ELECTRONIC EXPOSURE TIMER

by A. Ladwig

Many amateur photographers spend a disproportionate amount of their time in the dark-room. The exposure timer presented here can cut down that time because the exposure is controlled entirely electronically. That results not only in perfect prints every time, but also in a reduction in paper and chemicals used and that is good for the environment and for your wallet.

The traditional way to determine the exposure time for a photographic print is to use a test strip and expose the negative for a number of different periods. The strip is then developed and a judgment taken which exposure time is the most nearly perfect one and that time is taken to print the negative(s). Clearly, this technique wastes time, paper and chemicals. With the timer* described here, this technique becomes a thing of the past. It also ensures that the setting of the diaphragm in the enlarger does not affect the exposure meter.

The procedure with the timer is simplicity itself: the negative or slide is placed in the enlarger, the wanted size of the print is determined, the enlarger is focused, the photographic paper is placed on the easel and covered with a sheet of glass, and the start button on the timer is pressed. The electronics in the timer will ensure perfect exposure.

Principle of operation

Two methods are commonly in use to assess the correct exposure time for prints. The spot measurement is used for determining the exposure for a certain part of the photograph. This is of particular interest if the photo has sharp contrasts, such as somebody standing in the shade against a very bright background.

The second method is the integrated measurement in which the entire photograph is used to determine the correct exposure time. This is done by diffusing the light falling on to the paper with the aid of some frosted glass and measuring the light intensity.

The two methods may be combined by concentrating the integrated measurement on the light falling on the centre of the photograph, and this is the one used in the present timer. The light is measured at twelve different points spread across the paper. The diffuser is the paper on which the print will appear. This method of measurement is made possible by placing the light-sensitive cells of the exposure meter not above the paper as is usual, but underneath it. The only proviso of the method is, therefore, that the paper is translucent, which it normally is.

*Patent applied for (provisional Patent Number is G 89 08 446.2)

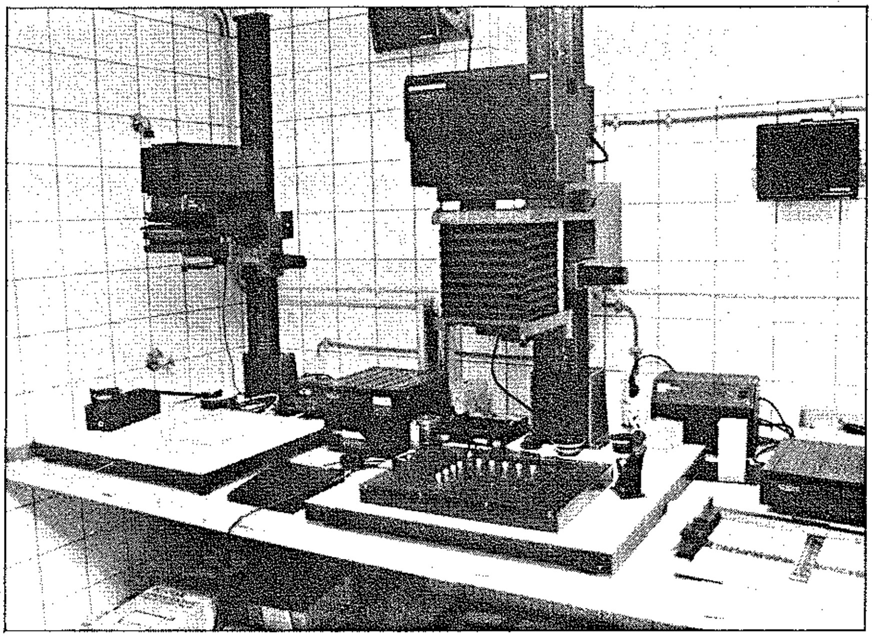

Fig. 1. The timer in use in a typical dark-room.

The design

The twelve light-sensitive cells are contained in a man-made fibre paper easel as shown in Fig. 2. Each of the cells consists of a phototransistor Type BPW40. The easel consists of a sheet of transparent perspex (US: lucite) into which 12 holes are drilled. The cells must not protrude through the sheet (since the paper would then not lie flat and cause the photo to be distorted). The diameter of the holes should preferably be larger at the paper side than at the underside.

Since experience shows that most photos are printed in 130×180 mm (5×7 in.) format, the prototype easel has been made in that format, too, but you may, of course, decide on other dimensions.

