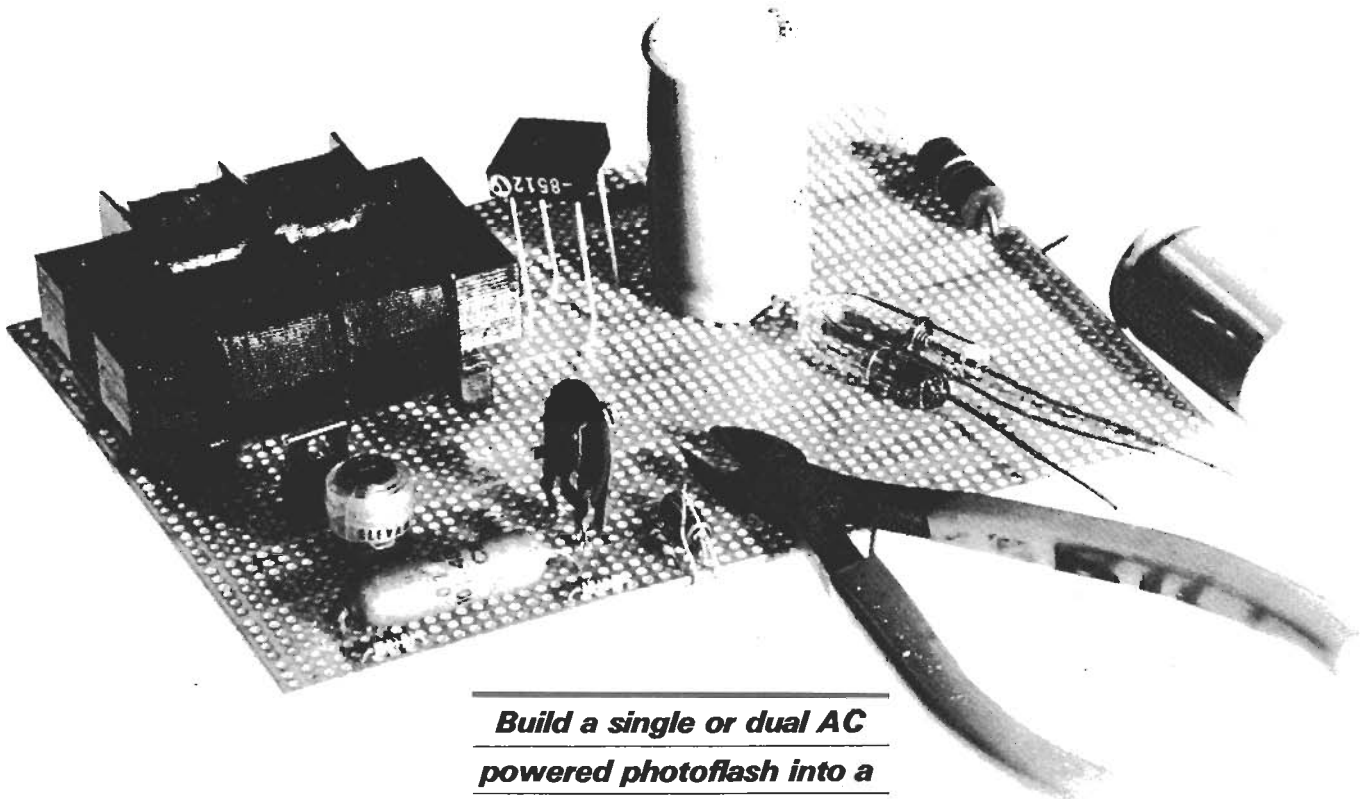
Photoflash Project



Build a single or dual AC powered photoflash into a softbox or direct reflector; includes design formulas.

By Bill Markwick

IF YOU do any studio photography, or you'd like to have a larger flash unit that will fill a room with soft light, or you'd just like to tinker with xenon tubes, here's the Electronics Today Photoflash. Most of the parts are available from Radio Shack, and you can substitute without too much trouble.

However, because of the variables involved, I'd like to point out that this project is for the determined tinkerer. The construction details and mounting methods are left largely to you.

