

March 1, 1966

R. J. J. HAMBLIN ETAL
MEANS FOR REGULATING ASPIRATED SECONDARY AIR
FOR EXHAUST GAS CONVERSION

3,237,399

Filed Nov. 4, 1963

2 Sheets-Sheet 1

Figure 1

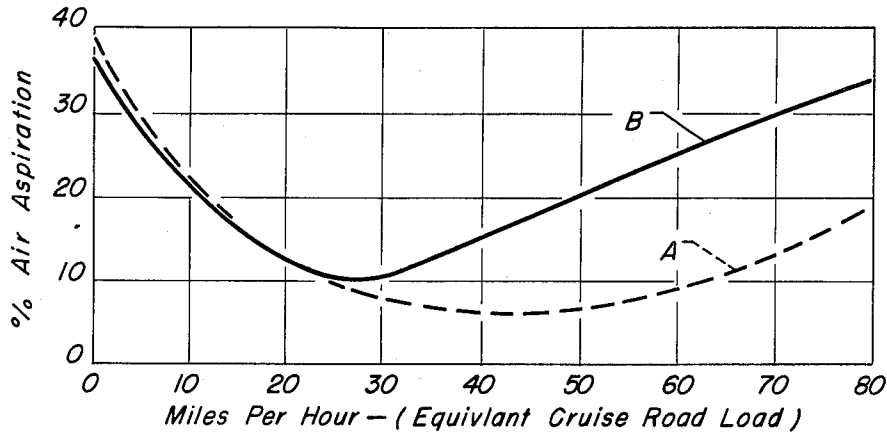


Figure 2

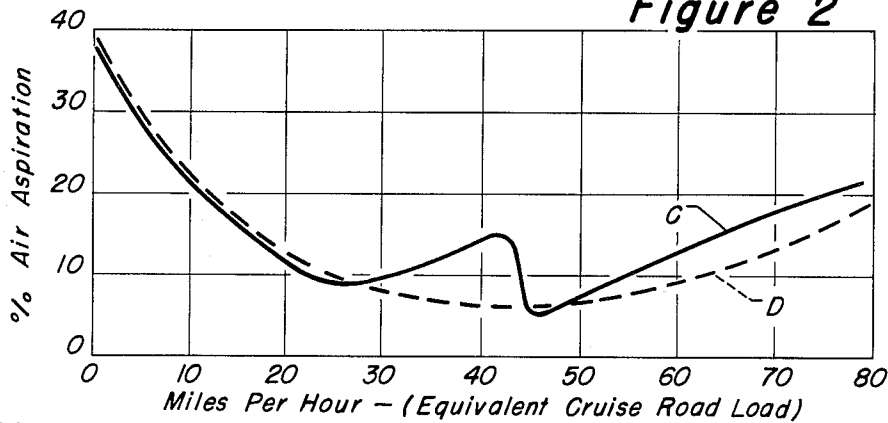
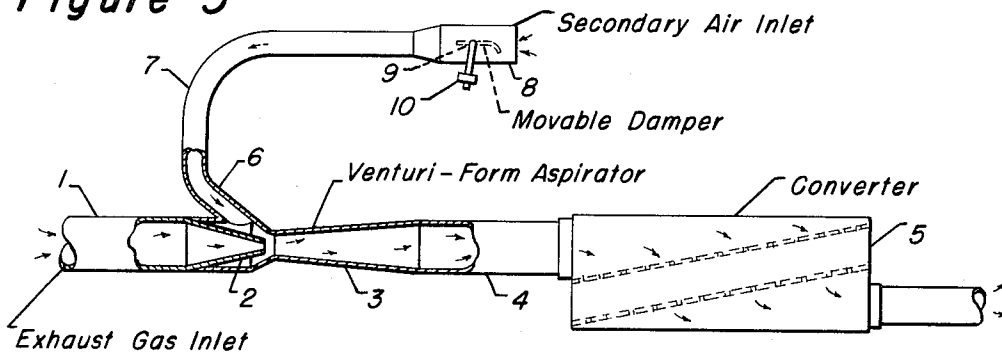


