

Sept. 2, 1947.

F. C. MOCK

2,426,741

CHARGE FORMING DEVICE

Filed Aug. 3, 1940

4 Sheets-Sheet 1

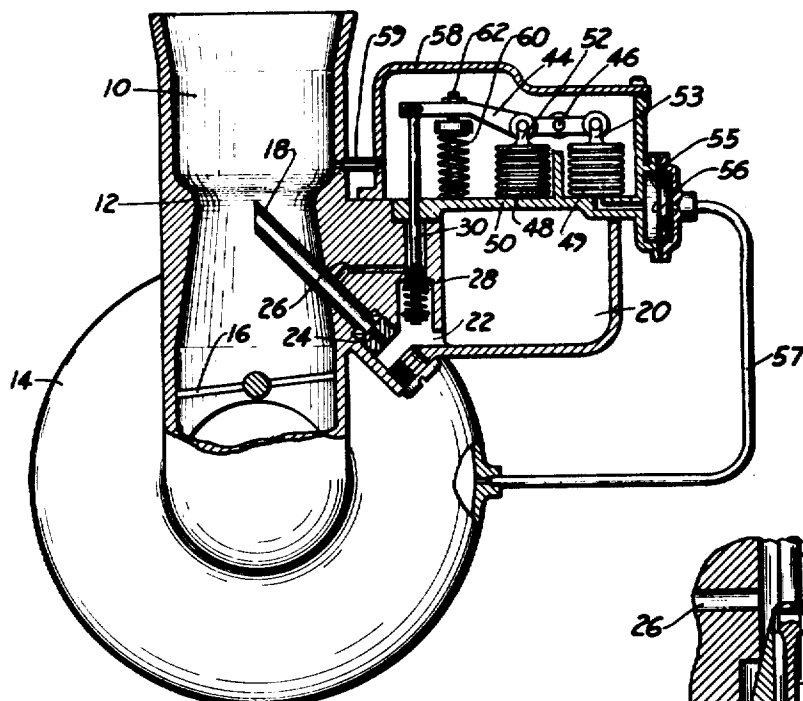


FIG. 1

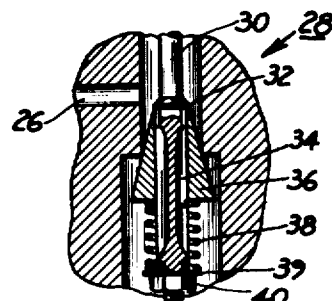


FIG. 3

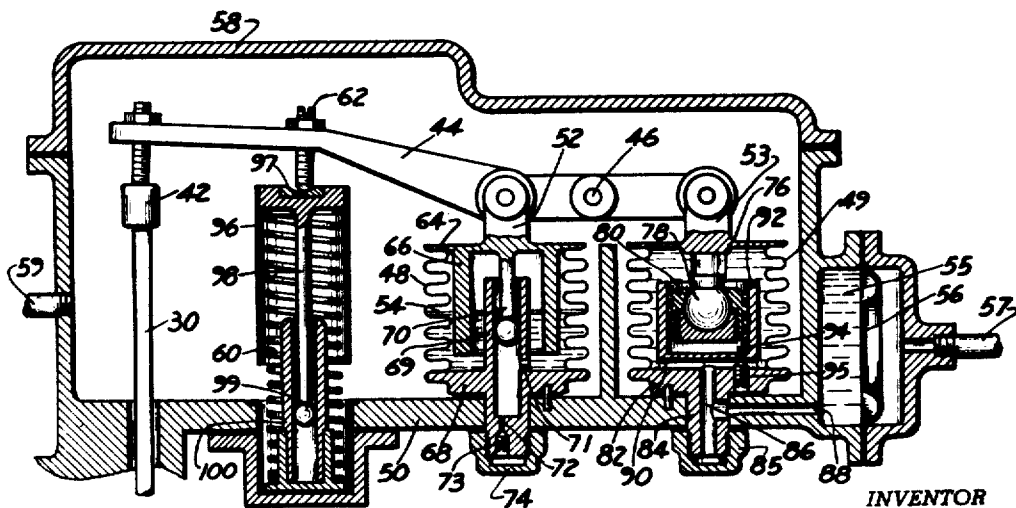


FIG. 2

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4 Sheets-Sheet 2

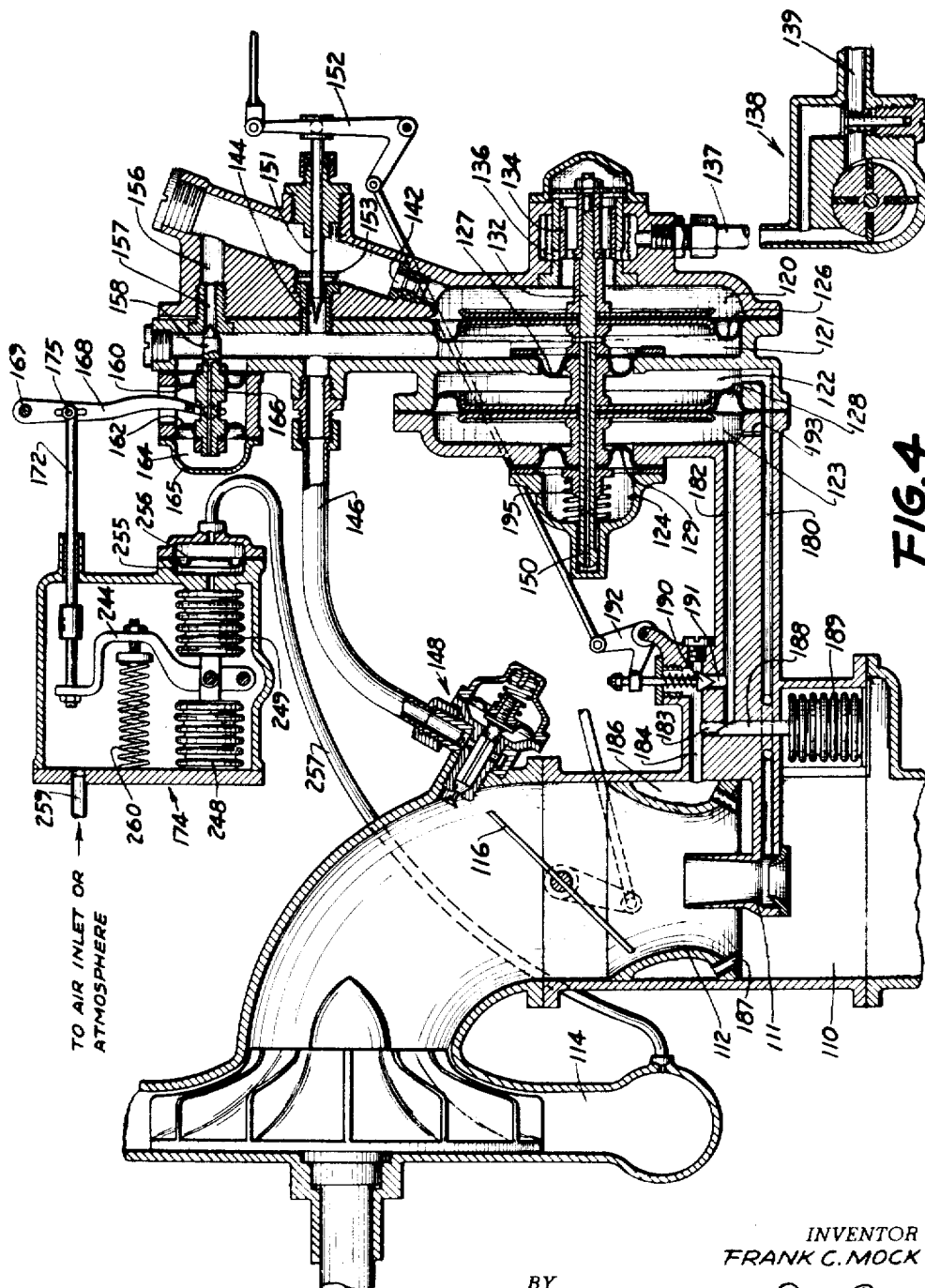


FIG. 4

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4 Sheets-Sheet 3

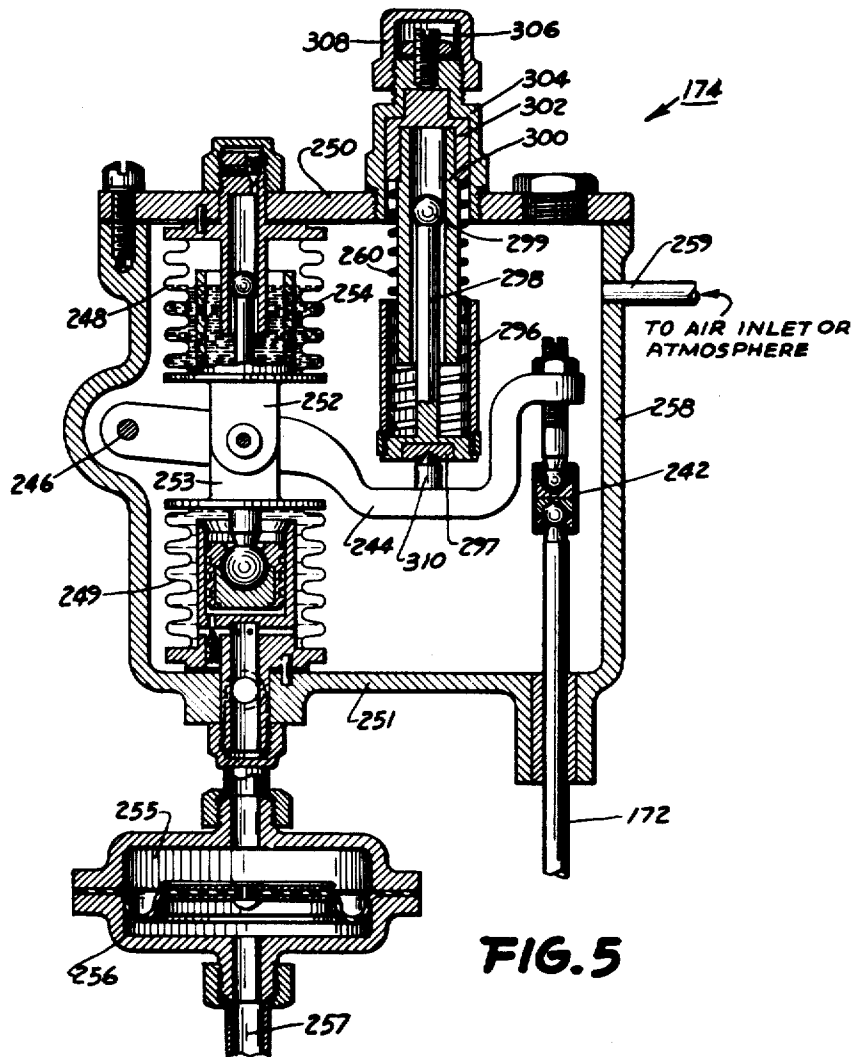


FIG. 5

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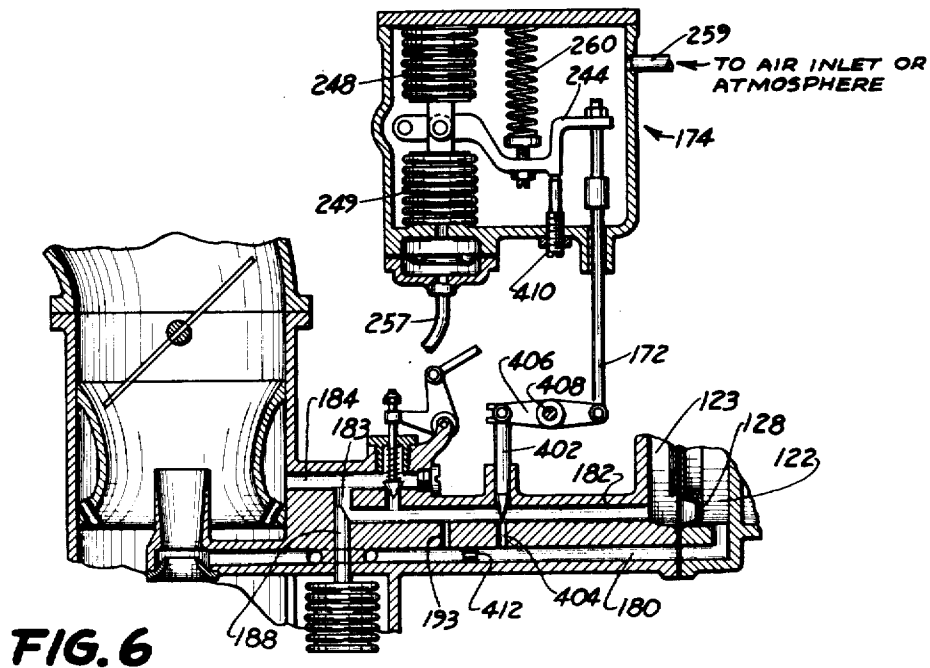
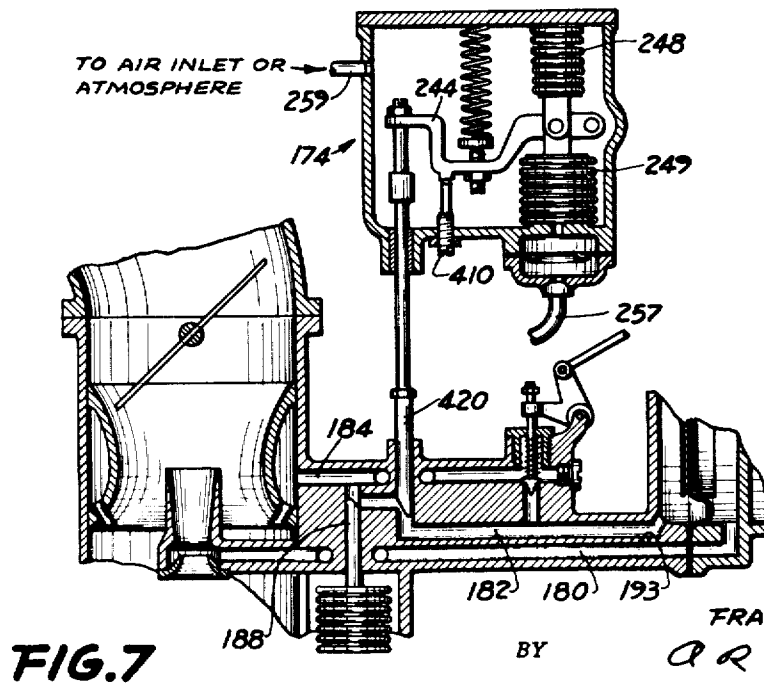
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4 Sheets-Sheet 4



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2,426,741

CHARGE FORMING DEVICE

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Application August 3, 1940, Serial No. 350,518

15 Claims. (Cl. 123-119)

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This invention relates to charge forming devices for internal combustion engines and more particularly to a control means for the supplementary fuel supply, or economizer system, for enriching the mixture supplied to the engine under certain conditions of operation. The invention is particularly adapted for use with an aircraft engine of the supercharged type but may be used on internal combustion engines of other types. The instant application is a continuation-in-part of my copending applications Serial Numbers 120,654, filed January 15, 1937 (now abandoned), and 202,206, filed April 15, 1938, now Patent No. 2,390,658, granted December 4, 1945, which in turn is a continuation of my copending, but now abandoned, application Serial No. 118,718, filed January 2, 1937.

