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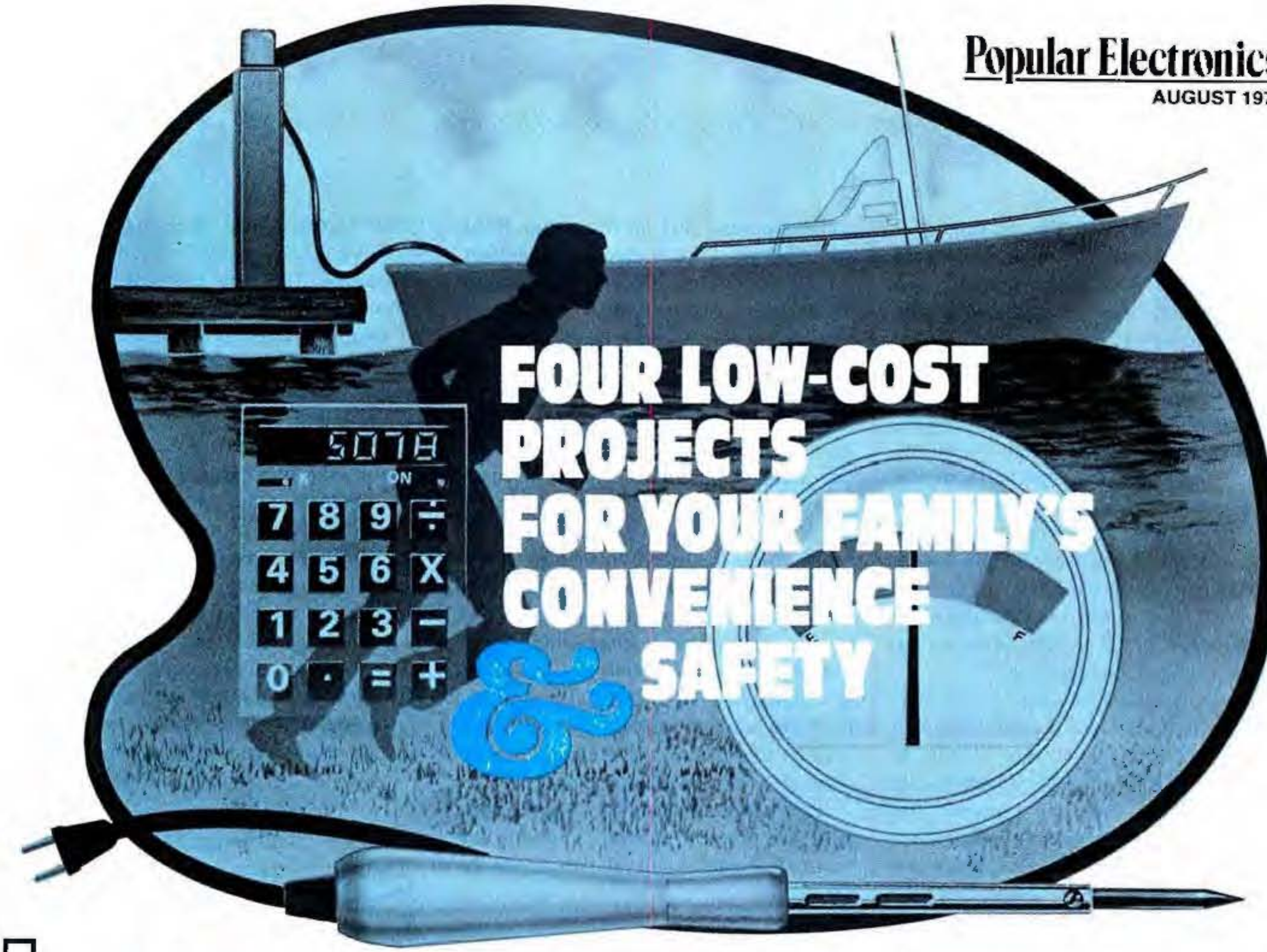


1. Solid-state level-sensing switch for sump pumps

By Phillip Windolph

A FLOODED basement is a minor household disaster. That's why most homeowners whose basements are prone to flooding install sump pumps. Some, however, have discovered to their chagrin that the pump somehow fails to operate when it is most needed. In many instances of failure, the pump itself is actually in perfect working order. Rather, it is the water-detecting actuator switch that's the culprit, never sending a turn-on command to the pump.