Figure 3



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Figure 4

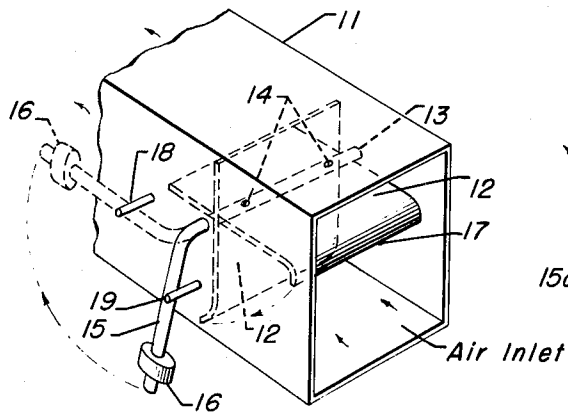


Figure 4a

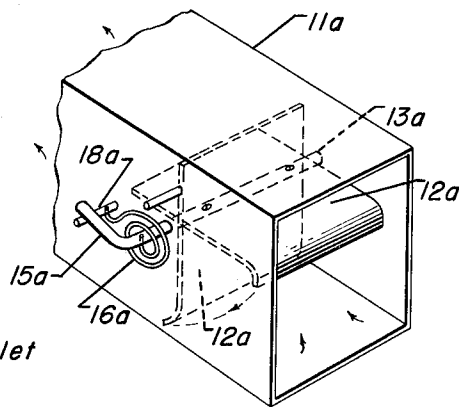


Figure 5

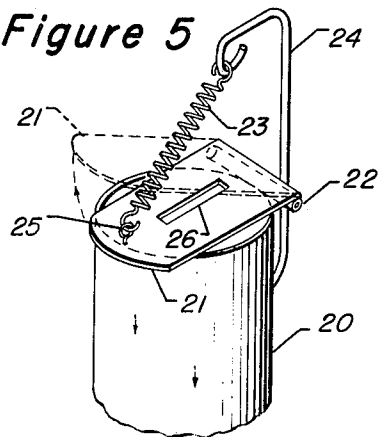


Figure 6

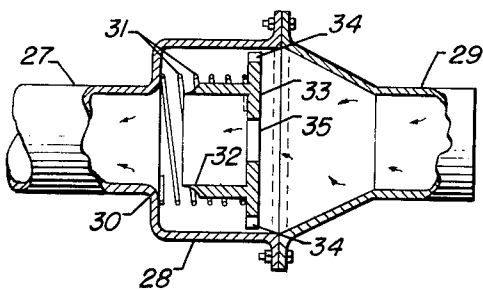
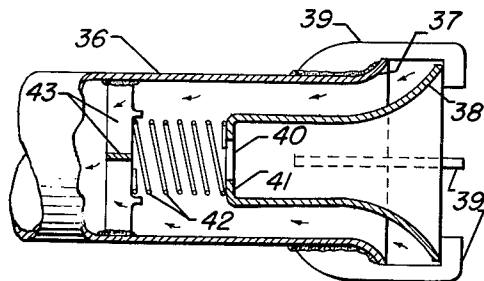


Figure 7



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3,237,399

MEANS FOR REGULATING ASPIRATED SECONDARY AIR FOR EXHAUST GAS CONVERSION

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3 Claims. (Cl. 60—30)

The present invention is directed to means for regulating aspirated secondary air and more particularly to the control of secondary air being admixed with engine exhaust gases for introduction into a converter for the oxidation of the combustible contaminants in said gases.

Various types of devices have been utilized to supply secondary air; however, most devices have operated to increase air flow along with increasing exhaust gas flows and not to decrease the proportion of aspiration responsive to motor speed or to the rate of flow of the exhaust gas stream. Inasmuch as excessive secondary air will have a chilling effect upon the reactant streams and the catalyst bed of a catalytic converter or upon the thermal reaction in a thermal reactor, the present invention provides means for reducing the supply of aspirated secondary air as the primary gas rate reaches a predetermined value.

The removal of certain components from vehicular exhaust gases is deemed to be of importance at the present time. The unavoidably incomplete combustion of hydrocarbon fuels by the gasoline or diesel engine results in the generation of substantial amounts of unburned hydrocarbons and other undesirable waste gases which are discharged to the atmosphere through the exhaust line. With the ever-increasing concentration of automobiles, particularly in urban areas, the resultant discharge of these undesirable products into the atmosphere may reach high proportions. These combustion products are known to react with atmospheric oxygen under the influence of sunlight to produce smog. Such waste gases include, for example, saturated and unsaturated hydrocarbons, carbon monoxide, aromatics, partially oxidized hydrocarbons such as alcohols, ketones, aldehydes and acids, and oxides of nitrogen and sulfur.

