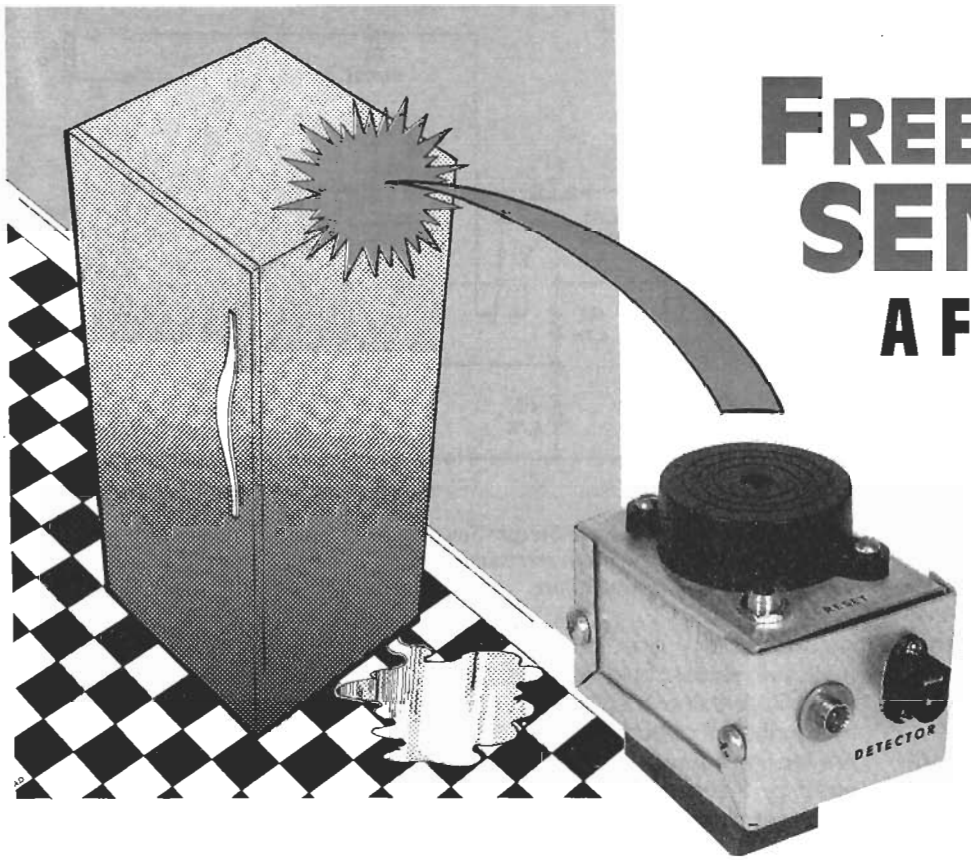
BUILD THE FREEZER SENTRY- A FOOD FREEZER MONITOR

DAVE SWEENEY



Afraid that your freezer may not be as reliable as it used to be? Do you sometimes forget to close the door completely? Put your mind to rest—the Freezer Sentry will warn you of a problem before disaster strikes!

Having a separate food freezer in the home provides years of convenient, economical storage for perishable food. Stuffed with chicken, beef, fish and various specialty items, the home freezer offers a comforting feeling—until something goes wrong. Tucked away in a corner of the basement or garage, the freezer is conveniently forgotten. But with no warning or outward signs, a freezer malfunction might occur, easily costing you hundreds of dollars in thawed and spoiled food.

Imagine the horror of opening the freezer to select your dinner, and instead you're greeted by the odor of thawed and spoiling meat, poultry, and special desserts. The contents of your freezer could thaw overnight just because someone left the door open a crack or turned off a critical circuit breaker while servicing some other electrical device. With the freezer door closed, mechanical failures could also cause undetected problems. A Freon leak could weaken the ability of the freezer to maintain proper temperature. An overheated motor or compressor failure could leave you with soft or perhaps spoiled food if the freezer is down for a day or so.

