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Inventor(s)	GRAY; Brandon Patrick et al.

BIOSAFETY CABINET WITH DIVIDED PLENUM

Abstract

A biosafety cabinet including a plenum and a divider positioned in the plenum. The divider divides the plenum into a supply section and an exhaust section. A blower is positioned adjacent the plenum and in fluid communication with the plenum. The blower is configured to simultaneously supply air to both the supply section and the exhaust section of the plenum. An exhaust filter is positioned between the exhaust section and an exhaust outlet. The air supplied to the exhaust section from the blower passes through the exhaust filter. A supply filter is positioned between the supply section and a work area. The air supplied to the supply section from the blower passes through the supply filter. An adjuster may be coupled to the divider to adjust a position of the divider in the plenum.

Inventors: **GRAY; Brandon Patrick (Prairie Village, KS), HAYS; Michael Brian (Peculiar, MO), FINCHAM; Victoria Grace (Shawnee, KS)**

Applicant: **LABCONCO CORPORATION** (KANSAS CITY, MO)

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This patent application claims priority to U.S. Non-Provisional patent application Ser. No. 18/144,340, entitled BIOSAFETY CABINET WITH DIVIDED PLENUM, and filed on May 8, 2023, which is incorporated by reference herein in its entirety.

BACKGROUND
[0002] Biological safety cabinets, otherwise known as biosafety cabinets, are laboratory containment devices typically equipped with High Efficiency Particulate Air (HEPA) filters. These biosafety cabinets are used in laboratories where microbiological and hazardous particulate are handled and provide both a sterile work area and a safe environment where a variety of experiments and studies can be performed. Biosafety cabinets typically have a frame that encloses the work area on all but one side. The remaining side provides an access opening to the work area that can be closed in whole or in part via a movable sash. The sash may be moved upwardly to provide access to the work area so that work can be performed. The sash may be moved downwardly to partially or completely close the work area. A blower unit is provided in the biosafety cabinet above the work area to provide clean down flow air to the work area. The blower is used to circulate air downwardly through a HEPA filter and then through the work area. A portion of this downward airflow combines with inflow air to form an “air curtain” at the front of the biosafety cabinet adjacent the access opening and passes beneath the work surface of the work area. The inflow portion of airflow is created by exhausting air through a HEPA filter out the top of the biosafety cabinet. Another portion of the downward airflow is directed to the back of the biosafety cabinet where it is then drawn upwardly through a plenum chamber. As the air moves downward through the work area, it may be contaminated by materials present within the work area. Therefore, prior to being exhausted into the room or removed outside the room by a separate building fume removal system, the air may be first passed through a HEPA exhaust filter.
[0003] The blower is of a size and powered to operate at a speed to provide sufficient airflow through the work area and establish the inflow airflow to insure that materials, including harmful contaminants, are contained within the work area and eventually passed to a filter area rather than escaping into the room or exhausted into the atmosphere. To this end, a portion of air is drawn into the biosafety cabinet at the front of the access opening formed when the sash is in an open or partially open position to block the outflow of air.
[0004] The amount of air drawn into the biosafety cabinet is in part dependent on the position of the movable sash as it determines the size of the access opening. Traditionally, biosafety cabinets are manufactured and calibrated to operate at a pre-determined maximum sash height. Typical sash heights are 8, 10, or 12 inches. A combination of detent mechanisms and alarm switches may be used to alert a user when the sash is not at the operational sash height (“OSH”). To change the OSH, a biosafety cabinet technician moves the detents and switches and re-calibrates the biosafety cabinet to ensure proper airflow. Recalibration may include adjusting the speed of one or more blowers, adjusting the position of one or more dampers, or removing or inserting plugs into an exhaust filter cover.
[0005] The prior art biosafety cabinets are typically provided with a sash grill located below the sash. This sash grill forms the lower-most surface of the access opening into the work area. Typically, the sash grill is provided with a number of perforations through which air drawn from outside the biosafety cabinet can flow, known as inflow air. The air flows through the sash grill

openings, under the work surface, and upwardly through a plenum at the back of the biosafety cabinet to be recirculated and/or exhausted by a blower. Inside the biosafety cabinet, a portion of air, known as downflow air, flows downwardly from the blower, through a supply HEPA filter, and then through a diffuser into the work area. The front portion of this HEPA-filtered airflow enters the sash grill. The rear portion flows into perforations near the lower-back of the work area and is drawn into the plenum to be recirculated and/or exhausted.

[0006] Biosafety cabinets have conventionally been classified by “Type” based on the configuration of airflow within the biosafety cabinet as well as the final destination of the exhaust air. Type A2 biosafety cabinets (“BSCs”) combine the mixed incoming air (inflow) and down flow air (downflow) and re-circulate approximately 70% of the combined air. The remaining air is exhausted after HEPA filtration, either back into the laboratory or via a building fume removal system.

[0007] Many conventional Type A2 BSCs have a blower that pressurizes a single plenum. As described above, the blower draws air from outside the biosafety cabinet through the sash grill openings and also air from within the work area of the biosafety cabinet. The blower supplies air to the single plenum, which is in fluid communication with both a supply filter and an exhaust filter. A ir passing through the supply filter enters the work area of the biosafety cabinet, and air passing through the exhaust filter is exhausted from the biosafety cabinet. The blower must pressurize the plenum to a level that is higher than the highest pressure drop of the exhaust filter and the supply filter. Typically, the supply filter is selected with a higher pressure drop than the exhaust filter to ensure that the airflow through the exhaust filter is at a sufficient rate for safe operation. Selecting a supply filter with a higher pressure drop means that the blower must be operated at a higher speed to pressurize the plenum to a level above the pressure drop of the supply filter. Operating the blower at a higher speed causes the blower to consume more power and generate more noise. Further, operating the blower at a higher initial speed lowers the available life span of the filters. The blower speed continuously increases over time as the filters are loaded with contaminants and become more resistant to airflow. When the blower speed reaches its maximum, the filters must be replaced to ensure continued safe operation of the biosafety cabinet. If the blower is at a higher initial speed to overcome the pressure drop of the supply filter, there is less speed increase available until the blower reaches its maximum speed and the filters need to be replaced.

