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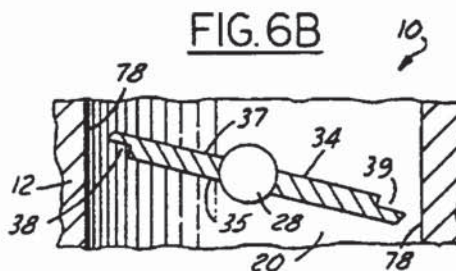
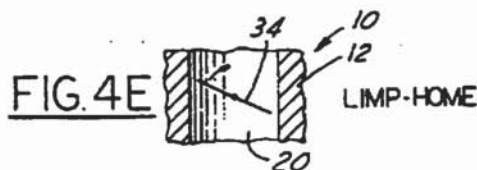
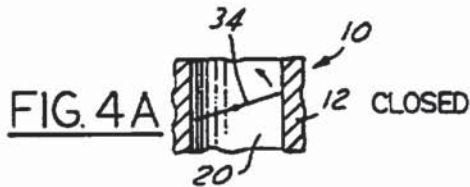
(58) Field of Search

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INT CL⁶ F02D 9/02 9/10 11/10
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(54) Abstract Title

A throttle valve for an internal combustion engine with a limp home position

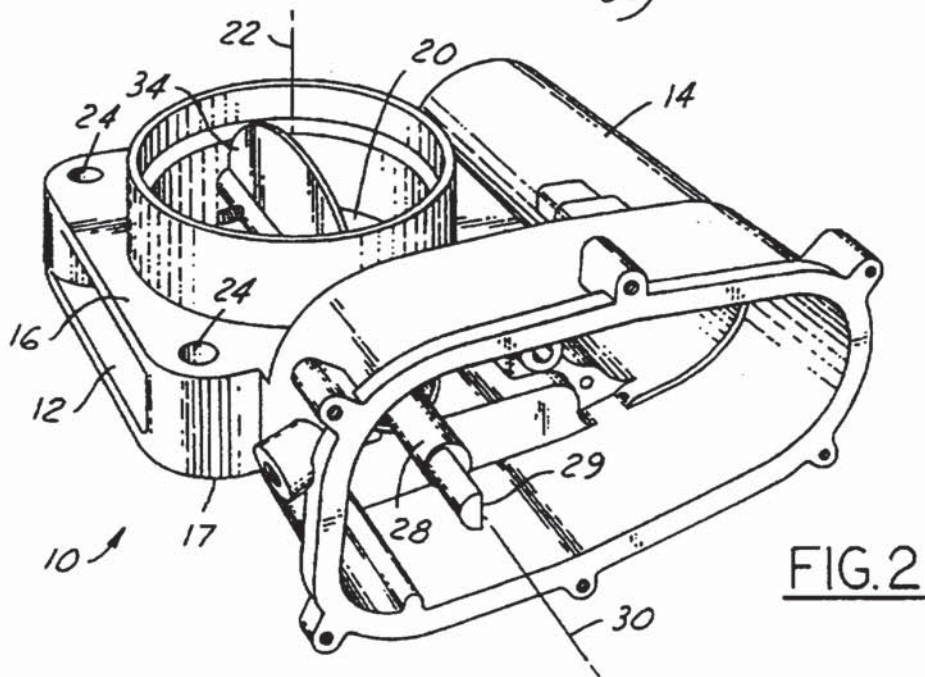
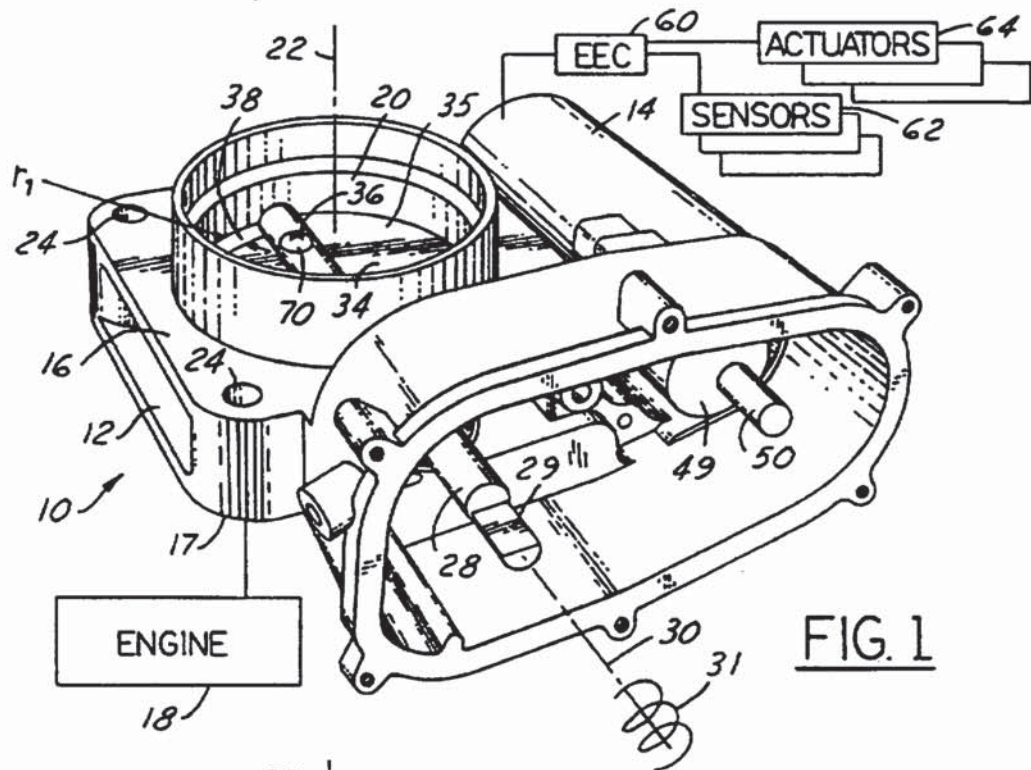
(57) An electronically controlled throttle valve 10 for an internal combustion engine comprises a throttle body 12 in which is located a throttle plate 34. The plate 34 is rotatable from an idle position (figure 4a) to a full power wide open position (figure 4c) and then past this on to a low power position which may provide a limp home mode (figure 4e). A biasing spring biases the plate 34 toward the low power position. Preferably the plate 34 has upper and lower surfaces with upper and lower reliefs 38, 39 respectively. The reliefs 38, 39 may be formed by stepped, curved or chamfered edge. In one embodiment the throttle plate may have an elliptical shape.

