Dec. 16, 1952

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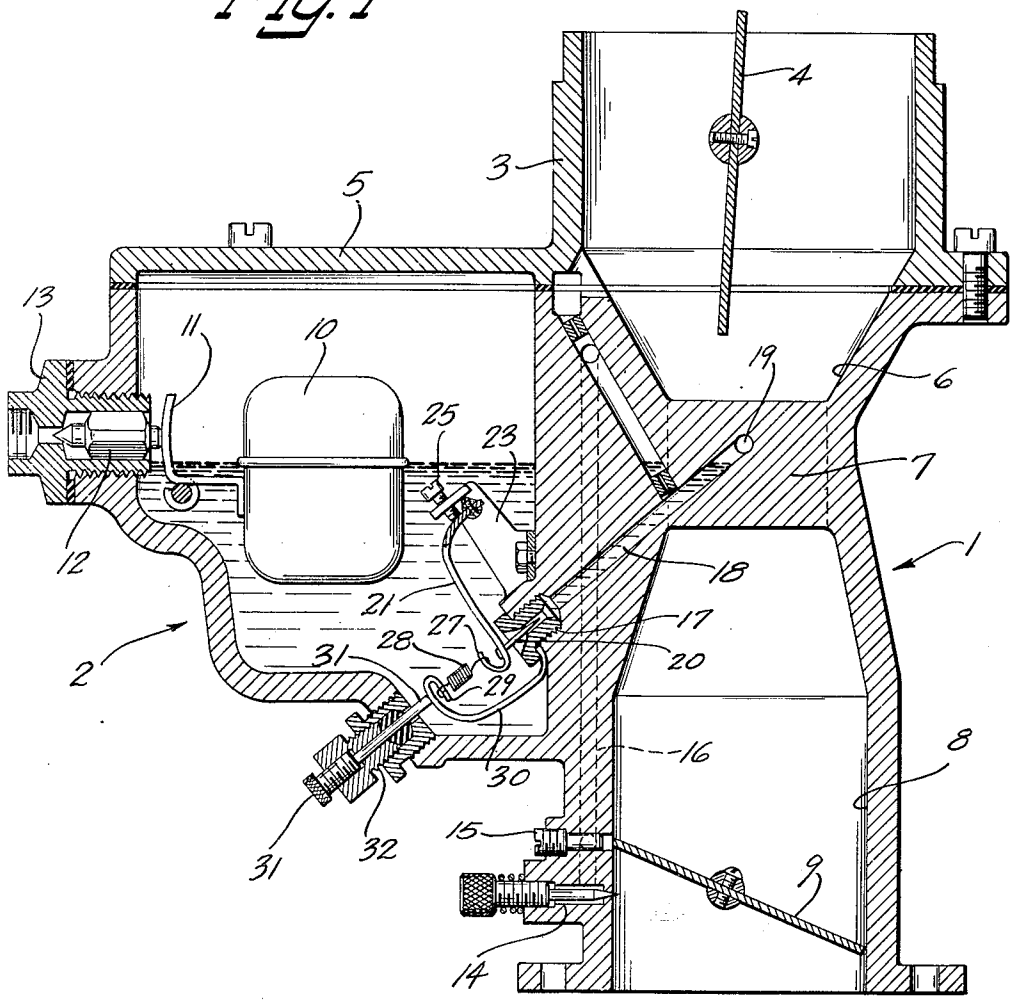
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ENTRAINMENT REGULATED FUEL AND AIR MIXTURE FORMING APPARATUS

