Feb. 22, 1966 L. A. DE PAS 3,236,133

MICROTOME COOLING AND DEHUMIDIFYING

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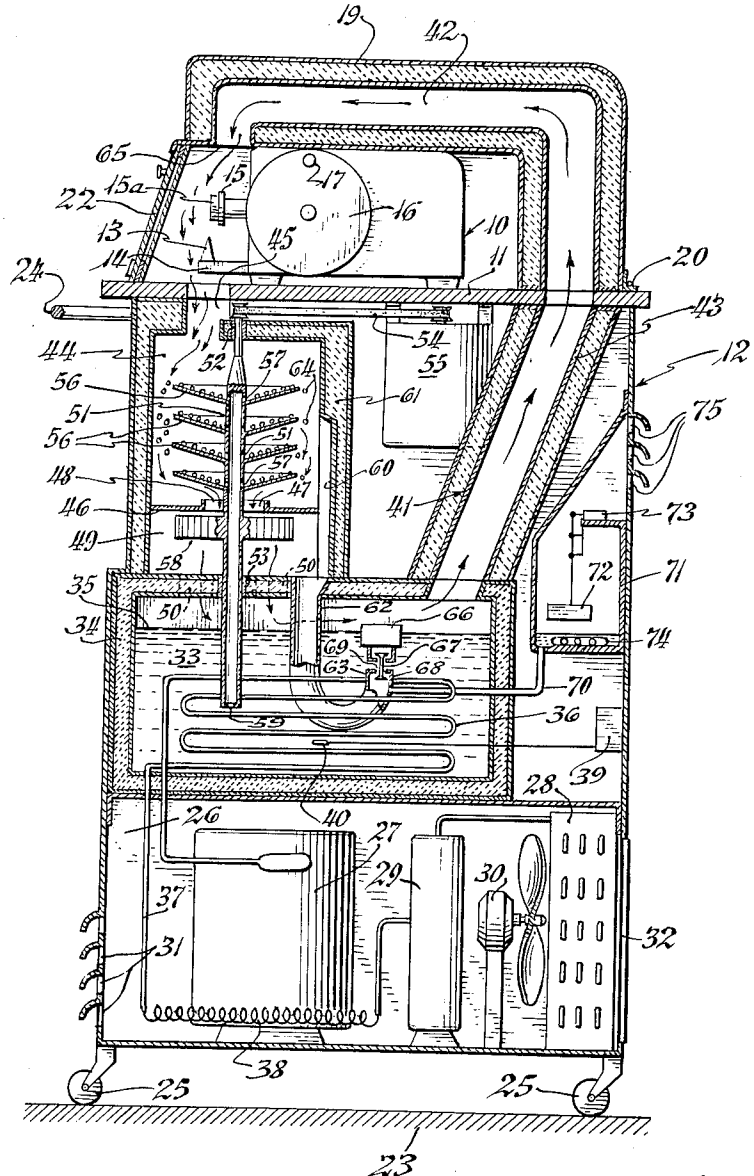
Fig. 1.



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MICROTOME COOLING AND DEHUMIDIFYING

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Fig. 2.

