

[54] **COMBUSTION PRODUCTS
GENERATING AND METERING
DEVICE**

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171, 172, 179; 43/125, 127, 128; 340/410,
411

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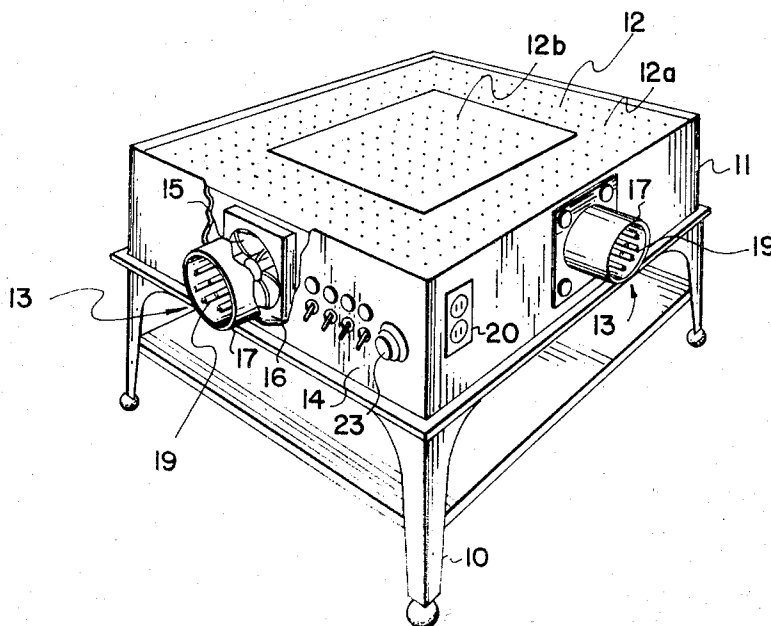
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[57] **ABSTRACT**

An apparatus for generating combustion products at a predetermined fixed rate, mixing the combustion products with air to achieve a given concentration, and distributing the resultant mixture to an area or device to be tested, wherein the apparatus comprises blowers, a holder for the combustion products generating materials (which materials burn at a predictable and controlled rate), a mixing plenum chamber, and means for distributing the air-combustion products mixture.

