

July 10, 1928.

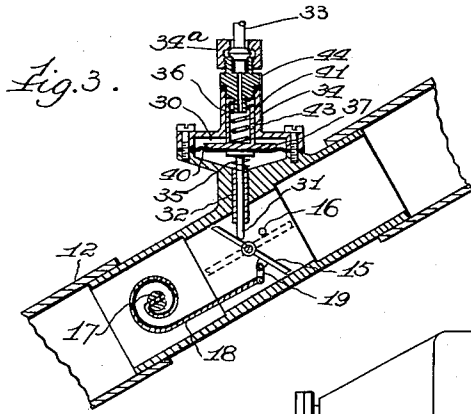
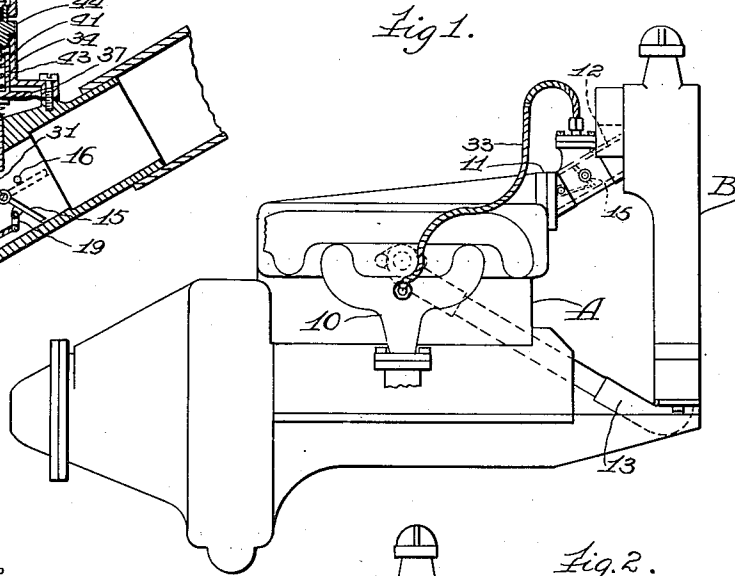
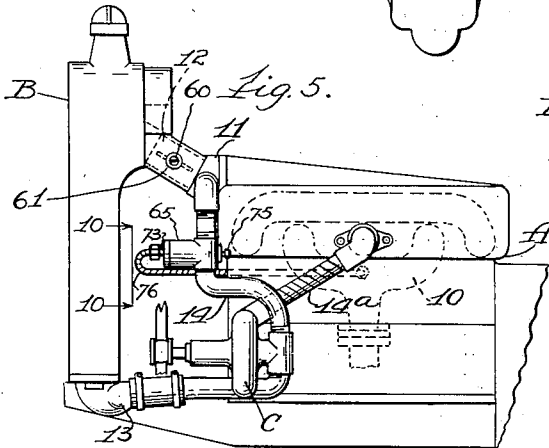
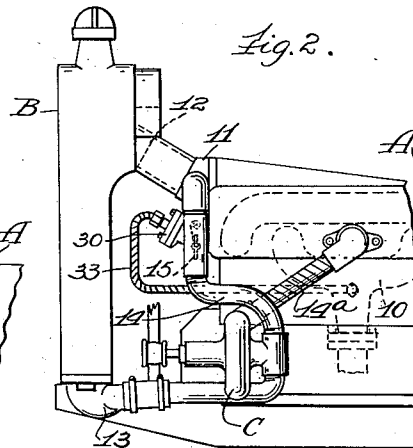
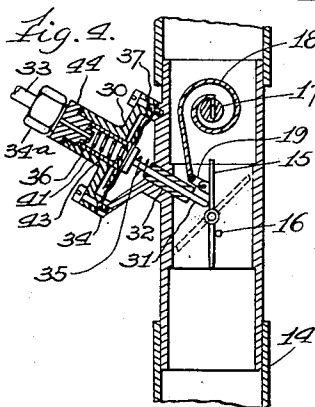
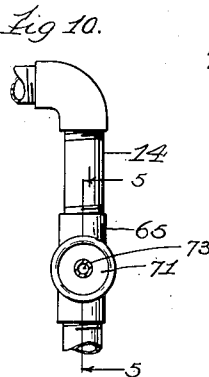
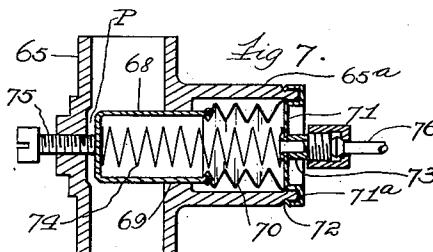
1,677,103

P. S. TICE

INTERNAL COMBUSTION ENGINE TEMPERATURE CONTROL

Filed Jan. 5, 1927

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 8.