For peace of mind, you can build the Freezer Sentry. An audio alert as well as a 5-volt remote-control output are activated if the freezer temperature rises or if there is a loss of AC power to the freezer. For a temperature problem, a special meltdown sensor inside the freezer detects a sustained temperature rise above 15° F. Regardless of the cause, a pulsating piezo-electric beeper sounds, and a 5-volt output for connection to a home-security system is activated. Because it latches in the on state once it is activated, the temperature alert will continue even if the temperature returns to normal. That feature will let you know that something went wrong, even if all appears OK when you examine the freezer.

Protecting A Freezer. To maintain the food for extended periods, a freezer is designed to keep the temperature of its storage area between −5° F and 0° F (well below 32° F, the freezing point of water). If a problem develops and you discover it in time, you might avoid a disaster. Even if the temperature in the freezer rises above freezing, the food will take a few hours to begin to thaw, and take even longer to spoil. If you detect a freezer meltdown in time, you might move your food to a neighbor's freezer, or, if there's room, to the freezer in the kitchen. A food loss might also be avoided by simply keeping the freezer door closed until the unit can be repaired.

The Freezer Sentry has to watch for two conditions: rising temperature in the freezer itself and a loss of AC power. The monitor itself is attached to the top or side of the freezer with a simple bar magnet glued to the Freezer Sentry's case. Inside the freezer, a special meltdown sensor is con-

nected to the Freezer Sentry. The sensor is designed to close a switch if the temperature sustains a rise above 15° F. The Freezer Sentry runs on a power supply that plugs into the same electrical outlet the freezer is plugged into. If AC power to the freezer fails, then the Freezer Sentry also loses AC power. In that event, a set of 8 AA batteries keeps the Freezer Sentry running, sounding the alarm.

The meltdown sensor contains a solution that stays frozen as long as the temperature is well below 15° F. The sensor is simple to build, easy to adjust, and is designed to keep the alarm circuit as simple as possible. When the temperature rises, the sensor solution melts (before the meat has a chance to thaw) and falls on two copper electrodes. For added reliability, a piece of aluminum foil is frozen to the solution to ensure the closing of the contacts when the weight of the solution pushes down on them.

Using a liquid switch provides significant advantages over the use of a thermistor for sensing a temperature rise in a freezer. Short air-temperature variations, due to opening the door during normal use, will not trigger a false alarm. Additionally, testing and calibrating a thermistor-based design would require warming and cooling the freezer or the use of a laboratory test chamber. Thermistor resistance in the temperature region where a food freezer operates does not change abruptly with temperature. To adjust the point where the alarm should trigger, the freezer would need to be defrosted and frozen for each adjustment, which is not practical. A liquid switch, however, allows a simple approach to setting the temperature at which the switch triggers. Instead of changing the freezer temperature, you adjust the mixture of the liquid in the switch to just freeze at the unit's normal operating temperature.

WARNING: The meltdown sensor uses a mixture of automotive antifreeze and tap water. The main ingredient in antifreeze, ethylene glycol, is **EXTREMELY POISONOUS**. There is a possibility that the antifreeze solution will completely melt if, for example, there is a freezer failure while you're not at home for an extended period of time. If the meltdown sensor leaks in any way, antifreeze might contaminate the food in the freezer. As an added safety precaution, the meltdown sensor could be placed in a plastic container, such as an empty margarine or cottage cheese tub. Any leaking fluid would then be captured by the container, preventing contamination.