17 Claims, 2 Drawing Figures



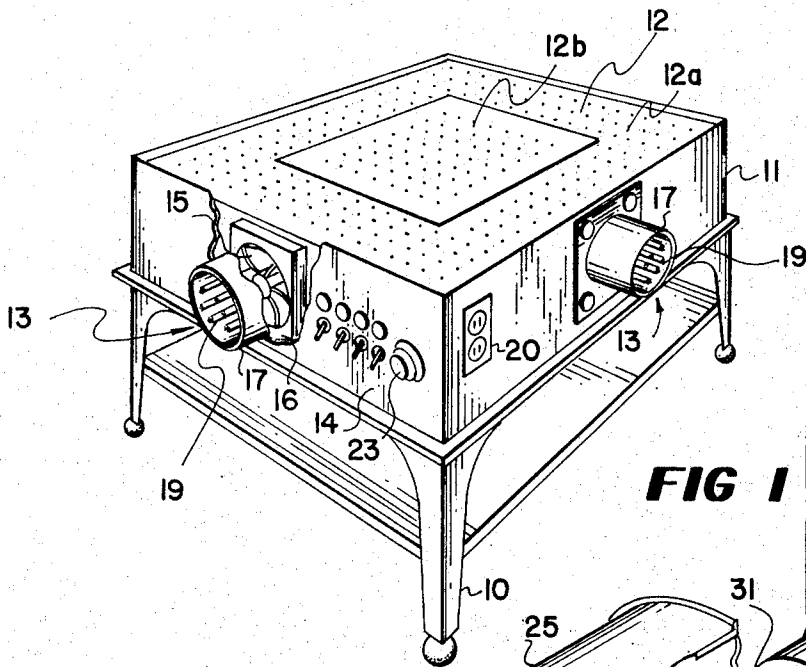


FIG 1

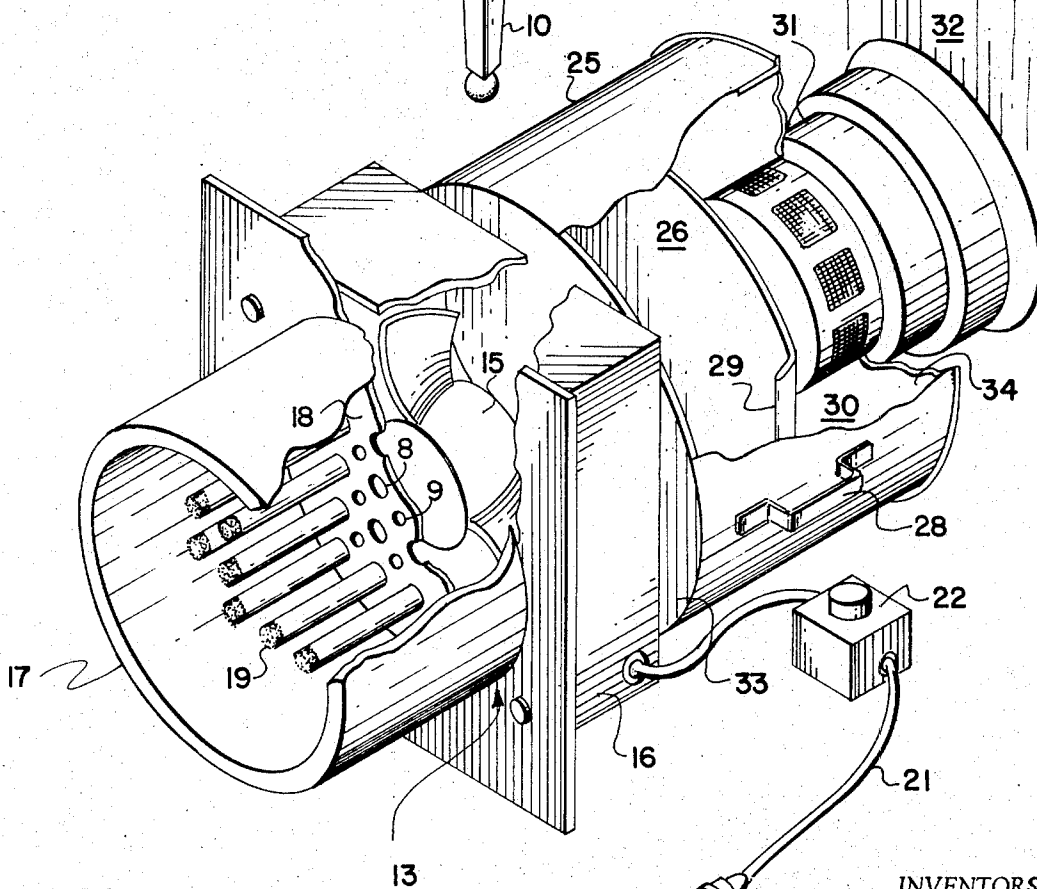


FIG 2

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COMBUSTION PRODUCTS GENERATING AND METERING DEVICE

ORIGIN OF THE INVENTION

The invention described herein was made by employees of the United States Government and may be manufactured and used by or for The Government for governmental purposes without the payment of any royalties thereon or therefor.

INTRODUCTION

The present invention is intended to simulate an incipient fire condition by developing an air-combustion products mixture of a given concentration and at a controlled rate, and thereafter distributing the resultant mixture into an area or device being tested. More particularly, the present invention is directed towards an apparatus for the production of a predetermined amount of air-combustion products mixture by burning materials that readily lend themselves to be burnt at a predictable and controlled rate, for example, cigarettes and cigars, and for the discharge of the produced air-combustion products mixture into a fixed test area in order to primarily determine the response of installed ultra sensitive products of combustion type detection devices. The invention can also be used to determine the operating characteristics and/or the response of individual detection devices by varying the air-combustion products concentrations in the atmosphere surrounding a detection device to thus enable calibration of the detection device.

The determination of the characteristics of the flow of air, containing combustion products (essentially gases, vapors, and particles), is essential in testing fire detection systems, especially in highly air conditioned environments such as computer rooms, facilities housing high density modules of electronic equipment, office buildings, and even private homes. Such installations are usually protected by thermal detectors or sprinkler systems having temperature sensitive water release fuses. These systems are inherently responsive only to relatively large amounts of heat given off by combustion, rather than to combustion products themselves, so that a fire would gain considerable headway and burn over a large area before these protection systems would be actuated. The present trend is to protect installations with detection devices operating upon the principle of products of combustion detection rather than heat to give early warning. Consequently, it is necessary to determine the smoke laden air flow characteristics within installations for the optimum location of detection devices. It is also necessary to determine the degree of response of each detection device to various air-combustion products concentrations in order to validate and evaluate the installations.

