THE RESTORER

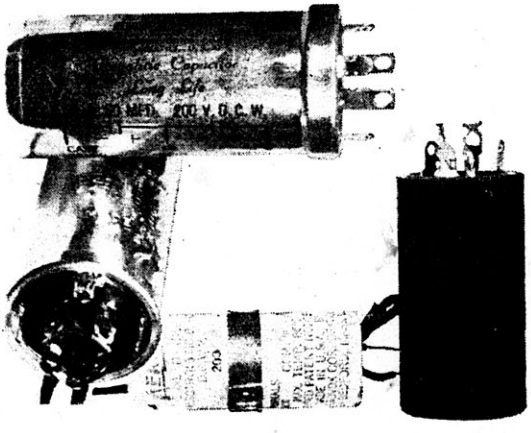
... gives your electrolytics a new lease on life

By H. E. SANDERS, W4CWK

IF YOU'RE one of the many experimenters who have large stocks of used electrolytic capacitors in storage, you know that such units often break down as soon as they are again placed in service. These capacitors aren't cheap, and you can avoid wasting them by using this efficient automatic restorer. Costing less than $16.00 to build, the device will give the most senile electrolytic in your spare parts box a new lease on life.

Inside the Electrolytic. Most electrolytic capacitors contain two sheets of thin aluminum foil which are held apart by a layer of electrolyte-impregnated paper or gauze separators and rolled into a cylinder. Each of these sheets is connected to one of the capacitor's pigtail leads, and the positive foil is coated with an insulating (dielectric) film of aluminum oxide. The thickness of this film, which is deposited on the side facing the electrolyte, determines the maximum safe working voltage of the capacitor.

When the capacitor is in service, the thickness of the dielectric film is adequately maintained by the circuit voltage. In storage, however, time and heat cause the film to deteriorate. Full voltage placed on an electrolytic that has been idle for some time will almost invariably puncture the weakened dielectric, ruining the unit.



It is possible, however, to electrically retore or "form" a deteriorated dieelectric film. One standard forming procedure has been to apply a very low voltage to the capacitor, slowly increasing it over a period of an hour or so, until the normal working voltage is reached.

How the Restorer Works. The unit described in this article has been designed to carry out the forming process described above automatically. The capac-

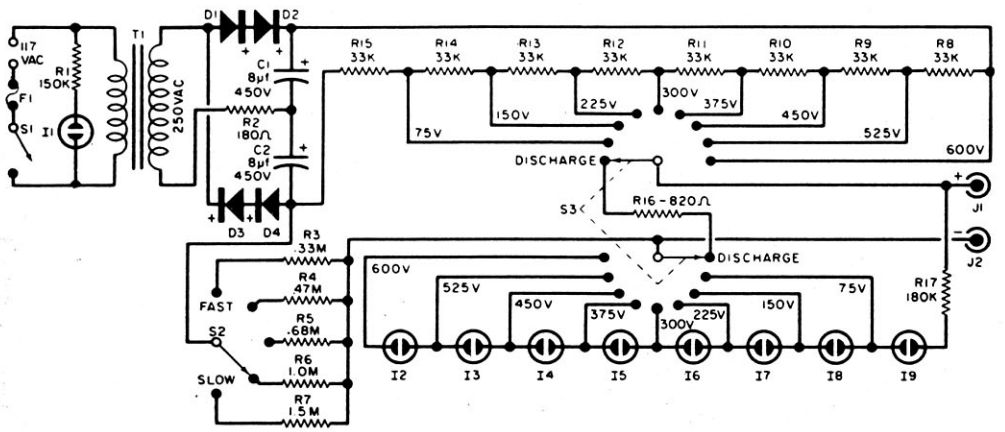
itor itself is made to adjust the speed of forming in accordance with its age and the condition of its oxide film. The progress of the forming is observed on a series of neon lamps.

Power for the automatic restorer is provided by transformer *T1* and a voltage-doubling full-wave rectifier circuit consisting of diodes *D1* - *D4* and capacitors *C1* and *C2*. Resistor *R2* protects the diodes from damage by excess current. The transformer's primary is connected to the line through a ¼-ampere fuse (*F1*) and a toggle switch (*S1*). Neon lamp *I1*, with its associated dropping resistor (*R1*), serves as an "on-off" indicator.

The approximately 700-volt d.c. output lamp is connected in series with the original one. Resistor *R17* protects the neon lamps from a current overload.

Voltage applied to the capacitor to be formed, through the series current-limiting resistor (see "Operation" section for appropriate voltage and resistance settings), divides between the two units as if they were both resistors. Since the unformed capacitor has a very low forward—or insulation—resistance, almost all the voltage is initially dropped across the resistor. The small drop across the capacitor begins the forming process, however, and as the deteriorated electrolytic film is restored, the capacitor's resistance gradually increases.