Here's a simple, dependable circuit to replace the often-unreliable (usually mechanical) switch supplied as part of the pump assembly. It will automatically activate the pump when the water level reaches the level of a pump trigger probe. Once activated, the pump will remain energized until the water level falls below a keep-alive probe. If the pump fails or cannot keep the water in check, an optional alarm will sound as the water level reaches a trigger probe specifically for that purpose. The project can be powered either by batteries or the ac line. Inexpensive components are employed, most of which will be found in any well-stocked junk box.

About the Circuit. The Electronic Sump Pump Switch is shown schematically in the figure. Positive voltage from the power supply is applied to the COMMON probe via resistors *R1* and *R2*. (This and all other probes are stiff wires or metal rods suspended above and extending to different levels in the sump.)

Replaces often-unreliable pump switch and sounds alert if water level continues to rise or pump isn't working

Low-cost Projects continued...

As can be seen in the figure, the COMMON probe extends almost to the bottom of the sump. Any water entering the sump comes into contact with this probe, but as yet nothing which would cause activation of the pump happens.

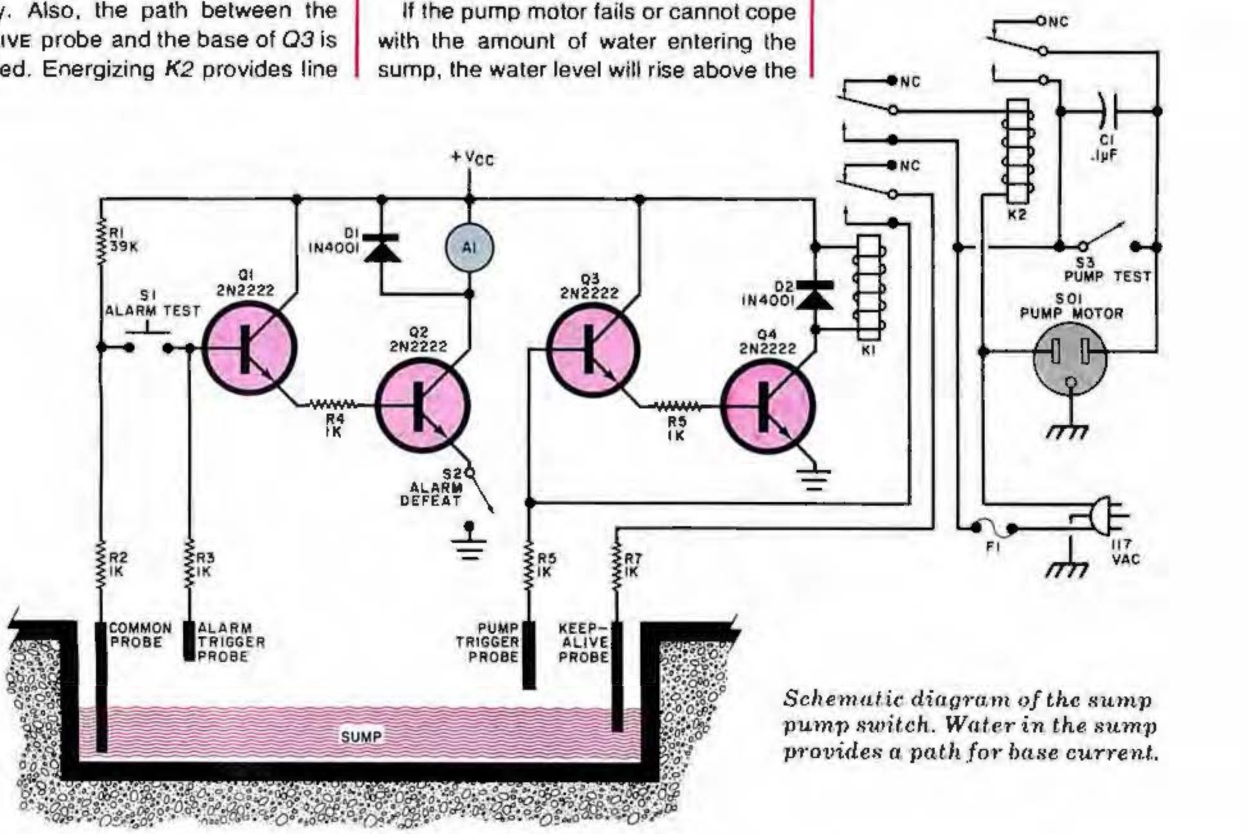
As the water level in the sump rises, the KEEP-ALIVE probe touches the water, but this still does not activate the pump. If the water reaches the level of the PUMP TRIGGER probe, current can flow from the positive supply voltage terminal through *R1*, *R2*, the water in the sump, *R5* and finally into the base of *Q3*. This transistor then turns on and provides base current for *Q4*. When *Q4* conducts, it energizes the coil of relay *K1*.