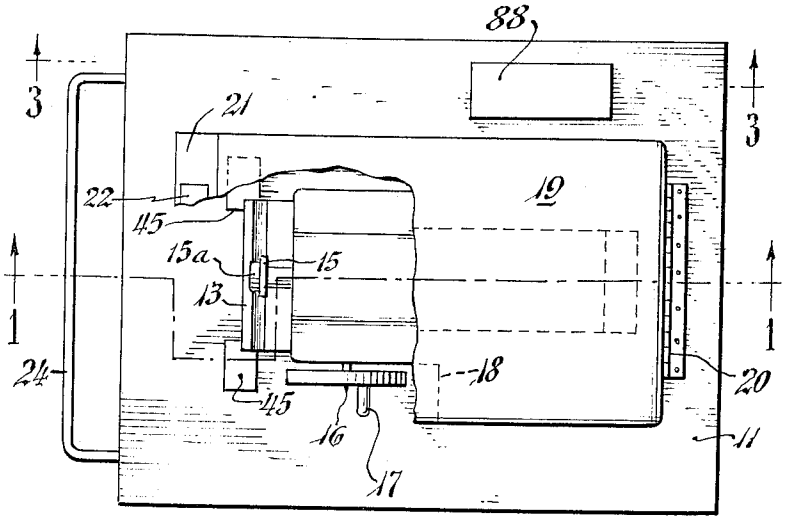
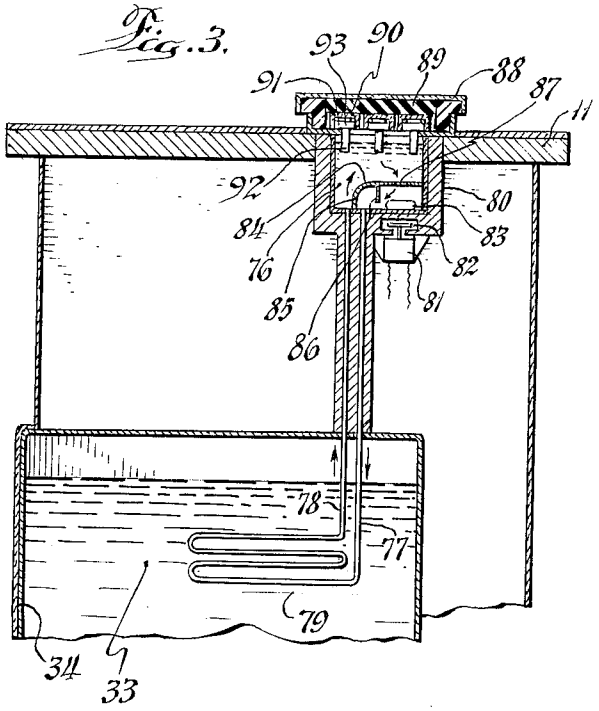


Fig. 3.



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MICROTOME COOLING AND DEHUMIDIFYING

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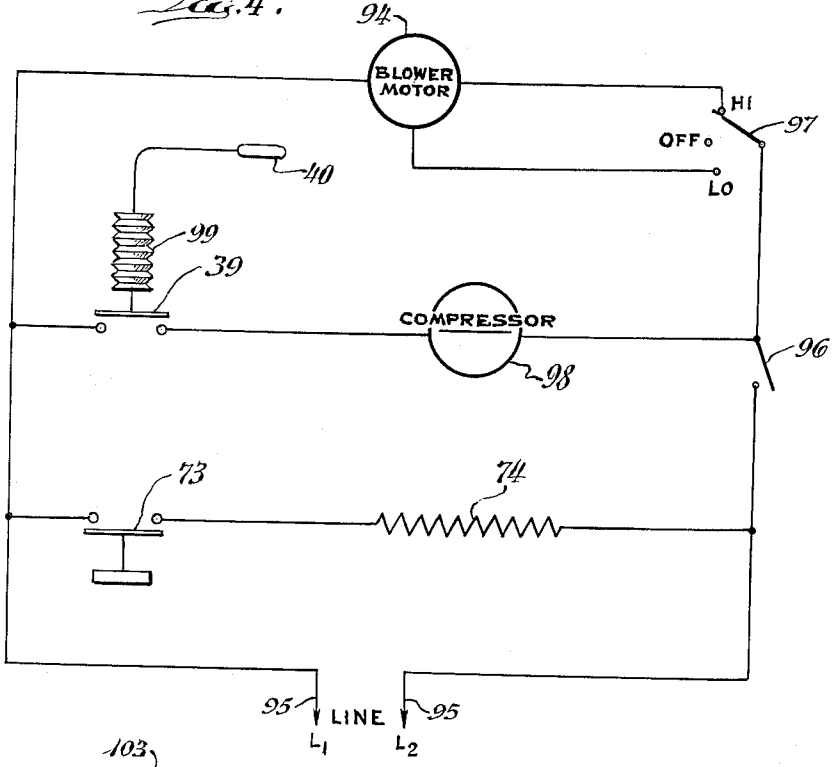
Fig. 4.