It has long been recognized that an enriched mixture is required to produce maximum power, as compared to that required for maximum economy; however, the particular operating conditions at which the mixture should be enriched, or the particular engine variables which should be used to effect the control of the enriching device, have not been entirely understood. In addition, an enriched mixture has a cooling effect tending to reduce the engine operating temperatures and therefore has a beneficial effect, quite apart from its effect on the power output, which finds particular usefulness in cooling the engine at high altitudes. In many cases this cooling effect is depended upon at high power outputs to keep the operating temperatures at a safe level and a failure to supply a rich mixture under these conditions might result in overheating and serious damage to the engine or failure thereof in flight. Breakage or failure of the control mechanism should therefore result in enrichment of the mixture under all conditions rather than in no enrichment at any time; or as it is generally expressed, the device should "fall rich" rather than "fall lean."

Since the absolute pressure of the charge in the intake manifold posterior to both the throttle and the supercharger largely determines the power developed per stroke of the engine it affords a convenient index of the richness required and is a satisfactory variable for operating the supplementary fuel supply control mechanism. At high altitude, however, the power produced at a given charge pressure is somewhat greater than at sea level, the decreased exhaust back pressure resulting in more complete scavenging of the exhaust gases and consequently a greater charge weight per stroke. In addition, at

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high altitude the air flow over the engine has a somewhat decreased cooling effect due to its decreased density. The increased power and decreased cooling accompanying a decrease in barometric pressure both tend to require that the economizer enrichment be provided at a lesser charge pressure at altitude than at ground level. In some cases these effects are of rather small amount and may be neglected.

Increased atmospheric temperature also has a double effect in the determination of the charge pressure at which an enrichment of the mixture should be provided. An increase in air temperature decreases the cooling effect of the air flow over the engine and therefore tends to require that the mixture be enriched at a lower charge pressure than at low temperatures. In addition, an increase in atmospheric temperature increases the charge temperature and consequently reduces the weight of charge per stroke at a given charge pressure thus decreasing the power output and tending to require that the mixture be enriched at a greater charge pressure. The two temperature effects are thus in opposite directions and in some cases the one may completely offset the other so that the desired economizer control should operate at a predetermined charge pressure independently of atmospheric temperature. In other cases, however, the decreased power effect more than offsets the loss in cooling and the desired economizer should then enrich the mixture at a somewhat increased charge pressure upon increase in atmospheric temperature.