Once this relay is energized, the normally open contacts are closed and two things happen. Line current is able to flow through the coil of *K2*, a heavy-duty ac relay. Also, the path between the KEEP-ALIVE probe and the base of *Q3* is completed. Energizing *K2* provides line voltage across *SO1* for the pump. If the sump pump is connected to the socket, it will be activated and will start to pump the water out of the sump.

As the water level drops, the conductive path provided by the water in the sump between the COMMON and PUMP TRIGGER probes will be interrupted. However, current will continue to reach the base of *Q3* via the KEEP-ALIVE probe, *R7*, and one set of contacts of relay *K1*. Because this probe extends almost to the bottom of the sump, relays *K1* and *K2* remain energized (as does the pump motor) until practically all of the water has been evacuated. When the water level drops below the free end of the KEEP-ALIVE probe, *Q3* is deprived of base current and is cut off. This causes *Q4* to stop conducting, deenergizing *K1*, *K2* and the pump motor.

If the pump motor fails or cannot cope with the amount of water entering the sump, the water level will rise above the PUMP TRIGGER and KEEP ALIVE probes and eventually reach the ALARM TRIGGER probe. This probe is part of the optional alarm circuit and should be mounted near the top of the sump. Although the alarm circuit is independent of the pump controller, it is a valuable addition to the project.

The alarm circuit closely resembles that of the pump controller and operates in a similar manner. Water reaching the ALARM TRIGGER probe provides a path for current to reach the base of *Q1*. This transistor begins to conduct and provides base drive for *Q2*. Transistor *Q2* then conducts and completes the circuit for audible alarm *A1*, which alerts the homeowner to the fact that water in the sump has risen to a critically high level. He can then try to get the pump working



Schematic diagram of the sump pump switch. Water in the sump provides a path for base current.

PARTS LIST

A1—De-energized buzzer, bell, Sonalert™ or similar audible alarm*
C1—0.1-μF, 1000-volt disc ceramic
D1,D2—1N4001 rectifier
F1—Fast-blow fuse*
K1—Dc-energized relay*
K2—117-volt relay*
Q1 through Q4—2N2222 or similar npn switching transistor*

The following are ¼-watt, 10% tolerance carbon-composition resistors:
R1—39,000 ohms*
R2 through R7—1000 ohms*
S1—Normally open pushbutton switch
S2—Miniature spst toggle switch
S3—Spst toggle switch*

SO1—Ac power socket
Misc—Line-powered, regulated or battery dc supply*; suitable enclosure; barrier terminal strip; perforated board; fuseholder; line cord; metal rods or stiff, solid-conductor wire; hookup wire; solder; self-tapping and machine hardware, etc.

*See text.

or, if necessary, bail the water out of the sump manually.

Two switches are associated with the alarm circuit and one switch is included in the pump controller. These switches provide test facilities for the alarm and pump (*S1* and *S3*, respectively) and the ability to silence the alarm (*S2*). The currents handled by *S1* and *S2* are relatively small, so miniature components can be used in these locations. Switch *S3*, however, as well as the contacts of *K2* must be capable of handling the current demanded by the pump motor, so use heavy-duty components.

The author employed a solenoid/spring-type buzzer as his prototype's audible alarm. Diode *D1* is connected across the buzzer to protect *Q2* from inductive spikes generated by the buzzer. Other types of alarms can be used, some of which will not require the inclusion of *D1*. A Sonalert™ or similar audio oscillator will not necessitate diode protection for *Q2*, but an alarm bell will.

Which type of audible alarm you choose is largely a matter of personal preference and parts availability. Similarly, there is a great deal of leeway in the choice of components *Q1* through *Q4* and *R1* through *R7*. General-purpose 2N2222 transistors are suggested in the parts list. Just about any low-power npn transistor is suitable for use as *Q1* and *Q3*. Exactly which transistor types are acceptable for use as *Q2* and *Q4* depends on the audible alarm and relay (*K1*) used. If the current demand of either load is fairly low, say, 300 mA or less, a general-purpose component such as type 2N2222 can be used as a relay or alarm driver.

