Oct. 31, 1967 E. P. GRENIER 3,349,714

POWER STEERING PUMP

Filed Oct. 11, 1965 2 Sheets-Sheet 1

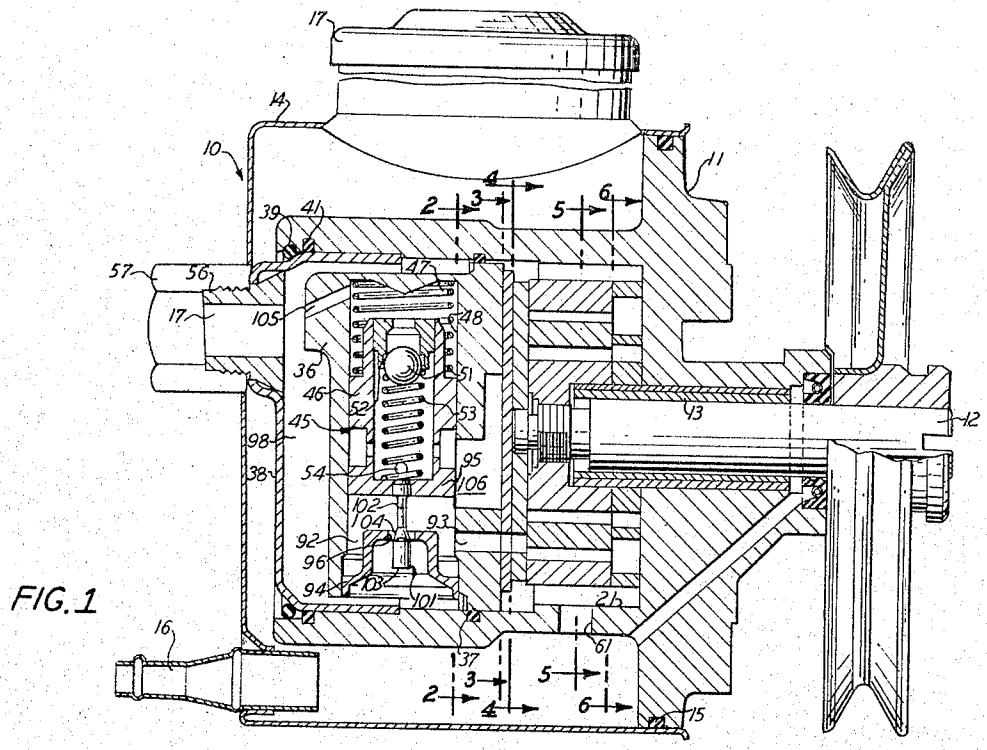


FIG. 1

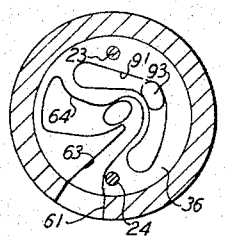


FIG. 2

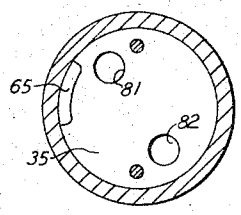


FIG. 3

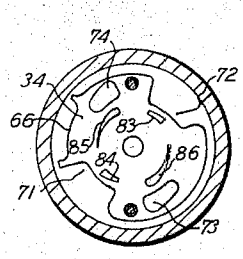


FIG 4

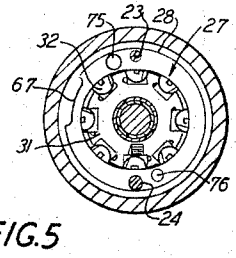


FIG. 5

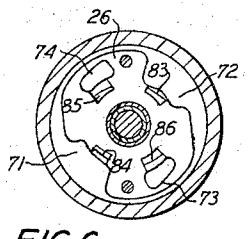


FIG. 6

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POWER STEERING PUMP

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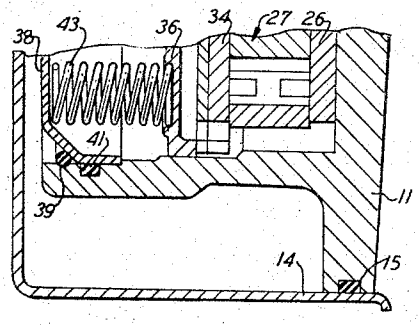