Tests with the prototype to verify that the principle is sound resulted in output voltages at five of the cells (P_1–P_5) as shown in Table 1. The tests were made with the negative in the enlarger first not illuminated for 1 second and then exposed to maximum illumination for 32 seconds. The diaphragm of the enlarger was stopped down by two *f*-numbers. The voltages were measured with a digital volt-

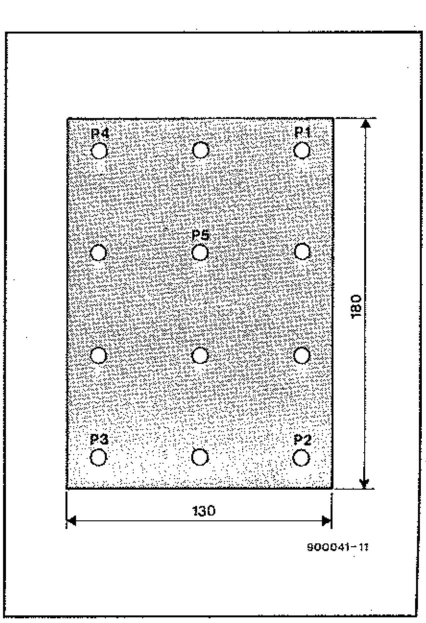

Fig. 2. Layout of the perspex (lucite) easel that houses the twelve photocells.

Table 1

	Exposure Min.	Max.
P_1	17 mV	490 mV
P_2	18 mV	495 mV
P_3	16 mV	491 mV
P_4	17 mV	488 mV
P_5	26 mV	750 mV

meter with R_i=10 MΩ.

It is clear that the cell at the centre of the easel (P_5) receives more light than those at the edges. Furthermore, the tolerances of the phototransistors proved to be small enough to be of no consequence to the operation.

The block diagram in Fig. 3 shows how the output voltages of the phototransistors are processed. First, they are summed and the total voltage, U_t, is fed to a time-voltage integrator. The output of the integrator, U_{int}, is proportional to the luminous flux radiated on to the easel. The output is then compared with a reference voltage, U_r: when these two potentials are equal, the exposure is correct. Since the sensitivity of different printing paper varies, the integrator is provided with a control with which the integration constant can be altered. This enables the timer to be calibrated according to the photographic paper used.

At the moment $U_{int}=U_r$, the lamp of the enlarger is switched off and the photo is ready for chemical processing. Arrangements may be made to switch on the dark-room lighting at the same time; this is, however, not advisable when colour photographs are being processed as that should take place in the dark.

During exposure, the light in the dark-room must be switched off, since diffused light will adversely affect the exposure measurement and, consequently, the quality of the print. As stated earlier (see also Table 1), the photocells provide a maximum output of 490–750 mV at an exposure time of 1 s and a minimum potential of 16–19 mV at an exposure time of 32 s. The output voltage, U_{int}, of the integrator at which the print is exposed optimally is calculated from:

$$U_{int}(t) = -\frac{1}{RC}\int_{t_0}^{t_1} U_t \, dt$$

where $t_1-t_0=t_{exp}$, the exposure time. From this, it follows that

$$U_{int}(t) = -\frac{1}{RC}(U_t t_1 - U_t t_0)$$

$$= -\frac{1}{RC} U_t t_{exp}$$

At the longest exposure time, the average output voltage of the photocells is 19 mV. The output of the integrator is then

$32\times12\times19\times10^{-3}$=7.3 V.

At the shortest exposure time used in the design stages, the average output of the photocells is 620 mV. At 1 s, the shortest period possible on the timer, the output of the integrator is

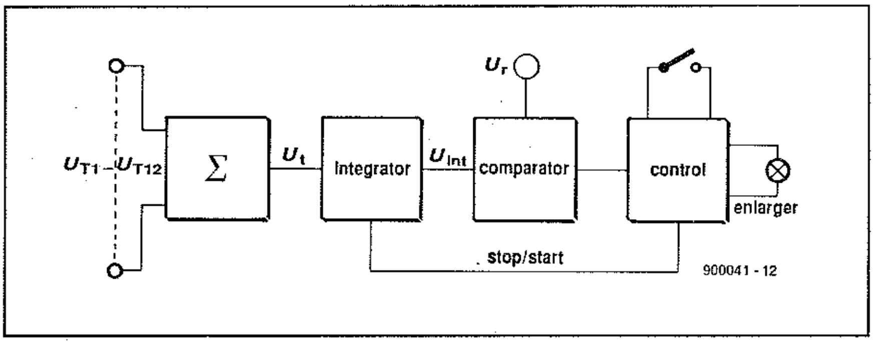

Fig. 3. Block diagram of the exposure timer.