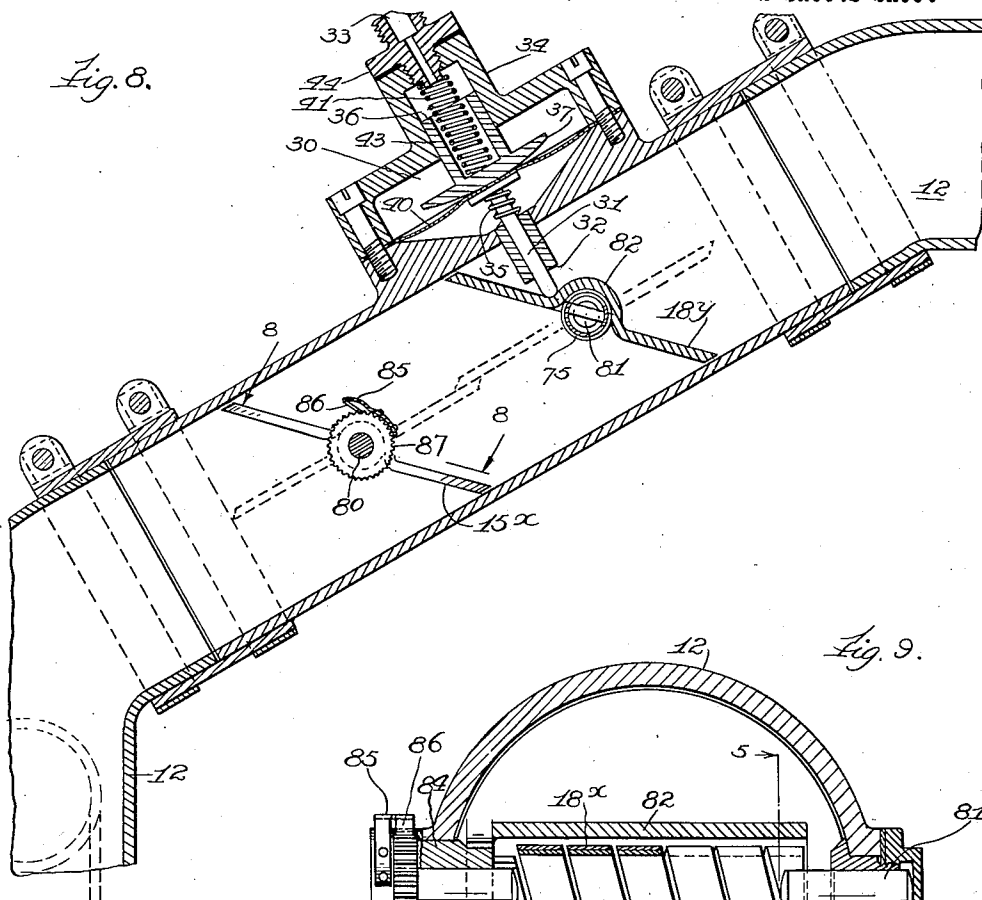


Fig. 9.