Methods for converting vehicular exhaust gases to harmless materials, such as, for example, carbon dioxide and water may be classified into two broad areas:

(1) catalytic conversion and (2) non-catalytic or thermal conversion. In the catalytic method, the exhaust gases leaving the engine are passed, with or without heating or cooling, into contact with a suitable conversion catalyst and the conversion products of the resulting reactions are thence discharged into the atmosphere. In general, the preferred conversion reactions involve more or less complete oxidation of combustibles, and to this end it is necessary to provide sufficient oxygen, obtained from air or other oxygen-containing gas, in the exhaust gases prior to contact with the catalyst. In the thermal method, the exhaust gases are simply heated to, or maintained at, a sufficiently high temperature, in the presence of oxygen so as to burn combustibles without utilization of a catalyst. With either method, it is necessary to provide at least a stoichiometric amount, and preferably an excess amount, of oxygen or air in the exhaust gases. It is not feasible to manipulate the carburetor in order to provide such excess air since this would seriously reduce the efficiency and/or power of the engine, and, therefore, it is usually desirable to separately add the required amount of air to the exhaust gases at a point between the exhaust valve ports of the engine and the catalytic or thermal conversion zone located downstream therefrom. Such additional air is also termed "secondary air," as

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opposed to the primary air injected by the carburetor and employed to support combustion of the fuel within the engine cylinders proper.

The amount of secondary air required for the efficient oxidation of the exhaust gases varies with engine operation. For example, reference to curve A in the accompanying FIGURE 1 of the drawings illustrates diagrammatically the amount of secondary air required for efficient oxidation in response to variations in engine operation. The percent of air aspiration expressed in pounds of air per one hundred pounds of exhaust gases is plotted against engine operation in equivalent cruise road load expressed in miles per hour. It is not intended that this curve, as well as the accompanying curves shown in the drawings, be representative of all engines or converter operations, but it does present graphically the typical secondary air requirements for the conversion of unburned components in an exhaust gas stream within a catalytic type converter receiving such exhaust gases from a Ford 332 cubic inch V-8 automobile engine. The use of an uncontrolled secondary air inlet into an aspirator in an exhaust gas line provides air injection in a manner which may be shown to be in accordance diagrammatically with curve B of FIGURE 1 of the drawing. Here again, it may be noted that the curve presented is merely representative of an aspirating operation utilizing an 1¼" diameter air inlet line to the diffuser section of a typical venturi-form aspirator fitted into the standard exhaust gas line of a V-8 automobile engine at a point ahead of a catalytic gas converter. A comparison of the two curves shows that a considerable quantity of excess secondary air is being aspirated by high speed engine operation and accompanying high gas flow rates. This excessive secondary air has an undesired controlling effect on the exhaust gas stream and the converter, and affects performance in two different ways. Firstly, the instantaneous conversion ability of the device is directly affected by operating temperature since the oxidation reaction rates increase more than proportionately as the absolute temperature of the operation increases. Secondly, the net rate of the accumulation of solid deposits, such as compounds of lead, having an adverse effect upon performance is decreased by an increase in operating temperature. In a catalytic unit, this high temperature effect is most pronounced in the upstream portion of the apparatus. The high temperature removal of the deposits can preclude rapid deactivation in the catalyst bed, while in the thermal devices, such deposits interfere with heat transfer rates in heat exchange sections of the apparatus.

The beneficial effects of controlling the aspiration of secondary air is best shown by reference to FIGURE 2 of the drawing; for example, curve C indicates in a diagrammatic manner how a "snap action" type of damper or regulator will serve to decrease secondary air introduction at higher engine speeds. In other words, a resulting operation conforming to curve C will more closely approximate the desired introduction of secondary air as illustrated in curve A of FIGURE 1. In still another type of mechanical regulation, as provided by a throttling type of damper or valve means, there may result a curve D type of operation which likewise approximates the regulation of aspirated secondary air in accordance with the desired amounts as illustrated by the curve A. In all of the various mechanical embodiments providing the regulation of secondary air by the present invention, there is no complete shut off of the secondary air at high speeds, but merely the reduction of the total quantity being aspirated. The use of properly sized balancing means in turn provide the initiation of the reduction in secondary air at predetermined engine speeds or exhaust gas flow rates.

Various pumping means may be used to introduce air

to a converter, but for simplicity, a preferred means of adding secondary air is with a jet pump or aspirator serially connected in, or forming a part of, the exhaust gas pipe system and disposed upstream from the gas conversion zone. Jet pumps are well known in the art of fluid transport and only a brief description of the principal elements thereof is necessary here. In essence, a jet pump consists of an inlet nozzle arranged to discharge into a venturi-shaped diffuser section. The diffuser generally comprises an inlet throat section having a cross-sectional area smaller than the jet pump outlet and a gradually expanding outlet section to increase the cross-sectional area up to that of the jet pump outlet. A conduit or other port means for conducting the aspirated or injected fluid connects with the interior of the diffuser at the zone of the nozzle opening and adjacent to the narrow portion of the venturi. A stream of motive fluid is passed through the nozzle and is thereby formed into a high velocity jet which passes into the diffuser and creates a region of low pressure at the upstream end thereof, into which the aspirated fluid is entrained. The diffuser functions to mix the motive fluid and the aspirated fluid and to convert some of the velocity head of the mixture into static head.

