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**NOTEBOOK COMPUTER WITH HEAT DISSIPATING
LID HINGE STRUCTURE**

5 The present invention generally relates to
component operating heat dissipation in electronic
apparatus and, in a preferred embodiment thereof, more
particularly relates to the transfer of electrical
component heat from the CPU housing portion of a
10 notebook computer to its associated display housing
portion for dissipation therefrom during use of the
notebook computer.

15 Various electronic components used in computers
generate heat during their normal operation. Among
these components are typically microprocessors. If not
removed from the heat-generating component, the heat
raises the device temperature to a level that degrades
the reliability and service life of the device, and may

also adversely affect nearby components as well. This problem has become more acute in recent years due to the increasing power of microprocessors, and other electronic components, accompanied by correspondingly greater heat generation.

Contemporary notebook and subnotebook computer designs incorporate a central processing unit (CPU) housing and a display housing which is pivotally secured to the CPU housing and serves as a lid for selectively closing the computer for storage and transport thereof, and opening the computer to display its keyboard portion. The display or lid housing contains the visual display assembly and various other components. A relatively small proportion of the heat generated during computer operation is generated within the display housing.

Typically, an operating small computer dissipates a large fraction of its heat by elevating the temperature of the various surfaces of the CPU housing. Without forced air circulation within the CPU housing, only natural convection and radiation are available to remove heat from the CPU housing. Both of these phenomena must occur at the exterior surfaces of the CPU housing in order to remove heat from the housing (as opposed from simply redistributing heat within the housing).

The heat that can be transferred from a given surface, either by natural convection (as opposed to some manner of forced convection) or radiation, is limited by the surface area available and by the temperature difference between the surface and its surroundings (for example, air). For a notebook computer, the exterior surface of the housing and other

case parts cannot be permitted to exceed temperatures that are comfortable to the user of the computer. At the same time, it is in the nature of such an intentionally compact computer class that the housing exterior surface must be small, so that the surface temperature must be correspondingly high to carry away the requisite amount of operating heat. These two conditions - the maintenance of relatively cool exterior surface temperature with only relatively small surface areas to dissipate relatively large operating heat quantities - are fundamentally contradictory.

It is therefore of great value to designers of small computers such as notebook computers to employ as much available surface area as possible for heat transfer to ambient via the heat transfer mechanisms of natural convection and radiation. The larger the external housing surface area that can be used for heat transfer, the lower the average surface temperature can be while still transferring heat at the same rate.

Currently, the back surface of the display housing of notebook computers is under-utilized in this respect in that during operation the temperature of this surface is elevated only slightly above ambient if at all. Meanwhile, the temperatures of the CPU housing surfaces approach levels that cause distinct operator discomfort when touched by the operator.

To the present applicant's knowledge, no production method is currently being utilized to efficiently transfer CPU housing heat to the display housing for dissipation to ambient air during computer operation. Heat is generally dissipated by a fan and/or by transfer through CPU housing exterior surfaces, as described above, without significant use

of the display housing as a heat transfer entity and without explicit efforts to transfer heat between the CPU housing and the display housing.

5 Despite the known availability of the display housing as a potential sizeable augmentation to the operation heat convection and radiation dissipation area of the housing portion of the computer, an important hindrance to the efficient use of the display housing as a heat rejection surface for CPU housing-generated heat is the requirement that the display or
10 housing rotate between open and closed positions relative to the CPU or base housing portion of the computer. While conducting heat between two fixed points is not generally difficult, transferring heat
15 between two points whose relative locations are designed to change is complex under the constraints of the design of diminutive computers such as notebook and subnotebook computers.

20 It is accordingly an object of the present invention to provide apparatus and methods for efficiently transferring operating heat from a heat generating electrical component in a first computer housing portion to a second computer housing portion pivotally secured to the first housing portion to
25 thereby facilitate heat dissipation to ambient from the second housing portion in a manner reducing the operating surface temperature of the first housing portion.

