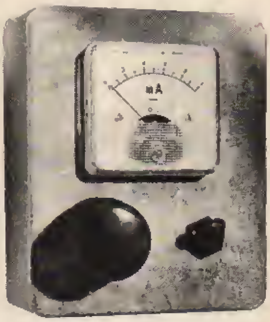
TRIAC LAMP REGULATOR

By J. N. WATT



SUITABLE FOR PHOTOGRAPHIC COLOUR PROCESSING CONTROL

COLOUR printing is becoming more and more popular with amateur photographers. In this process it is vital that the enlarger lamp output remains constant despite mains voltage fluctuations, for not only will the density of prints be affected by any changes, but colour balance will be altered also.

Since correct colour balance is probably the most difficult characteristic to achieve in printing, it is worth while to go to some trouble to eliminate as many variables as possible. A constant light output from the enlarger lamp will certainly go a long way towards achieving this.

In black and white printing also, a stable light level will assist in producing consistent results.

CONSTANT VOLTAGE

Probably the best method of ensuring a constant level of illumination is to run the enlarger from a constant voltage transformer—indeed, this is done in commercial colour printing laboratories. However, the cost of such a transformer could approach that of the enlarger itself.

The alternatives are either to work in the darkroom at times when mains voltage fluctuations are at a minimum, or use a resistive dropper in series with the enlarger lamp.

The resistance of the dropper is adjusted to give a constant voltage across the lamp. Since this voltage can be no higher than the lowest mains voltage experienced, a lamp of a lower rating is sometimes used, although as enlarger lamps are normally arranged to be overrun in any case, the light loss is often acceptable.

The disadvantages of a system using such a resistor are fairly obvious. It is wasteful, since excess voltage is spent as heat, and a large unwieldy resistor is required to achieve this dissipation.

SOLID STATE CONTROL

The use of some kind of solid state semi conductor device seems to be called for, and it is actually quite easy to construct a lamp dimmer control using a thyristor and a bridge rectifier. This would remove the objections of large bulk and the need for the dissipation of heat.

A further improvement is the use of a triac with a saving in components, for no bridge rectifier is then needed, to obtain full wave control.

TRIAC

Many readers are no doubt familiar with the operation of the thyristor in control applications. The triac operates in principle like the thyristor. When triggered into the conducting state by a suitable gate signal it will remain so until the current through the device is reduced to less than the holding current.

It is different however, in that it can conduct in either direction on application of a positive or negative gate signal. Having three electrodes and bilateral a.c. operation provides the derivative, triac, from *tri*ode, *a.c.*

In Fig. 1 is given the circuit of the controller. The symbol for the triac is that of two thyristors in inverse parallel. Because of its bi-directional properties MT1 and MT2 are used in place of anode and cathode, MT being the bi-directional anode, or more commonly termed "main terminal".

Integral to this particular device is a diac, or bi-directional trigger diode. The symbol for this logically enough is two diodes in inverse parallel. The input to the diac is the gate input which controls the triac in phase with the load current.

TRIGGER INPUT

The capacitor and resistor network preceding the triac gate make up a phase control circuit. By varying VR1 the phase angle at which conduction begins may be varied. The π arrangement of C4, R6 and C5 in combination with VR1, forms a circuit with a double time constant which provides smooth control from low to full power.

When the voltage on the gate capacitor exceeds the breakover voltage on the trigger diode this conducts and switches the triac on for periods in the positive and negative half cycles. The length of these periods is

