

June 15, 1943.

F. C. MOCK

2,322,195

THROTTLE CONTROL FOR INTERNAL COMBUSTION ENGINES

Filed April 10, 1941

2 Sheets-Sheet 1

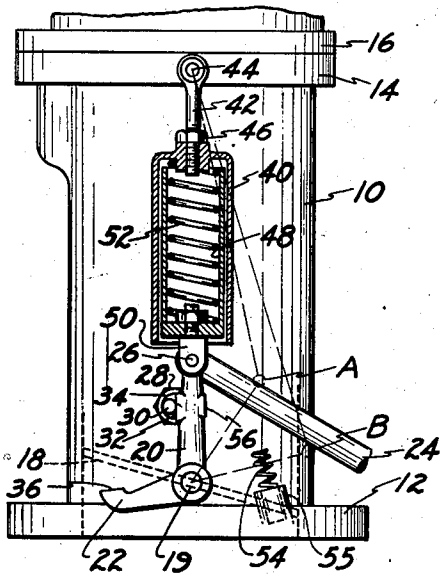


FIG. 1

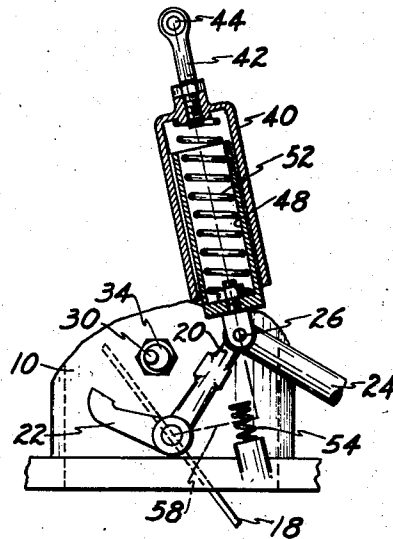


FIG. 2

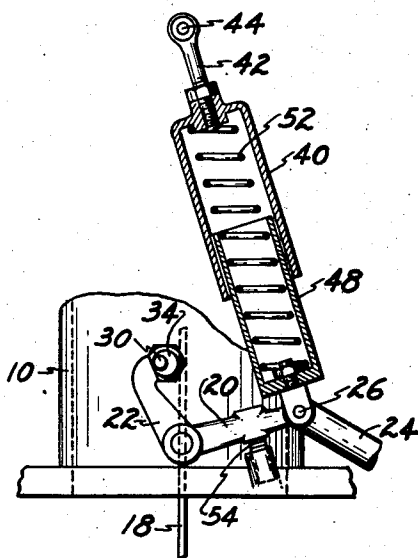


FIG. 3

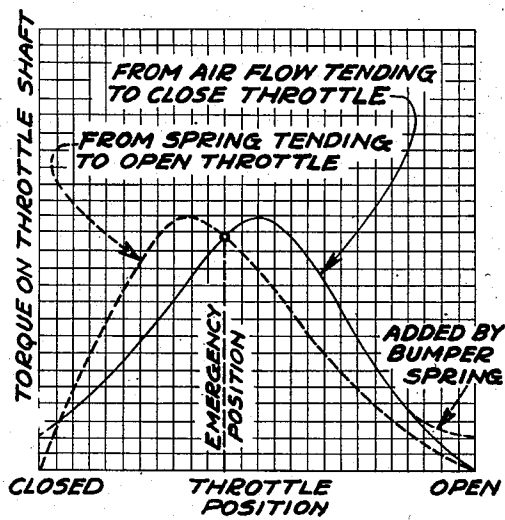


FIG. 4

INVENTOR
FRANK C. MOCK
BY *W. M. Crady*
ATTORNEY

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F. C. MOCK

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2 Sheets-Sheet 2

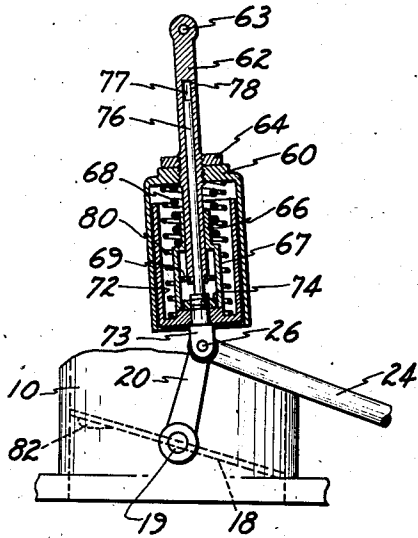


FIG. 5