BACKGROUND OF THE INVENTION

In the prior art method for obtaining a controlled simulated fire condition, a specified length and size of insulated copper wire was short circuited across the terminals of a low voltage battery. By this method, the insulation surrounding the wire was vaporized by the short circuited, hot wire over a fixed period of time. The insulated wire was weighed before and after the short circuiting period, and the weight loss was con-

sidered as the amount of material, forming the combustion products, released to the atmosphere. However, this prior art method did not produce actual combustion products since the insulation was, in reality, vaporized and not burned. Further, this method did not accurately lend itself to any precise scientific measurement by instrumentation intended for combustion product indication nor did the vaporized material necessarily affect the fire detection device in the same manner as actual combustion products.

The present invention, on the other hand, provides a means for generating, by the use of, for example, cigarettes, cigars, or other materials that burn at a predictable rate, and controlling a predetermined quantity of actual combustion products mixed with air, at a given controlled rate, so as to cause a response on a fire detection system utilizing products of combustion type detection devices such as commercial ionization detectors. By so doing, the numerical quantity and rate of generation of the combustion products provide a means for determining, in an area being tested, the degree of protection achievable by the existing fire detection system or, alternatively, provide a means for best locating the detection devices for a fire detection system that is to be newly installed. Thus, the present invention represents a distinct improvement over the prior art devices and methods.

Fire detection devices, operating on the products of combustion detection principle, are actuated when the concentration of combustion products in the air immediately surrounding them are at a given intensity. Other than the herein described invention, there are no known methods or apparatus for generating and controlling the quantity of combustion products with the degree of precision necessary to evaluate the functioning of an installed fire detection system or of individual detector devices themselves. This invention further, when used with a commercially available product of combustion concentration analyzer can be used to determine the best placement of the individual fire detection devices by determining the air paths of smoke laden air. The invention can also be used in a specialized configuration for calibrating and adjusting the response of individual detection devices to varying degrees of air-combustion products concentrations.

An object of the present invention is to generate controlled quantities of combustion products for use in determining the detection performance of incipient fire sensing apparatus.

A further object of the present invention is to determine the degree of protection provided by existing fire detection systems.

Another object of the present invention is to provide means for best locating, in a particular area, the detection devices of a fire detection system.

Still another object of the present invention is to provide a means for calibrating and adjusting the response of the individual detection devices to varying degrees of air-combustion products concentrations.

SUMMARY OF THE INVENTION

The apparatus of the present invention comprises a self-contained assembly wherein combustion products are discharged into a plenum by blower means and mixed therein with air. The plenum expels the com-

bustion products in a desired fashion for example, by a distribution means. The distribution means is adjustable so as to provide uniform combustion product distribution over a desired area. Further, it can be modified in shape to accommodate a commercial instrument type produce of combustion analyzer, should it be desired to calibrate such an instrument, or to accommodate individual detector devices, should the apparatus be used for adjusting the response of individual detection devices to varying degrees of air-combustion products concentration. Both the degree of combustion and the amount of air introduced into the plenum is controlled by installing a blower means having a variable speed motor. An air intake means houses the blower means and includes control means for controlling the air intake so that a constant amount of combustion products with air is drawn into the plenum per unit time. Such control means include a perforated cigarette holder plate having a first plurality of holes therein just big enough to hold a predictable burning combustion products generating material, e.g., cigarettes or cigars, and a second plurality of smaller holes to permit the intake of air to achieve ease of combustion of the combustion products generating material. By varying the number and weight of the predictable burning combustibles, the amount of combustion products produced can be varied over known ranges after calibration of the apparatus. Further, the number and location of the air intake means may be varied so that large variations, as needed, in air-combustion products concentration can be effected.

FIG. 1 shows an exemplary configuration of a multi-module type apparatus of the present invention utilizing a plurality of air intake means; and

FIG. 2 illustrates a partial cut-away section of single module type instrument of the invention comprising a single air intake means, including fan, perforated plate, and cigarettes, for feeding a predetermined quantity of air-combustion products mixture to an individual detection device.