$12\times620\times10^{-3}$=7.44 V.

From these results, it would appear that the reference voltage for the timer should be about 7.4 V. To make calibration possible, the level chosen in the prototype is 9 V.

The circuit

The circuit diagram of the timer is given in Fig. 4. The twelve phototransistors are connected as emitter followers whose emitters are connected to the summing circuit via 10 MΩ resistors. The phototransistors are shown in groups of four to coincide with the way they are to be fitted on three separate PCBs (see Fig. 5). This enables the constructor to experiment at an early stage with the mechanical layout of the exposure timer.

Opamp IC_1 sums the output voltages of phototransistors T_1–T_{12} and inverts the result. This inversion is necessary because integrator IC_2, which follows IC_1, also inverts its input.

Integration constant *RC* is obtained from R_{28}, P_1, and C_6. Preset P_1 enables the constant to be varied so that calibration to allow for the various types of paper is possible. If the range of the preset is not sufficient for a certain type of paper, the value of C_6 may be altered accordingly. When the exposure time is too long, halving the value of C_6 results in one stop down; when it is too short, doubling the value of C_6 results in one stop up.

The integrator is followed by IC_3, which compares the output of the integrator with a reference voltage, U_r, derived from potential divider R_{30}–R_{31}. As soon as the integrator voltage becomes larger than the reference voltage, the level at the output of IC_3 goes high and bistable (flip-flop) IC_{4a} is reset. This causes output $\overline{Q}$ to go high, which results in transistor T_{13} being switched on. The integrating capacitor, C_6, is then completely discharged and the timer is ready for use. At the same time, output Q of IC_{4a} goes low, which causes transistor T_{14} to switch off, so that relay Re_1 is deenergized. The timer is then switched off and the light in the dark-room comes on again (if wanted).

Since the enlarger is required to be on permanently during focusing and some other operations, switch S_2 has been added to bypass the electronics.

Start switch S_1 passes a clock pulse to

PARTS LIST

Resistors:

$R_1,R_3,R_5,R_7,R_9,R_{11},R_{13},R_{15},R_{17},R_{19},R_{21},R_{23}$ = 1 MΩ

$R_2,R_4,R_6,R_8,R_{10},R_{12},R_{14},R_{16},R_{18},R_{20}R_{22},R_{24},R_{27}$ = 10 MΩ

R_{25} = 470 kΩ

R_{26} = 820 kΩ

R_{28} = 6M8

R_{29} = 22 kΩ

R_{30},R_{32},R_{33} = 100 kΩ

R_{31} = 330 kΩ

R_{34} = 10 kΩ

P_1 = 2M5

Capacitors:

C_1–C_9,C_{12} = 100 nF

C_{10},C_{11} = 100 µF, 25 V

C_{14},C_{15} = 100 µF, 25 V, radial

Semiconductors:

IC_1,IC_2 = LF356

IC_3 = LM741

IC_4 = 4013

IC_5 = 7812

IC_6 = 7912

T_1–T_{12} = BPW40

T_{13} = BS170

T_{14} = BC547B

D_1,D_2 = 1N4148

D_3–D_6 = 1N4001

Miscellaneous:

K_1 = 5-way DIN plug, 180°

K_2 = 5-way DIN socket for PCB, 180°

S_1 = push-button switch, 1 make

S_2 = miniature switch, 1 make

Re_1 = relay, 12 V, for PCB mounting

Tr_1 = mains transformer, 2×9 V, 2.8 A

PCB Type 900041

bistable (flip-flop) IC_{4a}, which starts the entire measuring cycle. Since the D input of the bistable is connected permanently to the positive supply line, the Q output goes high when S_1 is pressed. The integrator commences operation and the enlarger is switched on. When the supply is switched on, network R_{33}–C_9 ensures that the bistable receives a clock pulse although the D input is then still low (because the time constant on that input is much longer). This ensures that after power-on the enlarger is switched off and the dark-