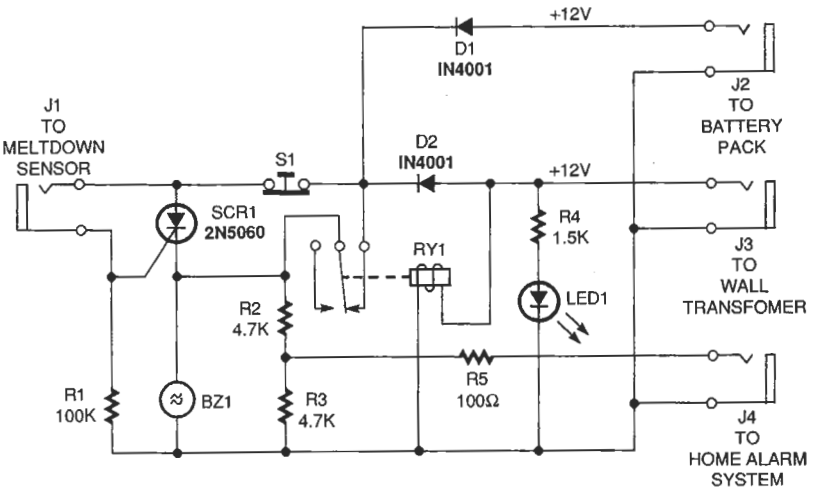


Fig. 1. The electronics for the Freezer Sentry is both simple and reliable. The meltdown sensor warns of a freezer malfunction and the relay together with the backup battery warns of AC power failure.

The Monitor Circuit. The electronic circuit for the Freezer Sentry, shown in Fig. 1, is quite simple. The heart of the circuit is SCR1, a silicon-controlled rectifier. That type of semiconductor acts like a solid-state switch—it will only conduct in one direction (like a diode) when a trigger voltage is applied to the gate terminal. That trigger voltage is supplied through J1 by the meltdown sensor when its contacts close. Resistor R1 is included to prevent any false triggering of SCR1 due to voltage fluctuations or noise from the power supply. Once SCR1 is triggered it latches on, sounding the alarm buzzer until the reset switch (S1) is pressed. The reset switch interrupts current flow through the SCR, letting it turn off.

Power for the circuit is supplied by a 12-volt DC wall-mounted transformer, which is connected to J3. As long as the wall-mounted power supply is working, relay RY1 will be activated, opening its normally-closed contact. Normal power will also be indicated by LED1, with R4 limiting the current flow through the light-emitting diode. If the AC power fails, LED1 will go out and RY1 will de-energize, closing the relay's normally-closed contacts. The relay contacts bypass SCR1, sounding the alarm. Backup power for that situation is supplied by a 12-volt battery pack, which is connected to the circuit through J2 and D1. Diode D1 prevents the AC-derived power supply

PARTS LIST FOR THE FOOD FREEZER MONITOR

SEMICONDUCTORS
D1, D2—1N4001 silicon diode
LED1—Light-emitting diode
SCR1—2N5060 silicon-controlled rectifier

RESISTORS
(All resistors are ¼-watt, 5% units.)
R1—100,000-ohm
R2, R3—4,700-ohm
R4—1,500-ohm
R5—100-ohm

ADDITIONAL PARTS AND MATERIALS
BZ1—Piezo beeper (Radio Shack 273-066 or similar)
J1, J3—Male coaxial power jack
J2—Audio jack, ⅛-inch
J4—Audio jack, 3/64-inch
RY1—Single-pole double-throw relay, 12-volt coil, PC-mount (Radio Shack 275-248 or similar)
S1—Single-pole, single-throw, normally-closed pushbutton switch, panel-mount
Printed-circuit board, case, bar magnets, 8 AA batteries, Battery holder (Radio Shack 270-387 or similar), wall-mount 12-volt DC 200-mA power adapter, wire, suitable plugs for J1–J4, aluminum foil, 35mm film canister and lid, automotive antifreeze, epoxy, hot-melt glue