It should be understood the drawings of FIGS. 1 and 2 are not drawn to scale but are merely illustrative and exemplary of two embodiments of the invention.

DESCRIPTION OF THE MULTI-MODULE TYPE APPARATUS

There is shown in FIG. 1 one embodiment of the apparatus of the invention in which a stand 10 supports a generally box-like shaped plenum 11 with four generally cylindrical shaped blower intake modules 13, one housed in each of the four side walls of the plenum, there being two blower modules 13 illustrated in the Figure. It should be understood, of course, that the plenum and blower modules 13 can take other configurations than those shown.

A distribution means 12 covers plenum 11 and acts as the outlet therefor. It comprises a fixed lower perforated plate 12a, which provides the top for plenum 11, and an adjustable upper perforated plate 12b, seated on, smaller than, and movable with respect to fixed lower perforated plate 12a, but with similar holes and hole spacings. By adjusting or sliding adjustable upper perforated plate 12b over fixed lower perforated plate 12a, the effective opening of distribution means 12 can be increased or decreased according to hole

alignment, thereby enabling control of the flow of air-combustion products mixture to be at a relatively uniform discharge over the entire area of the distribution means 12.

Each blower intake module 13, as shown in more detail in FIG. 2, includes a cylindrical inlet shroud 17 attached to a fan casing 16 having front and rear openings. Inlet shroud 17 houses a perforated cigarette holder plate 18 positioned perpendicular to the axis of shroud 17 and having a first plurality of holes 8 therein to accommodate a plurality of cigarettes 19 and a second plurality of holes 9, smaller than the first plurality of holes, to permit passage of air. A fan 15, housed with casing 16, is located behind perforated cigarette holder plate 18, coaxial with shroud 17.

In the side walls of plenum 11 are a control panel 14 having four switches, one for each blower module 13; a speed control regulator 23, capable of adjusting the speed of fans 15, either individually or collectively; and a receptacle 20 to which a power line, either A.C. or D.C., is connected to furnish power to the fans 15 via the switches of control panel 14 and speed control regulator 23.

By the proper selection of the positions of the switches of control panel 14, the apparatus can be operated with all blower modules 13 operating at once, with only one blower module 13 operating, or with any combination of the blower modules operating at one time. Caps (not shown) are provided to cover shrouds 17 of the blower modules 13 not being operated. This is done to prevent a reverse discharge from the unused blower modules. Further, for extreme low density, air-combustion products concentration requirements, one blower module 13 can be operated burning cigarettes while any one or all of the other blower modules can furnish dilution air.

The quantity of combustion products, as well as the quantity of dilution air, can be regulated to produce a desired mixture by varying the rotational speed of fans 15 by speed control regulator 23, which thus regulates the rate of combustion and the quantity of air moved by the apparatus. Further variations in the mixture composition can be achieved by the selection of the number of cigarettes 19 inserted in perforated cigarette holder plates 18 of blower modules 13. Accordingly, the apparatus can produce a wide range of quantities and concentration of air-combustion products by varying the number of cigarettes burned, the speed of the fans, and the number of blower modules operating with or without cigarettes.

OPERATION OF THE MULTI-MODULE TYPE APPARATUS

Referring only to a single blower module 13 of the multi-module type apparatus of FIG. 1, with cigarettes 19 positioned in perforated cigarette holder plate 18 of blower module 13, the speed of fan 15 preset by speed control regulator 23, and cigarettes 19 being lighted, a controlled amount of air is drawn from the atmosphere through and around cigarettes 19 to thereby make possible a self-sustaining combustion with all of the combustion products entering plenum 11, which functions as a mixing chamber. At the same time, should any of the holes in perforated cigarette holder plate 18 not contain cigarettes, then dilution air enters the

plenum 11 through these empty holes as well as through holes 9 and mixes with the combustion products in plenum 11. The combustion products and air mixture in plenum 11, under a slightly positive pressure, are expelled from plenum 11 via pre-adjusted distribution means 12 into the atmosphere of an area being tested.

