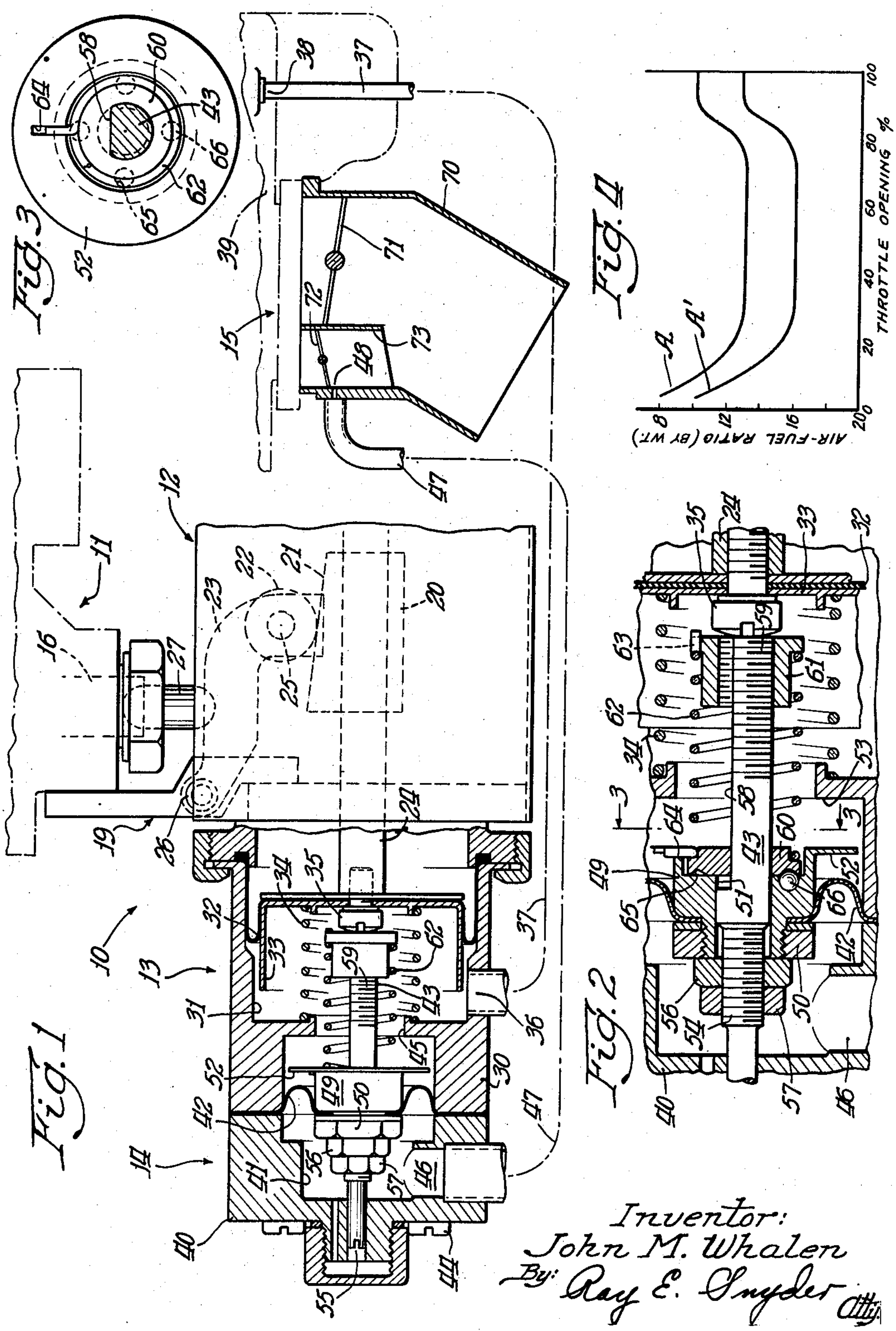
Sept. 22, 1964 J. M. WHALEN 3,149,619

FUEL INJECTION IDLE ENRICHMENT CONTROL MECHANISM

Filed Dec. 19, 1960



Inventor:
John M. Whalen
By: Ray E. Snyder
Atty.

