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Coupling thermal subsystems on head-mounted displays

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Coupling thermal subsystems on head-mounted displays

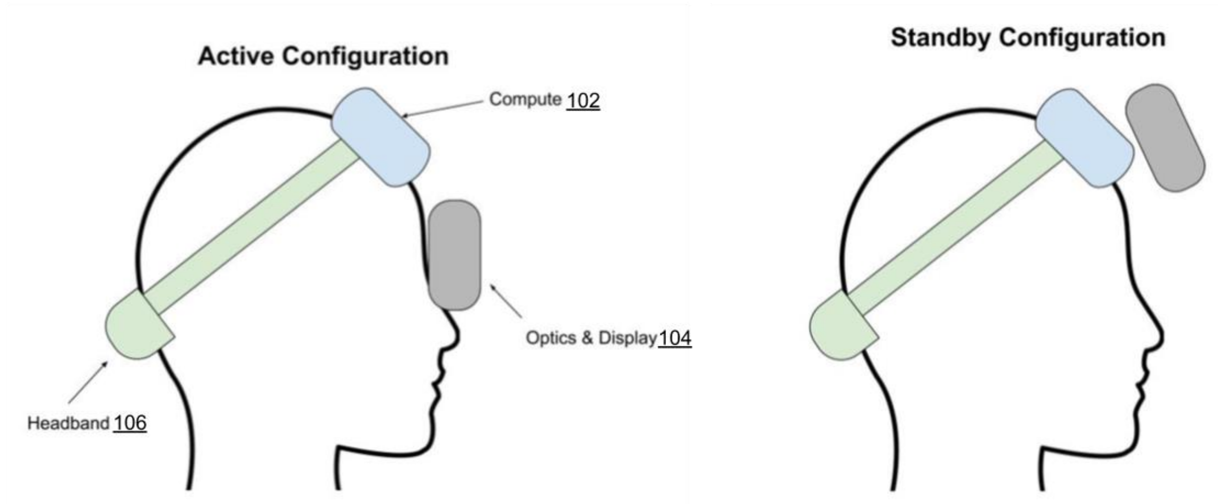
ABSTRACT

A multi-body augmented or virtual reality device is a head-mounted display whose constituent units can be flipped up, e.g., from over the eyes to over the forehead. In a multi-body AR/VR device, thermal problems associated with high processing power are exacerbated by the need to cool down each constituent unit. This disclosure describes techniques that achieve efficient thermal regulation in a multi-body wearable device by establishing a conductive or convective thermal path between the constituent units of the device. The techniques enable a flexible and ergonomic industrial design, and reduce duplicated componentry, weight and cost.

KEYWORDS

- Headset
- Head-mounted display (HMD)
- Multi-body device
- Modular headset
- VR goggle
- Thermal regulation
- Heat dissipation
- Augmented reality
- Virtual reality

BACKGROUND



(A) (B)

Fig. 1: (A) Active; and (B) standby modes in multi-body AR/VR devices

As illustrated in Fig. 1, a multi-body augmented or virtual reality (AR/VR) device comprises an optics and display (OD) body (or module) (104), and a compute body (102) strapped on to a user's head using a headband (106). The OD body can be flipped up, e.g., from over the eyes (Fig. 1A) to over the forehead (Fig. 1B). The configuration of the constituent bodies, e.g., the OD and the compute bodies, with respect to each other depends on the mode. In an active mode (Fig. 1A), the OD is in front of the user's eyes, and during a standby mode (Fig. 1B), the OD moves out of the user's line of vision and moves over the compute body, itself over the user's forehead.

In the active mode, the device is generally used to its maximum power budget and presents a substantial thermal load. During the standby mode, the device is not being used and has a correspondingly reduced thermal load. Thermal dissipation in AR/VR devices is an acute problem due to the high processing power of such devices. In a multi-body AR/VR device, thermal problems additionally pose a design problem: if the constituent modules, which each need to be cooled down, have their own thermal dissipation apparatus, the duplicated functionality results in an increased weight, cost, and complexity.

DESCRIPTION

This disclosure describes techniques that achieve efficient thermal regulation in a multi-body AR/VR wearable device by establishing a conductive or convective thermal path between the constituent modules of the device.