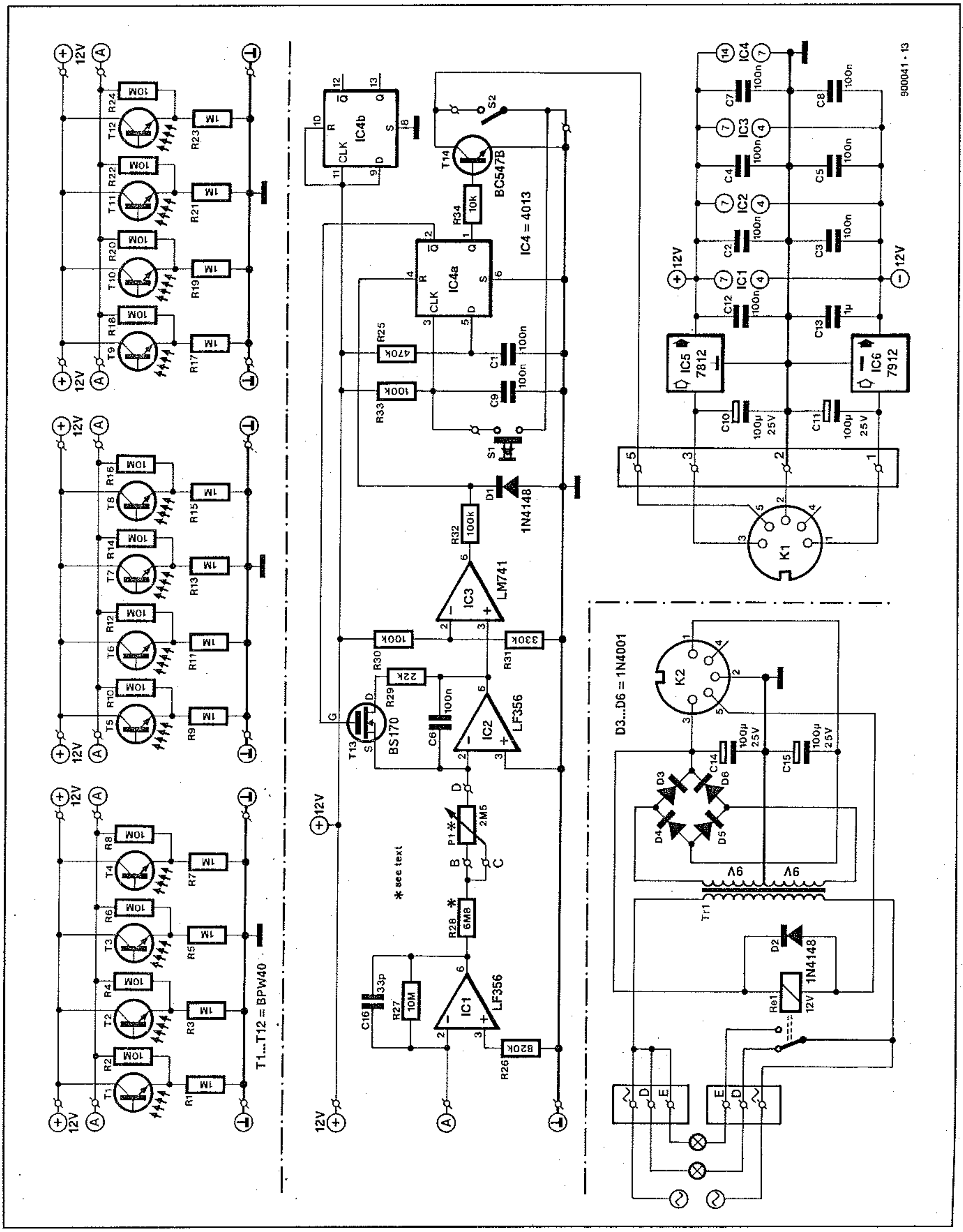

Fig. 4. Circuit diagram of the electronic exposure timer.

room lights are on.

From Fig. 4 it is seen that the circuit consists of two sections that are interconnected by a length of 4-way cable and two five-pin DIN plugs. This arrangement makes it possible for some of the components, such as the mains transformer, relay, mains entry to be fitted away from the working area, which then only needs to house the control box of the timer. An additional advantage is that mains-carrying parts are well away from the chemicals to lessen the likelihood of any mishaps.

The power supply for the timer is fairly simple. The alternating voltage at the secondary winding of the mains transformer is rectified (full wave) by D_3–D_6 and smoothed by C_{14} and C_{15}. A negative and a positive voltage are then supplied via a length of 4-way cable to the voltage regulators, IC_5 and IC_6, in the control box. These regulators provide supply voltages of +12 V and −12 V. The mains supply for the dark-room lights and the enlarger may be taken from the 3-way terminal blocks.

