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DEVICES AND METHOD FOR REGULATING COOLER FLOW THROUGH AUTOMOTIVE TRANSMISSIONS

Abstract

Methods and valves for providing a continuous flow of cooler fluid in a fluid circuit of a thermal control system between a cooler and automotive transmission such that free flow of cooler fluid between the cooler and transmission exists at vehicle start-up. Fluid flow to and from the cooler is bypassed in case of pressure increases in cooler lines or pressure differentials, for example cause by a blockage in the cooler, such that the cooler fluid flow bypasses the cooler and continues in the fluid circuit through a thermal element of the thermal control system and back to the transmission.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application claims priority to U.S. Provisional Application No. 62/752,539, filed on Oct. 30, 2018.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT
[0002] Not applicable.
THE NAMES OF THE PARTIES TO A JOINT RESEARCH AGREEMENT Not applicable.
REFERENCE TO A "SEQUENCE LISTING," A TABLE, OR A COMPUTER PROGRAM LISTING APPENDIX SUBMITTED ON A COMPACT DISC
[0003] Not applicable.
STATEMENT REGARDING PRIOR DISCLOSURES BY THE INVENTOR OR A JOINT INVENTOR
[0004] Not applicable.
BACKGROUND OF THE INVENTION
Field of the Invention
[0005] The present invention relates to methods for improving OEM (original equipment manufacturer) systems for supplying cooled fluid lubricant through an automotive transmission, and to replacement parts for effecting said improvements, namely, improved thermal control system valves replacing OEM valves in automotive transmissions in order to improve performance and reduce maintenance costs.
Brief Discussion of the Prior Art
[0006] Most heat in an automatic transmission is generated in the torque converter (TC). Heat generation is relatively low during a lockup, or fluid coupling, phase, but during torque multiplication, and especially at maximum stall, high vortex flow forces fluid to make hard turns which generates a high level of fluid friction against internal component surfaces (for example, impeller, stator, and turbine). During sustained hard working conditions in the transmission, fluid temperatures can flash up to 300-400° F. Thus, the most logical destination for liquid coolant, or fluid, flow is away from the torque converter is through a converter out line, which is a line directly away from the torque converter to the cooler. Since the fluid returning from the cooler is generally the coolest in the transmission, it is then ideal for fluid to flow through lubrication circuits (LUBE), where it lubricates and cools intermeshing gears, washers, bearings, and bushings under load. From there, the fluid drains into the sump where it is drawn through the sump filter by the pump, which supplies that line pressure from which converter feed is derived. Thus, the basic cycle for this portion of transmission function is: SUMP-FILTER-PUMP SUCTION-PUMP OUTPUT-LINE SUPPLY-TC FEED-TC OUT-COOLER-LUBE-back to SUMP. This strategy is typical, and has been employed universally in all automatic transmissions for nearly a century with only a few rare exceptions.
[0007] In the same way a catalytic converter offers back pressure (i.e., resistance to flow) in an exhaust system, the transmission fluid cooler offers resistance in the fluid cooling system of the transmission, resulting in a pressure differential between the converter out line to the cooler (also referred to as an out-line) as compared to a cooler return line to lubricate the transmission (also referred to as an in-line). Two examples will suffice to illustrate this pressure differential. First, Honda **4** and **5** speed transmissions will typically flow 1.5 GPM (gallons per minute) at 20-30 PSI (pressure/square inch) on the out-line, with about 6 PSI in the in-line. A Ford 5R110W transmission will flow 2-4 GPM at 20-40 PSI through the out-line, with 10-15 PSI on the cooler in-line. In this manner it is typical for most transmission cooler systems to maintain a 15-25 PSI differential

between out and in lines on either side of the cooler.

[0008] With an increased use of internal transmission computers, solenoids, sensors, pressure switches, and so forth, in modern automobiles, in combination with adaptive-learn and advanced shift control strategy programming, car manufactures have concluded that it is advantageous to warm the transmission fluid to an optimum operating temperature as quickly as possible, and thereafter maintain that controlled temperature throughout the drive cycle of the vehicle. The assumption is that if fluid temperature and viscosity are held constant, transmission functions can be controlled more consistently.

[0009] It has become quite fashionable in automotive engineering to employ the use of a thermostatic switch device to regulate flow through the transmission cooler. This “thermal element”, as it is most commonly called, is placed somewhere in the thermal control system of the transmission where it can connect the out-line and the in-line circuits. In some cases it is utilized in coordination with a flow control valve. Sometimes the thermal element itself is designed as a compound part, and functions as a thermally expanding valve. Other times, the thermal element itself is the flow stop device without the aid of a valve. In all cases, whether secondary devices are employed or not, the fundamental principles do not change. Fluid temperature is thermostatically controlled in similar fashions. ATF (automatic transmission fluid, or fluid) in transmissions has a preferred best working temperature of 50-180 degrees F. Generally, optimum running temperature in transmissions has typically been 145-165° F. Leaks, valve sticking, and other high-temperature malfunctions tend to appear above 200° F., but most notably above 225-235° F. or right above the boiling temperature of water. That's where issues in the thermal flow controlled transmissions typically arise. On the cold side, issues begin to arise below the freezing temperature of water, and at −35 to −40° F. below zero ATF begins to gel.

[0010] The actual physical location of the thermostatic switch device, or thermal element, in principal can be anywhere these two circuits can be physically bridged. Further, the cooler, the out-line, the in-line, and thermostatic switch device together are often referred to as a thermal bypass system. To date, manufacturers have used five different locations for the thermal element: TABLE-US-00001 TABLE 1 LOCATION EXAMPLE TRANSMISSION 1. In Transmission Pump Ford 5R110W 2. In Transmission Valve Ford 4/5R55E, 5R55W, 5R55N, 5R55S Body 3. In Transmission Case Ford 6R80 Under Valve Body 4. In The Cooler Dodge 68RFE, 545RFE 5. In The Cooler Lines GM 6L80E; Ford 4R75W, 6F35

[0011] Regardless of location, the purpose of the thermal element is identical, and in many cases the same exact physical part is used, and by different manufactures. For example, one thermal element has been used in Ford, GM, Dodge, and Mercedes transmissions.

[0012] There is however a difference in accessibility and/or serviceability between these difference locations. In the case of location #1, the transmission must be removed to access the pump. Location #2 requires valve body removal and disassembly. Location #3 requires valve body removal. Locations #4 and #5 are more easily and more cost effectively serviced, since they are external to the transmission. Thus, as more vehicles begin to use thermal flow control, location #5 is quickly becoming the preferred site for thermal element placement.

[0013] The structural shape of the thermal element also necessarily varies between most locations, most notability between a thermal element in the pump (location #1), an element in the valve body (location #2), an element in the case (location #3), and an element in the cooler or cooler lines (locations #4 and #5). Between the different possible locations, only valves used in locations #4 and #5 are likely to have an identical or highly similar structure, as the thermal element in the cooler lines (#4) can be integrally formed with the cooler (#5). Otherwise, a valve in the pump, for example, is not interchangeable with a valve meant to be used in a thermal element located in the transmission case.

[0014] There are a variety of different housings used to contain the thermal element of the same location between transmission manufacturers, but for the most part these are size and shape

