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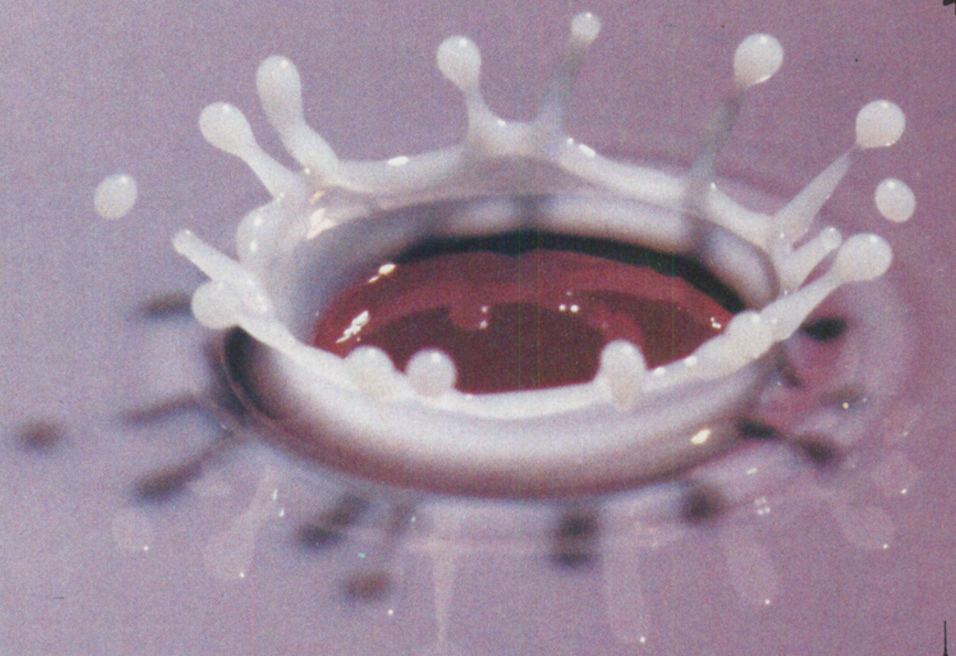