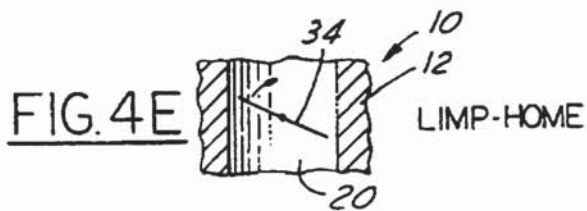
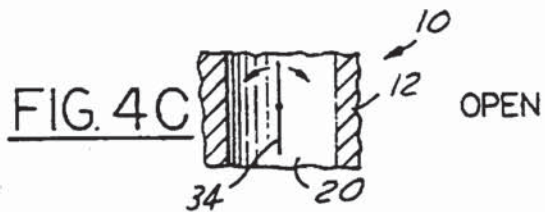
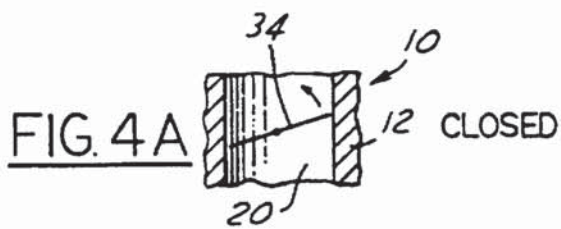
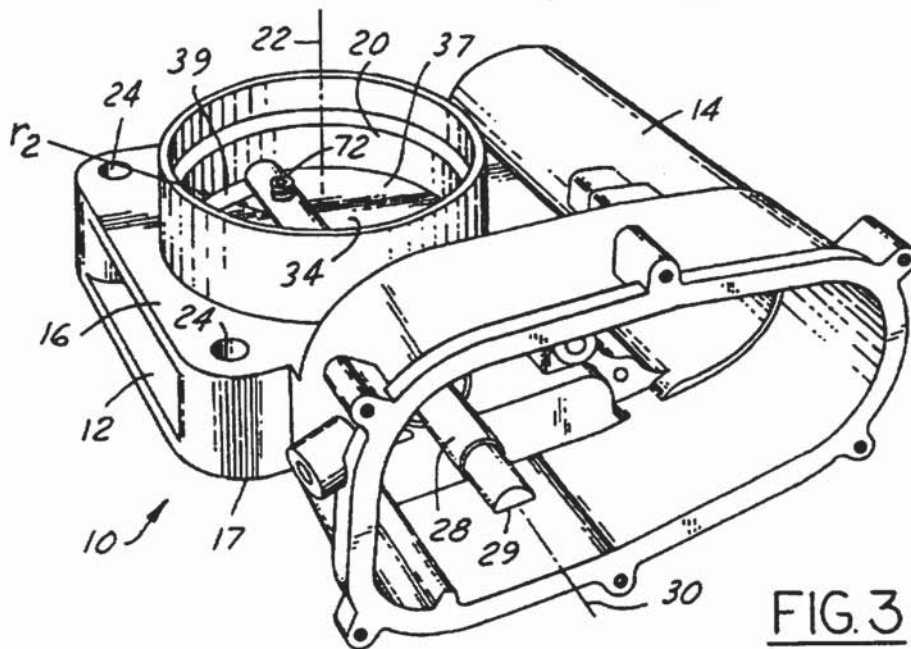


