Project 594

DEVELOPMENT TIMER

The Watkins Factor method of development is little known and at present almost unused — is this due to the lack of a proper timer? Phil Cohen has designed one.

IN 1893, a photographer called Alfred Watkins noticed that the time taken for an image to appear during the development of a photographic plate was a fixed fraction of the total development time.

The Watkins Factor

The phenomenon that Watkins noticed was that the total development time was a fixed number (called the Watkins Factor) times the period taken for the plate to be seen to darken initially. Now, whereas development time varies with temperature, concentration and 'age' of the developer, the Watkins Factor does not. If you develop a film for a *fixed* period, you *must* keep these three factors constant. If, however, you develop it using the Watkins Factor you can (within reasonable limits) *forget* the age, concentration and temperature.

This is all very well, but you would have to be able to see the film as it develops. This is not feasible with modern high-speed panchromatic film, which has to be developed in complete darkness. For this reason the Watkins Factor has been all but forgotten, hardly rating a mention in modern textbooks.

Theory

In the process of developing a print, developer slowly diffuses into the paper, reacting as soon as it reaches the photosensitized areas. The reaction is *diffusion controlled*. The reason why nothing appears for the first few seconds of development (called the 'induction period') is that the developer is still working its way into the paper.

With film you can't watch it develop, with paper you can so the Watkins method of development timing should be extremely useful to the amateur who can't afford a constant-temperature bath for his developer.

The Timer

It works like this: you set the appropriate Watkins Factor (which is specific to a particular developer and paper) on the front panel control. When you put the paper into the developer, you push the switch to 'START'. As soon as the first image starts to appear, you flick it back to 'TIME'. At the end of the development period the buzzer will sound. Then pull the paper out of the dish, wash it and fix it . . . viola!, beautiful prints.

It may take a bit of experiment to find the correct Watkins Factor. Once you have it, though, you need not bother too much about developer temperature and (within limits) its age and concentration.

Building It

Construction should begin with the pc board. Make sure all of the capacitors, diodes, transistors and ICs are inserted the right way round. RV2 and RV3 are 'upright' preset pots bent over to fit flat against the pc board.

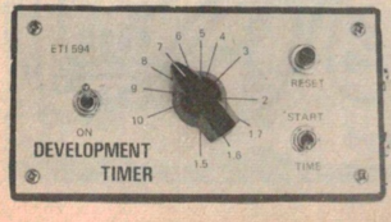
Mount C4 directly onto SW1, this keeps the batteries in place. The buzzer mounts on the end of the case with its leads passed through a hole. Note that the red lead goes to the '+' buzzer connection on the board.

Make sure that you use the correct tags of RV1. Refer to the wiring diagram. It is a log characteristic pot. A linear one will not have the same calibration scale.

Readers who would like a front panel reproduction , please write to: Project 594, Electronics Today Int, 15 Boundary St, Rushcutters Bay, 2011 NSW.

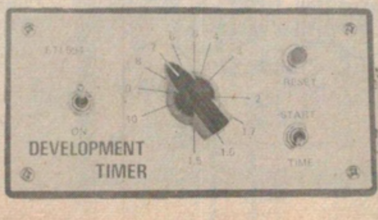
This print was developed in fresh, normally diluted developer. The print darkened after 15 seconds and total development time was 45 seconds. The Watkins Factor was thus 3.

1



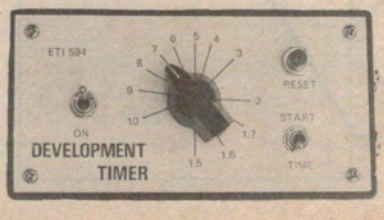
With the developer diluted to half its strength this print was developed for 45 seconds. Clearly, it is underdeveloped.

2



This print was developed in the diluted developer using the timer set for a Watkins Factor of 3. The result is very little different to the first print indicating that the Watkins Factor method is useful for 'old' developer.

3



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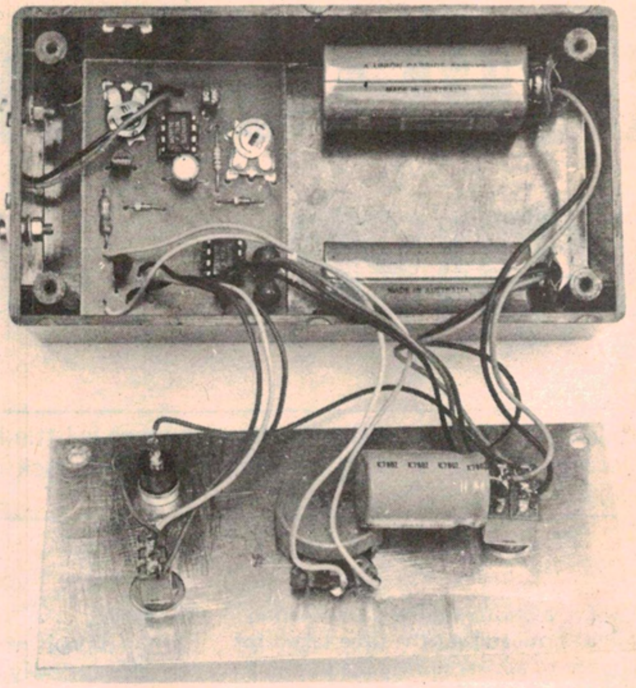
Setting Up

After finishing the unit, disconnect the 'TIME' and 'START' wires from SW2. Solder them together and put the most sensitive current meter you have between this joint and 0V (most medium-priced multimeters will do). Disconnect the wire which goes to the middle contact of SW2 and connect it to the + end of C4. Set RV1 to '2'. Switch on and adjust RV2 for a zero meter reading.