[0008] The airflow through each of the supply filter and the exhaust filter must be balanced to ensure safe operation of the biosafety cabinet. The airflow rate through each filter depends at least in part on the variation between the airflow resistances of the supply filter and the exhaust filter due to air flowing more easily through the filter with a lower resistance. A sliding damper is often positioned adjacent the exhaust filter to restrict the area of the exhaust filter that is directly exposed to the plenum. Even when using a sliding damper to attempt to balance the airflow through the filters, the airflow is still dependent on the variation in resistance between the filters. While the filters may be selected initially with resistances or pressure drops that ensure proper airflow through the filters, if the filters are loaded at different rates over time, it may not be possible to balance the airflow rate through the filters to achieve safe operating conditions. Use of the sliding damper also causes a higher resistance to airflow through the exhaust filter due to the restriction it presents to air flowing to the exhaust filter, which means the blower must be operated at a higher speed to achieve a desired airflow rate through the exhaust filter. Operating the blower at a higher speed consumes more power, generates more noise, and lowers available filter life.

[0009] To overcome some of the disadvantages of a biosafety cabinet with a single blower supplying air to a single plenum, some biosafety cabinets have two separate plenums each supplied with air from its own blower. A supply blower supplies air to a supply plenum, and an exhaust blower supplies air to an exhaust plenum. While this configuration may overcome some of the disadvantages set forth above, it is also more expensive to equip and operate a biosafety cabinet with two blowers. It consumes more energy than a single blower due to the inherent inefficiency of two blowers versus the inherent inefficiency of one blower.

BRIEF SUMMARY

[0010] A biosafety cabinet in accordance with an aspect of the invention described herein includes a divided plenum that defines two separate air passageways: a supply passageway extending from a supply inlet to a supply outlet, and an exhaust passageway extending from an exhaust inlet to an exhaust outlet. A single blower is configured to simultaneously supply air to both the supply passageway via the supply inlet and to the exhaust passageway via the exhaust inlet. An exhaust filter may be positioned within the exhaust passageway between the exhaust inlet and the exhaust outlet. In this manner, air supplied to the exhaust passageway from the blower passes through the exhaust filter. A supply filter may be positioned within the supply passageway between the supply inlet and supply outlet. In this manner, air supplied to the supply passageway from the blower passes through the supply filter. Because the two passageways are separate, airflow through the supply filter is independent of the pressure drop of the exhaust filter, and airflow through the exhaust filter is independent of the pressure drop of the supply filter. The divided plenum may be configured to be adjustable such that one or both of the passageways and/or one or both of the inlets may be enlarged or reduced in size. In some embodiments, an adjustable divider positioned within the plenum divides and separates the supply passageway and the exhaust passageway. In some embodiments, the adjustable divider is configured to be moveable in a manner that enlarges one passageway and/or inlet, while reducing the other passageway and/or inlet.

[0011] A biosafety cabinet in accordance with an aspect of the invention described herein includes a plenum and a divider positioned in the plenum. The divider divides the plenum into a supply section and an exhaust section. A blower is positioned adjacent the plenum and/or in fluid communication with the plenum. The blower is configured to simultaneously supply air to both the supply section and the exhaust section of the plenum. An exhaust filter is positioned between the exhaust section and an exhaust outlet. The air supplied to the exhaust section from the blower passes through the exhaust filter. A supply filter is positioned between the supply section and a work area. The air supplied to the supply section from the blower passes through the supply filter. The air supplied to the exhaust section from the blower may pass through the exhaust filter without entering the supply section, and the air supplied to the supply section from the blower may pass through the supply filter without entering the exhaust section.

[0012] Dividing the plenum into a supply section and an exhaust section each simultaneously pressurized by the blower may allow the biosafety cabinet to be operated in a more efficient manner than conventional biosafety cabinets having a single plenum pressurized by a blower. The speed of the blower can be set at a level so that the air within each of the supply section and the exhaust section is at a pressure just above the resistance or pressure drop of the supply filter and the exhaust filter, respectively. This speed is typically lower than the blower speed of a conventional biosafety cabinet, which needs to be set to generate enough positive pressure within the plenum to force air through the filter with the highest resistance. The filters of the biosafety cabinet described herein may also be selected to have a lower pressure drop than a conventional biosafety cabinet because airflow through the supply filter is independent of the pressure drop of the exhaust filter and airflow through the exhaust filter is independent of the pressure drop of the supply filter. The blower can be operated at a lower speed when the filters have a lower pressure drop, which reduces the power consumption and noise of the blower. Further, operating the blower at a lower speed extends the life of the filters because the filters may be loaded for a longer time period before the blower reaches its maximum operating speed.

[0013] In some embodiments, an adjuster is coupled to the divider. The adjuster is configured to adjust a position of the divider in the plenum. Adjustment of the divider in a first direction increases a volume of the supply section, and adjustment of the divider in a second direction increases a volume of the exhaust section. Adjusting the divider allows a technician to change the relative airflow rates through the exhaust filter and the supply filter independently of the variation between the airflow resistances of the supply filter and the exhaust filter.

[0014] The adjuster may include a cable attached to one end of the divider. The cable can be pulled to adjust the divider in one of the first direction or the second direction, and the cable can be pushed to adjust the divider in the other direction. The adjuster may alternatively include a motor that is operable to move one end of the divider.

[0015] Further, in some embodiments, the exhaust filter includes an inlet surface exposed to the exhaust section of the plenum. The exhaust section of the plenum is configured so that there is an unrestricted airflow path in the exhaust section from the blower to the inlet surface of the exhaust filter. With an unrestricted airflow path, the blower may be operated at a lower speed to achieve a desired airflow rate through the exhaust filter than if the airflow path was restricted. Operating the blower at a lower speed requires less power consumption and reduces the noise of the blower.