United States Patent Office

3,149,619
Patented Sept. 22, 1964

3,149,619
FUEL INJECTION IDLE ENRICHMENT CONTROL MECHANISM

John M. Whalen, Decatur, Ill., assignor to Borg-Warner Corporation, Chicago, Ill., a corporation of Illinois

Filed Dec. 19, 1960, Ser. No. 76,758
3 Claims. (Cl. 123—140)

This invention relates to an idle control mechanism for a fuel injection system that is adapted to enrich or increase the output of a fuel injection pump during idle condition of the engine.

In the conventional internal combustion engine, it is necessary to enrich the fuel supplied during idle conditions primarily to compensate for exhaust gas dilution. This enrichment is necessary on carbureted engines as well as on engines equipped with fuel injection systems. The effect of exhaust gas dilution is as follows:

When the engine is operated at idle condition, the throttle valve is almost completely closed, and the pressure within the air-intake manifold is much lower than atmospheric pressure. The pressure within a combustion chamber or cylinder during an exhaust stroke, however, is close to atmospheric pressure. When the air-intake valve opens, a portion of the exhaust gas remaining in the cylinder expands into the air-intake manifold. During the remainder of the intake stroke, the exhaust gas is sucked back into the combustion chamber before a mixture of fresh air and fuel enters the chamber. The fuel-to-air ratio supplied under this condition must be increased or enriched to offset the effects of the inert exhaust gas which dilutes the explosive mixture. The amount of enrichment necessary is a function of idle speed and valve overlap. When the throttle valve is opened, the pressure within the air-intake manifold rises and the effect of exhaust gas dilution is diminished. The proportion of fuel supplied thereafter should be decreased to maintain the proper air-to-fuel ratio.

It is an object of the present invention to provide a control system for a fuel injection pump, including a mechanism responsive to throttle condition for delivering a metering bias force to the system during idle or closed throttle condition.

It is a more particular object to provide a control system adapted to control the output of a fuel injection pump, including a manifold pressure responsive control means for controlling the output of the pump, and an adjustable idle enrichment control means for exerting a bias force on the manifold pressure responsive servomotor during idle or closed throttle condition.

It is a still more particular object to provide a control mechanism for a fuel injection pump, including a movable cam adapted to control the output of the pump, a manifold pressure responsive control means having a flexible diaphragm for moving the cam, and an idle enrichment control means having a flexible diaphragm and an adjustable plunger effective to exert a bias force on the cam, the diaphragm of said idle enrichment control means being responsive to a differential in pressure between atmospheric pressure and manifold pressure during closed throttle condition, and being inoperative during open throttle condition.

The invention consists of the novel constructions, arrangements, and devices to be hereinafter described and claimed for carrying out the above-stated objects and such other objects as will appear from the following description of a preferred form of the invention, illustrated with reference to the accompanying drawings, wherein:

FIG. 1 is a schematic view, partially in section, of the improved control mechanism of the present invention;

FIG. 2 is an enlarged sectional view of a portion of the control mechanism of FIG. 1;

FIG. 3 is a view taken on line 3—3 of FIG. 2; and

FIG. 4 is a graph of the air-fuel ratio demand of an internal combustion engine as a function of throttle opening.

Description

Referring to FIG. 1, the complete control mechanism is designated generally by the numeral **10** and is adapted to control the output of a fuel injection pump **11**. The mechanism **10** comprises a computer or integrator section **12**, a manifold pressure responsive control means **13**, an idle enrichment control means **14** and a throttle body **15**.

The fuel injection pump **11** includes a metering valve or shuttle valve **16** for metering the size of fuel charges delivered by the pump **11**. The pump **11** is driven in a timed relationship with the engine cam shaft by any suitable means (not shown). The total fuel output of the pump increases directly with engine speed, but the size of the charges delivered to the engine cylinders depends upon operating conditions. The fuel output hereinafter referred to will be the charge size.