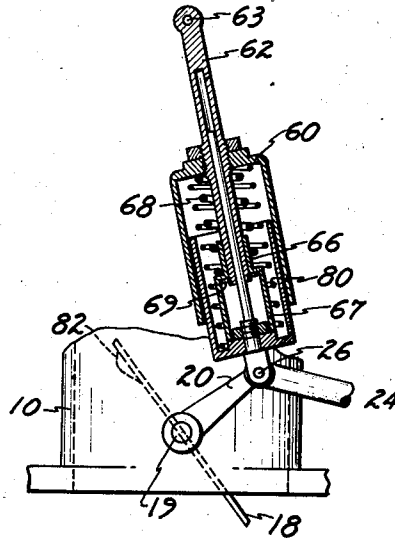


FIG. 6

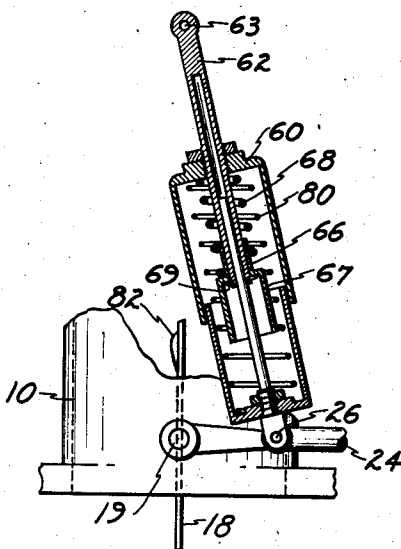


FIG. 7

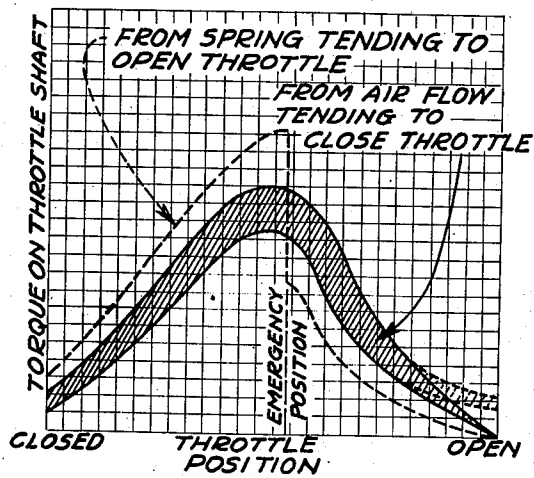


FIG. 8

INVENTOR
FRANK C. MOCK
BY *A R M Crady*
ATTORNEY

UNITED STATES PATENT OFFICE

2,322,195

THROTTLE CONTROL FOR INTERNAL
COMBUSTION ENGINES

Frank C. Mock, South Bend, Ind., assignor to
Bendix Aviation Corporation, South Bend, Ind.,
a corporation of Delaware

Application April 10, 1941, Serial No. 387,803

20 Claims. (Cl. 137—139)

This invention relates to throttle controls for internal combustion engines and more particularly for aircraft engines.