[0016] Another aspect of the invention described herein is directed to a method of supplying filtered air to a work area of a biosafety cabinet. The method includes the following steps: (a) providing a biosafety cabinet having a divided plenum that defines a supply passageway extending from a supply inlet to a supply outlet, and an exhaust passageway extending from an exhaust inlet to an exhaust outlet, wherein the supply passageway and exhaust passageway are separate from one another; (b) simultaneously supplying air to both the supply passageway and the exhaust passageway via a blower supplying air to the supply inlet and the exhaust inlet; (c) filtering the air supplied to the exhaust passageway via an exhaust filter positioned within the exhaust passageway between the exhaust inlet and the exhaust outlet; (d) filtering the air supplied to the supply passageway via a supply filter positioned within the supply passageway between the supply inlet and the supply outlet; and (e) setting the speed of the blower at a level such that the air within each of the supply passageway and the exhaust passageway is at a pressure above the resistance or pressure drop of the supply filter and the exhaust filter, respectively. In some embodiments, the method additionally includes the step of: (f) adjusting the size of one or both of the passageways and/or one or both of the inlets to balance the airflow rates through the filters. In some embodiments, adjusting the size of one or both of the passageways and/or one or both of the inlets is accomplished by moving an adjustable divider that divides and separates the supply passageway and the exhaust passageway. In some embodiments, the adjustable divider is moved to simultaneously enlarge one passageway and/or inlet, and reduce the other passageway and/or inlet.

[0017] A method of supplying filtered air to a work area of a biosafety cabinet in accordance with an aspect of the invention described herein includes the steps of: (a) providing a biosafety cabinet having a plenum with a divider that divides the plenum into a supply section and an exhaust section; (b) simultaneously supplying air to both the supply section and the exhaust section via a blower positioned adjacent the plenum and/or in fluid communication with the plenum; (c) filtering the air supplied to the exhaust section via an exhaust filter positioned between the exhaust section and an exhaust outlet; (d) filtering the air supplied to the supply section via a supply filter positioned between the supply section and a work area; and (e) setting the speed of the blower at a level such that the air within each of the supply section and the exhaust section is at a pressure above the resistance or pressure drop of the supply filter and the exhaust filter, respectively. In some embodiments, the method additionally including the step of (f) adjusting the volume of each section by moving the divider.

[0018] Additional aspects of the invention, together with the advantages and novel features appurtenant thereto, will be set forth in part in the description which follows, and in part will become apparent to those skilled in the art upon examination of the following, or may be learned from the practice of the invention. The objects and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] FIG. **1** is a perspective view of a biosafety cabinet in accordance with an exemplary embodiment of the invention described herein;

[0020] FIG. **2** is a top plan view of the biosafety cabinet shown in FIG. **1**;

[0021] FIG. **3** is a cross-sectional view taken through the line **3-3** in FIG. **2**;

[0022] FIG. **4** is a front perspective view of an upper portion of the biosafety cabinet shown in FIG. **1** with a front cover and a front panel of the biosafety cabinet removed;

[0023] FIG. **5** is a cross-sectional view of the upper portion of the biosafety cabinet taken through the line **5-5** in FIG. **2**;

[0024] FIG. **6** is a front perspective view of the upper portion of the biosafety cabinet with the front cover and the front panel of the biosafety cabinet removed and a front wall of a plenum removed;

[0025] FIG. **7** is a cross-sectional view of the upper portion of the biosafety cabinet taken through the line **7-7** in FIG. **2**;

[0026] FIG. **8** is a cross-sectional view of the plenum of the biosafety cabinet shown in FIG. **1**;

[0027] FIG. **9** is a detail view of the area identified as “FIG. **9**” in FIG. **5** showing a portion of an adjuster that is operable to adjust the position of a divider in the plenum of the biosafety cabinet;

[0028] FIG. **10** is a perspective view of the area shown in FIG. **9**;

[0029] FIG. **11** is a detail view of the area identified as “FIG. **11**” in FIG. **5** showing another portion of the adjuster;

[0030] FIG. **12** is a cross-sectional view similar to FIG. **5** but showing the divider of the biosafety cabinet moved downward from the position shown in FIG. **5** to enlarge an exhaust section of the plenum and reduce a supply section of the plenum;

[0031] FIG. **13** is a cross-sectional view similar to FIG. **5** but showing an alternative embodiment of adjuster that is operable to adjust the position of the divider in the plenum; and

[0032] FIG. **14** is a detail view of the area identified as “FIG. **14**” in FIG. **13**.

DETAILED DESCRIPTION

[0033] A biological safety cabinet, or biosafety cabinet, in accordance with an embodiment of the invention described herein is identified with the reference number **10** in FIG. **1**. The biosafety cabinet **10** includes a housing **12** that defines a work area **14** in a lower part of the biosafety cabinet **10**. As shown in FIG. **4**, the biosafety cabinet **10** contains a plenum **16**, a blower **18**, an exhaust filter **20**, and a supply filter **22** in an upper part of the biosafety cabinet **10**. The blower **18** is generally operable to draw air from the work area **14** and from outside the biosafety cabinet **10**, provide a portion of that air to the work area **14** through the supply filter **22**, and exhaust a portion of that air through the exhaust filter **20**. As described in more detail below, the biosafety cabinet **10** is further adjustable to alter the flow rate of the air passing through the supply filter **22** and the exhaust filter **20**.

[0034] Referring to FIGS. **1** and **3**, the housing **12** has a bottom panel **24** and a pair of upwardly extending opposing side panels **26***a-b* which are joined to the bottom panel **24**, such as by fasteners or welding. Extending upwardly from the bottom panel **24** and rigidly coupled between the side panels **26***a-b* is a rear panel **28** (FIG. **3**). The side panels **26***a-b* and the rear panel **28** extend upwardly from the bottom panel **24** to a top panel **30** (FIG. **3**). A front panel **32** (FIG. **3**) extends between the side panels **26***a-b* and downward from the top panel **30** approximately half-way toward the bottom panel **24**. A baffle **34** extends between the side panels **26***a-b* and is spaced inward from the rear panel **28**. The bottom of the baffle **34** is spaced a distance above the bottom panel **24**, as shown in FIG. **3**. Openings **34***a* (FIG. **1**) formed in a lower portion of the baffle **34** allow air from inside the work area **14** to be drawn by the blower **18** into the space between the baffle **34** and the rear panel **28**.