alterations necessary to accommodate differently sized cooler lines and different mounting locations. The valves used between these different housing shapes and sizes would be structured similarly, as the internal method of controlling cooler flow would be similar.
[0015] There are three possible states for known thermal bypass systems: [0016] 1. Fully OPEN when cooler is bypassed; [0017] 2. Fully CLOSED when ALL the flow is forced through the cooler; and [0018] 3. The INTERMEDIATE or PARTIAL ON state.
[0019] When the thermal element is fully open, fluid flows out of the converter, drops down and loops through the lockup control valve, and comes back up to a split. One direction goes to the flow valve. The other direction goes to the out fitting (out at the transmission and in at the cooler). Under pressure, flow always follows the path of least resistance, so the fluid flow chooses the in-line because the resistance in the cooler is much greater than that of the lube system. Pressure is transferred in both directions from the converter out circuit, but is equalized at the cooler return fitting, thus stopping cooler flow. Thus, in the OEM system, below a certain temperature, fluid flows in two directions and is stopped within the in-line near the connection of the cooler to the in-line. This system substantially prevents the flow of cooled fluid from the cooler to the transmission.
[0020] When the thermal element in an OEM system is fully closed, flow is restricted to one direction. This occurs when the fluid temperature is above the desired operating temperature. The thermal element is expanded sufficiently, due to silicon or a similar expanding element in the valve, to completely close the valve and prevent cooler bypass in order to force all fluid flow through the cooler to bring temperature down.
[0021] When the thermal element is cold, the valve allowing fluid flow through the thermal element is in an open, default position. When the thermal element is over the thermal temperature limit, for example, 250° F., the valve is in a closed, bypass position. But, as the fluid begins to cool, the thermal element begins to contract and holds the valve in a midway flow metering position where the valve is just cracking open in the bore. This is the normal operating state, where the element functions to sustain a predetermined ATF operating temperature, which is typically around 225-235° F. The thermal element holds the valve in a flow limiting position where part of the converter out flow goes through the cooler, and part of the flow bypasses through the thermal element directly to the transmission through the in-line. In this fashion, the fluid is partially cooled, and temperature is dynamically regulated. If ambient air temperature drops, and the cooler is more efficient, it bypasses more. If air temp rises, it pushes more fluid through the cooler.
[0022] There are multiple issues with this system, however, including: [0023] Overheating without setting diagnostic trouble codes as expected. [0024] Setting “phantom” codes as a result of erratic and inconsistent operation and/or temperature control. [0025] Silicon pack (thermal element valve) failure, leakage, and/or rupture with loss of fluid temperature control. [0026] Valves or other switching devices associated with the thermal element subject to sticking, which prevents proper and timely opening and closing of the thermal element. [0027] Cooler blocked and/or restricted with thermal system in cooler flow ON mode. This results in no cooler flow or lubrication, causing the planetary system to crash. [0028] When the thermal control system gets stuck in bypass mode, and cooler flow never begins, fluid can heat to nearly 400° F. At this temperature, if supplied oxygen, the ATF becomes a fuel and will sustain a fire.
[0029] Even when the thermal control system has not malfunctioned, high fluid operating temperatures increase expansion of valve body castings resulting in reduced and/or insufficient valve clearance. This causes slowed valve response to switching signals, sluggish regulation, and valve sticking with even the slightest amount of particle or carbon powder contamination. The same behavioral characteristics are observed with solenoids, especially PWM-type solenoids. Higher temperatures make it more difficult for adaptive learn solenoids to remain stable. The solenoids tend to drift, in an effort to dial in control of functions, while being compromised by temperature induced mechanical obstructions in multiple areas.
[0030] An improved thermal bypass control valve is discussed in U.S. Pat. No. 9,249,875 to

Mason. The valve of Mason is designed to operate as part of a thermal element in location #2, the valve body, which is the location of the thermal element in Ford® 5R55 series transmissions. While the valve of Mason would be applicable to other transmissions with the thermal element located in location #2, the valve of Mason would not be applicable to transmissions having thermal elements in locations #1, #3, #4, or #5. Thus, the improved thermal bypass control valve provided in Mason transmission cannot be applied to all other transmissions.

[0031] In view of the foregoing, there is a need for an improved process for supplying cooler to all automotive transmissions to avoid potential damage that may be caused to transmissions due to failure or faulty operation of thermal elements across various models of transmissions. There is a need to ensure constant flow of fluid through the cooling system.

[0032] There is also a need to ensure immediate fill of the cooling system with accurate fluid levels without a warm-up cycle. Further, there is a need for thermal bypass valves that accomplish these improvements across transmissions having the thermal element located in the pump, in the case, or in the cooler or cooler lines.

BRIEF SUMMARY OF THE INVENTION

[0033] The present invention is directed toward improved methods for regulating thermal control systems in automotive transmissions and thermal bypass valves that replace factory-original thermal bypass valves in thermal elements located at different locations within transmissions across multiple makes and models of such transmissions.

[0034] It is a primary objective of the instant disclosure to provide a method of converting an OEM thermal bypass control system from a three-state system to a two state system, comprising: removing a three-state OEM valve from a thermal element, wherein the OEM valve prevents any fluid flow between a transmission and a cooler in a default state, allows a full fluid flow between the transmission and the cooler past a fluid temperature threshold, and allows a partial fluid flow along a fluid temperature range below the fluid temperature threshold; replacing the OEM valve with a two-state valve in the thermal element; and the two-state valve allowing full fluid flow between the transmission and the cooler in a default state, and allowing for fluid bypass of the cooler when a pressure differential between fluid flowing from the transmission to the cooler and fluid flowing from the cooler to transmission exceeds a predetermined range.

[0035] Another objective of the instant disclosure is to provide a thermal bypass valve for installation into a transmission pump, the valve having a cylindrical blocker valve having a groove extending around a circumference of the blocker valve and along a length of the blocker valve, the groove defining an upper valve portion and a lower valve portion; a relief valve having a uniformly cylindrical body, a cylindrical cavity extending within and along a partial length of the relief valve, wherein the cylindrical cavity is open at a free end of the relief valve, and a cylindrical member extending from the relief valve along an end of the relief valve opposite the free end, wherein the cylindrical member has a smaller diameter than the relief valve; a spring; a valve plug; and a clip.

[0036] Another objective of the instant disclosure is to provide a thermal bypass valve for installation into a transmission case, the thermal bypass valve having a cylindrical body having an inner cylindrical cavity extending along a longitudinal length of the cylindrical body, the cylindrical body having a free end contiguous with the cylindrical cavity; a raised band coaxially extending around a circumference of the cylindrical body and proximate to the free end; a second raised band coaxially extending around a circumference of the cylindrical body along an end opposite the free end; a coaxial protrusion extending from the end opposite the free end; a tube extending within the cylindrical cavity proximate to the free end and perpendicularly to the longitudinal length of the cylindrical body, wherein the tube extends through opposite sides of the cylindrical body through two holes in the cylindrical body; a relief valve slidable within the cylindrical cavity; and a spring within the cylindrical cavity and compressible between the relief valve and a closed end of the cylindrical cavity;

[0037] wherein a plurality of openings in the cylindrical body are positioned adjacent to the raised

band, and a relief opening in the cylindrical body is positioned adjacent the second raised band; and wherein the thermal bypass valve is configured to insert into a transmission case of an automotive transmission.
[0038] Yet another objective of the instant disclosure is to provide a thermal bypass valve for installation into a cooler or external block connected to cooler lines, the thermal bypass valve having a cylindrical body, an inner cylindrical cavity extending along a longitudinal length of the cylindrical body, the cylindrical body having a free end contiguous with the cylindrical cavity, wherein a second cylindrical cavity is contiguous with the cylindrical cavity opposite the free end; a grooved blocker portion attached to the cylindrical body opposite the free end and adjacent to a grooved portion of the cylindrical cavity, the grooved portion having a plurality of openings into the second cylindrical cavity, wherein the grooved blocker portion has two grooves each extending along a circumference of the grooved blocker portion; and, a cap portion attached to the grooved blocker portion at an end opposite of the cylindrical body, the cap having a larger diameter than the grooved blocker portion, and a having a member attached at an end opposite the grooved blocker portion, a piston having a first cylindrical portion adjacent to a second cylindrical portion, the first cylindrical portion and second cylindrical portion defining a central cylindrical cavity extending along a longitudinal length of the piston and open at opposing free ends of the piston, wherein the first cylindrical portion has a greater diameter than the second cylindrical portion; a spring having an end with a smaller diameter than an opposing end; a bearing ball; two large O-rings; and a small O-ring, wherein the bearing ball is configured to rest partially within the second cylindrical cavity and secured by the spring along the end with a smaller diameter, and the spring is compressible by the piston along a free end of the first cylindrical portion, wherein the piston slidably engages the inner cylindrical cavity of the sleeve along the first cylindrical portion, wherein each O-ring of the two large O-rings engages a groove of the two grooves of the grooved blocker portion, wherein the small O-ring engages the circumference of the second cylindrical portion of the piston adjacent to the first cylindrical portion, and wherein the thermal bypass valve is configured to insert into an external thermostat block of an automotive transmission.
[0039] Embodiments of the present invention are intended to overcome the problems associated with lockup or other damage to components and gears within a transmission, especially the overdrive sun and planet gears of transmissions, by providing a replacement thermal bypass valve system which replaces the OEM thermal bypass valve system to provide a continuous flow cooler.
[0040] Another objective of the present invention is to provide replacement thermal bypass valves for different transmission series that default to a cooler flow ON state, instead of a cooler flow OFF state which is present in OEM thermal bypass valve systems.
[0041] A further objective of the present invention is to provide replacement thermal bypass valves for different transmission series that do not require a preheat cycle to raise temperatures to +212° F./+100° C. before allowing cooler to flow.
[0042] Yet another object of the present invention is to provide improved thermal control systems to increase cooler supply to and within transmissions to improve overall performance of the transmissions.
[0043] A better understanding of the systems and methods will be had with reference to the several views of the drawings, described herein.