FIG. 8

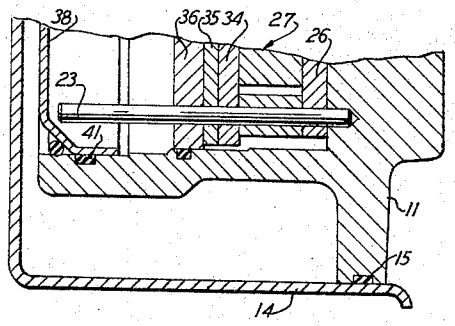


FIG. 7

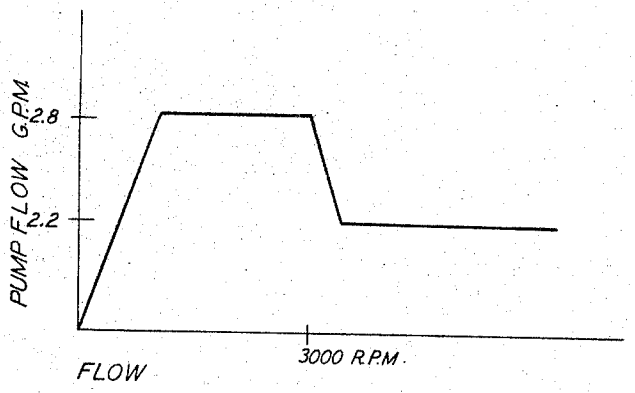


FIG. 9

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POWER STEERING PUMP

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Filed Oct. 11, 1965, Ser. No. 494,437
6 Claims. (Cl. 103—41)

This invention relates to a positive displacement type fluid pump that may be employed in a power steering system and more particularly to such a positive displacement type pump embodying a novel output volume or flow control regulator.

In power steering systems positive displacement pumps are ordinarily employed for supplying fluid under pressure to the power steering motive device and the pump is driven from the vehicle engine and accordingly is operated over a widely varying speed.

In a positive displacement pump the output volume of the pump will increase proportionally as the speed of the pump increases unless a flow control means is employed to limit the flow of the pump at higher speeds. In conventional power steering pumps a flow control valve has been employed that is positioned between the discharge port of the pump and the inlet port of the pump. This flow control valve has means associated with it for sensing the flow as it increases with increasing pump speeds and this ordinarily takes the form of an orifice positioned between the discharge port of the pump and the outlet to the power steering device. The fluid after it passes through the orifice is applied to one end of the flow control valve and this same end ordinarily is spring urged in such a direction as to cut off communication between the discharge port of the pump and the inlet port. When the pressure drop across the orifice reaches a certain predetermined level the force applied to the end of the valve adjacent the discharge port of the pump becomes greater than the force applied by the pressure of the fluid on the other side of the orifice and the force of the spring. This moves the flow control valve into position where a portion of the fluid discharged from the discharge port of the pump is bypassed or discharged into the inlet port.

In the ordinary power steering pump the action described above will provide, after a certain predetermined speed of the pump has been reached, a constant flow to the power steering device. It has been found that this type of flow control arrangement while satisfactory in certain applications has some definite disadvantages, for example, it may cause excessive heat buildups and high fluid temperatures as well as undesirable high power requirements for the pump.

The present invention remedies these disadvantages and provides an eminently satisfactory power steering pump by reducing the pump flow at engine or pump speeds above a predetermined level. This is done by providing the orifice described above with means for varying its effective area in accordance with the position of the flow control valve. This may be accomplished by means of a variable area metering rod or pin that is in effective engagement with an aperture thereby forming a variable area orifice. The area of the orifice is varied by the movement of the flow control valve and as the pump operates at progressively higher speeds the flow control valve will vary the position of the metering rod with respect to the aperture such that the higher cross-sectional area of the metering rod is in effective relationship with the orifice to effectively reduce the area of the orifice.

This action increases the pressure differential between the end of the flow control valve position adjacent the outlet or discharge port of the pump and the other end which is subjected to the spring pressure and the pressure of the

fluid after it is passed through the variable orifice. As a result the flow control valve will move into a new position in which a greater quantity of fluid from the output port is bypassed into the inlet port and a smaller quantity flows to the outlet of the power steering pump and to the power steering device coupled to this outlet.

In the prefered form of the invention, the metering rod has two sections of constant cross-sectional area, with one section having a lower cross-sectional area than the other. These two sections are intercoupled by a tapered section. When the speed of the pump is below a predetermined level the smaller section is in effective relationship with the aperture thereby creating an orifice having a certain cross-sectional area. This first section remains in effective position with respect to the aperture until a first predetermined speed level of the pump is reached. The tapered section moves into effective relationship with the aperture therebetween this first predetermined speed level and a second higher predetermined speed level. At speeds of the pump higher than the second predetermined speed level the second section of higher cross-sectional area comes into effective relationship with the aperture to provide an orifice having a constant but smaller cross-sectional area for speeds above the second predetermined speed level.

The above-described action reduces the pump flow at speeds above the first predetermined speed level in a substantially straight line relationship in which the flow decreases gradually as the speed of the pump increases. At speeds higher than the second predetermined speed level the output volume of the pump again becomes a constant due to the above-described action of the metering pin with respect to the aperture.

An object of the present invention is the provision of a constant displacement rotary type pump in which a novel flow control means is provided to reduce the pump flow when the speed of the pump reaches a predetermined level.

A further object of the invention is the provision of a power steering pump of the positive displacement type in which the flow of the pump is reduced at higher speed levels thereby reducing the power requirements for the pump and reducing the temperature of the fluid being pumped.

Another object of the invention is the provision of a power steering pump of the positive displacement type employing a novel flow control means that provides a constant flow for a certain speed range of the pump and provides lower constant flow at a higher speed range of the pump.

Other objects and attendant advantages of the present invention may be more readily realized when the specification is considered in connection with the attached drawings, in which:

FIGURE 1 is a sectional view of the power pump of the present invention;

FIGURE 2 is a partial sectional view taken along the lines 2—2 of FIGURE 1;

FIGURE 3 is a partial sectional view taken along the lines 3—3 of FIGURE 1;

FIGURE 4 is a partial sectional view taken along the lines 4—4 of FIGURE 1;

FIGURE 5 is a partial sectional view taken along the lines 5—5 of FIGURE 1;

FIGURE 6 is a partial sectional view taken along the lines 6—6 of FIGURE 1;

FIGURE 7 is a partial sectional view through the pump showing a dowel pin arrangement for holding various sections of the pump together;

FIGURE 8 is a partial sectional view through the pump showing a spring for biasing the various sections of the housing together; and

FIGURE 9 is a curve showing the output flow of the pump as a function of pump speed.

Referring now to FIGURE 1 there is shown pump **10** of the positive displacement type that includes a housing **11** having a rotatable shaft **12** mounted therein by means of a bushing **13**. A reservoir **14** in the form of a sheet metal can completely surrounds the periphery of the housing **11** and is sealed thereto by means of an O-ring **15**. The reservoir has an inlet **16** from an external device utilizing hydraulic fluid, for example, a power steering mechanism, and a filler cap **17** for filling the reservoir **14** with hydraulic fluid.

The pumping mechanism of the pump **10** is mounted within a chamber **21** formed in the housing **11**. A pair of dowels, one of which is shown in elevation in FIGURE 7 and which are designated by the numerals **23** and **24**, are anchored within the housing **11** and extend through the chamber **21**. These dowels carry and support the pumping mechanism. This pumping mechanism comprises a lower pressure plate **26** as can most readily be seen by reference to FIGURE 6. Mounted on the top of the lower pressure plate **26** is a pumping element cartridge generally designated by the numeral **27** in FIGURE 5. This pumping element cartridge comprises a cam insert **28** and a rotor **31**. The rotor carries a plurality of pumping slippers **32** each of which is U-shaped in cross-section and is open at each end to provide two sealing surfaces on each slipper.

An upper pressure plate **34** is positioned above the pumping element cartridge **27**. This upper pressure plate shown in detail in FIGURE 4 is similar to the lower pressure plate **26**. A separator plate **35** shown in FIGURE 3 is positioned above the upper pressure plate **34** and a valve plate **36** shown in detail in FIGURE 2 is positioned over the separator plate **35** and is sealed to the housing **11** by means of an O-ring seal **37** best shown in FIGURE 1. An end cap **38** fits over the valve plate **36** and engages a shoulder in the housing. The end cap **38** is retained in the housing by means of a lock ring **39** and is sealed thereto by means of an O-ring seal **41**.

Spring means that take the form of a pair of springs, one of which is shown at **43** in FIGURE 8, urge the valve plate **36**, the separator plate **35**, the upper pressure plate **34**, the pumping element cartridge **27** and the lower pressure plate **26** into sealing engagement to prevent leakage between the rotor and the upper and lower pressure plates.

The valve plate **36** houses a flow control valve generally designated by the numeral **45**. The flow control valve **45** comprises a valve spool or cylindrical valve member **46** that is biased toward a closed position by a spring **47** positioned within the cylindrical chamber **48** that houses the valve spool or cylindrical valve member **46**.

The flow control valve **45** also includes a pressure relief valve that has a ball **51** biased into engagement with an orifice in a relief plug **52** by means of a spring **53**. An orifice **54** is provided in the valve spool or cylindrical valve member **46** for permitting flow from the interior to the exterior thereof when the pressure of the fluid forces the ball **51** from its seat **52** under extremely high pressures.

The end cap **38** is provided with a fitting **56** that serves together with the fitting **57** attached to the sheet metal can forming reservoir **14** as an outlet for the power steering pump. This outlet is adapted to be connected to a power steering device such that fluid under pressure from the outlet powers this device and provides the energy necessary for operating a power steering system.

Fluid is pumped from the reservoir **14** defined by the sheet metal can through an oblong aperture generally designated by the numeral **61**. This aperture is in alignment with the inlet passage **63** in valve plate **36** as shown in FIGURE 2. From there the fluid is pumped through the bypass passage **64** in the valve plate and then through

the bypass grooves **65**, **66** and **67**, in the separator plate **35**, the upper pressure plate **34** and the cam insert **28**, respectively. This provides intake fluid in the space between the housing **11** and the stack of pump elements including the pumping element cartridge **27**, the upper and lower pressure plates **26** and **34**, and the separator plate **35**.

This intake fluid is in communication with the pumping elements of the pump including the rotor **31** and the slipper elements **32** through the inlet ports or grooves **71** and **72** located in each of the lower and upper pressure plates **26** and **34**. The fluid is pumped from the inlet ports **71** and **72** to the outlet ports **73** and **74** located in both the upper and lower pressure plates. Fluid received in the inlet port **71** of the upper and lower pressure plates is delivered under pressure to the outlet port **73** in the upper and lower plates and fluid received in the inlet port **72** of the upper and lower pressure plates is delivered under pressure to the outlet port **74** in the upper and lower pressure plates.

The outlet ports **74** in the upper and lower pressure plates are connected by means of a bore **75** positioned in the cam insert **27** while the outlet ports **74** in the upper and lower pressure plates are connected by a bore **76** in the cam insert **27**. The outlet ports **74** and **73** in the upper pressure plate **34** are in communication with circular apertures **81** and **82** respectively in the separator plate **35**.

Means are also provided to supply fluid to the volume behind the slippers **32**. This takes the form of small inlet ports **83** and **84** in the upper and lower pressure plates. The fluid is discharged from these volumes into small outlet ports **85** and **86** in the upper and lower pressure plates. The small outlet ports **85** and **86** are in communication with the outlet ports **73** and **74** in the lower pressure plate **26** and the small outlet ports **85** and **86** in the upper pressure plate **34** are in communication with the circular apertures **81** and **82** in the separator plate **35**.

As fluid under pressure is delivered into the two circular apertures **81** and **82** of the separator plate **36** it finds its way into the pressure port **91** in the valve plate **36** as shown in FIGURE 2. The fluid under pressure is then delivered to a chamber **92** through a discharge port **93** formed in the valve plate **36**. The chamber **92** is defined by the cylindrical bore or chamber **48** in the valve plate, by the end **95** of the valve spool or cylindrical valve member **46** and by an end wall member **94** that is juxtaposed with relationship to the end **95** of the valve spool or cylindrical valve member **46**. An aperture **96** is positioned in the end wall member **94** and it connects the chamber **92** with a chamber **98** formed or defined by the valve plate **36** and the end cap **38**. This aperture causes a pressure drop so that hydraulic fluid in the chamber **98** is at a lower pressure than the fluid in chamber **92**. The fluid in the chamber **98** is then delivered to the outlet of the pump defined by the fittings **56** and **57** as previously noted.