You can use one or more flashtubes, each with a maximum power of 50 watt/seconds (joules). The tube (or tubes) can be mounted in a homemade softbox, or fit into a reflector or other lamp, or just used bare-bulb for a floodlight effect. The recycle time at full power is about seven seconds, limited to avoid overheating the low-cost flashtubes.

Feel free to tinker with the various components. About all that can go wrong is that you overheat and blow the $4.95 flashtube, or take a poke from the 300V supply (painful but not likely to be lethal).

Oh, speaking of the things going wrong — (*'here it comes... he's gonna tell us we can't get some of the parts.'*) you may not be able to get some of the parts. At least not at the corner Radio Shack. At the time of planning this project, RS stocked trigger coils, photoflash capacitors, and flash tubes. As we went to press, the coil and capacitor had been discontinued, but there may still be stock available on the shelves. If not, there are substitutions listed for you, but they may mean top dollar. The RS versions were light-duty, very inexpensive, and suitable for tinkering. The subs are a bit more robust and rather more expensive. However — onward.

Theory

The flashtube consists of a glass tube with electrodes at each end and a filling of xenon gas. A third small electrode is attached to the outside of the tube. The internal electrodes are connected across a large capacitor charged to a high voltage (the tube is normally non-conductive), and the external electrode is attached to the output of a very high voltage trigger coil.

When the main reservoir capacitor is fully charged and you're ready to go, a smaller charged capacitor is switched across the primary of the trigger transformer, producing a decaying pulse with a maximum amplitude of about 4kV. This high voltage pulse on the external electrode ionizes the xenon gas inside the flashtube and makes it conductive; the effect is rather like triggering an SCR. The sudden low resistance of the flashtube discharges the main capacitor in about a millisecond, and the sudden rush of high current through the gas produces a burst of light. The light has an odd, discontinuous spectrum, rather spiky, but the eye and the film see it as pretty much the same thing as daylight. Its colour temperature may not be tightly specified

200 VOLTS		225 VOLTS		250 VOLTS	
CAP. = 100	W/S = 2	CAP. = 100	W/S = 2	CAP. = 100	W/S = 3
CAP. = 200	W/S = 4	CAP. = 200	W/S = 5	CAP. = 200	W/S = 6
CAP. = 300	W/S = 6	CAP. = 300	W/S = 7	CAP. = 300	W/S = 9
CAP. = 400	W/S = 8	CAP. = 400	W/S = 10	CAP. = 400	W/S = 12
CAP. = 500	W/S = 10	CAP. = 500	W/S = 12	CAP. = 500	W/S = 15
CAP. = 600	W/S = 12	CAP. = 600	W/S = 15	CAP. = 600	W/S = 18
CAP. = 700	W/S = 14	CAP. = 700	W/S = 17	CAP. = 700	W/S = 21
CAP. = 800	W/S = 16	CAP. = 800	W/S = 20	CAP. = 800	W/S = 25
CAP. = 900	W/S = 18	CAP. = 900	W/S = 22	CAP. = 900	W/S = 28
CAP. = 1000	W/S = 20	CAP. = 1000	W/S = 25	CAP. = 1000	W/S = 31
275 VOLTS		**300 VOLTS**		**325 VOLTS**	
CAP. = 100	W/S = 3	CAP. = 100	W/S = 4	CAP. = 100	W/S = 5
CAP. = 200	W/S = 7	CAP. = 200	W/S = 9	CAP. = 200	W/S = 10
CAP. = 300	W/S = 11	CAP. = 300	W/S = 13	CAP. = 300	W/S = 15
CAP. = 400	W/S = 15	CAP. = 400	W/S = 18	CAP. = 400	W/S = 21
CAP. = 500	W/S = 18	CAP. = 500	W/S = 22	CAP. = 500	W/S = 26
CAP. = 600	W/S = 22	CAP. = 600	W/S = 27	CAP. = 600	W/S = 31
CAP. = 700	W/S = 26	CAP. = 700	W/S = 31	CAP. = 700	W/S = 36
CAP. = 800	W/S = 30	CAP. = 800	W/S = 36	CAP. = 800	W/S = 42
CAP. = 900	W/S = 34	CAP. = 900	W/S = 40	CAP. = 900	W/S = 47
CAP. = 1000	W/S = 37	CAP. = 1000	W/S = 45	CAP. = 1000	W/S = 52

Watt/second values for various capacitors and operating voltages.

on the hobbyist tubes, but it will be in the neighbourhood of 5500 degrees K, matching nicely to daylight colour films.

