SLAC – PUB – 3465
October 1984
(I)

A CIRCULATING WATER COOLING SYSTEM FOR A CAMAC CRATE*

W. B. PIERCE
Stanford Linear Accelerator Center, Stanford University, Stanford, CA 94305

Abstract

This paper describes a circulating water cooling system used at SLAC for cooling and maintaining cleanliness of the SLC type Camac Crates.

A fully loaded Camac Crate can dissipate 1 kW of power. Recent additions to our instrumentation and control systems have resulted in the installation of Camac Crates in a rather hostile environment. The racks containing the Crates are situated in the Klystron Gallery. This gallery is not much more than a two-mile-long unheated, uncooled, unclean metal shed. On a warm day temperatures of 120°F have been measured; and over the years, dust layers of 1/2 inch can accumulate. It is because of this hostile environment that a cooling system has been designed.

The system shown in Fig. 1 consists of the loaded Camac Crate, a circulating water heat exchanger, called a Chiller Chassis, and a Blower Chassis to circulate the air within the closed system. To enclose the system, a lightweight aluminum shroud has been fabricated. The shroud is easily removed for maintenance. It works to reduce the volume of air that has to be cooled and to maintain a measure of cleanliness that is deemed necessary for continued satisfactory operation of these systems over the next few years.

The Blower Chassis consists of two globe fans that bring air in the rear of the chassis. The airflow direction is changed from horizontal to vertical by a metal deflector mounted at the front of the chassis. A diffuser is used at the exhaust area of the Blower Chassis to cause a more even distribution of air flow across the horizontal plane directly above the Blower Chassis. The airflow through the diffuser alone varies from 500 to 750 CFM. This chassis requires 5 units of rack space.

The Chiller Chassis is the system heat exchanger. It utilizes the recirculating cooling tower water as the vehicle for removing the heat from the system. The flow rate is between one to two gallons per minute. An automotive type radiator is mounted in the horizontal plane. The radiator is of the same dimensions as the blower diffuser and the bottom of the module space of the Camac Crate. The radiator acts as a second diffuser and reduces the flow rate and the variation in the airflow rate. With the radiator installed, this airflow rate varies from 450 to 500 CFM across the surface of the radiator (see Fig. 1). The Chiller Chassis requires two units of rack space. The rear section of the Chiller Chassis contains a temperature switch that is permanently set to +132°F. When the temperature is exceeded, the power is removed from the CAMAC Crate, but maintained to the Blower Chassis. A front panel light will indicate the existence of an over-temperature condition.

The water flow rate was varied between 1 and 1.5 gpm for our tests. At the rate of 1 gpm, the temperature rise across the radiator was 8°F. At a 1.5 gpm flow rate, the temperature rise is 4°F. The water pressure is always less then 20# and the temperature is between 68° and 78°F. The air temperature within the system is most dependent on this inlet water temperature. The circulating air out of the radiator is approximately 3° to 4°F greater than the inlet water temperature.

The Camac Crates used at SLAC are special designs and are given an SLC Camac Crate nomenclature. These Crates have the regulated power supplies mounted at the rear of the Crates. The power supplies have their own cooling fan which draws air in from the side of the Crate and exhausts it to the rear. This feature forces the enclosing shroud to have a special sliding vent to allow cooling air to be drawn through the power supply. This vent must be detached before installation or removal of the enclosing shroud (see Fig. 6). An air flow diagram is shown in Fig. 2. Note that the inlet air to the power supply is taken from the Camac exhaust air.

The Camac Crate is the primary source of heat in the system. If the + and − 6-volt power supplies are delivering maximum load, they are sourcing +300 W of power. It has been determined that the regulated power supplies dissipate 600 W. It is thus reasonable to expect 1 kW of power dissipated in the system. Test results using water flow rate and temperature rise verify these figures.

To enclose these three chassis, a lightweight aluminum shroud was fabricated that encloses the system. The shroud slips on from the rear and can be inserted or removed while the system is operational, with no disruption of any kind to the system.

Figure 1 is a sketch of the system. The TS numbers correspond to location of temperature sensor during tests with the system in a temperature controlled oven.

TS1 = Radiator Exit Air Temperature

TS2 = CAMAC EXIT AIR Temperature

TS3 = CHASSIS TEMPERATURE

TS4 = Power Supply Inlet Air Temperature

TS5 = Power Supply Exit Air Temperature

TS6 = Blower Inlet Air Temperature

INLET AND OUTLET WATER TEMPERATURES WERE MONITORED SEPARATELY.

The following incremental temperature differences can be determined.