The computer section **12** comprises a casing **19** attached to the pump **11**, a movable cam **20** having a cam surface **21**, a cam follower **22** in contact with the cam surface **21**, and a cam follower arm **23** carrying the follower **22**. The cam **20** is attached to a connecting shaft **24** of the manifold pressure responsive control means **13**. The cam follower or roller **22** is rotatably mounted on a pin **25** carried by the arm **23**, and the arm **23** is pivotally disposed on a pin **26** mounted in the casing **19**. A connecting link **27** is disposed between the cam follower arm **23** and the metering valve **16** of the pump **11**. The link **27** is moved longitudinally by the cam follower arm **23** for controlling the output of the pump **11** as the cam **20** is moved longitudinally under the influence of the control means **13**.

The manifold pressure responsive control means **13** comprises a casing **30** formed with an internal chamber or cavity **31**, a flexible diaphragm **32**, a spring retaining cup **33**, and a spring **34**. The spring retaining cup **33** and diaphragm **32** are attached to connecting shaft **24** by means of a screw **35**. The casing **30** is attached to the casing **19** and is formed with a port **36** opening into the chamber **31**. The port **36** is connected by means of a conduit **37** to a port **38** in the air-intake manifold **39**.

The idle enrichment control means **14** comprises a casing **40** formed with an internal chamber or cavity **41**, a flexible diaphragm **42** and an adjustable plunger **43** carried by the flexible diaphragm **42**. The diaphragm **42** is sandwiched between the casings **30** and **40** which are fastened together by a plurality of machine screws **44**. The plunger **43** extends through an opening **45** formed in the wall of the casing **30** and is adapted to contact the head of the screw **35** for exerting a force on the connecting shaft **24** and cam **20**. The casing **40** is formed with a port **46** opening into the cavity **41** and this port is connected by means of a conduit **47** to a port **48** formed in the throttle body **15**.

Referring to FIG. 2, an enlarged sectional view of a portion of the idle enrichment control means **14** is shown. The plunger **43** is carried by a sleeve **49** which is attached to the diaphragm **42** by means of a nut **50**. The sleeve **49** is formed with a central cylindrical bore **51** through which the plunger **43** extends. The sleeve **49** is formed with a circular flange **52** which is adapted to abut against a shoulder **53** formed in the casing **30**. The plunger **43** is formed with external threads **54** and an end slot **55** for receiving a screwdriver or other suitable tool. The initial position of the plunger **43** with respect to the screw **35** is set by means of an adjusting nut **56** threaded on the threads **54**. This position is locked by means of a locking nut **57**.

The plunger **43** is also formed with a longitudinal flat or keyway 58 throughout a portion of its length and with external threads 59. A detent collar 60 is keyed to the plunger 43 and is adapted to slide longitudinally along the keyway 58. A threaded collar 61 is threaded on threads 59 on the end of the plunger 43 adjacent the head of screw 35, and a spring 62 surrounds the plunger 43 and is disposed under compression between the threaded collar 61 and the detent collar 60. The collar 61 is formed with a slot 63 for receiving one end of the spring 62, and the flange 52 is formed with a slot 64 for receiving the other end of the spring 62. The detent collar 60 is formed with a plurality of depressions 65 on one side thereof which coact with a detent ball 66 for releasably holding the collar 60 in any one of a plurality of positions.

Once the initial position of the plunger 43 has been set with respect to the screw 35 by means of the adjusting nut 56, the magnitude of the idle bias force is obtained by adjusting the compression of the spring 62. The calibration of the idle bias force is obtained by inserting a screwdriver in the slot 55 and turning the plunger 43 within the collar 61. Since the spring 62 is anchored at one end to the collar 61, turning the plunger 43 causes the collar 61 to move longitudinally along the threads 59 for either increasing or decreasing the compression of the spring 62. The detent collar 60 is turned with the plunger 43 and the compression of the spring 62 tends to force the collar 60 axially to the left, as shown. The plunger 43 and collar 60 are turned until the desired compression of the spring 62 is obtained and the ball 66 rests in one of the depressions 65 formed in the collar 60. The detent ball 66 functions to hold the calibration of the spring 62 unless or until this adjustment is changed by manual operation.