While the operation of the apparatus has been described by referring to the performance of one blower module 13, there would be no difference in the operation of the multi-module type apparatus with all or some of the blower modules 13 performing, except for obtaining in plenum 11 a greater or less quantity and concentration of air-combustion products mixture in accordance with selected combination of blower modules 13 in use and by the choice of the number of lighted cigarettes 19 positioned in the blower modules. The rate of burning of cigarettes 19 and the rate of flow of the air-combustion products mixture from distribution means 12 is determined by the speed of fans 15, as set by speed control regulator 23, with the flow of the air-combustion products mixture being further controlled by the relative position of adjustable upper perforated plate 12b with respect to fixed lower perforated plate 12a.

SPECIFIC FUNCTION OF THE MULTI-MODULE TYPE APPARATUS

The multi-module type apparatus is used at various locations, in an area to be tested, as judgment dictates, to generate and expel predetermined quantities of air-combustion products mixture at a preselected rate and given concentration. The density of this mixture, in the ambient atmosphere throughout the various areas of the room, is read by a commercial products of combustion analyzer, e.g., an ionization type analyzer. Based on these readings, it is possible to produce a plot plan of the distribution of the combustion product densities in the tested area. From this analysis, the most promising locations for detection devices can be determined and the fire detection system be established for optimum response to incipient fires of varying magnitudes wherever they may originate. Once the fire detection system has been installed, the multi-module type apparatus can be used to validate the entire system for a final check-out on a performance basis.

DESCRIPTION OF THE SINGLE MODULE TYPE INSTRUMENT

A single module instrument for testing a detection device 31, is shown in FIG. 2. Its front end or blower module 13 is substantially the same as one of the blower modules housed in the side walls of plenum 11 of FIG. 1. It includes a cylindrical inlet shroud 17 for housing perforated cigarette holder plate 18 having a first plurality of holes 8 therein to accommodate a plurality of cigarettes 19 and a second plurality of smaller holes 9 to permit passage of air, and a fan 15 housed within casing 16. Power, either A.C. or D.C., is supplied to fan 15 from line 21 via switch-motor speed control 22.

A cylindrical cannister plenum 25, coaxial with shroud 17, is attached to blower module 13 at fan casing 16 and has an opening in its front end 33 that mates with the rear opening of fan casing 16. A baffle plate

26, located in cannister plenum 25, substantially perpendicular to the axis of shroud 17, is attached to the inside wall of cannister plenum 25, except where it has a tab portion 29 thereof, bent forward in the direction toward blower module 13 to provide an opening 30 between it and the inner wall of cannister plenum 25 so that the produced air-combustion products mixture is a homogeneous mixture and is prevented from directly impinging upon detection device 31. While not shown, rather than having tab portion 29 of baffle plate 26 forming opening 30, a number of holes can be provided in baffle plate 26 to accomplish the same effect. Rear end 34 of cannister plenum 25 has an opening therein for accommodating, for example, a detection device 31 to be tested as shown, attached to structure 32. A handle 28, affixed to cannister plenum 25, facilitates hand holding the single module instrument.

OPERATION OF THE SINGLE MODULE TYPE INSTRUMENT

With the single module instrument hand held by handle 28 to be positioned such that a detection device 31 to be tested passes through the opening in the rear end 34 of cannister plenum 25, fan 15 being turned on and operating at a specified speed in accordance with switch-motor speed control 22, and a predetermined number of lighted cigarettes 19 being in the holes of perforated cigarette holder plate 18 of blower module 13, a desired concentration of air-combustion products mixture can be made to impinge upon detection device 31 to actuate it, thereby checking its operability. Air is drawn by fan 15 through shroud 17 and cigarettes 19 to smoke the cigarettes. Additional air, drawn by fan 15 via the empty cigarette holes 8 and smaller holes 9 in perforated cigarette holder plate 18, is intermingled, inside cannister plenum 25, with the combustion products given off by the burning cigarettes 19. The air drawn through shroud 17 can be supplemented by additional air from an air intake member (not shown) which could be positioned, for example, between shroud 17 and fan casing 16. The air-combustion products mixture in cannister plenum 25 has its flow directed by baffle 26 so that it indirectly impinges upon detection device 31 via opening 30. Baffle 26 also assists in the mixing function. Operating thusly, and with proper selection of the speed of fan 15 and the number of cigarettes 19, any desired concentration of air-combustion products mixture can be produced immediately surrounding detection device 31 to thereby enable the detection device's sensing characteristics to be established.

