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[54] **TEST METHOD AND APPARATUS FOR CHARGE FORMING DEVICES**
7 Claims, 3 Drawing Figs.

[52] U.S. Cl. 73/118,
73/3

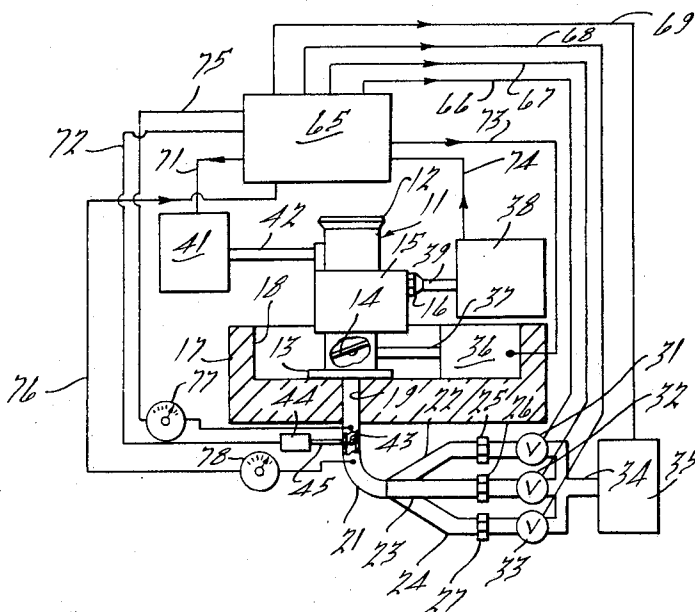
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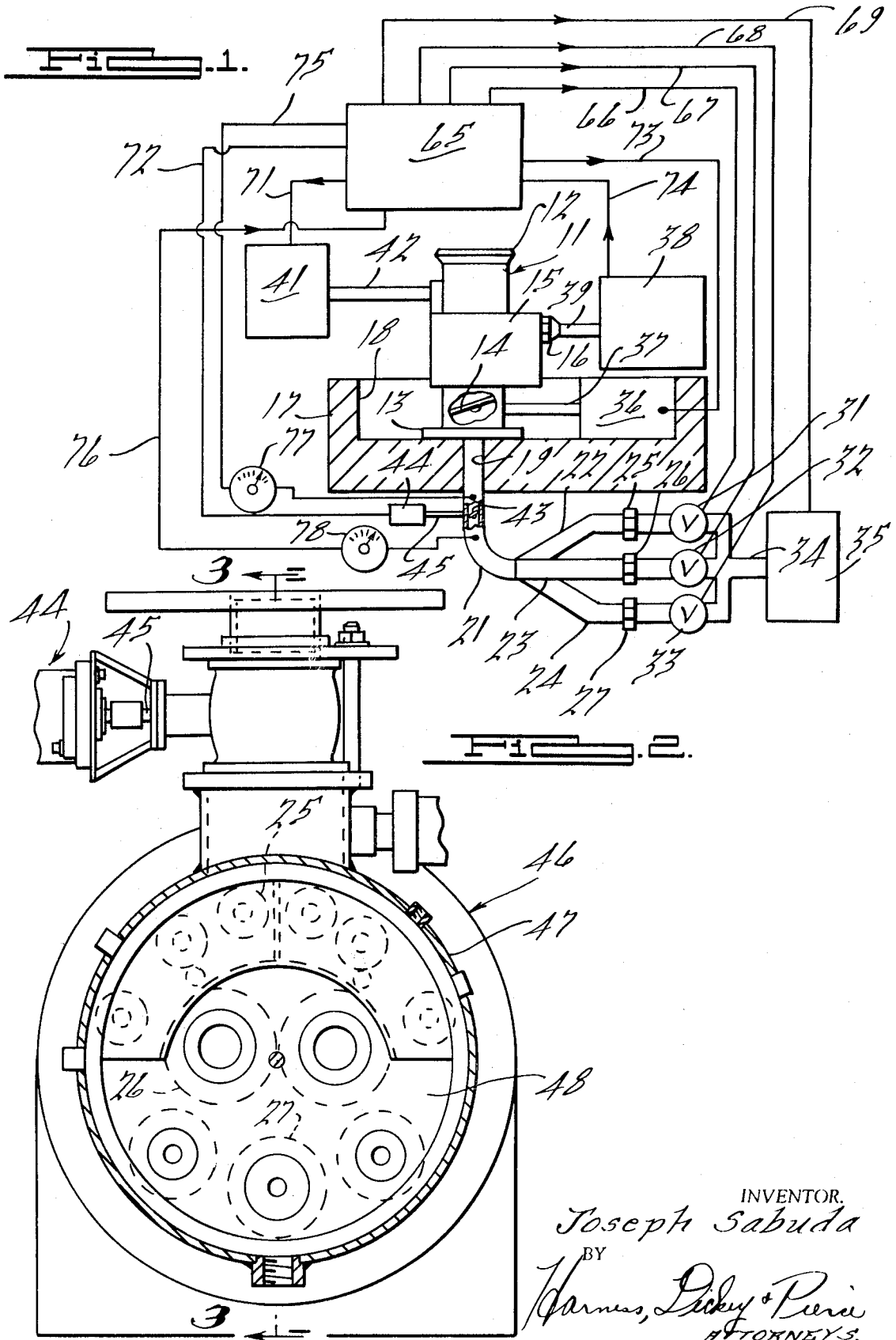
[50] Field of Search 73/118,
119, 3, 4