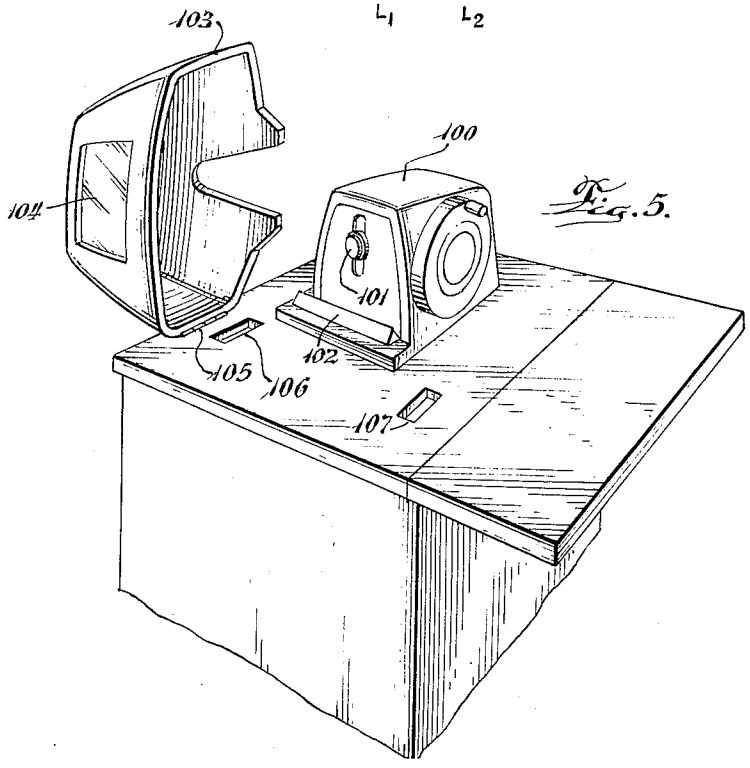


Fig. 5.

United States Patent Office 3,236,133 Patented Feb. 22, 1966

3,236,133

MICROTOME COOLING AND DEHUMIDIFYING

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Filed May 6, 1963, Ser. No. 278,014
19 Claims. (Cl. 83—170)

This invention relates to an air cooling apparatus for a microtome.

Microtomes are used to cut very thin sections from specimens, particularly biological specimens, so that they can be examined microscopically. The usual microtome employs a knife in combination with an apparatus that holds the specimen and moves it in relationship to the knife to slice off the thin sections. Such cut sections ordinarily vary in thickness between a fraction of a micron and a few microns.

When the specimens are biological, such as secured during an operation on the body, they are customarily frozen as rapidly as possible so that they can be handled. They are maintained frozen and transported to the microtome for slicing in thin sections.

One of the features of this invention is to provide an improved cooling apparatus for a microtome which provides a circulating cold dry atmosphere that contacts the specimen holder and thus the specimen thereon and the cutting means during the operation of the microtome so as to maintain the specimen and the sections cut therefrom in frozen condition.

Another feature of the invention is to provide such an apparatus wherein the cold dry air is circulated in a closed path continuously during which the air is continuously cooled and dehumidified.

Another feature of the invention is to provide such an apparatus having improved means for removing excess moisture from the cooling heat sink in order that this heat sink will operate with a high degree of efficiency continuously in removing the moisture in cooling the specimen.

A further feature of the invention is to provide such an apparatus including improved means for maintaining specimens in frozen condition preparatory to mounting on the microtome for cutting in which the cold heat sink is used to keep the specimens chilled.

Other features and advantages of the invention will be apparent from the following description of certain embodiments thereof taken in conjunction with the accompanying drawings. Of the drawings:

FIGURE 1 is a longitudinal sectional view of an apparatus embodying the invention taken substantially along line 1—1 of FIGURE 2.

FIGURE 2 is a plan view of the apparatus of FIGURE 1 partially broken away.

FIGURE 3 is a fragmentary sectional view taken substantially along line 3—3 of FIGURE 2.

FIGURE 4 is a wiring diagram of the electrical system of the embodiment.

FIGURE 5 is a fragmentary perspecive view of a second embodiment of the invention.