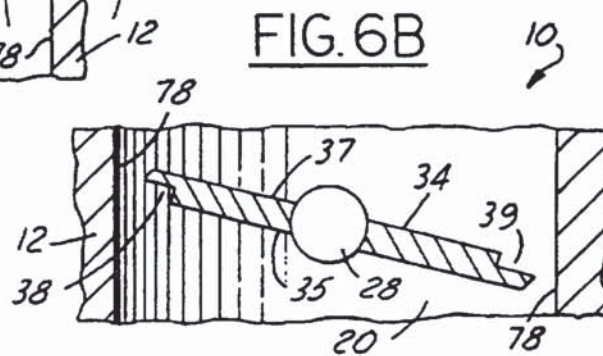
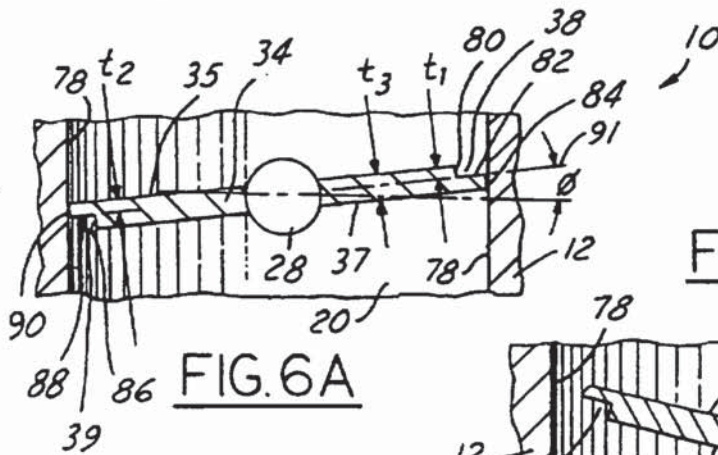
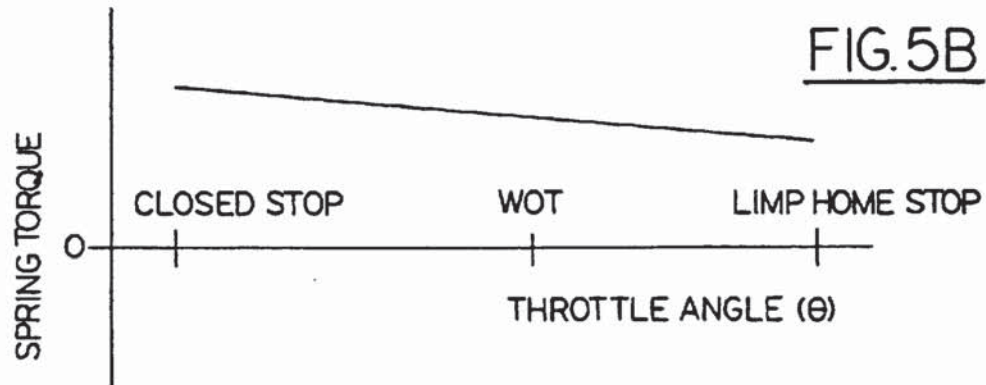
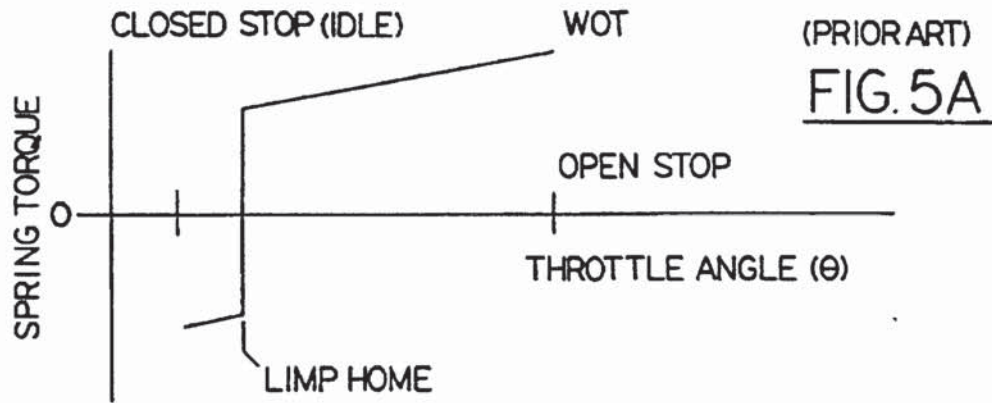
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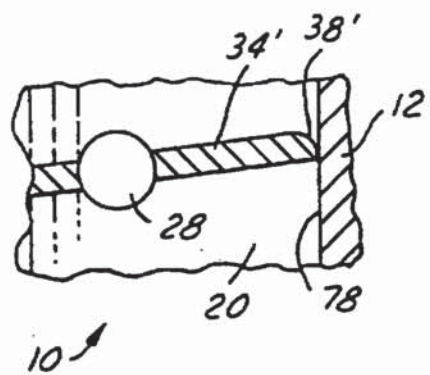
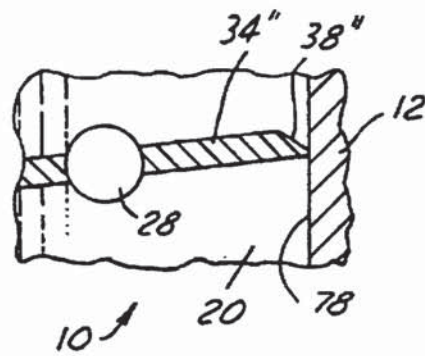