It is accordingly an object of the invention to enrich the mixture supplied to an internal combustion engine when the absolute pressure of the charge entering the engine exceeds a predetermined value.

It is a further object of the invention to supply supplementary fuel to an engine when the absolute pressure of the charge entering the engine exceeds a value determined by the atmospheric pressure.

It is a further object of the invention to provide a supplementary fuel supply which is rendered operative when the absolute pressure of the charge in the intake manifold posterior to the throttle and the supercharger exceeds a value determined by atmospheric pressure and temperature.

It is a further object of the invention to provide a supplementary fuel control mechanism in which a failure of the mechanism will produce an enriched mixture.

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A still further object of the invention is to provide an improved supplementary fuel control mechanism.

Other objects and advantages of the invention will be readily apparent from the following description taken in connection with the appended drawings in which:

Figure 1 is a diagrammatic view partially in section of a carburetor embodying the invention; Figure 2 is a vertical sectional view of a slightly modified form of the invention shown in Figure 1;

Figure 3 is an enlarged sectional view of the economizer valve of Figure 1;

Figure 4 is a diagrammatic sectional view of a charge forming device of the pressure feed type utilizing another modification of the invention for controlling a supplementary fuel valve;

Figure 5 is an enlarged sectional view of the economizer control mechanism of Figure 4;

Figure 6 is a diagrammatic sectional view of a portion of the charge forming device of Figure 4 in which the invention controls an air bleed passage to effect a supplementary fuel supply; and

Figure 7 is a view similar to Figure 6 of a modified arrangement in which the invention controls another of the air passages of the charge forming device to effect a supplementary fuel supply.

Figures 1 and 2 disclose very similar modifications of the invention, differing from each other only as pointed out hereinafter, and may be described together. There is disclosed a carburetor having an induction passage comprising an air inlet or scoop 10, a venturi 12, and a mixture outlet adapted to deliver into the intake of a supercharger 14. A throttle 16 controls the induction passage. A main fuel nozzle 18 receives fuel from the fuel reservoir 20 through passage 22 and metering orifice 24 and discharges it into the induction passage adjacent the constricted portion of venturi 12. A fuel passage 26 bypasses the metering orifice 24 and is controlled by an economizer valve indicated generally at 28. It is readily apparent that the passage 26 could discharge directly into the induction passage rather than into the main nozzle posterior to the metering orifice 24 as shown.

The economizer valve, as best shown in Figure 3, comprises a stem 30 having a shoulder 32. The lower portion of stem 30 is fluted as indicated at 34 and slidably receives a tapered valve member 36 which is normally urged against the shoulder 32 by a compression spring 38. The flutes 34 normally have an effective aggregate cross-sectional area equivalent to the effective fuel metering area of the economizer valve 28 when in open position. A spring retaining washer 39 and nut 40 retain the parts in assembled relation, the valve 28 acting merely as a solid type of fuel valve during normal periods of operation. Valve stem 30 is pivotally connected, preferably through a universal connection 42 as shown in Figure 2, to a lever 44 having a fixed pivot 46 at opposite sides of which are connected bellows 48 and 49. The bellows are fixed to a base member 50 and are pivotally connected to lever 44 by rods 52 and 53. In Figure 1 the bellows are of equal effective diameters and are connected to the lever 44 at equal distances from the fixed pivot 46; whereas in Figure 2 the bellows are at unequal distances from the pivot, the bellows 48 being preferably connected at a lesser distance from the pivot 46 than bel-

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lows 49. Instead of decreasing the lever arm of bellows 48 the bellows could be of somewhat smaller effective diameter than bellows 49 and accomplish an equivalent result as will be pointed out hereinafter.

Bellows 48 is partially filled with a body of oil 54. Bellows 49 is entirely filled with oil and communicates freely with a chamber 56 which is closed by a flexible diaphragm 58, the other face of which is connected through a conduit 57 with the induction passage posterior to both the throttle and the supercharger. As shown, the conduit 57 leads to the outlet ring of the supercharger and is thus subjected to supercharger discharge pressure. The pressure transmitted through conduit 57 may be either above or below atmospheric because of the action of the supercharger. Both bellows 48 and 49 are enclosed in a casing 59 which is connected by a passage 59 to the air scoop 10. A compression spring 60 having an adjusting screw 62 for varying the spring force urges lever 44 in a direction to close the economizer valve 28.

Referring more particularly to Figure 2 in which the details of construction are best shown it will be seen that the top closure plate 64 of bellows 48 is fixed to or formed integral with rod 52 and is provided with a cylindrical sleeve 66 extending downwardly within the bellows adjacent the inner edges of the corrugations of the bellows so as to restrict the flow of oil into and out of the corrugations for purpose of damping. The other end of the bellows is closed by a base plate 68 having a tubular member 69 extending upwardly within the bellows and slidably receiving the rounded end of a plunger 70 depending from the closure plate 64 to form a guide and dashpot. A restricted port 71 may be provided in the lower end of member 69 to permit equalization of the oil level in the bellows and in member 69. It will be noted that this construction permits of misalignment between the parts and damps vibration as is more particularly described and claimed in my copending application Serial No. 120,654, filed January 15, 1937. The bore of member 69 communicates with a filling aperture 72 which is closed by a set screw 73. The top of member 69 forms a stop to limit the extent to which the bellows may be collapsed. The lower portion of member 69 extends through the base member 50 and receives a nut 74 which secures the bellows to the base member.

If it is desired that the control be not affected by variations in temperature of the air entering the engine the bellows 48 is evacuated by collapsing the bellows to a predetermined point, filling the collapsed bellows with oil or other liquid having a relatively constant temperature-viscosity relation, sealing the bellows with set screw 73, and then forcing the bellows to a partially extended position by the spring 60. If, however, it is desired to modify the operation of the economizer in accordance with variations in entering air temperature, a predetermined quantity of gas, preferably an inert gas, is used in the space within the bellows above the oil level. By controlling the quantity of gas used in the space above the oil, that is the temperature, pressure and volume of the gas at the time of sealing, the sensitivity of the bellows to changes in temperature may readily be controlled, the bellows being non-responsive to temperature changes if the space is entirely evacuated, and becoming increasingly responsive as the degree of evacuation is decreased.