When a venturi-form aspirator is employed to inject air into an exhaust gas stream, the exhaust gas itself serves as the motive fluid, the secondary air being the injected fluid; thus, when aspirator means is applied to the exhaust gas stream of an internal combustion engine, especially a spark ignition engine operated under widely varying conditions of speed and load as in the case of a motor vehicle, peculiar difficulties are thereby encountered. The ordinary operation of a motor vehicle is customarily divided into four modes; namely, the modes of idle, acceleration, cruise and deceleration. At idle and deceleration, most spark ignition engines operate with a richer fuel-air ratio than during the open throttle operation of acceleration and cruise, and the concentration of combustibles in the exhaust gases is very much higher than during cruise and acceleration. The secondary air requirements for satisfactory conversion of the exhaust gas are hence larger, relative to exhaust gas flow, at such rich mixture, low engine speed operation; in other words, the mass ratio of secondary air aspirated to exhaust gas must be greater at low engine speed, and consequently at low exhaust gas flow, than at high engine speed, corresponding to high exhaust gas flow.

It is a principal object of the present invention to utilize a movable damper member in combination with an air inlet means to a venturi-form aspirator such that at high speeds for exhaust gas rates there is a partial blockage on the air flow through the inlet line.

It is a further object of the present invention to utilize a balancing means, which may be of the spring or counterweight type, in a simple, trouble-free arrangement in combination with the damper means so as to preclude frequent repairs or need for inspection.

In a broad aspect, the present invention provides in combination with an exhaust gas converter and a venturi-form aspirating means for introducing a mixed exhaust gas and air flow through said converter, an improved air inlet regulating means which comprises in combination, an open-ended air inlet conduit connective with the throat portion of said venturi-form aspirating nozzle, a movable normally open damper member positioned across said air inlet conduit, and a load balancing means connecting to said damper member, with said damper member placed and balanced with said balancing means to have a substantially fully open position and alternatively a partially blocking position across said air inlet conduit, and with the movement between such positions being responsive to the suction on said air inlet conduit, which varies with the exhaust gas flow rate through said aspirating nozzle.

In a somewhat more specific embodiment, the present invention provides flow regulation means for the air inlet

conduit to a venturi-form aspirator, which comprises in combination, a movable damper member in the form of a rotatable mounted plate positioned internally within the air inlet conduit, with said plate mounted on a rotatable shaft member and being sized smaller than the interior of said air inlet conduit to provide a predetermined space therebetween, said plate further having a curved aerofoil edge extending parallel to the shaft member, and said shaft member having at least one end portion extending through the wall of the conduit means and connecting to counterweight means, said counterweight means being angularly positioned to hold the pivotally mounted plate in a normally open position for low flow rates through the inlet conduit.

In still another movable plate embodiment, the movable damper member may comprise a plate section hingedly connected and positioned across the end portion of the air inlet conduit to the diffuser section of the venturi-form aspirator and suitable counterweight means connected to the hinged plate whereby there may be pulling in of the plate member to seat against the end of the conduit and a partial blocking of the inlet end of the air inlet conduit responsive to the gas flow rate through the venturi and a predetermined rate of air flow through the end of the conduit.

It is not intended to limit the operation and movement of a damper member to any one form of counterweight means inasmuch as special forms of tension or compression springs as well as adjustable and movable weight means on various types of lever arms may provide the desired balancing effect for the positioning of the damper plate means. The use of pivotally or hingedly mounted damper plate members connecting with the balancing means are normally operative to provide a form of "snap action" in block or unblocking the air flow through an inlet conduit. However, a throttling action may be provided by the use of balancing means which hold the damper member in a normally open position for low flow rates but will permit closure or full blocking effect responsive to increasing air flow rates around or through a particular damper member. Such balancing means may be either counterweight means or spring means. For example, a damper member may be urged into initiating the closure at gas flow rates corresponding to engine operation equivalents of from 30 to 35 miles per hour and a completion of the blocking by the damper member effective at 35 to 45 miles per hour. However, it should be noted that suitable spring balancing means or counterweight means may also be utilized to initiate closure of the primary gas flow rate which may correspond to from 10 m.p.h. to 50 m.p.h. and completed at rates corresponding to 20 to 60 m.p.h. The amount of blocking that is effected by the movable damper member itself may also vary and generally the regulating apparatus will provide for an unblocked flow or residual open area of 5 to 10 percent of the cross sectional area of the inlet line such that there will always be some aspiration of secondary air at high engine speeds.