Conductive coupling between constituent modules

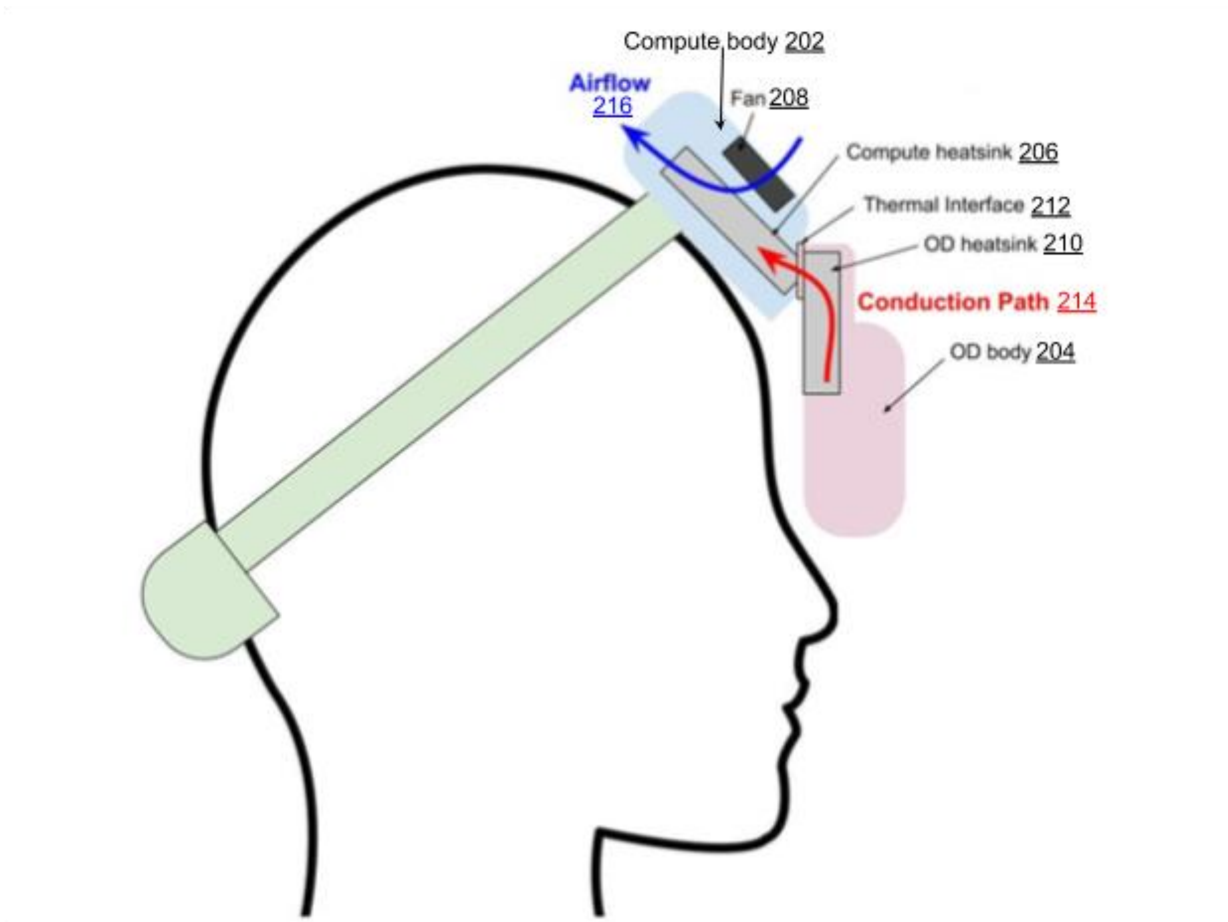


Fig. 2: Conductive coupling between constituent modules (active mode)

Fig. 2 illustrates a cutaway schematic of a multi-body AR/VR device in active mode and employing conductive coupling. As mentioned before, the multi-body AR/VR device includes a compute body (202) and an OD body (204). The compute body includes a compute heatsink (206), which serves as a primary heatsink, and a fan (208), which serves to dissipate heat. The OD body includes an OD heatsink (210) which serves as a secondary heatsink. In the conductive coupling approach, a physical coupling, e.g., a thermally conducting path (214), is established between the OD and compute bodies via a thermal interface (212) between the heatsinks of the compute and the OD bodies. The conducting path carries heat from the OD to the compute body, where it is dissipated away in an airflow (216) generated by the fan.

