

## 2 SETTING UP MR. SQUID®

### 2.1 What You'll Need

The first step in operating Mr. SQUID® is to be sure you have all of the necessary equipment. Figure 2-1 shows the components that are provided with Mr. SQUID®. They are as follows:

- Electronic control box (two 9 V batteries are included),
- Probe with the SQUID sensor,
- Cable to interconnect the electronics box and the probe, and
- Liquid nitrogen dewar.



Figure 2-1 Mr. SQUID® system components.

Apart from the parts included in the Mr. SQUID® package, there are several items that the user must supply in order to operate the system:

- An output device – either a 2-channel oscilloscope (capable of x-y display) or an x-y chart recorder. There are advantages to having both on hand, if possible.
- BNC coaxial cables for connecting the electronics box to the output device. These are standard items for any laboratory using electronic instruments.
- Liquid nitrogen. The dewar included with Mr. SQUID® holds about 1 liter of liquid nitrogen, which should last for several hours. There are hazards associated with the use of liquid nitrogen and with vacuum vessels used to contain it.

**DIRECT SKIN EXPOSURE TO LIQUID NITROGEN CAN CAUSE SEVERE BURNS.** Personnel experienced in the use of cryogenic liquids should be on hand for all experiments involving the use of liquid nitrogen and appropriate cautions must be taken. A special caution: when removing the Mr. SQUID<sup>®</sup> probe from the nitrogen dewar, be careful not to handle the cold end until it warms up completely (the frost will disappear when it has warmed completely).

## 2.2 Assembling the Mr. SQUID<sup>®</sup> System

In this section, we explain how to assemble the various parts of Mr. SQUID<sup>®</sup>. The set-up instructions refer to the various controls and connectors on the Mr. SQUID<sup>®</sup> electronics box with the numbers shown in Figure 2-2 below:

### STEP 1: Battery check

The first step is to check the batteries by pressing the power switch (9) downward to the “BATT CHK” position. If the batteries are functional, the red LED (8) will light; otherwise, you should open the battery compartment through the underside of the electronics box and replace the batteries with two 9-Volt batteries. To maximize the lifetime of the batteries, make sure the power switch is in the OFF position any time that Mr. SQUID<sup>®</sup> is not in use.

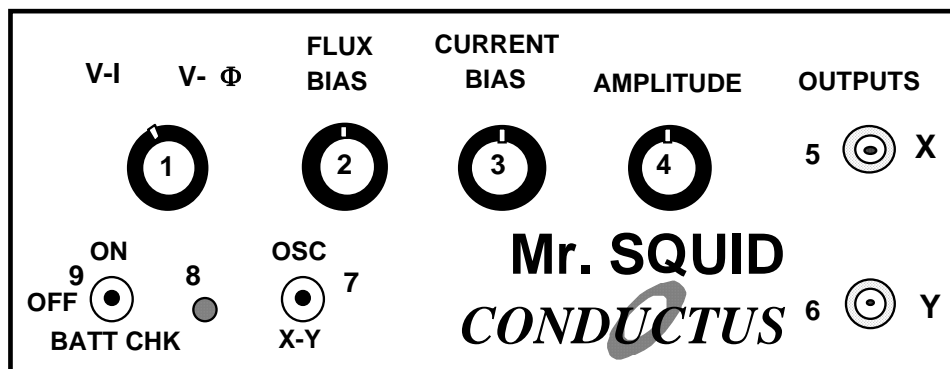


Figure 2-2 Front panel of the Mr. SQUID<sup>®</sup> electronics box.

### STEP 2: Add liquid nitrogen

Eye protection and gloves are advisable for anyone working with liquid nitrogen. Under all circumstances, be sure to follow the safety regulations of your laboratory. If you are uncertain about handling the liquid nitrogen, check with responsible people in your laboratory. The dewar supplied with Mr. SQUID<sup>®</sup> is manufactured specifically to handle liquid nitrogen, but it contains a glass vacuum vessel that can shatter if mishandled. Fill the dewar about 3/4-full with liquid nitrogen. If you will be using the system for a long time (more than a few hours), the liquid nitrogen level in the dewar will decrease due to evaporation. If the liquid level dips below that of the SQUID sensor, simply refill the dewar to its original level with more liquid nitrogen.