Description

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING
[0044] The present invention is shown and described in the following drawings:
[0045] FIG. **1** shows components of a factory-original thermal control bypass valve for installation in a transmission pump;

[0046] FIG. **2** shows a thermal control bypass valve embodiment of the present invention and constituent components designed for installation in a transmission pump;
[0047] FIG. **3** shows a side view of a relief valve of the thermal control bypass valve embodiment, as provided in FIG. **2**;
[0048] FIG. **4** shows a side view of a blocker valve of the thermal control bypass valve embodiment, as provided in FIG. **2**;
[0049] FIG. **5** shows installation of the thermal control bypass valve embodiment of FIG. **2** into a transmission pump;
[0050] FIG. **6** shows a factory-original wax pellet style thermal control bypass valve for installation in a transmission case;
[0051] FIG. **7** shows a thermal control bypass valve embodiment of the present invention designed for installation in a transmission case;
[0052] FIG. **8** shows a cross-sectional side view of the thermal control bypass valve embodiment, as shown in FIG. **7**, without an inner spring and valve;
[0053] FIG. **9** shows a cross-sectional side view of the thermal control bypass valve embodiment, as shown in FIG. **7**, with the inner spring and valve;
[0054] FIG. **10** shows a cross-sectional side view of the thermal control bypass valve embodiment rotated 90° along a longitudinal axis relative to the view of FIG. **9**;
[0055] FIG. **11** shows a side view of the thermal control bypass valve embodiment rotated 180° along a longitudinal axis relative to the view of FIG. **9**, and without a cross-sectional view;
[0056] FIG. **12** shows a bottom view of the thermal control bypass valve embodiment of FIG. **7**;
[0057] FIG. **13** shows a top view of the thermal control bypass valve embodiment of FIG. **7**;
[0058] FIG. **14** shows removal of the factory-original wax pellet style thermal control bypass valve of FIG. **6** from a transmission case and replacement with the thermal control bypass valve embodiment of FIG. **7**;
[0059] FIG. **15** shows a thermal control bypass valve embodiment of the present invention designed for installation in a thermal element block in cooler lines;
[0060] FIG. **16**A shows a cross-sectional side view of a sleeve and ball of the thermal control bypass valve embodiment of FIG. **15**;
[0061] FIG. **16**B shows a side view of the sleeve of FIG. **16**A rotated 45° along a central longitudinal axis;
[0062] FIG. **17** shows a cross-sectional side view of a sleeve of the thermal control bypass valve embodiment of FIG. **15**;
[0063] FIG. **18** shows a cross-sectional side view of the thermal control bypass valve embodiment of FIG. **15** with constituent parts operably assembled together;
[0064] FIG. **19** shows installation of the thermal control bypass valve embodiment of FIG. **15** into factory-original thermal element block;
[0065] FIG. **20**A shows a factory-original thermal control bypass valve in a default position to allow fluid bypass;
[0066] FIG. **20**B shows an illustration of a fluid circuit through a thermostat block with the valve of FIG. **20**A in a default, cooler bypass position according to prior art systems;
[0067] FIG. **21**A shows a factory-original thermal control bypass valve in an altered, extended position to allow fluid flow to the cooler;
[0068] FIG. **21**B shows an illustration of a fluid circuit through a thermostat block with the valve of FIG. **21**A in an altered position to permit fluid flow through the cooler according to prior art systems;
[0069] FIG. **22** shows an illustration of a fluid circuit through a thermal element with a valve in a default position allowing fluid flow through the cooler according to an embodiment of the present invention;
[0070] FIG. **23** shows an illustration of a fluid circuit through a thermal element with the valve in

an altered position to allow cooler bypass according to an embodiment of the present invention;

[0071] FIG. **24** shows an illustration of a fluid circuit through a transmission pump according to an embodiment of the present invention; and

[0072] FIG. **25** shows a thermal control bypass valve embodiment of the present invention designed for installation in a thermal element located in the cooler.

DETAILED DESCRIPTION OF THE INVENTION

[0073] In the following detailed description, systems, apparatuses, and methods for improving thermal control in automotive transmissions are described by providing references to the accompanying drawings which form a part of the description of how the invention works and does not limit the scope of the present invention. The present invention solves the problem of insufficient cooler flow to and through automotive transmissions due to OEM parts set to bypass fluid flow through the cooler by providing thermal bypass valves with improved structures that replace OEM thermostatic valves and increase cooler flow to and through referenced transmissions by defaulting the thermal control system to fluid flow through the cooler.

[0074] It will be appreciated that for simplicity and clarity of illustration, reference numerals may be repeated among the figures to indicate corresponding or analogous elements. In addition, numerous specific details are set forth in order to provide a thorough understanding of the embodiments described herein. However, it will be understood by those of ordinary skill in the art that the embodiments described herein may be practiced without these specific details. In other instances, well-known methods, procedures and components have not been described in detail so as not to obscure the embodiments described herein. Also, the description is not to be considered as limiting the scope of the embodiments described herein.

[0075] Dimensions are provided for valves and their individual parts and components. Such dimensions are typically identified as either diameter or length and denoted with D, or Ln. The dimensions are specific to the part particularly referenced and do not share common values across like-numbered elements in other valves or valve parts.

[0076] An OEM thermostatic valve **100** for installation in a transmission pump is shown in FIG. **1**. The valve **100** includes an upper portion **102**, a lower portion **104**, a spring **106**, a valve plug **110**, and a clip **108** to secure the valve plug in place. As discussed, the OEM thermostatic valve **100** defaults to a cooler flow OFF state, preventing flow of cooled fluid through the cooler system. In the OFF state, fluid is allowed to flow in both directions to the cooler (i.e. clockwise and counterclockwise in a fluid circuit), which causes a near equilibrium that substantially stops flow out of the cooler near a connection of the cooler and in-line. To switch the OEM thermal control system to a cooler flow ON state, a preheat cycle is required to raise temperatures to above 212° F. This in turn causes the OEM thermostatic valve to begin to close off fluid flow both directions to the cooler, and force fluid flow in a single direction such that hot fluid leaves the transmission enters the cooler to be cooled and is returned as cool fluid to the transmission. When the transmission is cooler than 165° F. (nominal) the flow of lubricant to the cooler is cut by 90%. The reduced flow is directed to lube, then to the pan. Therefore, if the transmission is cool enough for the thermostat to remain in the cooler flow OFF state, 90% of the new fluid mixes with the old fluid, while only 10% flows out and is replaced. If the OEM thermal bypass system malfunctions and the system is not turned to an ON state, the oil and transmission overheat due to a lack of freshly cooled lubricant supply. This in turn affects the pump, valve body, solenoids, sealing rings, and clutch drum operation.

[0077] FIG. **2** illustrates an embodiment of an improved thermal bypass valve **200** for installation in the transmission pump. A preferred embodiment of the thermal bypass valve **200** includes a blocker valve **204**, a relief valve **202**, and spring **206**. The thermal bypass valve **200** reuses the valve plug **110** and clip **108** of the OEM thermostatic valve **100** in this embodiment. A new plug **110** and clip **108** may be provided in further embodiments, but reusing the plug and clip from the OEM valve saves on costs associated with converting the thermal cooling system according to embodiments of the current invention. The remaining components of the thermostatic valve **100**, namely the upper portion **102**, lower portion **104**, and spring **106**, are removed from the transmission oil pump and discarded or recycled.

[0078] FIGS. **3** and **4** provide descriptions and dimensions of the relief valve **202** and blocker valve **204**. Dimensions provided for the valves **202** and **204** are preferred for a bypass valve **200** that is installed in the transmission pump of a Ford® 5R110W series transmission. The dimensions may be altered to conform to specific dimensions, if different, of other transmissions having the thermal element and corresponding thermal bypass valve in the transmission pump.

[0079] Referring now to FIG. **3**, a side view of the relief valve **202** of the thermal bypass valve **200** is shown. The relief valve **202** includes a uniformly cylindrical body **208** having a length L.sub.1 and a diameter D.sub.1. In the preferred embodiment, L.sub.1 is 0.950″ and D.sub.1 is 0.4758″ +/−0.002″. A cylindrical cavity **212** having a uniform diameter D.sub.2 extends within and along a partial length L.sub.2 of the cylindrical body **208**. The cavity **212** is contiguous with and open at a free end **209** of the cylindrical body **208** and is closed at an end **211** of the cavity opposite the free end. In the preferred embodiment, L.sub.2 is 0.440″ and D.sub.2 is 0.330″. A cylindrical member **210**, having a length L.sub.3 and a diameter D.sub.3, is coaxial with and extends away from the cylindrical body **208** along an end **213** of the cylindrical body opposite the free end **209**. In the preferred embodiment, L.sub.3 is 0.150″ and D.sub.3 is 0.100″.

[0080] Referring now to FIG. **4**, a side view of the cylindrical blocker valve **204** of the thermal bypass valve **200** is shown. The cylindrical blocker valve **204** includes a groove **220** having a length L.sub.3 and a diameter D.sub.3. In the preferred embodiment, L.sub.3 is 0.210″ and D.sub.3 is 0.395″. The groove **220** defines an upper cylindrical portion **222** and a lower cylindrical portion **224** directly adjacent to and on either side of the groove. The upper cylindrical portion **222** has a length L.sub.2 and a diameter D.sub.1. In the preferred embodiment, L.sub.2 is **0.500**″ and D.sub.1 is 0.4753″+/−0.002″. A beveled edge **226** of the upper cylindrical portion **222** is adjacent to the groove **220**, and has a length L.sub.5, included within L.sub.2, and decreases in diameter from D.sub.1to a diameter D.sub.2. directly adjacent to the groove **220**. In the preferred embodiment, L.sub.5 is 0.085″ and D.sub.2 is 0.445″. The lower cylindrical portion **224** has a length L.sub.4 and a diameter D.sub.4. In the preferred embodiment, L.sub.4 is 0.690″ and D.sub.4 is 0.4455″+/−0.0002″. The lower cylindrical portion **224** also has a beveled edge **228** along a free end **230** of the lower cylindrical portion **224**. The beveled edge **228** has a length L.sub.6 and decreases from D.sub.4 into a diameter D.sub.5. In the preferred embodiment, L.sub.6 is 0.085″ and D.sub.5 is 0.415″. The cylindrical blocker valve has an overall length L.sub.1, which is the sum of L.sub.2, L.sub.3, and L.sub.4, which is 1.400″ in the preferred embodiment.

[0081] FIG. **5** shows the thermal bypass valve **200** being inserted into a representative transmission oil pump **201**. To install the preferred embodiment of the thermal bypass valve **200**, the clip **108** is first removed from the valve plug **110**. The valve plug **110** is then removed, and both the valve plug and clip **108** are saved. Next, the upper portion **102**, lower portion **104**, and spring **106** of the OEM thermostatic valve **100** are removed from the cooler flow control valve section of the oil pump **201**. The upper portion **102**, lower portion **104**, and spring **106** of the OEM thermostatic valve **100** may then be discarded or recycled.

[0082] After discarding the OEM thermostatic valve **100**, the thermal bypass valve **200** of the present invention may then be installed. First, the cylindrical blocker valve **204** is inserted into cooler flow control valve section of the oil pump **201** along the free end **230** of the lower cylindrical portion **224** having the beveled edge **228**. The relief valve **202** is then inserted such that the cylindrical member **210** rests along a free end **232** of the upper cylindrical portion **222** of the blocker valve **204**. The spring **206** is then inserted such that a portion of the spring's length is contained within the cylindrical cavity **212** of the relief valve **202**. The spring **206** has a diameter that allows it to be secured within the cylindrical cavity **212** of the relief valve **202** without substantial lateral movement that would otherwise contribute to wearing of the cavity or misalignment of the valves **202** and **204** in the pump **201**. The valve plug **110** is then once again secured to the oil pump **201** and is further secured by the clip **108** to keep the thermal bypass valve **200** in the oil pump.

[0083] Further discussion of the cooler circuit of the thermal control system through the pump upon replacing the OEM valve **100** with the thermal bypass valve **200** or a similar embodiment is provided in reference to FIG. **24**.

[0084] In a default state, or position at vehicle start-up, the relief valve **202** blocks a line connection path between the in-line and out-line through the thermal element. This forces cooler fluid to flow from other transmission systems to the cooler via the out-line and return from the cooler to the transmission systems via the in-line. If PSI within the fluid circuit of in-lines and out-lines reaches the blow-off PSI, the relief valve **202** is forced outward away from a center of the pump, towards the plug **110**, and the spring **206** is compressed, thus allowing for cooler fluid flow through the line connection path and to include the thermal element in the fluid circuit to bypass flow to the cooler **1122**. This scenario would occur if a blockage in the cooler **1122** prevents fluid flow through the cooler. When pressure decreases in the out-lines, forces on the relief valve **202** decrease and the spring **206** expands to push the relief valve back towards the blocker valve **204**. This reestablishes flow from the pump and transmission to the cooler. The spring **206** is in a vented area between the relief valve **202** and plug **110**, so there is no counterbalance oil pressure on the spring side of the relief valve. Therefore, the blow-off PSI is equal to the spring tension divided by the area of the end of the valve **202**.

[0085] An OEM wax pellet style thermostatic valve **400** for insertion into a transmission case, or casing, is shown in FIG. **6**. By way of example, the thermostatic valve of the Ford® 6R60, 6R75, and 6R80 series transmissions are housed in the transmission case and are typically used in Ford® Explorer models (6R60 series transmission), Ford® Expedition and Lincoln® Navigator models (6R75 series transmission), and Ford® Mustang and F150 models (6R80 series transmission). The OEM thermostatic valve **400** has sleeve **402**, brass pellet **404**, and spring **406**, which are inserted into a transmission case or casing. As with the OEM thermostatic valve **100**, the OEM thermostatic valve **400** defaults to a cooler flow OFF state.

[0086] FIG. **7** illustrates an embodiment of a thermal bypass valve **300** for insertion into a transmission casing. Dimensions for the thermal bypass valve **300** are provided by way of example to fit into the corresponding thermal element for the Ford® 6R60, 6R75, and 6R80 series transmissions to replace the OEM valve **400**. However, the dimensions may be altered to fit within other transmissions having the thermal element located within the transmission case.

[0087] Referring now to FIG. **8**, a side view of an embodiment of the thermal bypass valve **300** is provided. The thermal bypass valve **300** has a cylindrical body **304**. The cylindrical body **304** has an inner cylindrical cavity **312** extending along a longitudinal length of the cylindrical body, the cylindrical body having a free end **310** contiguous with the cylindrical cavity, and along which the cylindrical cavity is open. The cylindrical cavity **312** has a length L.sub.9 and a diameter D.sub.4. In a preferred embodiment of the thermal bypass valve **300**, L.sub.9 is 1.250″ and D.sub.4 is 0.3942″+/−0.0002″. A raised band **308** coaxially extends around a circumference of the cylindrical body **304** and is located proximate to the free end **310**. A second raised band **306** coaxially extends around a circumference of the cylindrical body **304** along an end **307** opposite the free end **310**. The raised band **308** and second raised band **306** have a length L.sub.5 and a diameter D.sub.3. In a preferred embodiment of the thermal bypass valve **300**, L.sub.5 is 0.150″ and D.sub.3 is 0.6806″+/−0.0002″. A portion of the cylindrical body between the raised band **308** and second raised band has a length L.sub.3 and a diameter D.sub.1. In a preferred embodiment of the thermal bypass valve **300**, L.sub.3 is 0.830″ and D.sub.1 is 0.580″. Another portion of the cylindrical body **304** between the raised band **308** and free end **310** has a length L.sub.4 and has the diameter D.sub.1. In a preferred embodiment of the thermal bypass valve **300**, L.sub.4 is 0.170″.

[0088] A coaxial cylindrical protrusion **302** extends from the end **307** opposite the free end **310**.

The cylindrical protrusion **302** has a length L.sub.2 and a diameter D.sub.2. In a preferred embodiment of the thermal bypass valve **300**, L.sub.2 is 0.700″ and D.sub.2 is 0.450″. A relief opening **318** is provided in the cylindrical body **304** and is positioned between the raised band **308** and second raised band **306**, and proximate to the second raised band. In a preferred embodiment of the thermal bypass valve **300**, the relief opening **318** has a diameter of 0.0625″ and a center of the relief opening is positioned 1.110″ away from the free end **310**. A plurality of openings **316** are provided in the cylindrical body **304** between the raised band **308** and second raised band **306**, and proximate to the raised band. In a preferred embodiment of the thermal bypass valve **300**, each opening **316** has a diameter of 0.125″ and is positioned 0.390″ away from the free end **310**. In a preferred embodiment of the thermal bypass valve **300**, four openings **316** are provided proximate to the raised band and evenly spaced along the circumference of the cylindrical body **304**. In a preferred embodiment of the thermal bypass valve **300**, the entire length L.sub.1 of the valve is 2.000″.

[0089] Referring now to FIG. **9**, a side view of the preferred embodiment of the thermal bypass valve **300** is shown including a cylindrical relief valve **320** slidable within the cylindrical cavity **312**. A spring **322** is also positioned within the cylindrical cavity **312** between the relief valve **320** and a closed end **309** of the cylindrical cavity. The relief valve **320** has a cylindrical member **324** coaxial with the relief valve and extending from a free end **321** of the relief valve. The spring **322** is semi-compressed within the cylindrical cavity **312** to keep the member **324** in contact with a tube **326** extending across the cavity. During operation, forces may act on the relief valve **320** forcing the relief valve to slide further toward the closed end **309** of the cavity **312**, compressing the spring **322** further. When such forces are absent, the spring **322** expands to slide the relief valve **320** back to its relaxed, or default, position, with the member **324** in contact with the tube **326**, once the counteracting forces are no longer present. The relief valve **320** and spring **322** are omitted from the view provided in FIG. **8** for the purpose of clearly showing the varying lengths and diameters of the various elements of the valve **300**. FIG. **9** shows a view of the structures of the valve **300** within the cavity **312** omitted in FIG. **8**.

[0090] FIG. **10** provides a side view of the thermal bypass valve **300** rotated 90° relative to the view provided in FIGS. **8** and **9**. The tube **326** extends across the cylindrical cavity **312** between the free end **310** and the raised band **308**, and perpendicularly to the longitudinal length of the cylindrical body **304**. The tube **326** extends within two holes **314** in the cylindrical body **304** proximate to the free end **310**, and the two holes **314** are positioned 180° relative to each other along the circumference of the cylindrical body **304**. In a preferred embodiment of the thermal bypass valve **300**, each of the two holes **314** are 0.0625″ in diameter and a center of each hole is positioned 0.080″ from the free end **310**. Further, the tube is preferably hollow such that the two holes **314** and tube **326** form an enclosed cylindrical space across the cylindrical cavity **312**. However, the tube **326** may be solid in other embodiments of the valve **300**. A view from the opposite side of the valve **300** mirrors the view shown in FIG. **10**

[0091] FIG. **11** provides a side view of the thermal bypass valve **300** rotated 180° relative to the view provided in FIGS. **8** and **9**. In this view, one of the two holes **314** is shown, along with an opening of the plurality of openings **316**. As there is only one relief opening **318**, and it is on the opposite side of the cylindrical body **304**, another relief opening is not shown.

[0092] FIG. **12** shows a bottom view of the thermal bypass valve **300** provided in FIGS. **8** and **9**. The raised band **308** sets the outer most diameter of the valve **300**, along with the second raised band **306**. The two holes **314** and tube **326** are shown from a better view. The member **324** of the relief valve **320** rests against the tube **326**, keeping the relief valve within the cylindrical cavity **314**.

[0093] FIG. **13** shows a top view of the thermal bypass valve **300** provided in FIGS. **8** and **9**. This view would be seen by a user upon installing the valve **300** into the transmission casing. The second raised band **306**, along with the raised band **308**, sets the outer most diameter for the thermal bypass valve **300**. The cylindrical protrusion **302** is shown having a smaller diameter than the second raised band **306**, and the remaining elements are obscured in this view.

[0094] FIG. **14** demonstrates how the thermal bypass valve **300** replaces the OEM thermostatic valve **400** in transmissions having the thermal element in the transmission casing. After locating the thermostatic valve opening on the transmission case, the OEM thermostatic valve **400** is removed, including the sleeve, wax pellet, and spring. The OEM thermostatic valve **400** may then be discarded or recycled. The thermal bypass valve is then inserted into the thermostatic valve opening, such that the free **310** is inserted first and the cylindrical protrusion **302** is still visible after insertion.

[0095] In operation, the free end **310** of the valve **300** would be inserted into an opening between a thermal element chamber and an out-line leading fluid from the transmission to the cooler. Alternately, the valve sits in the thermal element chamber such that the raised band **308** creates a seal between a connection point of the in-line and out-line, such that fluid must flow from the out-line through free end **310** and through the cavity **312** to reach the in-line. In the default position, shown in FIG. **9**, the relief valve **320** blocks access to the thermal element chamber and in-line from the out-line, preventing cooler bypass, and forcing fluid to travel from the transmission through the out-line to the cooler and back to the transmission via the in-line, thereby ensuring cool fluid return to the transmission. Under high pressure in the out-line, such as when a blockage in the cooler prevents flow out through the in-line, forces on the relief valve **320** compress the spring **322** moving the relief valve into the cavity and toward end **309**. Once the spring **322** is compressed far enough, openings of the plurality of openings **316** allow fluid to exit the cavity **322** and enter the in-line to the transmission. This allows the fluid to bypass the cooler. Relief opening **318** allows fluid and/or air to escape or enter the cavity **312** between the relief valve **320** and end **309** during compression or expansion of the spring **322**. Raised band **306** forms the outer diameter and seal between the thermal element chamber, in-line, and external environment, closing the fluid circuit at the thermal element location.

[0096] An embodiment of a thermal bypass valve **600** for transmissions having a thermal element external to the transmission, in either a block in the cooler in-line and out-line or in the cooler itself, is shown in FIG. **15**. Dimensions provided in referenced to the valve **600** pertain specifically to an improved valve fitting into an external thermostat block of the Ford® 6R80E series transmission, model year 2014 and up, that is removably attached to an outside of the transmission case. However, the dimensions of the valve may be changed to fit other transmissions having the thermal element within the cooler or external blocks in the cooler line.

[0097] FIG. **15** shows the individual components of the thermal bypass valve **600** that fit into the external thermostat block after removal of the OEM thermostatic valve, including a sleeve **602**, two O-rings **604** and **606**, a conical spring **608**, a bearing ball **610**, a piston **614**, and a piston O-ring **612**. Further discussion of these components is provided below.

[0098] Referring now to FIG. **16**A, the sleeve **602** of the thermal bypass valve **600** is shown in greater detail, along with the bearing ball **610**. The sleeve **602** has a cylindrical body **620** with a cylindrical cavity **626** extending along a longitudinal length of the cylindrical body. The cylindrical cavity **626** is contiguous with and open along a free end **621** of the cylindrical body **620**. An opposite inner end **623** of the cylindrical cavity **626** is beveled toward a second cylindrical cavity **628**, which in turn is contiguous with the beveled inner end **623** of the cylindrical cavity **626**. The beveled inner end **623** is preferred, although not necessary, with use with a bearing ball **610**. The beveled end **623** helps to ensure that the bearing ball **623** sits fully within the opening between the cylindrical cavities **626** and **628** between expansion and contraction of the spring **608**. A squared end runs the risk of the bearing ball **610** getting caught between the spring **608** and end **623** without fully blocking fluid access to the cylindrical cavity **626**. The beveled edge ensures that, even in the event of a misalignment, the bearing ball **610** returns to fully sit within the opening between the cavities **626** and **628** to prevent and/or restrict fluid flow to the cylindrical cavity **626**.

[0099] The second cylindrical cavity **628** has a smaller diameter and length than the cylindrical cavity **626**. A closed end **625** of the second cylindrical cavity is pitched toward a grooved blocker portion **622** of the sleeve **602**. The cylindrical body **620** has a groove **629** extending around an outer circumference of the cylindrical body **620** along an end **627** opposite the free end **621**. A plurality of openings **630** in the groove **629** lead into the second cylindrical cavity **628**. The cylindrical body **620**, including the groove **629**, has a length L.sub.1. In a preferred embodiment of the valve **600**, L.sub.1 is 1.045″. The cylindrical body **620**, not including the groove **629**, has a length L.sub.5. In a preferred embodiment of the valve **600**, L.sub.5 is 0.915″. The cylindrical body **620** has a diameter D.sub.7. In a preferred embodiment of the valve **600**, D.sub.7 is 0.727″. The cylindrical cavity **626** has a diameter D.sub.6. In a preferred embodiment of the valve **600**, D.sub.6 is 0.5469″. The second cylindrical cavity **628** has a diameter D.sub.5. In a preferred embodiment of the valve **600**, D.sub.5 is 0.272″. Each of openings of the plurality of openings **630** has a diameter of 0.125″. In a preferred embodiment of the valve **600**, there are four openings **630** spaced equidistantly around the circumference of the groove **629**. There is a 0.005″ clearance between each opening of the plurality of openings **630** and the grooved blocker portion **622**.
[0100] Still referring to FIG. **16**A, the grooved blocker portion **622** of the sleeve **602** is contiguous at an end with the groove **629** and end **627** of the cylindrical body **620**. The grooved blocker portion **622** is itself cylindrical and has two grooves **632** and **633**. The grooves **632** and **633** are evenly spaced relative to each other about the circumference of the grooved blocker portion **622**. A cap **634** is attached to the grooved blocker portion along an end opposite the cylindrical body **620**. In use, the cap **634** seals the cooler and other components of the thermal bypass valve **600** within the external thermostat block. A cylindrical member **624** is attached to the cap on an end opposite the grooved blocker portion. The member **624** may be grooved itself to aid in removing the sleeve **602** from the external thermostat block. The cylindrical member **624**, cap **634**, grooved blocker portion **622**, grooves **632** and **633**, groove **629**, cylindrical body **620**, cylindrical cavity **626**, and second cylindrical cavity **628** are all coaxial and share a central longitudinal axis extending through the center of the sleeve **602** lengthwise. The grooved blocker portion **622** and cap **634** together have a length L.sub.2. In a preferred embodiment of the valve **600**, L.sub.2 is 0.455″. Each groove **632** and **633** have a length L.sub.7 and a diameter D.sub.4. In a preferred embodiment of the valve **600**, L.sub.7 is 0.077″ and D.sub.4 is 0.763″+/−0.001″. Lands **635**, **637**, and **639** of the grooved blocker portion **622** have a diameter D.sub.3. In a preferred embodiment of the valve **600**, D.sub.3 is 0.860″. Lands **637** and **639** have a length L.sub.6. In a preferred embodiment of the valve **600**, L.sub.6is 0.060″. Land **635** has a length L.sub.8. In a preferred embodiment of the valve **600**, L.sub.8 is 0.123″. The cap **634** has a length L.sub.3 and a diameter D.sub.1. In a preferred embodiment of the valve **600**, L.sub.3 is 0.058″ and D.sub.1 is 1.000″. The member **624** has a length L.sub.4 and a diameter D.sub.2. In a preferred embodiment of the valve **600**, L.sub.4 is 0.300″ and D.sub.2 is 0.325″.
[0101] FIG. **16**B shows a rotated view of the sleeve **602** to illustrate the plurality of openings **630** in the groove **629**. A view from the opposite side of the sleeve **602** mirrors the view shown in FIG. **16**B in the preferred embodiment.
[0102] Referring now to FIG. **17**, a side view of the piston **614** is provided. The piston **614** has a first cylindrical portion **640** adjacent to and continuous with a second cylindrical portion **642**. A central cylindrical cavity **644** extends through both the first and second cylindrical portions **640** and **642**, and the cylindrical cavity, first cylindrical portion, and second cylindrical portion are coaxial. A free end **646** of the second cylindrical portion **642** may have an outer edge **648** that is beveled. The cavity **644** is open along the free end **646** and an opposing free end **650** along the first cylindrical portion **640**. The piston has a length L.sub.1. In a preferred embodiment of the valve **600**, L.sub.1 is 1.120″. The first cylindrical portion has a length L.sub.3 and a diameter D.sub.1. In a preferred embodiment of the valve **600**, L.sub.3 is 0.620″ and D.sub.1 is 0.546″. The second cylindrical portion has a length L**2** and a diameter D**3**. In a preferred embodiment of the valve **600**,

L.sub.2 is 0.500″ and D.sub.3 is 0.427″. The cylindrical cavity has length L**1** and a diameter D**2**. In a preferred embodiment of the valve **600**, D.sub.2 is 0.272″. The beveled outer edge **648** has a length of 0.030″ in a preferred embodiment.

[0103] Referring now to FIG. **18**, the thermal bypass valve **600** and constituent components are shown and arranged for insertion into, and operation within, the external thermostat block. O-ring **604** is slipped over the sleeve **602** and secured within the groove **632** and O-ring **606** is slipped over the sleeve and secured within the groove **633**. The bearing ball **610** is inserted within the cylindrical cavity **626** of the cylindrical body **620** of the sleeve **602**. The conical spring **608** is then inserted into the cylindrical cavity **626** such that the smaller diameter end **660** is positioned around a surface of the bearing ball **610**. A larger diameter end **662** of the conical spring **608** is positioned against the free end **650** of the first cylindrical portion **640** of the piston **614**, which is also partially inserted into the cylindrical cavity **626** of the sleeve **602**. The piston O-ring **612** is secured around the second cylindrical portion **642** of the piston **614** adjacent to the first cylindrical portion **640**. The piston **614** and conical spring **608** keep the bearing ball **610** secured within an opening formed at the juncture of the second cylindrical cavity **628** and beveled end **623** of the cylindrical cavity **626** of the sleeve **602**. In a preferred embodiment of the valve **600**, the bearing ball has a diameter of 0.335″ or 8.5 mm.

[0104] In operation, fluid traveling through the out-line from the transmission to the cooler either passes through valve **600** via the plurality of openings **630** and second cylindrical cavity **628** and/or around the valve along the groove **629** to continue towards the cooler. This is a default position of the valve **600**, whereby fluid is allowed to flow from the transmission to the cooler and back again to supply cooled fluid to the transmission. The bearing ball **610** blocks access to the first cylindrical cavity **626** in the default position, as the spring **608** holds the bearing ball **610** in contact with an inner circumferential edge of the beveled inner end **623** shared by the second cylindrical cavity **628**. The O-rings **604** and **606** provide scaling edges that keep fluid from escaping through an opening in the thermostatic block through which the valve **600** is installed. When pressure builds up in the out-line, due for example to a blockage in the cooler preventing fluid flow from the cooler to the transmission via the in-line, forces act on the bearing ball **610** to compress spring **608**. This in turn opens a passage from the second cylindrical cavity **628** to the first cylindrical cavity **626** and allows fluid to bypass the cooler. Fluid then flows from the out-line through the plurality of openings **630**, into the second cylindrical opening, around the bearing ball **610**, past the spring **608** through gaps in spring coils, through the cavity **644** of the piston **614** and out of the valve **600** and into the in-line. Once pressure cases in the out-line, the spring **608** expands, forcing the bearing ball **610** to once again seal the connection point between the first and second cylindrical cavities **626** and **628**. The piston **614** slidably engages the cylindrical cavity **626** of the sleeve **626** along at least a partial length of the first cylindrical portion **640** such that fluid cannot escape the sleeve between the sleeve and piston in the cylindrical cavity. The O-ring **612** helps to ensure that fluid does not travel around an outer surface of the piston **614** and must pass through cavities **626**, **628**, and **644** of the valve **600** in order to bypass the cooler. The piston **614** does not move relative to the sleeve **602** during normal operation of the transmission and thermal control system.

[0105] Referring now to FIG. **19**, the thermal bypass valve **600** is inserted into the external thermostat block **702** after the OEM thermostatic valve is removed and discarded or recycled.

[0106] The second cylindrical portion **642** of the piston **614** is inserted into a recessed portion of the external thermostat block **702**, along with the piston O-ring **612**, and the sleeve **602**, two O-rings **604** and **606**, conical spring **608**, and bearing ball **610** are inserted into the external thermostat block such that the valve **600** is contained within the block **702** as shown in FIG. **18**. An OEM snap ring **704** is saved from the OEM thermostatic valve and used to secure the sleeve **602** and remaining components of the valve **600** in place. Together, the thermal bypass valve **600**, OEM snap ring **704**, and external thermostatic block **702** form an improved thermal control system **700**.