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3 Sheets-Sheet 1

Fig. 1



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3 Sheets-Sheet 2

Fig. 2

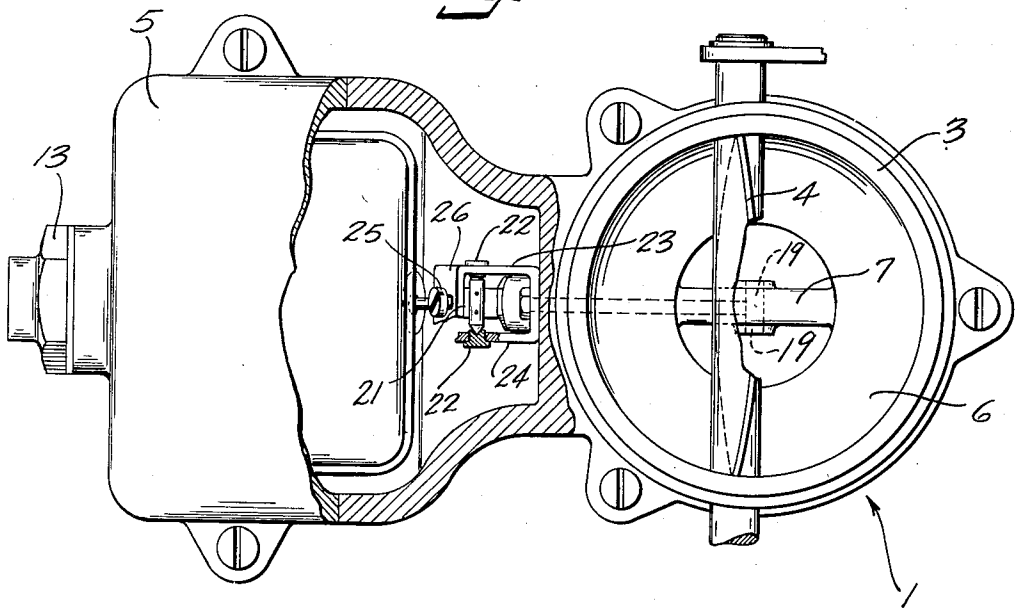
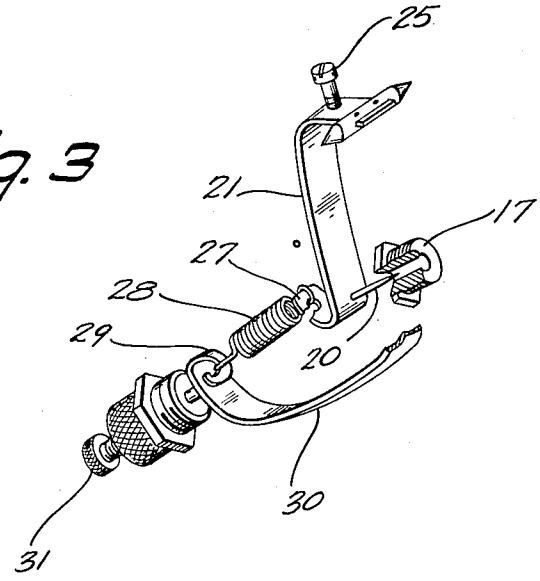


Fig. 3



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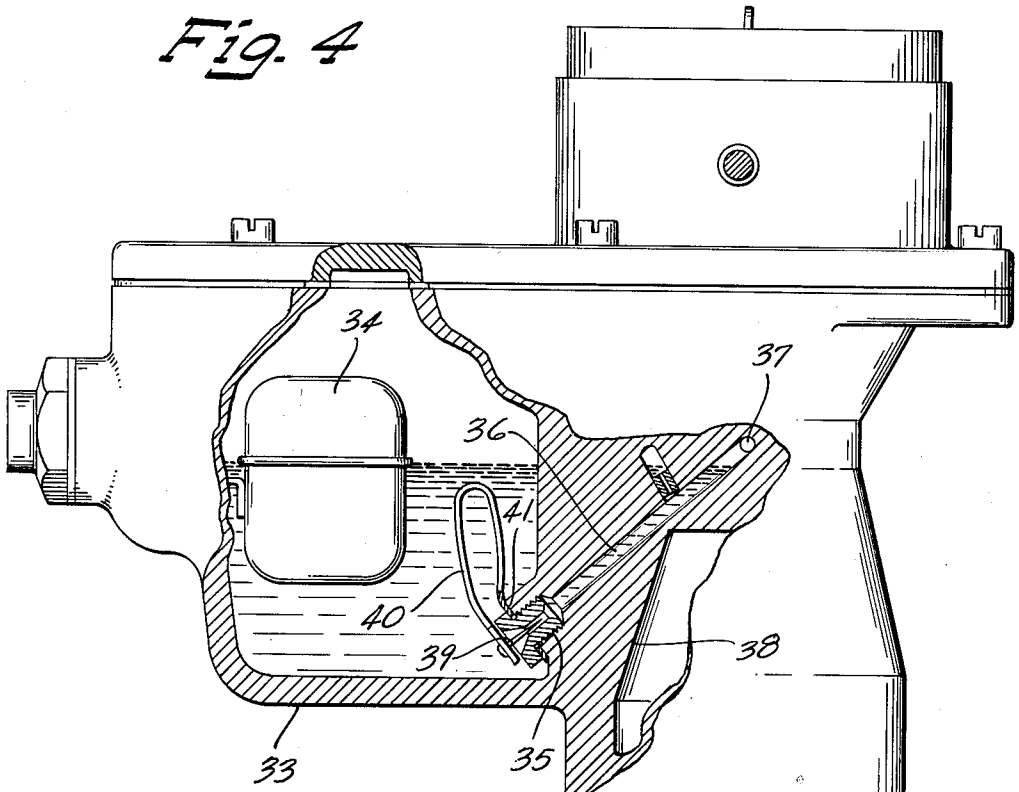
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Fig. 4