CALIBRATION

Both the multi-module type apparatus of FIG. 1 and the single module, type instrument of FIG. 2 can be directly calibrated in substantially the same manner. The cigarettes 19 are weighed before burning. They are then positioned in perforated cigarette holder plate 18; fan 15 is set to operate at a given speed; the cigarettes 19 are lighted; and the burning period is timed. At the end of a predetermined burning period, the cigarettes 19 are again weighed. The weight of the cigarettes 19 at the end of this burning period are subtracted from their initial weight, thereby the weight of that portion of the cigarettes that have burned is calculated. Now, having

the weight of the portion of the cigarettes burnt and knowing the time of burning, the burning rate is calculated by dividing the weight of the burnt portion by the time of burning.

During the burning period, the air flow from blower module 13 is measured by conventional air flow instrumentation. The air-combustion products concentration from a blower module 13 is then calculated by dividing the burning rated (calculated as described above) by the air flow. Repeating this procedure for various numbers of cigarettes and various speed settings of fan 15 will provide data for forming a calibration chart which can then be used in the future for the determination or choice of the various operating parameter, fan speed and number of cigarettes used. Such a chart will be directly applicable to the single module type instrument or to a single blower module 13 of the multi-module type apparatus should only a single blower module be in operation (the others being capped). In addition, it would also be applicable to a single blower module, of the multi-module type apparatus, being operated external thereof should it be desired to use the single blower module by itself in the testing of a small room, for example.

Referring particularly to the multi-module type apparatus of FIG. 1, when more than one blower module 13 is in operation, the same procedure for one blower module can be used for each of the blower modules to measure the air flow and calculate both the rate of burning and concentration of the air-combustion products mixture at each blower module. Should it be desired to obtain the total concentration of the air-combustion products mixture produced in plenum 11, the calculated rate of burning of all blower module 13 would be added, the measured air flow from all blower modules 13 would be added, and the ratio of the resultant totals of rate of burning to air flow would be calculated, the ratio thereby providing the total concentration of the air-combustion products mixture. Should any one of the blower modules 13 be functioning merely to supply air to plenum 11, the procedure just described would be just as applicable except that the air would be diluting the combustion products.

An alternative calibration procedure, equally applicable is as follows: the air-combustion products mixture, taken inside plenum 11 adjacent to distribution means 12 of FIG. 1 or through the opening in the rear end of cannister plenum 25 of FIG. 2, can be measured directly by a standard commercial combustion products analyzer and air flow measuring instrument to give a direct reading of the concentration of the air-combustion products mixture and its flow from the plenum, respectively.

GENERAL REMARKS

The single blower module 13 of the multi-module apparatus of FIG. 1 can be used individually by withdrawing it from the multi-module apparatus. Its use in this fashion is for small volume requirements or for insertion directly into electronic equipment to simulate a fire condition.

While the principal function of the invention described herein is as a test means to locate, install, and adjust highly sensitive fire detection apparatus so that the optimum use of the detection apparatus is obtained

for the detection of minute fires emanating from high value electronic equipment such as computers and radio electronic mechanisms, it can also be used in ordinary environment, air pollution studies, and as a means for introducing combustion products at a controlled rate into an air conditioning or ventilating system as trace elements to enable the establishment of air flow patterns.

Though specific embodiments of the invention have been described and illustrated, it will be clear that variations of the details of construction may be made without departing from the true spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. A combustion products generating and metering device comprising, in combination: a plenum having an inlet and an outlet; a blower module, housed in said inlet of said plenum, having an open rear end and a front end with apertures therein, a first group of said apertures adapted to hold a predetermined quantity of combustible material having a predictable burning rate, and a second group of said apertures being vacant to permit the passage of air into said plenum; a flow control distribution means associated with the outlet of said plenum for receiving and thereafter regulating the flow of the resulting air-combustion products mixture exiting said outlet of said plenum; and a products of combustion type detection device in proximity to said flow control distribution means.

2. The device of claim 1 wherein said combustible material is selected from the group consisting of cigarettes and cigars, said first group of said apertures is of a size appropriate for retaining said combustible material, and said second group of said apertures is smaller than said first group of apertures.

3. The device of claim 1 wherein said plenum has housed therein a deflection member to assist in achieving a homogeneous air-combustion products mixture and to properly direct the flow from said outlet.