Reference to the accompanying drawings of various flow regulating means will serve to further amplify the improved designs and arrangements under the scope of the present invention in providing movable and adjustable damper means which will move responsive to air aspiration rates.

FIGURE 3 of the drawing indicates diagrammatically the use of a venturi-form aspirator upstream from an exhaust gas converter to effect the suction and mixing of secondary air with the exhaust gas stream.

FIGURE 4 of the drawing indicates one form of movable "butterfly" type of movable damper member on a rotating shaft mounting within an air inlet conduit.

FIGURE 4(a) indicates a modification in the balancing of the damper member by the use of a spiral form of coil spring.

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FIGURE 5 of the drawing indicates diagrammatically a hinge mounting having a movable damper member which is spring balanced and operative to partially block air inlet flow directly at the end of the secondary air inlet conduit.

FIGURE 6 of the drawing is a sectional elevational view of one form of movable damper member which provides throttling action in effecting the gradual blocking of aspirated secondary air responsive to air flow rates through and around the damper member.

FIGURE 7 of the drawing also indicates in a sectional elevational view a modified form of movable throttling type of damper member which closes against a compression spring that urges the member into a normally open position.

Referring now particularly to FIGURE 3 of the drawing, there is shown an exhaust gas inlet line 1 which receives exhaust gases from an engine, not shown, and in turn passes such exhaust gases through a nozzle 2 into a venturi-form aspirator 3 and subsequently through line 4 to a catalytic converter indicated diagrammatically as 5. Secondary air to sustain the catalytic oxidation of combustibles in the exhaust gas stream is drawn into the diffuser section of the venturi-form aspirator 3 by way of inlet 6 and air inlet conduit 7. The latter has an open end portion 8 with a movable damper member 9 operative to effect partial blocking of the internal area of inlet section 8 responsive to air flow through the conduit and differential pressure across the damper plate. Damper member 9 is indicated diagrammatically as connective with a counterweight member 10 which holds the damper in a normally open position for low gas flow rates but can be raised responsive to movement of the damper member 9 under the influence of high air flow rates into the end portion 8. Increased air flow is in turn responsive to the rate of exhaust gas flow through aspirator 3 and the resulting suction on the air inlet conduits 6 and 7. As will be pointed out more fully hereinafter, various forms of movable damper means may be provided in combination with the air inlet conduit; however, the arrangement of FIGURE 3 shows diagrammatically the use of air regulating means in combination with an aspirated air inlet for a venturi-form aspirator which in turn is used in combination with an engine exhaust gas line providing a mixture of exhaust gases and secondary air to an exhaust gas converter means. The converter 5 is indicated as being of a catalytic form in the present embodiment but, here, again, it may be pointed out that an exhaust gas oxidizing unit may be of the "after burner" type utilizing high temperature thermal oxidation of the combustibles in the exhaust gas stream. Furthermore, the damper may be located at any convenient point in air conduit 7.

Referring now more particularly to FIGURE 4 of the drawing, there is indicated a substantially square or rectangular form of air inlet conduit 11 which is connective with a venturi-form aspirator, not shown. Rotatably mounted internally within the portion 11 is a substantially square or rectangular form of damper plate member 12 mounted on a rod or shaft member 13 which has end portions that extend through side walls of the end conduit section 11. The damper plate member 12 may be removably attached to the shaft member 13 by screw members 14, or alternatively, there may be a fixed riveted or welded connection between the two members. One end of the shaft 13 has an extended lever arm portion 15 and at least one threaded attached weight member 16 such that there is a counterweight action provided to position and balance the damper member 12 in a desired position within the end portion 11. Also, in accordance with the present invention, the lever arm 15 extends substantially at right angles from the shaft member 13 and at a small angle θ with respect to the perpendicular to the plane of the damper plate 12 such that when the weight 16 holds the counterweight arm 15 in a depending

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position against the stop 19, the damper plate will be in a normally open substantially horizontal plane. Of course, where the damper member is mounted in a conduit section which is not horizontal, then the balancing arm will be arranged at an acute angle with respect to the plane of the damper to properly hold it at a normally open position with respect to the angle of the conduit.