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Bellows 48 is closed at its upper end by a plate 76 which is fixed to or formed integral with rod 53. Plate 76 also has a depending portion extending downwardly within the bellows which terminates in a ball 78 forming a universal connection with a piston 80. The lower end of the bellows is closed by a base plate 82 having a hollow stem 84 formed integral therewith extending through a bore in the base member 50. A nut 85 closes the vertical passageway 86 in the stem 84 and also secures the bellows to the base member.

Passageway 86 communicates at its lower end with the chamber 55 through a passage 88 and at its upper end with the free space within the bellows through a plurality of radial passages 90. A sleeve 92 fixed to plate 82 and extending upwardly within the bellows slidably receives the piston 80, so as to form therewith a dashpot for damping vibrations. The outer surface of the sleeve may be closely adjacent the inner edges of the corrugations to restrict the flow of oil into and out of the corrugations for purpose of further damping vibrations of the bellows. A passageway 94 communicates the interior of sleeve 92, below the piston 80, with one of the radial passages 90 and is partially restricted by an adjustable needle valve 95. The effectiveness of the dashpot action of piston 80 may thus be readily adjusted or varied.

A spring retaining cup 96 receives the spring 60 and is urged upwardly thereby. A hardened rounded insert 97 in the head of cup 96 engages the end of adjusting screw 62 to urge lever 44 in a clockwise direction about the pivot 46 and thereby hold the economizer valve member 36 on its seat with a predetermined force. The cup 96 has a downwardly extending rod 98 formed integral therewith having a ball end 99 which is slidably received by a tubular member 100 extending upwardly from the base member 50. A guide is thus provided to maintain the spring retaining cup 96 in proper alinement.

During periods of operation at idle or low power outputs the valve 28 is held in a closed position under the combined forces of the spring 60 and bellows 48 and 49. The valve spring 38 under these conditions is sufficiently strong to maintain the valve member 36 against the shoulder 32. As the power increases the pressure posterior to the supercharger and consequently the pressures in conduit 57, chamber 55 and bellows 49 will also increase thereby tending to open valve 28. When the supercharger outlet pressure reaches a predetermined value the force of bellows 49 will overcome the other forces holding the valve closed and the valve will open to supply supplementary fuel. In Figure 1 the bellows 48 and 49 are of equal size and have equal lever arms relative to the fixed pivot 46. Variations in barometric or scoop pressure will act equally on the bellows 48 and 49 thus creating equal but opposite forces on lever 44 and entirely canceling the effect of these variations. In addition, if the bellows 48 has been completely evacuated leaving but a vacant space above the oil therein the bellows will be unaffected by changes in temperature. It should furthermore be noted that bellows 49 is also not affected by temperature changes since the change in the volume of oil resulting therefrom merely changes the position of the diaphragm 56 without changing the forces acting on the bellows. The arrangement of Figure 1 utilizing an evacuated bellows 48 therefore produces an economizer con-

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trol which is independent of barometric pressure or temperature and solely dependent upon the absolute pressure at the outlet of the supercharger.

As is generally known, an evacuated bellows is under rather severe stress and will therefore tend to fracture more readily than a gas-filled bellows. It will be readily apparent that the evacuation of bellows 48 creates an appreciable force tending to collapse the bellows and open the valve 28 which is normally counteracted by the force of spring 60. If the bellows 48 fractures during service the loss of this high collapsing force will result in the valve being held on its seat with a greatly increased force. Under these conditions, however, the force tending to seat the valve is so high that the spring 38 permits stem 30 to move upwardly relative to member 36 thereby uncovering the flutes 34 and permitting fuel to flow past the valve. The device therefore "falls rich," as was previously pointed out to be desirable.

If bellows 48 is but partially evacuated it will respond to changes in temperature of the entering air, an increase in temperature resulting in an increase in the expansive force of bellows 48 tending to seat valve 28 and therefore increasing the absolute supercharger outlet pressure required to open the valve 28. The effectiveness of changes in temperature on the required supercharger outlet pressure may be readily controlled by varying the volume and absolute pressure of the gas within bellows 48, as previously pointed out.

By utilizing unequal lever arms for bellows 48 and 49 (as shown in Figure 2), or bellows of unequal diameters, the forces created by the bellows on lever 44 by a change in entering air pressure will not balance each other and will vary the absolute pressure required at the supercharger outlet to open valve 28. The amount the required supercharger outlet pressure will change for a given change in air inlet pressure will depend upon the relative lever arms of the two bellows and/or the effective size of the bellows.

The economizer control unit is therefore capable of enriching the mixture when the absolute pressure posterior to the throttle and supercharger reaches a predetermined value, a value which may be independent of both the temperature and pressure of the entering air, or dependent to any desired degree upon the temperature, or pressure, or upon both the temperature and pressure of the entering air.

In Figures 4, 6 and 7 the invention has been applied to a charge forming device of the pressure feed type such as is particularly described in my copending application Serial No. 202,206, filed April 15, 1938. With particular reference to Figure 4, the main air passage includes an air intake 110, small venturi 111 and large venturi 112. The passage leads to the entrance of a supercharger 114 of an internal combustion engine and is controlled by throttle 116 which is operated by a rod extending from the pilot's cockpit. The pilot thus controls directly the air charge of the engine while the fuel charge is automatically controlled by a metering unit hereinafter described.