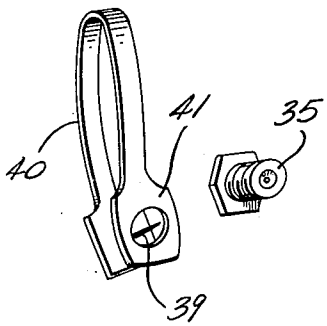


Fig. 5

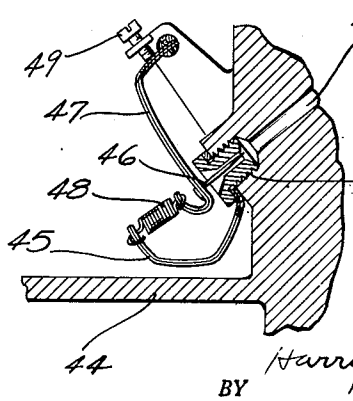


Fig. 6

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ENTRAINMENT REGULATED FUEL AND AIR MIXTURE FORMING APPARATUS

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Application September 1, 1950, Serial No. 182,846

7 Claims. (Cl. 261—19)

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This invention relates to air and fuel mixing apparatuses or carburetors for internal combustion engines and it resides more specifically in an improvement in apparatus of this class in which metering means are provided which regulate the flow of liquid fuel to the melting point with the air stream which metering means comprise a variable aperture orifice resiliently loaded and responsive to the rate of flow of fuel through the orifice to modify and reduce the discharge of the properties orifice at higher rates of flow.

Carburetors as heretofore constructed, in which liquid fuel from a constant level bowl is admitted through an orifice and jet into a Venturi throat for mixture with an air stream, have exhibited a tendency to deliver an increasingly richer mixture as the rate of air passage through the throat is increased. This tendency is aggravated at very low speeds by surface tension effects which cause the fuel to cling to the jets and to separate therefrom erratically. To overcome these difficulties air bleeds have been employed but such have insufficient effect in reducing over-richness at higher speeds. Efforts have also been made to employ supplementary orifices for feeding the jets which orifices are provided with valves for opening and closing the same in response to changes in manifold pressure. The desired uniformity of mixture, however, is not obtainable in this way since manifold pressure is not a true index of mass air velocity through the throat, but is markedly influenced by throttle setting and load on the engine.

The rate of feeding of liquid fuel through a short tube orifice, is dependent upon the head causing the flow (which, in a carburetor is largely determined by throat vacuum) and upon the fluid flow properties of the fuel under short tube orifice conditions. Vacuum at the throat is roughly proportional to the square of the volumetric velocity of the air, while the mass velocity of the fuel delivered is roughly proportional to the square root of the throat vacuum. Due to the difference between volumetric and mass velocity of the air, which is considerable, the desired proportionality of fuel and air forming the mixture is not preserved.

It is an object of this invention to provide an improved carburetor or mixing device which will deliver a more uniformly proportioned mixture

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of air and fuel throughout a wide range of rates of flow.

Another object of this invention is to provide a carburetor having jets large enuogh to feed-off properly and to supply a properly proportioned mixture of air and fuel to an internal combustion engine running at low speed but which will deliver a mixture which is not unduly rich when the engine is operating at high speed notwithstanding variations in load on the engine.