Once the voltage of the main capacitor drops to 50V or so, the tube becomes non-conductive once again and the capacitor begins charging for the next blast.

The Flashtube

The flashtube we used, Radio Shack number 272-1145, is ideal for this application because it's inexpensive, runs at 300V, and puts out 50 watt/seconds of power if you don't overdo it (the specs say maximum 4 flashes per minute at 50W/S). It was still in stock the last time we checked.

If you want to try others, the FT152A from Canadian General Electric is a good one, with its 125W/S rating. If you keep to the 50W/S figure, you can fire it off continuously every five seconds or so. Most camera stores that deal with professional photographers can order it for you, but it takes a long time to get one if it's not in stock, and it's over $50. The CGE FT118 and FT151 are more common, but I hesitate to recommend them because they prefer to run from 400V.

Flashtubes will only operate over a narrow range of voltages. The RS, for instance, must be run between 200 and 300V. If you go below the minimum, you'll get erratic triggering or none at all, and if you exceed the maximum, the tube may fire on its own as the gas breaks over and becomes conductive.

There's yet another flashtube that used to be available from Radio Shack: the Jumbo Xenon Strobe, number 272-1147. If you can still get this one (it's unlikely), it's a good sub. The specs on its packaging are wrong, though, and your RS dealer may not want to talk about it since its deletion.

If you've managed to locate a source of other tubes, make sure the tube can: put out 50W/S per flash at a rate of four flashes per minute, run at 300V, trigger from 4kV, and dissipate 12 watts or more.

The dissipation, incidentally, is found by multiplying the energy per flash (explained later) times the number of flashes per second:

Power = W/S x flashes/sec

Our flash is held to a recycle time of about seven seconds to give the tube a chance to cool. You can fire it off as fast as the capacitor recharges, as long as you don't exceed four flashes per minute total. The above formula works out to a dissipation of 3.3 watts at 50W/S and a F/S rate of .067 (four flashes/min). You can fire four flashes in rapid sequence, but then let it cool for a while.

A word of caution: a General Electric application note points out that tubes can be damaged in one flash by an overload, and we found out the hard way that they're right. The tube life (normally 8,000 flashes at full power for the RS) will be shortened drastically if it flashes at all. Don't exceed the maximum watt-second rating if you can avoid it.

The Capacitor

The capacitor determines the stored energy for the flash for a given voltage. The formula is:

$W/S = CV^2/2$ where C is in farads and V is in volts. The energy varies directly with the capacitance and directly with the square of the voltage; small changes in voltages make a big difference.

However, should you like a flash with different settings, the best way to do it is usually to change capacitors, because the tube may not take kindly to having its voltage changed; too low and you get erratic firing, too high and you shorten the life or make it fire from breakover. If you're interested in using the variable-voltage method, the 272-1145 is supposed to run as low as 200V; this gives a one-stop variation over the range from 200 to 300V.

The capacitors we used were the Radio Shack 272-1148, 500u at 330V, two in parallel for 1000u. If you can't find these, you can use any large electrolytic, or parallel several together, as long as the voltage ratings are 330V or more (more is better). Surplus stores are a good place to look, or you can go for computer-grade

from any major electronics supplier.

In another more powerful flash that I built for use around here, I used surplus-store capacitors, 1000u at 450V. They only cost $5 each, but they're the size of a 28 oz. can of tomatoes. Because they were a good deal, I built a separate power supply so I could run the tubes in various softboxes, reflectors, spotlights, etc.

You could also invest in some real heavy-duty proper photoflash capacitors. The Mallory EAF102 X 36 OU4C3PL is a 1000u, 360V unit available on special order from Mallory dealers. These are high quality professional units with very low internal resistance, but a bit expensive. Since photoflash capacitors are a bit rare, you might have to contact the makers: Emhart Canada Ltd., Mallory Components Division, 222 Dixon Road, Weston, Ontario, M9P 2M2, (416) 244-4239.