[56] **References Cited**
UNITED STATES PATENTS

2,597,231	5/1952	Edelen	73/118
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ABSTRACT: A method and apparatus for accurately calibrating and adjusting charge forming devices for internal combustion engines under conditions accurately simulating actual operating conditions. The charge forming device induction passage is placed in a fluid circuit that includes a sonic nozzle with a throttle valve being interposed between the charge forming device induction passage and the sonic nozzle. The sonic nozzle has the characteristic that at pressure differentials greater than a predetermined critical pressure differential the flow velocity through the throat is maintained at the sonic velocity. A pressure differential is established across the sonic nozzle, which pressure differential is greater than this critical pressure and by interrelating the operation of the throttle valve of the charge-forming device and the throttle valve of the test apparatus, the critical pressure ratio is maintained while various engine-operating conditions are simulated. The air and fuel flow through the carburetor can then be accurately measured at these varying conditions.





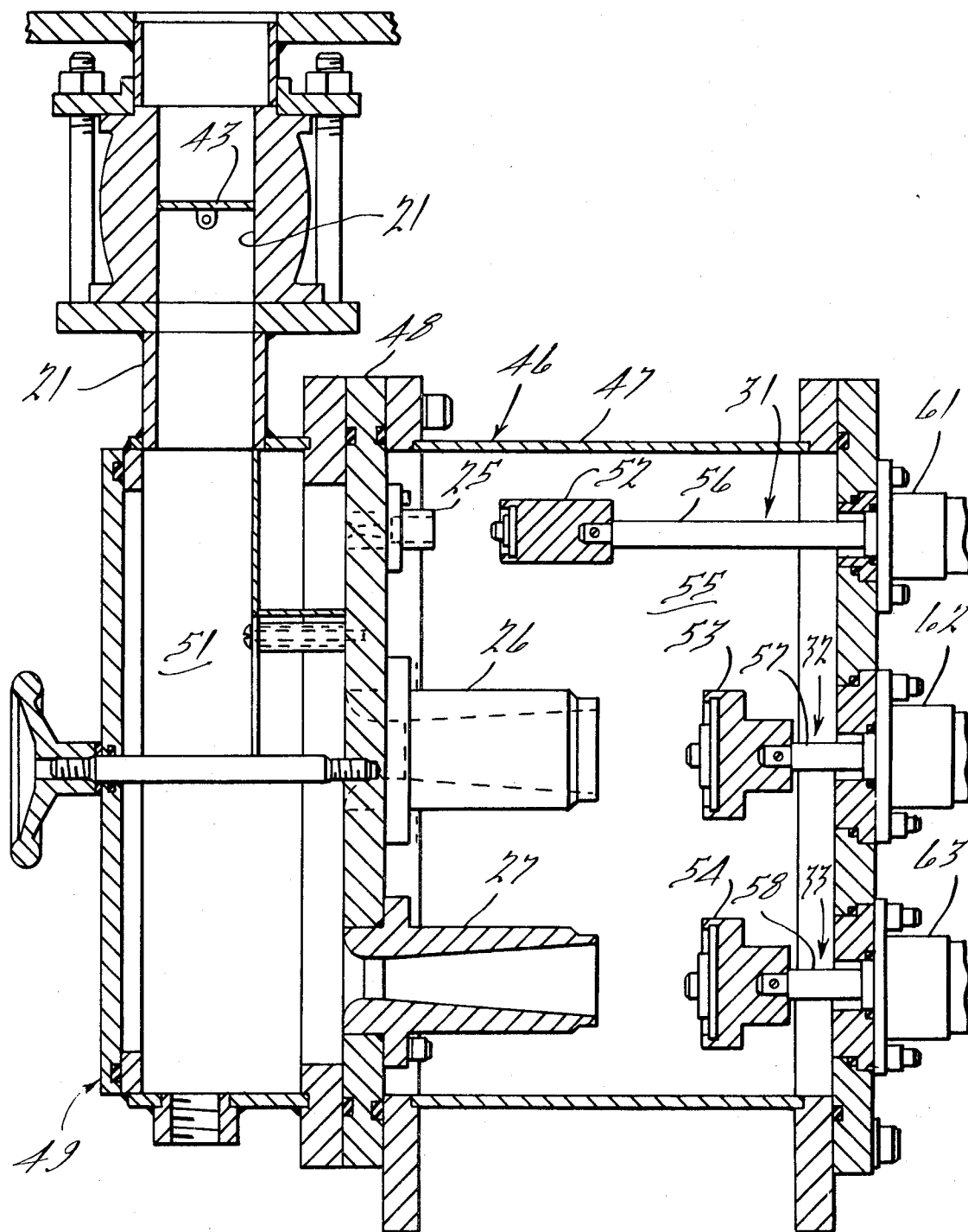


FIG. 2.

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TEST METHOD AND APPARATUS FOR CHARGE FORMING DEVICES

CROSS REFERENCE TO RELATED APPLICATION

This application represents, in some respects, an improvement over the method and apparatus disclosed in the copending patent application of Alexander W. Brueckner Ser. No. 629,790, filed Apr. 10, 1967, now U.S. Pat. No. 3,469,442 and entitled "Method and Apparatus for Calibrating Carburetors".

BACKGROUND OF THE INVENTION

This invention relates to a method and apparatus for calibrating charge forming devices and more particularly to an improved apparatus of that type.