In the embodiment of FIGURES 1–4 inclusive there is disclosed a conventional microtome **10** mounted on a supporting table **11** forming a part of the apparatus **12** embodying the invention. This microtome includes a front transverse knife **13** mounted on a ledge **14** beneath the holder **15** for the specimen **15***a*. On one side of the microtome there is provided a rotatable walled disk **16** that is rotated by means of a handle **17**. The disk **16** and handle **17** are exposed through an opening **18** in an enclosing cover **19** that is movably mounted about a hinge **20** on the table **11**. As shown in FIGURES 1 and 2, the cover **19** encloses the microtome **10** but can

be rotated away from the microtome about the hinge **20**. The front wall **21** of the cover **19** contains a hinged double paneled window **22** with an insulating air space therein through which a specimen on the holder **15** may be viewed during the cutting operation. Specimen holders are inserted and sliced sections removed through the opening covered by this window.

The air cooling apparatus is self-contained and is easily moved on a supporting surface such as a floor **23** by means of a front handle **24**. As shown in FIGURE 1, the apparatus is mounted on supporting casters **25**.

In order to cool and dry a circulating air stream in the apparatus there is provided refrigerating apparatus in a bottom machine compartment **26**. This refrigerating apparatus includes the customary compressor **27**, condenser **28**, refrigerant receiver **29** and blower **30**, all located in the compartment **26**. Cooling air is admitted to the compartment **26** through grill **32** in one wall of the machine compartment and is emitted through louvers **31** in an opposite wall. In the embodiment shown, the grill **32** is positioned adjacent the condenser **28** and the blower **30** is located behind the condenser so as to pull cooling air therethrough.

In order to cool and dehumidify the air stream there is provided an insulated liquid heat sink **33** in the form of a solution, such as an aqueous solution of a salt, and particularly a hygroscopic salt such as calcium chloride. This heat sink **33** is enclosed in an insulated housing **34** that is shown positioned above the machine compartment **26**. The liquid solution **33** forming the heat sink does not fill the enclosing housing **34** so that the heat sink solution has its upper surface **35** exposed.

In order to chill the liquid solution heat sink **33** to a subfreezing temperature the evaporator **36** of the refrigeration system is immersed in the liquid **33**. The compressor **27**, receiver **29**, condenser **28** and evaporator **36** are connected by the usual refrigerant tubing **37** in a refrigerant circuit which of course also includes the customary capillary **38**. Operation of the refrigeration system to maintain a desired low temperature in the liquid solution **33** is controlled by a customary thermostat **39** controlled by a sensing bulb **40** immersed in the liquid solution **33**.

In order to chill the specimen holder **15** and thus a specimen held therein as well as the knife **13**, there is provided a cooling air conduit **41**. This conduit which has insulated side walls throughout its extent includes one portion **42** in the hinged cover **19**, a second portion **43** communicating at its bottom with the top of the liquid heat sink housing **34** and at its top with the rear end of the conduit portion **43** and a cooling chamber portion **44** at the front of the apparatus and vertically above the front part of the liquid heat sink **33**.

As shown in FIGURES 1 and 2 the front end of the first air conduit portion **42** empties directly downwardly on the specimen holder **15** so as to contact first a specimen held thereon. From here the air separates into two streams on opposite sides of the holder **15** and contacts the knife **13** after which these streams flow through two laterally spaced openings **45** into the top of the cooling chamber **44**.

Toward the bottom of the cooling chamber **44** there is located a transverse partition **46** extending entirely across the chamber and provided with a large central opening **47** surrounded by an upwardly extending flange **48**. The partition **46** provides a blower space **49** and air flow from the cooling chamber **44** is through a pair of spaced openings **50** into the top of the heat sink housing **34** above the liquid surface **35**.

Extending vertically through the cooling chamber **44**, partition opening **47** and into the liquid **33** is a hollow tube **51** rotatably mounted in a top bearing **52** in the top

wall of the cooling chamber **44** and a bottom bearing **53** in the top wall of the chamber **34** that contains the air opening **50**. This tube **51** is rotated through a belt drive **54** by means of an electric motor **55**.

Mounted on the upper end of the tube **51** within the cooling chamber **44** are a plurality of upwardly dished or concave disks **56**. The tube **51** has a plurality of small openings **57** adjacent the top of each disk **56** for providing liquid flow from the interior of the hollow tube onto the top surface of the disk.