A preferred design for the damper plate 12 provides a curved "aerofoil" edge 17 across the upstream end portion thereof such that a slight curved surface continuously faces the incoming air inlet stream. This design permits an increasing flow rate of secondary air to increase pressure against the end of the damper plate member and gradually urge it downwardly against the action of the counterweight 16 on level arm 15 until at high flow rates above a predetermined engine speed, there will be a substantially vertical positioning for the damper plate member 12 and a substantially horizontal positioning of lever arm 15 and its weight 16. The positioning of a plate member 12 in a vertical plane effects a partial blocking of the air flow to the inlet conduit permitting only that flow which is around the periphery of the damper member or which may be provided through the damper member by perforations. Generally, a preferred design provides an approximate 85% of blocking air flow such that the remaining open space will permit a resulting residual aspiration for high speed engine operations. The present form of butterfly type of member having the counterweight means and the aerofoil edge can effect a relatively fast "snap action" type of operation or a slower throttling type of operation. The action depends upon the shape of the aerofoil section of the plate member, the amount of off-center mounting of the plate with respect to the rotating shaft member 13, the weight and angle of the balancing arm 15 and weight 16. Upper and lower stop members, such as 18 and 19, are shown being mounted on the side wall of the inlet section 11 to provide limits for the movement of the balance arm 15; however, generally, the movement of such arm 15 will be limited to approximately 90° of rotation by the action of the gravity loading from weight 16 causing the damper plate 12 to be in a normally open position, and alternatively the effect of the differential pressure caused by the atmospheric pressure on the upstream end of the plate and the decreased downstream pressure produced by high aspiration holding the plate member 12 in a substantially vertical plane.

In a variation of the movable damper member construction, there is shown in FIGURE 4a of the drawing the use of a coil spring 16a connecting between a shaft arm 15a and a stop 18a. Thus, the damper member 12a in conduit section 11a works against the spring 16a as a balancing member, with the latter supplying a restoring force to hold the damper in a normally open position in the conduit for low flow rates. In this embodiment, the angle of the conduit is not dependent upon a gravity acting counterweight and is not critical.

The counterweight may also be incorporated into the trailing edge of the damper plate and the stops 18 and 19 made internal. In such an embodiment the duct or conduit will be mounted at a suitable angle to the horizontal to have the damper in normally open position for low aspiration rates. Also, in the embodiment of the apparatus of FIGURES 4 and 4a the damper members may be adapted to conduit cross sections or shapes other than rectangular.

In the embodiment of FIGURE 5, there is shown an end portion of an air inlet conduit 20 having a damper plate 21 hingedly connecting to its side by hinge means 22 whereby the open end of inlet conduit 20 may be partially blocked as to the aspiration of secondary air. The connection of the secondary air inlet conduit to the aspirating means is not shown in the present FIGURE 5 but would be in accordance with the arrangement shown in FIGURE 3 of the drawing. At low speed engine op-

erations, the damper plate member 21 is in a normally open position as shown by the dashed lines, being held in a raised position by a suitable tension spring 23 extending between support member 24 and an eye member 25 which is in turn positioned on plate member 21 to suit the rate and tension of spring 23.

Damper plate member 21 may be sized somewhat smaller in width than the open end portion of conduit 20, as shown in the drawing, or alternatively may be provided with sufficient open slot means, such as 26, to permit a desired percentage of air inlet flow even in the closed or blocked position. The operation of the present embodiment is similar to that of the movable plate in FIGURE 4 of the drawing, where an increasing speed of engine operation will cause a greater exhaust gas flow through the venturi-form aspirator to in turn cause a sufficient amount of suction on the secondary air inlet line to cause a pressure differential between the suction side of the movable plate 21 and the external atmospheric pressure to cause a closure of the plate member 21 down against the open end of conduit 20. Generally, with the use of counterweight means or a tension spring, such as 23, for holding the movable plate member 21 in a normally open position for low engine speeds, there will tend to be a critical speed of operation where the pressure differential will snap the movable damper member against the end of conduit 20 in the blocked position such that the operation, like the embodiment of FIGURE 4, will be substantially in accordance with the operation shown in curve C of FIGURE 2 of the drawing. On the other hand, the choice of weight or gauge of the damper member 21, the size of the air inlet conduit 20, or in the type of tension spring utilized to hold the damper member in a raised position, there may be some degree of throttling action provided for the operation or closure of the damper member 21 responsive to variations in the exhaust gas flow rate end and the suction from the aspirator means. The present embodiment shows a single centrally located slot 26, in addition to the aforementioned unblocked openings which occur between the edges of the damper plate member 21 and the circular periphery of the open end of conduit 20; however, it should be noted that the damper plate may be made in a circular configuration and additional slot means, such as 26, may be provided to furnish the desired open area through the damper member whereby at least some secondary air is aspirated through the inlet conduit at high speed engine operations. It will be noted upon reference to curve A of FIGURE 2 that there is an increasing need of air for high speed operations primarily because of the high speed fuel enrichment arising from the usual carburetor construction having high speed jet means addition of fuel for high speed operations.