In carrying out principles of the present invention, in accordance with a preferred embodiment thereof, electronic apparatus, representatively a
5 notebook computer, is provided that includes a housing having first and second portions, with a heat generating component such as a processor being carried in the first housing portion.

A hinge structure interconnects the first and
10 second housing portions for pivotal movement relative to one another, the hinge structure having (1) a first section connected to the first housing portion, and (2) a second section which is connected to the second housing portion, is in a heat transfer relationship
15 with the second housing portion, and is rotationally coupled to the first hinge section.

A heat transfer member is operative to transfer therethrough heat generated by the component in the first housing portion to the second housing portion via
20 the hinge structure, the heat transfer member having a first portion in thermal communication with the component, and a second portion defining the first hinge section.

In a preferred embodiment of the invention, the
25 heat transfer member is a first thermosyphoning heat pipe having an evaporation end portion in thermal communication with the heat generating component, and a condensing end portion journaled in the second hinge structure section. Thus, the first heat pipe serves
30 the unique dual role of (1) transferring component operating heat from the first housing portion to the second housing portion for dissipation therefrom to ambient, and (2) defining a portion of the hinge

structure that pivotally interconnects the first and second housing portions to one another.

To provide an increased amount of friction between the heat pipe condensing end portion and the second hinge section in which it is journaled, thereby permitting the overall hinge structure to function as a rotational friction clutch mechanism, a higher coefficient of friction material is suitably placed on the opposing pivot surfaces of the heat pipe condensing end portion and the second hinge section in which the heat pipe condensing end portion is journaled.

According to another feature of the invention, the component operating heat transfer to the second housing portion is augmented using a second thermosyphoning heat pipe disposed in the second housing portion and having an evaporation end in thermal communication with the second hinge section, and a condensing end portion in thermal communication with the second housing portion at a location thereon spaced apart from the hinge structure.

FIG. 1 is a simplified perspective view of portions of CPU and display housing portions of a representative notebook computer in which heat pipes are incorporated in a specially designed heat dissipating hinge structure pivotally interconnecting the CPU and display housing portions and used to efficiently transfer electronic component operating heat from the CPU housing to the display housing for dissipation to ambient during use of the computer;

FIG. 2 is an enlarged scale cross-sectional view through the heat dissipating hinge structure taken generally along line 2-2 of FIG. 1; and

FIGS. 3 and 4 schematically illustrate alternate methods of heat conductively associating the condensing end of an auxiliary hinge structure heat pipe to the computer display housing.

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Perspectively illustrated in FIG. 1 is a portion of an electronic device, representatively a notebook computer 10, embodying principles of the present invention. Computer 10 includes a base or CPU housing portion 12, and a lid or display housing portion 14. CPU housing 12 has a generally rectangular shape with a bottom side wall 16, an upstanding peripheral wall 18 with an indented corner portion 18a, and an open top side 20 across which a keyboard structure (not shown) horizontally extends. Representatively, among other computer circuitry disposed within the CPU housing is a printed circuit board 22 mounted on the bottom side wall 16. A heat generating component, representatively a processor chip 24, is operatively mounted on the top side of the printed circuit board 22.

The display housing 14 has a rectangular configuration generally complementary to that of the CPU housing 12, and has a top side wall 26, a depending peripheral wall portion 28, and an open bottom side 30 across which a display screen 32 extends, the display screen 32 having a metal peripheral frame 34. Compared to the CPU housing 12 which typically has a variety of heat generating components (not shown) in addition to the representatively illustrated processor chip 24, the display housing 14 has only a relatively minimal amount of heat generating apparatus therein.

Thus, during operation of a conventionally constructed notebook computer its CPU housing tends to

become considerably warmer to the touch than its display housing - each of which dissipates heat generated therein primarily by the heat transfer mechanisms of radiation and natural convection to ambient. As notebook computers become faster and more powerful, and the operating heat loads within their CPU housings correspondingly increase, the exterior temperatures of their CPU housings continuously increase toward a user-unacceptable level, and the need for heat dissipation beyond the previously relied on heat radiation and natural convection to ambient from the CPU housing becomes more critical.

