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APPARATUS FOR CALIBRATING CARBURETORS

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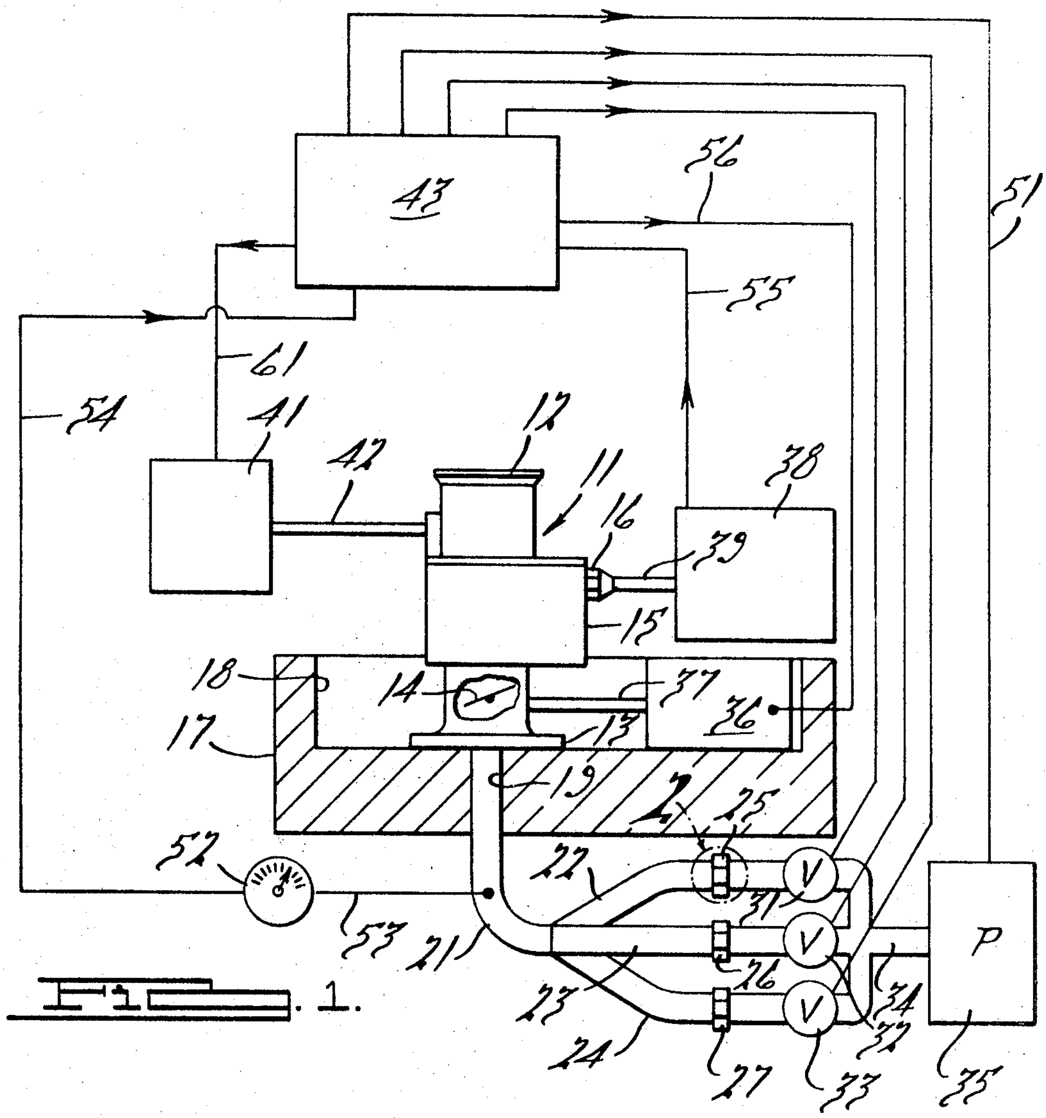

FIG. 1.

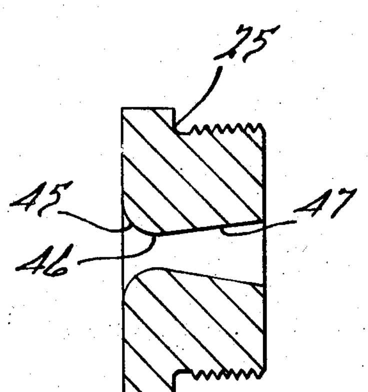

FIG. 2.

