FLOW DIVIDER FOR FUEL SYSTEM

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Fig. 5

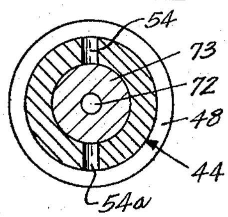
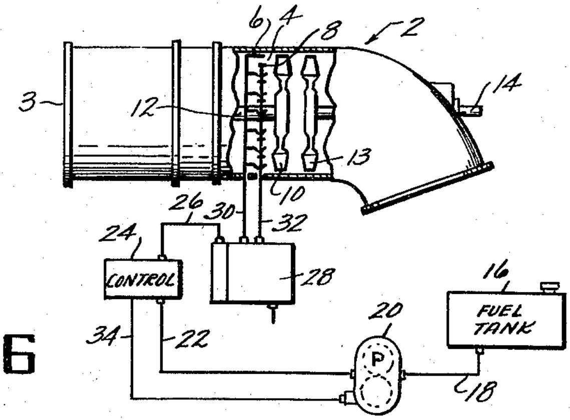


Fig. 1



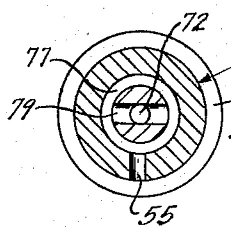


Fig. 6

Fig. 2

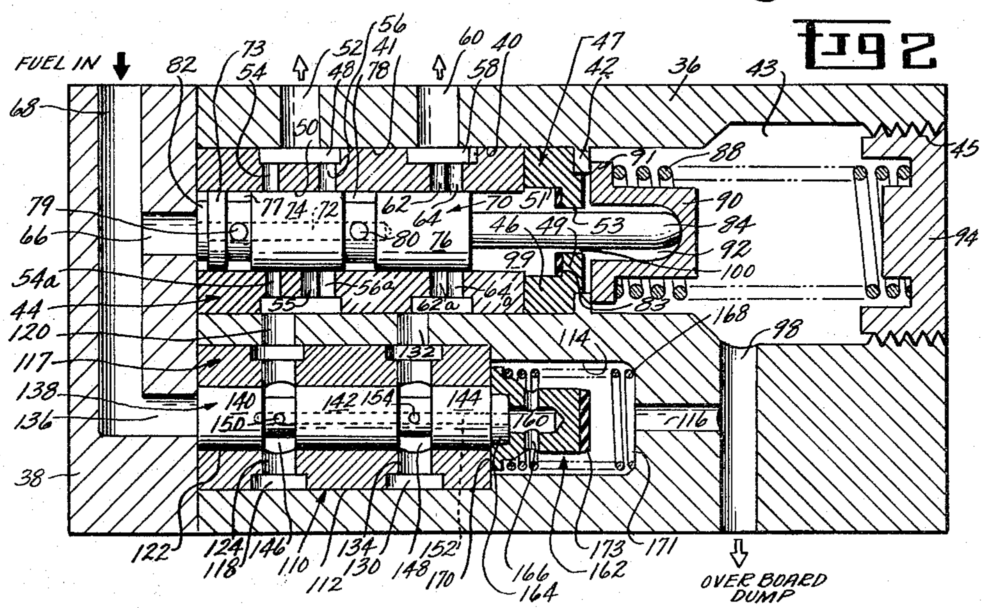
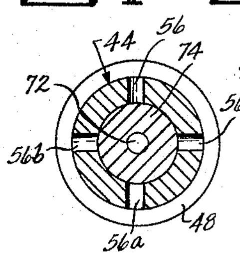
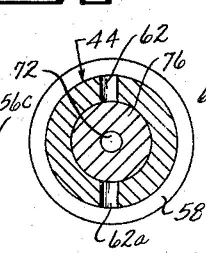
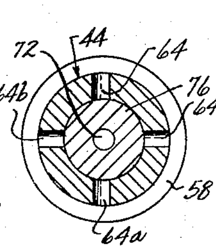


Fig. 7 Fig. 8 Fig. 9







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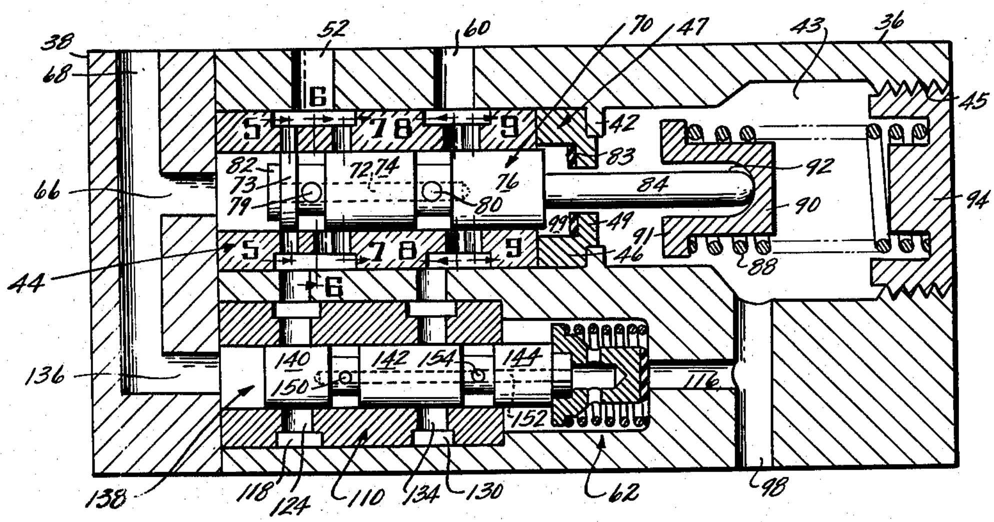
Dec. 6, 1960 R. S. BINFORD ET AL 2,963,082