The thermal interface can be of a resilient material that can withstand the abrasion resulting from a large number of normal-load contact and separation cycles. Alternatively, a preloaded metal interface, such as a copper foil over an elastomer can be used. The thermal interface can be a single component on either the OD body or on the compute body, or it can be a multipart component that is on both bodies. Fig. 2 illustrates an implementation that employs a single thermal interface affixed to the compute body. When the device is in the active mode, the heatsinks become thermally coupled via contact through this interface.

The compute heatsink can be a standard, fin-type heatsink with a solid metal end exposed to the exterior underneath the cosmetic surface, as is typical for consumer electronics. The OD heatsink acts as a thermal reservoir that bridges to the compute heatsink. Since it is not used in a convective mode, the OD heatsink does not need to be finned.

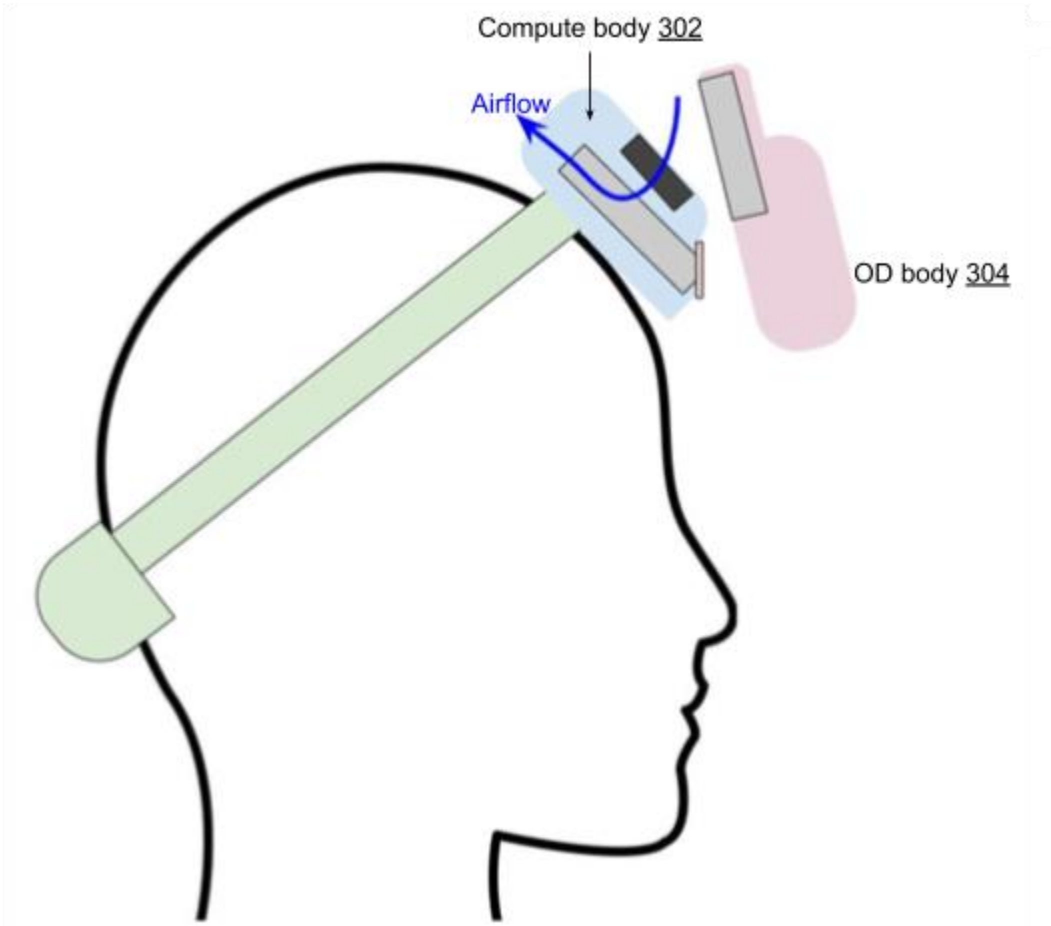


Fig. 3: Conductive coupling between constituent modules (standby mode)

Fig. 3 illustrates conductive coupling when the AR/VR device is in standby mode. During standby, the OD body (304) moves over the compute body (302), itself over the user's forehead, and consumes little or no power. Therefore, per the techniques of this disclosure, the conductive path between the heatsinks of the compute and the OD bodies is severed by having the OD body move out of contact with the thermal interface. The OD body sheds the little heat generated in standby mode through convection from its surface, additionally shedding heat from the heatsink, which acts as a thermal reservoir. The fan within the compute body can continue to run and generate an airflow that removes residual heat.