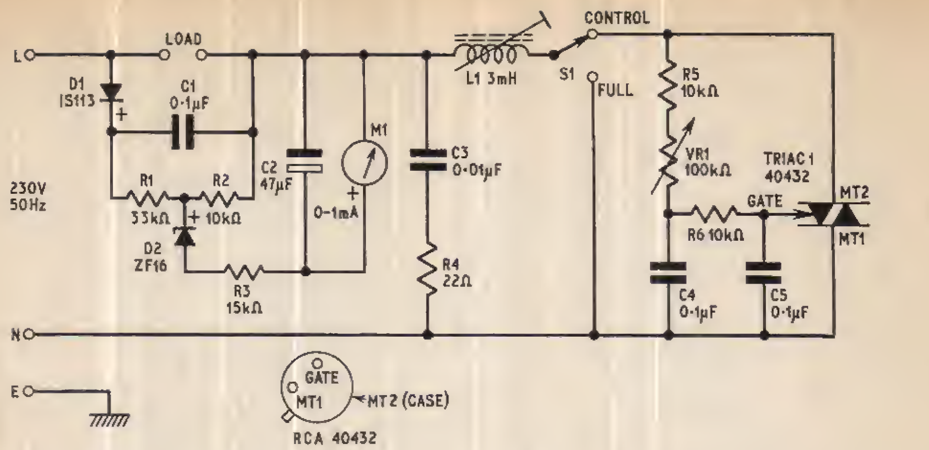


Fig. 1. Complete circuit of the triac lamp controller with meter circuit and interference suppression

governed by the setting of VR1, the cumulative effect of which is to permit the power to the load to be varied.

Typical load voltage waveforms for early triggering in the cycle are given in Fig. 2. Here, the power available would be near maximum.

INTERFERENCE SUPPRESSION

Improvements in the manufacture of s.c.r.'s and triacs has resulted in faster turn on times. In the case of the 40432 triac used, this time is about 2 to 3 microseconds. Pulses with such short rise times are a source of radio frequency interference and some form of suppression is necessary.

In the circuit, L1 and C3 prevent interference being fed back via the mains leads. Radiated interference is kept to a minimum by mounting the components in a metal box, then earthing this.

In practical tests carried out with a transistor radio, interference was only apparent with the radio held about a foot away from the completed controller.

The inductor L1 is made up by pile winding about 400 turns of 26 s.w.g. enamelled copper wire on a small Aladdin coil former complete with iron dust core.

Since this coil appears in series with the load there is a power handling limit of 200 watts.

VOLTAGE MONITORING

In order to be of value in enlarger lamp controlling, an accurate means must be provided for measuring the voltage applied to the lamp. Unfortunately, an ordinary moving coil voltmeter is calibrated for r.m.s. sine wave voltages, which is not much use for measuring the distorted waveshapes as given in Fig. 2.

A "true" r.m.s. voltmeter would indicate correctly since lamp light output is strictly dependent on applied r.m.s. voltage; but such r.m.s. meters are expensive and not easy to obtain.

METER CIRCUIT

The meter circuit, which is in parallel with the load terminals in Fig. 1, was developed to overcome this problem and found to be not only accurate in use but to have an advantage over r.m.s. meters for the range of voltage employed.

The diode D1 permits only positive going half cycles to charge C1.

R1 and R2 prevent the circuit from becoming a peak reading voltmeter and in combination with C1 effect a compromise between peak and average voltages to indicate true r.m.s. lamp output over the range 190 to 250 volts.

Since only this limited range is required, advantage is taken of the technique of expanding the meter scale with the Zener diode D2. The capacitor C2 removes the 50Hz ripple and gives meter needle stability.

As the object of the meter is to maintain a steady light output irrespective of mains fluctuation, calibration is unnecessary as the only requirement is an arbitrary constant meter setting.

CONSTRUCTION

All of the components of the controller fit inside a 4½in by 3½in by 2¼in die cast box. This provides at once, a robust housing as well as electrical screening. Reference to Fig. 3 gives the complete prototype wiring