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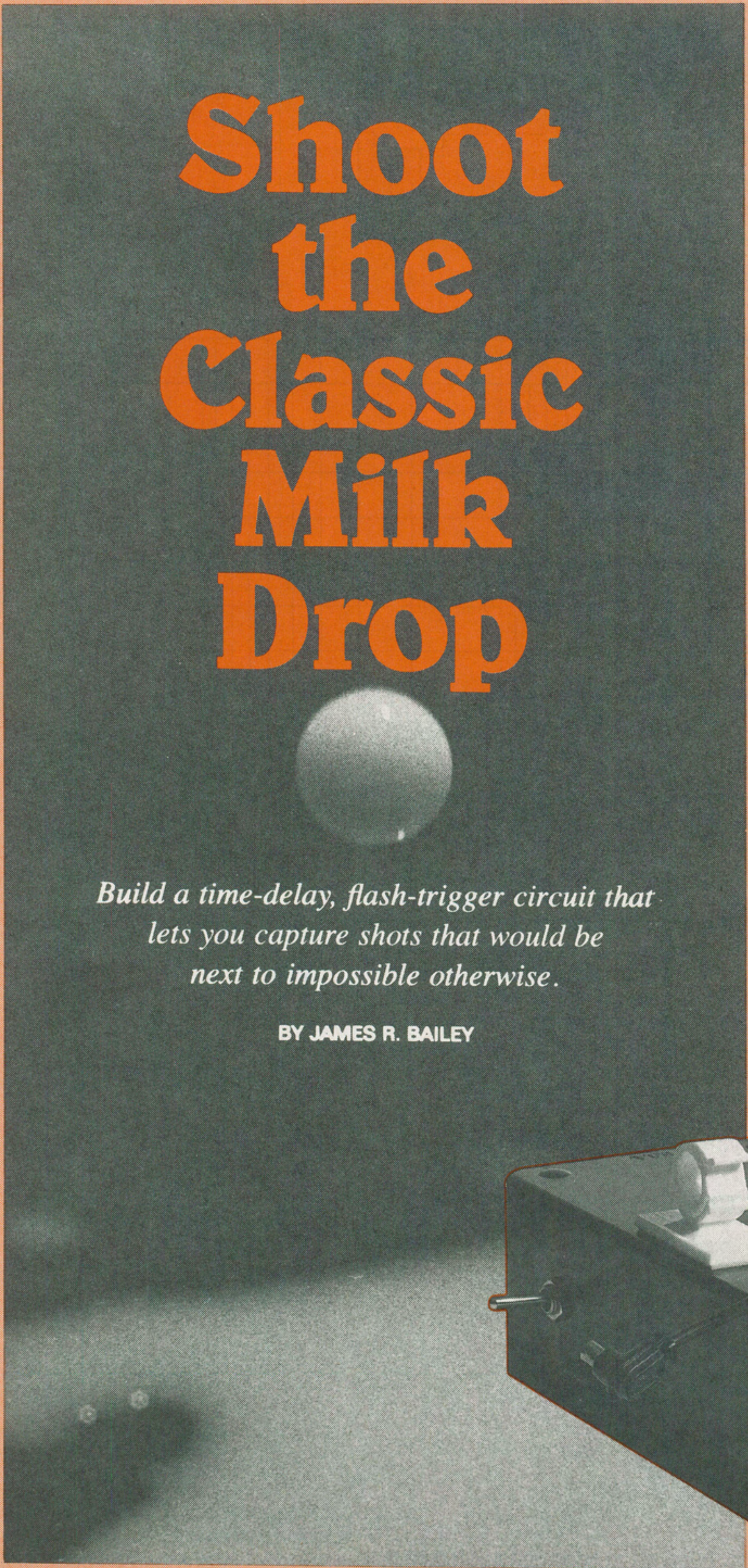
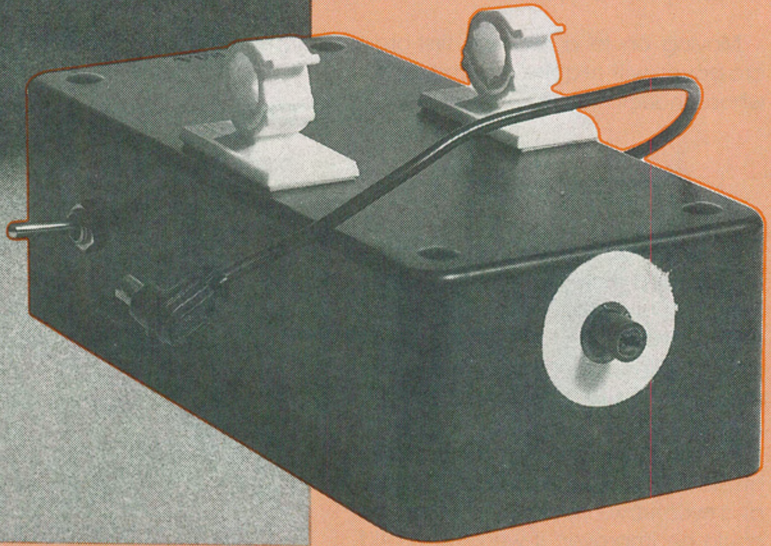
**Product Test Report**
- Pioneer Combination Laserdisc/CD player



# Shoot the Classic Milk Drop

*Build a time-delay, flash-trigger circuit that lets you capture shots that would be next to impossible otherwise.*

BY JAMES R. BAILEY



If you are like me, you have been amazed at the simple, yet classic beauty of the familiar "milk drop" photos. They are among the thousands of well-known images created by famed inventor and educator, Dr. Harold Edgerton. Now, you can shoot your own "classic" using your own camera and flash, coupled with this easy-to-make time delay flash trigger.