Also mounted on the hollow tube **51** immediately beneath the partition **46** is a blower wheel **58**. The blower **58** and opening **47** are so arranged that air flowing through the opening goes to the center of the wheel so that the blower operates in the customary manner.

The bottom of the tube **51** that is immersed in the liquid **53** is provided with a customary pumping opening **59** so that on rotation of the tube **51** liquid **33** is lifted within the tube and fed through the openings **57** onto the top surfaces of the disk **56** where it is sprayed in the form of small droplets throughout the cooling chamber **44**. This sprayed liquid falls onto the top of the partition **46** and is prevented from entering the blower **58** by the flange **48**. The liquid can, however, flow to the bottom of the blower space **49** by means of a recessed side wall channel **60** in the side wall **61** forming the cooling chamber **44**.

From the bottom of the blower space **49** the liquid is returned to the liquid heat sink **33** by way of a J-shaped drain tube **62** having its exit end **63** immersed in the liquid **33**.

During operation of the apparatus of this invention the rotation of the tube **51** and thus the blower **58** causes air to flow in a closed circuit through the conduit **41**. As shown, the air flows downwardly through the cooling chamber **44** where it contacts small droplets, illustrated at **64**, of heat sink liquid **33**. This contact serves to chill and dehumidify the air as previously described. The sprayed liquid is returned to the heat sink **33** by way of the channel **60** and tube **62** also as previously described.

The chilled and dehumidified air from the cooling chamber **44** is then drawn by the blower **58** through the opening **47** and forced through the openings **50** into the top of the liquid heat sink housing **34**. In here the air flows across the top surface **35** of the liquid **33** where it is further chilled and dehumidified and from the rear of the heat sink housing **34** flows upwardly through the conduit portion **43** into the conduit portion **42** in the cover **19**. In this portion **42** the chilled dry air is forced forwardly toward the front of the apparatus and then downwardly through an opening **65** directly onto the specimen holder **15** so as to immediately contact a specimen therein before contacting the knife **13**. From here the air flows through the pair of openings **45** into the top of the cooling chamber **44** to start a new circulation as previously described.

Because of the mounting of the cover **19** about the hinge **20** it is very easy to rotate the cover **19** about the hinge **20** to expose the specimen holder **15** and knife **13** when servicing of the microtome is required. Front wall **21** contains a transparent window **22** which is hinged and allows access to the specimen and specimen holder before and after the slicing operation.

During the continuous operation of this apparatus it of course extracts moisture from the specimen and also removes any moisture admitted by the opening and closing of the cover **19**. This extracted moisture is of course dissolved in the liquid heat sink solution **33** and tends slowly to increase the volume of the liquid. This increase in volume causes a float **66** to rise. Loosely suspended from this float **66** is a valve **67** having an enlarged head **68** on the interior of the drain tube **62** so that when the float **66** rises a predetermined distance the valve head closes an opening **69** in the exit end **63** of the tube **62**. Because of this enlarged head **68** internal liquid pressure within the tube **62** holds the valve closed even as this internal pressure diminishes.

With the exit opening **69** closed liquid flowing in the tube **62** is diverted by way of a side tube **70** into the bottom of a liquid evaporator **71**. Positioned in this evaporator is a float **72** which rises with the increasing liquid level in the evaporator to close a switch **73** which energizes an electric heater **74** in the bottom of the evaporator or boiler **71**. This heater thereupon boils off excess water which passes out in the form of water vapor through rear openings **75**.

As the water is boiled off in the boiler **71** the internal pressure within the tube **62** decreases. However, because of the enlarged head construction **68** of the valve **67** the valve does not immediately open until the level of the solution **35** drops. When the solution level has dropped to a predetermined level, float **72** forces valve **67** to open. This allows all the liquid flowing into tube **62** to return to liquid heat sink **33** through opening **69**.