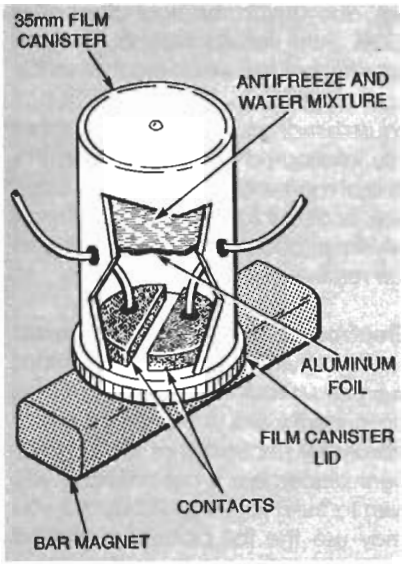
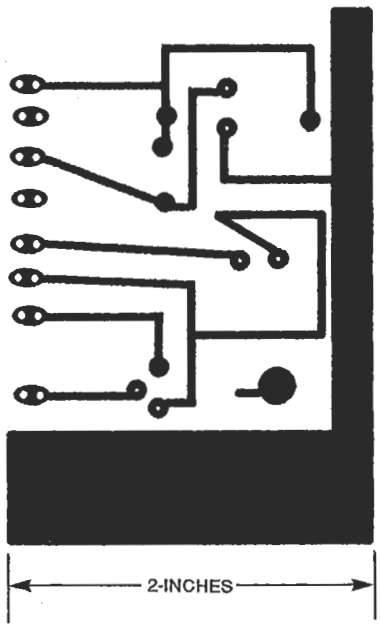


Fig. 2. The meltdown sensor contains a liquid that melts at about 15° F. When the liquid starts to melt, it falls down to the bottom of the canister, pushing an aluminum foil disc against the electrical contacts.



Here's the foil pattern for the Freezer Sentry. The circuit is simple enough to be built on a single-sided PC board.

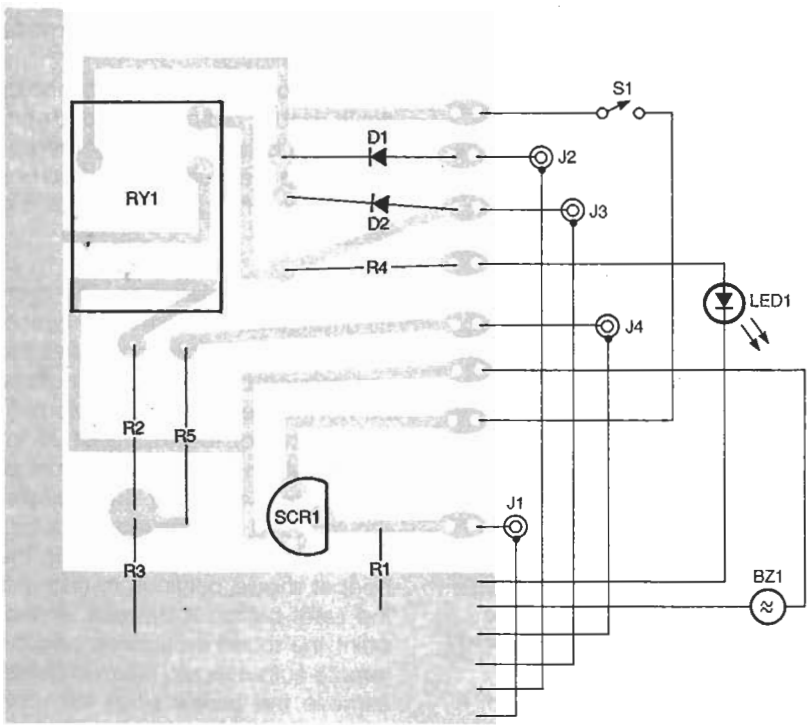


Fig. 3. If you want to etch a PC board from the foil pattern, use this placement diagram to locate the parts.

from attempting to charge the batteries, and D2 prevents the batteries from lighting the LED or energizing RY1 in the event of AC power failure. An additional feature of the circuit is that since the relay bypasses SCR1 during a loss of AC power, the reset button will not silence the alarm.

Regardless of which type of failure caused the alarm to sound, R2 and R3 form a voltage divider that provides a 5-volt signal to J4, with R5 limiting the current that can be drawn from J4. That signal could be connected to a home-alarm system or any other device you might wish to activate.

Assembling the Meltdown Sensor. You can easily build the meltdown sensor with only a few simple parts. The overall design of the sensor is shown in Fig. 2. The sensor housing itself is made from a plastic 35mm film canister. Attach a bar magnet to the lid of the film canister. The magnet will hold the unit in place on a freezer shelf. One method of attaching the magnet is to first drill a small hole in the film-canister lid. Using a screw with nut, attach a piece of flat aluminum plate to the lid. Glue a magnet to the aluminum with epoxy.