The effective area of the diaphragm 42 preferably is smaller than the effective area of the diaphragm 32, and the spring 62 is preferably of a comparatively low rate so that its force can be overcome during deceleration conditions as will be explained hereinafter.

The throttle body 15 comprises an air horn or casing 70 attached to the air-intake manifold 39, a large air throttle valve 71 and a small air throttle valve 72. The small air throttle valve 72 is disposed in a parallel air passage 73 formed within the casing 70 and is the primary control valve for regulating the amount of air entering the air-intake manifold 39. The valve 71 normally opens after the valve 72 is open a substantial amount. The port 48 is formed in the casing 70 at a point immediately adjacent the upper or upstream side of the throttle valve 72. When the throttle valve 72 is closed, the port 48 is subject to atmospheric pressure and when the valve is opened, the edge of the throttle valve blade passes beyond the port 48 so that the pressure developed at that point is substantially the same as the pressure within the air-intake manifold 39.

Operation

The control system 10 functions to meter the output of the pump 11 as follows:

When the engine is running, the pressure within the air-intake manifold 39 is less than atmospheric pressure and this pressure is transmitted through the conduit 37 to the control means 13. A differential in pressure between manifold pressure and atmospheric pressure is developed across the diaphragm 32. The force due to this differential in pressure tends to force the connecting shaft 24 and cam 20 to the left, as shown, against the action of the spring 34 and thereby tends to reduce the output of the fuel injection pump 11. The differential in pressure is determined by the speed of the engine and the degree of the opening of the throttle valves 72 and 71.

During idle conditions, both of the throttle valves 71 and 72 are substantially closed, the pressure within the air-intake manifold 39 is comparatively low, and the force due to the differential in pressure across the effective area of diaphragm 32 is comparatively large. The cam 20, therefore, is moved to the left tending to reduce the output of the pump 11.

As indicated above, it is necessary to enrich the fuel output during idle condition to compensate for exhaust gas dilution. The need for this enrichment is indicated by the graph of FIG. 4 which is a plot of the air-fuel ratio demanded by a fuel injection engine as a function of effective throttle opening. The upper curve on the graph shows the air-fuel ratio demand of a multi-cylinder engine with poor distribution, and the air-fuel ratio required at idle is indicated by the letter A. The lower curve shows the air-fuel demand of an ideal multi-cylinder engine. The demand of an engine equipped with fuel injection approaches the ideal because of its superior distribution. However, even for the ideal engine, considerable enrichment at idle is required, as indicated at A', because of exhaust gas dilution.

A bias force to produce the necessary enrichment during idle condition is provided by the control means 14. The bias force is developed by the spring 62, and a reaction base for the spring 62 is established by a pressure differential developed across the area of the diaphragm 42. Manifold pressure is applied through the control means 13 to the right side of the diaphragm 42. Atmospheric pressure is applied at closed throttle condition through the port 48 and conduit 47 to the left side of the diaphragm 42. The differential between atmospheric pressure and manifold pressure tends to force the diaphragm 42 and plunger 43 to the right until the flange 52 abuts against the shoulder 53. The end of the plunger 43 contacts the head of the screw 35 and exerts a bias force through the connecting shaft 24 on the cam 20. The plunger 43 is free to slide axially through the bore 51 against the action of the spring 62. The magnitude of the bias force so exerted, therefore, is determined by the calibration of the spring 62.

When the throttle valve 72 is opened, the blade of the valve opens past the port 48, the pressure in the conduit 47 becomes substantially equal to the pressure within the air-intake manifold 39, and the differential in pressure across the diaphragm 42 drops to zero. The reaction base for the spring 62 is thereby removed and the diaphragm 42 and plunger 43 are permitted to float freely without exerting any force on the cam 20. This condition persists until the throttle valve 72 is again closed.

The spring rate of the spring 62 is comparatively low so that the bias force can be overcome during deceleration. In addition, the diaphragm 42 is preferably of a smaller effective area than the diaphragm 32 so that the control means 14 is incapable of developing as much force as that developed by the control means 13.