Air currents and eddies resulting from the flow of air past a throttle valve of an internal combustion engine create a force or torque tending to move the valve toward either closed or open position depending upon the type of valve, its shape, and the manner in which it is mounted in the passage. For example, with a butterfly valve of the so-called balanced type in which the throttle shaft is centrally positioned in the passage, air currents create a torque tending to close the valve which varies with throttle position and reaches a maximum value when the throttle is in an approximately half-open position. Thus, a geometrically balanced throttle may be dynamically unbalanced. This maximum value, particularly in large engines, is of considerable magnitude and requires large actuating forces and heavy throttle control linkages to overcome it in positioning the throttle.

Furthermore, during periods of operation, the vibration of the engine together with this unbalanced closing torque may cause the throttle to creep toward closed position. Likewise, if the pilot's control is ruptured either by vibrations of the engine or, in the case of military aircraft, by a bullet or other projectile, the unbalanced closing torque will close the throttle, leaving the pilot with insufficient power to continue flight until a suitable landing field is available.

In some cases a spring has been provided which tends to open the throttle to its full open position if the normal throttle control ruptures. Thus, upon failure of the pilot's control the throttle opens automatically and allows the engine to develop its full power, whereby the pilot can maneuver the airplane and continue his flight until a landing field is available. This arrangement, however, is without any appreciable beneficial effect in reducing the actuating forces which the pilot must exert through the control mechanism to manipulate the throttle. The spring counterbalances, or slightly overbalances the maximum air closing force, as at half-throttle, thus reducing the necessary throttle operating forces through this range. However, when the throttle is near closed or wide open position the air force on the throttle is small but the spring force is large. The throttle actuating force to overcome the spring through these throttle ranges is as great or greater than the maximum air force. The maximum force which the pilot must exert in positioning the throttle is, there-

fore, at least as great as is necessary without the spring.

The use of a spring to fully open the throttle is open to a further objection in modern supercharged engines which are capable of developing their rated power up to a predetermined or rated altitude. At altitudes less than rated, the opening of the throttle should not exceed a definite partial opening to avoid too high a charge pressure which may damage the engine. A boost control is provided on some engines which automatically limits the throttle opening so that the charge pressure does not exceed some predetermined value. In other installations, it is the pilot's responsibility not to open the throttle beyond a position which produces the maximum permissible charging pressure.

If a spring is used with such supercharged engines to fully open the throttle upon rupture of the throttle controls, the engine becomes charged under too great a pressure at all altitudes below the rated altitude. This excess pressure can damage the engine and render it inoperative, thus defeating the purpose of the throttle opening spring.

It is, accordingly, an object of the present invention to provide a throttle control device which will at least partially balance the unbalanced force created by airflow past the throttle tending to move the throttle.

It is a further object of the invention to at least partially balance the air force on a throttle throughout the throttle operating range so that the throttle position may be adjusted by the application of a moderately small force to the throttle control mechanism.

It is a further object of the invention to reduce the force which the pilot must exert to move the throttle valve of the engine.

It is a still further object of the invention to provide a means for automatically positioning the throttle of an engine at a predetermined opening if the throttle control is ruptured.

It is another object of the invention to provide a combination throttle balancer and emergency throttle-position selector.

Further objects and advantages of the invention will be apparent from the following description taken in conjunction with the accompanying drawings wherein:

Figure 1 is an elevational view, partly in section, of a device embodying one modification of the invention;

Figures 2 and 3 are similar views of the modi-

fication of Figure 1 with the throttle in a partly open and wide open position respectively.

Figure 4 is a diagram illustrating the forces acting on the throttle in the modification of Figures 1-3;

Figures 5, 6 and 7 are elevational views, partly in section, of a device embodying another modification of the invention and respectively showing the parts in their relative positions at closed, partly open, and wide open throttle positions; and

Figure 8 is a diagram illustrating the forces acting on the throttle in the modification of Figures 5-7.

Referring more particularly to Figure 1 there is shown a throttle body 10 having flanges 12 and 14 whereby the body 10 is adapted to form a portion of the induction passage of an internal combustion engine. For example, the flange 12 may be bolted to the supercharger or directly to the intake manifold of an engine and a fuel supplying device may be bolted to flange 14 as indicated at 16; or the flange 12 may be bolted to the fuel supplying device and the flange 14 to an air entrance or air scoop section. Generally the throttle body 10 forms a portion of the carburetor or charge forming device.