FLOW DIVIDER FOR FUEL SYSTEM

Filed April 2, 1957 3 Sheets-Sheet 2

Fig 3



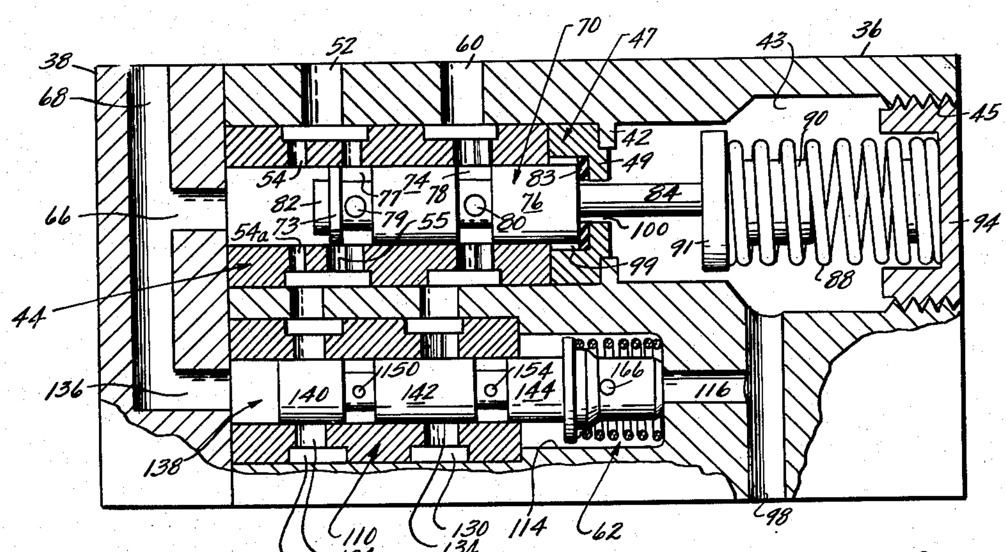


Fig 4

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Fig 10

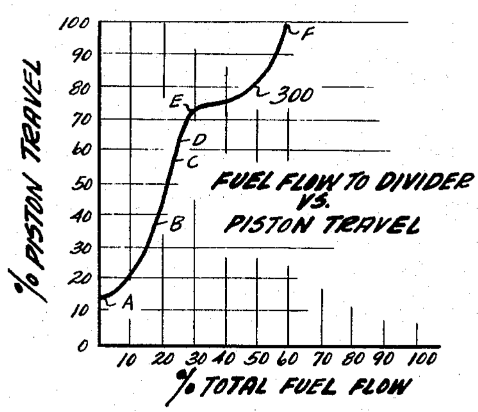


Fig 13

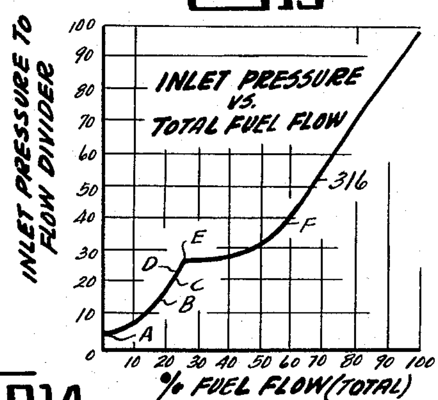


Fig 11

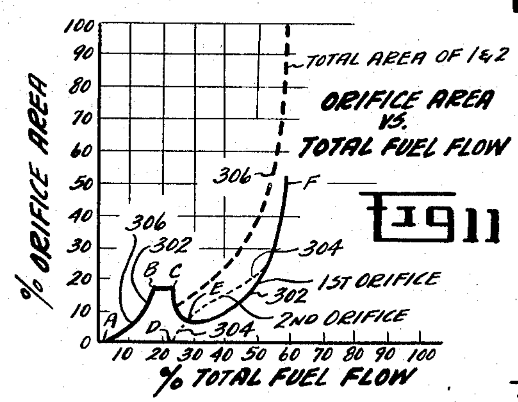
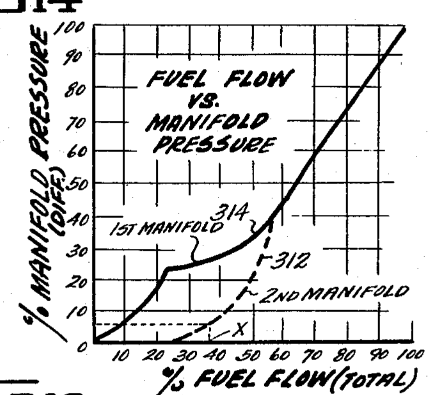


Fig 14



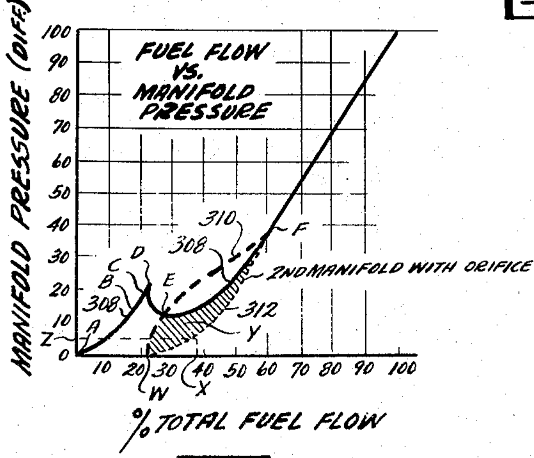
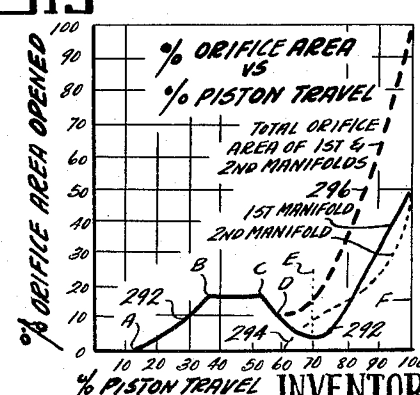


Fig 12

Fig 15



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FLOW DIVIDER FOR FUEL SYSTEM

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Filed Apr. 2, 1957, Ser. No. 650,201

10 Claims. (Cl. 158—36)

The present invention relates to a fuel flow divider or proportioner for use in an engine fuel system for dividing fuel flow between a set of one or more nozzles operating under low flow and low power conditions and a second set of one or more nozzles which is cut in when the power requirement is increased to a certain amount and which supplements the low power nozzles under high flow and high power conditions. More particularly, it relates to such a fuel divider or proportioner for use in a simplex fuel system in turbo engines, particularly turbo engines of the type used in aircraft. The invention also relates to a fuel system containing such a divider or proportioner.

In order to satisfy the large range of power requirements necessary for satisfactory engine operation, the rate of fuel flow from each nozzle, when the same number of nozzles are operating at all times, must vary over a range which exceeds the range of fuel flow over which conventional nozzles, especially simplex nozzles, can operate efficiently. A simplex nozzle is one which has a single, fixed nozzle area such that the pressure drop across the nozzle, and hence the spray pattern issuing from it, is primarily a function of the flow rate of the fluid passing through the nozzle. The most trouble occurs during low power requirements because with the number of nozzles required for proper flow conditions at maximum power, the fuel rate and hence fuel pressure at each nozzle must be cut down to rates at which conventional nozzles, especially simplex nozzles, have a poor spray pattern. This problem can be overcome by operating only a portion of the nozzles under low power and flow conditions and operating the others only during high flow or high power conditions. Thus, only a limited number of the total number of nozzles are operated in the low power range whereas all of the nozzles are operated in the high power range. Since the number of nozzles operating in the low power range is decreased and the total flow remains the same, the rates of flow from each nozzle are increased to rates at which a proper spray pattern is obtained. Separate manifolds are required for the nozzles operating only in the low power range and for the nozzles operating only in the high power range. With such an arrangement, if the valve cutting-in the second set of nozzles is suddenly opened wide when the cut-in power requirement is reached, the pressure in the fuel system suddenly drops to a pressure at which a proper spray pattern cannot be properly maintained. On the other hand, if the valve is initially opened by only a small amount to cut-in the second set and is thereafter gradually opened wider as power is increased, fuel flow into the second manifold past the restricted valve opening at cut-in power and over a relatively wide power range immediately above cut-in power is too small to build up sufficient pressure for a satisfactory spray pattern from the second set of nozzles. This relatively wide power range over which the spray from the second set is unsatisfactory

may be called the transition range and it constitutes a relatively large percentage of the total power range of the engine. Since unsatisfactory spray pattern causes dribbling and flame out, it is undesirable to operate the engine in the transition range except transitionally in going from a power requirement below the transition range to a power requirement above it. Consequently, a relatively large percentage of the total power range of the engine is unavailable for efficient steady state of operation of the engine, and the efficient steady state operating range is reduced below the minimum range normally required for satisfactory engine performance. Furthermore, over a substantial power range above the transition range, although the flow pattern from the second set is satisfactory, the pressure in the second manifold is below that at which optimum spray pattern is obtained.

For this discussion, cutting-in power may be defined as that pressure increase of the fuel required to cut-in the second manifold into the system between the steady state operating conditions at a percentage of the operating speed.