Accelerating this need for additional heat dissipation from a notebook computer CPU housing is the trend toward making the computer smaller and smaller. This, of course, reduces the exterior surface of the CPU housing available to dissipate internal operating heat to ambient via radiation and natural convection. The shrinking of the exterior space envelope of modern notebook and subnotebook computers continues to make conventional auxiliary methods of carrying away interior operating heat from the CPU housing, such as internal cooling fans, more difficult and ineffective.

The present invention, however, uniquely transfers operating heat from the processor 24 (or other heat generating component as the case may be) to the display housing 14, to take advantage of its large exterior surface area in supplementing the radiant and convective heat dissipation to ambient of the CPU housing 12, using a specially designed heat dissipating friction hinge structure 36 shown in FIGS. 1 and 2. In conjunction with other suitable hinge apparatus of a conventional configuration (not shown) the hinge

structure 36 serves to pivotally interconnect the display housing 14 to a rear side edge portion of the CPU housing 12 for pivotal movement between a generally upright operating orientation shown in FIG. 1, and a
5 generally horizontal closed position (not shown).

According to a key aspect of the present invention, however, the hinge structure 36 also serves to transfer a considerable amount of the operational heat from the processor 24 to the display housing 14
10 via the hinge 36 using a generally conventional thermosyphoning heat pipe 38 which is in heat transfer communication with the processor 24 and also uniquely defines a portion of the heat dissipating hinge structure 36.

15 The heat pipe 38 has an exterior copper wall portion 40, is sealed at both ends, and has an evaporation end portion 38a for receiving heat, and a condensing end portion 38b for discharging the received heat. The interior of the heat pipe 38 is under a
20 partial vacuum and contains a quantity of a vaporizable and condensable heat transfer liquid such as water. Along its length the interior side surface of the heat pipe 38 is lined with a suitable wicking material 42.

In a conventional manner, heat transmitted to the
25 heat pipe evaporation end 38a evaporates liquid disposed in the wicking material therein and causes the evaporated liquid to travel to the condensing end 38b through the interior 44 of the heat pipe 38 for removal of heat from the evaporated liquid via the condensing
30 end 38b of the heat pipe 38. The resultant cooling of the evaporated liquid in the heat pipe end portion 38b condenses the liquid which is then absorbed by the wicking material 40 in heat pipe end 38b and wicked

back to the heat pipe end 38a for re-evaporation to repeat the thermosyphoning heat transfer cycle just described.

5 A copper thermal block 46 (see FIG. 1) is positioned atop the processor 24 to conductively receive operating heat therefrom, and the evaporation end 38a of the heat pipe 38 is positioned against the top side of the thermal block 46 to in turn conductively receive heat therefrom for transfer to the
10 condensing end 38b of the heat pipe 38. The condensing end portion 38b of the heat pipe 38 is representatively extended outwardly through a circular opening 48 in the CPU housing peripheral wall 18 and journaled in a cylindrical passage 50 formed in a hinge section 52
15 suitably anchored to an inner side surface portion of the display housing in a heat conductive relationship therewith.

Representatively, the hinge section 52 is formed from copper, and the display housing 14 (like the CPU
20 housing 12) is formed from plastic. However, the display housing 14 could be formed from metal, with the hinge section 36 being an integral portion of the display housing, if desired.

As viewed in FIG. 2, in cross-section the hinge
25 section 52 has a partially circular base portion 54 through which the cylindrical passage 50 is formed, a radial slit 56 extending upwardly through the bottom side of base portion 54 into the cylindrical passage 50, and a partially circular top side projection 58
30 through which a cylindrical passage 60 extends parallel to the passage 50.