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APPARATUS FOR CALIBRATING CARBURETORS

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ABSTRACT OF THE DISCLOSURE

This application discloses a method and apparatus for accurately calibrating and adjusting charge forming devices for internal combustion engines. The apparatus is comprised of a stand for supporting the charge forming device, an apparatus for manipulating the charge forming device throttle valve, a fuel delivery and flow measuring unit, a vacuum pump or other structure for inducing an air flow through the charge forming device and a plurality of sonic nozzles and control valves therefor interposed in the flow path between the charge forming device and the vacuum pump. The operation of each of the aforenoted elements is controlled by a master control unit. In operation, this master control unit sequentially selects a flow path through one or more of the sonic nozzles, operates the throttle valve positioning apparatus to maintain sufficient upstream pressure upon the selected nozzle or nozzles to generate a sonic velocity at its throat whereby a finite mass flow rate is established through the charge forming device and senses a reading from the fuel flow measuring unit at this mass flow rate. After accomplishing the aforenoted test at a given mass flow rate, the master control selects another mass flow rate by switching the flow through a different sonic nozzle or nozzles and the fuel flow measuring unit measures the fuel flow at this new mass flow rate. Thus, the charge forming device is accurately calibrated at a plurality of points, the number of which depends upon the number of test points desired.

BACKGROUND OF THE INVENTION

This invention relates to a method and apparatus for calibrating charge forming devices.

As is well known, the function of a charge forming device such as a carburetor for an internal combustion engine is to deliver an accurate fuel-air mixture throughout the power and speed range of the associated engine. The actual rate of discharge at any point on the carburetor's flow curve is a compromise between a lean economy mixture and a richer mixture that assures adequate power reserve. In order to insure that a production carburetor will give satisfactory performance, it is conventional practice to test all of the carburetors produced. A common test method employs a device known as a "flow box" in which air is passed through the carburetor induction passage and fuel or a satisfactory equivalent therefor is fed to the carburetor for discharge into the induction passage through the carburetor fuel circuits. A predetermined pressure differential is established across the carburetor at a given throttle setting and the fuel flow is measured and adjusted. If the fuel flow can be adjusted within a predetermined range, the carburetor is considered to be satisfactory. This test method is not completely satisfactory since the actual mass flow rate through the carburetor will vary from carburetor-to-carburetor even though a given pressure differential is accurately maintained. In addition, the recent emphasis upon the reduction of the emission of smog producing constituents from the engine exhaust has necessitated a narrower range of variation in the discharge rate of the carburetor as well as a somewhat leaner overall mixture. Also, it is preferable if not imperative that all carburetors

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from the production line be tested. Previous test methods and apparatus have not lent themselves to 100% testing. The calibration of all production carburetors eliminates or substantially reduces the necessity for subsequent adjustment when the carburetor is assembled onto its associated engine.

It is, therefore, a principal object of this invention to provide an improved method and apparatus for calibrating charge forming devices.

It is another object of this invention to provide an automatic device for calibrating carburetors over a wide range and at a plurality of different points.

It is a further object of this invention to provide a method and apparatus for calibrating charge forming devices that accomplishes a more accurate adjustment.

SUMMARY OF THE INVENTION

The method embodying this invention is particularly adapted for calibrating a charge forming device having an induction passage, a throttle valve for controlling the flow through the induction passage and a fuel discharge circuit for discharging fuel into the induction passage. The fuel discharge circuit also includes at least one adjustable flow device for regulating the rate of fuel discharge. The method comprises the steps of establishing a pressure differential across the inlet and outlet ends of the induction passage for inducing a flow therethrough. The induced flow is passed through a sonic flow device that has an area wherein the flow is accelerated to the sonic velocity at a predetermined pressure differential. This sonic flow device has the characteristic that the velocity at the area does not exceed the sonic velocity at pressure differentials greater than the aforenoted predetermined pressure differential. In addition, once sonic flow is established through the device, the mass flow rate will be directly proportional to the upstream pressure. The throttle valve of the charge forming device is positioned to establish a pressure on one side of the sonic flow device sufficient to attain the sonic velocity and to generate a predetermined mass flow rate through the induction passage of the charge forming device. The discharge rate of the fuel discharge circuit is then measured at this predetermined mass flow rate.

