

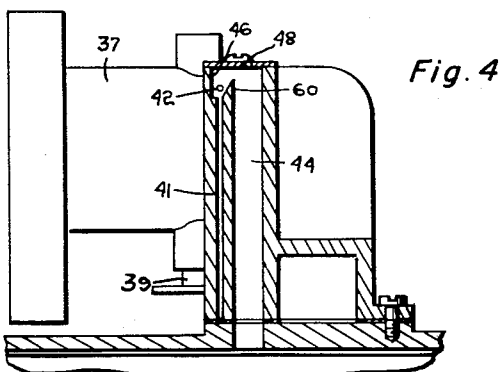
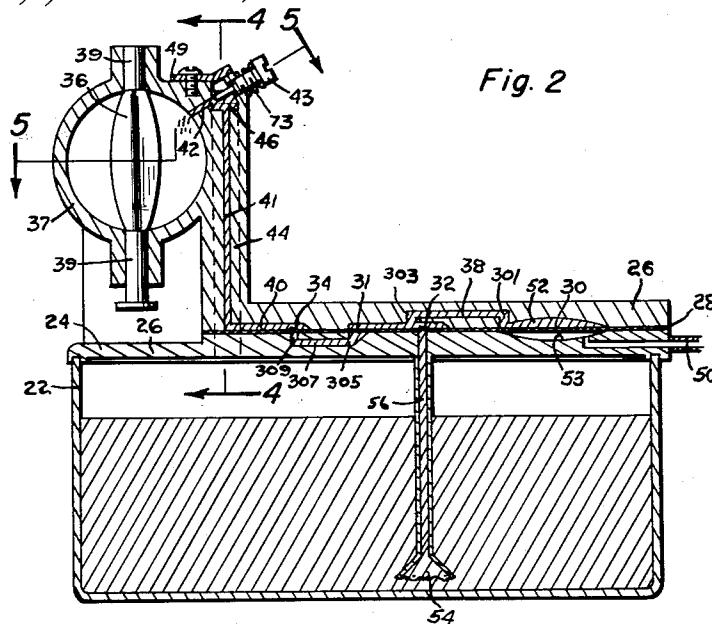
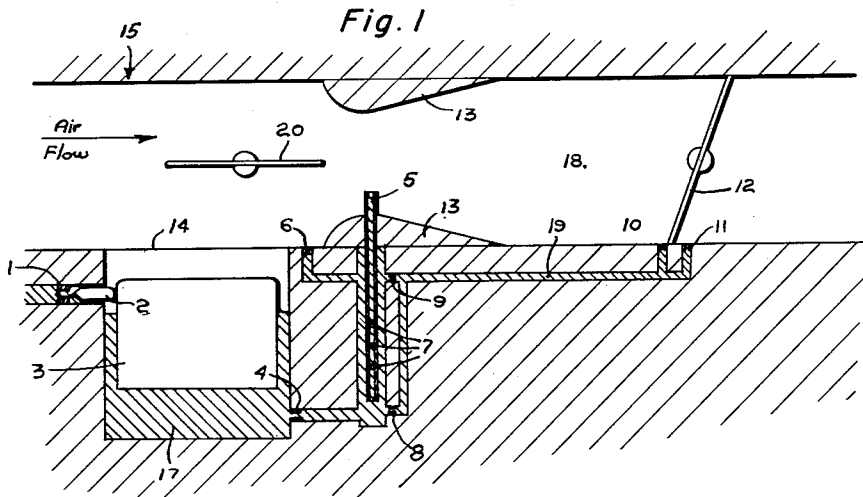
Aug. 1, 1961