The overall hinge structure 36, an integral portion of which is uniquely formed by the condensing

end 38a of the heat pipe 38, is what may be referred to as a controlled friction hinge or a rotational "clutch" which permits relative rotation between the display housing 14 and the CPU housing 12 while permitting the user to adjust and maintain the angular use orientation of the display screen 32 relative to the CPU housing 12. A "threshold" torque is frictionally maintained between the heat pipe end portion 38b and the hinge section. This threshold torque must be overcome by the user to change the previously selected angular orientation between the CPU and display housing portions 12,14 of the computer 10. Stated otherwise, the threshold torque serves to releasably prevent the display housing 14 from simply falling forwardly or rearwardly from its selected angular use orientation.

Since copper is representatively used to form the hinge section 52 and the outer wall portion of the thermosyphoning heat pipe 38, because of the high thermal conductivity of copper, the pivotal clutch friction and wear characteristics at the interface between the heat pipe end portion 38b and the hinge section are preferably improved by respectively placing thin layers 62,64 of a frictional material on the outer side surface of the heat pipe end portion 38b and the hinge section passage 50 within which the heat pipe end portion 38b is journaled. This frictional material is preferably a harder metallic material and may representatively be electroplated chrome deposited on the outer side surface of the condensing heat pipe end 38b and the interior side surface of the hinge section passage 50, or thin steel bands press-fitted into the passage 50 and onto the heat pipe end portion 38b. The radial slit 56 in the hinge section 52 permits the

insertion of the heat pipe end portion 38b into the passage 50 to slightly "spring" the hinge section base portion 54 outwardly in a lateral direction to maintain a suitable frictional clutch force between the contacting frictional material layers 62,64.

During operation of the computer 10, operating heat from the processor 24 is conducted to the evaporation end 38a of the heat pipe 38 through the thermal block 46. Operating heat received by the heat pipe evaporation end 38a is transferred along the length of the heat pipe 38 to its condensing/hinge member end 38b, and then transferred through the hinge section 52 to the display housing 14 for dissipation to surrounding ambient air by radiation and natural convection. Accordingly, processor (or other heat generating component) heat which in conventionally constructed portable computers was for the most part absorbed in the CPU housing, is now advantageously "split" between the CPU and display housings 12,14 with the result that the CPU housing 12 is now considerably cooler to the touch and the heat sensitive components in the CPU housing 12 are desirably subjected to lower operating temperatures.

During the usual operating orientation of the notebook computer 10, its CPU housing bottom side wall 16 is rested on a horizontal support surface such as a desktop or an airline seatback tray, thereby substantially interfering with both radiant and natural convention heat dissipation from this major exterior surface portion of the CPU housing 12. However, in contrast, the raised display housing 14 is entirely exposed to ambient air for purposes of radiant and convective heat dissipation thereto. Thus, the use in

the present invention of the display housing's large heat dissipation surface area adds a major supplemental heat dissipation path to the computer.

5 In the representatively illustrated portable notebook computer 10, CPU housing component operating heat transfer from the hinge section 52 to the display housing 14 is preferably augmented using an auxiliary second heat pipe 66 disposed in the display housing 14. Heat pipe 66 is of the same construction as the
10 previously described heat pipe 38, and has an evaporation end portion 66a, and a condensing end portion 66b. Evaporation end portion 66a is received in hinge section passage 60, which is in close proximity to the hinge section passage 50 that receives
15 the condensing end portion 38b of the heat pipe 38, and the condensing end portion 66b of the heat pipe 66 is spaced apart from the evaporation end portion 66a and in thermal communication with the display housing 14.

In this manner, heat received by the hinge section
20 52 from the condensing end portion 38b of the heat pipe 38 is transferred to the evaporation end portion 66b of the heat pipe 66 and then transferred through the heat pipe 66 to a location of the display housing 14 remote from the hinge section 52, thereby more efficiently
25 "spreading" CPU housing component heat along the display housing 14.

