considerable wear and sometimes need replacement—may be placed in position and the parts reassembled in the reverse order from that described for disassembly.

After the thermal plate has been removed, the seal area may be removed for repair and replacement by removing the cap screws **50**. Thus, it is easy to obtain access to the seal area without removing the pump cover body **17**. However, should access be needed to the motor, the pump cover body **17** can be lifted from the assembly when the nuts **23**, which hold the pump case **15** assembled to the flange **22** on the motor shell **16**, have been removed. Thus, ready access can be had to either the motor or the seal area.

The auxiliary pump assembly **13** is equally accessible to entry for repair and replacement by removal of the motor shell cover **18** and bearing housing cover **34**.

It is believed that a very compact, efficient and easily serviceable arrangement, which is novel and an improvement over prior structures, has been provided.

While the specific details of the invention have been herein shown and described, changes and alterations may be made without departing from the spirit of the invention.

I claim:

1. A compact, unitary, pump and motor assembly for pumping high pressure-high temperature fluids, such as for processing hydrocarbons in a reactor circulating system, comprising in combination in a housing assembly:

(a) container means comprising a pump case containing a fluid at high temperature and under high pressure to be pumped and having therein a pump impeller;

(b) a motor shell removably attached to said pump case and containing an electric motor having a stator and a rotor;

(c) a pump cover body between said pump case and said electric motor;

(d) a combined thermal plate and pump diffuser between said pump cover body and said impeller, said thermal plate forming a closure for said pump case and said diffuser extending into said pump case and surrounding said impeller, said thermal plate additionally engaging the surface of said pump cover body;

(e) auxiliary pump means in said motor shell;

(f) a drive shaft driven by said rotor and extending through said pump cover body and said thermal plate into said pump case and being drivingly connected to said impeller and to said auxiliary pump; and

(g) shaft seal means comprising a mechanical seal assembly surrounding said drive shaft and sealing against flow of fluid from the pump case into the motor shell;

wherein:

(h) the combined thermal plate and pump diffuser has a shaft opening;

(i) the pump cover body has a bore aligned with such shaft opening and which pump cover body is contiguous to said thermal plate when the latter is in position in said pump and motor assembly;

(j) said thermal plate has concentric groove means on its surface contiguous to said pump cover body and forming with said pump cover body a spiral-like fluid passage;

(k) a fluid inlet to said passage adapted to be connected to a source of fluid under pressure; and

(l) said fluid passage having a discharge opening whereby fluid entering said inlet flows through said passage and is discharged into said pump case through said pump cover body bore and said shaft opening.

2. A compact, unitary, pump and motor assembly for pumping high pressure-high temperature fluids, such as for processing hydrocarbons in a reactor circulating system, comprising in combination in a housing assembly:

(a) container means comprising a pump case containing a fluid at high temperature and under high pressure to be pumped and having therein a pump impeller;

(b) a motor shell removably attached to said pump case and containing an electric motor having a stator and a rotor;

(c) a pump cover body between said pump case and said electric motor;

(d) a combined thermal plate and pump diffuser between said pump cover body and said impeller, said thermal plate forming a closure for said pump case and said diffuser extending into said pump case and surrounding said impeller, said thermal plate additionally engaging the surface of said pump cover body;

(e) auxiliary pump means in said motor shell;

(f) a drive shaft driven by said rotor and extending through said pump cover body and said thermal plate into said pump case and being drivingly connected to said impeller and to said auxiliary pump; and

(g) shaft seal means comprising a mechanical seal assembly surrounding said drive shaft and sealing against flow of fluid from the pump case into the motor shell;

wherein:

(h) the combined thermal plate and pump diffuser is removably attached to the pump cover body and has a shaft opening in the center thereof;

(i) the pump cover body has a bore in the center thereof aligned with the shaft opening in the thermal plate and also has a stainless steel layer contiguous to the thermal plate when the latter is attached to the pump cover body;

(j) the thermal plate has a series of interconnecting generally concentric grooves on its surface contiguous to the pump cover body, and forming with the pump cover body a spiral-like fluid passage, a fluid inlet to said passage adapted to be connected to a source of fluid, said fluid passage opening into said bore whereby fluid entering said inlet flows through said passage and is discharge into said bore.