1. Temperature rise across CAMAC Crate [TS2 - TS1] variation was from 4° to 7°F.
2. Temperature rise across CAMAC Power Supply [TS5 - TS4] variation was 54° to 58°F.
3. Temperature drop across radiator [TS6 - TS1] typical 5° to 10°F.
4. Outlet water temperature – Inlet water temperature indicates the water temperature rise (flow rate was also monitored) typical values were 4°F at 1.5 gpm to 8°F at 1.0 gpm.

A rack mounted air conditioner was considered for this system. There are some distinct advantages to the air conditioner – the introduction of water into the rack is not highly desirable. The complete rack could be cooled and the air conditioners are easily moved. The disadvantages are: 1) The considerable power dissipation when expanded to accommodate the complete

*Work supported by the Department of Energy, Contract DE-AC03-76SF00515.

Presented at a Poster Session of the Nuclear Science Symposium Orlando, Florida, October 31 – November 2, 1984

accelerator; 120 units would be required; the every day power cost of the water cooled system is very nearly sero. 2) The cost of the ac units is close to $2000 per unit, which translates to $8000 per sector. Cost estimate for the proposed water cooled system is $4000 per sector. Over half of this cost is for the installation of the cooling tower water circulating system. Both systems are amenable to maintaining a clean system. As pointed out earlier, these systems exist in a hostile environment and maintaining a clean system is as important to some people as keeping the system cool. Expansion of the water cooled system is less expensive than the comparable ac system. An additional station can be added for approximately $500 whereas the ac would again cost the $2000 plus additional power costs.

Four of these water cooled systems have been installed at SLAC with a proposal in preparation for installation of 116 more to be installed by April of 1985. Detail drawings are available using DWG #137-003.

Photographs of the system in operation are shown in Figs. 3 through 5. A rear view of an unenclosed system is shown in Fig. 3. The same system is shown in Fig. 5 with the shroud in place and the cooling system in operation. Installation of the shroud has no effect on the front panel. Figure 4 shows an operational system. Note that the presence of the shroud is undetectable.

The two components that are unique to this cooling system are the shroud (Fig. 6) and the heat exchanger (Fig. 5). The actual heat exchanger is mounted to a chassis with some interlocking electronics mounted to the rear of the heat exchanger chassis.

The very simple electronics utilizes a thermostat to actuate a relay which removes power from the Camac Crate while maintaining power to the blower.

Summary

Four systems have been installed and operational for a period of nine months. To date there have been no failures, the systems have remained cool and clean through a very hot summer. The temperature of the circulating air leaving the heat exchanger remained within 3° to 4°F of the inlet water temperature, seemingly independent of ambient air. Temperature monitoring on the hottest of days indicated the system temperature tracked the water temperature. The system temperature increased approximately 4°F when the ambient temperature changes from 80° to 100°F. The cooling water was found to increase 4°F during this same period.

The temperature of the uncooled systems were very dependent on ambient and usually operating at a temperataure of 15° above ambient.