Representatively, as shown in FIG. 1, the condensing end portion 66b of the auxiliary heat pipe 66 is positioned against a copper thermal block 68 in
30 turn positioned against the interior side surface of the display housing top side wall 26. Alternatively, and by way of example, the heat pipe condensing end portion 66b may be positioned against the metal frame

portion 34 of the display screen 32 (as shown in FIG. 3), or against a metal EMI shield portion 70 of the display housing 14 (as shown in FIG. 70).

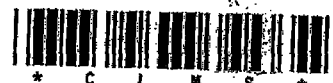
5 The foregoing detailed description is to be clearly understood as being given by way of illustration and example only, the spirit and scope of the present invention being limited solely by the appended claims.

1. Electronic apparatus comprising:
2 a housing having first and second portions;
3 a hinge structure interconnecting said first and
4 second housing portions for pivotal movement relative
5 to one another, said hinge structure having (1) a first
6 section connected to said first housing portion, and
7 (2) a second section which is connected to said second
8 housing portion, is in a heat transfer relationship
9 with said second housing portion, and is rotationally
10 coupled to said first hinge section;
11 a heat generating component carried in said first
12 housing portion; and
13 a heat transfer member operative to transfer
14 therethrough heat generated by said component to said
15 second housing portion via said hinge structure, said
16 heat transfer member having a first portion in thermal
17 communication with said component, and a second portion
18 defining said first hinge section.

2. The electronic apparatus of Claim 1 wherein:
2 said electronic apparatus is a portable computer.

3. The electronic apparatus of Claim 2 wherein:
2 said portable computer is a notebook computer.

4. The electronic apparatus of Claim 1 wherein:
2 said heat generating component is a first heat
3 pipe having an evaporating end portion in heat transfer
4 communication with said heat generating component, and
5 a condensing end portion defining said first section of
6 said hinge structure.



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2 5. The electronic apparatus of Claim 4 further
3 comprising:
4 a second heat pipe having an evaporating end
5 portion in heat transfer communication with said second
6 hinge structure section, and a condensing end portion
7 in heat transfer communication with said second housing
 portion.



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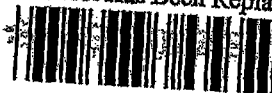
6. A heat dissipating hinge structure comprising:
2 a first heat pipe having an end portion defining
3 a first hinge structure section; and
4 a second hinge structure section formed of a heat
5 conductive material, said second hinge structure
6 section rotatably receiving said first hinge structure
7 section and being in a heat conductive relationship
8 therewith.

7. The heat dissipating hinge structure of Claim
2 6 further comprising:
3 a second heat pipe having an end portion secured
4 to said second hinge structure section, in a heat
5 conductive relationship therewith, for rotation with
6 said second hinge structure section relative to said
7 first hinge structure section.

8. The heat dissipating hinge structure of Claim
2 6 wherein:
3 said end portion of said first heat pipe is a
4 condensing end portion thereof.



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9. The heat dissipating hinge structure of Claim
6 wherein:

said second hinge section has a generally
cylindrical passage therein which receives said end
portion of said first heat pipe and has an interior
side surface with a coefficient of friction and lined
with a frictional material having a coefficient of
friction greater than that of said interior side
surface, and

said end portion of said first heat pipe has an
exterior side surface having a coefficient of friction
and being covered with a frictional material having a
coefficient of friction greater than that of said
exterior side surface and being frictionally but
releasably engaged by said frictional material on said
interior side surface of said second hinge section.

10. The heat dissipating hinge structure of Claim
9 wherein:

said second hinge section and the outer wall
portion of said first heat pipe are formed from copper,
and each of said frictional materials is formed from a
harder metal material.



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11. A method of dissipating heat from a heat
2 generating component in a first housing portion of an
3 electronic device, said method comprising the steps of:
4 providing a second housing portion having a hinge
5 section thereon;
6 providing a first heat pipe having an evaporation
7 end and a condensing end;
8 placing said evaporation end in thermal
9 communication with the component;
10 rotatably coupling said condensing end of said
11 first heat pipe to said hinge section; and
12 transferring heat from the component to said
13 second housing portion sequentially through said first
14 heat pipe and said hinge section.