3. A compact, unitary, pump and motor assembly for pumping high pressure-high temperature fluids, such as for processing hydrocarbons in a reactor circulating system, comprising in combination in a housing assembly:

(a) container means comprising a pump case containing a fluid at high temperature and under high pressure to be pumped and having therein a pump impeller;

(b) a motor shell removably attached to said pump case and containing an electric motor having a stator and a rotor;

(c) a pump cover body between said pump case and said electric motor;

(d) a combined thermal plate and pump diffuser between said pump cover body and said impeller, said thermal plate forming a closure for said pump case and said diffuser extending into said pump case and surrounding said impeller, said thermal plate additionally engaging the surface of said pump cover body;

(e) auxiliary pump means in said motor shell;

(f) a drive shaft driven by said rotor and extending through said pump cover body and said thermal plate into said pump case and being drivingly connected to said impeller and to said auxiliary pump; and

(g) shaft seal means comprising a mechanical seal assembly surrounding said drive shaft and sealing against flow of fluid from the pump case into the motor shell;

wherein:

(h) said pump cover body has a series of inwardly extending bores connected together to form a continuous zigzag-like fluid passage through said pump cover body;

(i) an inlet connection to said fluid passage adapted to be connected to a source of cooling fluid, such as water; and

(j) an outlet connection for said passage whereby fluid completing its circuit through said inlet and said bores is discharged from said outlet after performing its cooling function.

4. A compact, unitary, pump and motor assembly for pumping high pressure-high temperature fluids, such as for processing hydrocarbons in a reactor circulating system, comprising in combination in a housing assembly:

(a) container means comprising a pump case containing a fluid at high temperature and under high pressure to be pumped and having therein a pump impeller;

(b) a motor shell removably attached to said pump case and containing an electric motor having a stator and a rotor;

(c) a pump cover body between said pump case and said electric motor;

(d) a combined thermal plate and pump diffuser between said pump cover body and said impeller, said thermal plate forming a closure for said pump case and said diffuser extending into said pump case and surrounding said impeller, said thermal plate additionally engaging the surface of said pump cover body;

(e) auxiliary pump means in said motor shell;

(f) a drive shaft driven by said rotor and extending through said pump cover body and said thermal plate into said pump case and being drivingly connected to said impeller and to said auxiliary pump; and

(g) shaft seal means comprising a mechanical seal assembly surrounding said drive shaft and sealing against flow of fluid from the pump case into the motor shell;

wherein:

(h) said electric motor stator is within and contiguous with said motor shell and has a series of axial fluid passages across said stator between the stator and said shell;

(i) means comprising a stator spacer sleeve at one end of said stator and a second stator spacer sleeve at the other end of said stator having fluid conduit means on the outer circumference of each spacer sleeve and in register with the axial passages across the stator, each of said spacer sleeves having a plurality of said fluid conduit means, each of which is in fluid contact with a portion only of said stator passages; and

(j) an inlet for fluid under pressure in one said stator spacer sleeve and a discharge outlet for said fluid in the other said stator spacer sleeve, the arrangement being such that a sinuous fluid flow path through said spacer sleeves and across said stator is provided whereby the fluid is caused to cross said stator in an axial direction a plurality of times in traversing the entire circumference of said stator.

5. A compact, unitary, pump and motor assembly for pumping high pressure-high temperature fluids, such as for processing hydrocarbons in a reactor circulating system, comprising in combination in a housing assembly:

(a) container means comprising a pump case containing a fluid at high temperature and under high pressure to be pumped and having therein a pump impeller;

(b) a motor shell removably attached to said pump case and containing an electric motor having a stator and a rotor;

(c) a pump cover body between said pump case and said electric motor;

(d) a combined thermal plate and pump diffuser between said pump cover body and said impeller, said thermal plate forming a closure for said pump case and said diffuser extending into said pump case and surrounding said impeller, said thermal plate additionally engaging the surface of said pump cover body;

(e) auxiliary pump means in said motor shell;

(f) a drive shaft driven by said rotor and extending through said pump cover body and said thermal plate into said pump case and being drivingly connected to said impeller and to said auxiliary pump; and

(g) shaft seal means comprising a mechanical seal assembly surrounding said drive shaft and sealing against flow of fluid from the pump case into the motor shell;

wherein:

(h) said electric motor is provided with a series of axial fluid passages across its stator formed by alternating stator ridges and stator grooves, such stator ridges being positioned in and contiguous to the motor housing assembly whereby the latter forms one surface of each of said passages;

(i) an upper stator spacer sleeve and a lower spacer sleeve located respectively above and below said stator and contiguous thereto, said spacer sleeves having fluid inlet and exit means and raised lands and a series of spaced, staggered ridges, forming with said motor shell conduit spaces in fluid communication with the passages formed across the stator, whereby fluid entering the lower spacer sleeve flows across a series of the fluid passages formed on the stator into a conduit space on the upper spacer sleeve, is directed back across another series of passages formed on the stator into a bottom conduit space on the bottom spacer sleeve, is directed back through another series of passages formed on the stator into a second top conduit space of the upper spacer sleeve, is directed back across still another series of stator passages into a second bottom conduit space on the bottom spacer sleeve, is directed across the stator through still another series of stator passages into a discharge space in the upper spacer sleeve, thereby crossing the said stator in axial directions a plurality of times in a sinuous flow pattern in flowing once around the circumference of said stator, said lower spacer sleeve having connections to a source of fluid and said upper spacer sleeve discharge means for said fluid.