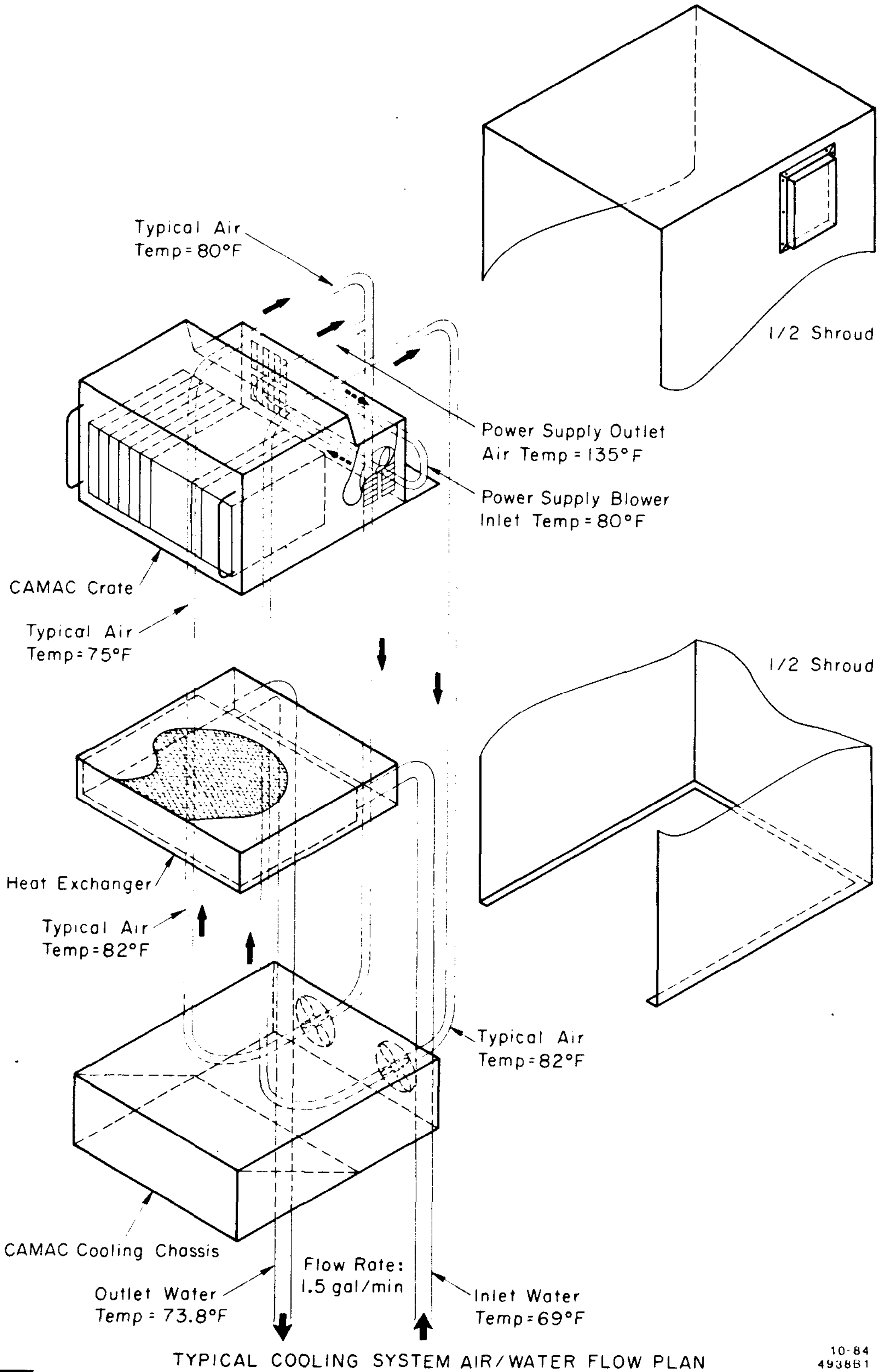


Fig. 1. Circulating Water Cooling System

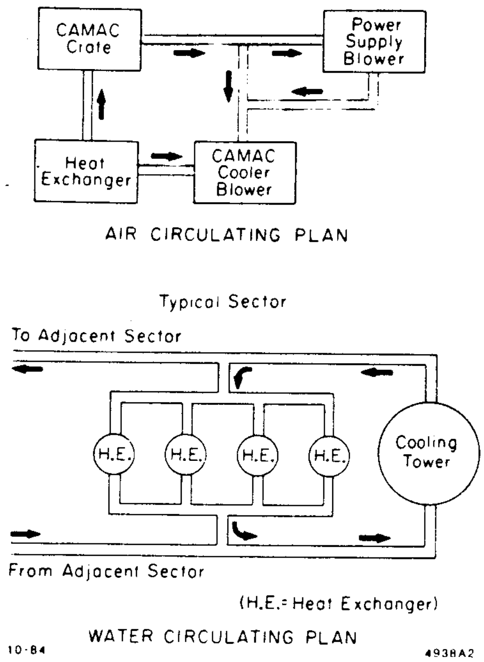


Fig. 2. Air and Water Circulating Systems

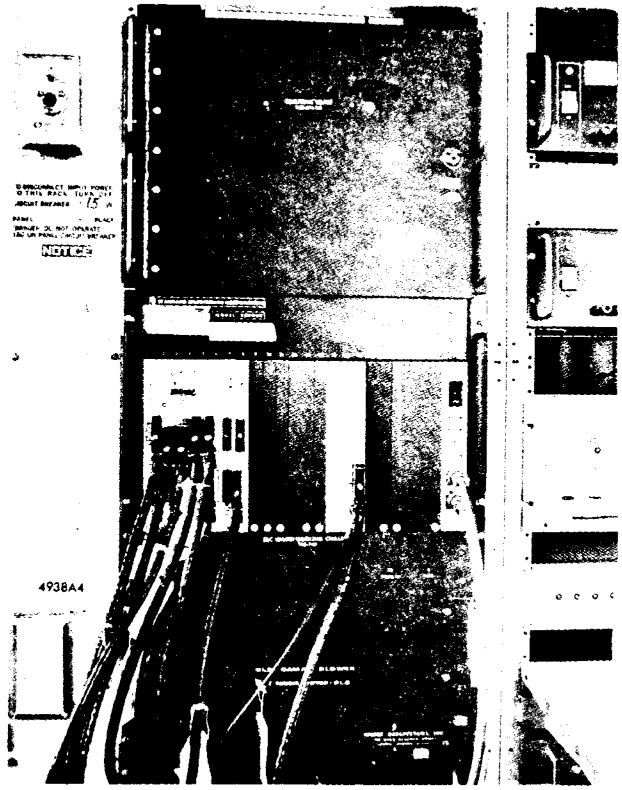


Fig. 4. Front View of Unenclosed System