[0107] Referring to FIG. **25**, an alternative embodiment of a thermal control bypass valve **1200** is shown. This valve **1200** is designed to be inserted into a thermal element located within the cooler itself. The valve **1200** shares similar structures with the valve **600** configured to be inserted into a thermal element located in the cooler lines.

[0108] A sleeve **1202** of the valve **1200** has an upper cylindrical portion **1212** and a lower cylindrical portion **1214** defined by a groove **1216** extending there between. The groove **1216** extends around a circumference of the valve **1200** and has a smaller diameter than either the upper cylindrical portion **1212** or the lower cylindrical portion **1214**. An inner cavity **1224** extends within an interior of the valve **1200**, with one of the inner cavity **1224** being closed and another end of the cavity open along a beveled edge **1222** increasing in diameter toward a free end **1220** of the valve **1200**. The beveled edge **1222** is adjacent to and contiguous with the inner cavity **1224** and the free end **1220** of the valve **1200**. At least one opening **1218** in the groove **1216** opens into the inner cavity **1224**, providing fluid access through at least two different openings in the valve **1200**. Two or more openings are preferred in the groove **1216**, to allow fluid access laterally through the valve **1200** by fluid traveling through the out-line, and to allow sufficient amounts of fluid into the inner cavity **1224** and through the free end **1220** during bypass. A first narrow groove **1228** extends around a circumference of the upper cylindrical portion **1212**, and a second narrow groove **1226** extends around a circumference of the lower cylindrical portion **1214**. These grooves **1226** and **1228** are wide enough to securely accommodate and hold O-rings **1208** and **1210**, respectively, which have identical dimensions. A bearing ball **1204** is held partially within the inner cavity **1224** and an area created by a circumference and width of the beveled edge **1222** by a conical spring **1206**. The conical spring **1206** engages the bearing ball **1204** about its surface along a small-diameter end **1240** of the spring. A large-diameter end **1242** of the spring **1206** supports the spring against an inner surface of the thermal element and provides an immovable support upon which the spring compresses during fluid bypass of the cooler.

[0109] The beveled end **1222** helps to ensure that the bearing ball **1204** fully closes the opening to the inner cavity **1224** along the free end **1220** of the valve **1200**. As with the valve **600** in previous embodiments, a squared end runs the risk of the bearing ball **1204** getting caught between the spring **1206** and end **1220** without fully blocking fluid access to the inner cavity **1224**. The beveled edge **1222** ensures that, even in the event of a misalignment, the bearing ball **1204** returns to fully sit within the opening at the free end **1220** to prevent and/or restrict fluid flow to the inner cavity **1224**.

[0110] A cap **1230** adjacent to the upper cylindrical portion **1212** opposite the groove **1216** provides an outer surface of the valve **1200** after installation and seals the valve within the fluid circuit of the thermal control system by preventing fluid from escaping past the cap. A member **1232** extends from the cap opposite the upper cylindrical portion **1212** to provide a surface for more easily removing and/or installing the valve **1200** in the thermal member.

[0111] In operation, the valve **1200** is inserted into a thermal element of the cooler, such that the groove **1216** and at least one opening **1218** are positioned in fluid connection with the out-line of the thermal control system. The cooler thermal element is shaped similar to the thermal block **702** shown in FIG. **19**, but made integral with the cooler instead of positioned in the cooler lines. Fluid traveling through the out-line from the transmission to the cooler either passes through valve **1200** via the at least one opening **1218** and inner cavity **1224** and/or around the valve along the groove **1216** to continue towards the cooler. This is a default, cooler flow position of the valve **1200**, whereby fluid is allowed to flow from the transmission to the cooler and back again to supply cooled fluid to the transmission. The bearing ball **1204** blocks fluid access through the inner cavity **1224** and out the free end **1220** in the default position, as the spring **1206** holds the bearing ball in contact with an inner circumferential edge of the beveled edge **1222** shared by the inner cavity **1224** and free end **1220**. The O-rings **1210** and **1208** positioned within grooves **1228** and **1226** provide sealing edges that keep fluid from escaping along an outer surface of the valve **1200** in either direction along a longitudinal length of the valve (i.e. toward the cap **1230** or free end **1220**).

When pressure builds up in the out-line, due for example to a blockage in the cooler preventing fluid flow from the cooler to the transmission via the in-line, forces act on the bearing ball **1204** within the inner cavity **1224** to compress spring **1206**. This in turn opens a passage from the inner cavity **1224**, around the bearing ball **1204**, and through the free end **1220** allowing fluid to flow from the out-line directly into the in-line, bypassing the cooler. Fluid then flows from the out-line through the at least one opening **1218**, into the inner cavity **1224**, around the bearing ball **1204**, past the spring **1206** through gaps in spring coils, and into the in-line. Once pressure cases in the out-line, the spring **1206** expands, forcing the bearing ball **1204** to once again seal the opening at the juncture of the inner cavity **1224** and beveled edge **1222**. Unlike the valve **600**, there is no piston element. The large diameter end **1242** of the spring **1206** rests around an opening of the in-line or similar structure. Even when compressed, fluid is allowed to laterally flow through the spring into the in-line. As thermal elements in the cooler lines and in the cooler are similar, depending on the make and model of a particular transmission, embodiments of valves **600** and **1200** may be interchangeable in structure and may be modified in particular dimensions to fit either thermal element.

[0112] As with valves shown in FIGS. **7** and **15**, the valve **600** utilizes a spring wherein the spring is present in the fluid flow of the system, and is therefore a differential pressure regulating device instead of a blow-off, or pressure-limit device as provided in FIG. **2**.

[0113] The valve **600** is compatible with at least Ford® 6R80/90, 4R70/75, and 6F35 transmissions.

[0114] The described valves replace OEM valves to apply embodiments of a process of converting the OEM thermal bypass control system, with the three operating states and features previously described, i.e. fully ON, fully CLOSED, and partial ON, to a two-state system that by default has a state with cooler flow switched ON, and as a secondary state has a safety bypass directly to a cooler return or lube as an emergency state when the cooler and or lines are blocked, pinched, or damaged in such a way as to seriously compromise cooler flow and lube. In the OEM state, when this happens, serious damage results from a starvation of lubricant and adequate cooling. The consequences can range from overheated fluid temperature to severe planetary damage, and possibly vehicle fire if an operator ignores warning lamps and continues to operate the vehicle, especially under heavy load. With the instant embodiments of the process applied to a transmission, lubrication is delivered despite cooler blockage. When the over-temperature warning lamp turns on, the operator may continue to operate the vehicle to return it for repair while averting a complete planetary system crash.

[0115] Depending on a particular transmission build, one of two preferred embodiments are employed to improve the thermal control system of an automotive transmission. Both embodiments provide the similar major features, as well as the benefits, that precipitate from them, although the implementation may vary according to vehicle specifics, the location of the thermal control system, and/or type of housing that contains it. One primary feature is full time cooler flow. Cooler fluid fills the cooler and lines immediately on initial fill after transmission rebuild or replacement. Further, there is an accurate fluid level check without a warm-up cycle. Next, there is an emergency safety bypass directly to the lube system to prevent catastrophic planetary failure in the event the cooler is restricted or blocked, or lines are pinched or smashed. There are also lower average operating temperatures, typically between 145-165° F., which is about a 70° F. reduction from OEM thermal control temperatures.