6. A pump and motor assembly as set forth in claim 4 wherein:

(a) said auxiliary pump means has a fluid inlet in fluid communication with a source of fluid under pressure for lubricating and cooling parts of said pump and motor assembly, and has a fluid outlet connection to said inlet in one said spacer sleeve;

(b) said pump cover body has a bore therethrough through which said drive shaft extends and a mechanical seal assembly surrounding said drive shaft and located in said pump cover body bore;

(c) said thermal plate having a shaft opening therethrough for said drive shaft, said shaft opening being in alignment with said bore of said pump cover body;

(d) fluid chamber means comprising an annular fluid chamber into which fluid is discharged from said spacer sleeve discharge outlet after it has passed over the entire circumference of said stator;

(e) fluid passage means comprising at least one fluid passage extending from said fluid chamber means to said pump cover body bore;

(f) an axially extending bore in said drive shaft, fluid passage means comprising a hole in said drive shaft in communication with said bore in said pump cover body, whereby a portion of the fluid entering said last-mentioned bore from the fluid chamber means through the fluid passage above-mentioned is conducted to the bore in said drive shaft;

(g) means comprising a pressure and flow reducing cell in said pump cover bore and in communication with fluid from said fluid chamber diverting a reduced portion of said fluid through said thermal plate drive shaft opening;

(h) means comprising at least one passage from said drive shaft bore discharging fluid therefrom into said motor shell; and

(i) passage means through said motor between said stator and said rotor and into said auxiliary pump inlet, the arrangement being such that fluid pumped by said auxiliary pump is carried across the stator in contact with the motor shell, through said passages in the pump cover body, over said mechanical seal assembly and a portion thereof going through said thermal plate opening, and the remainder thereof going through said drive shaft back into said motor shell, through said motor and into the inlet for said auxiliary pump where it is again recirculated.

7. A pump and motor assembly as set forth in claim 6 wherein:

(a) said motor shell has cooling means comprising a heat exchange shell surrounding said motor shell and attached thereto in fluid-tight relation;

(b) inlet connections for a cooling fluid in said heat exchange shell and a discharge port from said heat exchange shell; and

(c) a spiral tube having unconnected inlet and outlet openings entirely within said shell whereby a portion of the fluid entering said heat exchange shell flows around said spiral tube to said discharge port, and the remainder of said fluid flows through said spiral tube and back into said heat exchange shell prior to discharge from said discharge port.

8. A compact, unitary, pump and motor assembly for pumping high pressure-high temperature fluids comprising, in combination:

(a) a housing assembly comprising a pump case having therein a pump impeller and containing fluid at high temperature and under high presssure to be pumped, a motor shell removably attached to said pump case and containing an electric motor having a stator and a rotor, said motor shell having a motor shell cover;

(b) a thermal plate in the bottom of said pump case, said plate having an opening;

(c) a pump cover body adjacent to said thermal plate and having a bore therethrough aligned with the opening of said thermal plate, said pump cover body having a mechanical seal assembly located in said bore;

(d) an auxiliary pump in said motor shell;

(e) a drive shaft attached to said rotor whereby it is driven by said electric motor, said drive shaft also being attached in driving relation to said auxiliary pump and said impeller and extending from said motor shell through said pump cover body bore, said mechanical seal assembly, and said thermal plate opening into said pump case;

(f) fluid temperature regulating and lubricating means for said pump and motor assembly comprising a thermal plate cooling system, a pump cover body zigzag water circulating system, a motor cooling and seal lubricating system using fluid pressure from said auxiliary pump, which motor cooling and seal lubricating system includes a sinuous stator cooling fluid flow path with fluid connections in said pump cover to said mechanical seal assembly and return fluid connections through said drive shaft and said motor to said auxiliary pump means;

(g) a water jacket cooling means comprising a heat exchange shell with an open ended spiral tube therein located about the outer circumference of said motor shell; and

(h) fluid connections for a source of fluid to said thermal plate cooling system, said pump cover body water circulating system, said auxiliary pump and said heat exchange shell, whereby the temperature of said electric motor is maintained within tolerable limits.

References Cited

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ROBERT M. WALKER, Primary Examiner

U.S. Cl. X.R.

103—103; 310—63

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,478,689 Dated November 18, 1969

Inventor(s) Rowland E. Ball

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 8, line 65, "35" should be --135--; line 74, after "from" should be --the motor lubrication system, and the mixture is dis- --.

Column 9, line 1, omit "the motor *** is dis-"; line 3, "16" should be --115--.

Column 11, line 13, "b state" should be --be stated--; line 59, after "top" should be --end--.

Column 12, line 45, "recycle" should be --recycled--.

Column 13, line 2, "receive" should be --receives--.

Column 15, line 72, "axilially" should be --axially--.

SIGNED AND SEALED OCT 20 1970

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents