Aug. 20, 1946. R. W. SLOANE ET AL 2,406,114

CARBURETOR

Filed June 5, 1942 3 Sheets-Sheet 1

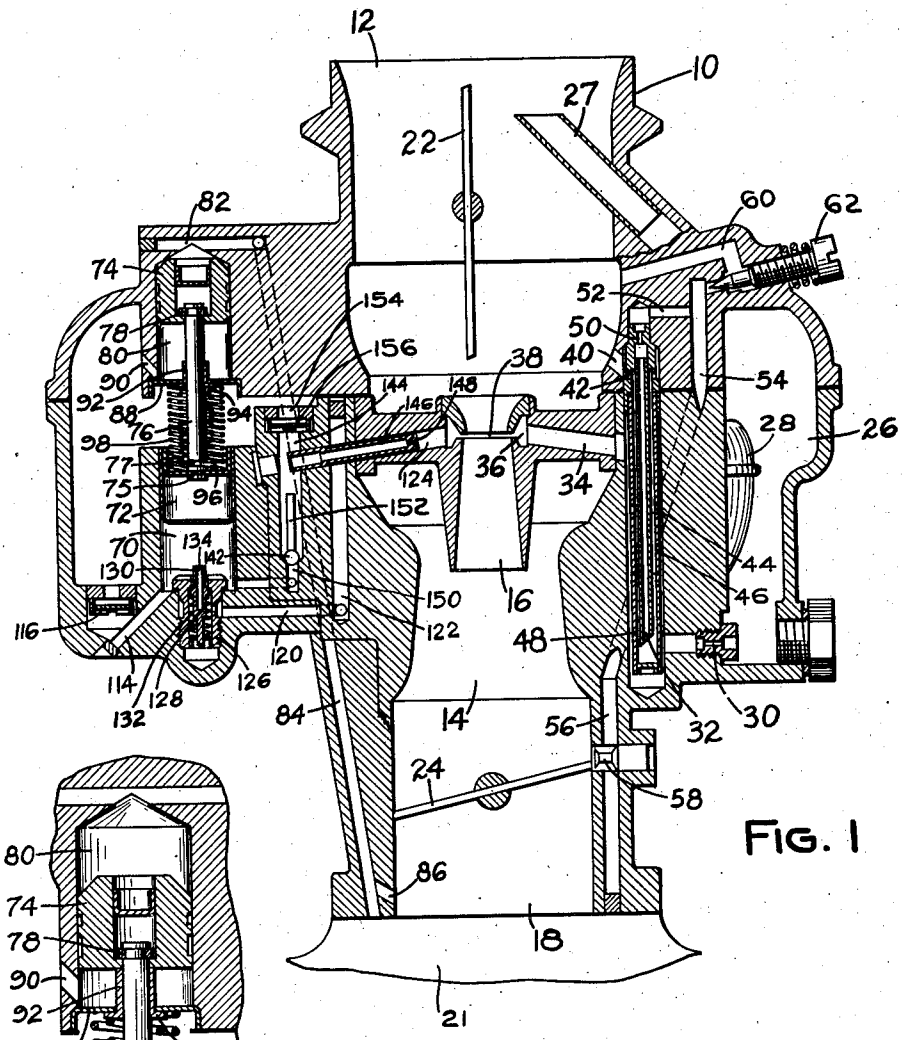


FIG. 1

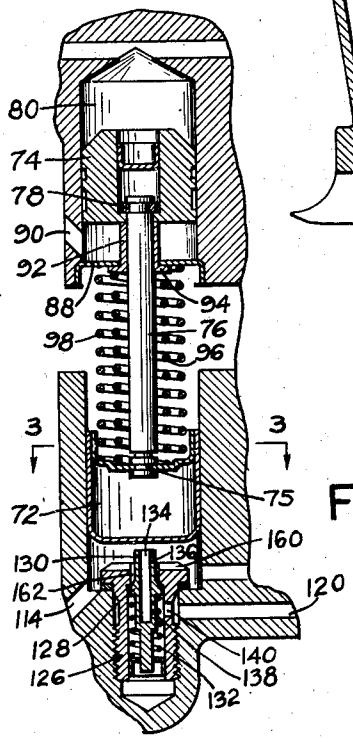


FIG. 2

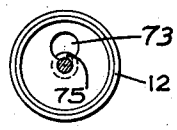


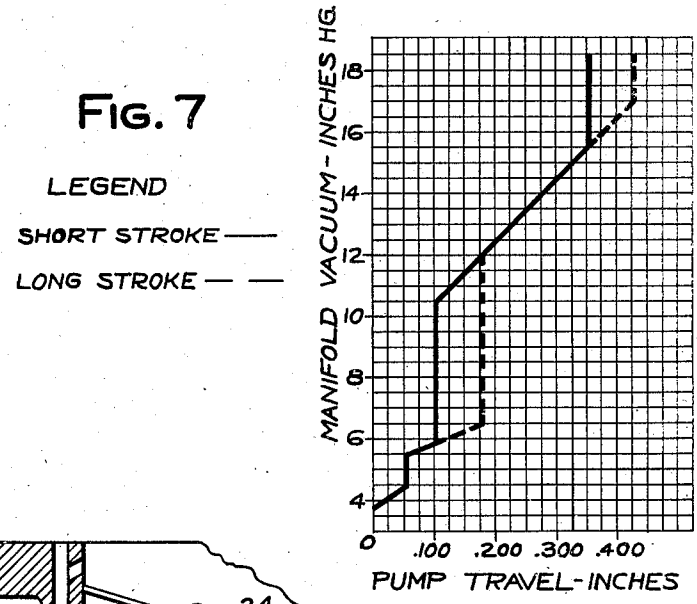
FIG. 3

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FIG. 7



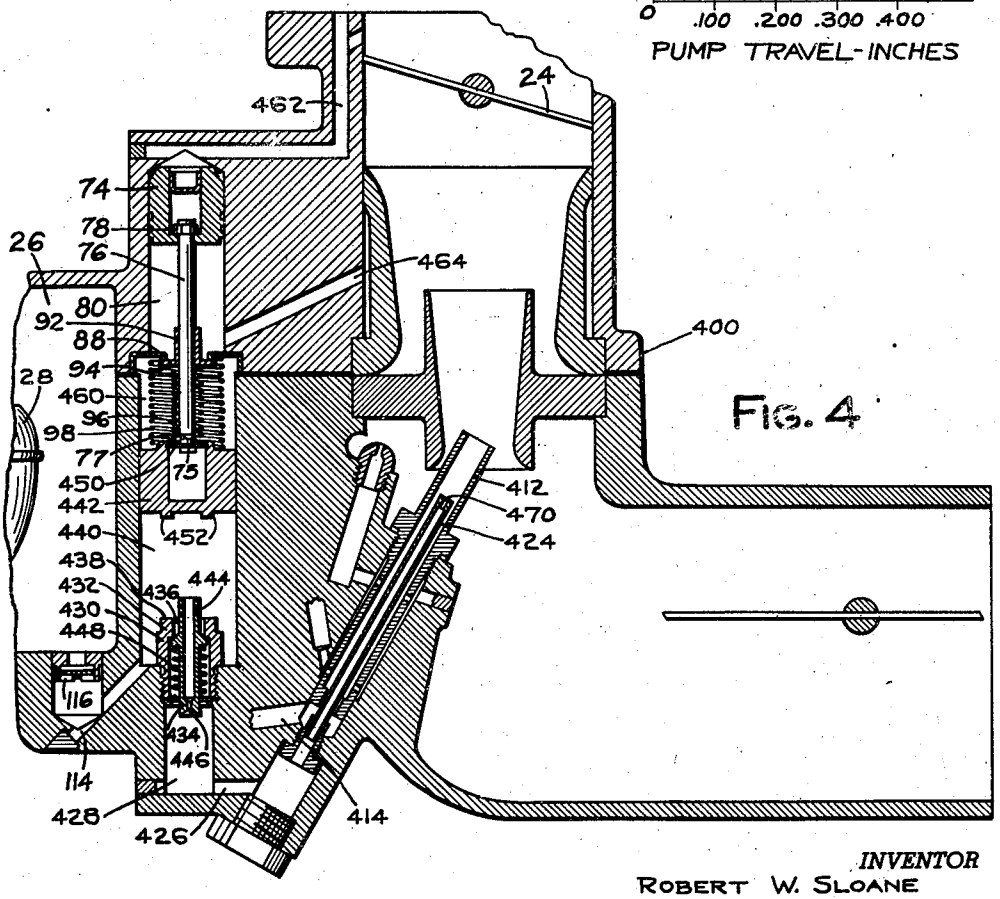


FIG. 4

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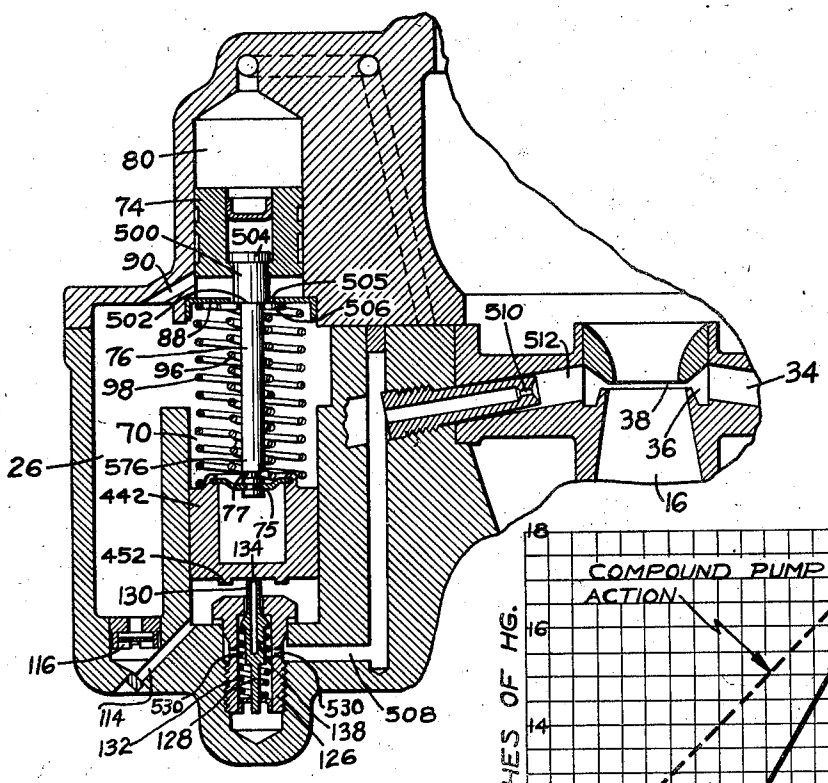


FIG. 5

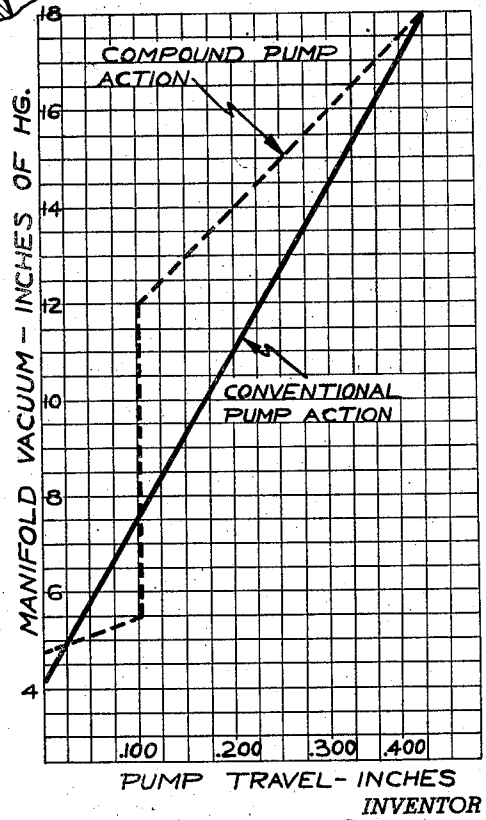


FIG. 6

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2,406,114

CARBURETOR

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Application June 5, 1942, Serial No. 445,864

7 Claims. (Cl. 261—34)

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This invention relates to carburetors for internal combustion engines such as are generally used in automotive vehicles and the like, and it is more particularly concerned with the matter of securing the proper fuel feed for acceleration of the engine, an important object being to provide an accelerating mechanism which accurately meets the various requirements of the engine.

It is well known to those skilled in the art to provide means for injecting extra fuel during opening of the carburetor throttle valve for accelerating the engine and for opening a power jet when the throttle is near its wide open position and/or the manifold vacuum is very low. One representative type of such devices includes a pump having a plunger or piston actuated by a spring and acting under the control of suction in the intake conduit posterior to the throttle valve. The spring is normally designed so that the piston will approach one end of its stroke as the manifold vacuum approaches a high value corresponding to idling operations and the other end of its stroke as the manifold vacuum approaches a relatively low value, at which time the plunger opens the power jet. In such vacuum operated pumps there is uniform pump travel throughout the entire range of manifold vacuum, which means that for an equal drop in vacuum an equal pump travel will be effected whether or not the throttle is near the wide open position or just off idle. Such uniform distribution of the available pump stroke over the entire manifold vacuum range is objectionable because an accelerating fuel discharge is required only throughout a limited throttle range as the throttle is opened from the idle position and generally any acceleration pump action when the throttle valve is beyond said limited range wastes fuel.

It is therefore another important object of the invention to provide an acceleration pump in which the major portion of the pump stroke occurs through a relatively high vacuum range as the throttle valve is moved through a limited range beyond the idling position.

The present invention further provides, in addition to means for delivering extra fuel for acceleration purposes, means for increasing the flow of liquid fuel during periods of operation when the manifold vacuum is low to thereby enrich the mixture during operation under heavy loads or at high speeds.

Another object of the invention is to provide a device of this character wherein an accelerating charge is forcefully supplied at a relatively rapid rate upon acceleration from low or idling speeds and at a relatively slow rate during opening of the power jet or economizer valve.