Construction

The five printed-circuit boards for the entire timer are shown in Fig. 5. Since these are delivered as one, they need to be separated with a fret saw (US: jig saw) before being populated.

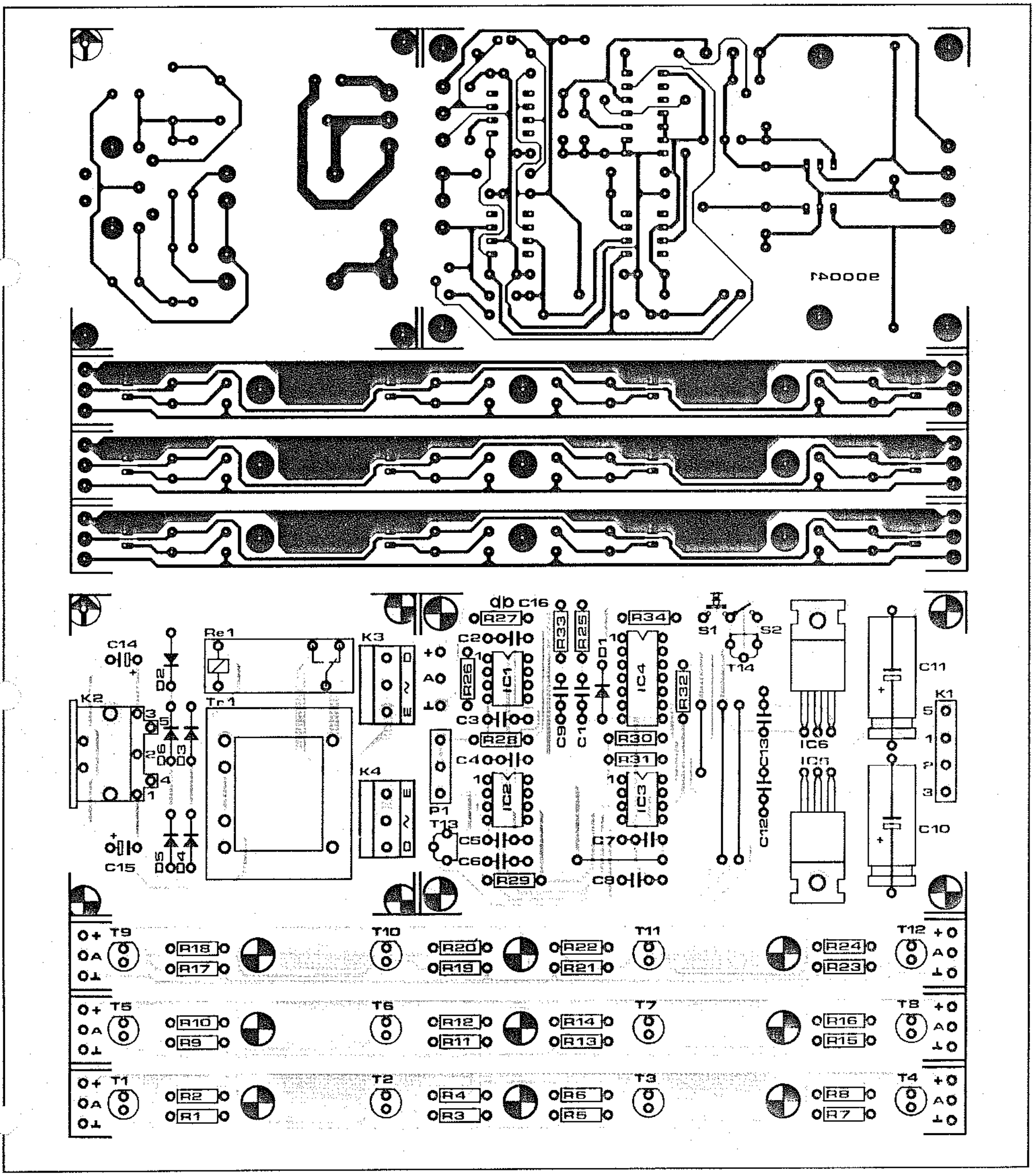

Fig. 5. The printed-circuit board for the electronic exposure timer consists of five parts.