4. The method of calibrating the device of claim 1 comprising the steps of weighing said combustible materials before and after a predetermined burning period; measuring the quantity of air drawn in by said blower module during the predetermined burning period; and determining the concentration of the combustion products-air mixture from the ratio of the difference in weight of said combustible materials before and after the predetermined burning period to the quantity of air drawn in during the predetermined burning period.

5. A combustion products generating and metering device comprising, in combination: a plenum having an inlet and an outlet; a blower module, housed in said inlet, having an open rear end and a front end with apertures therein, a first group of said apertures adapted to be filled with combustible materials having a predictable burning rate and a second group of said apertures being vacant to permit the passage of air into said plenum; and flow control distribution means associated with the outlet of said plenum for receiving and thereafter regulating the flow of the air-combustion products mixture exiting said outlet of said plenum, said flow control distribution means having a fixed plate with perforations therein for covering said outlet and a smaller plate with perforations therein parallel to

and in proximity with said fixed plate and covering only a portion thereof, said perforations in both plate being in substantial registry with one another, said smaller plate being movable with respect to said fixed plate so that the registry of said perforations in the plates can be varied.

6. The device of claim 5 wherein said combustible material is selected from the group consisting of cigarettes and cigars, said first group of said apertures is of a size appropriate for retaining said combustible material, and said second group of said apertures is smaller than said first group of apertures.

7. The device of claim 5, wherein said plenum has a plurality of inlets, each housing a blower module therein.

8. The device of claim 7 wherein at least one blower module includes no combustible material and thereby functions to solely provide diluent air.

9. In combination with a system for use in a confined area for determining the location, or for evaluating a pre-existing arrangement, of products of combustion type devices, the improvement comprising, in combination:

a plenum having an outlet and an inlet; a blower module, housed in said inlet, having an open rear end and a front end with apertures therein, a first group of said apertures adapted to be filled with combustible materials having a predictable burning rate and a second group of said apertures being vacant to permit the passage of air into said plenum, said blower module further including a controllable blower means housed therein; and flow control distribution means associated with the outlet of said plenum for receiving and thereafter regulating the flow of the air-combustion products mixture exiting said outlet of said plenum.

10. In the system of claim 9 said flow control distribution means including a fixed plate with perforations therein covering said outlet of said plenum, and a smaller plate with perforations therein parallel to and in proximity with said fixed plate and overlaying only a portion thereof, said perforations in said fixed plate and said smaller plate being in substantial registry with one another, said smaller plate being movable with respect to said fixed plate so that the registry of the perforations of the plates can be varied.

11. In the system of claim 9 said combustible material being selected from the group consisting of cigarettes and cigars, said first group of said apertures being of a size appropriate for retaining said combustible materi-

al, and said second of said apertures being smaller than said first group of apertures.

12. In the system of claim 9, said plenum having a plurality of inlets, each housing a blower module therein.

13. In the system of claim 12, at least one of said blower modules including no combustible material and thereby functioning to solely provide diluent air.

14. The method of producing and distributing predetermined amounts of an air-combustion products mixture to products of combustion type detection devices installed in a confined area to test their response, comprising the steps of: placing combustible materials having a predictable burning rate in a first group of apertures in a holder means; igniting said combustible material; operating a blower member to draw a predetermined quantity of combustion products, produced by said combustible materials, into a plenum; mixing in said plenum a predetermined quantity of air, being drawn in by said blower member via a second group of apertures in said holder means, with said combustion products to achieve a given concentration of air-combustion products mixture; and distributing to the detection devices under test, via a controlled distribution means associated with said plenum, the mixture of air-combustion products.

15. The method of claim 14 wherein said combustible materials are selected from the group consisting of cigarettes and cigars.

16. The method for determining where to best locate products of combustion type detection devices in a confined area comprising the steps of: placing combustible materials having a predictable burning rate in a first group of apertures in a holder means; igniting said combustible material; operating a blower member to draw a predetermined quantity of combustion products produced by said ignited combustible materials into a plenum; mixing in said plenum a predetermined quantity of air, being drawn in by said blower member via a second group of apertures in said holder means, with said combustion products to achieve a given concentration of air-combustion products mixture; and distributing to the area in which the detection devices are to be located, via a controlled distribution means associated with said plenum, the mixture of air-combustion products.

17. The method of claim 16 wherein said combustible materials are selected from the group consisting of cigarettes and cigars.

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