[0035] A work surface **36** is suspended above the bottom panel **24** and extends from the baffle **34** to a sash grill **38**. The work surface **36** also extends between the side panels **26***a-b*. The work surface **36** is used to hold objects necessary to perform experiments within biosafety cabinet **10**, such as beakers, flasks, and other conventional lab ware. The sash grill **38** extends generally along the front of biosafety cabinet **10** between the side panels **26***a-b*. The sash grill **38** further extends forward from the work surface **36** to the bottom panel **24**. The sash grill **38** includes openings **38***a* allowing air from outside the work area **14** to be drawn by the blower **18** into the space between the work surface **36** and the bottom panel **24**.

[0036] A movable sash **40** is mounted between the side panels **26***a-b* in a manner allowing it to be moved upwardly and downwardly. The sash **40** is movable to alter the size of a front opening **41** of the biosafety cabinet **10** through which the work area **14** is accessible. An air diffuser plate **42** extends between the side panels **26***a-b* and from the baffle **34** to the front panel **32**. The air diffuser plate **42** is positioned beneath the supply filter **22**, as shown in FIG. **3**, and is perforated to allow air passing through the supply filter **22** to enter the work area **14**. The work surface **36**, baffle **34**, side panels **26***a-b*, air diffuser plate **42**, and sash **40** define the work area **14**.

[0037] A front cover **44** is positioned in front of the front panel **32** and joined to the side panels **26***a-b* and top panel **30**. Opposing side covers **46***a-b* extend from the front cover **44** rearward to the rear panel **28**. Panels **24**, **26***a-b*, **28**, **30**, and **32**, as well as baffle **34**, work surface **36**, sash grill **38**, and air diffuser plate **42** may be made from metal such as stainless steel.

[0038] Referring to FIG. **3**, the blower **18** has an inlet **48** that draws air from the work area **14** through a recirculation duct **50**. The recirculation duct **50** includes a rear section **50***a* that is positioned between the rear panel **28** and the baffle **34** and a lower section **50***b* that is positioned between the bottom panel **24** and the work surface **36**. The lower section **50***b* of the recirculation duct is in fluid communication with the work area **14** through the openings in the sash grill **38**, and the rear section **50***a* is in fluid communication with the work area **14** through the openings in the lower portion of the baffle **34**. As the blower **18** operates, it draws air from the work area **14** through the recirculation duct **50** and the openings in the sash grill **38** and baffle **34**. The blower **18** also draws ambient air from outside the biosafety cabinet **10**, which passes through the front opening **41** and through the openings in the sash grill **38** into the recirculation duct **50**.

[0039] As shown in FIGS. **5** and **6**, the blower **18** has an outlet **52** that supplies air to the interior of the plenum **16** through an inlet **54** of the plenum **16**. The blower **18** is mounted to the plenum **16** so that substantially all of the air exiting the blower **18** enters the plenum **16** through the inlet **54**. A divider **56** positioned in the plenum **16** divides the plenum **16** into a supply section **58** and an exhaust section **60**. A ir from the blower **18** that enters the inlet **54** of the plenum **16** is divided by the divider **56** into exhaust air **62** (FIG. **5**) that enters the exhaust section **60** and supply air **64** that enters the supply section **58**. All of the exhaust air **62** passes through the exhaust filter **20** and exits the biosafety cabinet **10** through an exhaust outlet **66**. All of the supply air **64** passes through the supply filter **22** and enters the work area **14** through the air diffuser plate **42**. The blower **18** simultaneously supplies the exhaust air **62** to the exhaust section **60** and the supply air **64** to the supply section **58**. The blower **18** is further operable to simultaneously maintain a supply air pressure within the supply section **58** above an ambient air pressure, and an exhaust air pressure within the exhaust section **60** above the ambient air pressure. As described in more detail below, the divider **56** is adjustable in order to modify the relative flow rates of the exhaust air **62** and the supply air **64** (e.g., the divider **56** may be adjusted to increase the flow rate of the exhaust air **62** while decreasing the flow rate of the supply air **64**, or the divider **56** may be adjusted to increase the flow rate of the supply air **64** while decreasing the flow rate of the exhaust air **62**).

[0040] Referring to FIG. **4**, the plenum **16** includes a front wall **16***a*, an upper wall **16***b*, a first side wall **16***c*, a second side wall **16***d*, a first intermediate wall **16***e*, a rear wall **16***f* (FIG. **7**), and a second intermediate wall **16***g*. The walls **16***a-g* of the plenum **16** are shown as being joined together with fasteners, and may be joined together in any suitable manner. Further, any of the walls **16***a-g* may be integrally formed together (e.g., the upper wall **16***b* and first side wall **16***c* may be formed from the same sheet of material, and the second side wall **16***d* and intermediate walls **16***e* and **16***g* may be formed from the same sheet of material). The front and rear walls **16***a* and **16***f* are generally parallel and are each joined to the upper wall **16***b*, side walls **16***c-d* and intermediate walls **16***e* and **16***g*. The side wall **16***c* is joined to the front wall **16***a*, upper wall **16***b*, and rear wall **16***f*. The side wall **16***d* is generally parallel to the side wall **16***c* and is joined to the front wall **16***a*, intermediate wall **16***e*, and rear wall **16***f*. The first intermediate wall **16***e* is generally parallel to the upper wall **16***b*. The first intermediate wall **16***e* extends from an upper edge of the side wall **16***d* toward the side wall **16***c*. The second intermediate wall **16***g* is generally parallel to the side walls **16***c-d*. The second intermediate wall **16***g* is joined to and extends between the first intermediate wall **16***e* and the upper wall **16***b*. As shown in FIG. **7**, the inlet **54** of the plenum **16** is formed in the second intermediate wall **16***g*. Lower edges of the front wall **16***a*, side walls **16***c-d*, and rear wall **16***f* define a supply opening **68** (FIG. **7**) of the plenum **16**.

[0041] The plenum **16** further includes an exhaust filter mount **70** (FIGS. **4**, **6**, and **7**) that is mounted to and extends upward from the upper wall **16***b*. The exhaust filter mount **70** includes a front wall **70***a*, side walls **70***b-c*, and a rear wall **70***d* (FIG. **7**) that are joined together. The front wall **70***a* and side walls **70***b-c* are generally planar, and the rear wall **70***d* includes a first section extending upward from the upper wall **16***b*, a second section extending rearward toward the rear panel **28** of the housing **12**, and a third section extending upward toward the exhaust filter **20**. Upper edges of the walls **70***a-d* define an exhaust opening **72** (FIG. **7**) of the plenum **16**.