[0116] The first embodiment of the method includes providing a flow-blocking device that functions as a blow-off or pressure limit valve. FIG. **24** illustrates a thermal control system in transmission pump implementing a process with a pressure limit valve. The OEM valve is removed and replaced with a valve like the one shown in FIGS. **2-5** of the instant disclosure. The valve is installed into the pump replacing the OEM valve. In a default state, or position at vehicle start-up, the relief valve **1106** blocks a direct path **1134** between in-line **1120** and out-line **1118** through the

thermal element. This forces cooler fluid to flow from other valves **1128** in the pump **1132**, through out-lines **1134** and **1124**, to the cooler **1122**, through in-lines **1126**, **1120**, **1121**, and **1130** and back through gears **1116**, pump **1132** and other valves **1128**. If PSI within the fluid circuit of in-lines and out-lines reaches the blow-off PSI, the relief valve **1106** is forced outward away from a center of the pump **1132** and the spring **1108** is compressed, thus allowing for cooler flow from the valves **1128**, through out-line **1134**, line **1118**, line **1112**, the direct path **134**, line **1121**, through the gears **1116**, in-lines **1130**, and back into the valves **1128** to include the thermal element in the circuit and bypass the cooler **1122**. This scenario would occur if a blockage in the cooler **1122** prevents fluid flow through the cooler. When pressure decreases in the out-lines, forces on the relief valve **1134** decrease and the spring **1108** expands to push the relief valve back towards the blocker valve **1104**. This reestablishes flow from the pump and transmission to the cooler. The spring **1108** is in a vented area between the relief valve **1134** and cap **1110**, so there is no counterbalance oil pressure on the spring side of the relief valve. Therefore, the blow-off PSI is equal to the spring tension divided by the area of the end of the valve **1134**. The area of the valve and spring tension can then be altered to achieve a preferred blow-off PSI at which point the valve will switch the system between the cooler bypass configuration or the configuration allowing flow to the cooler.
[0117] A second embodiment of the method includes replacing an OEM valve in the thermal element with an intermediary or differential pressure regulating device. This pressure provides a counter-balance force on equal areas. FIGS. **20**A and **21**A show an OEM valve in a default and altered position, respectively. FIGS. **20**B and **21**B show the OEM valve installed in a thermal block in either the default or altered position, respectively, to illustrate a simplified thermal control fluid circuit. At start-up in an OEM system **900**, the valve **800** is retracted per FIG. **20**A, either fully or partially depending on fluid temperature as previously discussed, allowing cooler fluid flow from transmission **912** through the out-line **904**. The fluid then flows through an opening **914** into an inner cavity **908** of the thermal element **910** and back to the transmission **912** via an in-line **906**. This state of the OEM thermal control system **900** is shown in FIG. **20**B, and ensures that a majority of the fluid through the out-line **904** bypasses the cooler **902**. The design of the OEM valve **800** and system **900** assumes that full flow through the cooler would only be necessary when fluid temperatures becomes too high. In such a case, silicon in the valve **800** expands, causing the valve to lengthen and block the entrance to the inner cavity **908** of the thermal element **910**. The lengthened OEM valve **800** is shown in FIG. **21**A. As seen in FIG. **21**B, the altered OEM valve **800** blocks liquid flow through the opening **914**. Cooler fluid would then be forced from the transmission **912** through the out-line **904** to the cooler **902** and transported back to the transmission via the in-line **906**.
[0118] The second embodiment of the method pertains to environments where there is fluid pressure, or cooler return, in the area that contains the spring, as opposed to the first embodiment where the spring is in vented area separate from the fluid circuit. In this case the formula now includes cooler return PSI, so is expressed as follows:
[00001] $\mathrm{PRESSURE1(tocooler)} \times \mathrm{AREA} = \mathrm{SPRING} + \mathrm{PRESSURE2(coolerreturn)}$.
[0119] This formula is used to determine corresponding dimensions and structures of the valves of this embodiment to set a preferred pressure differential within the system for the system to maintain via the valve.
[0120] FIGS. **22** and **23** illustrate the application of the second embodiment of an inventive system **1000** improving the OEM system **900** shown in FIGS. **20**B and **21**B. A transmission **1012**, out-line **1004**, in-line **1006**, cooler **1002**, and thermal element **1010**, including a valve **1020**, are shown. A default state, or cooler flow ON, of the instant method is shown in FIG. **22**. An entrance **1014** to a bypass chamber **1008** of the thermal element **1010** from the out-line **1004** is closed by the valve **1020**, forcing fluid flow from the transmission **1012** directly to the cooler **1002** and back to the transmission via the in-line **1006** at start-up of the vehicle. This ensures a proper supply of cooled liquid lubricant during start-up. When cooler flow through the cooler **1002** is blocked, a pressure

differential is created such that pressure in the in-line **1006** approaches zero. In that instance, the system **1000** behaves as shown in FIG. **23** such that the valve **1020** is compressed by the fluid pressure in the out-line **1004**. This allows fluid through opening **1014** and into the bypass chamber **1008**, allowing fluid to flow from the out-line **1004**, through the bypass chamber and back to the transmission **912** via the in-line, bypassing the cooler **1002**.

[0121] For example, assuming that a particular transmission with all OEM parts regulates a minimum main line pressure of 65 PSI, and characteristically delivers 2.0 GMP at 40 PSI from the converter to the cooler lines (cooler out-line), the cooler in-line back to the transmission delivers the same 2.0 GPM at 20 PSI. If the cooler was to become blocked, then the cooler out-line would rise to nearly equal to main line PSI, so from 40 PSI to 65 PSI, and the cooler in-line would drop toward zero.

[0122] Conversely, a valve of the instant invention installed with a spring calibrated for a preferred pressure differential of 40-45 PSI would allow for a bypass supply of 1.0-2.0 GPM fluid at 15-25 PSI, at 60-65 PSI in the cooler OUT line, through the bypass chamber and back to the transmission through the cooler IN line. This keeps a steady supply of fluid into the planetary system. Maintaining a pressure differential range of 35-55 PSI is desired in this embodiment of the process, and a pressure differential of 45 PSI is most desired. In this situation, the fluid through the bypass chamber will be hotter than in a default state, but crucially an adequate supply of lubrication will continue to be provided to prevent catastrophic planetary failure. Valves of FIGS. **7** and **15**, and their corresponding embodiments may be employed in the instantly described method for improving fluid flow in the thermal control system. Such valves include fluid pressure, or cooler return, in the area that contains the spring.

[0123] Importantly, the embodiments of the present invention operate on fluid pressure in the cooler lines, either or both of the out-lines and in-lines. High pressure or pressure differentials can be obtained in either extreme heat or in extreme cold. Fluid in the lines of the system approaching either transitional state, between liquid-solid or liquid-gas states, can expand within the lines of the system and increase pressure necessary to instigate a bypass of the cooler. Most discussion so far has assumed high operating temperatures causing increased pressure, or non-temperature related pressurizing events, such as blockages in the cooler. However, extreme cold causes fluid in the lines to begin to gel into a viscous liquid and toward a solid. This slows or prevents cooler flow in the cooler and/or lines. Therefore, systems of the instant invention allow bypass of the cooler under extreme cold conditions and revert back to allowing flow through the cooler under normal operating temperatures, typically once the fluid melts from a gel form.

Claims

1. A thermal bypass valve, comprising: a cylindrical body having an inner cylindrical cavity extending along a longitudinal length of the cylindrical body, the cylindrical body having a free end contiguous with the cylindrical cavity; a raised band coaxially extending around a circumference of the cylindrical body and proximate to the free end; a second raised band coaxially extending around a circumference of the cylindrical body along an end opposite the free end; a coaxial protrusion extending from the end opposite the free end; a tube extending within the cylindrical cavity proximate to the free end and perpendicularly to the longitudinal length of the cylindrical body, wherein the tube extends through opposite sides of the cylindrical body through two holes in the cylindrical body; a relief valve slidable within the cylindrical cavity; and a spring within the cylindrical cavity and compressible between the relief valve and a closed end of the cylindrical cavity; wherein a plurality of openings in the cylindrical body are positioned adjacent to the raised band, and a relief opening in the cylindrical body is positioned adjacent the second raised band; and wherein the thermal bypass valve is configured to insert into a transmission case of an automotive transmission.

2. The thermal bypass valve of claim 1, wherein the tube prevents further expansion of the spring by impeding movement of the relief valve toward the free end.

3. The thermal bypass valve of claim 1, wherein the relief opening shares a common axis with at least one opening of the plurality of openings and at least one hole of the two holes.

4. The thermal bypass valve of claim 1, wherein the raised band and second raised band have the same diameter.

5. The thermal bypass valve of claim 1, wherein the coaxial protrusion has a smaller diameter than the cylindrical body.

6. The thermal bypass valve of claim 1, wherein each opening of the plurality of openings has a diameter of 0.125″, and the relief opening and each hole of the two holes have a diameter of 0.0625″.

7. The thermal bypass valve of claim 1, wherein the tube is hollow and a continuous opening is formed through the two holes and the tube.