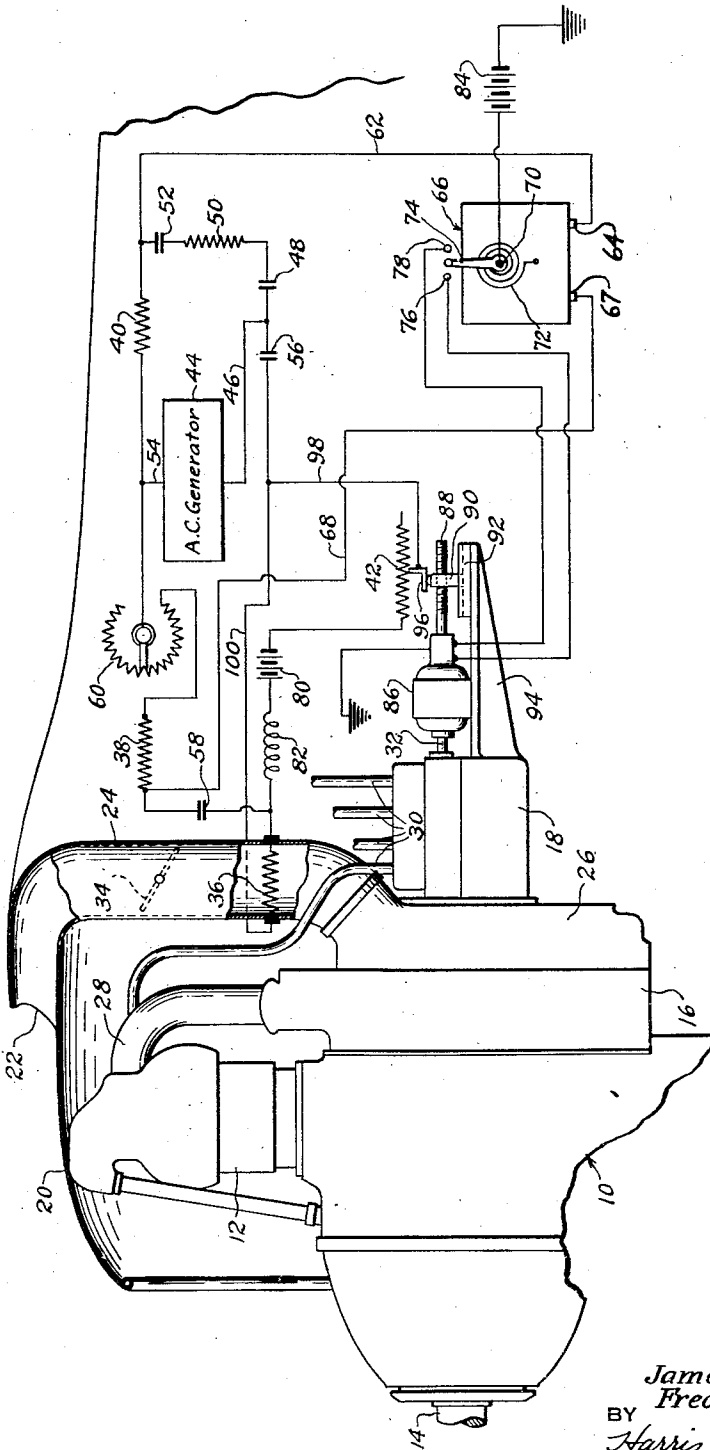


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J. W. COLVIN ET AL
FUEL PROPORTIONING DEVICE

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INVENTOR
James W. Colvin and
Frederick V.H. Judd
BY
Harris C. Luther
ATTORNEY.

UNITED STATES PATENT OFFICE

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FUEL PROPORTIONING DEVICE

James W. Colvin and Frederick V. H. Judd, West
Hartford, Conn., assignors to United Aircraft
Corporation, East Hartford, Conn., a corpora-
tion of Delaware

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This invention relates to improvements in charge forming apparatus and has particular reference to an improved charge forming apparatus for an internal-combustion engine.

An object of the invention resides in the provision of improved charge forming apparatus of the character indicated which will accurately measure the quantity of intake air flowing to the engine and will control the quantity of fuel supplied to the engine in accurate proportion to the quantity of intake air.

A further object resides in a charge forming apparatus of the character indicated which is automatically compensated for variations in air density and will accurately measure the flow of intake air in terms of weight or mass of intake air flowing per unit of time.

