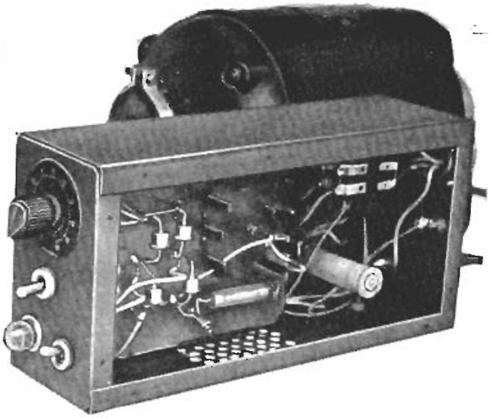
CONTROLLING DC MOTORS



SPEED CONTROL, REVERSING, AND DYNAMIC BRAKING FOR DC SHUNT MOTORS

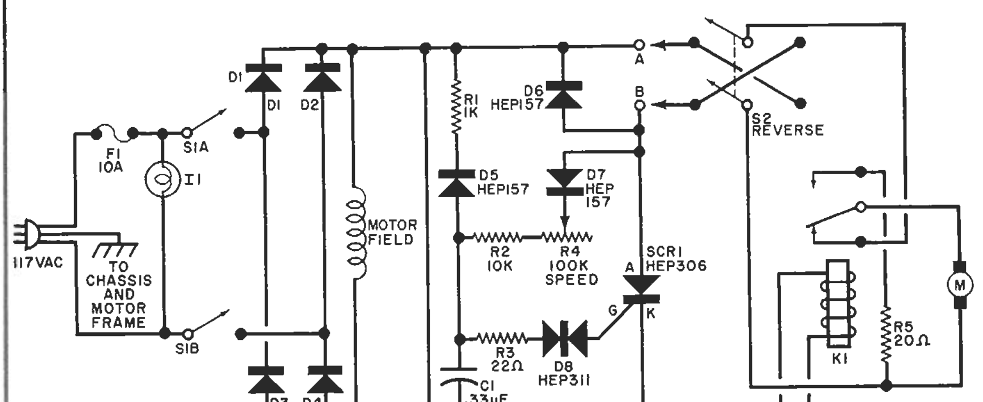
BY LAWRENCE FLEMING

ELECTRONIC speed controls for ac motors usually use an SCR or Triac in conjunction with a phase-shifting network. However, for a dc motor, another approach must be used. The circuit schematic in Fig. 1 is for a speed control that has been successfully used for some time with a ⅛-hp dc shunt motor on a metalworking lathe that requires frequent starts and stops and imposes a wide range of loads, including overloads. The full-wave circuit provides speed control, reversing, and dynamic braking.

The motor armature is in series with the anode of *SCR1*, while the field is connected across the rectified but unfiltered ac line. The SCR is fired by *D8*, a low-cost silicon bilateral trigger diode (diac) that behaves like a neon lamp except that (besides being solid state) it fires at a lower voltage.

Assume that the SCR has just fired and

Motor field gets rectified dc and armature is controlled by current through SCR.



PARTS LIST

C1—0.33-µF capacitor
D1-D4—HEP162 200V, 3A diode
D5-D7—HEP157 400V, 1A diode
D8—HEP311 bilateral trigger diode
F1—10A fuse and holder
I1—117V power-on indicator
K1—117V dc relay
R1—1000-ohm, ½-watt resistor
R2—10,000-ohm, ½-watt resistor
R3—22-ohm, ½-watt resistor
R4—100,000-ohm potentiometer
R5—20-ohm, 25-watt resistor
S1—Dpst slide or toggle switch
S2—Dpdt slide or toggle switch
S3—Spst slide or toggle switch
SCR1—HEP306 silicon controlled rectifier
Misc.—22-ohm, 1-watt resistor and 0.1-µF capacitor (optional); suitable chassis; perf board; mounting clips; three-way line cord; wire; mounting hardware; etc.

that its anode is at the same potential as the cathode and the motor is running. When the next zero point of the full-wave rectified ac is reached, the SCR is cut off. When the next positive-going cycle starts, *C1* starts to charge up through *R2*, *R4*, and *D7*. When the charge on *C1* reaches about 30 volts, *D8* breaks over and applies a short positive spike to the gate of *SCR1*. This turns on the SCR, supplying power to the motor. The cycle then repeats. Adjustment of *R4* determines the charging rate of *C1* and, hence, the firing time of *SCR1* and the motor speed.

However, if the back emf of the motor is high (at high speed), the SCR anode voltage does not rise so far and *C1* charges more slowly so that the SCR is fired later in the cycle. This produces a smaller power "burst" to the motor armature. If the back emf is low (motor slowing down), the SCR is fired earlier in the cycle, thus applying a heavier burst of power to the armature. In this way, speed regulation is attained.

Diode *D6* limits the inductive "kick-back" from the motor armature to prevent false firing of the SCR. Diode *D5* limits the charging current on *C1* to prevent undesirable transients.

Switch *S2* is connected to reverse the motor armature when this situation is required. Switch *S3* can be closed to activate *K1*, which connects a braking resistor (*R5*) across the motor armature. If the braking function is not desired, *S3*, *K1*, and *R5* can be omitted. If reversing is not required, omit *S2* and connect the motor armature directly to points A and B.

Construction. Since the entire circuit is necessarily "hot" from the ac power line, extreme care must be used in construction. The circuit may be built on perf board and mounted in a metal chassis. A three-conductor power lead must be used, with the center (green) lead connected directly to the metal chassis and to the motor frame. All connectors and cables must have appropriate UL ratings.

If the control is to be used on 117-volt permanent magnet motors, omit the field connections. The dynamic braking relay (*K1*) must have high-current contacts (20 A minimum) to handle the peak currents.

Because the recovery time between half cycles of the rectified ac is short, a fast-recovery SCR is required. Modern units will work fine, but some of the older SCR's may be too slow. This circuit is not recommended for 230-volt operation unless the recovery time of the SCR has been checked with the manufacturer's specifications.

Some semiconductor manufacturers suggest the use of an RC "snubber" circuit across an SCR to prevent spontaneous firing due to rapid rate of voltage rise due to transients. Typical values for the components to be used are 0.1 microfarads and 22 ohms connected in series between the anode and cathode of the SCR. Do not omit the resistor; a capacitor alone could raise the peak current to the damaging point.

If the motor speed does not go to zero when *R4* is at maximum resistance, increase the capacitance of *C1* by 0.1 microfarad or so. If the motor does not run until *R4* is almost at its minimum and then runs fast and erratically, suspect the SCR. If an SCR other than the one specified is used, *R3* may have to be changed to reflect the different gate sensitivity. ◈

A PROFESSIONAL TOUCH FOR SWITCH PATTERNS

The more professional looking your project, the more eye appeal it has. Even a really well-built project can look second rate if the front panel's switch position markings are irregular in size, shape, or location. However, you can convert a potentially difficult task to an easy job with the aid of a drill and some escutcheon pins, the latter available from most hardware stores. First mount the switch on the panel, being careful to properly orient it. Place a pointer or index knob on the shaft; then rotate the knob to each position, marking each location with a scriber or pencil. Locate each mark ⅛"-3/16" from the index or pointer to achieve a regular arc or circle. Remove the switch and carefully drill a hole at each location. The holes should be just small enough to provide a driving fit for the pins. Cut the pins to the panel thickness length, and carefully drive them into the holes with light taps of a hammer.

—*Gerald Larocque, WA1FRV*