[0042] Referring now to FIG. **8**, the divider **56** extends lengthwise across the plenum **16** from the side wall **16***c* to the inlet **54** formed in the intermediate wall **16***g*. Slots (not shown) formed in the side wall **16***c* receive tabs, one of which is identified as **74** in FIG. **8**, to pivotably mount the divider **56** to the plenum **16**. The tabs **74** are mounted to the plenum **16** adjacent an upper edge of the side wall **16***c*. The divider **56** has a first end **56***a* positioned at the end of the plenum **16** adjacent side wall **16***c* and a second end **56***b* positioned adjacent the blower **18** and inlet **54**. As shown in FIG. **7**, the divider **56** extends widthwise across the plenum **16** from the front wall **16***a* to the rear wall **16***f*. The divider **56** extends lengthwise and widthwise across the plenum **16** to separate the supply section **58** of the plenum **16** from the exhaust section **60** and substantially inhibit the movement of air from the supply section **58** to the exhaust section **60** and vice versa.

[0043] As shown in FIG. **8**, the divider **56** includes a first section **56***c* that is mounted to the side wall **16***c*, and a second section **56***d* that extends downward at an angle from the first section **56***c* to the inlet **54**. The second end **56***b* of the divider **56** is vertically adjustable within the plenum **16** via an adjuster **76** that is joined to the second end **56***b*. As the second end **56***b* moves vertically, the tabs **74** pivot within the slots of the side wall **16***c*. Instead of being pivotably mounted to the plenum **16** with tabs **74**, the divider **56** may be pivotably mounted to the plenum **16** in any suitable manner. For example, the divider **56** may be pivotably mounted to the plenum **16** with a hinge, pins extending outward from sides of the divider **56** that are received by holes in the front wall **16***a* and rear wall **16***f*, or pins extending from the front wall **16***a* and the rear wall **16***f* that are received by holes in sides of the divider **56**.

[0044] A guide **78** is also positioned in the plenum **16** beneath the divider **56**. The guide **78** is generally planar and extends from the bottom of the inlet **54** at an upward angle toward the side wall **16***c*. The guide **78** also extends between the front wall **16***a* and the rear wall **16***f*. The blower **18** is mounted to the wall **16***g* and oriented to blow air in the plenum **16** in a direction toward and generally perpendicular to the side wall **16***c*. The guide **78** assists in redirecting air from the blower **18** that enters the supply section **58** so that the air is generally distributed across the length of the plenum **16** from the side wall **16***c* to the side wall **16***d* (FIG. **4**).

[0045] The adjuster **76** is described herein with reference to FIGS. **9-11**. The adjuster **76** includes a cable **82** with a first end **82***a*, shown in FIGS. **9** and **10**, that is mounted to a bracket **83** and a second end **82***b*, shown in FIG. **11**, that is mounted to the second end **56***b* of the divider **56**. The cable **82** is received within a housing **84** that extends between the first and second ends **82***a-b* of the cable **82**. The cable **82** and housing **84** may be, for example, a typical push-pull cable and housing. Near the first end **82***a* of the cable **82**, the housing **84** is mounted to a bracket **86** that is mounted to the side panel **26***a* of the housing **12**. Near the second end **82***b* of the cable **82**, the housing **84** is mounted to the upper wall **16***b* of the plenum **16**. The bracket **83** (FIGS. **9** and **10**) is not fixedly mounted to the housing **12** of the biosafety cabinet **10**. Instead, the bracket **83**, and first end **82***a* of the cable **82**, are movable vertically with respect to the housing **12**. A threaded rod **88** engages a threaded surface (not shown) of the bracket **83**. A head **90** (FIG. **9**) of the threaded rod **88** is positioned above the top panel **30**. The head **90** is accessible by removing an access panel **92** (FIG. **2**) mounted to an upper cover **94** of the housing **12**.

[0046] Rotation of the threaded rod **88** in a first direction (e.g., a clockwise direction when viewing the top of the housing **12** as shown in FIG. **2**) moves the bracket **83** vertically upward thereby pulling the first end **82***a* of the cable **82** upward. As the cable **82** is pulled by the bracket **83**, the second end **82***b* (FIG. **11**) of the cable **82** pulls the second end **56***b* of the divider **56** vertically upward, which causes the divider **56** to rotate upward about its pivotal mounting to the side wall **16***c* (FIG. **8**). Movement of the divider **56** in this direction increases the volume of the supply section **58** of the plenum **16** and reduces the volume of the exhaust section **60** of the plenum **16**. Further, movement of the second end **56***b* of the divider **56** upward increases the cross-sectional area of the supply section **58** at the inlet **54** of the plenum **16** and decreases the cross-sectional area of the exhaust section **60** at the inlet **54** of the plenum **16**. Increasing the cross-sectional area of the supply section **58** at the inlet **54** increases a flow rate of the air supplied to the supply section **58** by the blower **18**, and decreasing the cross-sectional area of the exhaust section **60** at the inlet **54** decreases a flow rate of the air supplied to the exhaust section **60** by the blower **18**.

[0047] Rotation of the threaded rod **88** in a second direction (e.g., a counter-clockwise direction when viewing the top of the housing **12** as shown in FIG. **2**) moves the bracket **83** vertically downward thereby pushing the first end **82***a* of the cable **82** downward. As the cable **82** is pushed by the bracket **83**, the second end **82***b* (FIG. **11**) of the cable **82** pushes the second end **56***b* of the divider **56** vertically downward, which causes the divider **56** to rotate downward about its pivotal mounting to the side wall **16***c* (FIG. **8**). For example, FIG. **12** shows the divider **56** rotated downward relative to the position of the divider **56** shown in FIGS. **5**, **8**, and **11**. Movement of the divider **56** in this direction reduces the volume of the supply section **58** of the plenum **16** and increases the volume of the exhaust section **60** of the plenum **16**. Further, movement of the second end **56***b* of the divider **56** downward decreases the cross-sectional area of the supply section **58** at the inlet **54** of the plenum **16** and increases the cross-sectional area of the exhaust section **60** at the inlet **54** of the plenum **16**. Decreasing the cross-sectional area of the supply section **58** at the inlet **54** decreases a flow rate of the air supplied to the supply section **58** by the blower **18**, and increasing the cross-sectional area of the exhaust section **60** at the inlet **54** increases a flow rate of the air supplied to the exhaust section **60** by the blower **18**.