Inasmuch as an undesirable increase in richness in the mixture is accentuated as linear velocity of the air at the throat increases, some have resorted to throats of abnormally large cross-sectional area as a means for reducing the average air velocity thus minimizing undesirable changes in the mixture proportions. However, reduction in the velocity of the air stream entails inadequate atomization and aggravates erratic performance at low speds due to clinging of the fuel to the jets due to surface tension. As a result, carburetor design has tended toward a compromise, wherein a throat area is chosen which is too large for optimum atomization and good feeding-off from the jets but which is at the same time too small to avoid some undesirable over-richness at higher speeds.

Another object of this invention, therefore, is to provide a carburetor which may employ a throat having a cross sectional area small enough to ensure optimum atomization and feeding-off consonant with maintenance of substantially full volumetric capacity of the engine, without causing any undue increase in the richness of the mixture delivered at high speeds.

Another object of this invention is to provide a carburetor which attains the foregoing objectives and which at the same time is readily adapted to automatic compensation for changes in the physical properties of the fuel due to temperature variation.

The foregoing and other objects and advantages of this invention will be made to appear from the description of the invention following, which is set forth by reference to the accompanying drawings, forming a part hereof, in which there is set forth by way of illustration and not of limitation specific forms in which the apparatus of this invention may be constructed.

In the drawings,

Fig. 1 is a side view in elevation and in section showing one form of carburetor constructed in accordance with this invention,

Fig. 2 is a top plan view with parts broken away and in section of the carburetor shown in Fig. 1.

Fig. 3 is a fragmentary, detail, perspective view of the parts forming the variable orifice structure of the carburetor shown in Fig. 1,

Fig. 4 is a side view in elevation of another form of carburetor constructed in accordance with this invention, parts being shown broken away and in section, exposing a simplified form of a variable orifice construction,

Fig. 5 is an exploded, detail, perspective view of the parts forming the variable orifice of the carburetor shown in Fig. 4, and

Fig. 6 is a detail, fragmentary view in side elevation and in section of a variable orifice constructed in accordance with this invention and provided with temperature compensating means.

The form of the apparatus of this invention appearing in Figs. 1, 2 and 3 is embodied within a carburetor made up of a main air passage sleeve designated generally by the numeral 1 and a constant level fuel bowl designated generally by the numeral 2. The upper end of the air passage 1 is in the form of a cylindrical channel 3 enclosing a choke butterfly 4. The channel 3 is integrally joined with a cover 5 for the bowl 2. Extending downwardly from the channel 3 is a Venturi throat 6 which is spanned at its narrowest part by a jet bridge 7. The lower end of the Venturi throat 6 is integrally joined with a cylindrical sleeve 8 which houses a throttle butterfly 9.

The constant level chamber 2 is integrally joined with the Venturi throat 6 and encloses a pivotally mounted float 10 attached to a lever arm 11 arranged to act upon a float valve 12 slidably carried in a bushing 13 secured in position as shown. Beneath the throttle butterfly 9 in the position shown is the usual idling jet 14 joined with an air bleed control 15 and a low speed passage 16 as shown.

Under partly or fully open throttle conditions fuel passes from the bowl 2 through a main metering orifice 17 and a main fuel passage 18 to jets 19 emerging on opposite sides of bridge 7. Jets 19 are preferably of ample area such as will minimize feeding-off difficulties at low speeds and as such too large to impose any appreciable metering effect. The rate of passage of air downwardly through the throat 6 determines the pressure prevailing at the jets 19, said pressure being reduced in proportion roughly to the square of the volumetric rate of flow of air through the throat 6. The hydrostatic head available to propel the fuel from the bowl 2 to the jets 19 is thus established and the quantity of fuel passing to the jets is largely determined by resistance occurring in the main metering orifice 17.

In order to regulate resistance to the flow of fuel through the main metering orifice 17, a throttling needle 20 having a long slender configuration is provided. Preferably the needle 20 is conical with a taper such that the altitude of the cone is in excess of four times the diameter of the base so that a substantial entraining force will become applied thereto. If desired the needle may be grooved or otherwise shaped to enhance the entraining action. The needle 20 occupies a substantially central position within the bore of orifice 17 and is rigidly mounted on the end of a carrier arm 21 freely pivoted at its upper

end upon pivot bearings 22—22 secured in mounting arms 23 and 24. An adjustable stop screw 25 carried on an extension 26 of the arm 23 acts to limit outward movement of the arm 21 and the needle 20 secured thereto.