A metering rod or pin **101** actuated or carried by the valve spool or cylindrical valve member **46**, is employed in conjunction with the aperture **96** to form a variable area orifice. This metering rod or pin **101** includes a first or central area **102** having a constant cross-sectional area and a second or end section **103** having a larger constant cross-sectional area. The two sections **102** and **103** are interconnected by a tapered section **104**.

Fluid under pressure in the chamber **98** also flows through an orifice or opening **105** in the valve plate **36** to pressurize the end **106** of the valve spool or cylindrical valve member **46** that is remote from the chamber **92**. The areas of the ends of the valve spool or cylindrical valve member **46** may be substantially equal so that the end **95** of the valve spool or cylindrical valve member **46** in the chamber **92** is subjected to the outlet pressure of the pump while the end **106** of the valve spool or cylindrical valve member **46** adjacent the opening **105** is

subjected to the lesser pressure due to the pressure drop across the variable orifice that is defined by the aperture **96** in the member **94** and the metering rod or pin **101**. When the flow of fluid reaches a certain desired magnitude at a certain predetermined speed of the pump, the pressure differential just described overcomes the force exerted by the valve spring **47** and causes the valve spool or cylindrical valve member **46** to shift so as to provide communication between the chamber **92** and a bypass port **106** in the valve plate **36**. This bypass port **106** is in communication with the bypass passage **64** position in the valve plate member **36**.

When the pump is at rest the spring **47** will force the valve spool or cylindrical valve member **46** into engagement with the end wall member **94** that carries the aperture **95** and hence the smaller cross-sectional area section **102** of the metering pin **101** will be in effective position with respect to the aperture **96**. In this position, the valve spool or cylindrical valve member **46** will prevent communication between the chamber **92** and the bypass port **106** and as the speed of the pump increases, flow of the hydraulic fluid from the pump outlet at the fittings **56** and **57** will increase as a substantially linear function of the speed of rotation of the rotor of the pump, since the pump is a constant displacement pump. This linear increase is shown on the curve of FIGURE 9.

When the speed of the pump reaches a predetermined speed and the flow reaches a given rate the differential force on force valve member **46** due to the pressure differential between the fluid in the chamber **92** acting on one end of the valve and the fluid in the chamber that houses the spring **47** in the other end reaches a point where the valve spool **46** or cylindrical valve member is moved to provide communication between the chamber **92** and the bypass port **106**. This dumps a portion of the fluid from the discharge port of the pump as at **93** into the bypass port **106** and therefore bypasses a portion of the fluid pumped. As a result the flow of the pump will remain at a substantially constant level as long as section **102** of the metering pin **101** remains in effective relationship with aperture **96**, since the area of the orifice defined by aperture **96** and section **102** of the metering pin **101** remains constant under these conditions.

When the speed of the pump, however, reaches a certain predetermined level the tapered section **104** of the metering rod or pin **101** moves into effective engagement with the aperture **96** and the flow of the pump drops off as shown on the curve since as the tapered portion is encountered the pressure differential increases due to the decrease in the effective area of the orifice and this dropping off will occur in a substantially linear fashion until another higher predetermined pump speed is reached. At this time the larger cross-sectional area portion **103** of the metering rod or pin **101** will be effective to further reduce the effective area of this orifice. The area of the section **103** is constant for a considerable portion of the axial length of the metering pin **103** and as a result the flow of the pump will remain at a constant value for speed above this second predetermined higher speed.

Thus, at higher pump speeds the flow of fluid from the pump that is available at the outlet of the pump will be reduced, and preferably will be reduced to a lower constant value. This lowers the temperature of the oil from the temperature that would prevail had the flow remained constant at the higher level shown on the curve and it also reduces the amount of power needed to drive the pump. Both of these are significant advantages in a power steering system since the lower temperature of the oil or hydraulic fluid aids in preventing sticking of the valves in the power steering system that might otherwise occur due to the higher temperatures and further, the lowering of the power requirements necessary to drive the pump has a distinct advantage in permitting this power to be utilized in doing other effective work.