As the capacitor's resistance becomes



Schematic diagram of the "Restorer." Switch S3 taps the power supply's voltage divider, selecting the "forming" voltage, and also controls the indicating lamp circuit. Switch S2 inserts the proper current-limiting resistor.

of the power supply is dropped across a voltage divider made up of resistors *R8* through *R15*. The voltage drop across each of these resistors is on the order of 90 volts. One section of switch *S3* taps the voltage divider, determining the multiple of 90 volts which will be applied (through a series current-limiting resistor) to the capacitor being formed. The current-limiting resistor to be used (*R3*, *R4*, *R5*, *R6* or *R7*) is selected by switch *S2*.

The other section of *S3* controls the automatic indicator circuit. In the lowest-voltage position of this switch, neon lamp *I9* is connected across the capacitor being formed. For each successively higher position of *S3*, an additional neon

greater, a larger proportion of the voltage is dropped across it. When the voltage across the capacitor has risen to the value at which *S3* is set, the lamp (or lamps) associated with that position of *S3* will fire—indicating that the forming is complete. Switch *S3* is calibrated in 75-volt intervals because the NE-2 neon lamps used at *I2* - *I9* fire at 75 volts each.

Before disconnecting the restored electrolytic, *S3* is turned to the "discharge" position. In this way the capacitor, its charge drained through *R16*, is made safe to handle.

Construction Details. The restorer is built into an 8" x 6" x 3½" aluminum utility box equipped with an "L"-shaped

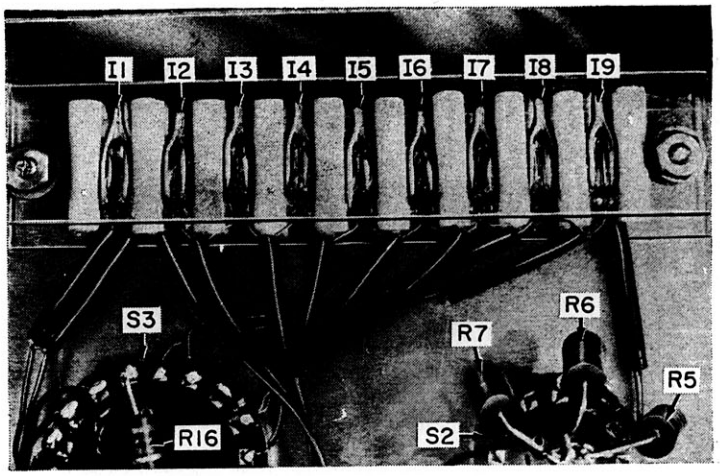
mounting shelf. The shelf is formed from a 5½" x 4¼" piece of heavy aluminum; make a 90° bend along the long dimension, 1" in from one end. The resulting lip is used to bolt the shelf into the utility box.

Mount transformer *T1* on one side of the shelf and the remainder of the power supply components (*R2, R8 - R15, D1 - D4, C1* and *C2*) on the other. To facilitate construction, the resistors are wired onto a terminal board; drill two 3/16" ventilation holes in the board below each resistor. The diodes can be mounted on a long terminal strip.

When installing the shelf, position it so that transformer *T1* is inverted, with its weight resting on the bottom of the utility box. Banana plugs *J1* and *J2*, switches *S1, S2* and *S3*, and the indicating lamps are mounted directly on the box. Before making the front-panel opening for the lamps, construct the lamp holder as described below.

The author made the lamp holder by bending a 2½" x 5½" piece of plexiglass (along its long dimension) into a "U" shape. You can get the same effect, however, by bolting together two 1" x 5½" plexiglass strips, spacing them about ¼" apart. One of the strips, of course, need not be transparent—so you can substitute wood, metal, or any other material you happen to have handy.