In the aforementioned copending patent application of Alexander W. Brueckner the advantages of employing sonic flow devices in the calibration of charge forming devices and particularly automotive carburetors has been noted. The apparatus and method disclosed in that application have provided a new tool for accurately calibrating such devices. In accordance with the teaching of that application a sonic flow device is interposed in the path of flow through the induction passage of the charge forming device and a critical pressure is established across the sonic flow device so that the mass flow rate will be directly related to the pressure on one side of the sonic flow device as long as this critical pressure is maintained or exceeded. The apparatus shown in that application permits the calibration of a charge forming device over a wide range of points. In some regards, however, that apparatus does not permit accurate measurement of the charge forming device performance under varying conditions. The reason for this is that it is impossible to calibrate the carburetor at varying flow rates with a given throttle setting. Such a condition corresponds to changes in engine speed as a result of load at a given throttle setting. Such conditions can be simulated with the aforementioned apparatus and method only by switching the flow from one sonic flow device to another or by changing the groupings of such flow devices in circuit with the induction passage of the charge-forming device. It is also impossible, for the same reason, to test the charge-forming devices performance at a constant flow rate while changing the throttle position of the charge-forming device. Of course, combinations of the aforementioned conditions also cannot be simulated with the previously proposed device.

It is, therefore, a principal object of this invention to provide a method and apparatus for testing charge-forming devices in conditions more closely simulating actual engine-operating conditions.

It is another object of the invention to provide a method and apparatus for calibrating charge-forming devices under dynamically changing conditions.