**How It Works.** The schematic diagram for the time delay circuit is shown in Fig. 1. The circuit is built around a single 4093 quad 2-input NAND Schmitt trigger. Two gates from that quad package (U1-a and U1-b) are configured as a set-reset flip-flop, which is triggered by a phototransistor (Q1). As long as Q1 is illuminated by a beam of light, one input of U1-a is held high. When the beam is interrupted, say by a falling milk drop, the input to U1-a is pulled low via resistor R1.

That causes U1-a's output to go high, thereby forcing U1-b's output low. At that point, C2 (which, in conjunction with R2 and R3, determines the length of the time delay) begins to discharge through R2 and R3. The actual delay time in seconds is given by:

$$t_d = C \times (R2 + R3)$$

When C2 has discharged sufficiently, U1-c's output goes high, triggering SCR1 and firing your flash. Now C1 begins to charge through R4, which takes about a half second. When that time has elapsed, U1-d's output goes low, resetting U1-a and U1-b to their initial state. Capacitor C2 then quickly recharges through D1, so that it's ready for the next shot. The half-second delay produced by C1 prevents double exposing your shots.

**Construction.** The author's prototype of the trigger-delay circuit was built on a printed-circuit board (see Fig. 2) measuring 1½ by 2½ inches. After etching your circuit board, install the components using Fig. 3 as a guide. Be careful when handling U1. It's a CMOS device and can be damaged by static discharges. Also, when installing C1 and C2, be sure to observe the proper polarity.

Mount the phototransistor, Q1, near one end of the circuit board. The lead nearest to the flattened edge of the phototransistor is the collector, and should be connected to the +9-volt bus (as shown). Before installing Q1 bend the ends of its leads to form a 90° angle to line up with a hole that will be drilled in one end of the circuit's enclosure (more on that in a moment). Just about any phototransistor will work for Q1. Both infrared and visible light types are acceptable.

You'll need a short length of black plastic tubing to fit over Q1 to help keep it lined up with the hole. The author used a section cut from an old disposable ballpoint-pen housing. A hole about 1⁄16 inch was drilled in the sealed upper end of the pen housing to allow light to get to Q1. Be careful not to make the hole too large; if you do, a drop of milk may be too small to block all the light.

GE C106D SCR's come both with and without heat-sink tabs. For this project the tab is unnecessary, so you can cut it off if desired to prevent shorting. You can also use Teccor T106D's. Do not substitute any other SCR for SCR1; either version of the 106D is inexpensive and have been used successfully on many flash and control projects.

Next prepare the enclosure that will house the time-delay circuit by drilling holes for S1, R2, Q1, and the flash cord. The author's circuit was housed in an enclosure measuring about 5 1⁄16 by 2⅝ by 1⅝ inches. The author drilled a hole in one end of the enclosure for Q1. That hole should be small enough to fit Q1's plastic tubing snugly. Cement the tubing in place.

Drill a hole in the side of the enclosure for the flash sync cord. For the sync cord, cut the male end off of a photographic extension cord. Use the female end and the wire for this project.