Convective coupling between constituent modules

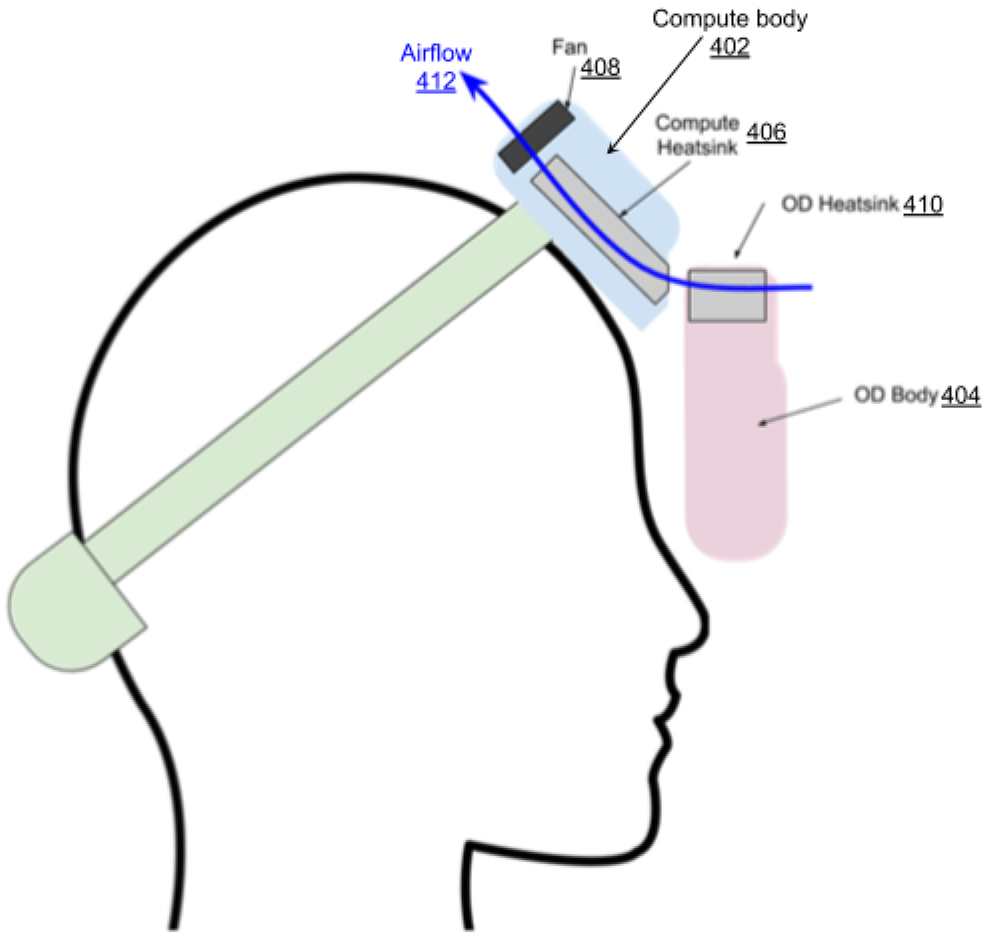


Fig. 4: Convective coupling between constituent modules (active mode)

Fig. 4 illustrates a cutaway schematic of a multi-body AR/VR device in active mode and employing convective coupling. The compute body (402) includes a compute heatsink (406), which serves as a primary heatsink, and one or more fans (408), which serve to dissipate heat. The OD body (404) includes an OD heatsink (410), which serves as a secondary heatsink. In the convective coupling approach, the one or more fans establish an airflow (412) that removes heat from the primary heatsink, which in turn also draws heat from the secondary heatsink. The fans on the compute body can be placed anywhere along the airflow path, and may operate either to push air or to pull air (or both) over the heatsinks. Fig. 4 illustrates an implementation using a pull-type axial fan. As the heatsinks are operating in a convective mode, both primary and secondary heatsinks can have fins. The movement of the OD body to its active-mode position serves to align the flow path.