In FIGURE 6 of the drawing there is shown still another embodiment of movable damper means which is operative to decrease the proportion of secondary air intake responsive to increasing exhaust gas flow rates. An air inlet conduit 27 is provided with an enlarged damper holding section 28 and an air inlet end 29. The interior of the enlarged section 28 accommodates a compression spring 31 which in turn engages and supports a hollow cylindrical form damper plug member 32. The latter has a tapering downstream end portion adapted to engage and seat within a tapering seat section 30 at the upstream end of conduit 27. The upstream end portion of the damper plug member 32 has a perforate transverse plate section 33 that extends in a flange-like manner beyond the exterior wall of the cylindrical portion 32 to provide a shoulder portion to in turn hold the end of compression spring 31. The latter thus holds the damper member in a normally open position away from the seat 30 for low air flow rates. The major portion of the exterior periphery of the transverse section 33 is, however, spaced inwardly from the inside wall of section 28 such that air flow may pass in a sub-

stantially annular flow around the damper member 32, from the intake section 29 to the conduit section 27, as long as the spring member 21 is holding the damper plug 32 away from the seat 30. Spaced portions 34 project from the periphery of the transverse plate section 33 to act as guide members within the inside wall of section 28. The present embodiment indicates a single opening 35 within the central portion of transverse plate 33, although a plurality of smaller openings may be utilized instead to be in conformance with the present invention to provide a percentage of secondary aspiration at high speed operations even though the damper member may be in the blocking position.

In the operation of the present embodiment, an increasing exhaust gas flow rate in turn provides a greater aspiration and suction from the venturi-form aspirator means to cause an increase in differential pressure between the downstream side of the movable damper member 32 and the external atmospheric air inlet side thereof, such that the differential pressure will gradually push against the compression spring 21 to effect a fully blocking position at the downstream end of the damper plug member 32 engaging the seat 30. Here again, the point at which the fully blocking position will be accomplished will depend upon various factors, including: the area of the transverse plate 33 with respect to the inside diameter of the enlarged section 28, the type of compression spring 31, the size of the secondary air inlet conduit 27, the aspirator design, and the like. The present design, however, tends to provide a throttling type of reduction in the secondary air intake responsive to increasing gas flow rates through the aspirator such that the type of operation is substantially in accordance with the curve D of FIGURE 2 of the drawing. Full blocking by the damper member, permitting flow only through the central opening 35, may be accomplished at any predetermined speed, equivalent to say 35 to 45 miles per hour vehicular speed, although, of course, other modified designs and adjustments may be made to provide the desired blocking at other predetermined speeds.

In FIGURE 7 of the drawing, there is shown still another embodiment of moveable damper means operative at the end of an air inlet conduit 36 such that secondary air may be partially blocked as the exhaust gas flow rates increase. In this design, the very outer end of the air inlet conduit 36 is partially curved to provide a seating surface 37 which in turn can engage a damper plug member 38 which has an outwardly flaring portion at the upstream end thereof. The flaring cylindrical form damper member 38 is positioned and supported within the end of conduit 36 by means of a plurality of exterior guides and holding members 39 that are spaced around the outside of conduit 36. The internal downstream end of the damper member 38 has a central open portion 40 within an inwardly projecting flange section 41 which in turn connects with and engages a compression spring 42 which holds the damper member in a normally open position for low flow rates. The opposing downstream end of the compression spring 42 is in turn held within the central portion of the air inlet conduit 36 by one or more transverse supporting rib members 43. The transverse members 43 are arranged with their edges toward the direction of gas flow such that air flow may be passed with least hindrance to the aspirator and become mixed with the exhaust gas flow prior to entering a suitable gas converter means. In other words, as set forth in connection with the other embodiments, the present unit is for use in combination with a venturi-form aspirator means which will provide suction and cause the intermixing of secondary air with the flow from an exhaust engine to effect a mixed stream introduction into a suitable catalytic or thermal conversion unit, as indicated in FIGURE 3 of the drawing.