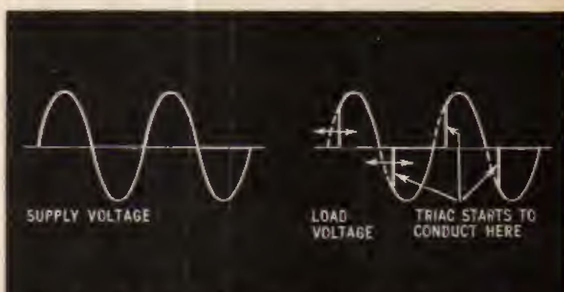


Fig. 2. Supply and load waveforms indicating triac switch on points

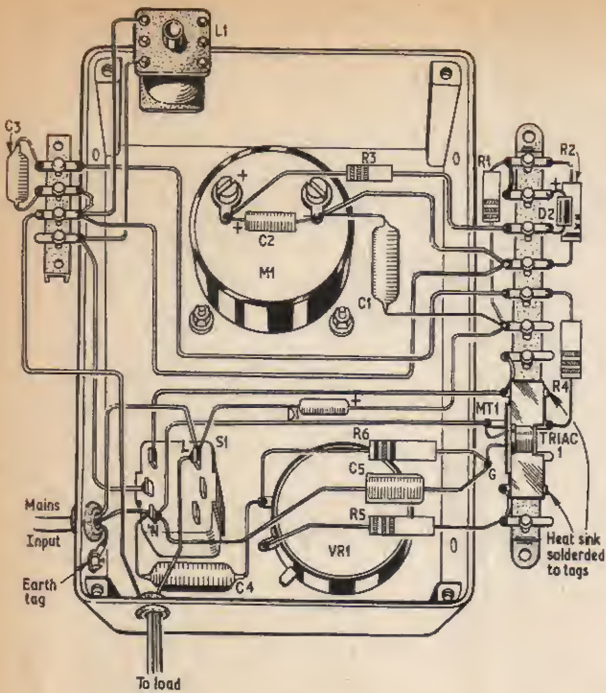


Fig. 3. Wiring of the controller in a diecast box. The tag strips are shown removed from their mountings to show the connections of the triac mounted on the heat sink (note the two leads which connect to tags)

COMPONENTS . . .

Resistors
R1 33kΩ 1W
R2 10kΩ 1W
R3 15kΩ
R4 22Ω
R5 10kΩ
R6 10kΩ
All ±10% ½ watt carbon except R1 and R2

Potentiometer
VR1 100kΩ wirewound

Capacitors
C1 0·1μF polyester
C2 47μF elect. 6V
C3 0·01μF polyester
C4 0·1μF polyester
C5 0·1μF polyester

Triac
Triac 1 40432 (R.C.A.) with heatsink (Electrovalue, 28 St. Jude's Road, Englefield Green, Egham, Surrey)

Diodes
D1 1S113
D2 ZF16 16V Zener

Inductor
L1 3mH (for details see text)

Meter
M1 0·1mA f.s.d. moving coil

Switch
S1 Single pole changeover toggle switch

Miscellaneous
Die-cast box (Eddystone) 4½ in × 3½ in × 2¼ in
Aladdin coil former 4mm with square base, dust iron core, 26 s.w.g. enamelled copper wire
Tag strip

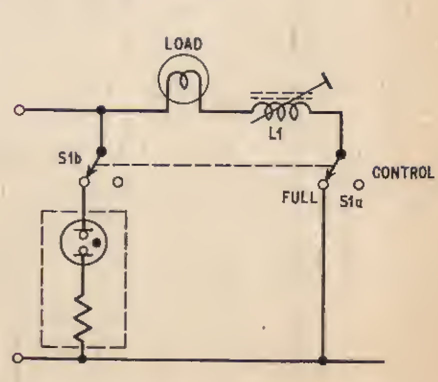
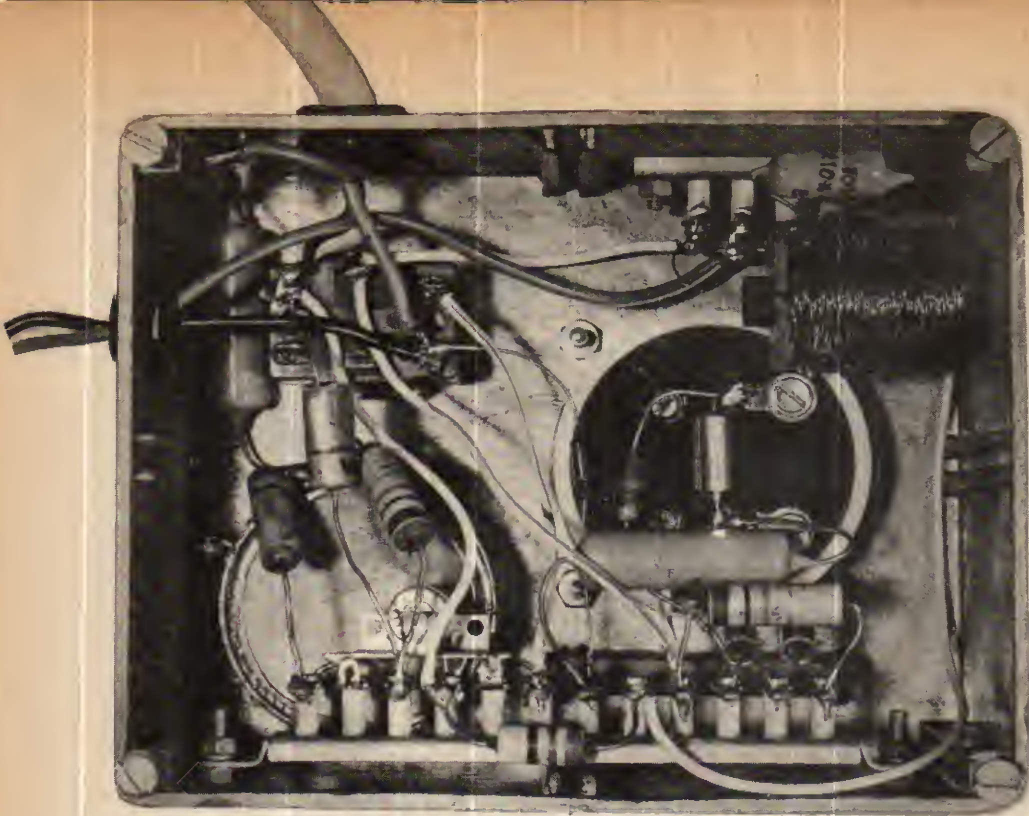