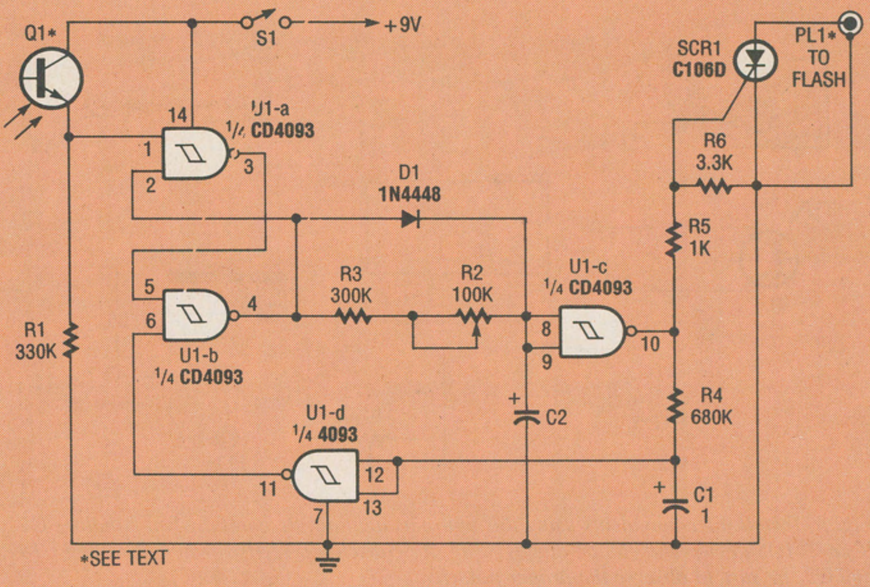



*Fig. 1. The time-delay trigger circuit is built around a single 4093 quad 2-input NAND Schmitt trigger. Two gates from that quad package (U1-a and U1-b) are configured as a set-reset flip-flop.*

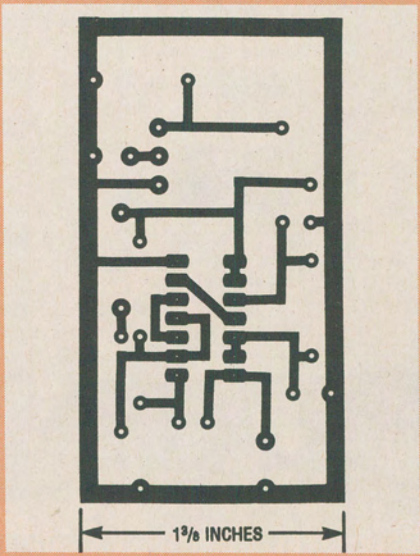
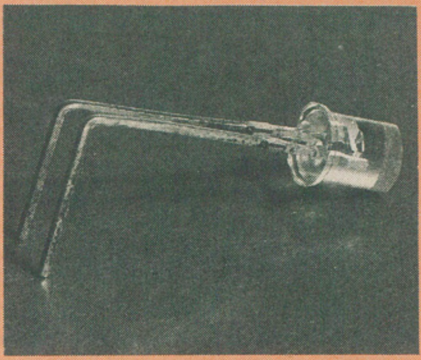



*Fig. 2. The author's prototype unit was built on a printed-circuit board measuring 1⅜ by 2½ inches.*

Attach two adhesive-backed plastic cable clamps to the bottom of the case along the centerline. They are used to attach the delay unit to the ringstand. Cut a disc about ⅝-inch in diameter from a white, self-adhesive label. Make a hole in the center to fit around the photocell opening in the case. Mount the disc around the hole. The disc will serve as a target for lining up to take your splash photos.

**Testing.** Before mounting the circuit board in the enclosure, attach the battery and make sure that the circuit is functioning correctly. Temporarily solder the sync cord to the appropriate points on the circuit board. The white or center lead goes to the anode of SCR1. The black lead or outer conductor goes to ground. A few flashes have negative-polarity sync circuits; if that is the case with your unit, it will be necessary to reverse those connections.

To determine if the sync cord is properly connected for your flash unit, plug the sync cord into your flash unit. If your flash unit has a variable-power "manual" setting, set it to minimum power for the quickest recycle time. Turn the flash unit on, but leave the delay turned off for the moment. Connect a voltmeter across the anode and cathode of SCR1. The anode should be positive and the cathode negative. The voltage is unimportant and is likely to be any-



*Just about any phototransistor (infrared or visible light type) is fine for Q1. Before installing Q1, bend the ends of its leads to form a 90° angle (as shown here) so that it lines up with the hole in the end of the enclosure.*