A throttle valve 18 controls the flow of air or mixture to the engine and is secured to a shaft 19 which is pivotally mounted in the body 10. As shown, the throttle shaft 19 is centrally mounted in the passage of body 10 and the throttle is, therefore, generally referred to as a balanced throttle; however, the shaft could be slightly offset to the right or left, if desired, to create an unbalanced valve of the suction-closing or suction-opening type. A lever having arms 20 and 22 is secured to the throttle shaft and may be actuated by the pilot or operator to control the position of the throttle through a control rod 24 pivotally connected to the lever at 26. An adjustable rotary stop member 28 is mounted on the body 10 and has an eccentric portion 30 adapted to engage a flange 32 on arm 20 to adjust the closed or idling position of the throttle. The member 28 also has a concentric stop portion 34 adapted to engage the flange 36 of arm 22 when the throttle reaches wide open position, as shown in Figure 3. Rotation of the member 28 thus variably limits the closing movement of the throttle without disturbing the wide open throttle stop setting.

A cylindrical cup-like member 40 threadedly receives a bolt 42 which is pivoted to the throttle body or other fixed member at 44, the threaded connection providing an adjustment which may be locked by a lock nut 46. A second cylindrical cup-like member 48 is slidably received within the member 40 to form a telescoping or collapsible link therewith and is pivotally connected to the lever arm 20 by a stud 50 fastened securely to the base of the member 48. A spring 52 within the cup members urges the members apart and, particularly when the throttle is partially open, urges the lever 20 in a direction to open the throttle. The throttle opening torque so created will be determined by the force of the spring and its effective movement or lever arm on the throttle shaft 19.

A bumper type compression spring 54 is received in a recessed boss 55 and is adapted to engage the flange 56 on the throttle lever arm 20 as the throttle approaches wide open position, as shown in Figure 3, to urge the throttle toward closed position. As will be later apparent, any other

type of spring, such, for example, as a torsion spring acting on the throttle shaft or a tension type throttle return spring acting on control rod 24, could be used to create a force tending to close the throttle at wide open throttle position.

The diagram of Figure 4 illustrates the various forces or torques acting on the geometrically balanced or centrally mounted throttle valve of Figures 1-3. In solid line is shown the torque created by air flow past the throttle during normal operation tending to close the throttle. When the throttle approaches wide open position the bumper spring adds to the air flow torque an increment indicated in Figure 4 by the dotted extension of the solid curve.

With the throttle substantially closed for idling operation, as shown in Figure 1, the spring 52 is highly compressed and exerts a relatively large force; however, the axis of members 40 and 48 extends through or closely adjacent to the center of the shaft 19 and provides a zero or very small effective movement arm and consequently the spring produces very little torque tending to move the throttle, as indicated by the point of beginning of the dotted curve of Figure 4.

As the throttle opens from closed position and the arm 20 moves toward the position indicated at A of Figure 1 and shown in Figure 2, the effective moment arm of the spring force increases at a relatively rapid rate, whereas the spring length increases, and consequently the spring force decreases, at a relatively slow rate. This results from the fact that during this portion of the throttle movement the point 26 is traversing the top portion of its arcuate path in which its component of movement to the right is moderately large and its component of movement downwardly is relatively small. In the position shown in Figure 2, the spring 52 has elongated a relatively small amount and its effective lever arm relative to shaft 19 has increased to a substantial value, as shown by the dotted line indicated by the numeral 58 in Figure 2. The throttle opening torque thus increases rather rapidly as the throttle opens from the closed position as indicated by the dotted curve in Figure 4.