The lower end of the arm 21 is bent upwardly and notched as appears more clearly in Fig. 3 to provide a spring attachment 27 to which a controlling spring 28 of very light tension is attached. The opposite end of spring 28 is secured to the end 29 of a spring-tension adjusting, anchorage leaf 30 which is fixed in place under the head of the orifice member 17 as shown. Behind the adjusting leaf 30 in alignment with the spring 28 is a threaded adjusting stem 31 threadingly received within the packed bushing assembly 32 as shown. Rotation of the stem 31 will cause an alteration in the position of end 29 of the anchorage leaf 30 and thus a change in tension in spring 28.

In operation, tension of spring 28 is so adjusted that the arm 21 remains in contact with the stop screw 25 at the lowest operating speeds. As engine speed and the rate of air flow through the throat 6 is increased fuel is more rapidly withdrawn from the bowl 2 passing through the orifice 17. In so doing entraining forces acting upon the needle 20 set up a slight force tending to cause the needle 20 to enter the orifice 17 and reduce the hydraulic radius of the same. This force is resisted by the slight tension of spring 28 with the result that the needle 20 occupies positions progressively farther into the bore of the orifice 17 as the rate of flow therethrough increases. In this way the discharge characteristics of the orifice 17 are modified and reduced as the rate of flow therethrough increases. Flow through the orifice 17, with increased head, therefore is less than the normal simple quadratic relationship would prescribe. Inasmuch as it is the mass velocity of the air passing through the throat 6 which is to be related to the rate of flow of fuel to the jets 19 in order to preserve uniformity of mixture at varying rates of speed and the pressure head created at the throat 6 is a function of linear velocity rather than mass velocity of the air, the rising resistance properties of the orifice 17 above described act to cause the desired correlation to be more closely approached.

Inasmuch as a simple tubular metering orifice, proportioned to provide a correct mixture at lower speeds, produces a mixture as much as 20% too rich at wide open throttle and maximum speed, it is preferred that the tension of spring 28, in relation to the maximum entraining force available, be such as to permit the needle to move to reduce the hydraulic radius of the effective orifice about 20%. If for any reason it may be desired that some increase in richness occur with increased speed the tension of spring 28 may be made somewhat greater.

With tension correctly adjusted a substantial improvement in fuel economy is attainable particularly with engines used for tractor propulsion, marine propulsion and other industrial drives which operate for long periods with large throttle openings. These results are obtained with no sacrifice in flexibility and smoothness of performance since a mixture of adequate concentration is ensured at all speeds in immediate response to engine demand. This immediate accommodation to engine demand arises out of the novel dependence of the apparatus of this invention upon entrainment forces created by the

fuel stream itself at a point very close to the jets 19. The total quantity of fuel between the orifice 17 and the jets 19 is very small so that the lag in response, if any, is negligible.

It is not the purpose or intent of the improvement of this invention to supplant the use of air bleeds. For the purpose of minimizing surface tension effects at lower speeds air bleeds are distinctly helpful and it is contemplated that air bleeds may be employed in conjunction with the improvement of this invention. Because of the entrainment action of the metering valve employed in connection with this invention vapor lock produced by excessively volatile fuels is somewhat less disruptive of engine performance, since vapor obstruction immediately causes the entrainment valve to open to its fullest, facilitating restoration of fuel delivery.

Through the use of this invention it is possible to restrict the opening of the Venturi throat of the carburetor sufficiently to provide air velocities, over the greater part of the range of normal operation, which are high enough to markedly improve atomization, and in the lower ranges of operation, which are high enough to improve the feed-off characteristics of the jets, and this may be accomplished, as explained, without undesirable over-richness of the mixture in the upper speed ranges. The enhanced atomization which results has been found to improve over-all engine performance, more than offsetting the small attendant reduction in volumetric efficiency of the cylinders.

It is contemplated also that the improvement of this invention will find usefulness in conjunction with valve controlled supplementary orifices regulated by manifold pressure or otherwise where modification of the mixture curve by such means may more closely approximate the requirements of particular engines.