Cut two "D" shaped pieces of copper-clad printed-circuit board such that they will easily fit side by side on the inside of the film canister's lid without touching each other. Solder two very thin wires to the PC boards. The wires should be long enough to reach from the location where the meltdown sensor will be in the freezer to where the alarm circuit will be without being stretched tight. Those PC boards are the switch contacts. Drill two holes near the top of the film canister and run the wires through them. Use hot glue to hold the PC board contacts on the film can lid. Hot glue will hold the PC board contacts sufficiently as long as the wires are not severely pulled.

In a disposable plastic container, mix a solution of 3 parts water to 1 part antifreeze. An easy way to measure the ingredients is by using two additional film canisters—one for antifreeze and one for water. Pour one film canister of antifreeze and three film canisters of water into the plastic container and mix well. The mixture is designed to freeze at 0° F. Because of the poisonous nature of antifreeze, do not use a plastic mixing container that will be saved and used elsewhere later—residual antifreeze on the bowl might possibly come in contact with food. After creating the proper mix, the plastic bowl and canisters should be thrown away.

The mixture can be carefully tested in the freezer. Fill the meltdown sensor half full of the mixture. Cut a circular disc of aluminum foil slightly smaller than the inside diameter of the film canister. Carefully "float" the aluminum disc on the antifreeze mixture and set the container upright in the freezer with a freezer thermometer next to it. After 24 hours, check the

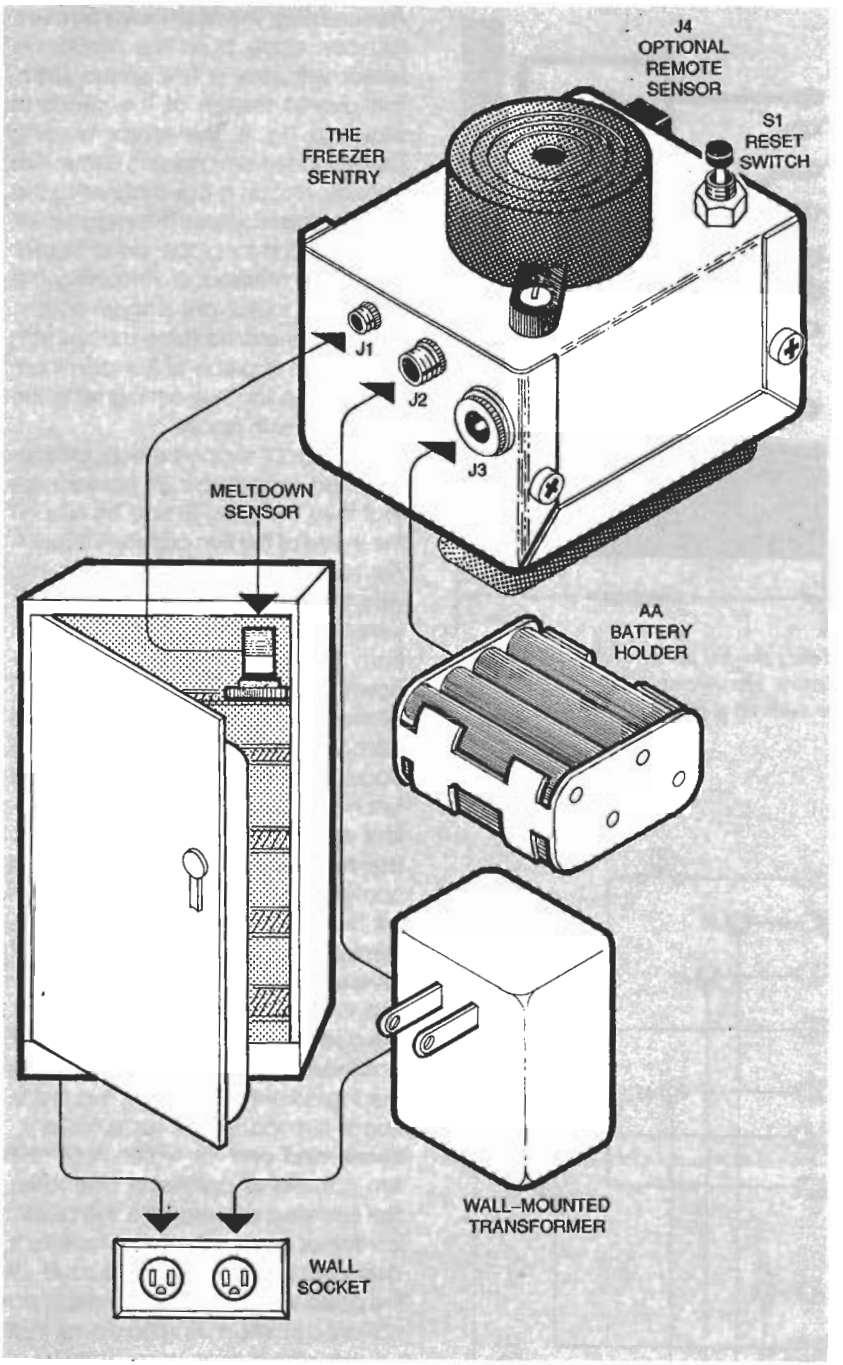


Fig. 4. A typical Freezer Sentry installation follows this general arrangement. The wall-mounted transformer should be connected to the same wall outlet that the freezer is plugged into.

temperature and the mixture. The temperature reading should be between 0° F and -5° F. The mixture should be frozen solid. If it is not, it will be "slushy". Add 3 teaspoons of water to the mixture to raise its freezing point and repeat the process for filling and freezing the switch. Once frozen, the switch must be kept frozen. After capping the sensor, turn it upside down so that the mixture will fall if it melts, and place it where it will operate in the freezer.

If you are concerned about putting antifreeze in the freezer even if placed in a second container for improved safety, you can try substituting 200-proof grain alcohol for the antifreeze. The mixture ratio will be different, so you'll have to experiment to find the proper amounts of alcohol and water for the sensor. Grain alcohol, also called medical alcohol, is 100% pure natural alcohol. It is not "denatured" like wood alcohol, so it is non-poisonous—that is, it will not cause blindness or death. It will just get you intoxicated at about 2 times the rate of most vodkas (about 50% alcohol), or about 3 times the rate of most whiskeys (about 35% alcohol) due to the relative content of alcohol.

Electronics Assembly. The Freezer Sentry circuit can be built using either a printed-circuit board or hand-wired on a perfboard. A PC board is not absolutely necessary, as the component placement is not critical. If you wish to build your own PC board, you may use the foil pattern published here and follow the parts-placement diagram in Fig. 3. It is a good idea to use different connector hardware for each connection to the circuit in order to avoid errors when plugging in the sensor and other connections. The connector combinations in the Parts List are by no means definitive—they just represent the choices made for the prototype.

A small aluminum chassis box holds the PC board, alarm buzzer, and connectors. A large magnet can be epoxied onto the aluminum chassis box for easy mounting of the unit on the freezer itself.

Testing And Installation. The overall arrangement in Fig. 4 is a typical Freezer Sentry installation. To test the unit, connect both power and battery, but not the meltdown sensor. Momentarily connect the inputs at J1 together, which simulates a closure of the meltdown sensor. The beeper should sound, and the remote output should change from 0 to 5 volts. The beeper should continue to ring until the reset button is pressed. At that point, the sound should stop and the remote output should return to 0 volts. Remove the power pack from the wall. Again, the beeper should sound and the remote output change from 0 to 5 volts.

Replace the power pack and press the reset button. Plug in the meltdown sensor, and the Freezer Sentry is ready to go. The next time that the freezer is defrosted, monitor the temperature with a thermometer to verify that the sensor triggers the alarm when the temperature rises to about 15° F. Ω