As the throttle 18 and arm 20 move from position A to position B of Figure 1, the latter position corresponding to wide open throttle as shown in Figure 3, the point 26 moves downwardly at a rapid rate, thus rapidly decreasing the spring force, and to the right at a slow rate, thus slowly increasing the effective lever arm. The throttle opening torque thus decreases and approaches zero as the spring 52 approaches its free length, as indicated by the decreased value of the dotted curve of Figure 4 as the throttle moves from an intermediate toward a fully open position.

The unbalanced torque acting on the throttle is thus reduced by the instant invention from the torque value represented by the solid curve to the torque represented by the difference between the solid and dotted curves. It is to be noted, however, that the torque characteristic resulting from the spring and the variable effective lever arm between cylinders 40 and 48 and lever 20 may be readily controlled and varied by adjusting the spring characteristic and the limits of the effective lever arm. If desired, a torque characteristic resulting from the spring could be provided which at all throttle positions would substantially balance the torque characteristic resulting from air flow.

The spring and lever arm arrangement of Figures 1-3, in addition to partially balancing the

throttle, also serves as an emergency throttle-positioning device in the event the throttle control rod breaks or is shot away. If this occurs while the engine is being operated at a moderate throttle opening, the spring force, being greater than the air force, will open the throttle to a position corresponding to the intersection of the solid and dotted curves and labeled "emergency position" in Figure 4. Similarly, if rupture of the control occurs when the throttle is open beyond the "emergency position" the air force, being greater than the spring force, will close the throttle to the "emergency position." The throttle is thus positioned at an intermediate opening at which ample power is developed to continue flight or to maneuver for a landing without danger of overcharging the engine at ground level or altitudes below rated altitude.

It may be noted in Figure 4 that if rupture occurred while the throttle was fully closed the throttle would not open, since the air force exceeds the spring force. This may be avoided by having the axis of members 40 and 48 approach but not attain alignment with the axis of shaft 19 when the throttle is closed, as is particularly shown in the modification of Figure 5. The initial point of the spring force curve may thus be moved upwardly any desired amount.

When the throttle is wide open there is very little force, if any, resulting from air flow tending to close the throttle; consequently the throttle might tend to remain wide open if fracture of the control occurred. To avoid this possibility, a bumper or other type of spring may be utilized to urge the throttle from the wide open position toward a closed position. This may also be accomplished by anchoring the ends of spring 52 in the members 40 and 48 and having the spring designed to reach its free length at a throttle position less than wide open and to become a tension spring urging the throttle closed at throttle positions beyond the free length position.

In Figures 5-7 there is disclosed a modification of the instant invention which, as will later become apparent, substantially balances the throttle while providing a more positive throttle positioning device for emergency use.

With reference to Figures 5-7 there is shown a cylindrical cup-like member 60 threadedly received on a bolt 62 which is pivotally mounted on the body 10 or other fixed member at 63. A nut 64 locks the member 60 in its adjusted position on the bolt. A collar 66 having an enlarged cylindrical extension 67 is slidably received on the lower portion of bolt 62 and is urged downwardly by a spring 68 acting between the member 60 and the collar. A pin 69 or other stop means is provided in the bolt 62 to limit the downward movement of the collar 66.

A second cup-like member 72 is slidably received within the member 60 and is pivotally secured to the throttle lever 20 at 26 by a stud 73 and nut 74. The stud 73 has a rod-like extension 76 which is slidably received in a bore 77 of the bolt 62, a port 78 being provided to vent the air from the bore 77. The port 78 may be very small, or eliminated if desired, to obtain a dashpot effect tending to damp relative movement of the members 60 and 72. A spring 80 is provided within the members 60 and 72 tending to urge them apart and thus tending to open the throttle. When the throttle is closed, as shown in Figure 5, the cylindrical extension 67 of the collar 66 is engaged by the base of the cup-like member 72 and compresses the spring 68 which thus adds its force to the force

of spring 80 tending to separate members 60 and 72 to thereby open the throttle.