Fig. 4. The substitution of a double-pole change-over switch for S1 enables a neon lamp to be used as a full power indicator.



and component layout details. Here, mounting strips with ceramic stand-offs are used to carry the majority of components, with the remainder supported by the switch, control potentiometer and meter terminals.

When ordering the triac the heat sink should be included. The latter is soldered to the long tag strip terminals, then the triac is clipped in. A view of the heat sink mounted triac is given in Fig. 3.

In view of the light loading of the triac—less than 1A—the use of a heat sink as such is not really called for, but it does provide a convenient way of mounting.

If a double-pole change-over switch is available, it is worth while to make use of the second pole as in Fig. 4 to bring in a neon indicator.

The neon will light when the enlarger lamp has full, uncontrolled, power applied to it, and acts as a warning to the photographer that this is so. The inadvertent use of this setting for exposing, giving over-exposure of the print, should thus be avoided.

USING THE CONTROLLER

The output of the controller is adjusted as required so that a constant meter reading is obtained; the reading chosen must, of course, be a little lower than that given by the lowest mains voltage likely to be encountered.

The switch S1 can be used to apply the full voltage to the lamp for the purpose of focusing.

The numbered curves A and B in Fig. 5 indicate light output from a 75 watt enlarger lamp with:

(a) Variation of applied voltage, that is, without the controller.

(b) Variation of mains voltage but with a constant meter reading setting of 0·6mA.

Graph (c) Uncontrolled meter reading with changing mains voltage.

The output of the lamp in the lower graph is expressed in terms of the reading on a Weston-3 exposure meter. It can be seen that the change of almost 1½ stops, given by an uncontrolled lamp when the mains changes from 250 volts to 200 volts, can be reduced to zero by this controller, so giving good correction for both black and white and colour photography. ★

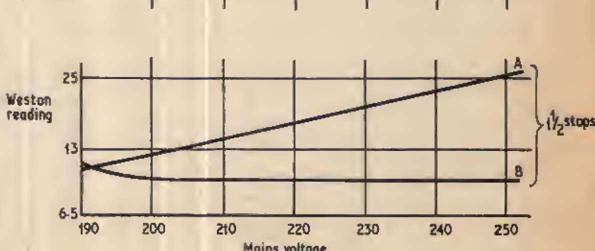


Fig. 5. Graphs showing light output from 75W enlarger lamp with: (a) Variation of applied voltage, (b) variation of mains voltage with constant meter reading of 0.6mA, (c) Uncontrolled meter reading with changing mains voltage