12. The method of Claim 11 further comprising the
2 steps of:
3 providing a second heat pipe having an evaporation
4 end and a condensing end;
5 placing said evaporation end of said second heat
6 pipe in thermal communication with said hinge section
7 to receive heat from said condensing end of said first
8 heat pipe; and
9 placing said condensing end of said second heat
10 pipe in thermal communication with said second housing
11 portion to thereby augment the transfer of heat from
12 the component to said second housing portion.



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13. A portable computer comprising:
2 a CPU housing;
3 a heat generating component in said CPU housing;
4 a display housing;
5 a hinge section secured to said display housing in
6 a heat transfer relationship therewith; and
7 a first heat pipe operative to transfer heat from
8 said component to said hinge section and thus to said
9 display housing for dissipation therefrom,
10 said first heat pipe having an evaporating
11 end portion thermally communicated with said component
12 to receive operating heat therefrom, and a condensing
13 end portion journaled in said hinge section to permit
14 said display housing to pivot about said condensing end
15 portion relative to said CPU housing.

14. The portable computer of Claim 13 wherein:
2 said portable computer is a notebook computer.

15. The portable computer of Claim 13 wherein:
2 said heat generating component is a processor.

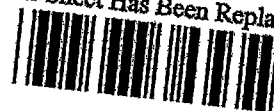
16. The portable computer of Claim 13 wherein:
2 said condensing end portion of said first heat
3 pipe and said hinge section form a friction hinge
4 structure.

17. The portable computer of Claim 13 further
2 comprising:
3 a second heat pipe having an evaporating end
4 portion in heat transfer communication with said hinge
5 section, and a condensing end portion in heat transfer
6 communication with said display housing.



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18. The portable computer of Claim 17 wherein:
2 said display housing has an outer wall portion,
3 with an inner side surface,
4 said portable computer further comprises a
5 metallic heat transfer member positioned against said
6 inner side surface in a spaced relationship with said
7 hinge section, and
8 said condensing end portion of said second heat
9 pipe is in contact with said heat transfer member.

19. The portable computer of Claim 17 wherein:
2 said display housing has a display screen with a
3 metallic frame, and
4 said condensing end portion of said second heat
5 pipe is in contact with said metallic frame.

20. The portable computer of Claim 17 wherein:
2 said display housing has a metallic EMI shield
3 member therein, and
4 said condensing end portion of said second heat
5 pipe is in contact with said EMI shield member.

21. The portable computer of Claim 13 wherein:
2 said portable computer further comprises a
3 metallic heat transfer member sandwiched between and in
4 heat conductive contact with said heat generating
5 component and said evaporating end portion of said
6 first heat pipe.

22. The portable computer of Claim 21 wherein:
2 said heat generating component is a processor.



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23. The portable computer of Claim 17 wherein:
2 said hinge section has a first generally
3 cylindrical passage therein which receives said
4 condensing end portion of said first heat pipe, and a
5 second generally cylindrical passage which receives
6 said evaporating end portion of said second heat pipe.

24. The portable computer of Claim 23 wherein:
2 said first and second passages are closely spaced
3 within said hinge section and generally parallel to one
4 another.

25. The portable computer of Claim 13 wherein:
2 said hinge section has a generally cylindrical
3 passage therein which receives said condensing end
4 portion of said first heat pipe and has an interior
5 side surface with a coefficient of friction and lined
6 with a frictional material having a coefficient of
7 friction greater than that of said interior side
8 surface, and
9 said condensing end portion of said first pipe has
10 an exterior side surface having a coefficient of
11 friction and being covered with a frictional material
12 having a coefficient of friction greater than that of
13 said exterior side surface and being frictionally but
14 releasably engaged by said frictional material on said
15 interior side surface of said hinge section.

26. The portable computer of Claim 25 wherein:
2 said hinge section and the outer wall portion of
3 said first heat pipe are formed from copper, and each
4 of said frictional materials is formed from a harder
5 metallic material.

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