However, if a load draws more than 300 mA, a higher-power driver will have to be used. A good rule of thumb is to use a transistor with a collector current rating that is double the current required by the alarm or relay coil. The author employed a sensitive 6-volt relay for *K1* (Sigma No. 70R4T-6DC), which permitted the use of a low-power npn driver. Diode *D2* was included to protect the relay driver from inductive spikes.

The values specified for the fixed resistors (*R1* through *R7*) are nominal ones. Substitutions can be made freely if you want to use components you have on hand. However, do not make the fixed resistances so low that they tax the base current ratings of the transistors employed in the project.

Either a line-powered or battery supply can be used for the project. The exact value of supply voltage is not critical and can be chosen to accommodate a particular dc relay (*K1*). Practical supply voltages range from 6 to 15 volts. Although it is not necessary, voltage regulation is desirable in a line-powered supply. The widespread availability of voltage regulator ICs makes the inclusion of regulation simple and inexpensive.

If the alarm circuit is included in the project, battery power enjoys a significant advantage over a line-powered supply—it will still provide power to the project if the commercial power line is blacked out. Of course, if line power is not available, the pump motor will not be activated, even though *K1* will be energized. The alarm circuit, however, will be activated if the water in the sump rises to the level of the ALARM TRIGGER probe. This will alert the homeowner that water is accumulating and had best be bailed out before any damage occurs. Also, when neither the alarm nor pump controller circuit is triggered, practically no current is drawn from the battery supply. If nonrechargeable batteries are used to power the project, long operational life can be expected.

Construction. The circuit is relatively simple, which suggests the use of perforated board and point-to-point wiring techniques. Remote mounting of the alarm and pump controller circuits will simplify any future servicing. If this is done, the circuit board, relays, switches and power supply can be housed in a suitable enclosure which can be installed at some convenient location.

A four-terminal barrier strip can be mounted on the control box for the leads running to the sump probes. These probes can be fashioned from either metal rods or lengths of solid No. 12 or No. 14 copper wire and should be mounted rigidly above the sump. The probes are of varying length, with the COMMON probe extending almost to the bottom of the sump, the KEEP-ALIVE probe extending almost as deeply, the PUMP TRIGGER probe reaching about halfway down, and the ALARM TRIGGER probe extending only a short distance into the sump. Suitable lengths of hookup wire should be soldered to the probes and routed to the barrier terminal strip on the control box.

When constructing the control box, be sure to observe the polarities of all semiconductors and, if a line-powered supply is built in, of electrolytic capacitors. Use the minimum amount of solder and heat consistent with making good connections. Take special care in wiring the 117-volt ac portions of the project so that no shock hazard is present.

Checkout and Installation. After the control box has been wired, connect short lengths of hookup wire to the barrier terminal strip. Remove a portion of the insulation from the free end of each wire. Next, fill a drinking glass or measuring cup with water and place the wire connected to the COMMON probe terminal into the water. Place the wire connected to the KEEP-ALIVE probe terminal into the water. (Keep these and all probes from touching each other to realistically simulate actual operation. No damage will occur, however, if the probes accidentally come into contact.) Activation of the pump controller, indicated by a click as the relays are energized, should not yet happen.

Now insert the wire connected to the PUMP TRIGGER probe terminal into the water. You should hear a click as the relays are energized. If desired, a lamp can be connected to power socket *SO1* and the line cord connected to the power line (assuming this has not yet been done). The lamp will then indicate that the relays are energized and that line power is reaching socket *SO1*.

Remove the PUMP TRIGGER wire from the water. The relays should remain energized and no click should be heard. Then remove the KEEP ALIVE wire from the water. At this time, the relays should drop out and a click heard. Finally, insert the ALARM TRIGGER wire into the water. The alarm should sound and remain on until the wire is removed from the water.

Press the ALARM TEST pushbutton and keep it depressed. The alarm should sound and remain activated until the ALARM DEFEAT switch is opened. The operation of the PUMP TEST switch can be checked by closing it and observing whether the load connected to socket *SO1* receives line power.

Once it has been determined that the control box is functioning properly, a permanent installation can be made. Mount the control box at some convenient point and interconnect it with the sump probes and pump motor. Be sure to bypass the stock pump-activating switch as it is no longer needed. As a final check, you can quickly fill the sump with water. The alarm should sound until the pump has lowered the water level beyond the reach of the ALARM TRIGGER probe. The pump should remain on until the KEEP ALIVE probe is no longer immersed, at which point nearly all of the water will have been taken out. ◇

(Projects continued overleaf)