It is a further object of the invention to provide a method and apparatus for calibrating charge forming devices at a given throttle valve setting and with a varying mass flow rate through the charge-forming device.

It is a yet further object of the invention to provide a method and apparatus for calibrating charge-forming devices during a change in the throttle valve setting of the device.

SUMMARY OF THE INVENTION

A test apparatus embodying this invention is particularly adapted for calibrating charge forming devices 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 apparatus includes a base for supporting the charge-forming device, air conduit means adapted to register with the induction passage of the supported charge forming device and means for creating a pressure differential in the air conduit means for inducing flow through the charge-forming device induction passage. A sonic flow device is interposed in the air conduit, which

sonic flow device has an area wherein the flow velocity at the area is equal to the sonic velocity of the fluid flowing at a critical pressure differential and which velocity does not exceed the sonic velocity at a greater pressure differential than the critical pressure differential. Throttle valve means are interposed in the air conduit between the sonic flow device and the induction passage of the charge-forming device for maintaining the critical pressure across the sonic flow device over a variation of flow rates or throttle positions of the charge-forming device. Means are provided to measure the fuel flow through the discharge circuit of the charge-forming device, thus enabling computation of the air-fuel ratio at a wide variety of conditions.

An apparatus described in the preceding paragraph is particularly adapted for performing a method of calibrating a charge-forming device at a given throttle position and under varying mass flow rates, such conditions corresponding to a change in engine speed or load at a given throttle setting. In such a method, the throttle valve of the test apparatus is manipulated to maintain the critical pressure across the sonic flow device while altering the mass flow rate through the charge-forming device.

The apparatus previously described is also particularly adapted for performing a carburetor test method wherein the carburetor throttle position is changed during the test procedure without changing the mass flow rate through the carburetor. In such a test procedure, the throttle valve of the test apparatus is manipulated so as to maintain the critical pressure difference across the sonic flow device while the charge-forming device throttle valve position is changed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partially schematic illustration of a test apparatus embodying this invention and adapted to perform methods embodying this invention.

FIG. 2 is an enlarged view showing a portion of the test apparatus and particularly the sonic flow devices and the related mechanism.

FIG. 3 is an enlarged cross-sectional view taken along the line 3—3 of FIG. 2.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring first to FIG. 1, 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 and 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 carburetor 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.

A test apparatus throttle valve 43 is interposed in the conduit 21 between the branch passages 22, 23 and 24 and the air passage 19 of the base 17. Hence, the test stand throttle valve 43 is interposed between the throttle valve 14 of the carburetor 11 and the sonic nozzles 25, 26 and 27. The test stand throttle valve 43 is operated by means of a control device 44 that is connected to the throttle valve 43 by means including a shaft 45. The control device 44 may be an electrical solenoid or a hydraulic or pneumatic motor or the like.

FIG. 1, as has been noted, is a schematic illustration of the test apparatus. The actual construction of the portion of the apparatus including the sonic nozzles 25, 26 and 27 and test apparatus throttle valve 43 is shown in some detail in FIGS. 2 and 3 and this apparatus will now be described by particular reference to these figures. The apparatus comprises a nozzle box or chamber, indicated generally by the reference numeral 46 and which has a generally cylindrical outer wall 47 that is closed at one end by a plate 48. A cover assembly 49 overlies the plate 48 and defines an air chamber 51. The air chamber 51 is in communication with the conduit 21 in which the test apparatus throttle valve 43 is positioned.

Supported within the plate 48 are the sonic nozzles 25, 26 and 27. Each of these nozzles is sized differently to accommodate different flow conditions as will become more apparent as this description proceeds. The solenoid valves 31, 32 and 33 are comprised of respective plungers 52, 53 and 54 that are reciprocally mounted in a chamber 55 into which the sonic nozzles 25, 26 and 27 extend. Each of the plungers is connected to a respective piston rod 56, 57 and 58 and is supported by the respective piston rod. The piston rods are, in turn, operated by solenoids 61, 62 and 63 so as to selectively bring the plungers 52, 53 and 54 into sealing engagement with the downstream end of the sonic nozzles 25, 26 and 27.