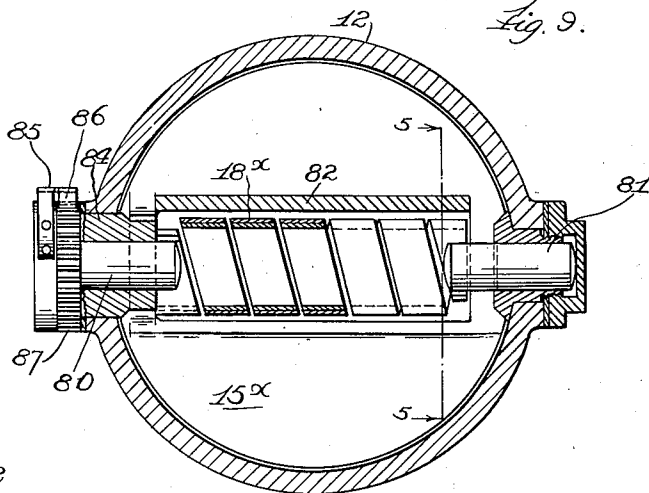
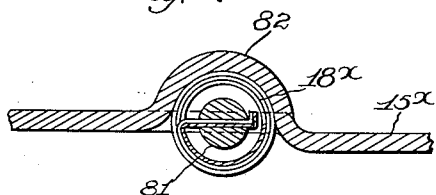


Fig. 6.



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UNITED STATES PATENT OFFICE.

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INTERNAL-COMBUSTION-ENGINE-TEMPERATURE CONTROL.

Application filed January 5, 1927. Serial No. 159,065.

The purpose of this invention is to provide a construction of internal combustion engine for motor vehicle by which the temperature of the engine may be automatically regulated for most desirable power development throughout variations of running conditions in respect to speed and load and under different atmospheric conditions causing different heat loss by radiation and different efficiency of the cooling apparatus for controlling the temperature of the cooling medium employed. It consists in the elements and features of construction shown and described as indicated in the claims.

15 In the drawings:—

Figure 1 is a partly diagrammatic view of the general character of a side elevation of an automobile engine including the customary radiator and cooling water circulatory connections, for indicating the relative positioning of the different parts involved in this invention with respect particularly to the engine and the radiator, the circulation means being of either the thermo-syphonic type,—that is, effected without any use of pump for producing forced circulation of the cooling medium,—or by means of a pump in the water passage between the bottom of the radiator and the bottom of the cylinder jacket.

Figure 2 is a similar view in which the engine shown equipped with this invention has a pump for forced circulation of the cooling medium, and, in the circulatory system has the customary by-pass sometimes used for permitting more or less of the cooling water to by-pass the radiator to avoid the cooling action of the same with thermostatically and pressure-controlled valve in the by-pass pipe.

Figure 3 is a detail section of the cooling water pipe connections from the engine jacket to the radiator in an installation of the type indicated in Figure 1, showing on an enlarged scale both the pressure and thermostatic devices applied to one valve in a circulatory system for accomplishing the purpose of this invention.

Figure 4 is a view similar to Figure 3 showing a combined pressure and thermostatically operated valve in the by-pass of a force circulatory system shown in Figure 2.

Figure 5 is an elevation of an engine having forced cooling circulation with by-pass and having pressure controlled valve in the

by-pass pipe and thermostatically controlled valve in the pipe leading from the engine jacket to the radiator.

Figure 6 is a sectional view showing the thermostatically controlled valve in the construction illustrated in Figure 5.

Figure 7 is a sectional view showing the construction of the pressure controlled valve in the form illustrated in Figure 5.

Figure 8 is a longitudinal section of the pipe leading from the engine jacket to the radiator having separate valves successively positioned in it, one controlled thermostatically only and the other both pressure and thermostatically controlled.

Figure 9 is a partly sectional view on an enlarged scale of a desirable form of the thermostat controlling element which is embodied in the forms shown in Figures 5, 6 and 8.

Figure 10 is an elevation of the pressure controlled valve shown in Figure 5, looking in the direction of the arrow, 10—10, on Figure 5.

Before proceeding to describe the construction in detail, the principles and considerations derived from experience with automobile engines under various considerations of service which have led to and enter into the present invention may be briefly set forth.

Tests show that the fuel economy of an engine other than at full load is improved by operating the engine with jacket-water temperatures that are higher than those ordinarily used in ordinary automobile operation. In many modern cars it is attempted by means of thermostats to keep the jacket water at the jacket outlet toward the radiator approximately at a temperature of 150° to 160° F. This is a compromise temperature range, being somewhat higher than that which permits full power development, and somewhat lower than that which permits maximum fuel economy.