An air foil section 82 is secured to or formed integrally with the lower face of the throttle valve 18, whereby a force is created by air flow therepast at wide open throttle position tending to close the throttle. The purpose of the airfoil section 82 is thus similar to that of the bumper spring 54 of the embodiment of Figure 1. Obviously, either arrangement could be used with either embodiment of the invention.

In Figure 4, the force resulting from airflow tending to close the throttle is represented by a simple curve. However, due to variations in friction in the throttle shaft bearings and to other variable quantities of friction in the throttle control mechanism, the effective force tending to close the throttle may vary between certain limits as shown by the cross-hatched area in Figure 8. The force resulting from the airfoil section 82 is represented by the dotted extension of this area.

With the throttle in closed position, as shown in Figure 5, springs 68 and 80 are highly compressed but, as before, due to the small effective lever arm of the spring force relative to the throttle shaft 19, create a relatively small torque tending to open the throttle as indicated by the initial point of the dotted curve of spring force in Figure 8. As the throttle opens from the position of Figure 5 to that of Figure 6, the effective lever arm increases with a resultant increase in the spring torque tending to open the throttle. When the throttle position of Figure 6 is attained the collar 66 engages the stop pin 69, thus eliminating the force of spring 68 at throttle openings beyond that of Figure 6. The spring force tending to open the throttle is thus sharply decreased as shown by the vertical portion of the dotted curve of Figure 8. As the throttle opens from the position of Figure 6 toward the wide open position of Figure 7, the spring force is further reduced as spring 80 approaches its free length.

As will be apparent, the vertical portion of the spring-force curve may be obtained at any throttle position to satisfy the desired requirements by properly positioning the stop 69 and may be of any desired extent by properly proportioning the two springs. Also, the springs and the limits of the effective lever arm may be so designed to substantially balance the throttle throughout the range of throttle positions while providing a means for respectively opening or closing the throttle to the emergency position if the throttle control is ruptured with the throttle opened less or more than this desired amount.

Although the invention has been particularly described in connection with a centrally pivoted throttle, it will be apparent that it could also be utilized with throttle valves mounted off-center of the body 10, either of the suction opening or suction closing type. With such valves there will be an opening or closing torque dependent in amount upon the engine suction and the difference in effective area of the two portions of the valve on either side of the throttle axis. Since both the suction and the effective area decrease as the throttle is opened from closed position, an increment varying from a maximum at closed throttle to substantially zero at wide open throttle would have to be added to the solid curves of Figures 4 and 8 for a suction-closing type of valve or subtracted for a suction-opening type of valve in order to determine the total torque on the throttle resulting from engine suction and

airflow. The spring-force or dotted curve could be made to substantially agree as desired with this newly formed solid curve by having the spring axis approach or pass over the throttle shaft centerline as the throttle approached closed position and by proportioning the spring characteristics and the limits of the spring's effective lever arm.

It will be apparent that many other modifications could be made without departing from the spirit of the invention, such as one utilizing tension springs rather than compression springs, and I, therefore, do not intend the invention to be limited to the particular embodiments described, nor otherwise, except in accordance with the terms of the subjoined claims.

I claim:

1. A device for controlling the throttle of an internal combustion engine comprising a throttle shaft movable between throttle-open and throttle-closed positions, and means for substantially reducing the unbalanced force on the throttle resulting from air flow therepast comprising spring means for urging the shaft toward one of said positions with a torque which is a maximum at an intermediate shaft position and diminishes with movement of the shaft toward either the open or closed positions.

2. A device for controlling the throttle of an internal combustion engine comprising a throttle control element movable between throttle-open and throttle-closed positions, a pilot's throttle control, and means for substantially reducing the unbalanced torque on the throttle resulting from pressures created thereon during periods of normal operation and for positioning the throttle at a partially open position upon failure of the pilot's throttle control comprising spring means for urging the throttle toward one of said limit positions with a torque greater than, and in a direction opposite to, the said unbalanced torque at throttle positions between said partially open position and one of said limit positions and with a torque less than, and in a direction opposite to, the said unbalanced torque at throttle positions between said partially open position and the other limit position.