FIGURE 3 illustrates a device for storing specimens in frozen condition preparatory to cutting sections with the apparatus of this invention. Here there is provided on the table **11** an insulated liquid reservoir **76** of an anti-freeze liquid, such as ethylene glycol, and this reservoir is connected in a closed circuit including an outlet conduit **77**, an inlet conduit **78** and a coil **79** therebetween immersed in the liquid **33**. With this arrangement liquid in the reservoir **76** is continually circulated down the conduit **77**, through the coil **79** and back up the conduit **78** so as to be chilled by the liquid heat sink **33**.

This movement of liquid is provided by a pump which operates on the magnetic stir principle. On the bottom of the insulated housing **80** containing the reservoir **76** there is provided an electric motor **81** which when energized rotates a magnet **82**. Directly opposite this magnet **82** and located in the bottom of the reservoir **76** is a second magnet **83** that is free to move within the bottom of the reservoir. This magnet **83** is enclosed in a housing **84** at the bottom of the reservoir with the housing including a dividing wall **85** between the reservoir ends of the conduit **77–78**. Extending from the housing **84** and surrounding the magnet **83** is a cylindrical flange **86**. Located in the housing **84** immediately above the second magnet **83** is an opening **87**.

The top of the reservoir housing **80** on the top of the table **11** is enclosed by an insulated cover **88** the top of which is provided with resilient material such as sponge rubber **89**. Within the cover **88** and beneath the resilient material **89** there are located three inverted metal cup-shaped members **90** that serve as auxiliary heat sinks operating in conjunction with the heat sink reservoir **76**. These cups are adapted to enclose metal heat transfer members **91** each made up of a stem **92** extending down into the reservoir **76** and a top disk **93** integral with the stem adapted to support a specimen thereon. A specimen freezing system in which similar heat transfer members are used is disclosed and claimed in the copending application of Everett F. Cox, Serial No. 278,828, filed May 8, 1963, now Patent No. 3,176,472, and assigned to the same assignee as the present application.

With the above described construction rotation of the first magnet **82** by the motor **81** causes corresponding rotation of the second magnet **83** in the bottom of the reservoir **76**. This rotation of the magnet **83** causes liquid to be forced outwardly around the bottom edge of the flange **86** while simultaneously drawing in liquid from the main reservoir through the opening **87**. The outwardly forced liquid is thereby forced down the conduit **77**, through the coils **79** and back up the conduit **78** to the reservoir **76** to complete the circuit. As can be seen, the liquid in the reservoir **76** is continually circulated to extract heat from the specimens by way of the members **91** and transfer this heat to heat sink **33**.

FIGURE 4 shows a conventional wiring diagram for the apparatus. The blower motor **94** is connected across

the electric lines 95 and is controlled by a master line switch 96 and a three position switch 97 in series. Connected in parallel across the lines 95 are the compressor motor 98 and the heater 74 for the boiler 71. The compressor 98 is in series with the thermostat switch 39 which is operated as previously described by the bulb 40 through a bellows 99. The heater 74 is in series with its float operated switch 73 to function in the manner previously described.

FIGURE 5 illustrates another embodiment of the invention. Here the microtome 100 is exposed and the holder 101 and knife 102 may be enclosed by a hinged cover 103 having a hinged window 104 therein that is similar to the previous window 22. This cover 103 is movable about a hinge 105 and is shown in FIG. 5 in open position. Chilled, dehumidified air is directed onto the specimen held in the holder 101 through one opening 106 and this air is returned to the cooling and dehumidifying portion of the apparatus through an opposite opening 107.

In a typical embodiment of this invention the solution 33 was a saturated solution of calcium chloride. The solution temperature was maintained at about −18° F. and the air temperature fed through the upper opening 65 was about −12° F. while the return air temperature into the cooling chamber 44 was about +40° F. The microtome knife was maintained during operation of the apparatus at about −8° F. and the system extracted about 2500–3000 B.t.u. per hour.

As can be seen, the apparatus of this invention has a number of new and unobvious advantages. Thus, it is completely self-contained and can be moved about from place to place. It operates continuously to provide dry cold air and because liquids are not directed against the specimen or the knife there is no build-up of frozen liquid such as frost on the specimen or the knife. The operation of the apparatus is automatic with the heat sink temperature being maintained at the proper level automatically and with extracted and dissolved moisture being removed periodically and automatically. As the air is dry when it contacts the specimen and knife there is no frost deposited from the air. No defrosting of the cooling evaporator 36 is required, as this evaporator is immersed in the liquid heat sink 33.