A. P. FENTON
CHARGE FORMING DEVICE

2,994,517

Filed July 17, 1957

3 Sheets-Sheet 1



INVENTOR

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his ATTORNEYS

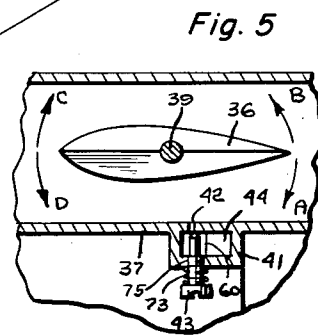
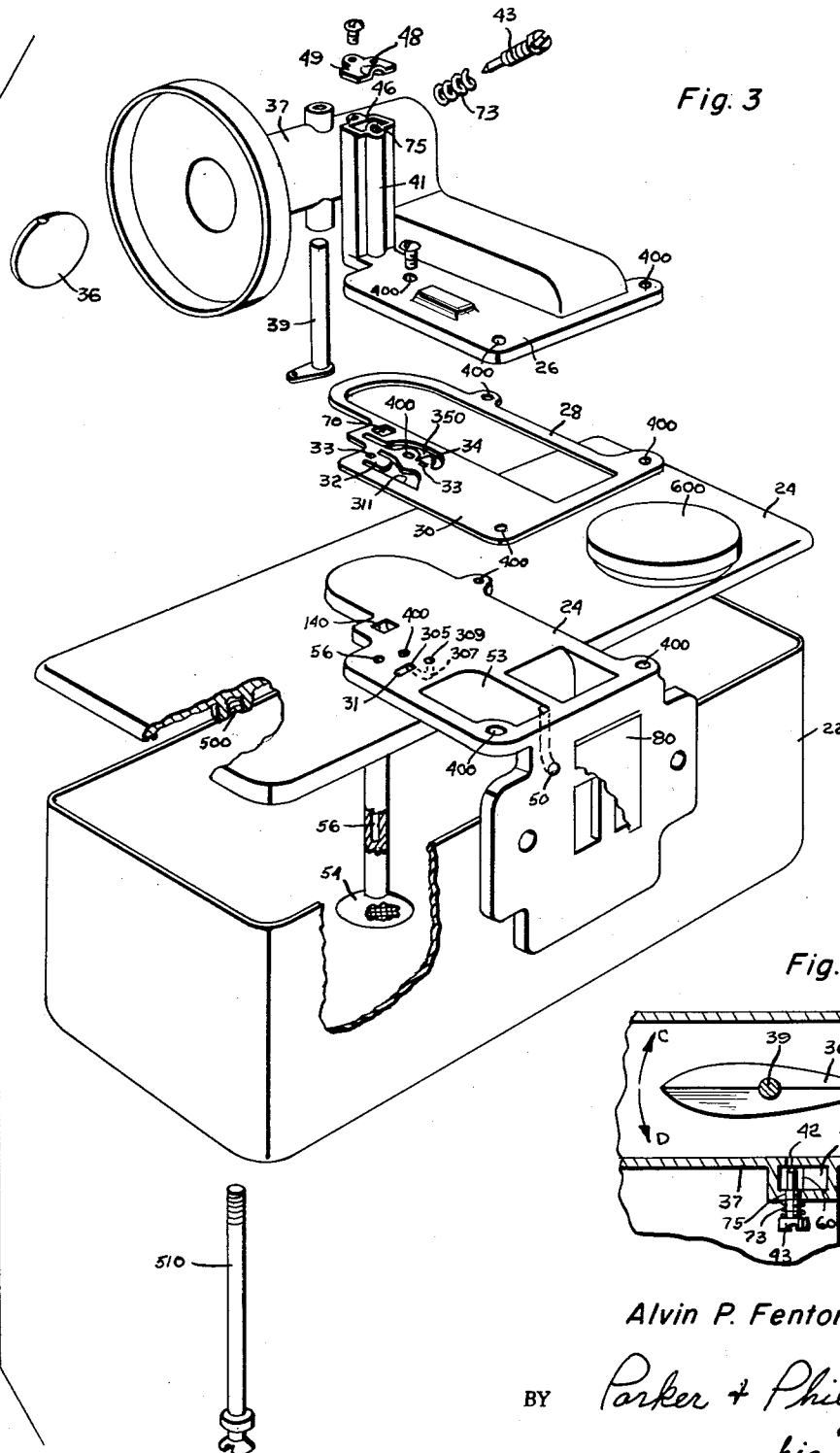
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3 Sheets-Sheet 3