In the convective coupling approach, no physical path between the heatsinks is established; rather a convective path between the heatsinks is established using airflow. The lack of a physical path enables a relatively high flexibility in design, as the parts do not need to physically interact. Additionally, the lack of a thermal interface, and degradation thereof, makes more robust the thermal connection between the constituent modules of the device.

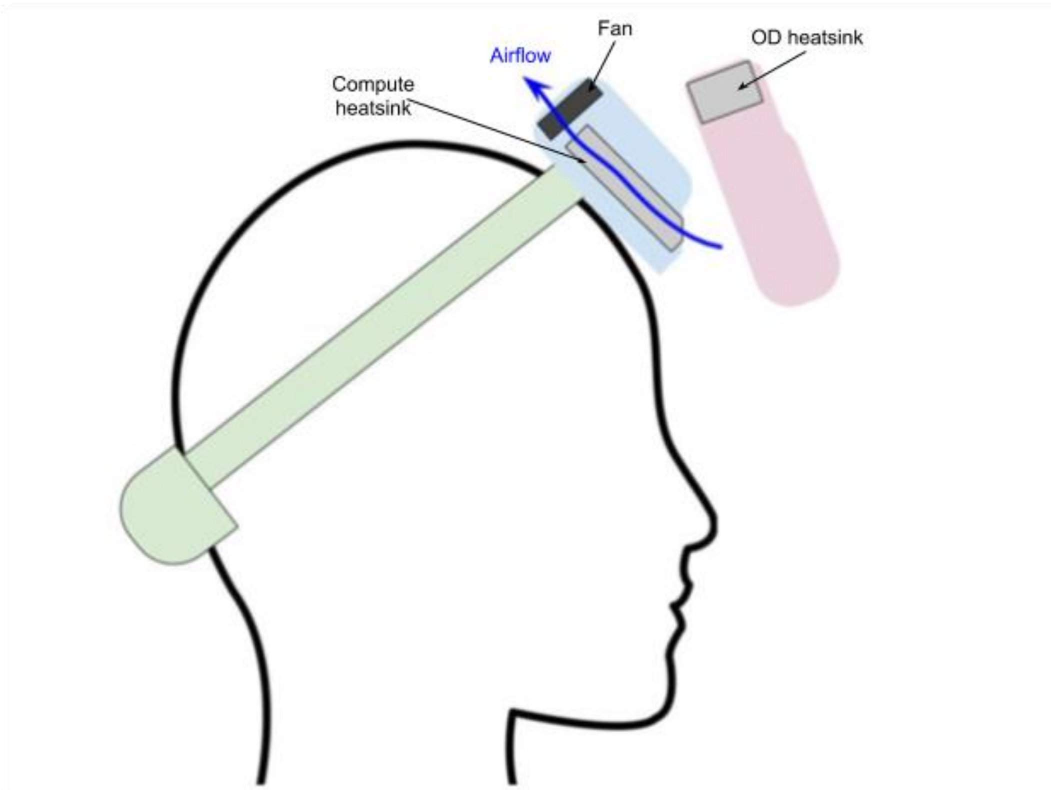


Fig. 5: Convective coupling between constituent modules (standby mode)

Fig. 5 illustrates convective coupling when the AR/VR device is in standby mode. The fan can continue to generate airflow to remove any residual heat generated by the constituent modules of the multi-body AR/VR device.