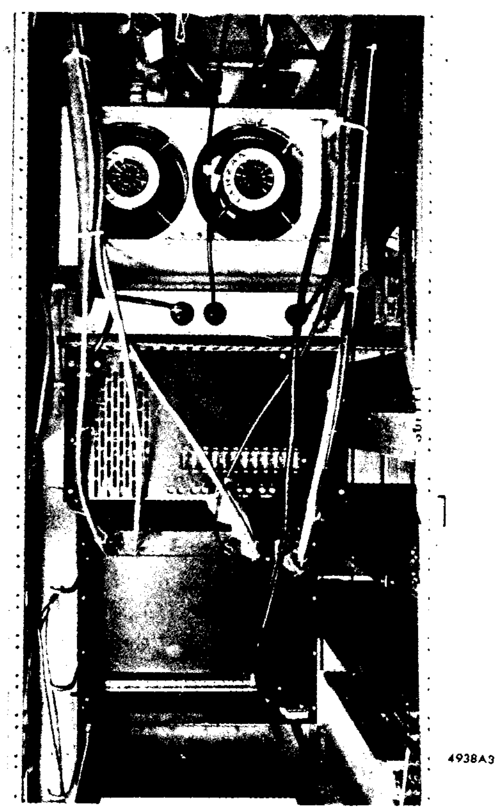


Fig. 3. Rear View of Unenclosed System

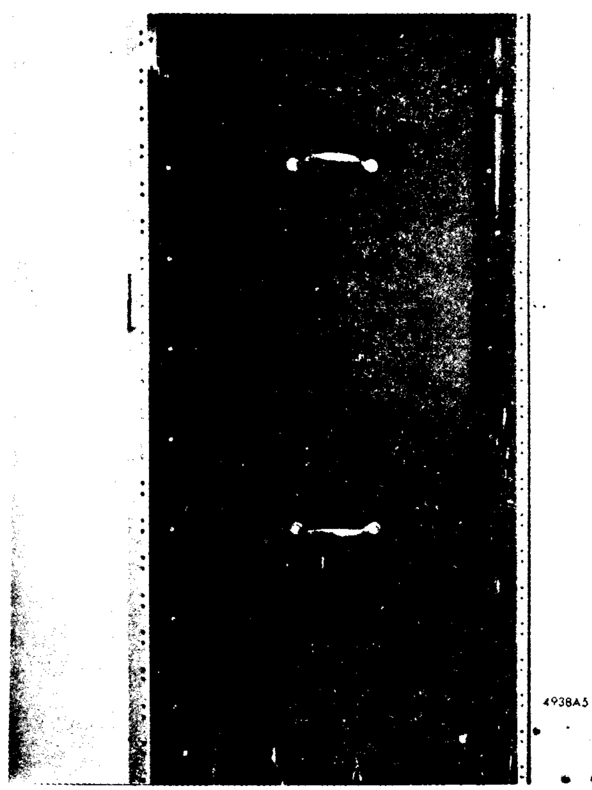
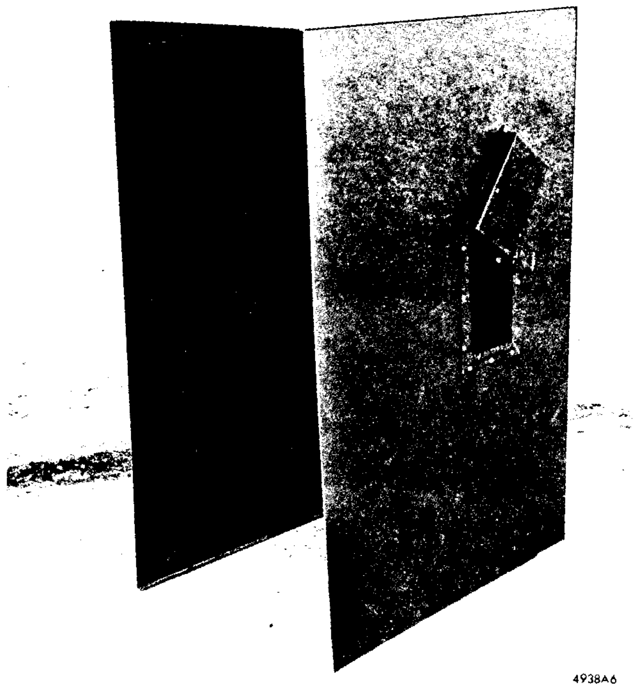


Fig. 5. Rear View of Enclosed System



4938A6

Fig. 6. Shroud