Having described my invention as related to the embodiments shown in the accompanying drawings, it is my intention that the invention be not limited by any of the details of description, unless otherwise specified, but rather be construed broadly within its spirit and scope as set out in the accompanying claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. Air cooling apparatus for a microtome having a specimen holder and cutting means for the specimen, comprising: means defining a closed system cooled air conduit in which said holder and cutting means are located; and means for guiding substantially all the air in said conduit in a stream directly against the specimen in said holder prior to said air reaching said cutting means.

2. Air cooling apparatus for a microtome having a specimen holder and cutting means for the specimen, comprising: means defining a closed system cooled air conduit in which said holder and cutting means are located; and transparent viewing means in said conduit for viewing said specimen during cutting.

3. The apparatus of claim 2 wherein said conduit and viewing means are each thermally insulated.

4. Air cooling apparatus for a microtome having a specimen holder and cutting means for the specimen, comprising: means defining a closed system cooled air conduit in which said holder and cutting means are located; means for moving air through said conduit; means providing in said closed system a liquid heat sink chilled to a subfreezing sink temperature; and means for contacting the moving air with said liquid to dry and chill the air.

5. Air cooling apparatus for a microtome having a specimen holder and cutting means for the specimen, comprising: means defining a closed system cooled air conduit in which said holder and the cutting means are located; means for moving air through said conduit; means providing a cooling chamber as a part of said closed system air conduit; means providing in said closed system a liquid heat sink chilled to a subfreezing temperature; means for distributing a portion of liquid from said heat sink in thermal contact with moving air in said cooling chamber to dry and chill the air therein; and means providing an auxiliary cooling chamber as a part of said closed system conduit, said auxiliary cooling chamber including an exposed surface of said heat sink for direct contact of said moving air with said surface.

6. Air cooling apparatus for a microtome having a specimen holder and cutting means for the specimen, comprising: means defining a closed system cooled air conduit having one portion in which said holder and cutting means are located; and means mounting said one portion for movement relative to said holder and cutting means for providing access to said holder and cutting means on movement of said one portion.

7. Air cooling apparatus for a microtome having a specimen holder and cutting means for the specimen, comprising: means defining a closed system cooled air conduit having one portion in which said holder and cutting means are located; means mounting said one portion for movement relative to said holder and cutting means for providing access to said holder and cutting means on movement of said one portion; and transparent viewing means in said one portion for viewing said specimen during cutting.

8. Air cooling apparatus for a microtome having a specimen holder and cutting means for the specimen, comprising: means defining a closed system cooled air conduit in which said holder and cutting means are located; means for moving air through said conduit; means providing a cooling chamber as a part of said closed system air conduit; means providing in said closed system a chilled liquid heat sink; and movable means located in both said cooling chamber and said liquid heat sink means for simultaneously transferring portions of liquid from said heat sink to said cooling chamber, distributing said portions in thermal contact with moving air in said cooling chamber and operating said air moving means.

9. Air cooling apparatus for a microtome having a specimen holder and cutting means for the specimen, comprising: means defining a closed system cooled air conduit in which said holder and cutting means are located; means providing a cooling chamber as a part of said closed system air conduit; means providing in said closed system a chilled liquid heat sink; means for distributing portions of liquid from said heat sink in thermal contact with moving air in said cooling chamber; catch means for receiving said distributed portions; air moving means adjacent said catch means for moving air through said closed system conduit including said cooling chamber; and means for conveying liquid from said catch means to said liquid heat sink in a path that is externally of said air moving means.

10. Air cooling apparatus for a microtome having a specimen holder and cutting means for the specimen, comprising: means defining a closed system cooled air conduit in which said holder and cutting means are located; means for moving air through said closed conduit; means providing in said closed system a cooling chamber as a part of said air conduit; means providing in said closed system a chilled liquid heat sink; means for spraying portions of liquid from said heat sink in thermal contact with moving air in said cooling chamber; catch means in said cooling chamber for catching falling liquid from said spraying; means forming one path in said closed system for moving air relative to said catch means; and means forming a second separate path for liquid from said catch means.