The metering unit comprises chambers 120, 121, 122, 123 and 124 separated from each other by diaphragms 126, 127, 128 and 129 which are connected to a control rod 132 having a sleeve valve 134 connected thereto at its right end (as shown) and controlling fuel inlet ports 136. Fuel is delivered to ports 136 through conduit 137 by an engine driven constant pressure type fuel pump

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indicated at 130 which receives fuel from a source, such as a fuel tank, through conduit 130. The pump thus delivers fuel through ports 130, which are varied in effective area of opening by the axial positioning of sleeve valve 134, into the unmetered fuel chamber 120, through fixed metering orifice 142, an adjustable metering orifice 144, into metered fuel chamber 121, and through passage 146 to a pressure responsive fuel discharge jet indicated at 148 which discharges in the induction passage posterior to the throttle 116. A passage 150 in the control rod 132 interconnects the chamber 124 and the metered fuel chamber 121. The effect on control rod 132 of metered fuel pressure acting on sealing diaphragm 127 is thus balanced out by its equal and opposite effect on sealing diaphragm 129. A tapered needle 151 is connected to pivoted lever 152 and has a disc 153 secured thereto to close orifice 144, by movement of lever 152 to the left, during periods of inoperation. During normal periods of operation the needle 151 is positioned approximately as shown; however, if it is desired to manually enrich the mixture the needle may be further withdrawn from the orifice by movement of lever 152. An economizer bypass 156 is provided around the adjustable metering orifice 144 and includes a metering restriction 157 controlled by an economizer valve 158. Diaphragms 160 and 162 are connected to the stem of valve 158, the former forming a portion of the wall of the metered fuel chamber 121 and the latter forming a chamber 164 with a cap 165. A passage 166 in the valve 158 connects the chamber 164 with the metered fuel chamber to balance out the effect of the metered fuel pressure on diaphragm 160. A lever 168 is pivoted at one end at 169 and engages the stem of valve 158 intermediate the diaphragms 160 and 162 at its other end. A guided control rod 172 of an economizer control unit indicated generally at 174 is pivotally connected to the lever 168 at 175 for actuating the valve 158 to enrich the mixture, a slot being provided in the lever to permit pivotal movement thereof.

A passage 180 connects air chamber 122 with the throat of venturi 111 and passages 182, 183, 184, chamber 186 and tubes 187 connect the air chamber 123 with the scoop or air entrance 110. A valve 188 connected to a sealed bellows 189 controls the effective area of the latter connection. A spring loaded valve 190 controls a bypass 191 around the valve 188. A pivoted lever 192 having an overrunning connection with the valve 190 is arranged to open the valve after a predetermined movement of lever 152 to eliminate the effect of valve 188 if desired. A restricted passage 193 connects air chamber 123 to passage 180.

During operation, air flow through the main air passage creates a differential pressure between the air scoop and the venturi throat which varies as the square root of the rate of air flow. The air scoop and venturi pressures are transmitted to air chambers 123 and 122 and create a force to the right on diaphragm 128 and control rod 132 tending to open the fuel inlet valve 134. Fuel flow through the metering unit creates a differential force across the metering orifices and therefore a differential in the fuel pressures in the unmetered fuel chamber 120 and metered fuel chamber 121 which is proportional to the square root of the rate of fuel flow. The differential in fuel pressures acting on diaphragm 126 creates a force to the left on control rod 132 tending to close the fuel valve 134. The control rod 132 and valve 134 thus regulate the fuel flow so as to

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maintain the fuel force on rod 132 equal to the air force. Since the air force and fuel force on the rod 132 are respectively proportional to the quantities of air and fuel being delivered to the engine a constant ratio is maintained between these quantities thus providing a constant mixture richness. Spring 195 engages control rod 132 creating an additional force tending to open the valve 134 which is of appreciable amount compared to the air force at idle but of negligible amount at higher air flows. This increases the fuel flow at idle to provide a rich mixture as is desired.

As the density of the entering air decreases from increase in altitude or increase in temperature, the air differential created by the venturis increases for a given weight of air and tends to increase the mixture richness. At such times the bellows 189 expands and valve 188 restricts passage 182. The bleed 193 which previously had but a negligible effect in disturbing the pressures in chambers 122 and 123 now becomes effective to decrease the pressure in chamber 123 thus reducing the pressure which would otherwise be present in chamber 123 and maintaining the differential pressure across diaphragm 128 at a constant value for a given weight of air flow. The mixture is thus maintained at a constant richness at all altitudes unless varied by a change in the fuel metering area, as for example by withdrawing needle 151 from orifice 144. The orifice 142 is relatively large compared to the normal metering area of orifice 144 and therefore has very little metering effect. If, however, the valve 151 is entirely withdrawn the orifice 142 becomes effective to meter the fuel and thus limits the maximum richness which is obtainable at the will of the pilot. The orifice 142 could be omitted if desired.

The economizer control unit 174, shown in detail in Figure 5, is quite similar to that of Figure 2 and consequently corresponding parts are given corresponding reference numerals with the addition of 200. Control rod 172 is connected through universal connection 242 to a lever 244 having a fixed pivot 246. Bellows 248 and 249 are pivotally connected at one end to lever 244 by rods 252 and 253 and are fixed at their other ends to base members 250 and 251. Bellows 248 is preferably partially filled with a body of oil 254. Bellows 249 is entirely filled with oil and communicates freely with a chamber 255 which is closed by a flexible diaphragm 256, the other face of which is connected by conduit 257 to the supercharger outlet. The bellows are enclosed in a casing 258 which may be open to atmosphere or be connected through conduit 259 to the air inlet 110. The bellows 248 and 249 have internal structure comparable to that of the bellows 48 and 49 of Figure 2. Bellows 248 and 249 are connected to lever 244 on the same side of fixed pivot 246, in contrast to the modification of Figure 2; however, in either case the bellows act in opposition to each other and produce an equivalent result.

Since bellows 248 is normally evacuated, it creates a force tending to move lever 244 in a counterclockwise direction which is much greater than that exerted by the bellows 249 tending to move the lever in the opposite direction. A resilient means is therefore provided to overcome this unbalance and to urge the valve 158 onto its seat with a predetermined force such that the supercharger outlet pressure acting on bellows 249 must reach a predetermined value before the valve 158 will open. As shown, such resilient

means comprises a sleeve 300 carried by a cup member 302 which is slidably mounted in a cylindrical member 304. The member 304 carries an adjusting screw 306 bearing on the end of the cup 302 for adjusting its position and consequently the force of spring 260. A cap 308 encloses the adjusting screw. A rod 298 has a ball end 299 slidably mounted in the sleeve 300 and terminates in a head 297 bearing against a knife edge 310 carried by lever 244. A sleeve 296 is secured to head 297 and serves as a partial housing for the spring 260 which bears at one end against head 297 and at its other end on the cup member 302.