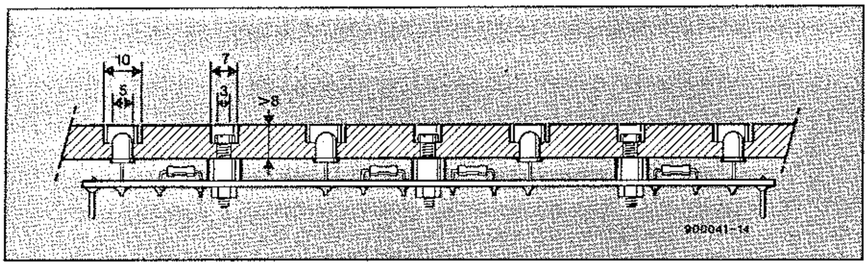

Fig. 6. Construction of the perspex (lucite) easel. It is important that the upper surface is smooth to ensure that the paper lies perfectly flat.

The three prints housing the phototransistors must be mounted on to the perspex (US: lucite) easel as shown in Fig. 6. The perspex sheet must be thick enough to take in the bodies of the phototransistors. After the three PCBs have been interconnected, they are linked to the motherboard by a length of 3-way cable.

It is advisable to start by placing the required wire bridges on the motherboard and then mount the other components. The regulators do not need a heat sink and may therefore be fitted directly on to the board. Potentiometer P_1 and switches S_1 and S_2 are mounted on the front panel of the enclosure that contains the motherboard.

It also possible to fit the motherboard underneath the easel. Two different types of DIN connector must then be used for connecting the board to the power supply and to the switches and potentiometer which are then housed in a small, separate box.

If at all possible, fit the power supply board in a man-made fibre enclosure with moulded mains plug. If wanted, the darkroom light(s) can be switched from this unit via a separate cable. The enclosure should be fitted with a hole through which the DIN plug for the power lines can be passed.

Once the boards have been completed and fitted in the enclosures, P_1 must be adjusted with the aid of a number of test exposures. The setting so found needs to be altered only if photographic paper with a different sensitivity is used in the future. ■

MIDI-TO-CV INTERFACE

Some additional notes

Although the MIDI-to-CV interface was described fully in our February 1991 issue, it was though that some additional notes might prove useful to a number of readers.

MIDI connections

The MIDI-IN socket, K_6 (next to the mains input plug) must be connected via a suitable MIDI cable to the MIDI output of your MIDI keyboard, synthesizer, or other equipment. The MIDI input signal appears unchanged at the MIDI OUT socket (MIDI through function). The name of that socket may seem somewhat confusing ('through' function at 'out'), but that is because the interface isprincipally intended to output the data in changed format (e.g., filtered). Other equipment may be connected to the MIDI OUT socket, but this must be controlled by the same data as the present interface.

Connection to CV/gate

The connection to a monophonic synthesizer is via the two 6.3 mm connectors marked "CV OUT" and "GATE OUT". The 1 V/octave tone control voltage is available at the CV socket. The 0 V reference point (i.e., the MIDI code for 0 V control voltage) is normally 36, which is equivalent to low C on a standard five-octave keyboard.

The 0–5 V gate voltage is available at the gate socket. Depending on the type of synthesizer, this is a positive gate signal, i.e, +5 V when a key is depressed and 0 V when the key is released, or a negative gate signal, i.e., 0 V when a key is depressed and +5 V when the key is released. Consult your synthesizer handbook to ascertain which of these signals you need.

The gate LED lights when a correct gate signal is applied. This diode can also be used to check whether the interface is functioning correctly, even when this is not (yet) connected to a synthesizer.

Setting the MIDI channels

The MIDI channels are set with the aid of the 4-pole DIP switches, SW_1–SW_4, on the interface board. The settings and associated channels are shown in Fig. 3. The settings should be carried out before the equipment is switched on (if they are made while the equipment is switched on, the channel will not change).

Faultfinding check list

If the interface does not work (correctly) check the following.

- Is the power supply correct? The LED should light briefly on power on and then go out again. Are the power lines reversed?
- Are the connections to the MIDI transmitter and synthesizer in order? These include the earth connections!
- Has the correct MIDI channel be set on the interface? Does the gate LED light when the controlling MIDI equipment sends data on the set MIDI channel? Does the MIDI sender transmit on the correct channel? For security's sake, check the MIDI cable and whether the MIDI sender operates correctly.
- Do the sent tones lie in the correct range, i.e., normally between 36 and 97 or five octaves from low C.
- Does the gate LED light correctly, but the connected equipment does not function? This is almost certainly a failure of the cable connecting the interface to the synthesizer.
- If the scale of the interface does not correspond exactly with that of the synthesizer, shown by the increasing detuning away from the reference point, a correction can be made with potentiometer P_1.

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