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Still another object of the invention is to provide a compound or multiple stage acceleration mechanism that is under the control of suction in the intake manifold posterior to the throttle valve and in which the major portion of the acceleration pump stroke occurs upon decrease in manifold vacuum in the high vacuum range and a small portion of the stroke, sufficient to open the power jet, occurs in the very low vacuum range, the device being inoperative throughout a substantial vacuum range intermediate said high and low ranges.

A further object of the invention is to provide a device of this character wherein the small portion of the pump stroke reserved for opening the power jet occurs with a slight change of manifold vacuum in a relatively low vacuum range.

Another object is to provide an acceleration pump of this character wherein the length of the pump stroke is adjustable.

Still another object is to provide a device of this character that is simple in construction, dependable in action and relatively inexpensive to manufacture.

Other objects and advantages of the invention will be apparent to those skilled in the art from the following description or may be ascertained from a study of the accompanying drawings in which several preferred embodiments of the invention are shown. It will be evident that the principles of the invention may be incorporated in various forms and the employment of any structures, arrangements, or modes of operation that are properly within the spirit of the invention and scope of the appended claims is contemplated.

In the drawings:

Figure 1 is a vertical section of a carburetor embodying the invention;

Figure 2 is an enlarged vertical section through the acceleration device showing the piston thereof in an intermediate position;

Figure 3 is a horizontal section of the pump plunger taken on line 3—3 of Figure 2;

Figure 4 is a sectional view of a carburetor embodying a modification of the invention;

Figure 5 is a fragmentary sectional view of a carburetor embodying another modification of the invention;

Figure 6 is a chart illustrating the characteristics of conventional acceleration pump action and the characteristics of the action of the pres-

ent invention, both plotted against manifold vacuum; and

Figure 7 is a chart further illustrating characteristics of the action of the invention and plotted against manifold vacuum.

Throughout the specification reference to the position of various parts or the direction of movement thereof is made with regard to same as viewed in the drawings, and similar reference characters represent similar parts although where such parts are modified in structure and operation they are given a further differing reference character.

Referring more particularly to Figure 1 there is shown, for purposes of illustration only a plain tube downdraft carburetor 10 having an induction passage including an air inlet 12, large and small venturis 14 and 16 respectively and a mixture outlet 18 which is attached to the intake manifold 21 of an internal combustion engine. The air inlet is controlled by the usual offset choke valve 22 and the mixture outlet is controlled by a throttle valve 24.

The carburetor is provided with a liquid fuel chamber 26 having a well known air connection with the air inlet by means of an impact tube 27 and having the usual float mechanism 28. A main fuel system includes a calibrated fuel jet 30 which receives fuel from the fuel chamber 26 and discharges same by way of fuel passages 32 and 34 into an annular channel 36 in the small venturi 16 from which it is drawn by suction into the air stream of the induction passage through a slot 38, air being bled to the main fuel system through passages 40 and 42, and openings 44 in a tube 46. There is further provided an idling system including an idling tube 48, calibrated jet 50 and fuel passages 52, 54 and 56, the idling fuel being discharged through the well known idling jet or plug 58 adjacent one edge of the throttle valve 24 and air is bled to said idling fuel through a passage 60 communicating with the induction passage and controlled by an adjustable needle valve 62.

The present acceleration device is of the compound type wherein the operation thereof is in a plurality of distinct stages having different characteristics as will be described hereinafter, one embodiment of the invention being shown in Figures 1, 2 and 3. The device comprises a fuel cylinder 70 disposed within the fuel chamber 26, although if desired said cylinder may be suitably mounted externally of the carburetor. An accelerating fuel plunger or piston 72 is reciprocably received in the cylinder 70, the complete piston assembly of the device including a vacuum actuated piston 74 connected with piston 72 by a rod 76. The rod 76 is secured to piston 74 in the known manner by a clip 78 in an annular groove in the end of said rod which extends into the interior of piston 74. The piston 72 is attached to the rod 76 by means of a keyhole slot 73 cooperating with groove 75. A second groove 77 is also provided for a purpose that will be hereinafter described.

Above cylinder 70 is an oppositely disposed vacuum cylinder 80 operably receiving the vacuum piston 74 and having its upper end connected with the carburetor induction passage posterior to the throttle valve 24 by suction passages 82, 84 and 86 whereby the piston 74 is subjected to and controlled by manifold vacuum which is generally considered as the vacuum posterior to said throttle valve. A collar 88, pressed into an annular recess provided therefor, closes

the lower end of cylinder 80, and a vent 90 from said cylinder opens into the fuel chamber 26 to relieve any undesired pressure that might otherwise occur below the vacuum piston 74. If desired, the vent 90 may open into the air inlet passage 12.