Fig. 6

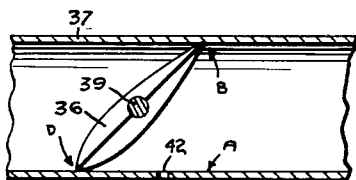


Fig. 10

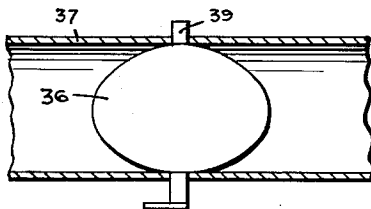


Fig. 7

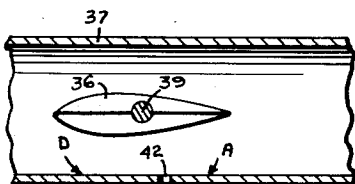


Fig. 9

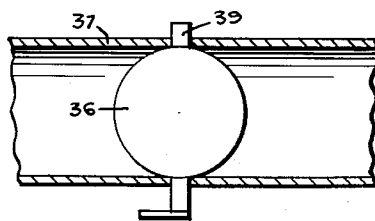


Fig. 8

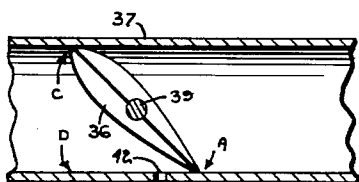


Fig. 12

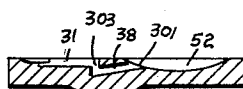
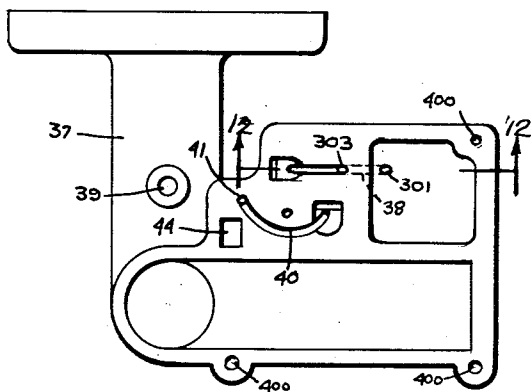


Fig. 11



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2,994,517

CHARGE FORMING DEVICE

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4 Claims. (Cl. 261-62)

This invention generally relates to a novel charge forming apparatus for supplying and controlling the delivery of fuel and air mixtures to an internal combustion engine. More particularly, this invention pertains to a novel carburetor of reduced cost and improved performance as compared to the carburetors which are now commercially available. In one specific embodiment this invention pertains to a novel carburetor which is particularly adapted for use with two cycle lawn mower engines.

In order to better understand how the carburetor of this invention differs from other carburetors, it is believed that it would be beneficial to first briefly review the manner in which one of the more common commercial carburetors operates. One of these prior art carburetors is illustrated in FIGURE 1.

All carburetors are, of course, primarily designed so as to perform the basic function of metering and mixing the fuel and air which are to be fed into the combustion chamber of the engine. The air-fuel ratio required for optimum engine operation will vary with varying engine operating conditions. For example, a rich air-fuel mixture is required at idle and small throttle openings; a maximum economy air-fuel mixture is desirable at intermediate loads; richer mixtures are desired at wide open throttle-maximum power conditions; and an extremely rich mixture is required for cold starting.

In the side elevational view of a conventional carburetor arrangement shown in FIGURE 1, it will be observed that fuel is admitted to float chamber 17 by means of a valve arrangement 1 and 2, and the level of the fuel maintained at any desired point in chamber 17 by means of float 3 acting in conjunction with valve arrangement 1 and 2. Float chamber 17 may either be vented to the atmosphere or vented to the upstream side of the air manifold through opening 14. The float chamber fuel level is below the outlet of the fuel nozzle 5. Air is drawn into the left end of carburetor manifold 15 and passes through venturi section 13, the venturi section 13 having a throat diameter which is about three-fourths as large as the carburetor manifold 15. When air is drawn through the venturi section 13 with sufficient velocity, the resulting reduction in pressure at the venturi region will cause fuel to flow up through jet passageway 4 into the center of nozzle 5 where it discharges into the air stream passing through the venturi 13.