3. A control device for an internal combustion engine comprising a throttle movable between limit positions corresponding to closed and fully open throttle positions, a manually operable throttle control, and means for substantially reducing the unbalanced torque on the throttle resulting from operation of the engine and for positioning the throttle in a predetermined partially open position upon failure of said manual control comprising spring means for slightly overbalancing said unbalanced torque at throttle positions between said partially open position and one of said limit positions and for slightly underbalancing said unbalanced torque at throttle positions between said partially open position and the other of said limit positions.

4. In a carburetor, a throttle valve which tends to move in one direction in response to forces resulting from airflow, and yielding means urging the throttle in the opposite direction with a torque greater than that created by said airflow forces through a portion of the throttle operating range, equal to the said airflow torque at an intermediate throttle position, and less than the airflow torque through another portion of the throttle operating range, said intermediate position being immediately adjacent and between said two portions.

5. In a carburetor having an induction passage, a throttle in said passage, a throttle control lever movable between limit positions corresponding to closed and fully open throttle, yielding means resisting movement of said lever toward one of said limit positions with a force that increases as said one limit position is approached and having an effective moment arm relative to said lever that approaches zero as said one limit position is approached.

6. A device for controlling the throttle of an internal combustion engine comprising a throttle shaft, a lever secured to the shaft, and a spring yieldingly resisting movement of the lever toward closed throttle position and adapted to be increasingly stressed as the throttle approaches closed position, said spring and lever being arranged to provide an effective moment arm for the spring relative to the throttle shaft which approaches zero as the throttle approaches a closed position.

7. In a carburetor having an induction passage, a throttle shaft and attached throttle valve pivotally mounted therein, said valve being of a type which tends to close in response to pressures created thereon during periods of operation, and means for urging said throttle toward open position comprising a spring adapted to be increasingly stressed as the throttle moves toward closed position, and a connection between the spring and throttle shaft providing the spring with an effective moment arm relative to the shaft which decreases as the throttle is moved toward closed position and is substantially zero when the throttle is in fully closed position.

8. The invention defined in claim 7 comprising in addition, means operable at least at wide open throttle during periods of operation for urging the throttle toward closed position.

9. A device for controlling the throttle of an internal combustion engine comprising a throttle shaft, a lever secured to the shaft, a collapsible link pivotally mounted at one end and connected to the lever at its other end, and means yieldingly resisting collapse of said link comprising a pair of springs and means for rendering one of said springs inoperative during a portion of the collapsing movement of said link.

10. A device for controlling the throttle of an internal combustion engine comprising a throttle shaft, a lever secured to the shaft, a pair of telescoping members, means forming a pivotal support for one of said members, means for pivotally connecting the other member to said lever, said members being arranged so that the axis thereof substantially intersects the shaft axis when the members are in their fully collapsed positions, a pair of springs within the members urging them toward an extended position, and stop means for rendering one of the springs inoperative when said members are extended beyond a predetermined amount.

11. An emergency position selector for the throttle valve of an internal combustion engine comprising a throttle shaft, a control lever secured to the throttle shaft and movable between limit positions corresponding to closed and fully open positions of the throttle, a pair of springs adapted to be increasingly stressed as the lever approaches one of said limit positions and urging the lever toward the other limit position, said springs and lever being arranged to provide a decreasing effective moment arm for the springs as said one limit position is approached to produce a decreasing rotative torque on said lever, means

operative at an intermediate position of the lever upon movement thereof toward the other of said limit positions for rendering one of said springs inoperative to thereby abruptly diminish the rotative torque, whereby the torque will be substantially reduced at lever positions beyond said intermediate position.