The collar 88 has a central opening for slidable reception of a sleeve 92 which is slidable on rod 76, said sleeve having a flange 94 adjacent its lower end and below collar 88 and against which one end of a small relatively strong spring 96 reacts, the other end of said spring reacting against the fuel piston 72. A second spring, 98, which is large and relatively weak, reacts between the collar 88 and said piston 72.

In the supplementary or auxiliary fuel system, fuel enters the cylinder 70 through an inlet passage 114 communicating with the fuel chamber 26, passage 114 being normally open but having a check valve 116 therein to prevent return flow of fuel during the discharge stroke of the piston 72. It should be noted that fuel that may accumulate above piston 72 may flow over the upper end of cylinder 70 and return to the fuel reservoir or chamber 26.

Two auxiliary fuel discharge systems from cylinder 70 are shown in the embodiment of the invention illustrated in Figures 1 and 2, both of which discharge fuel into the annular channel 36 of the small venturi.

One discharge system, termed the power or economizer system, includes passages 120, 122 and 124 and is provided with a power jet regulator including a body 126 and power jet regulator or economizer valve 128 integral with a stem 130 and positioned intermediate the ends thereof. One end of said stem extends into the fuel cylinder 70 whereby the piston 72 may engage same and open the valve 128. A spring 132 yieldingly urges said valve 128 closed.

A by-pass from one side of valve 128 to the other includes a longitudinal passage 134 through the valve stem 130, opening at one end into the cylinder 70 and provided with a lateral duct 136 adjacent said end. Below the valve 128 a lateral, calibrated metering jet 138 connects the passage 134 with the interior of the body 126, said body having a calibrated power jet 140, larger than the jet 138, communicating with passage 120. Thus when the valve 128 is closed there is a flow of fuel through the economizer system metered by the jet 138 and when said valve is open the fuel is metered by jet 140, the advantage of the by-pass arrangement being that it eliminates the "flat spot" or "hole" which normally tends to appear upon slight accelerations from the low speed or idling operation just off idle. If desired, however, the by-pass 136, 134, and 138 may be eliminated.

The other auxiliary fuel discharge system, termed the accelerating discharge system, includes passages 142, 144 and an accelerating nozzle 146 received in passage 124, said nozzle 146 discharging fuel through a calibrated jet 148. It should be noted that nozzle 146 is of less diameter than the passage 124 to permit the flow of fuel from passage 122 through said passage 124.

The passage 144 is enlarged through the major portion of its length, as shown in Figure 1, and has a gravity actuated check vavle 150 adjacent the lower end, urged to closed position by a weight 152. The upper end of passage 144 is vented at 154 to the upper portion of the fuel chamber 26 to prevent fuel from being sucked from jet 148 when the acceleration pump is not operating, said

vent being controlled by a check valve 156 which is closed by the pressure of the acceleration fuel in passage 144 while the pump is discharging.

The operation of this device is as follows: When the throttle is at idle the suction in the intake manifold below the throttle is approximately 18 or 19 inches of mercury, which will raise the vacuum piston 74 to its upper limit of movement, drawing piston 72 correspondingly upward and compressing or loading springs 96 and 98.

The discharge stroke of the pump is divided primarily into two stages. The first stage comprises the major portion of said stroke and includes the piston travel from the upper limit of movement, as shown in Figure 1, to the point at which piston 74 engages the upper end of the sleeve 92, as shown in Figure 2. It is effected by both springs 96 and 98 upon a drop in manifold vacuum through the relatively high vacuum range when the throttle is opened off idle, and due to the combined strength of springs 96 and 98 the discharge is forceful and at a rapid rate. It will be noted that at the end of the first stage of the pump stroke piston 72 is closely adjacent to but spaced slightly from the upper end of valve stem 130.

When piston 74 engages the end of sleeve 92 no further expansion of spring 96 can occur. Thereafter, said spring is ineffective to actuate the piston 72 and is carried along with the piston assembly throughout the remaining portion or second stage of piston travel which comprises only a small part of the total stroke. This second stage is effected solely by the comparatively weak spring 98 and said stage is reserved primarily for opening the power regulating valve 128 by piston 72, although as said piston is opening the valve it will also effect a slow accelerating fuel discharge which improves the operation of the engine during this transition period. In this connection, before the assembly can progress on downward, the vacuum above piston 74 must be diminished by an amount sufficient to equal the preloaded force or initial tension in spring 96 when restrained to the length shown in Figure 2.

From the foregoing description of the invention and its operation it will be understood that there is a substantial difference in the pressure characteristics of the spring action of the two stages and consequently there is a substantial intermediate vacuum range wherein no movement of the piston occurs. The lower limit of this range is that value of vacuum just sufficient to overcome the force of spring 98 and a slight drop in vacuum through a very low vacuum range below this value will permit said spring to actuate the piston 72 which will thereupon engage valve stem 130 and open valve 128. During the opening of said valve the counter force of valve spring 132 must be overcome and this spring will tend to retard or interrupt the movement of the piston. However the force of spring 132 is relatively slight and is readily overcome by spring 98 so that it does not adversely affect the proper functioning of the device.

It should be further noted that spring 132 is preferably so calibrated that neither the pressure of the fuel in the cylinder 70 during the downward movement of the piston 72, nor suction from the induction passage on the power or economizer discharge system, nor the combination of said force and vacuum will open the valve 128 prior to its actuation by the piston 72.

When the piston 72 is at the lower limit of movement it will rest on the upper face of the valve body 126 and the flow of fuel into said body will be by way of a slot 160 and an annular passage 162 about the valve stem 130.

When valve 128 is open the jet 140 becomes the primary metering restriction and the by-pass 136, 134, 138 is substantially without effect. Consequently, the by-pass is effective during part throttle operation only.

In order that the operation of the present acceleration mechanism and its advantages over conventional vacuum controlled acceleration devices will be better understood, reference is now made to Figure 6. The solid line illustrates the characteristics of the conventional or common vacuum operated acceleration pump action. It will be seen that there is uniform pump travel throughout the entire range of manifold vacuum which means that for an equal drop in vacuum in the intake manifold, which is determined by the speed of the engine and the position of the throttle valve, an equal pump travel will result whether or not the throttle is adjacent wide open position or just off idle.

The dotted line curve illustrates the characteristics of the action of the present invention, disregarding the effect of the power jet valve spring 132. The manifold vacuum points in inches of mercury, used on the curve, are for illustration only, for by proper proportioning of the strength of the springs, the length of sleeve 92, and/or varying the total length of the piston stroke these points can be varied over a large range.

As shown in said dotted line curve, the fuel piston will travel from the extreme retracted end of the stroke of approximately .425" to .1" from the opposite end of piston travel upon a drop of manifold vacuum through the range between 18" and 12" of vacuum. There is then no further piston travel until the manifold vacuum has dropped to 5.5" of Hg, the remaining .1" of pump travel occurring between approximately 5.5" and 5" of manifold vacuum during which portion or stage of the pump stroke the valve 128 of the power regulator is opened.

If desired the pump stroke may be adjusted by attaching the piston 72 to groove 77 instead of to the groove 75. This will vary the total length of the stroke inasmuch as the upward travel of the piston assembly is limited by the distance the vacuum piston 74 can travel before reaching the top of the vacuum cylinder 80. Attachment of the piston in the groove 75 provides a short piston stroke, and attachment in the groove 77 provides a longer stroke. Other spacings of the grooves and/or additional grooves may however be provided or other means for adjusting the position of the piston 72 on the rod 76 or adjusting the total stroke of the device may be used, the illustrated arrangement being a preferred one. Variation in the length of the piston stroke could also be made by means of an adjusting arrangement between the vacuum piston 74 and the rod 76.

In Figure 7 the characteristics of the action of the present invention are shown according to two piston adjustments. The solid line curve indicates the characteristics of the action when the adjustment is for the short stroke, the longer stroke being indicated by the broken line curve. The hook or drop in the curve around 5.5 to 4.5 inches of mercury is caused by the amount of pre-loading of spring 132 of the power jet regulator valve. It will be noted that the vacuum points of the device charted in this figure vary somewhat from those shown in Figure 6. This

is due to different spring characteristics. These points, however, are also used only by way of example and may be altered as desired.

It will be further noted that adjustment of the piston stroke varies the values of vacuum, in the higher vacuum range, required to start the device in motion. This is due to the fact that varying the length of the piston assembly varies the relative spacing from the piston 72 to the collar 88 and the flange 94 of the sleeve 92 when the assembly is in the uppermost position. This results in the compression of the springs 96 and 98 being correspondingly varied when the device is in this position. Consequently, it will require a vacuum of smaller magnitude to cause the device to reach the upper limit of its travel when the piston 72 is assembled in groove 75 than when it is assembled in groove 77. At this point, it will be noted, by referring to Figure 1, that the transition from the high vacuum range to the low vacuum range will occur after the same amount of pump travel from the upper position, regardless of the groove into which the piston 72 is assembled.

It will be apparent from the foregoing that the characteristics of the device may be varied by varying the length of the stroke. Moreover, by also varying the length of sleeve 92, and by varying the thickness of the flange 94 of sleeve 92, in order to vary the amount of initial tension in spring 96 and in order to change the time of transition from the higher to the lower vacuum range, a considerable number of operative combinations become available without changing the springs. If the spring's rates are also varied, innumerable other operative combinations are possible, resulting in a device which may be readily adapted to meet the various acceleration and economizer requirements of different makes, types and sizes of engines.

Attention is particularly called to the fact that by lengthening the sleeve 92, the length of the first stage of the stroke is shortened in the higher vacuum range. This is especially advantageous for engines that do not require so large an initial acceleration charge for satisfactory performance as it increases traffic economy where the throttle valve is seldom in the wide open position.

In Figure 4 a modification of the invention is incorporated in an updraft carburetor 400. In the carburetor as illustrated the main fuel system includes a discharge tube or nozzle 412 connected with the main metering jet (not shown) by a fuel passage 414 said main metering jet being connected with the fuel chamber 26 and air is bled in the well-known manner to said main fuel system.

Within the tube 412, and discharging fuel therein, is a calibrated power and accelerating nozzle 424 of smaller diameter than the inside dimension of tube 412. The power and accelerating nozzle 424 is supplied with fuel by way of a horizontal passage 426 and a vertical passage 428 having a regulator adjacent the upper end.

The regulator comprises a body member 430 screwed into passage 428 and in which is operably received a valve 432 intermediate the ends of a longitudinally bored valve stem 434. One end of stem 434 extends through fuel passage 436 which is controlled by the valve 432, said stem being of smaller cross-section than the fuel passage 436 and extends into fuel cylinder 440. Lateral fuel orifices 444 are provided adjacent the upper end of stem 434 and the lower end of the bore is shown as having a calibrated regulator

jet 446. A spring 448 yieldingly urges the valve 432 closed and is calibrated to maintain said valve in this position against suction on the jet 470.

In the embodiment of the invention shown in Figure 4 a modified type of fuel piston 442 is shown which is provided with a disk 450 having a keyhole orifice similar to the orifice 73 shown in Figure 3 so that said piston may be attached to rod 76. To prevent closing of fuel passage 436 by the piston 442 when at its lower limit of movement, lugs 452 are provided which are adapted to engage head 438 of member 430 and space the piston 442 from the head 438. However, if desired, lugs 452 may be dispensed with and the head 438 may be slotted as shown in Figures 1 and 2 or any other suitable arrangement may be provided to insure the flow of fuel from the cylinder 440 into passage 428 when the piston 442 is at its lower limit of movement.

Cylinder 440 is provided adjacent the upper end with an overflow passage 460 and the upper end of vacuum cylinder 80 is connected with the induction passage posterior to the throttle valve 24 by a passage 462, said cylinder 80 also has a vent 464 from a point adjacent the lower end thereof to the induction passage anterior to the throttle valve.

In this embodiment of the invention the fuel is metered by jet 446 when the valve 432 is closed as said jet is smaller than the calibration of the metering jet 470. Upon discharge movement of the accelerating piston 442, the volume of fuel discharged from the cylinder 440 is such that it cannot all pass through jet 446 and consequently the valve 432 is forced open by the pressure of said fuel. The metering jet 470 of the power and accelerating nozzle 424 then meters the accelerating fuel charge. Said jet also serves to meter the fuel for the power mixture when the power regulator valve 432 is opened by piston 442.

The embodiment of the invention illustrated in Figure 5 is shown as incorporated in a carburetor of similar construction as that shown in Figure 1 and the regulator is also similar to that shown in the latter figure. The accelerating fuel piston, however, is similar to the one shown in Figure 4.

Pistons 74 and 442 are connected by a rod 576 which is similar to the rod 76 except that the upper end is enlarged at 500 to provide a shoulder 502 and there is an enlarged head 504 disposed within piston 74 whereby said piston raises said rod and piston 442. The enlarged portion 500 is adapted to pass through an opening 505 in collar 88 so that shoulder 502 will pick up a washer 506 on the accelerating stroke of the pump, the washer being slidable on rod 576 and engageable with the under side of collar 88 when the pistons are raised. Spring 96 reacts between washer 506 and piston 442 and spring 98 reacts between said piston and the collar 88. When the shoulder 502 engages the washer 506 further expansion of spring 96 is prevented. Varying the length of the enlarged portion 500 effects changes in the operation of the device comparable to changes in the length of sleeve 92 in Figures 1, 2 and 4.

In this embodiment there is also but one fuel discharge passage, 508, from the accelerating pump cylinder 70 which is controlled by the regulator, the passage 508 including a power and accelerating jet 510 discharging into a passage 512 which communicates with channel 36 in the small venturi.

When the valve 128 is closed, fuel is metered by the jet 138; and when the valve is open, jet 510 meters the fuel for the power mixture as well

as the charge of accelerating fuel, orifices 530 having a combined area large enough so that they are not calibrating factors.