FIG. 7A

FIG. 7B



THROTTLE VALVE SYSTEM

Field of the Invention

5 The present invention relates to electronically controlled throttle valve systems for internal combustion engines.

Background of the Invention

10

Conventional vehicles are governed by the operator through the mechanical connection between the accelerator pedal and the throttle valve that controls the airflow entering the engine. When an electronically controlled throttle is used, the mechanical connection is replaced by an electrical connection. This gives the engine control system greater flexibility in delivering the operation requested by the driver while optimising constraints related to regulated emissions and fuel economy. However, an additional constraint when using an electronically controlled throttle is that the valve typically includes a so called, "limp home" position. This limp home position allows the throttle to return to a position to allow some airflow through the valve bore, thereby allowing greater valve control under certain engine operating conditions.

One approach to providing a limp home position is to use opposing biasing springs to urge the throttle plate to an intermediate position between the maximum power position (or maximum area position, typically termed WOT) and the minimum power position (or minimum area position). The intermediate position can be selected to provide just enough airflow to idle the engine and provide the limp home mode.

Another approach to providing a limp home position is to use a biasing spring that urges the throttle plate only in one direction to a position past the normally closed throttle position. In other words, the throttle plate is

able to rotate in the throttle bore through the closed position to a partially open position. This partially open position can be selected provide to just enough airflow to idle the engine and provide the limp home mode.

5 There are disadvantages with the above approaches. For example, when using opposing biasing springs to urge the throttle plate to an intermediate position between the maximum power position and the minimum power position, there is a discontinuity in the spring force at this intermediate
10 position. In other words, the spring force changes direction at this intermediate position. This causes poor closed loop control performance when the desired throttle plate position is near this intermediate position. The problem is exacerbated in that this intermediate position is
15 selected to be near the normal idling position, which is where throttle plate control is critical. Thus, the total engine control system is extremely sensitive to this discontinuous spring force during a critical engine operating mode. This may cause poor engine idle quality and
20 low customer satisfaction.

Another disadvantage is that the intermediate limp home position can not be easily adjusted. Changing the intermediate position requires changing hardware in a complex mechanism.

25 When using a biasing spring that urges the throttle plate only in one direction to a position past the closed throttle position, the engine control problem near idle is reduced; however, another control problem becomes more apparent. In particular, it is sometimes necessary to
30 completely restrict the throttle airflow to control the engine due to very low airflow requirements and leaks caused by other air sources, such as, for example, fuel purging and vacuum actuators. Thus, because this prior art does not have a "No Flow" position, the minimum flow position must be
35 adaptively learned as the components wear, expand and contract due to temperature variations, and move do to manufacturing tolerances. In addition, decreasing the flow

at the minimum flow position requires increasingly complex and expensive manufacturing processes because the throttle plate must be a perfect circle at the edge with, ideally, infinitesimally small thickness. Indeed, because the
5 throttle plate must rotate through the closed position, it is impossible to completely seal the throttle plate relative to the throttle bore.

Yet another disadvantage is that while the limp home position may be easily adjusted, the minimum flow position
10 can not be easily adjusted. Changing the minimum flow position requires changing hardware and manufacturing processes.

Object of the invention

15

The invention seeks to provide a throttle valve system for an internal combustion engine that provides a limp home position, allows for simple electronic control, and is easily manufactured.

20

Summary of the invention

According to a first aspect of the present invention, there is provided an electronically controlled throttle
25 valve for use with an internal combustion engine, said valve comprising:

a throttle body adapted for communication between an intake port of the engine and an ambient atmosphere;

a throttle plate located in said throttle body, with
30 said throttle plate rotating from an idle position to a full power position and on to a low power position, with said full power position being between said idle position and said low power position; and

a biasing spring biasing said throttle plate toward
35 said low power position.

In accordance with a second aspect of the invention, there is provided an electronically controlled throttle valve for use with an internal combustion engine, said valve comprising:

5 a throttle body adapted for communication between an intake port of the engine and an ambient atmosphere;

a throttle plate located in said throttle body, said throttle plate having an upper plate surface having an upper relief and a lower plate surface having a lower relief, with
10 said reliefs allowing said throttle plate to rotate through a full power position; and

a biasing spring biasing said throttle plate away from a normal operating range through said full power position to a low power position.

15

By using a biasing spring urging the throttle plate only in one direction, the controllability problems due to opposing spring forces is avoided. Also, by having the limp home position past the maximum power position, the necessity
20 and associated manufacturing difficulties with moving the throttle plate through the closed (or minimum flow area) are avoided. Further, a closed in bore, or zero flow, position is possible without addition mechanisms or complex manufacturing.