The jacket water temperature operates in two ways to affect the fuel economy; first by controlling the friction losses in the engine which are substantially inversely as the viscosity of the lubricant, which in turn is inversely as the temperature of the lubricant film, thus making fuel economy vary approximately directly with the temperature of the jacket water; second, by affecting the vaporization of fuel. Since only

that part of the fuel that is vaporized will be burned explosively for developing power, the effectiveness of the fuel supply to the engine increases as the operating temperature increases until the temperature is reached at which all the fuel is vaporized. In automobile engines experiment shows that a water jacket temperature of from 190° to 200° F. is required to accomplish this. The vaporization is so nearly complete with the jacket water within this temperature range that much leaner mixtures can be used than those which satisfactorily operate at say 150° F.; thus accounting for a further possible gain in fuel economy at less than full load.

At full load or maximum power it is found that the best general average temperature for the jacket is at or somewhat below 140° F., say 135° to 140° F. Temperature within this range is the best balance between the friction and the volumetric-efficiency-controlling factors, therefore permitting the engine to develop the greatest power of which it is capable.

Since the close approach to maximum possible fuel economy is a main consideration under the demands of load conditions less than the maximum, and since maximum possible powers should be available under full load demand, it appears that the most desirable control of jacket water temperature will be such as to maintain engine temperature (jacket water temperature) within a range of 190° to 200° F. under load conditions, substantially less than the maximum, and to reduce the temperature automatically to within the range from 135° to 140° F. when operating at full load.

This is accomplished in the apparatus shown in the drawings in which a valve in the water circulating passage is controlled as to degree of opening and closing for governing the rate of circulation between the water jacket and the radiator in suitable relation to the changes in intake manifold pressure which varies directly as the load demands upon the engine. Such intake manifold pressure control valve, however, cannot operate alone for exact control but will only operate in general for controlling in the right direction; and for obtaining accurate control of water jacket temperature this pressure control must be supplemented by thermostatic control. It is equally obvious that the thermostatic control alone cannot yield the exact result as to temperature necessary for the purpose. Accordingly the present invention consists in the provision of co-operating devices for modifying the circulation,—(a) thermostatically according to the temperature of the cooling water at a point in its circulatory course at which its temperature most nearly corresponds to the engine tempera-

ture resulting from engine operation and atmospheric conditions; and (b) in accordance with the intake manifold pressure which corresponds to the load demands upon the engine.

Referring to the drawings: The engine in totality is indicated at A, with the intake manifold showing at 10, the water jacket out-lead connection at 11, with pipe connection, 12, to the radiator shown in totality at B, having return pipe, 13, to the engine jacket; and in the case of forced circulation by pump, C, having by-pass pipe from the engine jacket to the pump shown at 14, with return pipe to the jacket at 14^a.

In the case of forced circulation by pump, a valve control for the cooling water circulation may be located in the by-pass pipe, 14, and is so shown in Figures 2 and 4, being illustrated as a pivoted valve, 15, dimensioned so as to stand closed to the limit at an angle of 45 degrees across the water passage in which it is placed, as shown in dotted line in Figure 4, a stop pin, 16, being provided to stop it at its wide open position which is extending longitudinally of the pipe at an axial plane thereof, as shown in full line in Figure 4. It will be understood that the valve is not fitted to the pipe so closely as to totally exclude circulation past it at the limit of its so-called "closed position", but, on the contrary, there is always enough of the circulatory fluid being pumped through the by-pass and passing the valve to keep the thermostatic device at the temperature of the circulated fluid. Experience shows that a one-eighth inch diameter hole through the valve plate, or an equivalent clearance around the valve, permits ample circulation for this purpose. Mounted in the by-pass pipe on a fixed stud, 17, is a bi-metallic spring member, 18, having one end portion coiled spirally and secured at the inner end of the coil to the stud, 17, the remaining portion of the bi-metallic bar extending tangentially from the outermost coil of the spiral in a general direction longitudinally of the pipe and connected by a short link, 19, to the valve, 15, at a short distance from the pivot of the latter. This bi-metallic bar, hereinafter referred to as the thermostatic device, has its spiral coiled with the metal having the higher coefficient of thermal expansion at the outer side of the coil; and the parts are mounted and connected at ordinary atmospheric temperature as seen in Figure 4 with the valve at wide open position and the thermostatic spring device under slight tension for holding the valve at wide-open position slightly pressed against the stop pin. When thus assembled, it will be understood that the rise of temperature of the water circulating through the by-pass pipe raising the temperature of the thermostatic device, will