An object of the present invention is to provide a flow divider which automatically cuts-in the second set of nozzles without any substantial pressure drop in the fuel system and in which the power range over which the spray pattern from the second set is unsatisfactory (transition range) is reduced to a minimum, thereby increasing the power range over which the spray pattern of the second set of nozzles is satisfactory and consequently the steady state operating range of the engine. It is another object of this invention to reduce the transition range to a substantially negligible amount and therefore to increase the efficient steady state operating range to cover substantially the entire range of engine operation. Another object is to narrow the transition range to such an extent that it is located outside of the steady state operating range normally required for satisfactory engine operation so that there is no need to operate the engine in the transition range except when changing from one steady state power requirement to another. It is another object of the present invention to provide such a flow divider having a minimum transition range and a maximum steady state operating range and in which the total fuel flow to the nozzles increases in accordance with a relatively smoothly graduated schedule and as a function of increases in power requirements throughout the entire range of engine operation including the transition range and in which after power has been increased by a predetermined amount above cut-in power, flow to the first set of nozzles increases together with flow to the second set, as a function of increase in power requirements. It is yet another object of this invention to improve the spray pattern from the second set of nozzles over a substantial power range above cut-in power, including power settings within and above the transition range. These objects are accomplished by providing a mechanism which is responsive to increases in power requirements through and above cut-in power to accelerate the rate at which fuel pressure and fuel flow increase in the second manifold in response to such increases in power requirements. This is done by providing a pressure variable orifice through which fuel must flow to the first manifold and the size of which varies automatically in response to and as a function of variations in power requirements to automatically commence to reduce the rate of flow to the first manifold at about the same time that the second manifold is cut-in and flow is initiated to the second set. The rate of flow to the first manifold continues to be automatically reduced by the variable orifice in response to and as a function of power increases within a predetermined power range immediately above cut-in power. Since the valve opening to the second manifold is opening in response to and as a function of these same power increases, the rate of flow to the second manifold increases faster than the rate of flow to the first manifold is decreasing so that the total flow to both manifolds continues to increase. Since both manifolds have the same fuel supply, reducing the flow to the first manifold serves to increase the pressure and flow available for the second manifold which results in accelerating the rate at which the pressure and fuel flow increase in the second manifold in response to power increases within a power range defined by cut-in power and a power substantially above cut-in power. This reduction in flow to the first manifold is accomplished by decreasing the size of the orifice at about the same time that the second manifold is cut-in, and continuing to decrease the size thereof in response to and as a function of power increases within the above mentioned predetermined power range immediately above cut-in power. Since the valved opening to the second manifold also comprises a pressure responsive variable orifice which opens in response to cut-in power and continues to increase in size in response to and as a function of further power increases, the effect is to balance the available fuel flow between both manifolds by means of a pair of variable orifices. During low power requirements the orifice to the first manifold is open and the orifice to the second manifold is closed. The size of the first orifice automatically begins to decrease in size in response to and as a function of power increases within a predetermined power range immediately below cut-in power and continues to decrease in size when the orifice to the second manifold begins to open. Thereafter in response to and as a function of further power increases within a predetermined power range immediately above cut-in power it continues to decrease in size as the second orifice increases in size also as a function of the power increases. By commencing to reduce the size of the first manifold orifice prior to cutting-in the second manifold, fuel pressure is built up in the divider so that when the second manifold is cut-in, the acceleration of pressure build up and fuel flow in the second manifold is more rapid. Also if reduction in size of the first orifice is not commenced prior to cutting-in the second set but is commenced simultaneously therewith, the orifice size would have to be reduced by a relatively large amount so suddenly that excessive fluctuations in total fuel flow and flow to the first manifold will occur. However, so long as the size of the first orifice is reduced when the second manifold is cut-in and in response to power increases immediately above cut-in power the transition range is substantially narrowed even if the size of the orifice is not reduced in response to power increases below cut-in power. After the orifice to the second manifold has been opened by a predetermined amount, the size of the first orifice automatically begins to increase with further increases in power requirements. During power increase in this range the orifice to the second manifold is also increasing in size so that the rate of flow to both manifolds increases together until both orifices are in their wide open position. Thus, to review the activity of the first orifice, when flow is initiated into the flow divider the size of the orifice to the first manifold at first increases in response to and as a function of power increases until a predetermined power below cut-in power is reached, whereafter it decreases in response to and as a function of further power increases until a second predetermined power is reached above cut-in power whereafter it is increased in response to and as a function of further power increases together with the size of the second manifold orifice. The maximum size of the first orifice should not be substantially smaller than the sum of the orifice areas of the first set of nozzles.

Another object of the present invention is to provide a flow divider of the type referred to above in which flow to the first manifold is automatically initiated only after fuel pressure delivered by the fuel control unit to the divider has reached a predetermined minimum amount, whereby the build up of pressure in, and fuel flow to, the first manifold is accelerated after flow thereto is initiated.

Another object of the present invention is to provide a flow divider downstream of the fuel control unit and in which substantially all of the metered fuel flowing from the fuel control unit is delivered to the nozzles during the entire range of engine operation with the exception of an inconsequential amount which is lost due to slight, unavoidable leakage during power requirements below those at which fuel flow through the flow divider is substantially unrestricted. This is an important advantage in small engines such as that described in U.S. application Serial No. 548,987 filed by G. W. Lawson on November 25, 1955, now Patent No. 2,912,823, and assigned to the assignee of the present application in which the flow divider of the present invention is particularly suited to be used and in which, because of the relatively small quantities of fuel involved, any substantial diversion of the metered fuel flowing from the fuel control unit has a detrimental effect on engine operation. This is accomplished by providing a pressure responsive element for controlling flow through the divider to the two manifolds, one end of which is exposed to fuel pressure delivered from the fuel control unit and the other end of which is exposed to a space communicating with overboard drainage, such space being substantially sealed off from communication with fuel flowing into and through the divider except for inconsequential leakage. The space is completely sealed off from overboard drainage when the flow of fuel through the flow divider is substantially unrestricted at high power requirements so that under such conditions there is substantially no leakage of fuel from the divider. Preferably the pressure responsive element is a piston. One end of the piston is exposed to fuel pressure and the other end is exposed to the space. The tight fit between the portion of the piston adjacent the space and the hollow member in which it moves, seals the fuel from the space except for inconsequential leakage. One end of the piston is supplied with a valve which shuts the space off from communication with the overboard drainage when the piston has reached the limit of its movement.

A further object is to provide a flow divider having a drainage valve responsive to changes in fuel pressure delivered to the fuel divider for automatically providing communication between the nozzles and overboard drainage when both sets of nozzles are shut off from communication with fuel supply to the divider and for automatically shutting off communication between the nozzles and overboard drainage whenever either one or both of the sets of nozzles are in communication with the fuel supply to the divider. When fuel flow to the first manifold is initiated only after the fuel pressure delivered to the divider reaches the predetermined minimum amount as set forth above, the drainage valve is responsive to fuel pressure higher than a value substantially less than this minimum pressure to shut off the nozzles from communication with overboard drainage. Preferably the drainage valve and flow divider form a single light weight unit of simple and inexpensive construction thereby making it particularly suitable for use with the small engines referred to above.

Briefly stated, and in accordance with one aspect of this invention, a flow divider for a fuel system in a turbo engine is provided for supplying fuel to a plurality of burner nozzles in which only a portion of the total number of nozzles are operated over a low power range and other nozzles are cut-in and operated by the flow divider over a high power range to supplement said portion of nozzles, and in which flow to the other nozzles is restricted by a decreasing amount in response to power increases immediately above cut-in power, and in which the flow divider is responsive to the power increases for accelerating the rate at which the pressure in, and fuel flow to, the other nozzle increases.

The construction of the present invention is especially suitable for use with small turbo engines of the type referred to above because in such engines the range of fuel flow and fuel pressures over the entire range of engine operation is smaller than in conventional engines so that relatively small deviations in flow and pressure are harmful and because, it is relatively small in size, simple in construction and is embodied in a single, compact, light weight unit. Simplicity and lightness in weight are essential in such engines. Although the construction of the present invention is suitable for use in duplex systems, it is especially adapted for use in simplex fuel systems employing simplex nozzles, which have a constant fixed orifice area. The range of pressure and flow over which a proper spray pattern is obtained in simplex nozzles is less than that for duplex nozzles. However, simplex systems and nozzles are less expensive and are more simple than duplex systems and nozzles, which require relatively complicated control units. Consequently, a simplex system is more suitable for use with small engines.