An apparatus for performing the aforenoted method is comprised of a vacuum pump for creating the pressure differential and a sonic flow nozzle positioned in a conduit leading from the carburetor to the vacuum pump. Means are provided for measuring the fuel discharge of the carburetor and for adjusting the fuel discharge rate if the fuel discharge varies from within a predetermined range.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a partially schematic illustration of a calibration apparatus for a charge forming device, which apparatus embodies this invention.

FIGURE 2 is an enlarged cross sectional view of the area encompassed by the circle 2 in FIGURE 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT OF THE INVENTION

In the drawings the reference numeral **11** indicates generally a carburetor or other charge forming device adapted to be calibrated or adjusted by the apparatus and method embodying this invention. The carburetor **11**, which may be of any known type, includes an induction passage defined in part by an air horn or inlet **12** and an air outlet flange **13** in which a throttle valve **14** is supported. In addition, the carburetor **11** includes conventional fuel discharge circuits and preferably embodies flow adjusting devices for adjusting the fuel flow at idle, off idle and full throttle operation. These adjusting devices may be needle valves that cooperate with the carburetor fuel discharge passages for regulating the fuel flow, air bleed controls or any other known type of fuel adjusting devices. Fuel is supplied to the various discharge circuits from a float bowl **15** into which fuel is introduced by a fuel inlet fitting **16** in a known manner.

The testing apparatus comprises a test stand base **17** defining a cavity **18** in which the mounting flange **13** of the carburetor **11** is adapted to be supported and fixed by a suitable automatic clamping means (not shown). The automatic clamping means may be of any known type such as one which includes pneumatically operated clamps for fixing the carburetor flange **13** to the stand base **17**. Preferably, locating means are also incorporated either with the clamping means or upon the base **17** for accurately orienting the carburetor **11** with respect to the base **17**. The test stand base **17** is formed with an air passage **19** that is adapted to register with the outlet side of the carburetor induction passage and particularly with the portion adjacent the outlet flange **13** when the carburetor is clamped thereupon.

A conduit **21** extends from the passage **19** terminates in a plurality of branch conduits **22**, **23** and **24**. Sonic nozzles **25**, **26** and **27** are interposed in the passages **22**, **23** and **24**, respectively, upstream of solenoid operated valves **31**, **32** and **33**. Downstream of the valves **31**, **32** and **33** the passages **22**, **23** and **24** merge in a common passage **34** that extends to a vacuum pump **35**.

A throttle valve control unit **36** is supported on the mounting portion **17** and has an operating member **37** that is adapted to be automatically connected to the throttle linkage of the carburetor **11** for operating the throttle valve **14**. The throttle valve control unit **36** may comprise any form of hydraulic, pneumatic or electrical servo unit that is operative to maintain an accurate position of the operating member **37** and throttle valve **14** in response to a given signal. The end of the operating member **37** adjacent the throttle valve linkage may be provided with any known form of automatic clamping device to effect an automatic connection to the throttle valve linkage.

A fuel control circuit including a fuel feed and flow measuring device **38** delivers fuel to the carburetor **11** by means of a fuel conduit **39** that is connected to the fuel inlet fitting **16**. The device **38** may be of any known type and preferably incorporates a flow meter that will accurately measure extremely small liquid flows and which may be of any known type. In addition, any known form of automatic clamping device is provided for automatically coupling the conduit **39** to the carburetor fuel inlet fitting **16**.

A fuel discharge adjusting device **41** is provided with one or more adjusting arms **42** that are adapted to coact with the fuel flow adjusting devices of the carburetor **11**, there preferably being one such adjusting arm **42** for each fuel adjustment of the carburetor **11**. The adjusting device **41** may be of any known type and preferably includes a structure such as a hydraulic or pneumatic solenoid for moving the adjusting arm **42** into registry with the respective fuel flow adjusting device of the carburetor **11**. If the fuel flow adjusting device is a conventional needle valve, a screw driver like tool may be supported at the outer end of the adjusting arm **42** for registry with the slotted end of the needle valve. The adjusting device **41** may include a form of stepping solenoid for incrementally locating the adjusting arm **42** if a needle valve is employed.