25

Brief description of the drawings

The invention will now be described further, by way of example, with reference to the accompanying drawings, in
30 which:

Figures 1-3 are perspective views of various operating positions of a throttle valve of the present invention;

Figures 4a-4f are cross-sectional views showing a comparison of throttle plate positions between prior art
35 valves and the valve of the present invention;

Figures 5a-5b are plots of the spring torque versus the throttle plate angle for prior art valves and a valve of the present invention;

Figures 6a-6b are cross-sectional views showing
5 enlarged views of a throttle plate; and

Figures 7a and 7b are partial cross-sectional views showing enlarged views of alternative embodiments of the invention.

10 Detailed Description of the Preferred Embodiments

Referring to Figures 1-3, an electronic throttle valve
10 includes throttle body 12 coupled to motor housing 14.
The throttle body 12 has an upper flat surface 16 adapted to
15 be connected to an air induction system (not shown) and a
lower flat surface 17 adapted to be connected to engine 18.
The throttle body 12 has a throttle bore 20 with a bore
centreline 22 axially located perpendicular to the upper
flat surface 16. The throttle body 12 also has mounting
20 holes 24 axially located perpendicular to the upper flat
surface 16. A throttle shaft 28 is mounted in the throttle
body 12 for rotation about an axis 30, which is generally
parallel to upper flat surface 16 and the lower flat surface
(not shown). The shaft 28 also has a notch 29 adapted to be
25 connected to a motor drive train (not shown for the sake of
clarity). A throttle plate 34 is connected to the throttle
shaft 28 by screws 36. The throttle plate 34, which has an
elliptical exterior shape, has an upper throttle surface 35
and a lower throttle plate surface 37. The shaft 28 is also
30 connected to a biasing spring 31 for urging throttle plate
34 towards a limp home position, shown in Figure 3 and more
particularly described later herein.

The throttle plate 34 also has an upper relief 38
(shown in this example as a stepped edge) in upper throttle
35 plate surface 35 and a lower relief 39 (also shown in this
example as a stepped edge) in lower throttle plate surface
37, which allows throttle plate 34 to seal with throttle

bore 20 with an easily manufactured geometry. Thickness t_1 (see Fig. 6a) of upper stepped edge 38 and thickness t_2 (see Fig. 6a) of lower stepped edge 39 are equal such that the total thickness t_3 of throttle plate 34 is the sum of
5 thickness t_1 and t_2 . Upper stepped edge 38 also has constant radial width r_1 (see Fig. 1) which is equal to constant radial width r_2 (see Fig. 3) of lower stepped edge 39. Upper stepped edge 38 extends approximately half way around throttle plate 34, starting and ending at throttle
10 shaft 28. Similarly, upper stepped edge 39 extends approximately half way around throttle plate 34, starting and ending at throttle shaft 28. However, lower stepped edge 39 is on the opposite side of shaft 28 as upper stepped edge 38. The stepped edges 38, 39 allow throttle plate 34
15 to rotate past a full open position (see Fig. 2) to a limp home position (see Fig. 3), which will be described later herein with particular reference to Figures 6a-6b. Motor housing 14 surrounds electric motor 49 (see Fig. 1) with output shaft 50 axially located parallel to axis 30 of shaft
20 28 to drive shaft 28 via the not shown drive train. The electric motor is controlled by powertrain control module (PCM) 60. PCM 60 also communicates with various sensors 62 and actuators 64.

Referring now specifically to Figure 1, valve 10 is
25 shown in an idling engine operating condition. Throttle plate 34 is in a position that allows a small amount of airflow necessary for maintaining idling operation of the engine. Screws 36 are in a position where screw head 70 is shown, along with upper throttle surface 35 and upper
30 stepped edge 38.

Referring now specifically to Figure 2, valve 10 is shown in a near maximum power position, where throttle plate 34 has been rotated approximately a quarter of a full rotation from the position shown in Figure 1. Throttle
35 plate 34 is in a position that allows near maximum airflow.