By making bellows 248 and 249 of the same size and evacuating bellows 248 an economizer control is obtained, as was described in connection with Figure 1, which will enrich the mixture when the absolute pressure of the supercharger outlet exceeds a predetermined value independently of the entering air temperature or pressure. Also, if bellows 248 is made smaller than bellows 249, as in the modification of Figure 7, the absolute supercharger outlet pressure required to open fuel valve 188 will decrease with decrease in barometric or air inlet pressure. Also, by using a gas filled bellows 248 rather than an evacuated bellows the device will be temperature responsive and the absolute supercharger outlet pressure required for operating valve 188 will change with change in air temperature an amount dependent upon the volume and pressure of the gas within the bellows.

It will be apparent that by reversal of fixed pivot 169 and pivot 175 the valve 188 could be arranged to open in the opposite direction such that the spring type valve of Figure 3 could be utilized with the arrangement of Figure 4.

The economizer control units of Figures 6 and 7 are substantial duplicates of Figure 4 but operate air bleed valves, rather than fuel valves, to accomplish an economizer enrichment.

In Figure 6 a valve 402 controls a passage 404 connecting the passages 180 and 182 and is pivotally connected to one end of a lever 406 which has a fixed pivot at 408 and is connected at its other end to the economizer control rod 172. A stop screw 410 is provided in the economizer control unit 174 and engages the lever arm 244 when the valve 402 is open the proper amount for normal operation. Under these conditions the lever 244 is urged against the stop 410 by spring 260 with a predetermined force which must be overcome by the supercharger outlet pressure acting on bellows 249 before the valve 402 can move toward closed position.

The bleed passage 193 is preferably placed to the left of passage 404 and a restriction 412 inserted in the passage 180 between the passages 193 and 404. The passage 180 to the left of the restriction 412 is relatively large such that the bleed 193 has no substantial effect on the pressure in chamber 122 but reduces the pressure in chamber 123 when the altitude control valve 188 restricts the passage 183. On the other hand, the bleed 404 is relatively small compared with the passages 182 and 183 such that the bleeding action therethrough has substantially no effect on the pressure in chamber 123, but due to the restriction 412 has an appreciable effect on the pressure in chamber 122. Altitude control is thus obtained by modifying the pressure in chamber 123 whereas the economizer control is obtained by modifying the pressure in chamber 122. When so arranged, each control operates independent-

ly of the other. It will be apparent that passages 193 and 404 could be reversed in position in which case each control would operate on the other of the chambers 122 and 123 from that described above. Furthermore by varying the relative sizes of passages 193 and 404 and restriction 412, either or both controls could be made to have an effect on the other control.

During periods of normal operation the pressure in chamber 122 of the metering unit is modified due to the bleeding action of passage 404. The differential pressure acting across diaphragm 128 is reduced as compared to that existing between the Venturi throat and the air scoop; however, it will always bear a fixed relation to the Venturi-to-air-scoop differential pressure, unless modified by the action of the bellows controlled valve 188. The device therefore meters the fuel in accordance with air flow as in Figure 4, a slightly larger metering orifice being required for a given mixture richness due to the reduced effective Venturi-to-scoop differential pressure acting on diaphragm 128 at any given air flow. When the supercharger discharge pressure exceeds a predetermined value the lever 244 moves upwardly off of stop 410 and closes the valve 402, decreasing or eliminating the air bleed action through passage 404. The increased differential pressure across diaphragm 128 resulting from the closing of valve 402 increases the fuel flow for a given weight of air thus providing an enriched mixture as is desired.

The modification of Figure 7 is very similar to that of Figure 6. In Figure 7 the economizer valve 420 and bellows controlled valve 188 operate in series to control the effective area of passage 182 and consequently together control the effectiveness of the fixed bleed 193 between passages 180 and 182. Closing movement of valve 188 with increase in altitude further restricts passage 182 rendering bleed 193 more effective, producing an altitude mixture control as before. When the supercharger outlet pressure exceeds a predetermined value lever 244 moves off of stop 410 and opens the valve 420, thus decreasing the effectiveness of the bleed 193 and increasing the richness of the mixture as is desired. The bellows 248 is, as shown, smaller than bellows 249 therefore making the device responsive to variations in air inlet pressure transmitted to the economizer control unit through conduit 259.

Although the invention has been described with particular reference to several modifications it is to be understood that the invention is not limited thereto nor otherwise than by the appended claims, it being apparent that the invention could be used to accomplish an economizer control in other ways, or to position a control element in response to variations in the absolute pressure of any desired fluid or in response to the absolute pressure of one fluid source and the pressure and/or temperature of a second fluid source.

I claim:

1. In a device for supplying fuel to an engine having a fuel pump and regulating means for controlling the rate of fuel supply, a control device comprising an evacuated bellows responsive to changes in barometric pressure, a second bellows connected to the engine intake manifold to be responsive to pressure changes therein, and means jointly controlled by said bellows to automatically modify the control effected by said regulating means.

2. In a device for supplying fuel to an engine having a fuel pump and regulating means for

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controlling the rate of fuel supply, a control device comprising an evacuated bellows responsive to changes in barometric pressure, a second bellows connected to the engine intake manifold to be responsive to pressure changes therein, a lever connected to both of said bellows to be jointly controlled thereby, a spring urging said lever to a normally balanced position, and control means operated by said lever to modify the control effected by said regulating means.

3. A sensitive control element for an engine carburetor having a throttle controlled induction passage comprising a bellows, means connecting the interior of said bellows to the carburetor induction pipe posterior to the throttle to be responsive to pressure variations therein, a second bellows sealed with a predetermined interior pressure, a control member connected to both of said bellows to be actuated jointly thereby, and means including a body of liquid in each of said bellows to damp vibrations thereof.

4. In a charge forming device for an engine having a supercharger on the downstream side of said device, a source of fuel, a source of air, means for controlling the normal fuel supply to the engine, a device rendered operative for enriching the mixture of air and fuel when the pressure posterior to the supercharger exceeds a predetermined value, and means responsive to temperature for modifying said predetermined value.

5. In a charge forming device for an internal combustion engine having a supercharger, an induction passage having a throttle, an air supply, a main fuel supply, a supplementary fuel supply, a valve controlling said supplementary fuel supply, means responsive to the pressure posterior to the supercharger and throttle for actuating said valve to enrich the mixture, and means responsive to temperature for varying the value of said pressure necessary to actuate said valve.

6. In a charge forming device for an internal combustion engine provided with a supercharger, and an induction passage having a throttle and a main fuel supply; means for supplying supplementary fuel to the engine, means responsive to the pressure posterior to the throttle and supercharger controlling said supplying means, and means responsive to variations in barometric pressure and temperature for modifying said control.

7. In a charge forming device for an internal combustion engine provided with a supercharger and an induction passage having a throttle and a main fuel supply; a supplementary fuel supply, a valve for normally rendering the supplementary fuel supply inoperative, and means responsive to variations in the pressure posterior to the throttle and supercharger and to variations in the pressure and temperature of the air supplied to the device for actuating said valve to supply supplementary fuel to the engine.

8. In a charge forming device having an induction passage including a throttle, an air supply, a normal fuel supply, a supplementary fuel supply, means for controlling said supplementary fuel supply including a valve, means responsive to the differential between the pressure of the air supplied to the device and the pressure in the induction passage posterior to the throttle connected to said controlling means, and means responsive to the pressure of the air supplied to the device connected to said con-

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trolling means for at least partially neutralizing the effect thereon of variations in said air pressure.

9. In combination with a supercharged internal combustion engine having a throttle controlled induction passage, a normal fuel supply, means for supplying supplementary fuel to the engine; and a valve controlling said supplying means, a sealed bellows and a second bellows connected to said valve for controlling the same, means for subjecting the outside of the sealed bellows and one side of the second bellows to a source of substantially atmospheric pressure, and means for subjecting the other side of said second bellows to the pressure in the induction passage posterior to the throttle and supercharger.

10. In a charge forming device having an induction passage including a throttle and a supercharger, means for normally supplying fuel to the induction passage, means for supplying supplemental fuel to the induction passage, a valve controlling said last named supplying means, and a control unit for said valve comprising a bellows sealed with a predetermined interior pressure connected to said valve, a second bellows connected to said valve, a diaphragm chamber, means connecting one side of said diaphragm chamber to the interior of said second bellows, said second bellows, said connecting means and said one side of the diaphragm chamber being filled with liquid to damp vibrations of the second bellows, and means connecting the other side of said diaphragm chamber to the induction passage posterior to both the throttle and the supercharger.

11. In a charge forming device for an engine having a normal fuel supply, a supplementary fuel supply, valve means including a stem and a spring loaded valve member thereon for controlling the supplementary fuel supply, a bypass uncovered by movement of the stem relative to the valve member when the valve means is closed with an abnormal force, and means for controlling said valve means comprising a flexible chamber responsive to variations in barometric pressure and a second flexible chamber responsive to pressure changes in the induction passage of the engine.

12. In a charge forming device having means for normally supplying fuel to an engine, a passage for supplementary fuel, a valve in said passage, means including an evacuated member for controlling said valve, and means becoming operative upon failure of said evacuated member to bypass supplementary fuel past said valve.

13. In a charge forming device, a fluid passage, a valve controlling said passage, means including a sealed capsule responsive to changes in pressure controlling said valve, said capsule being at times subjected to an external pressure different than the internal pressure thereof, the capsule and valve being operatively interconnected in a manner such that upon failure of the capsule a closing force is exerted on said valve, and means becoming operative upon failure of the capsule to provide a by-pass for fluid past said valve.

14. In a charge forming device for an engine having an air induction system provided with a supercharger, fuel metering means for maintaining a predetermined normal ratio of fuel to air, means rendered operative by an increase in pressure beyond a predetermined value in the air induction system posterior the supercharger for enriching the charge, and means responsive

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to temperature for modifying the action of said enriching means.

15. In a charge forming device for an engine having an air induction system provided with a supercharger, fuel metering means for maintaining a predetermined normal ratio of fuel to air, valve means adapted to meter supplementary fuel to the normal supply and enrich the fuel-air mixture under abnormal charge pressure and temperature conditions, means responsive to changes in pressure and temperature controlling said valve means, and means for subjecting said pressure and temperature responsive means to a measure of the pressure and temperature of the air comprised in the charge.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,191,905	Cloedy et al.	Feb. 27, 1940

Number
2,129,613
2,084,496
2,184,413
2,217,364
5 897,730
1,289,435
2,232,351
2,227,267
2,020,778
10 2,148,230
1,998,362
2,284,687
2,070,009
2,116,876
15 2,088,954

14

Name	Date
Wunsch et al.	Sept. 6, 1938
Lockwood	June 22, 1937
Della Chiesa et al.	Dec. 26, 1939
Halford et al.	Oct. 8, 1940
Fulton	Sept. 1, 1908
Fulton	Dec. 31, 1918
Udale	Feb. 18, 1941
Lozivit	Dec. 31, 1940
Gregg	Nov. 12, 1935
Berger	Feb. 21, 1939
Dodson	Apr. 16, 1935
Schimanek	June 2, 1942
Goodman	Feb. 9, 1937
Beardsley	May 10, 1938
Gregg	Aug. 3, 1937

FOREIGN PATENTS

Number	Country	Date
834,242	France	1938
458,624	England	1936

Certificate of Correction

Patent No. 2,426,741.

September 2, 1947.

FRANK C. MOCK

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 12, line 6, claim 9, for "a normal fuel supply," read *and a normal fuel supply*; line 8, for "engine; and" read *engine*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 7th day of December, A. D. 1948.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.

13

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