The solenoid valves **31**, **32**, **33**, the vacuum pump **35**, the throttle adjusting servo **36**, the fuel feed and flow measuring device **38** and the fuel discharge adjusting devices **41** are each connected in circuit to a computer or other master control device, indicated generally by the reference numeral **43**, as will become more apparent as this description proceeds.

OPERATION

Before discussing specifically the detailed operation of the disclosed apparatus and method, a discussion of its principle of operation appears to be in order. An important feature of the invention is the use of the sonic nozzles **25**, **26** and **27** for accurately establishing predetermined mass flow rates through the tested carburetor. FIGURE 2 is a cross sectional view of the sonic nozzle **25** which is comprised of a convergent section **45**, a minimum area throat **46** and a divergent section **47**. As is well known, at a critical pressure differential across the nozzle **25**, the fluid flowing through the nozzle will be accelerated to its sonic velocity at the throat **46**. Pressure differentials greater than this critical pressure differential will not increase the velocity at the throat **46**. Once the sonic velocity is obtained at the throat **46**, any increase in pressure on the upstream side of the nozzle **25** will not cause an increase in the throat velocity. In addition, the mass flow rate through the nozzle **25** will be directly related to the upstream pressure. The use of the sonic nozzle **25**, therefore, permits the mass flow rate through the carburetor induction passage to be accurately determined at a given downstream pressure so long as this pressure is sufficient to maintain sonic velocity through the nozzle **25**. The use of the sonic nozzles has the further advantage that they will not permit pulsations of the vacuum pump **35** to be transmitted back to the carburetor induction passage.

By employing a plurality of such sonic nozzles in parallel flow circuit with the carburetor **11**, it is possible to accurately control the mass flow rate through the carburetor, depending upon which of the sonic nozzles is interposed in the flow path through the carburetor induction passage. One sonic nozzle may be employed for each point at which the carburetor **11** is to be tested or, alternatively, a number of such nozzles may be used in parallel flow circuits. This latter embodiment permits a greater number of test points with a given number of sonic nozzles. Since the mass flow rate is accurately determined, the exact fuel-air ratio discharged by the carburetor may be accurately measured by the device **38** which measures the fuel flow through the carburetor **11**. Appropriate adjustment of the fuel discharge circuit being tested under these conditions will permit accurate control of the fuel discharge of the carburetor.

Referring now specifically to the operation of the disclosed device, information is fed into the control unit **43** of the test apparatus from a standard, accurately calibrated carburetor that has the desired flow characteristics as determined by dynamometer and other testing. This master carburetor is positioned upon the test apparatus as shown in FIGURE 1 of the drawings. When so positioned, the automatic clamping mechanism (not shown) is actuated to lock the carburetor to the test stand base **17**, the fuel conduit **39** is automatically coupled to the carburetor inlet fitting **16** and the throttle valve actuating device **37** is automatically engaged with the throttle lever. The fuel adjusting devices **42** need not be connected to the master carburetor when its flow data is being registered by the control unit **43**. Any suitable structure for accomplishing these automatic engagements may be provided depending upon the type of carburetor being tested and various other factors. Alternatively, these connections may be made manually.

When operating the described test apparatus, it is preferable to use a liquid to simulate the fuel flow other than gasoline. The high volatility of gasoline fuels might, in some instances, cause false readings due to vaporization within the sonic nozzles. Any well known test fluid may be used for this purpose. Preferably, the same fluid will be used to calibrate the production carburetor as that used during the recording of the flow data of the master carburetor.

When the master carburetor **11** is in place, the control device **43** actuates the vacuum pump **35** by means of a control circuit, indicated schematically by the reference numeral **51**. The vacuum pump **35** will create a pressure differential across the carburetor **11** from its air horn **12** to its discharge flange **13** that is preferably greater than the pressure differential at the extreme range to be tested. The first carburetor circuit to be tested, normally the idle circuit, is operated by closing the solenoid valves **32** and **33** and opening the solenoid valve **31** through schematically indicated circuits interconnecting the respective solenoid valves to the control device **43**. The flow through the carburetor **11** will then pass from the conduit **21** through the branch passage **22** and sonic nozzle **25** to the vacuum pump **35**. A pressure indicating device **52** is connected to the conduit **21** upstream of the branch passages **22, 23** and **24** by means of a conduit **53**. The pressure indicating device **52** is in circuit with the control device **43** as shown schematically at **54**. If desired, a similar pressure connection may extend from the conduit **34** to the control device **43** to measure the pressure differential across the respective sonic nozzles. Such a connection may not be required if the output of the vacuum pump **35** is constant since in that case the device **52** will reflect the pressure differential.