first relax the tension by which said device operating as a spring, holds the valve at open position against the stop pin; and that, the temperature rise continuing, the tension will be reversed and the tangent arm of the thermostatic device will swing the valve in its closing direction; and at some temperature predetermined by the dimensions of the parts, the valve will reach closed position at which it is shown in dotted line in Figure 4. In accordance with the experience above recited as to the temperature at which fuel economy and maximum power development respectively are obtained, an expert in this art, designing this construction, will proportion the several elements described so that the valve will be at fully closed position when the temperature has reached 200° F., thereby forcing the maximum circulation of the cooling water from the engine jacket through the radiator instead of through the by-pass.

If the valve were controlled solely by the thermostatic device, this would give the maximum efficiency of fuel economy under what might be termed ordinary running conditions, as distinguished from the condition of maximum load requiring the maximum power development of which the engine is capable without regard to fuel economy; and since there is direct relation between the intake manifold pressure and the load requirement of the engine by the employment of this intake manifold pressure to modify the valve opening in the direction of hastening the movement relatively to the temperature of the circulating fluid, and thereby preventing the temperature from becoming too high for the best power development, the engine will be enabled to develop its maximum power under the stimulus of the maximum load. This is accomplished by providing mounted on the outside of the passage containing the valve a pressure chamber, 30, one side of which consists of a flexible diaphragm, 40, rendering the chamber expansible and reducible; and extending from the side of the diaphragm which is toward the pipe and through the wall of the pipe, a stem, 31, guided in a sleeve bearing, 32, mounted for that purpose in the pipe wall, said stem being thus directed for encountering the valve so that the intrust of said stem operates to move the valve in the direction in which it is moved by the thermostatic member upon rise of temperature, that is, away from open toward closed position of the valve, said stem serving thus as a variable stop to prevent the valve from moving from any intermediate position toward wide-open position. The device for operating the valve by intake manifold pressure is identical in construction in the two types of circulatory system shown in Figures 1 and 3, and 2 and

4, respectively, and the following description will apply equally to Figures 3 and 4. The chamber, 30, at the side opposite the flexible diaphragm wall of said chamber has a central hollow boss, 34, to whose outer end there is connected a pipe, 33, which leads to the engine intake manifold for introduction of intake manifold pressure into the chamber, 30, to cause its expansion and contraction and to cause the flexible diaphragm, 40, to actuate the stem, 31, and hold it in operative relation to the valve for affecting the position of said valve as above described in respect to said valve in the by-pass passage. In the hollow boss, 34, there is mounted for sliding axially with respect to the diaphragm chamber wall, a plunger 36, having an expanded head, 37, seating on the diaphragm and curved to accommodate the latter at its expanded position; and a coil spring, 41, in the plunger stem, 43, which is hollow to accommodate said spring reacting between the plunger, and a stop collar, 44, screwed into the outer end of the hollow boss, 34, deeply enough to leave outwardly from it, enough threaded length of the boss for connecting the pipe, 33, leading from the engine intake manifold by a coupling nipple, 34^a. At the outer side of the diaphragm,—that is, outwardly with respect to the chamber, a light spring, 35, coiled about the stem, 31, reacts between the head of the stem, 31, and the guide sleeve, 32, which is fixed in the pipe to cause the stem, 31, to follow the motion of the diaphragm, 40; and the diaphragm is thus movably positioned yieldingly between the two springs, 35 and 41. With atmospheric pressure, or nearly atmospheric pressure, in the intake manifold, the spring, 41, pushes the plunger, 36, the diaphragm, 40, and the stem, 31, inwardly with respect to the water passage tending to hold the valve, 15, at an intrust closed, or partly closed, position tending to increase the freedom of circulation of the cooling water between the engine jacket and the radiator, resulting in lowered temperature of the cooling water, regardless of the action or tensioning of the thermostatic device.

Upon reduction of engine output, as by motion of the engine throttle in a closing direction, the pressure in the engine intake reduces in proportion to the change in load on the engine, and the communicating pipe, 33, transmits this pressure change to the diaphragm, 40, causing a proportionate compression of the spring, 41, and proportionate withdrawal of stem, 31, under influence of its spring, 35, thus permitting a like proportionate movement of valve, 15, in the direction to cause use of water temperature. The parts of the pressure actuated valve controlling device are proportioned so that the valve is free of pressure control at minimum

intake manifold pressures, and is then solely under control of the thermostatic member.