The following description and claims and the accompanying drawings describe and show by way of illustration only and without limitation what is now considered to be the preferred embodiment of the invention.

In the drawings:

Fig. 1 is a schematic view of a small turbo engine of the type described in application Serial No. 548,987, now Patent No. 2,912,823, and embodying an embodiment of the flow divider of the present invention.

Fig. 2 is a section in elevation of the flow divider shown in Fig. 1 while the engine is shut off.

Fig. 3 is a view similar to that shown in Fig. 2 soon after the second set of nozzles has been cut in.

Fig. 4 is similar to Fig. 3 with both orifices in wide open position.

Fig. 5 is a sectional view taken along the line 5—5 of Fig. 3 with the flow divider control piston valve removed.

Fig. 6 is a sectional view taken along the line 6—6 of Fig. 3 with the piston valve of the flow divider removed.

Fig. 7 is a sectional view taken along the line 7—7 of Fig. 3 with the piston valve of the flow divider removed.

Fig. 8 is a sectional view taken along the line 8—8 of Fig. 3 with the piston valve of the flow divider removed.

Fig. 9 is a section taken along the line 9—9 of Fig. 3 with the piston valve of the flow divider removed.

Fig. 10 is a graph showing the relationship between piston travel and total fuel flow to the flow divider.

Fig. 11 is a graph showing how the sizes of the first and second orifices and the total orifice area vary in response to variations in total fuel flow to the divider.

Fig. 12 is a graph showing how the pressure in the first and second manifolds of the flow divider of the present invention vary with variations in total flow to the divider as compared to the pressure in the second manifold using a flow divider without an orifice associated with the first manifold.

Fig. 13 is a graph showing how the pressure at the inlet of the flow divider varies with variations in total fuel flow to the divider.

Fig. 14 is a graph showing how the pressure in the first and second manifolds of a divider having a variable orifice associated with the second manifold but with no variable orifice associated with the first manifold, varies with variations in total fuel flow to the divider.

Fig. 15 is a graph showing the relationship between the orifice areas and the travel of the flow divider piston.

The following is a table showing points on the curves of Figures 10–15.

Table I

Station of Piston	Orifice to 1st Manifold	Orifice to 2nd Manifold
A	54 and 54*a* starting to open, 55, 56, 56*a*, 56*b*, and 56*c* closed.	62 and 62*a* and 64, 64*a*, 64*b* and 64*c* closed.
B	54 and 54*a* fully opened, 55, 56, 56*a*, 56*b* and 56*c* closed.	62 and 62*a* and 64, 64*a*, 64*b* and 64*c* closed.
C	54 and 54*a* beginning to close, 55 closed, 56, 56*a*, 56*b* and 56*c* closed.	62 and 62*a* and 64, 64*a*, 64*b*, and 64*c* closed.
D	54 and 54*a* closing, 55 opening, 56, 56*a*, 56*b* and 56*c* closed.	62 and 62*a* starting to open, 64, 64*a*, 64*b*, and 64*c* closed.
E	54 and 54*a* closed but ready to start to open, 55 opening (about ½ open), 56, 56*a*, 56*b*, and 56*c* closed.	62 and 62*a* continuing to open (less than ½ open), 62 and 62*a* closed.
F	54 and 54*a* fully open, 55 closed, 56, 56*a*, 56*b*, and 56*c* fully open.	62 and 62*a* fully open, 64, 64*a*, 64*b*, and 64*c* fully open.

Referring to the figures, 1 is a turbo prop engine (see Fig. 1) in which a compressor (not shown) at the front of the engine compresses air delivered to the engine at air intake 3. The compressed air is directed from the compressor into combustion chamber 4 into which fuel flows from a first set of simplex nozzles 6 and a second set of simplex nozzles 8. The hot exhaust gases drive a gas turbine 10 which drives the compressor through the shaft 12. The spent gases from the turbine 10 drive the power turbine 13 which drives the power shaft 14 which in turn through appropriate gearing (not shown) drives a propeller or helicopter rotor.

Fuel is supplied to nozzles 6 and 8 from fuel tank 16, through line 18, pump 20, line 22, a fuel control unit 24 for controlling the total amount of fuel delivered to the burners, line 26, flow divider 28 and manifold 30 for the first set of nozzles 6 and manifold 32 for the second set of nozzles 8. A return fuel line 34 leads from the control unit 24 back to the low pressure side pump 20.

The power generated by the engine is controlled by the rate of fuel flow from control 24 to flow divider 28 and thence to the nozzles 6 and 8, which is in turn controlled by the position of a metering valve or valves (not shown) in control unit 24, which in turn is controlled by the pilot through a power control lever and by certain other automatic compensating mechanisms used in conventional power control units. One such control unit is described in U.S. patent application Serial No. 634,544 filed January 16, 1957, now abandoned and assigned to the same assignee as this application.

The flow divider 28 (see Figs. 2 to 9) comprises a main casing 36 having attached to one end thereof an end casing 38. Casing 36 has a bore 40 passing from one end thereof to the other and comprising a relatively long front portion 41 of reduced diameter and a shorter rear portion 43 of larger diameter. The end of 43 is threaded at 45. The portion 41 of the bore has an annular ridge 42 intermediate the ends thereof and extending inwardly therefrom.

An annular sleeve generally indicated at 44 and the enlarged portion 46 of a retaining ring generally indicated at 47 are snugly received in the portion of bore 41 to the left of ridge 42 and are retained in position by the abutment of one end of the sleeve against casing 38 and by abutment of the shoulder on ring 47 formed by the juncture of the enlarged portion 46 thereof and a smaller portion 49, against the ridge 42, the portion 49 being snugly received in the left hand portion of the opening formed by the inner surface of ridge 42. The center bore 50 of sleeve 44 is aligned with an enlarged portion 51 and a smaller portion 53 of an aperture passing through retaining ring 47, passage 51 being larger in diameter than the bore 50. The sleeve 44 has an annular groove 48 extending around the outer periphery thereof and communicating with an outlet passage 52 in the casing 36 which in turn communicates with the manifold **30** for the burner nozzles **6**. The annular groove **48** communicates with the bore or space **50** inside of the hollow sleeve **44** through a pair of holes **54** and **54*a*** which extend through opposite sides of sleeve **44** and are in axial alignment with each other (see Fig. 5). The holes are of substantially equal diameter. The annular groove **48** also communicates with space **50** through a single hole **55** spaced to the right of holes **54** and **54*a*** and of the same diameter (see Fig. 6). The annular groove **48** also communicates with space **50** through two pairs of holes **56** and **56*a*** and **56*b*** and **56*c***, the holes of each pair being in opposite sides of the sleeve and all the holes **56**, **56*a***, **56*b***, and **56*c*** being of the same diameter as holes **54**, **54*a***, and **55** and in axial alignment with each other. Holes **56**, **56*a***, **56*b*** and **56*c*** are spaced directly to the right of and closely to hole **55** (see Fig. 7). Only a thin wall separates hole **56*a*** from hole **55**. This thin wall can be dispensed with and the two holes can be merged together in the form of a slot so long as a cross sectional area thereof equal to the cross sectional area of hole **56*a*** is aligned with holes **56**, **56*b*** and **56*c*** and so long as a cross sectional area thereof equal to that of hole **55** lies to the left of holes **56**, **56*b*** and **56*c***. A second annular groove or recess **58** extends around the periphery of sleeve **44** and is spaced to the right of annular groove **48**. Annular groove **58** communicates with outlet passage **60** in casing **36** which in turn communicates with the manifold **32** of the set of burners **8**. Annular groove **58** communicates with bore **50** through a pair of holes **62** and **62*a***, which extend through opposite sides of sleeve **44** (see Fig. 8), are in axial alignment with each other and are of the same diameter as holes **54**, **54*a***, **55**, **56**, **56*a***, **56*b*** and **56*c***. Annular groove **58** also communicates with space **50** through two pairs of holes **64** and **64*a*** and **64*b*** and **64*c***, the holes of each pair being in opposite sides of sleeve **44** (see Fig. 9) and being in axial alignment with each other and of the same diameter as the holes **62** and **62*a***. Holes **64**, **64*a***, **64*b*** and **64*c*** are located directly to the right of holes **62** and **62*a***. Only thin walls separate hole **62** from hole **64** and hole **62*a*** from **64*a***. These thin walls can be eliminated and holes **62** and **64** and holes **62*a*** and **64*a*** can be merged into two slots providing a cross sectional area of each slot equal to the cross sectional area of hole **64** in the case of one slot and hole **64*a*** in the case of the other slot are axially aligned with holes **64*b*** and **64*c*** and so long as a cross sectional area of each slot equal to the cross sectional area of hole **62** in the case of one slot and **62*a*** in the case of the other slot are axially aligned with each other and are located to the left of holes **64*b*** and **64*c***. The individual holes of each set of holes can be arranged around the circumference of the sleeve in any desired manner so long as they are axially aligned with each other. For instance, the axes of the two sets of holes are not required to be displaced by 90° as shown in Fig. 9.