The chamber 55 is connected by the conduit 34 to the vacuum pump 35. Thus, upon operation of the vacuum pump 35 a flow will be induced through the charge forming device 11, past the test apparatus throttle valve 43 and into the chamber 51. This flow will pass through one or more of the sonic nozzles 25, 26 and 27 depending upon which ones of the solenoid valves 31, 32 and 33 are open and, more particularly, which of the plungers 52, 53 and 54 are axially spaced from their respective sonic nozzles. In FIG. 3 each of these plungers is shown in its fully opened position.

A master control unit 65 is provided that is in circuit, in any suitable manner, with the solenoid valves 31, 32 and 33 and particularly with their solenoids 61, 62 and 63 as shown schematically in FIG. 1 by the conductors 66, 67 and 68. The master control unit 65 is also in circuit with the vacuum pump as shown schematically in this figure by the conductor 69; with the fuel discharge adjusting device 41, as by the conductor indicated schematically at 71; with the test apparatus throttle-positioning device 44 as indicated schematically by the conductor 72; and with the charge-forming device throttle adjusting servo 36, as indicated schematically by the conductor 73. A fuel flow signal is transmitted to the master control 65 from the fuel measuring device 38, as by means indicated schematically by the conductor 74. Signals of the pressure upstream and downstream of the test apparatus throttle valve 43 are also transmitted to the master control device 65 by means indicated schematically by the conductors 75 and 76, respectively. Pressure gauges 77 and 78 are also inserted in these circuits.

OPERATION

The principle of using sonic flow devices in connection with the calibration and testing of carburetors and a test method are disclosed in the aforementioned copending patent application. The disclosed apparatus operates upon the same principle and is capable of performing the same types of test procedures as those described in the aforementioned copending application of Alexander W. Brueckner. These test procedures are accomplished in the same general manner and during the fixed flow point, fixed throttle valve position tests, the test apparatus throttle valve 43 may be held in a fully opened position. Briefly summarized, for each test point the master control 65 or, alternatively, the operator, selects the appropriate sonic nozzle or group of sonic nozzles to be opened and a flow is established by operating the vacuum pump 35. The carburetor throttle valve 14 is positioned by the device 36 to establish the desired pressure differential across the selected sonic nozzles and the air and fuel flows are measured.

It has been noted that the apparatus shown in the aforementioned copending application is not capable of testing dynamic conditions. That is, it is not truly capable of testing the performance of carburetors or charge forming devices during changing flow conditions or at a constant flow, but variable throttle valve setting condition. The instant test device is, however, capable of testing these conditions and thus more accurately duplicates actual engine operating conditions. If it is desired to test the carburetor 11 at a fixed setting of the throttle valve 14 but with different or changing mass flow rates, the appropriate sonic nozzle or group of sonic nozzles is selected either manually or automatically and a flow is established by operating the vacuum pump 35. The test apparatus throttle valve 43 is then operated by the device 44 either manually or automatically to a number of different positions to vary the pressure differential across the carburetor 11 and the mass flow rate. In each position, however, it is essential that the pressure in the conduit 21 upstream of the sonic nozzles is greater than the pressure required to establish the critical pressure differential across the sonic nozzles. The throttle valve 43 permits this variation in the mass flow rate through the carburetor 11 without upsetting the sonic flow condition through the sonic nozzles.

If it is desired to test the carburetor 11 at a fixed flow rate but with variable positions of its throttle valve 14, again the appropriate sonic nozzles are selected. The carburetor throttle valve 14 and the test apparatus throttle valve 43 are then manipulated. The carburetor throttle valve 14 is moved through the desired test pattern and the test apparatus throttle valve 43 is manipulated either manually or automatically by the master control 65 so as to maintain the critical pressure in the conduit 2.

It should be readily apparent that the test apparatus described also permits the carburetor 11 to be tested with both a variation in the setting of its throttle valve 14 and the mass flow rate through the carburetor induction passage. At all times, the test apparatus throttle valve 43 may be positioned to maintain the critical pressure in the conduit 21. In addition to adding this versatility to the test apparatus, the use of the test apparatus throttle valve 43 between the tested carburetor and the sonic nozzles permits a lesser number of sonic nozzles to be used by a given test procedure. This is true even when the apparatus is performing test procedures of the type which may be performed by the apparatus disclosed in the aforementioned copending application.