During the idle test, the throttle valve controlling servo **36** and its actuating member **37** perform no function and the throttle valve **14** remains in its normal idle position. This should establish a predetermined pressure upon the pressure sensing device **52** which is indicative of the pressure differential across the sonic nozzle **25**. The sonic nozzle **25** is designed so that this pressure differential exceeds the predetermined critical pressure at which the flow through its throat exceeds the sonic velocity of the fluid flowing. If the critical pressure differential is not attained, the idle position of the carburetor throttle valve **14** may be appropriately adjusted. After a predetermined time interval to permit the fuel flow to stabilize, the fuel flow meter **38** sends a signal to the control device **43** by means of an interconnecting circuit indicated schematically by the reference numeral **55**. This condition is thus recorded by the control device **43**.

The control device **43** then closes the solenoid valve **31** and opens the solenoid valve **32** through the respective circuits. The flow from the carburetor **11** will then pass through the sonic nozzle **26** which like the sonic nozzle **25** is designed to experience sonic flow at its throat at a predetermined pressure differential, which is established by the pressure differential corresponding to that attained when the throttle valve **14** is at its normal off-idle position. The throttle valve **14** is then automatically moved to this position by means of the servo device **36** which is connected in circuit to the control device **43** as shown schematically at **56**. The pressure sensing device **52** returns a signal to the control device **43** to indicate when this throttle opening has been reached. After the predetermined time delay necessary to permit fuel flow to stabilize, the fuel flow meter **38** returns a signal to the control device **43** via circuit **55**, thus indicating the fuel flow of the master carburetor at the off-idle position.

The control device **43** then closes the solenoid valve **32** and opens the solenoid valve **33** through the appropriate circuits so that the flow through the carburetor **11** subsequently passes through the sonic nozzle **27**. The sonic nozzle **27** is designed so that the sonic velocity will be reached at a critical pressure differential equivalent to that generated by opening the throttle valve **14** to its wide open position. The control device **43** then actuates the throttle actuating servo **36** through circuit **56** to move the throttle valve **14** to its wide open position. When this position is reached and after the fuel flow is stabilized, the fuel flow meter **38** returns the signal for recording to the control device **43**. The control device **43** now contains the accurate information of the fuel flow of the master carburetor at idle, off-idle and full throttle positions. Although the operation described has assumed the use of a separate sonic nozzle for each calibration point, it is to be understood that additional tests points may be obtained through the use of groups of nozzles in parallel flow paths or through the use of additional nozzles.

After the data is recorded by the control device **43**, the master carburetor is released from the test apparatus either automatically or manually. Each carburetor coming off of the production line of the type corresponding to the master then may be positioned upon the test stand **17**. The control device **43** automatically actuates the clamping mechanism, fuel adjustment mechanisms **41**, fuel feed and measuring device **39** and the throttle valve actuating servo **36** in the manner previously described. As has been previously noted, the fuel feed device and flow measuring device **28** delivers the same liquid to the carburetor **11** as was used in conjunction with the recordal of the data from the master carburetor. Visual tests for fuel leakage may then be made and any fluid leakage from the carburetor **11** will enter the cavity **18** for return to its source. After the visual leakage test has been made and passed, the test procedure is initiated by the control device **43**. The solenoid valve **31** is first opened with the solenoid valves **32, 33** being closed and the vacuum pump **35** is started in operation. The throttle valve **14** is held in its normal idle position and assuming the desired pressure signal is indicated by the pressure sensing device **52**, the first fuel test will be initiated. The fuel flow measuring device **38** sends a signal to the control device **43** by the circuit **56** indicating accurately the amount of fuel flowing through the idle fuel discharge circuit of the charge forming device **11**. If the stablized fuel flow is within a predetermined range of that of the master carburetor, the control circuit **43** will pass to the next test. If not, the fuel adjustment device **41** which is in circuit with the control **43**, as indicated schematically by the reference numeral **61**, will be actuated. A single increment adjustment in the idle fuel discharge is made and flow continues to pass through the sonic nozzle **27**. After the flow again stabilizes, the fuel flow measuring device **38** will return a signal to the control device **43** by the circuit **55**. If the desired fuel flow is now present, the control device **43** will pass to the next test. If not, a further adjustment will be made by the fuel adjusting device **41**. If sufficient adjustment cannot be made by the device **41** to bring the carburetor **11** into specification, it will be rejected. Assuming that the adjustment can be made, the device will pass to the next fuel test and so on in the manner previously described.