Inlet port **66** in the casing **38** communicates with space **50** of sleeve **44** and also communicates with the main fuel line **26** (Fig. 1) through passage **68**.

Slidably received in the bore or space **50** of sleeve **44** is a piston valve generally indicated at **70** having a passage **72** extending from the left hand end thereof partly through the piston. The piston has three lands **73**, **74** and **76**, the peripheries of which are snugly but slidably received by the wall of bore **50**. Land **73** is thinner than the other two lands **74** and **76** and is separated from land **74** by an annular recess **77** extending around the periphery of the piston. An annular recess **78** separates the land **74** from land **76**. Passages **79** provide communication between the passage **72** and the recess **77** and passages **80** provide communication between the passage **72** and the recess **78**. The left hand land **73** extends to the left into an end portion **82** of reduced diameter, the end of which engages the right hand side of casing **38** as shown in Fig. 2 to limit the left hand movement of the piston valve **70**. The right hand land **76** extends to the right into

a rod **84**, which passes, and is movable, through aperture **51**, **53** in ring **47**. Since aperture **51** in ring **47** is larger in diameter than the land **76** and the bore **50** of the sleeve, the land **76** is free to move into aperture **51** when the piston valve **70** is moved from its leftmost position shown in Fig. 2 to its rightmost position shown in Fig. 4, in which latter position the right hand end of the land sealingly engages the annular sealing ring **83**, which is carried by retaining ring **47** within the aperture **51** and is seated on the shoulder formed by the juncture of apertures **51** and **53**. The wall of aperture **53** is spaced from the periphery of rod **84** to provide an annular passage **100** therebetween.

Piston valve **70** is biased to the left into the position shown in Fig. 2 by means of a spring **88** which engages and is seated on a spring seat **90** having a recess **92** which receives the end of rod **84**. The end wall of recess **92** is urged against the end of the rod by the spring **88**. The other end of spring **88** engages and is seated on a plug **94** which is screwed into internally threaded end portion **45** of bore **43**.

Overboard drainage passage **98** in casing **36** provides communication between bore **43** and the atmosphere (overboard drainage). The aperture **51** in ring **47** and the right hand portion of bore **50** form an overboard drainage space **99** to which the right hand end of the piston **70** is exposed and the space **100** between rod **84** and aperture **53** forms an overboard drainage port which provides communication between drainage space **99** and overboard drainage through **43** and **98** when the piston valve **70** is in all positions except that shown in Fig. 4, in which position the right hand end of land **76** is pressed tightly against sealing ring **83** by the fuel pressure applied to the other end of the piston **70** to seal off space **99** from port **100**. Sealing ring **83** is made of natural or synthetic rubber or any other kind of material ordinarily used for sealing rings in fuel systems.

Casing **36** has a second bore generally indicated at **110** comprising an enlarged portion **112**, a smaller portion **114** and a narrow passage portion **116**, which communicates with passage **98**.

A hollow sleeve generally indicated at **117** is located in the wider portion **112** of the bore **110**. It has an annular groove **118** extending around the periphery thereof. Groove **118** communicates with the groove **48** through the passage **120** and communicates with the inner space or bore **122** of sleeve **117** through passages **124** in the sleeve. Another annular groove **130** extends around the periphery of sleeve **117** and communicates with groove **58** through passage **132** and with space **122** through passages **134** in the sleeve. One end of the inside space **122** of the sleeve **117** communicates with the fuel passages **68** and **26** through inlet port **136**.

A valve piston generally indicated at **138** is slidably received in bore **122** of the sleeve **117** and has three lands, **140**, **142** and **144**, the outer peripheries of which are snugly but slidably received by the wall of bore **122**. An annular recess **146** extending around the periphery of piston **138** separates land **140** from land **142** and an annular recess **148** extending around the periphery of **138** and spaced from recess **146** separates land **142** from land **144**. Passages **150** provide communication between recess **146** and a passage **152** extending from the right hand end of piston **138** partially through the piston. Passages **154** provide communication between recess **148** and passage **152**. Passage **152** communicates with a recess **160** in a hollow seal carrying member generally indicated at **162** mounted on a reduced end portion **164** of the piston valve **138**, the reduced end portion **164** being received in an enlarged end portion of recess **160**. The seal carrying member **162** moves to the right and left with the piston **138**. The recess **160** communicates with the portion **114** of the bore **110** through holes **166** and the space **114** in turn communicates with overboard drainage passage **98** through the passage **116**. The piston valve 138 is urged to the left by a light spring 168 biased between a flange portion 170 of seal carrying member 162 and the shoulder 171 formed by the juncture of the portions 114 and 116 of the bore 110. Member 162 is retained on portion 164 of piston 138 by the force of spring 168. Movement of the valve piston 138 to the left is limited by engagement of the left hand end thereof with the wall of casing 38 and right hand movement of the valve piston is limited by the sealing engagement of the sealing disc 173 attached to the end of member 162 with the shoulder 171 as shown in Figs. 3 and 4. The sealing disc 173 is made of the same material as sealing ring 83.

The sum of the cross sectional areas of holes 54, 54*a*, 55, 56, 56*a*, 56*b*, and 56*c* should not be substantially smaller, and preferably is substantially larger, than the sum of the orifice areas of the first set of nozzles 6 and the sum of the cross sectional areas of holes 62, 62*a*, 64, 64*a*, 64*b* and 64*c* should not be substantially smaller, and preferably is substantially larger, than the sum of the orifice areas of the nozzles 8. In effect, holes 54, 54*a*, 55, 56, 56*a*, 56*b* and 56*c* comprise a first variable orifice through which fuel passes from inlet port 66 to the first manifold 30 and nozzles 6 and the holes 62, 62*a*, 64, 64*a*, 64*b*, and 64*c* comprise a second variable orifice through which fuel passes from inlet port 66 to the second manifold 32 and nozzles 8. The sizes of these orifices are varied between fully open and fully closed and with relation to each other by sliding movement of piston 70 within the sleeve 44 in response to changes in power requirements effected by control unit 24 and which are transmitted to the flow divider as changes in fuel flow and hence fuel pressure delivered to inlet port 66. When the holes of each orifice are fully open, as shown in Fig. 4, they no longer act as orifices but permit the free flow of fuel to their respective sets of burners. The rest of the fuel passages through the divider are large enough to permit the free flow of fuel therethrough.