While certain modifications of the invention have been shown and described it is to be understood that one or more of the various features of one modification may be substituted for corresponding features of another modification, or may be added thereto. Further, a diaphragm type of accelerating mechanism, incorporating the functions and features of the illustrated piston type pump mechanism, may be used and the invention may be incorporated in a horizontal delivery type of carburetor or the like as well as the types shown and described herein. If desired, there may be an independent accelerating discharge jet or nozzle discharging directly into the induction passage and the control of the mechanism may be by other means than manifold vacuum.

It will also be apparent to those skilled in the art that various other changes may be made in the form, construction and arrangement of the parts without departing from the spirit and scope of the invention or sacrificing all of its material advantages, the forms hereinbefore described being merely preferred embodiments of the invention.

We claim:

1. In a charge forming device for an internal combustion engine: an induction passage; a throttle valve controlling said passage; a source of fuel; a main fuel system adapted to deliver fuel to the induction passage from said source; an accelerating device adapted to receive fuel from said source and deliver it to the induction passage, said device including a pumping member having a predetermined discharge stroke and controlled by manifold vacuum; relatively strong yielding means for forcefully effecting a predetermined major portion of the discharge stroke of the pumping member during decrease of vacuum in a high manifold vacuum range; and relatively weak yielding means for effecting the remainder of the discharge stroke upon a slight decrease of manifold vacuum in a low vacuum range.

2. The combination with a carburetor having an induction passage controlled by a throttle valve, of an acceleration device having a piston with a predetermined discharge stroke and controlled by a vacuum posterior to the throttle; a pair of springs in parallel for effecting discharge movement of the piston, one of said springs being stronger than the other; means for limiting the effectiveness of the stronger spring to a predetermined major portion of the discharge stroke of the piston; the weaker spring being effective throughout the entire stroke of the piston and adapted to independently complete said stroke; and a valve controlling a passage from the acceleration device and openable by the piston during that portion of its stroke effected solely by the weak spring.

3. In a carburetor having an induction passage controlled by a throttle: an acceleration device having a piston controlled by vacuum posterior to the throttle, said piston having a predetermined discharge stroke; and a pair of springs for effecting discharge movement of said piston; one of said springs being effective throughout the entire discharge stroke of the piston, the other spring being effective in cooperation with the one spring to actuate the piston through part of its stroke only.

4. In a carburetor for an internal combustion engine, an induction passage controlled by a throttle, a fuel chamber, and a main fuel delivery system: an auxiliary fuel system subject to suction by air flow in the induction passage; a regulator valve controlling said auxiliary system; an acceleration device connected with the fuel chamber, a pumping member for said device controlled by manifold vacuum; yielding means for actuating the pumping member throughout a major portion of its discharge movement; means for rendering said yielding means inoperative throughout the remaining portion of the movement of the pumping member; weaker yielding means for effecting said remaining portion of the discharge movement of the pumping member; said pumping member opening the regulator valve during the movement effected by the weaker yielding means; and a discharge passage for accelerating fuel from the acceleration device to the induction passage.

5. In a carburetor having an induction passage controlled by a throttle valve: an acceleration device including a fuel cylinder; a fuel piston operative therein; a vacuum cylinder connected with the induction passage posterior to the throttle; a vacuum piston operative therein; a rod connecting said pistons; a fixed member; a spring reacting between said fixed member and the fuel piston; a sleeve slidable relative to said rod and adapted to engage the fixed member; and a second spring adapted to react between the sleeve and the fuel piston; said sleeve being so arranged that the vacuum piston will engage one end of same as it approaches one end of its stroke.

6. In a carburetor having an air passage controlled by a throttle: an acceleration device having a fuel cylinder; a piston therefor; a piston rod secured to said piston; means for controlling the piston by vacuum posterior to the throttle valve; a fixed member adjacent the piston rod; a slidable member on said rod and engageable with the side of the fixed member adjacent the piston, a pair of springs, one of said springs reacting between the piston and the fixed member and the other spring reacting between the piston and the slidable member; a shoulder on said rod adapted to engage the slidable member upon a predetermined movement of the piston in one direction.

7. In a carburetor having an induction passage controlled by a throttle valve: an acceleration device including a fuel cylinder; a piston operable therein; a vacuum cylinder connected with the induction passage posterior to the throttle; a vacuum piston operative therein; a rod connecting said pistons; a fixed member; a spring reacting between said fixed member and the fuel piston; a sleeve slidable relative to said rod and adapted to engage the fixed member; a second spring adapted to react between the sleeve and fuel piston; said sleeve being so arranged that the vacuum piston will engage one end of same as it reaches a predetermined position adjacent the end of its discharge stroke thereby rendering said second spring inoperative for further discharge movement; an auxiliary fuel system; and a valve controlling same, said valve being opened by the fuel piston upon discharge movement beyond said predetermined position.

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