The valve, 15, being located in the pipe line leading from the engine jacket to the radiator as seen in Figure 1, instead of in the by-pass pipe as seen in Figure 2, the proportions and adjustments of the parts at normal position are substantially as shown in Figure 3, the thermostatic device being connected with the valve for holding it normally at the closed limit to be opened by the thermostatic device upon rise of temperature, and adapted in the absence of the intake manifold pressure operated device, to bring the valve to wide-open position against the stop pin when the temperature reaches 200° F.; and the pressure-operated device is mounted with respect to the valve so that the stem, 31, is in touch with the valve at the opposite side of its pivot from the connection of the thermostatic device, and operates upon increase of pressure in the intake manifold beyond a predetermined minimum at which the pressure acting on the diaphragm is sufficient to overcome the resistance of the spring, 35, to move the valve toward open position, regardless of the action of the thermostatic device, and so as to bring the valve to wide-open position when the intake manifold pressure is at the maximum due to maximum load demand upon the engine.

It is not essential that the two controls, thermostatic and by intake manifold pressure, should be applied to the same valve. A close approach to optimum control of water temperature can be obtained with two valves, one of which is controlled by the temperature of the circulatory cooling fluid, while the other is controlled by intake manifold pressure. Two such valves are best employed in a forced circulation system having a by-pass, and it is usually most convenient to locate the pressure-controlled valve in the by-pass pipe and the thermostatically-controlled valve in the pipe line from the engine jacket to the radiator. Such construction and arrangement is seen in Figure 5, wherein the valve, 60, located in the pipe line, 12, is held by the thermostatic coiled spring, 61, normally at closed position when the engine is not running, and both engine temperature and intake manifold pressure are atmospheric, the thermostatic device, 61, being constructed as hereinafter described to begin to open the valve when the temperature of the circulatory fluid approaches 130° F., and set it at wide open position shown in dotted line when the temperature approaches 200° F. In this form of installation the intake-manifold-pressure-controlled valve located in the by-pass passage, may be a simple form of plug shut-off valve, the plug, 68, being hollow and having a bellows extension, 70, of this hollow cylindrical body, the margin of said flexible

extension being clamped between the cover, 71, of the slideway, 69, of the plug, with a coil spring, 74, housed in the cavity of the hollow plug member reacting between said member and the plug, 71, in the direction for closing the valve, said cover having an apertured nipple, 73, for connecting the valve by the pipe, 76, with the engine intake manifold, the spring, 74, being of such stiffness and length as to cause the valve to be held closed with intake manifold pressure under engine conditions for developing maximum power, and to be fully open when the intake manifold pressure declines to the minimum developed when the engine is idling.

In the simple arrangements of parts of Figures 1 and 2, supplemented by Figures 3 and 5 respectively, no provision is made to keep the water temperature from going below the desirable minimum value, or to bring it up quickly to the desirable minimum, as in cold weather when the cooling or heat dissipating capacity of the radiator is relatively high. In both cases, Figures 1 and 2, application of full load brings the full cooling capacity of the radiator into play, regardless of temperature.

This is obviated in Figure 8 in which two valves are employed, valve, 15*, being only under thermostatic control so that it remains closed until attainment of the minimum desired water temperature, say 135 degrees F. to 140 degrees F., and valve 18, under combined pressure and thermostatic control as described above, the thermostat being set to open the valve in the range 190 degrees to 200 degrees F. This arrangement stops all circulation of water through the radiator until attainment of the minimum desired temperature, when valve, 15*, opens, bringing valve, 18*, into control as described above. The arrangement of Figure 8 is probably the commercially most desirable part of this invention, since it operates universally and equally well with all types and variations of circulatory systems,—as thermosyphonic, or forced circulation with or without radiator by fans, etc. It also, as noted maintains both upper and lower temperature limits by direct thermostatic control.