Resist the temptation to put capacitors in series; there's the problem of dividing up the operating voltage properly between them.

If you'd like to have a variable-power flash, you can switch in different capacitors. Each doubling or halving of capacitance represents one stop, photographically speaking. The listing shows the output in watt-seconds for various combinations of voltages and capacitances.

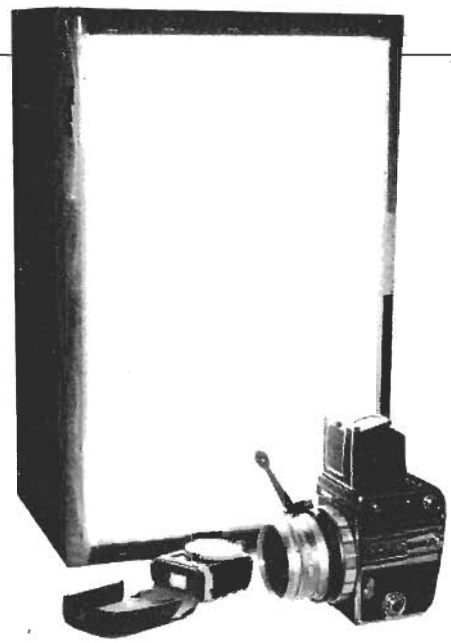
If you're building a multiple unit, remember that *each tube requires its own capacitor.* If you try to run several tubes from a single capacitor bank, the tube with the lowest resistance gets most of the power. It could be high enough to damage it. I've only used one trigger coil for simplicity, but for more than two tubes, you should add another for each pair of tubes.

You can add lots more than two tubes if you want, though the recycle time will get longer.

The Resistors

The purpose of the series resistor (the 2k2) is twofold: first, and most important, it isolates the tube from the transformer to make sure that the tube cuts off and doesn't keep glowing when the capacitor is discharged; second, it increases the recycle time to give the tube a chance to cool. The value of 2k2 was arbitrarily chosen for a reasonable recycle time; you can substitute if you like. By the way, these 1W resistors will get very hot during charging; because it's for such a short time you can get away with it. If you prefer, you can use 2W to 5W units.

There should be an isolating series resistor for *each* flashtube used. The minimum value for the resistor is: R = T/7C, where T is the time between flashes in seconds and C is the storage capacitor in farads. For longer charge times, the formula for the time in seconds is: T = 5RC. It may turn out to be slightly longer or shorter than calculated because the R should include the effective resistance of the transformer secondary, and also, electrolytic capacitors have very wide tolerance ranges.



The well-worn ET mini softbox, about 1 x 1 x 2 feet. A sheet of glass protects the double layer of frosted film.

The 47k shunt resistors are important to prevent the output voltage from rising; we used a 229-series transformer because it was small and inexpensive, but its 230V output means that the rectified and filtered output can rise to well over 330V, exceeding the capacitor's voltage rating. The 47k keeps the power supply under load at all times. If you're using more than two tubes, you don't need extra 47k resistors as long as there's at least one in the circuit.

The Transformers

Anything will do for a power transformer as long as the DC output doesn't exceed the capacitor voltage ratings. The 229B230 I used has a 50mA, 230V secondary, adequate for fast recharge even with multiple tubes. You can also use the 229A230, a 25mA unit, or any other suitable transformer. The AC voltage from the secondary is: VAC = VDC x .707. Just work backwards from the desired DC, or if you already have a junkbox full of transformers, the DC will be: VDC = VAC x 1.414.

Measure the AC secondary voltage with no load connected; if we ignore the 47ks for the moment, the capacitor voltage will rise to the peak of the *unloaded* AC voltage. Remember that commercial specs for power transformers are usually full-load values. You may have to adjust the shunt resistor if the voltage exceeds your capacitor's rating. The current rating isn't too important; the lower it is, the longer the recycle time, and vice versa.

The trigger coil is designed for Class I triggering, which is what most photoflas' tubes use. This requires an output pulse o 4kV, an energy of at least 3.2 millijoules (a millijoule is 1/1000 of a watt/second), and a duration of at least 50uS. The RS 272-1146 coil specs want a primary input of 300V from a .022u capacitor; this is only 1mJ. I've increased the trigger capacitor to .1u, giving 4.5mJ, enough to fire two tubes. If you get occasional misfiring with two tubes, solder another .1u 400V across the first.

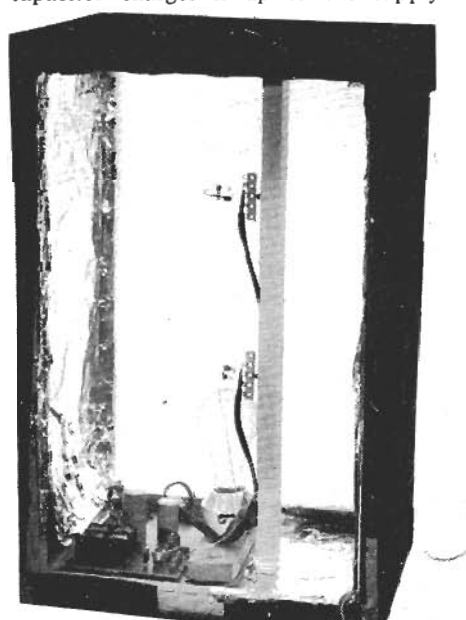
If you can't find this coil, Hammond makes a photoflash trigger, the 616B, a Class I type. It's a heavy-duty unit that'll cost you about $20, though it will last forever. It prefers 120V on the capacitor instead of 300V. Not to worry; put a 1M resistor across the .1u trigger capacitor.

Occasionally you'll come across tubes that require a high-energy trigger, such as the CGE FT151. These use Class II triggering: 10kV and 20mJ. Hammond makes the 616E Class II trigger; it will also work with the Radio Shack tubes, though I've found that the 10kV pulse will break through normal wire insulation. You'll need sleeving or HV wire for the trigger leads should you use Class II.

The Firing Circuit

You could use the shutter contacts on your camera to directly connect the trigger capacitor across the coil, but this mean slight sparking of the contacts and 300 on your leads. I've used an SCR, the RS 276-1020 (6A, 400V), to reduce the trigger current to a few milliamps and the operating voltage to about 25V. The SCR can be almost any unit with a current rating of 1A or more and a voltage rating of 400V or more (2N3529, C6D, S401E, etc.). It doesn't need heatsinking because it doesn't dissipate any significant power.

The 1M resistor in series with the capacitor charges it up to the supply



The interior of the softbox, showing the perfboard, 150W lamp and two 50W/S tubes.

ltage within 1/2 second. When the SCR triggered, it effectively connects the coil primary across the capacitor, discharging it rapidly to produce the required HV pulse.

The 1uF capacitor is used to make sure that a good strong initial current is applied to the gate for reliable triggering. This can be any value you have on hand from 1u to 10u, with a minimum voltage rating of 35V.

Occasionally SCRs can be triggered by static or noise on the shutter leads. If this happens, try connecting a small capacitor from the gate to the cathode; a .001u is a good starting point and should short-circuit noise voltages.

Other Components

A neon light (with or without an internal resistor) is included to let you know when the flash is charged. Neons won't come on until they reach a specified firing voltage; because of variations in this voltage I've included a trim pot. You'll find that neon firing is "soft"; as the voltage rises, the tube lights long before it reaches maximum brightness, especially if the neon has an internal current-limiting resistor. For this reason, the capacitor continues charging after the lamp has lit, even if you're finicky about setting the trim pot. Refer to the watt-second listing and use a DC voltmeter on the power supply to see w much the power will increase after e lamp lights. You might find another 10 or 15 percent is added after the neon triggers. I've never found it makes much difference photographically.

If you're using a softbox, you'll probably want to add a modelling light; otherwise you're using it blindly as far as shadowing goes. I used a 150W kitchen bulb; it isn't much light, but it gives you an idea of the effect.