In the operation of the present embodiment, there will be secondary air intake between the upstream ends of the

air inlet conduit 36 and the damper member 38, with an annular peripheral flow carrying around the exterior wall of the damper member 38, as well as some percentage of secondary air flow substantially axially through the center of the hollow damper member 38 and the upstream opening 40. However, as the exhaust gas flow rate increases and the aspiration causes a greater suction and differential pressure force against the upstream side of the movable damper member 38 there will be a corresponding increase of the pressure of damper member 38 against the compression spring 42 until such time as the damper member effects a closure against the seating section 37 at the end of the conduit 36. At this point, the only secondary air flow will be that which is drawn through the central opening 40 from the interior of the damper member 38. Generally, the operation of the present embodiment will be similar to that of FIGURE 6 providing a throttling type of operation, for usual designs and constructions of the damper member and selection of compression springs, whereby the operation is substantially in accordance with curve D of FIGURE 2.

From the descriptions of the foregoing embodiments, it should be noted that variations may be made in providing a movable damper means to at least partially block the secondary air flow through a conduit responsive to exhaust gas flow rate or engine speed by reason of the use of a venturi-form aspirator. Further, it may be noted that by a proper choice of balancing means there may be throttling action or a substantially "snap action" type of control in effecting the blockage to air flow at predetermined engine speeds or gas flow rates and that such balancing means may be either counterweight means or spring means. In all embodiments, however, it is within the scope of the present invention to provide some partially open area such that secondary air flow is not blocked entirely, even at high speeds or flow rates; such open area being around the damper or through an opening or openings in the damper itself or in the conduit downstream of the damper.

We claim as our invention:

1. In combination with an engine exhaust gas converter and a venturi-form aspirating nozzle which provides exhaust gas and secondary air flow to said converter, an improved secondary air inlet regulator means comprising, in combination, a secondary air inlet formed from an open-ended conduit connected with the throat portion of said venturi-form aspirating nozzle, a damper member having a rotatably mounted plate positioned internally within said air inlet conduit on a shaft member mounted thereon, said plate being sized smaller than said inlet air conduit to provide space therebetween, said plate further having a curved airfoil edge extending parallel to said shaft member, a load means comprising a spiral wound coiled spring member connected to at least one end portion of said shaft member and having its other end fixedly connected with said air inlet conduit and positioned to hold the rotatably mounted plate open in said air inlet conduit at low flow rates therethrough, said load means being balanced against air flow through the conduit to effect movement of the damper and partial blocking of the air inlet, and said damper member acting responsive to and throttling said air flow thereby to correspond substantially to the stoichiometric amount of secondary air needed for efficient oxidation of the exhaust gases at all engine speeds.

2. In combination with an engine exhaust gas converter and a venturi-form aspirating nozzle which provides exhaust gas and secondary air flow to said converter, an

improved secondary air inlet regulator means comprising, in combination, a secondary air inlet formed from an open-ended conduit connected with the throat portion of said venturi-form aspirating nozzle, a damper member comprising a rotatably mounted plate positioned entirely within said air inlet conduit on a shaft member mounted therein, said shaft member having at least one end portion extending through the wall of said air inlet conduit, said plate sized smaller than said inlet conduit to provide space therebetween, said plate further having a curved airfoil edge extending parallel to said shaft member, load means connected to the end of said shaft member which extends through the wall, and said load means being positioned to hold the rotatably mounted plate open at low flow rates through said inlet conduit and balanced against air flow through the conduit to effect movement of the damper and partial blocking of the air inlet, and said damper member acting to responsive to and throttling said air flow thereby to correspond substantially to the stoichiometric amount of secondary air needed for efficient oxidation of the exhaust gases at all engine speeds.

3. In combination with an engine exhaust gas converter and a venturi-form aspirating nozzle which provides exhaust gas and secondary air flow to said converter, an improved secondary air inlet regulator means comprising in combination, a secondary air inlet formed from an open-ended conduit connective with the throat portion of said venturi-form aspirating nozzle, a movable hollow plug-form damper member positioned within the end portion of said conduit, peripheral seat means within the interior of said conduit adapted to engage a peripheral portion of said damper member, whereby air flow around said damper member may be blocked, guide means holding said damper member in a restricted aligned movement within and along said conduit portion, compression spring means having one end in engagement with said damper member and the other end in engagement with support means from the interior of said conduit and holding said damper member in a normally unseated position therein, and air passageway means extending through said damper member and said seat means in said conduit whereby limited air flow may continue uninterrupted through said conduit when said damper member engages said seat, said compression spring means balanced against air flow through the conduit to effect movement of said damper with respect to its seat and partial blocking of the air flow, and said damper member acting responsive to and throttling said air flow thereby to correspond substantially to the stoichiometric amount of secondary air needed for efficient oxidation of the exhaust gases at all engine speeds.

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