Before going further it should be noted that the characteristics of a simple jet carburetor produces an air/fuel ratio which can be represented by the following Equation #1:

$$\frac{\text{Air}}{\text{Fuel}} = \frac{AaCa}{AfCf} \sqrt{\frac{da}{df} \frac{h}{h-h'}}$$

In this equation A represents area; C the coefficient of discharge; d the density; h the head causing flow; h' the fixed head required to start fuel flow; and subscripts a and f indicate air and fuel respectively.

Increasing the air flow through the venturi reduces the pressure (increasing h) and hence the density of the air. The areas are of course fixed. Ca and Cf remain practically constant. Therefore, an increase in h and a decrease in da will lead to a lower air/fuel ratio (rich mixture) at higher air flows. The simple carburetor must therefore be altered in its flow characteristics in order to supply an acceptable mixture. This is usually accomplished by providing an air bleed (6) which progres-

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sively reduces the suction on the fuel (reduces the increase in the value of h in Equation #1) and thus provides an acceptable mixture over a wider range of air flow.

Examining Equation #1 indicates that when h has a value less than h' there would be no fuel flow. This happens at very light loads or at idle and therefore an auxiliary fuel circuit usually referred to as the idle circuit must be incorporated. Such an idling circuit is shown in FIGURE 1. When the throttle valve 12 is nearly closed, the idle port 11 is subjected to full manifold vacuum. This causes fuel to flow through the idle passageway 8, air to flow through bleeds 6 and 9 and idle progression port 10. The relative size of these restrictions and the location of the progression port 10 control the mixture with the throttle in the idle position. If now the throttle is slightly opened, the throttle valve 12 moves to progressively block off the progression port 10. This restricts the bleeding action of the progression port and prevents the mixture from being leaned by the additional air admitted by the throttle. Additional opening of the throttle will finally swing the throttle valve 12 past the progression port and it will begin to deliver fuel. When it has reached its maximum delivery, further opening of the throttle increases the air flow through the venturi 13 sufficiently to cause the main nozzle 5 begin flowing.

At still higher air flows the depression due to the venturi effect on the nozzle 5 may become large enough to not only stop the flow of fuel from ports 10 and 11, but actually convert them into back bleeds which assist the main air bleed 6 in maintaining a more nearly correct mixture.

If the throttle is slowly opened until the main jet begins to flow and then closed again, it must be closed farther before the main jet stops flowing than it was when the fuel began to flow. This means that if the mixture delivered by the carburetor is correct as the throttle is being opened, it will be too rich as the throttle is being closed. This is exactly opposite to engine requirements. Usually carburetors are calibrated to give too rich a mixture at this point and since this transition point happens to come at or near the no load condition on a rotary mower, erratic engine operation results. The absence of this transition point in the carburetor of this invention is one of the main factors for its improved performance.

The rich mixture required for starting when cold is procured by restricting the entering air with choke valve 20 which is normally manually closed until the engine fires and then opened.

Orifices 11 and 4 are usually adjustable in small engine carburetors instead of fixed as shown. Holes 4, 6, 7, 8, 9, 10 and 11 must have the correct diameter, length and entrance shape and holes 7 and 10 must be accurately located because the flow characteristics and hence carburetor calibration will be materially affected by any of these factors.

Those skilled in the art will recognize that the type of carburetor construction shown in FIGURE 1 is rather expensive to manufacture because of the many parts and control orifices which are necessary and also because this construction does not permit the engine to operate at maximum efficiency under all load conditions.

One object of the present invention therefore is to provide a charge forming apparatus for an internal combustion engine which is of reduced cost and improved performance as compared to the carburetors which are now commercially available.

Another object of this invention is to provide a charge forming device which is particularly useful in conjunction with two cycle lawn mower engines.

Further objects and advantages are within the scope of

this invention such as those relating to the arrangement, operation and function of the related elements of the structure, to various details of construction and to combinations of parts, elements per se, and to economies of manufacture and numerous other features as will be apparent from a consideration of the specification and drawings.