I claim:

1. A test apparatus for calibrating a charge-forming device having an induction passage, throttle valve for controlling the flow through the induction passage and a fuel discharge circuit for discharging fuel into the induction passage, 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, a sonic flow device interposed in said air conduit, said sonic flow device having an area wherein the flow velocity at said area is equal to the sonic velocity of the fluid flowing therethrough at a critical pressure differential and which velocity does not exceed said sonic velocity at a greater pressure differential than said critical pressure differential, throttle valve means interposed in said air conduit between said sonic flow device and the induction passage of the charge-forming device for changing the pressure drop across the charge-forming device and means for fuel the flue flow through the discharge circuit of the charge-forming device.

2. A test apparatus as set forth in claim 1 wherein the sonic flow device is positioned downstream of the base and of the charge-forming device induction passage, the throttle valve means being positioned between the charge-forming device induction passage and the sonic flow device, the means for inducing a flow through the charge-forming device induction passage comprising a vacuum pump positioned downstream of the sonic flow device.

3. A test apparatus as set forth in claim 1 wherein there are a plurality of sonic flow devices each sized to accommodate a different flow condition and valve means for controlling the flow through each of said sonic flow devices.

4. A test apparatus as set forth in claim 3 wherein there is one throttle valve means interposed between all of the sonic

nozzles and the charge-forming device.

5. The method of calibrating a charge-forming device over a simulated speed range at a fixed throttle valve setting wherein the charge-forming device has an induction passage, fuel discharge means for discharging fuel into the induction passage and throttle valve for controlling the flow through the induction passage, said method comprising the steps of placing the charge forming device induction passage in circuit with a sonic flow device having an area wherein the flow velocity at the area is substantially equal to the sonic velocity of the fluid flowing therethrough at a critical pressure differential which velocity does not substantially exceed the sonic velocity at a greater pressure differential than the critical pressure differential, establishing a flow through the charge-forming device induction passage and through the sonic flow device in series by establishing a pressure differential across the sonic flow device, throttling the flow in an area between the sonic flow device and the charge forming device induction passage independently of movement of the throttle valve of the charge forming device for altering the flow rate through the charge-forming device induction passage while maintaining at least the critical pressure difference across the sonic flow device, and measuring the flow of fuel discharged by the charge-forming device.

6. A method of calibrating a charge-forming device as set forth in claim 5 wherein the calibration is further accomplished over a range of settings of the throttle valve of the charge-forming device, said method further including the step of altering the position of the throttle valve of the charge-forming device and simultaneously varying the amount of throttling of the airflow to establish the desired flow rate through the charge-forming device induction passage at desired settings of the throttle valve of the charge-forming device while maintaining the critical pressure differential upon the sonic flow device.

7. The method of calibrating a charge-forming device at a fixed mass flow rate and over varying positions of the throttle valve of the charge-forming device wherein the charge-forming device includes an induction passage, fuel discharge means for discharging fuel into the induction passage and a throttle valve for controlling the flow through the induction passage, said method comprising the steps of placing the charge-forming device induction passage in circuit with a sonic flow device having an area wherein the flow velocity is substantially equal to the sonic velocity of the fluid flowing therethrough at a critical pressure differential and which velocity does not substantially exceed said sonic velocity at a greater pressure differential than said critical pressure differential, establishing a flow through the charge-forming device induction passage and through the sonic flow device, simultaneously altering the position of the charge-forming device throttle valve and throttling the established flow at a point between the sonic flow device and the charge-forming device induction passage for maintaining the desired flow rate while maintaining a critical pressure difference upon said sonic flow device, and measuring the rate of fuel discharge of the charge-forming device.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,604,254 Dated September 14, 1971

Inventor(s) Joseph Sabuda

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 5, line 9, "2" should be -- 21 --,
column 5, line 42 delete "fuel the flue" and
insert -- measuring the fuel --

Signed and sealed this 29th day of February 1972.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents