BUILD VARIABLE-SPEED MAGNETIC STIRRER

COVER STORY
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electronics IN THE chemistry LAB

UNIFORM MIXING AND STIRRING WITH ELECTRONICS

A MAGNETIC STIRRER that mixes chemical solutions smoothly, thoroughly, and without splashing is here. A photographer can use it to mix developers or hypo, and chemists, pharmacists, biologists, and other lab workers will find many uses for it.

Laboratory procedures are speeded up, or made more exact, by uniform stirring action while reagents are being added or while various ingredients are being blended. For example, during a titration, an acid or base is added to a solution until the proper pH is obtained. (See article on page 33.) Without constant stirring, it is easy to overshoot the balance point and thus waste time and materials. Other applications involve mixing or stirring toxic, volatile, or flammable solutions which must be kept stoppered and mixing dyes or colored solutions before they are analyzed in a

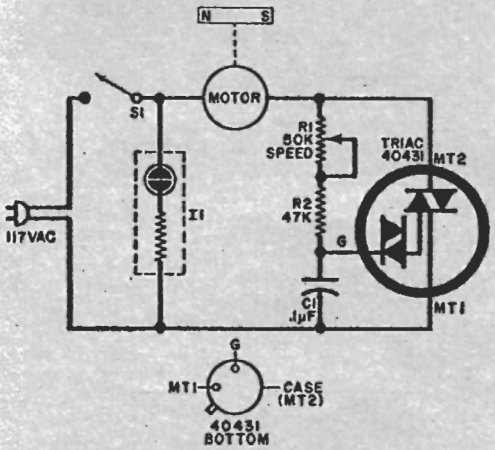

Fig. 1. Use of a triac with built-in trigger simplifies circuit design and provides smooth control of motor speed from creep to maximum.

PARTS LIST

C1—0.1-μF, 200-volt capacitor
I1—Neon indicator lamp with resistor assembly (117-volt)
Motor—Shaded-pole a.c. motor (R.M.S. M4RK or similar)
R1—50,000-ohm linear potentiometer (with attached switch)
R2—47,000-ohm, ½-watt resistor
S1—S.p.s.t. switch, part of R1
Triac—RCA type 40431 (do not substitute)
Misc.—Triac heat sink (Wakefield 254-SI or similar), aluminum posts ¼" diameter by 1½" long internally threaded for 6-32 screws (H. H. Smith 8349 or similar) two required, 6-32 binding-head screws (four required), 4-lug terminal strip, aluminum box 5" x 4" x 3", sheet of thin (1/16"-thick) cork to cover top of box, self-adhesive plastic (white), epoxy glue, grommet, rectangular driving magnet 1" x ½" x ¼", stirring magnet, wire, rubber feet (4), knob.
Note: Plastic-coated stirring magnets and retrievers are available from Arthur H. Thomas Co., Box 779, Philadelphia, Penna. The driving magnet is available from Maryland Magnet Co., 5412 Gist Ave., Baltimore, Md. 21215.

colorimeter. One non-chemical use has been suggested—mixing alcoholic drinks without a shaker!

The magnetic stirrer consists of two magnets, a low-power a.c. motor, and an electronic motor-speed control. One of the magnets (called the driver) is attached to the shaft of the motor so that it rotates in a horizontal plane as the motor revolves. The other magnet (called the stirrer) is placed within the beaker, flask, bottle, or other non-magnetic container which is placed atop the magnetic stirrer, directly over the driver magnet.

As the motor and the driver magnet rotate, the stirrer magnet attempts to keep in magnetic alignment, and in the process, constantly stirs the liquid in the container.

There are many ways to control the speed of the motor. The simplest would be to use a power rheostat in series with the motor. While this is low in cost, it generates heat which might be undesirable in some applications. A Variac could be used, but this is a bulky, relatively expensive component. By making use of a triac, however, a simple low-cost elec-

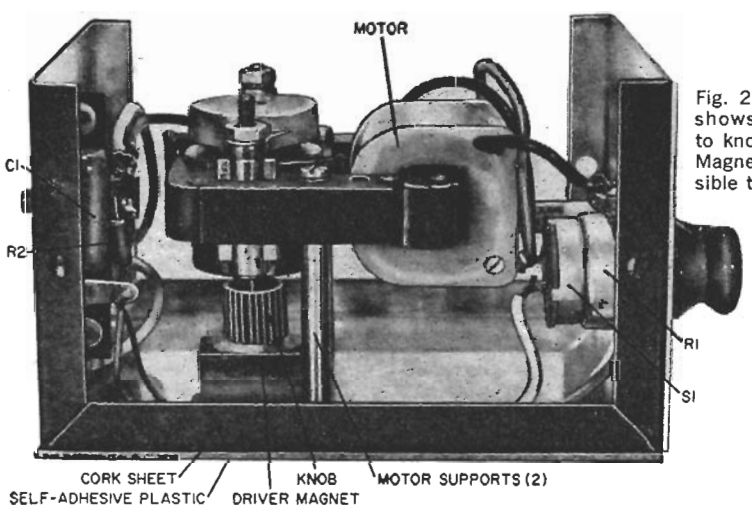

Fig. 2. View of inverted chassis shows driver magnet fixed to knob secured to motor shaft. Magnet must be as close as possible to non-magnetic frame top.

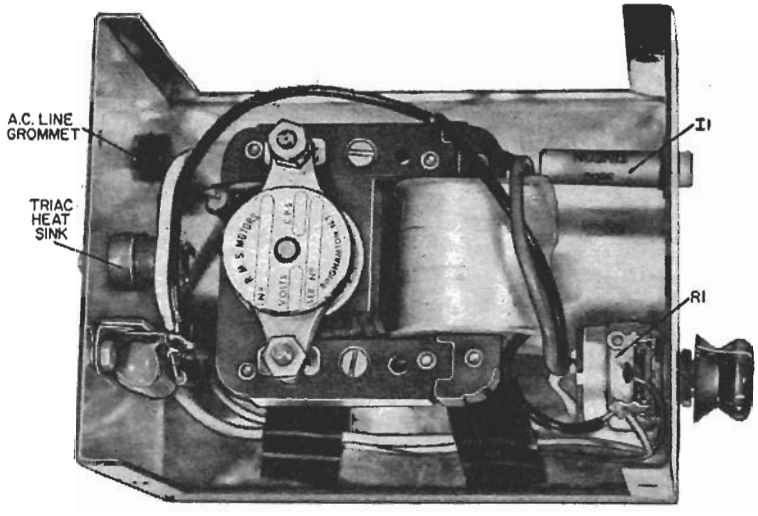

Fig. 3. When testing the magnetic stirrer with the top off, be sure not to touch any of the wiring since all of the circuit is connected to the a.c. power line. Do not use the metal chassis as a common tie point for any of the circuit.

tronic circuit such as that shown in Fig. 1 can be constructed. This circuit does not generate heat and provides for infinite variation of motor (therefore, stirring) speed. Remember that a triac is similar to an SCR, but has the advantage of being bidirectional so that only one triac is required for full-wave control. Gating of the triac and actual speed are controlled by the phase-shifting network consisting of *R1, R2,* and *C1*..

Construction. The motor and speed-control circuit are assembled in a 5″ × 4″ × 3″ aluminum box as shown in Figs. 2 and 3. To get a good fit within the close confines of the box, shorten the motor shaft by approximately ⅜″. A small knob from an old radio is used to attach the driver magnet to the motor shaft. To do this, first enlarge the hole in the knob until it is a snug fit on the motor shaft. Slide the knob on the shaft, and hold the ¼-inch thick driver magnet to the top of the knob. The distance from the top of the magnet to the laminations of the motor should be slightly less than 1½″. Using a good quality cement, preferably epoxy, secure the knob on the shaft. Then cement the driver magnet to the upper surface of the knob taking care to center it for good balance. Place the finished motor assembly to one side and allow the cement to dry.

Drill a hole in the side of the chassis to accept the triac heat-sink mounting bolt, then secure the heat sink to the chassis (see Fig. 3). Mount the four-lug terminal strip near the heat sink. Slide the triac into the heat sink and secure it in place using a flat spring. The heat sink has a built-in insulator so that no external insulating washers are needed. Mount capacitor *C2* and resistor *R2* on the terminal strip. On the other side of the chassis, drill holes to mount potentiometer *R1* and power-on indicator *I1*.

Using the two mounting holes on the motor as a guide, drill two holes in the upper surface of the chassis. Making sure that the driver magnet is secure to the knob and that the knob is firm on the motor shaft, mount the motor to the chassis using 6-32 binding-head screws and two internally threaded aluminum mounting posts ¼″ in diameter by 1½″ long. The driver magnet should be free to rotate as close to the top of the chassis as possible. Wire the circuit as shown in Fig. 1. Triac MT2 terminal is the case of the triac which is plated to accept a soldered connection. Use a low-wattage soldering iron to make this connection, so as not to damage the triac by overheating it. Pass the a.c. line through the chassis using a rubber grommet as an insulator.

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MAGNETIC STIRRER

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Clean the top outside surface of the chassis, and glue on a sheet of 1/16"-thick cork that just covers the top. The appearance of the stirrer will be enhanced by covering the cork surface with white self-adhesive plastic sheet. White is used so that the true color of the liquid being stirred is visible. Allow the cork cement to dry thoroughly before applying the plastic or wrinkles will appear.

Testing and Use. Apply power to the circuit by rotating the speed-control potentiometer (*R1*) until switch *S1* closes and power-on indicator *I1* lights. As *R1* is rotated, the motor (and driving magnet) should spin faster and faster. Make sure when you wire the potentiometer, that the slowest motor speed occurs just after *S1* turns on. Turn off the power before the next step.

Fill a small beaker with water and place it on the white upper surface of the magnetic stirrer, directly above the driver magnet. Drop in a steel paper clip or small bar magnet. It will instantly align itself with the driver magnet. Position the beaker until the paper clip or bar magnet is centered within the beaker. As *R1* is rotated and power comes on, the stirring magnet will start to rotate (with the motor), and as *R1* is rotated up its range, the stirrer will rotate faster and produce a vortex in the water.

To avoid chemical interactions with the liquid being stirred, especially with corrosive or very active solutions, it is best to use a stirring magnet having a protective plastic coating. A magnet with a teflon coating is available (see Parts List).

A very handy gadget to have is a stirring-magnet retriever. This enables you to extract the stirring magnet without putting your fingers in the solution (with possible disastrous results if the solution happens to be corrosive or toxic). You can make a retriever by sealing a small magnet within a long plastic tube, or you can purchase one at low cost (see Parts List). —30—