FIGURES 2, 3, 4 and 5 illustrate one specific embodiment of a carburetor construction contemplated within the scope of this invention. FIGURE 2 is an end elevational view which illustrates in a very simplified fashion the basic element and concepts of a fuel system constructed in accordance with the teachings of this invention. The combination shown in FIGURE 2 includes a fuel tank 22, a fuel tank cap 600, a lower cover casting 24 which has its underside fastened to the upper rim of fuel tank 22 by threaded hole 500 and bolt 510, and an upper cover casting 26 which is superimposed over and supported by lower casting 24. A flexible diaphragm 28 is interposed between casting 24 and casting 26 and is clamped in a fixed position when castings 24 and 26 are bolted together (e.g. through bolt holes 400 with bolts 410). Diaphragm 28 may be made of any suitable leak-proof cloth, fabric, plastic, rubber, leather or thin metallic material so long as it will reliably function in the manner hereinafter described and so long as the diaphragm material will not be adversely affected by the fuel. Diaphragm 28 contains and unsupported section 30 and two small flap valves 32 and 34.

The upper portion of cover casting 26 also includes air manifold 37, tear-drop shaped throttle 36, throttle shaft 39, fuel passages 38, 40 and 41, overflow passage 44, metering orifice 42, adjusting needle 43, fuel well 46 and vent 48.

In its broadest sense, the present device is designed to receive fuel and air from suitable sources of supply and to transform said fuel and air into a mixture suitable for combustion, said device comprising in combination:

- (a) an air manifold 37.
- (b) a throttle valve 36 located within said air manifold 37 and being mounted on an axis, each end of the throttle valve extending a substantial distance from said axis.
- (c) said air manifold 37 being of substantially constant cross section in the throttle area.
- (d) said throttle valve 36 having a mid portion of considerable thickness as compared with its end portions, whereby a venturi effect is created in said air manifold 37.
- (e) means to move said throttle so that its ends move beyond the center position in each direction through arcuate paths about an axis.
- (f) a fuel passageway 38, 40 and 41 leading to said air manifold 37.
- (g) said fuel passageway merging into an orifice 42 as it enters the air manifold 37, and
- (h) the front portion of said throttle 36 being adapted to move through a first arcuate path toward one side of said air manifold 37 and the rear portion on said throttle 36 being adapted to move through a second arcuate path toward the other side of said air manifold 37 said orifice 42 being located between planes drawn through the points where the extensions of said first and second arcuate paths would intersect the inner walls of said air manifold 37, said planes being normal to the axis of said air manifold.

The carburetor of FIGURE 2 operates in a very simple and efficient manner. Alternate pressure and vacuum from the engine crankcase (not shown) is applied to the unsupported section 30 of diaphragm 28 through passage 50. This cyclic pressure change causes the unsupported section 30 of diaphragm 28 to flex in an up and down direction and to thus produce an alternate pressure and partial vacuum in the cavity formed by the concavity 52 in casting 26. Section 30 of diaphragm 28 thus acts as a pump and the section itself is preferably substantially flat and so designed that its alternate up (or both up and

down) flexures will tend to approach to at least a limited degree the upper outline of concavity 52 during its upward flexure. When a partial vacuum exists in cavity 52—53 due to the downward movement of section 30, fuel is drawn up through screen 54, up through inlet pipe 56, through inlet valve 32, into adjacent passage 38, and down through opening 301 into concavity 52. The upward motion of section 30 creates a pressure on the fuel in concavity 52 and this pressure causes the fuel in concavity 52 to flow upwardly through opening 301, through passage 38, and down through opening 303. The pressure which causes the fuel to move down through opening 303 also causes flap valve 32 to close and since the fuel moving through passage 38 and opening 303 cannot return to the fuel tank 22 via closed inlet flap valve 32, the fuel is forced through well 31, opening 305, passage 307, opening 309 and through outlet valve 34 into passages 40 and 41 until it fills fuel cavity 46. The fuel in fuel cavity 46 either passes through metering orifice 42 and goes to the engine or the fuel overflows the weir 60 and returns to the fuel tank 22 through overflow passage 44.