*STEP 3: Cooling down the probe*

Carefully lower the sensor end of the probe into the dewar, as shown in Figure 2.3 below. The foam cap to the Mr. SQUID<sup>®</sup> dewar has a hole and a slot in it to support the Mr. SQUID<sup>®</sup> probe. It will take several minutes for the SQUID sensor on the end of the probe to reach a stable temperature of 77 K. You should wear eye protection and gloves during this procedure as the liquid nitrogen may splash as the probe is introduced into the dewar. The critical temperature ( $T_c$ ) for the YBCO superconductor in Mr. SQUID<sup>®</sup> is approximately 90 K. It is important to cool the SQUID into the superconducting state with a minimum of external magnetic fields present. This will reduce the effects of a phenomenon known as magnetic flux trapping, which will adversely affect the performance of the SQUID. To cool the SQUID in the lowest ambient field, it is best to shut off any nearby electrical devices, such as radios or computers. It is also advisable to leave the probe cable unconnected until after cooldown. We will discuss the consequences of flux-trapping later.



Figure 2-3 Mr. SQUID<sup>®</sup> inserted into liquid nitrogen dewar.

*STEP 4: Connecting the probe.*

After cooling the probe, attach one end of the connection cable provided with Mr. SQUID<sup>®</sup> to the warm end of the probe and the other end to the SQUID Input connector (10) on the back of the electronic control box shown in Figure 2-4 below. The cable can be connected in one orientation only.

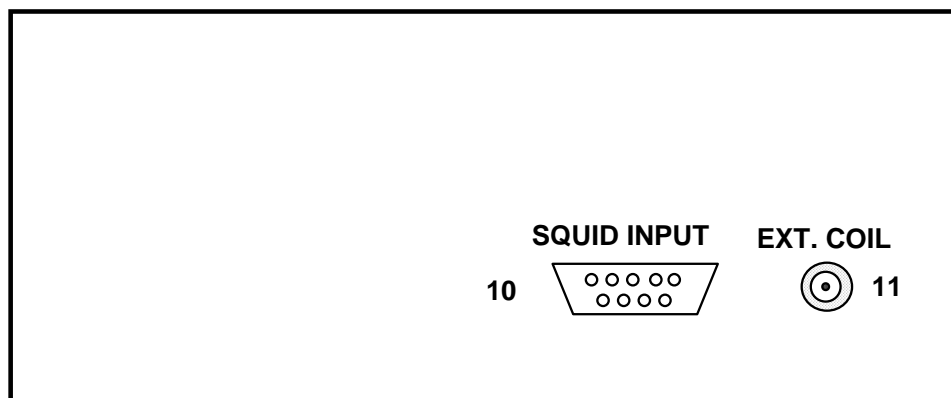


Figure 2-4 Rear panel of the Mr. SQUID<sup>®</sup> electronics box.

*STEP 5: Connect the Output Device*

Connect the BNC coaxial cables to the output connectors labeled X (5) and Y (6) on the front panel of the control box. The free end of the X cable should be attached to the horizontal input or x-axis of your display device (either a 2-channel oscilloscope or an x-y recorder.) Likewise, the free end of the Y cable should be connected to the vertical input or y-axis. While either display device is quite sufficient for Mr. SQUID<sup>®</sup> operation, using both an x-y chart recorder and an oscilloscope can be convenient for viewing and plotting the output of Mr. SQUID<sup>®</sup>. Since there are a variety of display devices available in laboratories, we cannot specify the optimal configuration of the controls here. Therefore, please refer to the manufacturer's instructions for proper operation of the display device you have chosen to use.



Figure 2-5 An operating Mr. SQUID<sup>®</sup> system using an oscilloscope display.

At this point, the Mr. SQUID<sup>®</sup> system is ready for operation. Your set-up should look more-or-less like that shown in Figure 2-5 above, except perhaps for the replacement of the oscilloscope with an x-y recorder.

The basic operation of Mr. SQUID<sup>®</sup> is outlined in the following sections. If Mr. SQUID<sup>®</sup> represents your first experience with superconductive electronics, we suggest that you follow the Getting Started instructions for New Users (Section 3). This is in the form of a primer that discusses the phenomenon of superconductivity, and includes a simple theory of SQUIDs. It details the step-by-step demonstration of the basic SQUID experiments possible with Mr. SQUID<sup>®</sup>. On the other hand, if you are already familiar with SQUID operation, or you have already used Mr. SQUID<sup>®</sup> and merely need to refresh your memory with the details of its operation, you can use the Getting Started instructions for Advanced Users (Section 4). These two versions cover the same material but are quite different in approach.