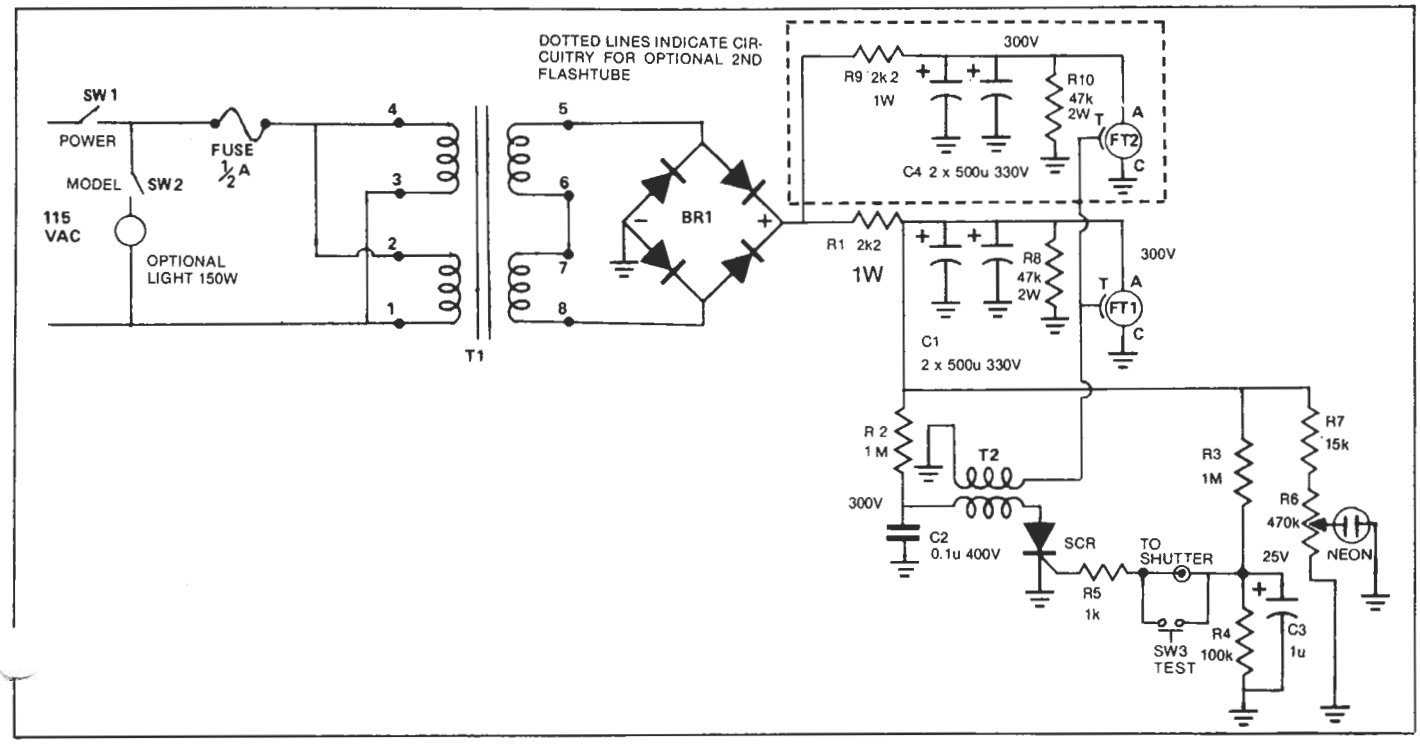
The rectifier bridge is a readily available VS447; you can use any other 400V bridge, or use four 400V diodes such as the 1N4004.

Construction

I used perfboard for the components because it's a small circuit. You could use Veroboard or make your own PCB. There isn't anything critical about the circuit; use common sense when dealing with the 300V wiring. A 1000u at 300V discharging through your pinkies is *very* startling. The 4kV out of the trigger coil is harmless but unnerving to touch.

The softbox can be made from almost anything. I used 1 x 2 spruce covered in fibreboard and fastened together with an electric glue gun and a few nails. The inside is lined with aluminum foil to minimize light absorption, and the front is covered with two layers of drafting film ("mylar"). Any translucent white film will do, even paper. The circuit is fastened to the wood frame, and the tubes are mounted on terminal

Two alternate mounting methods that we used; a hardware store clip-on reflector with its electrical socket replaced by a flashtube, and a miniature focusing spotlight with its lid up.



The schematic of the photoflash, single or dual tube. See the text for parts substitutions.

PARTS LIST

Resistors ..... 1/2W 5% unless noted
R1,9 ..... 2k2, 1W
R2,3 ..... 1M
R4 ..... 100k
R5 ..... 1k
R6 ..... 470k trimpot
R7 ..... 15k
R8,10 ..... 47k, 2 to 3W

Capacitors
C1, 4 ..... 2 x 500uF, 330V
C2 ..... 0.1u, 400V
C3 ..... 1u electro., 35-63V

Other (see text for substitutions)
SW1,2 ..... SPST power toggle switch
SW3 ..... SPST push-to-make pushbutton
Neon ..... any neon pilot light
FT1,2 ..... Radio Shack 272-1145
T1 ..... Hammond 229B230
T2 ..... Class I trigger coil, Radio Shack 272-1146
BR1 ..... VS447 or equiv
SCR ..... Radio Shack 276-1020

Misc
Flash cord with sync connector, 1/2 amp pigtail fuse, socket for domestic lightbulb, 150W bulb, perfboard, etc.

strips (RS 274-688) fastened to a crossbar with wood screws.

We couldn't locate a chassis-mount sync connector in time, so I bought a short flash extender cord from the local camera store and cut one end off. It hangs out of the box, a bit inelegant, but it works.

If you go for the clip-on reflector, you might want to locate an old or new tube socket to hold the flashtube. Strip out the regular bulb socket from the insides of the unit and you'll find that a tube socket fits in nicely. Pull out the tube pins, solder the wire leads to the tube, and epoxy everything in place. To avoid trying to run 4kV up the cable, glue the trigger coil in behind the tube socket; the leads from the SCR/capacitor can be light duty paired wire. The leads to the flashtube should be fairly heavy (at least 18 ga.), particularly if the extension cable is lengthy.

Also shown in the photo is a focussing spotlight we found at a store-window decoration supplier. It originally had a 150W miniature bulb on a platform that slid for focussing. I removed the original wiring and epoxied a tube socket and coil in its place, giving us a photoflash that focuses from a tiny spot to a wide flood. Next I have to add a small modelling lamp, probably a 115VAC halogen projector lamp.

Use

If you make the softbox version, you'll have the equipment to make first-rate still photos. The worst way to do a product shot or portrait is on-camera direct flash. Despite all the hoopla about intelligent flashes and so on, there's no getting away from the fact that on-camera flash wipes out surface detail and depth by flooding light along the camera axis (detail and depth are created by shadows). Put the flash above and to the side, and you'll create a much better illusion of 3-D, soften the shadows with the softbox and you're on your way to super quality.

The exposure is something of a guess because of so many variables: power, tubes, method of mounting, etc. However, a starting point for the softbox is a guide number of 60 with ISO 100 and two 50W/S tubes; this will get you started. Divide the distance in feet into 60 to get the aperture. Make a series of test shots at various apertures to find the optimum. I know it isn't much of a guide number, even when you compare it to tiny portables, but a lot of light is lost in the softbox itself; you're also covering a much larger area than the little portables.

The bare-bulb effect is the easiest: just mount the tube or tubes in a tube socket or utility box or what have you. The light obtained is a combination of direct and bounce, and it's ideal for photos of entire rooms. Whatever mounting method you use, put sleeving on any exposed tube leads to prevent shocks.

If the tube (or tubes) are in a clip-on reflector, you'll get the equivalent of a powerful floodlight. The guide number for a single tube at 50W/S and ISO 100 is 100.

The flash duration can only be guessed at because I don't have proper specs for the tubes, something typical of a large number of Radio Shack components. The duration depends on the capacitance, the voltage at which the tube stops conducting, and the effective resistance of the tube during conduction. A typical value for small tubes is 1 millisecond, and even if it strays considerably from this, the flash is short enough for sharp photos even if the subject is moving. Perhaps one of our readers might accept the challenge of designing a flash-duration measurement method. Photograph a fan blade rotating at a known speed? Use a photocell in place of the film? If you come up with a working method, let us know and we'll mention it in a future issue. ■