FIGURE 3 is a three dimensional view of a carburetor which is very similar but not identical to the construction and design of the carburetor shown in FIGURE 2 and for this reason the same numerals have been used to designate corresponding parts in both FIGURES 2 and 3. Since the foregoing description of the construction and operation of the carburetor shown in FIGURE 2 also applies to the carburetor of FIGURE 3, those skilled in the art will readily understand the essential construction and operation of the carburetor shown in FIGURE 3. In the interests of eliminating any undue verbosity a description of the construction and operation of FIGURE 3 will be omitted except to briefly review those features of the carburetor shown in FIGURE 3 which are not shown in FIGURE 2. Understanding of FIGURE 3 will be facilitated by simultaneously referring to FIGURES 4, 5, 11 and 12.

FIGURE 3 provides a clearer showing of the exact design and configuration of diaphragm 28. In this view of diaphragm 28 it will be observed that rather small rectangular apertures 33 are located at the rear of the curved front edge of tongue-like flap valves 32 and 34, the purpose of these apertures being to keep flap valves 32 and 34 from bulging in an upward direction and therefore leaking when the valves have seated themselves over their respective orifices. Cut out portions 311 and 350 are essentially coextensive with the passageway area between flap valve 32 and opening 303 and between flap valve 34 and opening 41, but it should be understood that cut out portions 311 and 350 could also be designed so that they would cover either more than or less than the passageway area between the aforementioned flap valves and openings 303 and 41. Opening 70 in diaphragm 28 permits open communication between overflow passage 44, opening 140 and the fuel tank 22.

FIGURE 12 is a sectional view along 12—12 of FIGURE 11.

In FIGURES 2, 11 and 12 it will be observed that the back portion of the chamber immediately above valve 32 and the back portion of the chamber immediately above valve 34 slope downwardly at an angle. The lower sloping edges of these chambers are preferably designed to contact apertures 33 at their midpoint.

FIGURE 3 also shows the particular manner in which the fuel well 46 is covered with a plate 49 and the manner in which needle 43 and spring 73 are positioned so as to engage threaded hole 75.

FIGURE 4 is a view taken along section 4—4 of FIGURE 2 showing additional structural details relative to air manifold 37, passage 41, metering orifice 42, overflow passage 44, fuel well 46 and weir 60. This view clearly shows that the fuel rising through passage 41 will fill well 46 and the fuel which does not pass through

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metering orifice 42 will flow over weir 60 and down through overflow passage 44 into the fuel tank.

FIGURE 5 is a view taken along section 5—5 of FIGURE 2 showing additional structural details as to air manifold 37, tear-drop (ellipsoidal) shaped throttle 36, throttle shaft 39, passage 41, orifice 42, needle 43 and weir 60. In this view it will be seen that metering orifice 42 is disposed between points D and A, point D being the point at which the front end of throttle 36 touches or most closely approaches the side of air manifold 37 and point A being the point at which the rear end of throttle 36 touches or most closely approaches the side of air manifold 37.

It is therefore seen that as long as the engine is running, fuel is being circulated by virtue of the pump action of diaphragm 28 and a fixed head of fuel is maintained on metering jet 42. When the engine stops, fuel seepage occurs in a backward direction through flap valves 32 and 34, thus allowing the bulk of the fuel in all of the passages to return to the fuel tank.

The pump action of diaphragm 28 is sufficiently great to fill all of the fuel passages and cavity 46 in a very few revolutions of the engine, thus enabling the engine to be started with one pull of the starting rope.

FIGURE 6 is a plan view of the throttle in full choke position.

FIGURE 7 is a plan view of the throttle in wide open position.

FIGURE 8 is a plan view of the throttle in closed position.

FIGURE 9 is a side elevation view of the throttle in closed position.

FIGURE 10 is a side elevation view of the throttle in wide open position (showing that the throttle is elliptical in shape).