[0048] Referring back to FIG. **5**, the exhaust filter **20** is positioned in the airflow path between the exhaust section **60** of the plenum **16** and the exhaust outlet **66** of the housing **12**. The exhaust filter **20** is supported by the exhaust filter mount **70** and positioned between the mount **70** and the top panel **30**. The air that is supplied to the exhaust section **60** of the plenum **16** from the blower **18** passes through the exhaust filter **20** to remove contaminants from the air before the air passes through the exhaust outlet **66**. The blower **18**, plenum **16**, and divider **56** are configured so that the air supplied to the exhaust section **60** from the blower **18** passes through the exhaust filter **20** without entering the supply section **58**. The exhaust filter **20** has an inlet surface **20***a* that is exposed to the exhaust section **60** of the plenum **16**. The exhaust section **60** of the plenum **16** is configured so that there is an unrestricted airflow path in the exhaust section **60** from the blower **18** to the inlet surface **20***a* of the exhaust filter **20**. "Unrestricted" as used herein means that the airflow path from the location where air from the blower **18** enters the exhaust section **60** of the plenum **16** to the inlet surface **20***a* of the exhaust filter **20** is not reduced in cross-sectional area more than five percent (5%) at any point (i.e., at any location along the airflow path from the blower **18** through the exhaust section **60** to the inlet surface **20***a*, the cross-sectional area of the airflow path is not reduced more than five percent (5%) from the cross-sectional area of the airflow path at any other location along the path that is nearer to the blower **18**).

[0049] As shown in FIG. **5**, the supply filter **22** is positioned in the airflow path between the supply section **58** and the work area **14**. The supply filter **22** is supported on a supply filter mount **100** (FIGS. **5** and **7**) that extends between the side panels **26***a-b*. The supply filter **22** is positioned between the mount **100** and the lower edge of the plenum **16**. The air that is supplied to the supply section **58** from the blower **18** passes through the supply filter **22** to remove contaminants from the air before the air enters the work area **14**. The blower **18**, plenum **16**, and divider **56** are configured so that the air supplied to the supply section **58** from the blower **18** passes through the supply filter **22** without entering the exhaust section **60**.

[0050] FIGS. **13** and **14** show an alternative adjuster **200** that may be used with the biosafety cabinet **10** in place of the adjuster **76** described above and shown in FIGS. **9-11**. As shown in FIG. **14**, the adjuster **200** includes a motor **202** that is mounted to the plenum **16** above the divider **56**. The motor **202** is operable to rotate a threaded rod **204** that engages a threaded opening **206** in the second end **56***b* of the divider **56**. Rotation of the threaded rod **204** in one direction causes the second end **56***b* of the divider **56** to move vertically upward, and rotation of the threaded rod **204** in the opposite direction causes the second end **56***b* of the divider **56** to move vertically downward. In addition to the adjusters **76** and **200** disclosed herein, any other suitable electromechanical or non-electromechanical adjustment mechanism may be used to move the second end **56***b* of the divider **56** vertically upward and downward to adjust the position of the divider **56** within the plenum **16**.

[0051] In use and as shown in FIG. **3**, blower **18** is operated to provide downward airflow through the biosafety cabinet **10**, and particularly through work area **14**. Prior to entering the work area **14**, the air first passes through the supply filter **22**, preferably a HEPA filter, to remove contaminants. Biosafety cabinet **10** may be operated with sash **40** located a specified distance away from sash grill **38**. To ensure that contaminants from the work area **14** do not escape through the opening between sash **40** and sash grill **38**, blower **18** directs air downwardly along the rear surface of sash **40** and into the openings **38***a* of grill **38** from above the work area **14** to provide a protective curtain of air that facilitates containment within work area **14**. A portion of the air from blower **18** also moves toward the rear of work surface **36** and enters the recirculation duct **50** through the openings **34***a* in the lower portion of the baffle **34**. The air exhausted out of the exhaust outlet **66** (through the exhaust filter **20**) is replaced by the inflow of ambient air from outside the biosafety cabinet **10** flowing inwardly through the front opening **41**. The air drawn through the front opening **41** passes through the openings **38***a* in sash grill **38**. The air drawn through front sash grill **38** travels through the recirculation duct **50** beneath work surface **36** and between the baffle **34** and rear panel **28** as it is drawn upwardly by blower **18**. The air in the recirculation duct **50** enters the blower **18**, which recirculates a portion of the air through the supply filter **22** and exhausts a portion of the air through the exhaust filter **20**.

[0052] As described above, the single blower **18** supplies both the supply air **64** (FIG. **5**) and exhaust air **62** to the plenum **16** with the divider **56** dividing the air output from the blower **18** into the supply air **64** and the exhaust air **62**. The position of the divider **56** is adjusted to ensure that the balance between the airflow rates of the supply air **64** and the exhaust air **62** is appropriate to ensure safe operation of the biosafety cabinet **10**. For example, the airflow rate of the exhaust air **62** needs to be at a level that creates a negative pressure within the work area **14** to draw ambient air into the front opening **41** (FIG. **1**) and sash grill **38** of the biosafety cabinet at a rate that prevents contaminants in the work area **14** from exiting the biosafety cabinet **10** through the front opening **41**. Further, the airflow rate of the supply air **64** passing through the supply filter **22** needs to be at a sufficient level to provide a downward laminar flow of air through the work area **14** that provides