In the described test apparatus, the vacuum pump **35** and sonic nozzles **25, 26** and **27** are positioned downstream of the charge forming device **11**. It should be readily apparent that other arrangements are possible so long as a pressure differential is obtained across the carburetor **11** and that each of the sonic nozzles experiences the amount of mass air flow through the carburetor induction passage. The depicted relationship is preferred, however, since it most closely approximates the actual conditions to which the carburetor is exposed. In addition, although nozzles have been illustrated, any type of flow devices such as orifice plates, may be employed so long as they have the characteristic that a sonic velocity is attained at a predetermined pressure differential and this velocity is not exceeded at higher pressure differentials. Alternatively, a variable area orifice or flow nozzle may be provided that will have sonic characteristics at each of the predetermined points. The characteristics of these sonic flow devices will permit accurate measurement of the mass flow rate even though there may be some variations in the pressure differential generated by the vacuum pump. Any pulsations generated by the vacuum pump **35** will not be transmitted back to the induction passage of the carburetor **11** due to the interpositioning of the sonic nozzles between the vacuum pump **35** and the carburetor **11**. It is also to be understood that the specific sequence of test points may be varied without departing from the invention. It should also be apparent that the control device 43 may control a number of different test stands and the information regarding the performance of the master carburetor may be recorded on any type of memory unit for subsequent use.

Various other changes and modifications may be made without departing from the spirit and scope of the invention, as defined by the appended claims.

What is claimed is:

1. A test apparatus for calibrating a charge forming device having an induction passage, a throttle valve for controlling the flow through the induction passage and a fuel discharge circuit for discharging fuel into the induction passage, said test apparatus being effective to calibrate the charge forming device by measuring the air-fuel ratio discharged from the induction passage and including at least one adjustable means for regulating the amount of discharge of the fuel discharge circuit, said apparatus comprising a base adapted to support a charge forming device, air conduit means adapted to register with the induction passage of the supported charge forming device, means for creating a pressure differential in said air conduit means for inducing flow through the charge forming device induction passage, said air conduit means having a plurality of branch passages defining parallel flow paths, valve means for selectively controlling the air flow through said branch passages, a sonic flow device interposed in each of said branch passages downstream of the charge forming device induction passage, each of said sonic flow devices having an area wherein the flow velocity at said area is equal to the sonic velocity of the fluid flowing therethrough at a respective critical pressure differential and which velocity does not exceed said sonic velocity at a greater pressure differential than said respective critical pressure differential, and means for measuring the fuel flow through the discharge circuit of the charge forming device.

2. A test apparatus as set forth in claim 1 wherein the base forms a portion of the air conduit means and is in registry with the outlet end of the charge forming device induction passage, the means for creating the pressure differential in said air conduit means comprising a vacuum pump positioned downstream of the branch passages.

3. A test apparatus as set forth in claim 1 further including means for adjusting the adjustable fuel discharge means of the charge forming device when the means for measuring the fuel flow indicates a deviation from a predetermined range.

4. A test apparatus as set forth in claim 1 further including throttle valve actuating means for positioning the throttle valve of the supported charge forming device and means for coordinating the operation of the selected valve means and said throttle valve actuating means for positioning the charge forming device throttle valve to maintain a pressure upon one side of the respective sonic flow device sufficient to establish sonic flow therethrough.

5. A test apparatus as set forth in claim 4 further including means for adjusting the adjustable fuel discharge means of the charge forming device when the means for measuring the fuel flow indicates a deviation from a predetermined range.

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