Referring now specifically to Figure 3, valve 10 is shown in the limp home position in which throttle plate 34

has been rotated nearly one half of a full rotation from the position shown in Figure 1 and approximately one quarter of a full rotation from the position shown in Figure 2. Screws 36 are in a position where bottom screw portion 72 is shown, along with lower throttle surface 37 and lower stepped edge 39. Of course, to obtain the limp home position, some airflow is necessary. Thus, plate 34 is prevented from fully closing off airflow through bore 20 by the use of appropriately positioned throttle plate limp home stop (not shown)

Referring now to Figures 4a-4f and specifically to Figure 4a, the closed in bore position of throttle plate 34 is shown for the present invention with an arrow indicating the allowed direction of travel. Referring now to Figure 4b for comparison, the closed in bore position of a throttle plate is shown for the prior art along with an arrow indicating the allowed direction of travel. Referring now to Figure 4c, the open throttle position of throttle plate 34 is shown for the present invention with arrows indicating the allowed directions of travel. In particular, the present invention has a throttle plate 34 that can move away from the open throttle position in either direction. This ability is due to upper stepped edge 38 and lower stepped edge 39, which will be described later herein with particular reference to Figures 6a-6b. Referring now to Figure 4d for comparison, the open throttle position of a throttle plate is shown for the prior art with an arrow indicating the allowed direction of travel. Referring now to Figure 4e, the limp home throttle position of throttle plate 34 is shown for the present invention with an arrow indicating the allowed direction of travel. This limp home position is approximately one half of a complete rotation from the closed in bore position. Referring now to Figure 4f for comparison, the limp home throttle position of a throttle plate is shown for the prior art with an arrow indicating the allowed directions of travel, with the limp

home position being in between the minimum and maximum airflow positions.

Referring now to Figures 5a-5b and specifically to Figure 5a, a plot of the spring torque on a throttle plate versus the throttle angle of rotation (θ) is shown for prior art systems. When the throttle valve of prior art systems is under no external forces (i.e. from the not shown motor), the throttle plate will move in a direction of less absolute value of spring torque. Thus, the rest position, under no external force, is the limp home position. In particular note the change in spring torque direction at the limp home position, which is between the closed position (closed stop) and the maximum open position (open stop). Also, this limp home position is in the range of positions experienced during engine idling operation. Referring now to Figure 5b, a plot of the spring torque on throttle plate 34 versus the throttle angle of rotation (θ) is shown for the present invention. When throttle valve 10 is under no other external force, throttle plate 34 will move in the direction of decreasing the spring torque until throttle plate stops at the limp home position, which is past the maximum airflow position. In other words, throttle plate 34 will move to the limp home position when under no other external force other than the spring torque.

Referring now to Figures 6a-6b, cross-sectional views of valve 10 are shown. In Figure 6a, a cross-sectional view of throttle plate 34 in the closed position described previously herein with particular reference to Figure 4a is shown. The cross section shown represents a planar cross-section of valve 10 parallel to bore centreline 22 and perpendicular to shaft axis 30 along throttle shaft 28. Upper stepped edge 38 has first edge 80 which is perpendicular to upper plate surface 35 as well as perpendicular to lower plate surface 37. In addition, upper stepped edge 38 has second edge 82 which is parallel to both upper plate surface 35 and lower plate surface 37. Upper stepped edge 38 also has third edge 84 which is parallel to

bore surface 78. Lower stepped edge 39 has fourth edge 86 which is perpendicular to upper plate surface 35 as well as perpendicular to lower plate surface 37. In addition, lower stepped edge 39 has fifth edge 88 which is parallel to both upper plate surface 35 and lower plate surface 37. Lower stepped edge 39 also has sixth edge 90 which is parallel to bore surface 78 and third edge 84. The second edge 82 and fifth edge 88 lie in the same plane along centreline 92 of plate 34. Figure 6b represents valve 10 when throttle 34 is in the limp home position.