A still further object resides in the provision of an improved charge forming apparatus of the character indicated which does not require any venturi or other restriction in the air intake system of the engine in order to measure the quantity of intake air flowing to the engine and, by thus facilitating the flow of intake air, increases the efficiency of the engine supercharger and also increases the efficiency of the engine, particularly at high altitudes.

A still further object of the invention is to automatically compensate for variations in the temperature of the air forming part of the charge.

An additional object resides in the provision of an improved charge forming device of the character indicated which is electrically actuated and is light in weight and simple in construction and operation.

Other objects and advantages will be pointed out hereinafter or will become apparent as the description proceeds.

In the accompanying drawing, in which like reference numerals are used to designate similar parts throughout, there is illustrated a suitable mechanical embodiment for the purpose of disclosing the invention. The drawing, however, is for the purpose of illustration only and is not to be taken as limiting or restricting the invention as it will be apparent to those skilled in the art that various changes in the illustrated embodiment may be resorted to without in any way exceeding the scope of the invention.

In the drawing, the single figure is a diagrammatic illustration of a fragmentary portion of an internal-combustion engine, such as is conventionally employed for the propulsion of aircraft, showing the application thereto of a charge form-

ing apparatus constructed according to the invention.

Referring to the drawing in detail, the engine, generally indicated at 10, may have a plurality of cylinders, one of which is indicated at 12, a power shaft 14 for driving a propulsive device such as an aeronautical propeller, a blower section or supercharger 16 and a fuel pump 18. The engine may be enclosed in a conventional streamlined cowl 20 provided with an opening or air scoop 22 from which an intake air duct 24 leads to the inlet 26 of the supercharger 16. From the supercharger, intake pipes, one of which is indicated at 28, lead to the intake ports of the various engine cylinders and fuel lines 30 lead from the pump 18 to the various cylinders to inject metered quantities of fuel into the cylinders at properly timed intervals. The fuel pump 18 illustrated is of a type well known to the art and frequently referred to as "Bosch" type fuel-injection pump and is driven from the engine by a suitable drive mechanism not illustrated. The quantity of fuel injected by the pump is controlled by rotation of a regulating shaft 32 which varies the stroke or displacement of the pump plungers in a manner well known to the art.

While a particular type of fuel injection pump has been illustrated for the purpose of disclosing the invention, it is to be understood that the invention is not in any way limited to this particular type of pump or to a fuel injection engine but that any other type of fuel feeding apparatus may be used providing it is subject to control to accurately meter the quantity of fuel supplied to the engine.

Within the intake air duct 24 between the entrance opening 22 and the supercharger inlet 26 there is a throttle 34 which may be either manually or automatically operated and in the arrangement shown, between this throttle and the supercharger air intake there is a wire resistance grid or filament 36 extending across the interior of the air intake duct. This grid or filament, however, may be located at any point in the induction system in which it is subject to the total air flow through the system.

While the drawing shows an engine having a supercharger 16, it is to be understood that the invention is in no way limited to such an engine but that the improved charge forming apparatus may be applied with equal facility to an un-supercharged engine in which case the grid or filament 36 would be disposed in the intake air duct somewhere in the induction system.

The grid or filament 36 constitutes one element

of a form of "Wheatstone" bridge including the additional resistances 38, 60, 40 and 50. The "Wheatstone" bridge circuit is energized by the high frequency alternating current generator 44. The alternating current may pass through the portion of the bridge circuit including the conduit 46, the condenser 48, the temperature responsive resistance 50, the condenser 52, the resistance 40 and the conduit 54 and may also flow through the portion of the bridge circuit including the conduit 46, the condenser 56, the resistance 36, the condenser 58, the resistance 38, the adjustable rheostat 60 and the conduit 54. In accordance with the operative principles of the "Wheatstone" bridge, the ratio of current flowing through the two parts of the bridge will be controlled by the resistance encountered in each bridge portion. The first described bridge portion is connected through a conduit 62 with one terminal 64 of a sensitive alternating current ammeter, generally indicated at 66, and the other portion of the bridge is connected through the conduit 68 with the opposite terminal 67 so that the current flowing through the ammeter is dependent upon the difference in potential between the two portions the "Wheatstone" bridge. This bridge is so arranged that it has a normal or initially adjusted unbalance providing a potential which rotates the armature 70 of the ammeter against the force of the coil spring 72 to a position such that the pointer 74 is substantially mid-way between the contact point 76 and 78. If now the potential between the two portions of the "Wheatstone" bridge increases the pointer 74 will be moved into contact with the point 78 and if the potential decreases the pointer will be moved by the spring 72 into contact with the point 76 for a purpose which will presently appear.