Appearing in Fig. 4 is a simplified form of the apparatus of this invention wherein a constant level bowl 33 regulated by a float 34 is arranged to deliver fuel through an orifice 35 and a passage 36 into jets 37 positioned in conventional fashion in a bridge in a throat 38.

A long slender valve needle 39 is positioned within the bore in the metering orifice 35 and mounted on the lower end of a U shaped resilient leaf 40 having an anchor end 41 engaged and held in place by a collar on the end of orifice 35. The resilient leaf 40 is proportioned as to length, thickness and width to provide the resisting force required to permit needle 39 to assume the positions desired under various rates of flow. While this form of the apparatus of this invention has the advantage of greater simplicity and lower cost it must be carefully constructed since means for adjusting the same while an engine is operating are absent.

Inasmuch as the flow properties of liquid fuel are subject to alteration by change in temperature, it is desirable at times to compensate for such changes. To provide an entrainment adjusted needle with means for compensating for such temperature change the apparatus appearing in Fig. 6 may be provided. In this form of the apparatus a main metering orifice 42 is positioned as shown with respect to a main fuel passage 43 and a constant level bowl 44. Beneath the head of the orifice 42 is held an anchoring leaf 45 formed of a bimetallic temperature responsive material. The outer layer of the anchor 45 is composed of a metal having a higher coefficient of expansion. A needle 46 rigidly mounted on the end of a pivoted arm 47 is urged to the position shown by the light tension spring 48. An adjustable stop screw 49 is positioned as shown to limit outward movement of the arm 47.

Arm 47 like leaf 45 is composed of a bimetallic temperature responsive strip in which the metal having the higher coefficient of expansion is on the rearward side. Under conditions of higher temperature the arm 47 positions the needle 46 inwardly within the orifice 42 with respect to positions assumed at lower temperatures. At the same time the anchorage 45 follows this movement preventing any increase of the tension applied by the spring 48. In this way departures from the desired performance of a carburetor due to temperature change may be offset.

I claim:

1. In a carburetor including an air conducting sleeve having a constricted throat, a fuel jet disposed in said throat, a fuel containing chamber adapted to maintain a body of fuel adjacent said throat, and a fuel passage joining said fuel chamber and said jet, the improvement therein comprising a fixed orifice disposed in said fuel passage, a flow responsive restricting member mounted in said orifice for movement therein to and from positions providing increased and diminished hydraulic radii for said orifice, means for mounting said flow responsive restricting member in said orifice for response to the entraining force of liquid flow therethrough to variably reduce the hydraulic radius thereof, said member including a light tension resilient means connected to and acting upon said restricting member yieldably opposing said entraining force.

2. In a carburetor in accordance with claim 1, that form of the same in which the means for mounting the restricting means comprises a pivoted arm upon which the movable restricting member is mounted for movement, and the resilient means is in the form of a separate spring secured at one end to the arm and anchored at its opposite end.

3. In a carburetor in accordance with claim 1, that form of the same in which the means for mounting the restricting means comprises a pivoted arm upon which the movable restricting member is mounted for movement, the resilient means is in the form of a separate spring secured at one end to the arm, and an adjustable anchorage is provided to which the opposite end of the spring is secured.

4. In a carburetor in accordance with claim 1, that form of the same in which temperature responsive means providing a mounting for the movable restricting means is employed to alter the position of adjustment of the movable restricting means.

5. In a carburetor in accordance with claim 1, that form of the same in which the fixed orifice is in the form of a short tubular constriction in the fuel passage and the movable restricting means is in the form of a tapering needle positioned for axial movement within said orifice to vary the hydraulic radius of the same, the taper of said needle being in a form approximating a cone having an altitude at least four times the diameter of its base.

6. In a carburetor in accordance with claim 1, that form of the same in which a movable arm having a free end is provided as the mounting for the movable restricting means which is secured to the free end of said arm for movement therewith, said arm comprising a bimetallic

thermostatic leaf distortable in response to temperature changes to cause the hydraulic radius of the orifice to be reduced as temperature increases.

7. In a carburetor in accordance with claim 1 that form of the same in which the means for mounting the flow responsive restricting means comprises a leaf spring having an anchored end and a free end upon which the flow responsive restricting member is mounted for response to entraining force, said leaf spring acting as the resilient means opposing said entraining force.

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