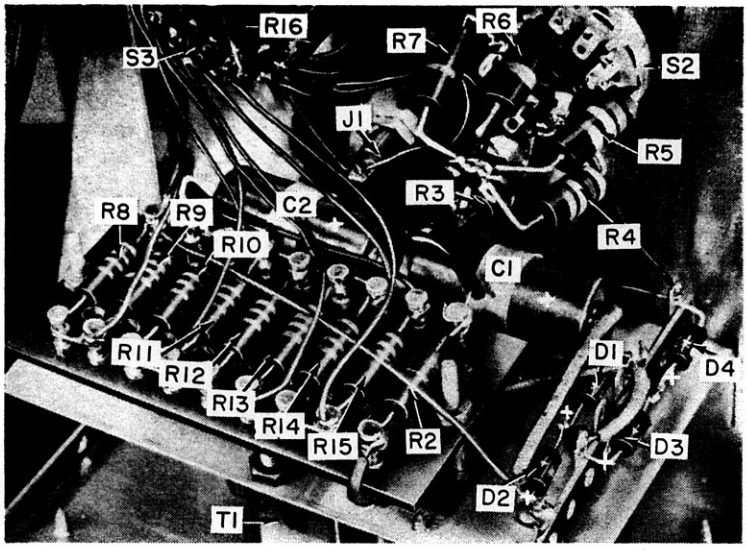
The "on-off" indicator lamp (*I1*), as well as voltage indicator lamps *I2 - I9*, are inserted between the strips. Use only new NE-2 lamps; old ones may



Details of the Restorer's lamp holder can be seen clearly in this photo; the author made his holder from a single strip of plexiglass. Use of quick-drying cement keeps lamps and rolled-paper separators in place.

PARTS LIST

C1, C2—8-μf., 450-volt electrolytic capacitor
D1, D2, D3, D4—400-PIV, 200-ma. silicon rectifier (Sarkes-Tarzian 2F-4 or equivalent)
F1—¼-ampere, 3AG fuse
I1 - I9—Neon lamp (General Electric NE-2 or equivalent)
J1, J2—Banana jack (one red, one black)
R1—150,000-ohm, ½-watt resistor
R2—180-ohm, 1-watt resistor
R3—0.33 megohm
R4—0.47 megohm
R5—0.68 megohm
R6—1.0 megohms
R7—1.5 megohms
(all 2-watt resistors)
R8 - R15—33,000-ohm, 1-watt resistor
R16—820-ohm, 1-watt resistor
R17—180,000-ohm, ½-watt resistor
S1—S.p.s.t. toggle switch
S2—1-pole, 5-position, non-shorting rotary switch
S3—2-pole, 9-position, non-shorting rotary switch
T1—Power transformer; primary, 117 volts; secondary, 250 volts @ 25 ma. (Knight 62 G 008 with filament winding and plate winding CT unused, or equivalent)
1—8" x 6" x 3½" aluminum utility box (Bud CU-3009A or equivalent)
Misc.—Sheet aluminum for shelf, line cord and plug, test leads, terminal board and strips, plexiglass strips, cement, hardware, fuse clip, wire, etc.



The Restorer's "L"-shaped mounting shelf is fastened to the rear of the front panel. Transformer T1, though fastened to the shelf, is really supported by the bottom of the box.

have drawn heavy currents in prior usage, causing them to fire at a voltage which is too low. The NE-2's are separated with ¼"-diameter x 1"-long cylinders made of rolled paper, and both the lamps and cylinders are held in place with quick-drying cement.

When the cement has dried, measure the assembly to determine the proper dimensions for the front-panel opening. The same screws that hold the unit together may be used to fasten it to the front panel.

Operation. Plug a set of test prods into *J1* and *J2*, and clip them to the capacitor to be formed—being sure to observe the polarity. If the polarity is accidentally reversed, no harm will come to the capacitor but forming will not occur.

Switch *S2* selects one of the five possible series current-limiting resistors. Faster forming takes place with the lower resistances, but you'll get a higher quality capacitor with the higher ones. Some high-capacitance units, however, will never complete forming at the higher resistance settings. A little experience will soon show you how to use *S2*, but in general you should stick to the 1.0-megohm setting unless you're in a hurry or the capacitance is too high.

Switch *S3* simply selects the d.c. working voltage marked on the capacitor's shell. All possible voltages, of course, are not available, and it may occasionally be necessary to select a slightly higher one. A 20% or 30% excess voltage is not harmful.

After setting switches *S2* and *S3* to their proper positions, flick on power switch *S1* and await results. Relatively new capacitors will form in a few minutes; very old ones may take several hours. When the forming is complete, the appropriate indicator lamps will light.

It's not necessary to disconnect the capacitor from the "former" as soon as the lamps light. The voltage across the restored unit will soon drop to a lower level and remain there, even if you wait all day. When you do disconnect it, though, remember to drain its charge first by turning *S3* to the "discharge" position.

Two electrolytics of the same working voltage may be formed at the same time by connecting them in parallel across *J1* and *J2*. A 330,000-ohm, 1-watt resistor should be placed in series with each one, and the .33-ohm position of *S2* should be used. Under these conditions, one of the capacitors should complete forming before the other. When the indicating lamps light, therefore, disconnect the capacitors and reconnect them individually in the normal way. The unit which requires more forming will not relight the indicators. —30—