sterile (HEPA-filtered) air to protect products or materials being worked on in the work area **14**.
[0053] The blower **18** operates at a speed necessary to ensure that the airflow rate of the supply air **64** passing through the supply filter **22** and the airflow rate of the exhaust air **62** passing through the exhaust filter **20** are sufficient to ensure safe operation of the biosafety cabinet **10** as described above. The flow rates of the air passing through the supply filter **22** and exhaust filter **20** depend on the speed of the blower **18** and the resistance of the filters to air flowing therethrough. As the filter **20** becomes loaded with contaminants, the resistance of the filter increases. The biosafety cabinet **10** and blower **18** may be configured to sense the increased resistance over time and automatically increase the speed of the blower **18** to compensate for the increased filter resistance thereby ensuring that the airflow rates through the filters **20** and **22** are at a level to ensure safe operation of the biosafety cabinet **10**. For example, the blower **18** may be a commercially available energy efficient blower having a motor with electronic intelligence capable of maintaining a constant airflow rate into the plenum **16**. The blower **18** may have a programmable, variable speed motor configured to maintain a substantially constant airflow rate through the exhaust filter **20** and the supply filter **22**. To maintain a substantially constant airflow rate, the blower **18** may be programmed so that the blower motor increases the speed of the blower wheel to compensate for any increased resistance to airflow attributable to contaminants accumulating within the exhaust and supply filters **20** and **22**. The blower **18** may include an electronically commutated motor (ECM), although other motors could also be used in the biosafety cabinet **10**. The blower motor may be programmed to follow a torque and speed curve to supply air at a constant airflow rate to the plenum **16** despite loading of the exhaust and supply filters **20** and **22**.
[0054] The divider **56** may be adjusted to balance the airflow rates through the filters **20** and **22** to ensure that the airflow rates are sufficient for safe operation of the biosafety cabinet **10**. For example, if the airflow rate through the supply filter **22** is too low relative to the airflow rate through the exhaust filter **20**, the divider **56** may be adjusted upward to cause more air from the blower **18** to flow into the supply section **58** of the plenum **16**. If the airflow rate through the exhaust filter **20** is too low relative to the airflow rate through the supply filter **22**, the divider **56** may be adjusted downward to cause more air from the blower **18** to flow into the exhaust section **60** of the plenum **16**. Adjustment of the divider **56** may be necessary to ensure sufficient airflow rates through the filters **20** and **22** due to differences in the rates of loading of the filters **20** and **22** over time. For example, if the resistance to airflow of one of the filters **20** or **22** increases at a greater rate than the other of the filters **20** or **22** due to loading of the filters by contaminants, the ratio of the airflow rates through the filters will gradually change over time. The filter **20** or **22** with a higher rate of resistance increase will allow a lower amount of airflow through the filter relative to the filter with a lesser rate of resistance increase. The divider **56** may be adjusted to compensate for the difference in the rate of filter resistance increase between the filters **20** and **22**. For example, the divider **56** may be moved to increase the volume of the supply section **58** if the resistance of the supply filter **22** increases at a greater rate than the resistance of the exhaust filter **20**, and the divider **56** may be moved to increase the volume of the exhaust section **60** if the resistance of the exhaust filter **20** increases at a greater rate than that of the supply filter **22**.
[0055] The biosafety cabinet **10** may be classified as a Class II, Type A2 biosafety cabinet suitable for personnel, product, and environmental protection when work is performed in the biosafety cabinet such as microbiological work or sterile pharmacy compounding. The negative pressure in the work area **14** causing air to flow inwardly through the front opening **41** provides personnel protection by not allowing contaminants to exit through the front opening **41**. The downward laminar airflow from the supply filter **22** through the work area **14** provides product protection by covering the work area with sterile (HEPA filtered) air and subsequently the products being worked on in the biosafety cabinet. The exhaust filter **20** provides environmental protection by filtering contaminants from the air before that air is exhausted from the biosafety cabinet.
[0056] The biosafety cabinet **10** may have the following advantages relative to a conventional

Class II, Type A2 biosafety cabinet that has a single blower, which supplies air to a single plenum in fluid communication with both a supply filter and an exhaust filter. First, the biosafety cabinet **10** is adjustable via the divider **56** to change the relative airflow rates through the exhaust filter and the supply filter independently of the variation between the resistances of the supply filter and the exhaust filter. With a conventional biosafety cabinet having a single plenum, the airflow rate through each filter depends at least in part on the variation between the resistances of the supply filter and the exhaust filter due to air flowing more easily through the filter with a lower resistance. While the filters may be selected initially to ensure proper airflow through the filters, if the filters are loaded at different rates over time, it may not be possible to balance the airflow rate through the filters to achieve safe operating conditions. Further, while conventional biosafety cabinets may have a sliding damper operable to adjustably restrict the area of the exhaust filter that is exposed to the single plenum, the airflow rate through the filters is still dependent on the resistance variation between the filters.

[0057] The biosafety cabinet **10** may also be operated in a more efficient manner than a conventional Class II, Type A2 biosafety cabinet. As described above, the biosafety cabinet **10** is designed with an unrestricted airflow path in the exhaust section **60** from the blower **18** to the inlet surface **20***a* of the exhaust filter **20**. With an unrestricted airflow path, the blower **18** may be operated at a lower speed to achieve a desired airflow rate through the exhaust filter **20** than if the airflow path was restricted. In contrast to biosafety cabinet **10**, many conventional biosafety cabinets have a sliding damper or other restriction means to restrict the area of the exhaust filter that is exposed to the plenum. The restriction causes a higher resistance to airflow through the filter necessitating a higher blower speed to achieve a desired airflow rate through the exhaust filter. Operating the blower at a higher speed means that more power is needed to operate the blower, and the blower generates more noise. Thus, by having an unrestricted airflow path from the blower **18** to the inlet surface **20***a* of the exhaust filter **20**, the biosafety cabinet **10** may operate more efficiently by consuming less power to achieve a desired airflow rate through the exhaust filter **20** than a conventional biosafety cabinet. The biosafety cabinet **10** may also generate less noise during operation.

[0058] Further, the biosafety cabinet **10** may be operated in a more efficient manner than a conventional Class II, Type A2 biosafety cabinet because the plenum **16** is divided into a supply section **58** and an exhaust section **60** that are each simultaneously pressurized by the blower **18**. This is in contrast to a conventional biosafety cabinet having a single plenum pressurized by a blower. With a conventional biosafety cabinet the blower speed needs to be set a level that will pressurize the air within the entire plenum higher than the greatest resistance to airflow or pressure drop of either the supply filter or the exhaust filter so that air will flow through the filter with the highest resistance. Typically, the supply filter is selected with a higher pressure drop than the exhaust filter so that the airflow through the exhaust filter is at a sufficient rate for safe operation. With the biosafety cabinet **10** described herein, the speed of the blower **18** can be set at a level, and the divider **56** adjusted, so that the air within each of the supply section **58** and the exhaust section **60** is at a pressure just above the resistance or pressure drop of the supply filter **22** and exhaust filter **20**, respectively. Because the entire plenum **16** of the biosafety cabinet **10** does not need to be pressurized above the filter having the highest resistance, the blower **18** can be operated at a lower speed than the blower of a traditional biosafety cabinet. As described above, operation of the blower **18** at a lower speed is more efficient due to less power consumption by the blower and also generates less noise.