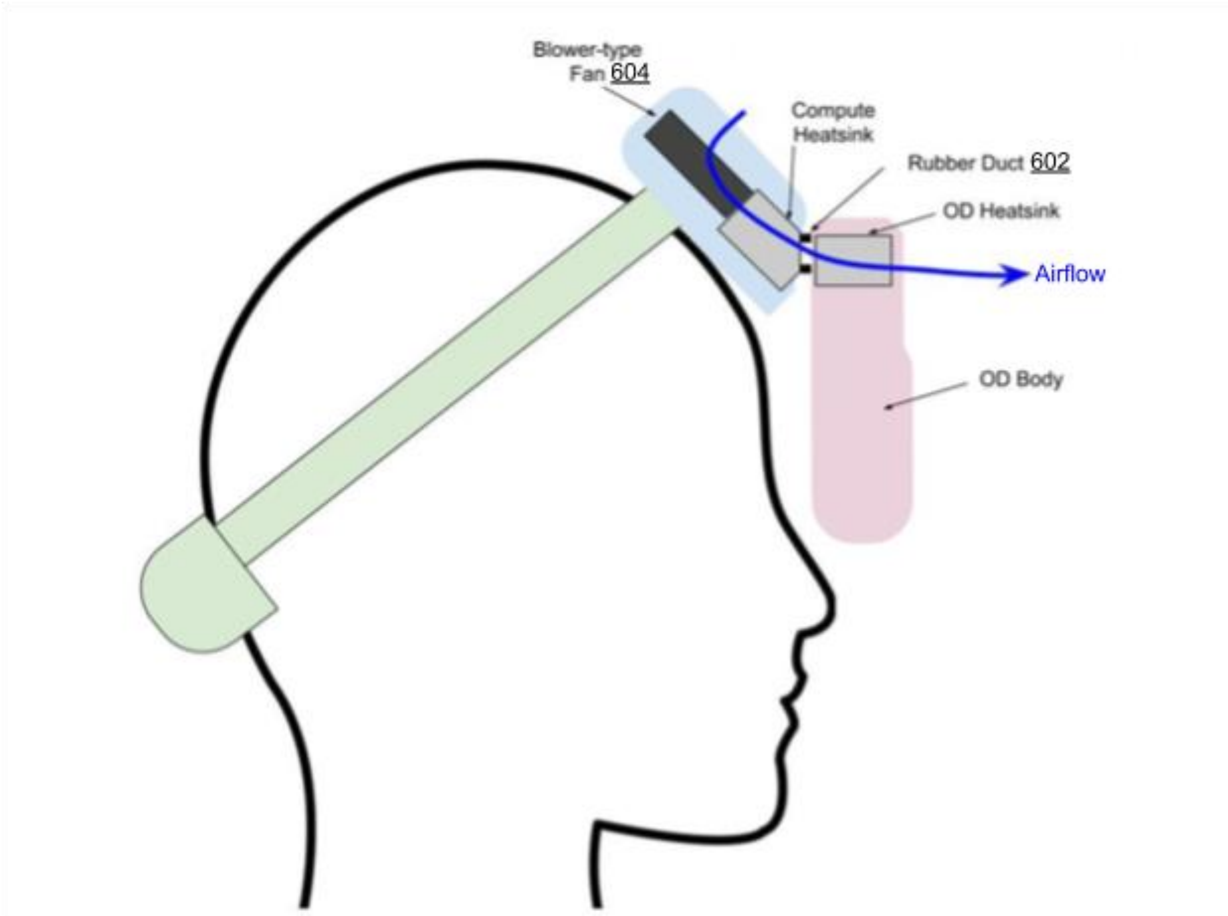


Fig. 6: An example implementation of convective coupling

Fig. 6 illustrates another example implementation of convective coupling. In this implementation, there are ducts (602) between the two bodies to ensure steady airflow. The ducts can be of a pliant, rubber-like material, e.g., silicone, that compresses to ensure a seal on the air channel. In this example implementation, a pusher-type blower-fan (604) generates the airflow that removes heat from the primary and secondary heatsinks.

The conductive and convective approaches can be combined into a hybrid approach. For example, the OD heatsink can make contact with the compute heatsink through a conductive interface but still allow airflow from the fan of the compute body to remove heat directly from the OD heatsink via convection. In the hybrid approach, rather than or in addition to the rubber duct that couples the heatsinks, a conductive interface can be used to couple the heatsinks.

In this manner, a wearable, multi-body AR/VR device in active mode is thermally regulated by establishing a thermal path that couples its constituent modules. Some advantages of the described techniques are as follows:

- The techniques obviate the need for separate thermal pathways for the constituent bodies, reducing cost, weight, and duplicated componentry.
- The techniques enable high thermal output components to be distributed between the bodies while still achieving effective cooling.
- The techniques enable flexible and ergonomic industrial design, since the bodies do not have a physical thermal connection beyond an interface, linkage, or hinge.

Alternative to the techniques described herein, and with additional penalties in terms of weight, volume, and duplicated componentry, each of the constituent modules of the multi-body AR/VR device can have its own heatsink or other heat dissipation apparatus.

CONCLUSION

This disclosure describes techniques that achieve efficient thermal regulation in multi-body augmented or virtual reality devices by establishing a conductive or convective thermal path between the constituent units of the device. The techniques enable a flexible and ergonomic industrial design, and reduce duplicated componentry, weight and cost.