The above-mentioned difference in potential between the two sides of the "Wheatstone" bridge is due to the unbalance caused by differences in the resistance in the circuit constituting these two bridge portions. The resistances 38 and 40 are substantially fixed or constant and may be different from each other by an amount sufficient to produce the normal or initially adjusted unbalance in the bridge circuit resistances described above. Departures from this normal unbalance are caused by variations in the resistance of the resistance elements 36 and 50. These elements may be substantially equal when both are at the same temperature but are so arranged that their resistance varies rapidly with changes in temperature. An increase in temperature increases the resistance of these elements 36 and 50 and correspondingly any decrease in temperature reduces their resistance. The resistance grid or filament 36 is heated from a substantially constant source of direct current, such as the battery 80, through a circuit including the choke coil 82, the resistance 36 and the variable resistance 42. This heating circuit for the filament 36 is separated from and is independent of the bridge circuit. As illustrated, this heating circuit is D. C. while the bridge circuit is A. C. Also by means of the choke coil 82 and condensers 48 and 52 the heating effect of the D. C. current is prevented from affecting the resistance 50. The resistance element 36 is heated at a rate such that its actual temperature is dependent upon the mass flow rate of intake air through the duct 24, that is, upon the product of the velocity of intake air flow times the density of the intake air, times the cross-sectional area of the air flow duct. However, the resistance element 36 acts as a ther-

mometer, measuring temperature variations of the intake air, as well as a flow meter measuring the quantity of intake air flowing past it per unit of time. As the fuel is to be metered by pump 18 in proportion to the quantity of intake air it becomes necessary to compensate the resistance elements for temperature variation and this is done by utilizing the resistance element 50 in the other portion of the bridge circuit as a compensating thermometer. This element 50 is so mounted that it is constantly exposed to temperature variations of the atmosphere but is not subjected to an appreciable air velocity so that it responds directly to temperature variations and compensates the unbalance between the two portions of the bridge circuit for variations in the temperature of the intake air, leaving only an unbalance due to the initial or normal unbalance mentioned above and to variations in the flow rate of intake air flowing past the element 36.

The initial or normal unbalance between the two portions of the bridge circuit can be adjusted by changing the adjustable rheostat 60 and this rheostat may also be utilized, if desired, to provide an economizer action providing a richer fuel mixture for certain operating conditions such as idling and full power operation. If desired this rheostat may be operatively connected with the control for the throttle 34 in order to render the economizer action automatic upon operation of the throttle to produce the particular operating condition.

With the resistance element 36 thus heated by a predetermined amount and compensated by resistance 50 for variations in the air temperature, and with a quantity of heat removed from this element 36 proportional to the weight of air flowing past it per unit of time, the change thus caused in the potential between the two portions of the bridge circuit by the variations in the resistance of the resistance element 36 induced by the abstraction of heat from this element by the intake air will be proportional to the intake air flow.

The arm 74 of the micro-ammeter 66 is connected at its center to a source of current, such as the battery 84, while the terminal points 76 and 78 are connected to a reversible electric motor 86 in such a manner as to cause the motor to rotate in one direction when the arm 74 is in contact with the terminal point 76 and in the opposite direction when the arm 74 is in contact with the terminal point 78. The motor is drivingly connected with the pump stroke adjusting shaft 32 to change the cyclic capacity of the pump under the control of the micro-ammeter 66 which is in turn controlled by the unbalance in the bridge circuit caused by air flow induced variations in the resistance of the resistance element 36. The shaft of the motor 86 drives a threaded shaft 88 upon which is threaded a nut 90 slidable in a cross head 92 carried by the motor support 94 and carrying a movable contact 96 which engages the variable resistance 42. This contact is connected through the conduits 98 and 100 into the heating circuit of the resistance element 36 to control the amount of current fed to the resistance element 36 from the battery 80. By means of this arrangement including the variable resistance 42 and movable contact 96 the heating of the element 36 is maintained at all times proportional to the quantity of intake air flowing past the element to maintain a constant relationship between the quantity of intake air and the resistance of the resistance element. When the