It will be obvious to those skilled in the art after inspecting the drawings that the venturi action adjacent the throttle is the major factor involved in drawing the fuel through metering jet 42 and into air manifold 37.

The throttle 36 is tear-drop shaped in plan view and produces a pressure drop in the throttle bore which obeys the same laws as a venturi. The essential difference in the fuel circuit from the constant head cavity 46 to the carburetor throat is that the fuel is fed to the metering jet 42 under slight pressure. Looking back at Equation #1 we find that it remains the same except that the $-h'$ term now becomes $+h'$. Now if the h' term is chosen correctly the term

$$\frac{h}{h+h'}$$

will increase in value at the same time that da is decreasing and a relatively constant mixture is obtained over a very wide range of air flows. Even at the low flows associated with engine idling the mixture does not lean out. Instead it becomes richer in agreement with engine requirements. With this system it thus becomes entirely feasible to use only one jet for all engine requirements.

Idle requirements normally call for a still further enrichment of the mixture than that provided by the slight pressure feed to the metering jet 42 described above. This is easily accomplished by poistioning the outlet for metering jet 42 between the point of minimum area produced by the throttle and the point where the throttle seals on the bore in the closed position (that is between A and D or between B and C). The exact position depends on the amount of idle enrichment required by the individual type of engine and can readily be determined by one skilled in the art. The metering jet 42 should of course be made adjustable to enable the operator to tailor the mixture to the exact requirements of the engine.

Normal movement of the throttle valve is from fully closed to a position parallel to the axis of the air manifold as in a normal carburetor. If however the governor (not shown) is allowed to rotate the throttle valve be-

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yond the wide open throttle position when the engine is stopped and to return it to the wide open position as the engine picks up speed this throttle will also work surprisingly well as an automatic choke requiring practically no attention on the operator's part.

The one-way reed valve 80 normally used on two cycle engines can be incorporated into the carburetor by designing the mounting flange to accept the reed. The casting can also act as an air cleaner support thus reducing the total number of parts.

Some of the advantages of the carburetor of this invention are immediately evident but some are not and therefore it is believed worthwhile to review the various advantages very briefly.

(1) Reduced cost of manufacture and assembly because:

(a) Simple castings with fewer than normal drilled holes and with only two holes (main jet and throttle shaft holes) which are critical in size and location (compared to the 12 or more holes necessary on many present carburetors) reduce the cost of manufacture and assembly.

(b) It eliminates the complete float mechanism which normally consists of 7 separate pieces and which usually require careful machining and soldering. The one die cut diaphragm which makes possible the elimination of the float is comparatively inexpensive.

(c) The use of a combination throttle and choke eliminates 5 separate pieces and two assembly operations.

(d) No brass tubes or jets are required.

(e) Fewer machining and assembly operations.

(2) Improved reliability because:

(a) Float mechanisms wear rather rapidly. Wear, foreign objects lodging between the needle and seat, gum formation on the needle or excessive engine vibration cause the float valve to leak. If the leak is bad the operation of the engine is affected. If it leaks only a small amount the slow leak may produce a fire hazard when the engine is stored.

(b) All brass parts can be eliminated in the carburetor of this invention without impairing operation or adding to the cost of manufacture. Brass parts in the normal carburetor catalyze the gum forming chemical reactions in gasoline when it is stored. Gum formation can cause anything from mild malfunctioning of the carburetor to complete failure requiring expensive servicing or complete replacement of the carburetor. The design of the instant carburetor permits seepage past the flap valves and will thus allow the sensitive parts of the fuel system to be drained in storage and the gum can therefore form only in the gas tank where it would be harmless.

(c) The ordinary carburetor supplies a richer mixture than desired under some operating conditions and leaner than desired under others. These deviations from the ideal mixture are normally within the limits that the engine will accept but they make the adjustments more critical and will cause malfunctioning with only a small change in mixture due to environmental conditions or dirt in the system. The carburetor of this invention can be calibrated so that the delivery curve matches engine requirements. Then if it is adjusted midway between the rich and lean limits of satisfactory performance the mixture can change a relatively large amount before malfunctioning occurs. The elimination of a system in which a change in restriction in any one of ten holes will upset carburetor calibration also produces a more nearly correctly calibrated carburetor.