What I claim and desire to secure by United States Letters Patent is:

1. A power steering pump of the constant displacement type comprising a pump chamber having inlet and discharge ports, a rotor operable in said pumping chamber for pumping fluid between said inlet and discharge ports, a valve chamber positioned between said inlet and discharge ports and having an opening connecting said inlet and discharge ports, a valve member positioned in said valve member positioned in said valve chamber, spring means positioned in said valve chamber and engaging one end of said valve member for urging said valve member into a position to close said opening, an outlet orifice positioned adjacent the other end of said valve and having one side in communication with said one end of said valve member and adapted to be coupled to a power steering mechanism, said outlet orifice having the other side positioned in communication with said discharge port of said pump, and means operable by the movement of said valve member for reducing the effective area of said orifice when the speed of the rotor exceeds a predetermined level.

2. In a rotary pump, a housing having a rotor chamber positioned therein and an intake port and a discharge port communicating with the rotor chamber at spaced points, rotor means positioned in said rotor chamber and operable for pumping fluid from said intake port to said discharge port, portions of said housing defining a substantially cylindrical valve chamber spanning said intake and discharge ports with said discharge port being positioned adjacent one end of said cylindrical valve chamber and with said intake port being positioned in a direction toward the other end of said cylindrical valve chamber, a cylindrical valve member positioned in said cylindrical valve chamber, spring means positioned in said cylindrical valve chamber and engaging said cylindrical valve member for urging said cylindrical valve member in a direction toward said one end of said cylindrical valve chamber and covering said intake port, said housing including an outlet adapted to be connected to a power steering apparatus, said cylindrical valve chamber having an end wall member that together with said one end of said cylindrical valve member defines a chamber that is in communication with said discharge port, an orifice positioned in one of said members and a variable area metering rod carried by the other of said members extending through said orifice, said variable area orifice being in communication with the other end of said cylindrical valve member and with said outlet, whereby said variable area metering rod varies the effective area of said orifice as said cylindrical valve member is moved in said cylindrical valve chamber due to varying speeds and output volumes of said pump.

3. The combination of claim **2** in which said variable area metering rod has a free end portion and a central portion with the end portion having a larger cross-sectional area than said central portion and an intermediate tapered portion interconnecting said free end portion and said central portion, said central portion being positioned in said orifice when the speed of the pump is below a predetermined speed, said tapered portion being positioned in said orifice when the speed of the pump is between said predetermined speed and a higher predetermined speed and said free end portion being in position in said orifice when the speed of the pump is above said higher predetermined speed, the relative movement of said metering rod and said orifice being caused by the movement of said cylindrical valve member in said cylindrical valve chamber as the speed of the pump increases.

4. A power steering pump comprising a housing including an inlet port and discharge port and having a pumping chamber, a rotor positioned in said pumping chamber for pumping fluid from said inlet port to said discharge port, a flow control valve member positioned between said inlet and said discharge ports and having

one end positioned in communication with said discharge port, spring means engaging the other end of said flow control valve member and urging said valve member in a direction to close communication between said inlet and said discharge ports, said housing including means forming an outlet adapted to communicate with a power steering device, fluid passage means connecting said discharge port and said one end of said valve with said outlet and said other end of said valve, and variable area orifice means positioned in said fluid passage means between said one end of said flow control valve and both said outlet and said other end of said valve and operable directly by the movement of said flow control valve for reducing the volume of fluid flowing from said outlet when the speed of the rotor exceeds a predetermined level.

5. The power steering pump of claim 4 in which said fluid passage means includes an end wall member positioned in juxtaposed relationship to said one end of said flow control valve member and said variable area orifice means includes an opening positioned in one of said members and a variable area metering rod attached to the other of said members and extending in an axial direction through said opening.

6. The combination of claim 5 in which said variable area metering rod has a first section of constant cross-sectional area and a second section of constant and smaller cross-sectional area and a tapered section interconnecting said first and said second sections, said second section being positioned in operative relatioinship within said aperture when the speed of said rotor is below a predetermined level, said tapered section and said aperture being brought into operative relationship by the movement of said flow control valve member when the speed of the rotor is between said predetermined level and a higher predetermined level, and said first section of said metering rod being brought into operative relationship with said aperture by the movement of said flow control valve when the speed of the rotor is above said higher predetermined level.

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Disclaimer

3,349,714.—*Emile P. Grenier*, Ann Arbor, Mich. POWER STEERING PUMP. Patent dated Oct. 31, 1967. Disclaimer filed June 23, 1974, by the assignee, *Ford Motor Company*.

Hereby enters this disclaimer to claims 1 through 6 of said patent.

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