As previously described, thickness t_1 of upper stepped edge 38 and thickness t_2 of lower stepped edge 39 are equal such that the total thickness t_3 of throttle plate 34 is the sum of thickness t_1 and t_2 . The thickness t_3 is preferably defined by the following equation:

$$t_3 < D \times \tan \emptyset, \text{ where:}$$

D is the diameter of throttle bore 20; and,

\emptyset is the angle of the throttle plate when in the closed position.

Turning now to Figures 7a and 7b, alternative embodiments of the present invention are shown. For the sake of clarity, only one side of plate 34 in bore 20 is shown in Figs. 7a and 7b. In Fig. 7a, relief 38 is formed as a curved edge 38' in upper throttle plate surface 35. The curvature is sized so as to allow plate 34 to operate past the maximum power position as previously described. In Fig. 7b, relief 38 is formed as a chamfered edge 38'' in upper throttle plate surface 35. The chamfer is sized so as to allow plate 34 to operate past the maximum power position as previously described. Of course, those skilled in the art will recognise in view of this disclosure that other configurations for relief 38 may be used which will allow plate 34 to operate past the maximum power position as described in this specification.

CLAIMS

1. An electronically controlled throttle valve for use with an internal combustion engine, said valve comprising:
 - 5 a throttle body adapted for communication between an intake port of the engine and an ambient atmosphere;
 - a throttle plate located in said throttle body, with said throttle plate rotating from an idle position to a full power position and on to a low power position, with said
 - 10 full power position being between said idle position and said low power position; and
 - a biasing spring biasing said throttle plate toward said low power position.
- 15 2. An electronically controlled throttle valve for use with an internal combustion engine, said valve comprising:
 - a throttle body adapted for communication between an intake port of the engine and an ambient atmosphere;
 - a throttle plate located in said throttle body, said
 - 20 throttle plate having an upper plate surface having an upper relief and a lower plate surface having a lower relief, with said reliefs allowing said throttle plate to rotate through a full power position; and
 - a biasing spring biasing said throttle plate away from
 - 25 a normal operating range through said full power position to a low power position.
3. A throttle valve as claimed in Claim 2, wherein each said relief is formed as a stepped edge.
- 30 4. A throttle valve as claimed Claim 2, wherein each said relief is formed as a curved edge.
5. A throttle valve as claimed Claim 2, wherein each
- 35 said relief is formed as a chamfered edge.

6. A throttle valve as claimed in of claims Claim 2 to 5, wherein said upper relief extends over approximately half said throttle plate.

5 7. A throttle valve as claimed Claim 6, wherein said lower relief extends over approximately half said throttle plate.

8. A throttle valve as claimed in Claim 7, wherein
10 said lower relief occupies an opposite side of said throttle plate from said upper relief.

9. A throttle valve as claimed in any preceding claim, wherein said biasing spring urges said throttle plate
15 in only one direction.

10. A throttle valve as claimed in any preceding claim, wherein said throttle body portion has a cylindrical throttle bore.

20

11. A throttle valve as claimed in any preceding claim, wherein said throttle plate has an elliptical shape.

12. An electronically controlled throttle valve for
25 use with an internal combustion engine constructed and adapted to operate substantially as herein described with reference to and as illustrated in Figs 1, 2, 3, 4A, 4C, 4E, 5B, 6A, 6B, 7A and 7B of the accompanying drawings.

30



Application No: GB 9916618.3
Claims searched: 1-12

Examiner: David Glover
Date of search: 4 October 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): F1B BBA, BBB, BBC, BBD

Int Cl (Ed.6): F02D 9/02, 9/10, 11/10

Other: Online: EPODOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	GB 2252641 A (Weber)	
A	EP 0466227 A (General Motors) note rotational range of valve and chamfered peripheral edge	
A	DE 4039937 A (Audi) note limp home throttle position is before idle position	
A	US 5778853 (Saito) note fail safe and limp home modes	

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.

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E Patent document published on or after, but with priority date earlier than, the filing date of this application.