(d) The automatic operation of the choke will prevent flooding of the engine by an operator unfamiliar with the proper operation of a manual choke.

(e) Since the fuel chamber 46 is provided with an easily removable cover the operation of the pump and the cleanliness of the only jet can be easily checked, even by an unskilled operator and unnecessary service operations thereby eliminated.

(f) The elimination of external fuel lines and fittings reduces the danger of fire due to fuel leakage.

(g) Continuous circulation of the fuel reduces the concentration of dirt which normally settles out in the float chamber of an ordinary carburetor. The tendency for the jet 42 to plug and change the air-fuel mixture is thus reduced and in the unlikely event that it does plug it can be easily cleaned without completely dismantling the carburetor.

(h) The adjustments (one for idle speed and one for mixture) can be positioned in easily accessible locations and the adjustments are simple, thereby allowing the operator to easily make them correctly. Furthermore, since prior art carburetors require the careful balancing of the idle and main adjustments and since this often must be done by a service man who may not be able to satisfactorily load the engine to perform the main needle adjustment, the carburetor may be maladjusted even by a skilled service man. The resulting maladjustment may not prevent operation of the engine but it usually shortens the period between spark-plug fouling and port clogging.

(i) The carburetor of the present invention provides the correct mixture at all times and therefore reduces the build up of carbonaceous deposits in the cylinder, ports and spark plugs, thus lengthening the time between minor overhauls.

(3) It reduces the amount of exhaust smoke common to most two cycle engines because the mixture does not need to be set too rich to prevent it from becoming too lean under certain operating conditions.

(4) Economy of operation is not usually of major importance but the use of the instant carburetor reduces fuel consumption and thus allows longer operation between filling the tank and reduces the frequency of that nuisance.

(5) Vibration has less effect on the carburetor of this invention because it can be mounted close to the engine, thus reducing the amplitude of vibrations. In addition the tank mounting is very rigid. The natural frequency is thus far above any ordinary operating speed. On most engines this is not so and is the main cause for gas tank and bracket failure.

(6) Because of the very close proximity of the overflow weir and main jet, angle operation at much more than 45° is possible (45° is the maximum with present carburetors).

While certain preferred embodiments of this invention have been specifically disclosed, it will be understood that the invention is not limited thereto, as many variations and modifications will be readily apparent to those skilled in the art and the invention is to be given its broadest possible interpretation within the terms of the following claims.

What is claimed is:

1. A device which is designed to receive fuel and air from suitable sources of supply and to transform said fuel and air into a mixture suitable for combustion, said device comprising in combination:

- (a) an air manifold,
- (b) a throttle valve located within said air manifold and mounted on an axis, each end of the throttle valve extending a substantial distance from said axis;
- (c) said air manifold being of substantially constant cross section in the throttle area,
- (d) said throttle valve having a mid portion of considerable thickness as compared with its end portions, whereby a venturi effect is created in said air manifold,
- (e) means to move said throttle so that its ends move beyond the center position in each direction through arcuate paths about an axis,
- (f) a fuel passageway leading to said air manifold,
- (g) said fuel passageway merging into an orifice as it enters the air manifold, and
- (h) the front portion of said throttle being adapted to move through a first arcuate path toward one side of said air manifold, and the rear portion on said throttle being adapted to move through a second arcuate path toward the other side of said air manifold, said orifice being located between planes drawn through the points where the extensions of said first and second arcuate paths would intersect the inner walls of said air manifold, said planes being normal to the axis of said air manifold.

2. The charge forming device according to claim 1, which additionally contains a small overflow well and an overflow conduit for said well, wherein said orifice is fed by said small overflow well and the overflow conduit for said overflow well leads back to the fuel reservoir.

3. The charge forming device according to claim 2 wherein said overflow well and orifice are so positioned with respect to each other that the fuel will flow by gravity downwardly into the air manifold.

4. The charge forming device according to claim 1 wherein said throttle valve is tear-shaped in plan view and elliptical in side elevation.

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