In operation when the engine is shut off there is no fuel pressure in the fuel line 26 and the springs 88 and 168 force the valve piston 70 and the drainage valve piston 138 respectively to the positions shown in Fig. 2. When the pistons are in this position land 74 seals off the first set of burners 6, first manifold 30, passage 52, groove 48 and holes 54, 54*a*, 55, 56, 56*a*, 56*b* and 56*c* from inlet port 66 and land 76 seals off the second set of burners 8, second manifold 32, passage 60, groove 58 and holes 62, 62*a*, 64, 64*a*, 64*b* and 64*c* from inlet port 66 so that no fuel flows to either set of burners. Burners 6 are drained overboard through manifold 30, passage 52, groove 48, passage 120, annular groove 118, passages 124, recess 146, passages 150, passage 152, recess 160, holes 166, space 114 and passages 116 and 98. Burners 8 are drained overboard through manifold line 32, passage 60, groove 58, passage 132, groove 130, passages 134, recess 148, passages 154, passage 152, recess 160, holes 166 and passages 114, 116, and 98.

On starting up the engine with the pilot's power control lever and consequently the metering valve or valves in control unit 24 in Start position, the pump 20 is rotated by the starter to build up fuel pressure in inlet ports 66 and 136. When the pressure reaches a predetermined amount sufficient to overcome the relatively light spring 168 the drainage piston valve 138 is moved to the right from the position shown in Fig. 2 to the position shown in Figs. 3 and 4 in which sealing disc 173 is pressed tightly against shoulder 171 and the lands 140 and 142 cover the openings of the passages 124 and 134, whereby both sets of nozzles are sealed off from communication with overboard drainage. The pressure continues to rise in inlet port 66, thereby forcing piston 70 to move gradually to the right until the inlet port pressure rises to about 5% (see point A in Fig. 13) and the piston has traveled about 14% of its total range of travel (see point A in Fig. 10), whereupon a further increase in flow to the inlet port and consequently a further increase in pressure causes the left hand portion of land 74 to begin to uncover holes 54 and 54*a* and fuel begins to flow from port 66 through passage 72, passages 79, recess 77, holes 54 and 54*a*, groove 48, passage 52, first manifold 30 and finally through the first set of nozzles 6 to the combustion chamber where it is ignited and burned. The position at which the piston comes to rest and hence the amount by which the holes 54 and 54*a* are uncovered is determined by the maximum pressure built up at inlet port 66 when the pilot's power control lever is set at Start, which in turn is determined by the total amount of fuel permitted to flow through control unit 24 to the inlet port 66 when the pilot's power control lever is at this power setting. As more power is called for by manipulation of the pilot's power control lever the metering valve or valves in unit 24 open further to deliver more fuel to the inlet port 66 with the result that the fuel pressure rises and causes the piston 70 to move further to the right whereupon land 74 uncovers more of holes 54 and 54*a* until they are completely uncovered (see B in Table I and Figs. 10 to 13 and 15). Upon further increase in power, and consequently greater flow to the divider, piston 70 is moved further to the right causing land 73 to begin to cover holes 54 and 54*a* (see C in Table I and Figs. 10 to 13 and 15). More of the holes 54 and 54*a* are covered by land 73 as power is increased until they are about half covered, whereupon further movement of the piston to the right in response to further increases in power by manipulation of the pilot's power control lever, causes land 74 to begin to uncover hole 55 at the same time that land 73 is covering more of holes 54 and 54*a*. When hole 55 is uncovered fuel begins to flow from port 66 through passage 72, passages 79, recess 77, hole 55, groove 48, passage 52 and manifold 30 to nozzles 6 in addition to the fuel flowing to nozzles 6 through holes 54 and 54*a*. Further movement to the right of piston 70 in response to further increases in power and hence further increases in flow to port 66 causes land 73 to cover more of holes 54 and 54*a* and land 74 to uncover more of hole 55 until cut in power and consequently cut in flow (23%) is reached (see D in Table I and Figs. 10 to 13 and 15), whereupon land 76 begins to uncover holes 62 and 62*a* and fuel begins to flow from port 66 through passage 72, passages 80, recess 78, holes 62 and 62*a*, groove 58, passage 60, second manifold 32, nozzles 8 and into combustion chamber 4 where it is ignited and burned. The increase in power requirement and hence the increase in flow to, and pressure in, port 66, which causes land 76 to begin to uncover holes 62 and 62*a* to thereby cut in the second set of nozzles 8, also causes land 73 to continue to cover more of holes 54 and 54*a* and causes land 74 to continue to uncover more of hole 55. Further increases in power and hence in flow to the divider immediately above cut in power D causes the piston to continue to move to the right whereby land 73 further closes holes 54 and 54*a*, land 74 further opens hole 55 and land 76 further opens holes 62 and 62*a* until the piston reaches the position shown in Fig. 3 in which holes 54 and 54*a* are fully closed and fuel flow therethrough ceases, hole 55 is about half open and holes 62 and 62*a* are partly (less than half) open (see E in Table I and Figs. 10 to 13 and 15). Thereafter, as power requirement and hence flow into the divider continues to be increased by further manipulation of the pilot's control lever, holes 54 and 54*a* begin to be uncovered by movement of land 73 to the right, whereupon fuel begins to flow from port 66 through bore 50, holes 54 and 54*a*, groove 48, passage 52, first manifold 30 and nozzles 6 in addition to fuel flowing from port 66 through passages 72 and 79, recess 77, hole 54, groove 48, passage 52 and manifold 30. At the same time more of hole 55 is uncovered by land 74 and more of holes

62 and 62*a* continue to be uncovered by land **76**. Further movement of the piston to the right in response to further increases in power and hence further increases in flow into the flow divider causes land **73** to open holes **54** and **54*a*** wider, land **74** to open hole **55** wider and land **76** to open holes **62** and **62*a*** wider until hole **55** is fully open, whereafter holes **56**, **56*a***, **56*b*** and **56*c*** begin to be uncovered by land **74** at the same time that holes **54**, **54*a***, **62** and **62*a*** continue to open wider. Opening of holes **56**, **56*a***, **56*b***, and **56*c*** causes fuel to begin to flow from port **66** through passages **72** and **79**, recess **77**, holes **56**, **56*a***, **56*b*** and **56*c***, groove **48**, passage **52** and manifold **30** to nozzles **6** in addition to the fuel flowing from port **66** through holes **54**, **54*a*** and **55**. Further movement of piston **70** to the right in response to further power increases causes land **76** to open holes **62** and **62*a*** wider, land **73** to open holes **54** and **54*a*** wider and land **74** to open holes **56**, **56*a***, **56*b*** and **56*c*** wider until holes **62** and **62*a*** are completely uncovered. Continued power increases cause land **76** to begin to uncover holes **64**, **64*a***, **64*b*** and **64*c***, land **73** to continue to uncover holes **54** and **54*a***, and land **74** to continue to uncover holes **56**, **56*a***, **56*b*** and **56*c***. The uncovering of holes **64**, **64*a***, **64*b*** and **64*c*** causes fuel to begin to flow from port **66** through passages **72** and **80**, recess **78**, holes **64**, **64*a***, **64*b***, and **64*c***, groove **58**, passage **60** and manifold **32** to nozzles **8** in addition to the fuel flowing through holes **62** and **62*a*** to nozzles **8**. Thereafter, further movement of piston **70** to the right in response to further power increases causes land **73** to continue to uncover more of holes **54** and **54*a***, land **74** to continue to uncover more of holes **56**, **56*a***, **56*b*** and **56*c*** and land **76** to continue to uncover more of holes **64**, **64*a***, **64*b*** and **64*c*** until holes **54** and **54*a*** are completely uncovered. Thereafter more of holes **56**, **56*a***, **56*b***, and **56*c*** continue to be uncovered by land **74**, the hole **55** begins to be covered by land **73** and more of holes **64**, **64*a***, **64*b***, and **64*c*** continue to be uncovered by land **76** until holes **56**, **56*a***, **56*b***, and **56*c*** are completely uncovered whereafter hole **55** continues to be covered by land **73** and holes **64**, **64*a***, **64*b*** and **64*c*** continue to be uncovered by land **76** until holes **64**, **64*a***, **64*b*** and **64*c*** become completely uncovered by land **76** and hole **55** becomes completely covered by land **73** when the piston **70** reaches the position shown in Fig. 4 (see F in Figs. 10 to 13 and 15) in which all holes except **55** are completely uncovered, and space **99** is sealed off from port **100**. Hole **55** is covered in order that the sum of the cross sectional areas leading to nozzle **6** when the piston is in its furthermost position to the right (Fig. 4) is substantially equal to the sum of the cross sectional areas leading to nozzle **8** so that the rate of flow through both sets of nozzles and both orifices is the same.

The holes are closed and opened in a reverse manner when the piston is moved to the left from the position shown in Fig. 4 to the position shown in Fig. 2 by the force of spring **88** in response to decreases in power setting or requirement and hence decreases in flow to, and pressure in, port **66**. When the engine is shut off the decrease in pressure in inlet port **66** first causes the piston **70** to move to the position shown in Fig. 2 whereafter as the pressure continues to decrease at ports **66** and **136**, piston **138** is moved from the position shown in Figs. 3 and 4 to the position shown in Fig. 2 by spring **168**, whereupon fuel is free to drain out of the nozzles and the fuel lines leading thereto beyond the piston **70**.

Thus, for every power requirement as determined, for example, by the setting of the pilot's power control lever and hence for every rate of fuel flow to the flow divider the piston **70** occupies a particular position, which determines the orifice area of each of the orifices at that particular power requirement and rate of flow, which in turn determines the manner in which the fuel available at that power requirement is distributed between the first and second manifolds.

The close fit between the periphery of the land **76** and the inner surface of bore **50** of the sleeve **44** seals off space **99** from fuel passing through the divider except for inconsequential leakage of not substantially more than 120 cc. per hour and preferably not more than 60 cc. per hour. This inconsequential flow of fuel drains overboard from space **99** through port **100**, bore **43** and passage **98**. The right end of the piston **70** is vented overboard or to some other low pressure drainage source in order to permit the piston to move to the right in response to increases in fuel pressure in inlet port **66**. Consequently, space **99** needs to be open to overboard drainage only when piston **70** is spaced to the left of its furthermost right hand position, as shown in Fig. 4. When the piston is in the latter position (during relatively high power requirements) the end of land **76** is pressed tightly against sealing ring **83** by the pressure at inlet port **66** to seal off space **99** from overboard drainage and consequently there is no fuel leakage at all. Thus, with the flow divider of the present invention, substantially all of the metered fuel flowing from the control or metering unit is delivered to the nozzles with the exception of an inconsequential amount at lower power requirements, and total fuel flow to and through the nozzles is at all times substantially equal to total fuel flow to port **66**. Since only an inconsequential amount of fuel escapes between the outer periphery of land **76** and the inner surface of bore **50**, solid residues of material present in the fuel do not collect therebetween in any substantial amount.

The line **300** in Fig. 10 shows how the position of the piston **70** varies in response to variations in total fuel flow to the manifold and hence in response to variations in power requirements. The stations A to F referred to above are marked thereon.

The line **302** in Fig. 11 shows how the orifice area of the first variable orifice (**54**, **54*a***, **55**, **56**, **56*a***, **56*b*** and **56*c***) to the first manifold **30** varies in response to variations in total fuel flow to inlet port **66** and hence in response to variations in power requirements. Line **304** in Fig. 11 shows how the orifice area of the second variable orifice (**62**, **62*a***, **64**, **64*a***, **64*b*** and **64*c***) to the second manifold **32** varies in response to variations in total fuel flow to the divider and hence in response to variations in power requirements. Line **306** shows how the total orifice area of both the first and second orifices to both manifolds **30** and **32** varies in response to variations in total fuel flow to the divider. The stations A to F are marked on each of these lines. It is noted that the orifice area of the first orifice to the first manifold and nozzle **6** increases in size (holes **54** and **54*a*** are opening) in response to increases in power requirements and total flow into the divider between A and B, but at C, which is substantially below cut in power D, it begins to decrease in size in response to further increases in power requirements (**54** and **54*a*** are closing). It continues to decrease in size in response to further power increases within the power range immediately below cut in power (from C to D), at the same time that the second manifold and nozzles **8** are cut in at D and in response to further power increases within a power range immediately above cut-in power (D to E). It stops decreasing in size at E (holes **54** and **54*a*** become fully closed) and increases in size in response to power increases above E. Although hole **55** is opening in response to power increases just below, through and above cut in power at D, e.g., a power range defined by a power setting somewhere between C and D and the power setting at E, the two holes **54** and **54*a*** are closing so that the net result is that the size of the first orifice continues to decrease at a lesser rate than when the holes **54** and **54*a*** were closing and **55** was closed. However, as soon as holes **54** and **54*a*** start to open in response to power increases above E the first orifice begins to increase in size in response to increases in power. Although the size of the first orifice decreases in response to power increases above D the size of the second orifice is opening at a faster rate than the first orifice is closing so that the net result is that the total orifice and of both orifices increases to accommodate the increased flow to the divider. The rate of increase in size of the first orifice in response to power increases is increased after holes **56**, **56a**, **56b** and **56c** are opened and the rate of increase in size of the second orifice in response to power increases is increased, after holes **64**, **64a**, **64b** and **64c** are opened. It is noted that the piston **70** reaches the end of its right hand travel at 59% total flow and the sizes of the orifices remain the same during further power and flow increases.

In Fig. 12, line **308** shows the manner in which the pressure in the first manifold **30** varies in response to variations in total fuel flow to the flow divider and hence in response to variations in power requirements. Line **310** shows how the pressure of the second manifold **32** varies in response to variations in total fuel flow to the flow divider and hence in response to variations in power requirements. Line **312** shows how the pressure varies in the second manifold when the orifice (**54**, **54a**, **55**, **56**, **56a**, **56b**, and **56c**) to the first manifold is maintained constant.

With reference to line **308**, the flow to, and pressure in, the first manifold increases in response to increases in power requirements in the power range A to D. Although increase in power in the range C to D causes the total first orifice area to the first manifold **30** to decrease, the flow to, and pressure in, manifold **30** continues to increase because of the increase in pressure at inlet port **66**. However, simultaneously with the cutting in of the second orifice to the second manifold **32** at D, the rate of flow to, and pressure in the first manifold begins to decrease along with the decrease in orifice area to the first manifold and continues to do so in response to power increases above cut in power until E is reached. However, the flow to the second manifold is increasing in response to these same power increases above cut in power D at a greater rate than the flow to the first manifold is decreasing so that the total flow to both manifolds continues to increase (see line **316** in Fig. 13). The flow to, and pressure in, both the first and second manifolds increases in response to increases in power requirements and hence total flow above E and over the power range EF.

A comparison of lines **310** and **312** in Fig. 12 will show that the manipulation of the first orifice to the first manifold as set forth above causes the increase in pressure in the second manifold to be greatly accelerated in response to power increases within the range of power requirements D to F above cut in power D. The great advantage of this acceleration is apparent when it is remembered that the spray pattern of nozzles **8** is unsatisfactory at pressures below a minimum pressure and therefore during power requirements at which the pressure in the second manifold is below this minimum pressure the nozzles **8** do not operate satisfactorily. Consequently, these power requirements are not available for efficient steady state operation of the engine. Assuming that the minimum pressure at which nozzles **8** will operate satisfactorily is 25 p.s.i. which is 5% manifold pressure and marked Z in Fig. 12, with a flow divider not having the variable orifice of the present invention between the divider inlet and the first manifold (line **312**) this pressure of 25 p.s.i. (5%) will not be built up in the second manifold after it is cut in at D (total flow and power requirement of 23%) until the total flow or power requirement has reached 37%, marked X in Fig. 13. Consequently, the nozzles **8** will not operate satisfactorily in the range of power requirements DX (transition range) from 23% to 37%, which is 14% of the total power range. Since it is not desirable to operate the engine under steady state conditions in this transition range, the available steady state operating range of the engine is reduced by 14%. Thus, 14% of the total range of power is not available for efficient steady

state operation. This is a serious disadvantage in that many power settings are included in this transition range which should be available for steady state operation in order to obtain proper engine performance.

With the use of applicant's flow divider, after the second manifold is cut in at 23% power (D) pressure is built up to 25 p.s.i. (5%) in the second manifold at 24% power (see line **310** in Fig. 12) marked W in Fig. 12 so that the transition rangs is reduced from 14% to 1%, thereby making available for efficient steady state operation 13% more of the total power range. A 1% transition range is so small that from a practical standpoint it may be considered to be negligible and to be located outside of the normal steady state operating range of power requirements. Consequently, for practical purposes, substantially the entire power range of the engine is available for steady state operation. A transition range which is for example less than 3% may be considered to be located outside of the normal steady state operating range of power requirements.

Furthermore, although the spray pattern of the nozzles is not satisfactory when the pressure is below a certain minimum amount (5% in the case of the nozzles referred to above) the higher the pressure is below this amount the more improved is the spray pattern. On the other hand, although the spray pattern is satisfactory above this minimum amount, the higher the pressure above this minimum amount the better it is. Consequently, in accordance with the present invention, improved burner performance is obtained in the area Y between the power range D and F due to the increased pressure in the manifold **32** in this range.

Line **312** is also shown in Fig. 14 together with line **314**, which indicates pressure in the first manifold without the first orifice.

In Fig. 15, line **292** shows how the size of the first manifold orifice (**54**, **54a**, **55**, **56**, **56a**, **56b** and **56c**) varies with piston travel, line **294** shows how the size of the second manifold orifice (**62**, **62a**, **64**, **64a**, **64b**, and **64c**) varies with piston travel and line **296** shows how the total orifice area varies with piston travel. The points A to F are marked on each of these lines.

At point A in Figs. 11 to 16, the first orifice area is zero. At point D when the second set of nozzles is cut in, the size of the first manifold orifice is about 16.5% larger than the sum of the nozzle orifice areas of the first set of nozzles **6**. At point E, the size of the first manifold orifice is smaller than the size of the second manifold orifice but is still about 2% larger than the sum of the nozzle orifice areas of the first set of nozzles **6**. At this point E, the size of the second manifold orifice is about 16.5% larger than the sum of the nozzle orifice areas of the first set of nozzles **6**. At this point E, the size of the second manifold orifice is about 16.5% larger than the sum of the nozzle orifice areas of the second set of nozzles **8**. From this, the relationship of the first orifice area with respect to the sum of the nozzle orifice areas of the first set of nozzles **6** and the relationship of the second orifice area with respect to the sum of the nozzle orifice areas of the second set of nozzles **8** can be easily computed over the entire range of piston travel since the size of the simplex nozzle orifices is fixed. For example, when the piston is in the position shown in Fig. 4 with the first orifice substantially 100% open, the size of the first orifice area is about 11.5 times the sum of the nozzle orifice areas of the first set of nozzles.

While a particular embodiment of the invention has been illustrated and described, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from the invention and it is intended to cover in the appended claims all such changes and modifications that come within the true spirit and scope of the invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. In a fuel burner and supply system, first burner nozzle means adapted to be operated over substantially the entire range of total fuel flow to said burner system, second burner nozzle means adapted to be cut-in and operated to supplement said first nozzle means during high total fuel flow range only, a flow divider for dividing fuel flow between said first and second nozzle means and including fuel flow passages for connection thereto, first valve means interposed in said fuel flow passage to said first nozzle means, second valve means interposed in said fuel flow passage to said second nozzle means, means for actuating said second valve means in valve opening direction to cut-in said second nozzle means during high fuel flow range, and means operative substantially concurrently with cut-in of said second nozzle means for actuating said first valve means to partially closed position.

2. In a fuel burner and supply system, a plurality of burner nozzles of which only a portion of the total number are operated over a low flow range and other nozzles are cut-in and operated to supplement said portion of said nozzles over a high flow range, a flow divider for dividing fuel between said portion of nozzles and said other nozzles including fuel flow passages for connection to the nozzles, first variable orifice means interposed in said fuel flow passage to said portion of nozzles, second variable orifice means interposed in said fuel flow passage to said other nozzles adapted to be opened to cut-in fuel flow to said other nozzles, and means responsive to a fuel pressure condition indicative of a predetermined total flow to said divider operative to increase the size of said second variable to cut-in said other nozzles and further operative substantially concurrently to reduce the size of said first variable orifice.

3. A fuel system according to claim 2 wherein said pressure responsive means and said first variable orifice include means for reducling the size of said first variable orifice as a function of increases in total flow to said divider within a predetermined total flow range extending from immediately below to immediately above the total flow at which said other nozzles are cut-in.

4. A fuel system according to claim 3 wherein said pressure responsive means and said first variable orifice include means for increasing the size of said first variable orifice to increase the fuel flow to said portion of nozzles as a function of increases in total flow to said divider above said predetermined total flow range above cut-in flow.

5. A fuel system according to claim 4 wherein the lower limit of said pretermined flow range below cut-in flow is defined by a predetermined total flow and the upper limit of said predetermined flow range above cut-in flow is defined by another higher predetermined total flow, said pressure responsive means and said first variable orifice including means for increasing the size of said first variable orifice as a function of increases in total flow below said first predetermined total flow.

6. A fuel system according to claim 5 wherein the opening of said first variable orifice is initiated and hence said portion of said nozzles are cut-in in response to a minimum fuel pressure delivered to the divider, said minimum pressure being substantially smaller than the pressure at which said other nozzles are cut-in, the size of said first variable orifice being increased as a function of increases in total flow above that at which said minimum pressure exists and below said first predetermined total flow.

7. A fuel system according to claim 5 wherein the maximum size of said second orifice is not substantially less than the total nozzle orifice area of said other nozzles and the maximum size of said first orifice is not substantially less than the total nozzle orifice area of said portion of nozzles.

8. A flow divider according to claim 7 wherein said nozzles are simplex nozzles and said system is a simplex system.

9. A flow divider comprising an inlet port, a first outlet port, means for providing communication between said inlet port and said first outlet port, a second outlet port, means for providing communication between said inlet port and said second outlet port, said means for providing communication between said inlet port and said first outlet port comprising a first orifice, said means for providing communication between said inlet port and said second outlet port comprising a second orifice, valve means responsive to changes in pressure delivered to the inlet port for varying the size of said orifices, said second orifice being closed by said valve means when the pressure at the inlet port is below a predetermined amount, said valve means being responsive to said predetermined inlet pressure to initiate the opening of said second orifice and being responsive to increases in inlet pressure above said predetermined pressure to increase the size of second orifice as a function of said pressure increases, said valve means being responsive to pressure increases above a pressure substantially smaller than said predetermined pressure and below a pressure substantially higher than said predetermined pressure, for decreasing the size of said first orifice as a function of said last mentioned pressure increases, said valve means being responsive to pressure increases above said substantially higher pressure for increasing the size of said first orifice as a function of the last mentioned pressure increases.

10. A flow divider according to claim 9 including a hollow member in which said orifices are located and wherein said valve means comprises a valve piston movable in said hollow member, one end of said piston being exposed to fuel pressure at the inlet port.

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