The specific form of thermostatic element shown in Figures 5, 6, 8 and 9 consists of spirally coiled bi-metallic strip, one end of which is attached to a pintle, 80, which projects into the pipe at one side for pivoting the valve, co-operating for that purpose with a pintle, 81, projecting in from the opposite side, the other end of the spiral being attached to the valve which is a metal stamping formed with a diametrically extending semi-cylindrical boss and recess, 82, into the opposite ends of which the two pintles project and in which the spiral thermostatic element is positioned. The pintle, 80, is through a bushing, 84, fixed in the pipe a

exteriorly provided with a spring arm, 85, terminating as a pawl at 86 for engaging a ratchet toothed flange, 87, with which the bushing, 84, is provided, the pintle being 5 turned in the bushing to suitably coil the spiral device as a spring to cause it to react for holding the valve at closed position when the parts are cold,—that is, at atmospheric temperature, adapted to begin to open the 10 valve upon the relaxing of the coil as the temperature approaches 130° F., as above described.

In referring to intake manifold pressure varying in accordance with the engine speed 15 and load demands upon the engine, it is not overlooked that said intake manifold pressure under all running conditions is sub-atmospheric, and the variation in this sub-atmospheric pressure or suction is made 20 available for the purpose indicated by the spring, 41, acting normally for holding the diaphragm chamber expanded against exterior atmospheric pressure which is the force operating mechanically for the move- 25 ments described.

It will be obvious that within the scope of the invention a great variety of mechanical devices may be substituted for the diaphragm chamber and connections for causing 30 changes in intake manifold pressure to operate the valve and also that the thermostatic device may be constructed in a great variety of forms, and I do not limit myself to the specific devices shown in either of 35 these respects.

I claim:—

1. In combination with an internal combustion engine having a circulatory cooling system comprising a water jacket and a 40 radiator in circulatory relation thereto, valve means for controlling the rate of circulation between the engine jacket and the radiator, means connected for being affected by and responsive to the engine intake mani- 45 fold pressure with operating connections from said pressure-responsive means to said valve means arranged for moving the valve to augment the water circulation through the radiator upon predetermined rise of intake 50 manifold pressure, and to diminish the water circulation through the radiator upon reduction of said pressure.

2. In combination with an internal combustion engine having a circulatory cooling 55 system comprising a water jacket and a radiator in circulatory relation thereto, valve means for controlling the rate of circulation between the engine jacket and the radiator; thermostatic means positioned for 60 being affected by and responsive to the en-

gine temperature, with operating connections from said thermostatic means to said valve means, and means connected for being affected by and responsive to the intake 65 manifold pressure, with operating connections from said pressure-responsive means to said valve means arranged for increasing the opening of the valve upon predetermined rise of intake manifold pressure, and diminishing said opening upon reduction of 70 said pressure.

3. In the construction defined in claim 1, the pressure-responsive means consisting of a flexible diaphragm, a chamber of which it constitutes part of the enclosing wall; 75 fluid pressure connections from the intake manifold to said chamber and operating connections from said diaphragm to said valve means.

4. In the construction defined in claim 1, 80 the pressure-responsive means consisting of a flexible diaphragm, a chamber of which it constitutes part of the enclosing wall; fluid pressure connections from the intake manifold to said chamber; yielding means 85 resisting the chamber-enlarging movement of the diaphragm, and operative connections from said diaphragm to the valve means.

5. In the construction defined in claim 1, the pressure-responsive means consisting of 90 a flexible diaphragm, a chamber of which it constitutes part of the enclosing wall; fluid pressure connections from the intake manifold to said chamber; means opposing the chamber-enlarging movement of the dia- 95 phragm, adapted to yield to permit such movement upon the access of predetermined pressure from the intake manifold, and adapted to yield gradually for operating the valve means proportionately to the increase 100 of said intake manifold pressure to a predetermined limit.

6. In the construction defined in claim 1, the pressure-responsive means comprising 105 an expansible and reducible chamber having a fluid pressure connection with the engine intake manifold; a movable member of said chamber by whose movement the chamber is expansible and reducible, operatively connected with the valve means, and yielding 110 means opposing the chamber-expanding movement of said movable member constructed for opposing unyieldingly a predetermined degree of pressure and for yielding to greater pressure proportionately to 115 the excess above the predetermined degree.

In testimony whereof, I have hereunto set my hand at Chicago, Illinois, this 28th day of December, 1926.

PERCIVAL S. TICE.