[0059] Additionally, the design of the biosafety cabinet **10** allows the supply filter **22** and exhaust filter **20** to be selected independently of each other without reference to the resistance or pressure drop of the other filter. As described above, with a conventional biosafety cabinet, the blower needs to be set at a speed that will pressurize the plenum above the highest resistance of the two filters. Further, the supply filter is typically selected with a higher pressure drop than the exhaust filter to ensure sufficient airflow through the exhaust filter. Because the supply filter **22** and exhaust filter **20** of the biosafety cabinet **10** can be selected independently of each other, each of the filters may be selected to have the lowest pressure drop possible taking into account other specifications that the filters need to meet for safe operation. This allows a wider tolerance of the pressure drop for each filter, and eliminates the need to “match” a supply filter with an exhaust filter based on their pressure drop. Both of these advantages reduce manufacturing cost.

[0060] In addition to consuming less power and generating less noise, operating the blower **18** at a lower initial speed when the filters are new allows a user of the biosafety cabinet **10** to use the supply filter **22** and exhaust filter **20** for a longer length of time. As the filters are loaded over time, the blower **18** gradually increases in speed to overcome the increased resistance or pressure drop caused by the filter loading. When the blower **18** reaches its maximum speed and is no longer able to force air through the loaded filters at an airflow rate necessary for safe operation of the biosafety cabinet **10**, the filters must be replaced. Since the blower **18** can be operated at a lower speed than the blower of a traditional biosafety cabinet for the reasons set forth above (i.e., unrestricted airflow path to the exhaust filter, ability to select pressure drop of the exhaust and supply filters independently of each other, and pressurization of each of the supply section and exhaust sections of the plenum just above the pressure drop of the supply filter and exhaust filter, respectively), the filters can be loaded for a longer time period until the blower **18** reaches its maximum speed. This reduces cost of ownership to the user.

[0061] The biosafety cabinet **10** may also be more efficient than a conventional biosafety cabinet having two blowers, one to direct air through the supply filter and another to direct air through the exhaust filter, because it takes more power to operate two blower motors than a single blower motor.

[0062] The biosafety cabinet **10** may be designed and operated in accordance with the following parameters. The blower **18** may operate with an airflow rate of between 500 to 1200cubic feet per minute (CFM). All or substantially all of the air from the blower **18** enters the plenum **16**. The airflow rate into the exhaust section **60** of the plenum **16** may be between 260 to 630 CFM. The remainder of the airflow from the blower **18** enters the supply section **58** of the plenum **16**. The specific airflow rate of the blower **18** and the airflow into the different sections of the plenum **16** may depend on the width of the biosafety cabinet **10** and the height of the front opening **41** defined by the position of the sash **40**. The width of the biosafety cabinet **10** may be, for example, three, four, five, or six feet, and the height of the front opening **41** may be, for example, eight, ten, or twelve inches. The blower **18** may have a motor that draws an electric current of between two to six amps. The current draw of the motor may depend on the width of the biosafety cabinet, the height of the front opening **41**, the voltage of the power source (e.g., 120 or 240 volts), and the loading of the filters.

[0063] When the blower **18** is operating, the air within the plenum **16** may be positively pressurized to between 0.3 to 1 inches of water. The resistance to airflow or pressure drop of the exhaust filter **20** may be between 0.20 to 0.55 inches of water, and the pressure drop of the supply filter **22** may be between 0.35 to 0.70 inches of water. Both the exhaust and supply filters **20** and **22** may be HEPA or ULPA filters.

[0064] From the foregoing it will be seen that this invention is one well adapted to attain all ends and objectives herein-above set forth, together with the other advantages which are obvious and which are inherent to the invention.

[0065] Since many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matters herein set forth or shown in the accompanying drawings are to be interpreted as illustrative, and not in a limiting sense.

[0066] While specific embodiments have been shown and discussed, various modifications may of course be made, and the invention is not limited to the specific forms or arrangement of parts and steps described herein, except insofar as such limitations are included in the following claims.

Further, it will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

Claims

1. A biosafety cabinet comprising: a divided plenum that defines a supply passageway extending from a supply inlet to a supply outlet, and an exhaust passageway extending from an exhaust inlet to an exhaust outlet, wherein the supply passageway and the exhaust passageway are separate from one another; and a single blower configured to simultaneously supply air to both the supply passageway via the supply inlet and to the exhaust passageway via the exhaust inlet.

2. The biosafety cabinet of claim 1, additionally comprising: an exhaust filter positioned within the exhaust passageway between the exhaust inlet and the exhaust outlet, such that air supplied to the exhaust passageway from the blower passes through the exhaust filter; and a supply filter positioned within the supply passageway between the supply inlet and supply outlet, such that air supplied to the supply passageway from the blower passes through the supply filter.

3. The biosafety cabinet of claim 2, wherein the divided plenum is configured such that airflow through the supply filter is independent of a pressure drop of the exhaust filter and airflow through the exhaust filter is independent of a pressure drop of the supply filter.

4. The biosafety cabinet of claim 3, wherein the divided plenum is configured to be adjustable such that one or both of the passageways and/or one or both of the inlets may be enlarged or reduced in size.

5. The biosafety cabinet of claim 3, wherein an adjustable divider is positioned within the plenum to divide and separate the supply passageway and the exhaust passageway.

6. The biosafety cabinet of claim 5, wherein the adjustable divider is configured to be moveable (1) in a manner that enlarges the exhaust passageway and/or exhaust inlet, while reducing the supply passageway and/or supply inlet, and (2) in a manner that enlarges the supply passageway and/or supply inlet, while reducing the exhaust passageway and/or exhaust inlet.