11. The apparatus of claim 10 wherein said catch means comprises a transverse partition beneath which is located said air moving means and having an air opening therein protected from substantial liquid flow therethrough by baffle means adjacent said opening.

12. Air cooling apparatus for a microtome having a specimen holder and cutting means for the specimen, comprising: means defining a closed system cooled air conduit in which said holder and cutting means are located; means providing a cooling chamber as a part of said closed system air conduit; means providing in said closed system a chilled liquid heat sink; catch means comprising a transverse partition in said cooling chamber having an air opening therein protected from substantial liquid flow through said opening by baffle means; a rotatable member extending through said opening; means mounted on said rotatable member in said cooling chamber for spraying liquid therein; means mounted on said rotatable member beneath said partition for moving air in said closed system conduit; and means for conveying liquid from said catch means to said liquid heat sink in a path that is externally of said air moving means.

13. The apparatus of claim 12 wherein said cooling chamber is located above said liquid sink and said rotatable member extends downwardly into said sink and carries pump means for lifting liquid from said sink to said spraying means.

14. Air cooling apparatus for a microtome having a specimen holder and cutting means for the specimen, comprising: means defining a closed system cooled air conduit in which said holder and cutting means are located; means providing a cooling chamber as a part of said closed system air conduit; means providing in said closed system a chilled liquid heat sink beneath said cooling chamber; catch means comprising a transverse partition in said cooling chamber having an air opening therein protected from substantial liquid flow through said opening by baffle means; a rotatable member extending through said opening into said liquid heat sink, said rotatable member having a hollow interior and provided on its lower end with pump means for lifting liquid up said interior; spaced means mounted on said rotatable member in said cooling chamber for spraying liquid therein, said rotatable member being provided with flow means communicating with said spaced means to deliver liquid thereto; blower means mounted on said rotatable member beneath said partition for moving air in said conduit; and means for conveying liquid from said catch means to said liquid heat sink in a path that is externally of said air moving means.

15. Air cooling apparatus for a microtome having a specimen holder and cutting means for the specimen, comprising: means defining a closed system cooled air conduit in which said holder and cutting means are located; means for moving air through said conduit; means providing a chilled liquid heat sink; means for contacting the moving air in said closed system conduit with said liquid to dry and chill the air, the liquid tending to increase in volume from dissolved moisture from said air; a liquid evaporator separate from said liquid heat sink having evaporating means; means for directing excess liquid after a predetermined increase in volume to said evaporator; and means operable by liquid in said evaporator to activate said heating means to evaporate liquid.

16. Air cooling apparatus for a microtome having a specimen holder and cutting means for the specimen, comprising: means defining a closed system cooled air conduit in which said holder and cutting means are located; means providing a cooling chamber as a part of said closed system air conduit; means providing in said closed system a chilled liquid heat sink; means for distributing portions of liquid from said heat sink in thermal contact with moving air in said cooling chamber; a conduit having an exit for returning said liquid portions to said liquid heat sink, the liquid tending to increase in volume from dissolved moisture from said air; a liquid evaporator separate from said liquid heat sink having evaporating means; means for directing excess liquid after a predetermined increase in volume to said evaporator from said conduit, said directing means including a valve for closing said conduit exit after said predetermined volume; and means operable by liquid in said evaporator to activate said heating means to evaporate liquid, said valve having means associated therewith for maintaining the valve closed until a predetermined volume of liquid has been evaporated.

17. In an air cooling apparatus for a microtome having a specimen holder, cutting means for the specimen, and a cold liquid heat sink for cooling the specimen, a device for maintaining specimens prior to mounting on said holder, comprising: a liquid reservoir; means for transferring liquid to and from said reservoir in heat transfer relationship with said heat sink; and insulated means for mounting a specimen in heat transfer relationship with said reservoir.

18. The device of claim 17 wherein the liquid transferring means comprises a closed circuit conduit including a coil immersed in said heat sing and a magnetically operated pump means in said reservoir.

19. The device of claim 17 wherein said specimen mounting means includes a heat transfer member having one portion extending into the liquid in said reservoir and a second portion out of said liquid for supporting said specimen.

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