12. A device for controlling the throttle of an internal combustion engine having a throttle control element movable between limit positions corresponding to throttle open and throttle closed positions, a manually operable control for said throttle, and means for substantially counterbalancing the torque on the throttle resulting from pressures thereon during periods of engine operation and for positioning the throttle at a partially open position upon failure of the manual control comprising a pair of springs jointly urging the control element toward one of said limit positions, and means for rendering one of said springs inoperative at said partially open position, whereby both springs are effective at throttle positions between one of said limit positions and the partially open position to create a torque on the throttle greater than, and in a direction opposite to, the said pressure created torque and only one of said springs is effective at throttle positions between the partially open position and the other limit position to create a torque less than, and in a direction opposite to, the said pressure created torque.

13. In a carburetor having a throttle valve of a type which tends to move toward closed position in response to pressures created during periods of operation, a manually operable control for the throttle and means for substantially balancing the torque tending to close the throttle and for positioning the throttle at a partially open position upon failure of the manual control comprising a pivotally mounted lever rotatable with the throttle, a pair of telescoping cup-like members pivotally connected respectively to the lever and to a fixed support and forming a collapsible expansible link adapted to collapse as the throttle approaches closed position, said members being arranged so that their axis substantially intersects the pivot of said lever when the throttle is closed to provide a substantially zero moment arm therebetween, a spring within the members and engaged thereby for resisting collapse of said link, and a second spring engageable by said members only when the throttle is closed more than a predetermined amount for further resisting collapse of said link.

14. The invention defined in claim 13 comprising in addition a protuberance on said throttle valve adapted to create a throttle closing torque during periods of operation with the throttle in substantially fully open position.

15. A control device for an internal combustion engine comprising a shaft and attached throttle valve movable between limit positions corresponding to closed and fully open throttle valve positions, a lever secured to the shaft, a collapsible link connected at one end to said lever and pivotally mounted at the other end, and spring means yieldingly resisting collapse of said link with a force which progressively increases throughout substantially the entire throttle operating range as the throttle moves from one limit position to the other limit position, said

link being so constructed and arranged that the effective moment arm of the spring means relative to the lever approaches zero as said other limit position is approached.

16. A control device for an internal combustion engine comprising a throttle movable between limit positions corresponding to closed and fully open throttle positions, and means for overcoming at least a portion of the unbalanced torque on the throttle resulting from air flow therepast comprising a pair of springs urging said throttle toward one of said limit positions and means for rendering one of said springs inoperative at throttle positions between one of said limit positions and an intermediate throttle position.

17. In a carburetor having an induction passage, a throttle shaft extending transversely of the passage and positioned substantially centrally therein, a throttle secured to said shaft of a type which tends to close in response to forces resulting from airflow therepast, a lever secured to the shaft, and means for urging the throttle toward open position comprising a pair of telescoping members having a compression spring therebetween, means for pivotally connecting one of said members to the lever, and a pivotal support for the other of said members, said telescoping members being so constructed and arranged that the axis thereof substantially intersects the throttle shaft axis when the throttle is in closed position.

18. A control device for an internal combustion engine comprising a shaft and attached throttle valve movable between limit positions corresponding to closed and open throttle valve positions, a lever secured to the shaft, a collapsible link connected at one end to said lever and pivotally mounted at the other end, and spring means yieldingly resisting collapse of said link with a force which progressively increases throughout substantially the entire throttle operating range as the throttle moves from one limit position to the other limit position, said spring means including means for abruptly increasing said force at an intermediate throttle position.

19. In a carburetor having an induction passage, a throttle in said passage movable between limit positions corresponding to closed and fully open throttle positions, and yielding means resisting movement of the throttle toward closed position with a force abruptly increasing at an intermediate throttle position comprising a pair of springs, one of said springs being preloaded and becoming operative at said intermediate throttle position.

20. In an internal combustion engine, a throttle valve movable between limit positions corresponding to closed and fully open throttle positions and tending to move in one direction in response to forces resulting from airflow, and yielding means urging the throttle in the opposite direction with a torque greater than that created by air flow at throttle positions between an intermediate throttle position and one of said limit positions and with a torque less than that created by air flow at throttle positions between the intermediate throttle position and the other of said limit positions.

FRANK C. MOCK.