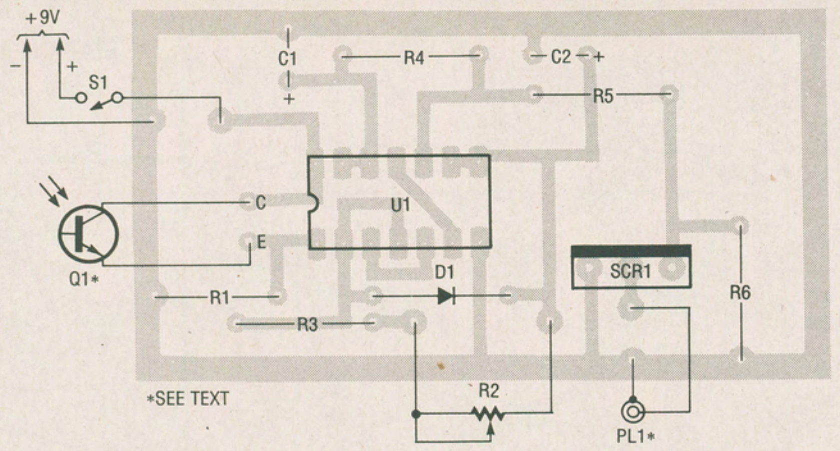



*Fig. 3. Install the components using this figure as a guide. Be careful when handling U1. It's a CMOS device and can be damaged by static discharges. Also, when installing C1 and C2, be sure to observe the proper polarity.*

## PARTS LIST FOR THE TIME DELAY FLASH TRIGGER

**SEMICONDUCTORS**

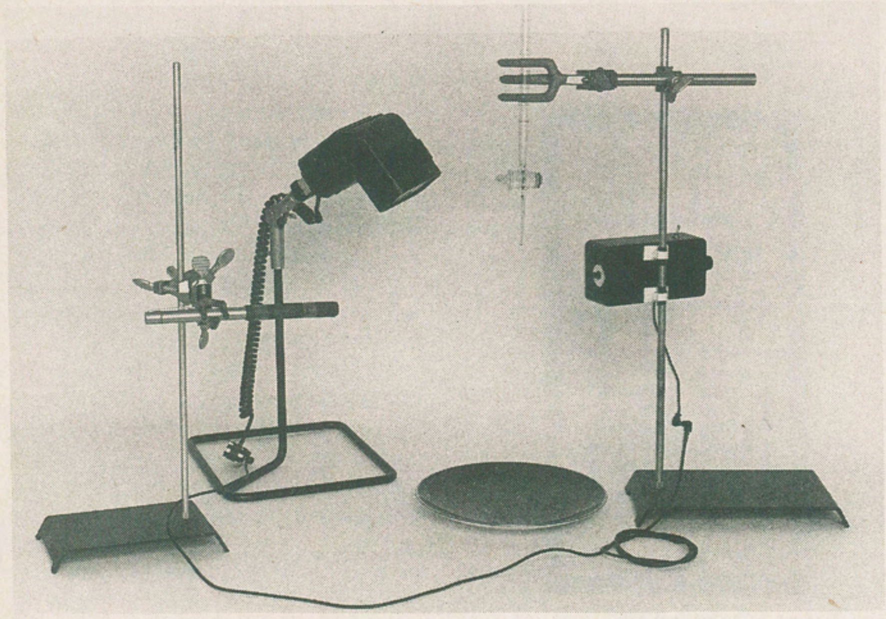
U1—CD4093 quad 2-input, NAND Schmitt-trigger, integrated circuit
Q1—NPN phototransistor, see text
SCR1—C106D or T106D silicon-controlled rectifier
D1—1N4448 or similar fast-recovery silicon diode

**RESISTORS**

(All fixed resistors are ¼-watt, 5% units.)
R1—330,000-ohm
R2—100,000-ohm potentiometer
R3—300,000-ohm
R4—680,000-ohm
R5—1000-ohm
R6—3300-ohm

**ADDITIONAL PARTS AND MATERIALS**

C1, C2—1-μF, 35-WVDC, Tantalum capacitor
S1—SPST toggle switch
Perfboard materials, 5 1/16- × 2 5/8- × 1 5/8-inch plastic enclosure, cable clamps, 9-volt transistor-radio battery and connector, sync cord, knob, wire, solder, hardware. etc.



*Here is the author's set up. Two adhesive-backed plastic cable clamps were used to attach the time delay trigger circuit to the ringstand.*

where from 2 to 250 volts—depending on the design of the flash. If the anode is negative with respect to the cathode, unsolder the sync cord leads from the board and reverse the connection.