During deceleration, both valves 71 and 72 are closed, and since the speed of the engine is normally greater than at idle speed, the pressure within the control means 13 and the air-intake manifold 39 is less than at idle condition. For deceleration condition, therefore, the force developed across the diaphragm 32 is sufficient to move the cam 20 and connecting shaft 24 to the left against the action of the spring 34 and servomotor 14 for leaning out or reducing the output of the pump 11. Since enrichment is desired during idle but not during deceleration, it is important that the control means 13 be effective to overcome the bias force of the control means 14 during deceleration.

There has been provided by this invention an improved control mechanism for a fuel injection pump that is effective to increase or enrich the output of the pump during idle condition, that is overcome during deceleration conditions, and that is completely ineffective during open throttle condition.

It is to be understood that the invention is not to be limited to the specific constructions and arrangements shown and described, except only insofar as the claims may be so limited, as it will be understood to those skilled in the art that changes may be made without departing from the principles of the invention.

What is claimed is:

1. In a control mechanism for a fuel metering device adapted to supply fuel to an internal combustion engine having an air-intake manifold and an air-throttle valve for controlling the flow of air into the manifold, the combination of a movable cam connected to the metering device for controlling the fuel output thereof, a manifold pressure responsive control means connected to said cam and adapted to move it in response to changes in manifold pressure, and an idle control means comprising a flexible diaphragm and a plunger carried by said diaphragm and adapted to exert a limited bias force on said cam, said plunger carrying resilient adjusting means for calibrating the amount of bias force to be exerted thereby, and said idle control means being operably connected by means of a conduit to a port adjacent the air-throttle valve and responsive to pressure determined by the position of the throttle valve for exerting the bias force during closed throttle condition.

2. In a control mechanism for a fuel injection pump adapted to supply fuel to an internal combustion engine having an air-intake manifold and an air-throttle valve for controlling the admission of air into the manifold, the combination of a movable element connected to the pump for controlling its output; a manifold pressure responsive control means connected to said element and adapted to move it in response to changes in manifold pressure; and an idle control means adapted to exert a limited force on said element during closed throttle condition, said idle control means comprising a casing, a flexible diaphragm mounted in said casing, an adjustable plunger carried by said diaphragm, and resilient adjusting means carried by said plunger for calibrating the amount of force to be exerted by the idle control means, a conduit connected to said idle control means and to a port in the air-intake manifold for applying manifold pressure to one side of said diaphragm, and a second conduit connected to said idle control means and to a port adjacent the air-throttle valve for exerting a different pressure on the other side of said diaphragm, the different pressure becoming substantially equal to manifold pressure upon opening of said throttle valve.

3. In a control mechanism for a fuel injection pump adapted to supply fuel to an internal combustion engine having an air-intake manifold and an air-throttle valve for controlling the admission of air into the manifold, the combination of a movable cam connected to the pump for controlling its output, a hollow casing, a flexible diaphragm mounted in the casing, a collar carried by said diaphragm, an adjustable plunger slidably disposed within said diaphragm and adapted to exert a limited force on said cam, adjustable resilient means carried by said plunger for calibrating the amount of force to be exerted thereby, means including a first conduit connected to said casing and to a port in the air-intake manifold for applying manifold pressure to one side of said diaphragm, and means including a second conduit connected to said casing, a port adjacent and upstream from the air-throttle valve for applying a different pressure on the other side of said diaphragm, whereby the pressure differential between manifold pressure and said different pressure is effective on said diaphragm to provide a reaction base for said plunger during closed throttle condition and the pressure differential becoming substantially zero upon opening of said throttle valve past said second port.

References Cited in the file of this patent

UNITED STATES PATENTS

1,960,432	Barker et al.	May 29, 1934
2,562,656	Blakeslee	July 31, 1951
2,798,469	Helmschrott et al.	July 9, 1957
2,808,819	Hagele et al.	Oct. 8, 1957
2,891,784	Taylor	June 23, 1959
2,894,735	Zupanic	July 14, 1959
2,908,491	Suozzo	Oct. 13, 1959
2,984,467	Cedarholm	May 16, 1961
3,064,636	Dahl	Nov. 20, 1962