motor 86 has brought the movable contact 96 to the proper setting to adjust the flow of heating current through the resistance element 36 for the particular quantity of intake air flowing past this element the bridge circuit will again be balanced, that is, the potential difference between the two portions of the circuit will return to the value which returns the microammeter arm 74 to its position between the points 75 and 78 and the engine will then continue in operation with the new pump setting until the quantity of intake air is again varied, which variation will cause a re-setting of the pump regulator in the manner indicated above. When the mass flow rate of intake air increases, the temperature of filament 36 decreases which unbalances the bridge circuit. More heating current is then required to balance the bridge circuit and restore the temperature of the filament 36 to normal. To accomplish this the screw 88 when rotated with shaft 32 to increase the fuel delivered by pump 18 moves the contact 96 to reduce the resistance 42 in the heating circuit. Similarly when the mass flow rate of intake air decreases, the temperature filament 36 increases and unbalances the bridge circuit in the opposite direction and moves the contact 96 in a direction to increase the resistance 42 in the heating circuit.

While, in the apparatus shown, the arrangement utilizes a relatively large direct current for heating the resistance element 36 and a relatively small high frequency alternating current for the bridge and ammeter circuits, it would be entirely feasible by slightly revising the circuit to retain the separation of the currents to reverse these currents, using a direct current for the bridge and ammeter circuits and an alternating current for heating the resistance element. Also, it would be possible to use direct current altogether by providing a separate, electrically insulated heating element for the resistance element.

While a suitable mechanical embodiment has been hereinabove described and illustrated in the accompanying drawing for the purpose of disclosing the invention, it is to be understood that the invention is not limited to the particular embodiment so illustrated and described but that such changes in the size, shape and arrangement of the parts may be resorted to as come within the scope of the sub-joined claims.

Having now described the invention so that others skilled in the art may clearly understand the same, what it is desired to secure by Letters Patent is as follows:

1. A fuel controlling means for an internal combustion engine comprising, an air intake duct, an adjustable fuel feeding device, a resistance element in said air duct, means to heat said element, said means comprising an electric circuit including said element, electrically actuated means operatively connected between said resistance element and said fuel feeding device for regulating said fuel feeding device in accordance with variations in the mass flow rate of air through said intake duct as indicated by variations in the resistance of said resistance element, and means to vary the heat supplied to

said element proportioned to the mass flow of air through said intake duct for different adjustments of said fuel feeding device.

2. A fuel controlling means for an internal combustion engine comprising, an air intake duct, an adjustable fuel feeding device, electrical apparatus for adjusting said fuel feeding device in accordance with variations in the mass flow rate of air through said air intake duct, said electrical apparatus comprising a resistance element disposed in said air intake having a predetermined variation in electrical resistance with variations in temperature, an electric circuit including said element for supplying heating current directly to said resistance element at a predetermined variable rate proportional to the mass flow of air through said intake duct, and means controlled by variations in resistance of said resistance element to regulate said fuel feeding device.

3. A fuel controlling means for an internal combustion engine comprising in combination, an air intake duct, an adjustable fuel feeding device, and electrical apparatus for adjusting said fuel feeding device in accordance with variations in the mass flow rate of air through said air intake duct, said electrical apparatus comprising, a resistance element disposed in said air intake duct and having a predetermined variation in electrical resistance with variation in temperature, means for supplying heating current to said resistance element to render the temperature drop of said resistance element proportional to the mass flow rate of air through said intake duct, means exposed to the temperature of free intake air for compensating said resistance element for changes in atmospheric temperature, and means including a "Wheatstone" bridge connected with said resistance element and said temperature compensating means for adjusting said fuel feeding device in accordance with variations in the mass flow rate of air in said intake duct, and means to vary the heat supplied to said resistance element proportioned to the mass flow of air through said intake duct as said fuel feeding device is adjusted.

4. A fuel controlling means for an internal combustion engine comprising, an electrical resistance element positioned in a gas stream, a heating circuit directly connected to said element, a "Wheatstone" bridge circuit electrically connected with said element, means for energizing one of said circuits with direct current, means for energizing the other circuit with alternating current, a current measuring element in said bridge circuit and having an element movable in response to current variations in the two sides of said bridge, a fuel metering device having a regulating element operatively connected with the movable element of said current measuring device to vary the amount of fuel delivered by said pump, and means controlled by adjustment of said fuel metering device to vary the current in the heating circuit for said element, whereby the heat applied to said element will be proportioned to the mass flow of air through said intake duct.

JAMES W. COLVIN,

FREDERICK V. H. JUDD.