Attach a 9-volt battery to the battery connector and turn on the power switch. Make sure no direct light is shining on Q1. The flash should fire every second or so. Rotating R2 should change the time interval between flashes. If the flash does not fire, check the battery to make sure it's fresh. Shine a bright pen light on Q1 and the flashing should stop. Briefly interrupt the beam with a pencil or other object and the flash should fire a moment later.

If a fresh battery fails to make the flash fire, momentarily place a short across the sync cord to see if the flash is working. It should fire each time you short out the sync cord. Assuming the flash is working, check the following voltages: with Q1 lit, pin 1 should be at 8.5 volts and 0 volts when dark; pin 3 should be at 0 volts with Q1 lit; pin 4 at 8.5 volts with Q1 lit; pin 10 at 0 volts with Q1 lit; pin 11 at 8.5 volts with Q1 lit. With the exception of pin 1 of U1, the voltages should alternate between the high and low readings with Q1 dark.

If the voltages do not check out, then SCR1 is probably defective, otherwise suspect U1 or that a capacitor is installed backwards.

Once you have everything working, temporarily disconnect the sync cord from the printed-circuit board, feed it through the hole in the enclosure, and reconnect it to the circuit board at the point indicated in Fig. 3. Insert Q1 into its tubing and secure the circuit board to the bottom of the enclosure with double-sided foam adhesive tape. Mount S1 and R2 to the enclosure.

Add a piece of insulating cardboard or foam over the circuit board to isolate it from the battery, which will lay above it in the case. Close up the enclosure, and install a knob on the shaft of R2.

**Taking the Photo.** The ideal source for falling milk drops is a glass laboratory burette. Mount it on a ring stand with its tip about eleven inches above the table. Place a dark or brightly colored dinner plate below the burette. Clip the delay box onto the ring stand (see photos). Position the photocell so that it is about ½ inch below the tip of the burette. Fill the burette with either milk or half milk/half water.

Support a pen light about a foot away from the delay box and aim it at the photocell. Tape a black pape: hood around the pen light to confine the beam. It should light the ring around the photocell. Connect your flash to the delay and set it for minimum

*(Continued on page 101)*

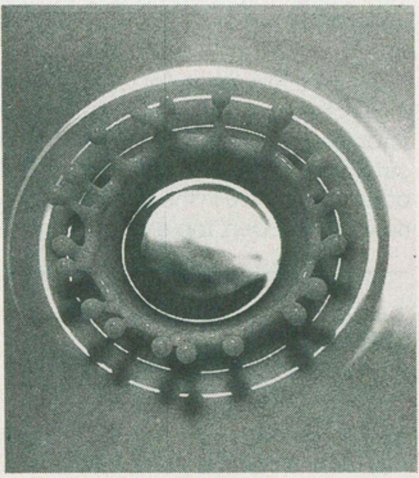
## CLASSIC MILK DROP

*(Continued from page 42)*

power as before. Place it near the pen light and aim it downward toward the plate.

Your camera should have a macro-focusing lens with at least a 100-mm focal length. The falling milk splashes, and the longer focal length will keep the lens surfaces at a relatively safe distance. Load the camera with ISO/100-speed film.

Turn off the room lights and open the burette slightly to allow one drop to fall about every one to two seconds. Move the burette until you see the shadows of the falling drops cross the photocell. The flash should fire as each drop passes. Adjust the delay knob until you see



*This milk crown—a drop of milk actually splashing off a solid surfcae—is but one example of an action that requires split-second timing to capture on film.*

the "crown" splash. Your vision persistence will hold the image long enough to see the splash clearly.

Once you have the delay set to your liking, simply set your camera's shutter to "B" and open it just long enough to record the next splash. Set the aperture as small as possible for maximum depth of field. Don't let more than a thin layer of milk accumulate in the plate. Too much milk makes the "crowns" less spectacular. To get a cone-shaped splash, make the milk deeper.

Timing is quite important to catch the splash. Since the tolerance of electrolytic capacitors tends to be pretty wide, you may need to make R3 a bit larger or smaller to get the proper time delay. Otherwise, you can raise or lower the height of the burette until you see the splash. ■