What you have just done is to ensure that when the resistance of RV1 is at the '2' value, the current through Q1 is the same as that through Q2 (see 'How It Works'). This is to correct for differences between the two FETs which seldom have the same characteristic.

Now adjust RV3. Turn it fully clockwise and then slowly rotate it until the buzzer sounds (if it doesn't — there's something wrong). After this happens, turn it back about one-eighth turn. The timer is now fully set up.

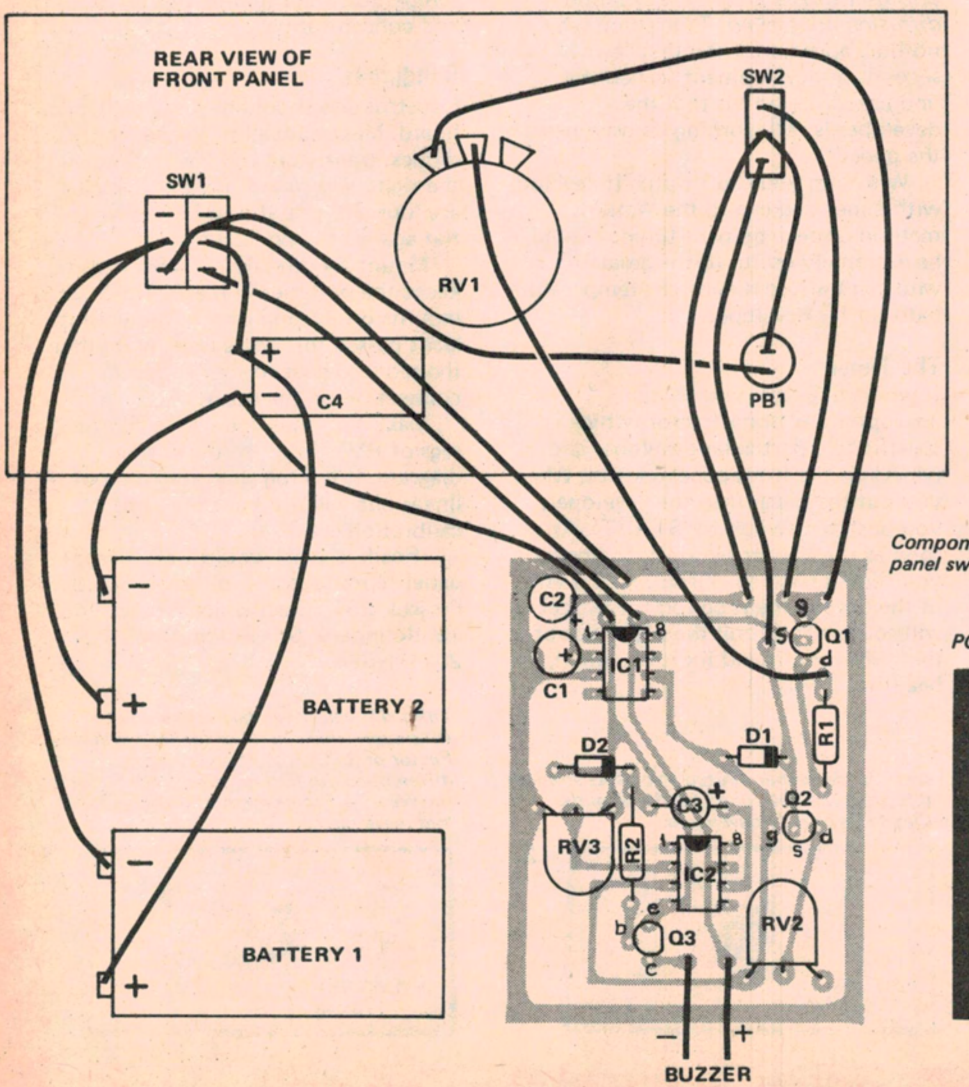
Re-connect the unit as shown in the diagrams. Switch on and set SW2 to 'TIME'. Short out C1 temporarily to remove the charge put on it during the setting-up. With RV1 set to 2, switch SW2 to 'START' for five seconds and then push it back to 'TIME'. Five seconds later, the buzzer should sound.



An interior view of the Timer. Note how the batteries are arranged. C4 can be seen mounted on the switch. This keeps the batteries in place when the box is closed.

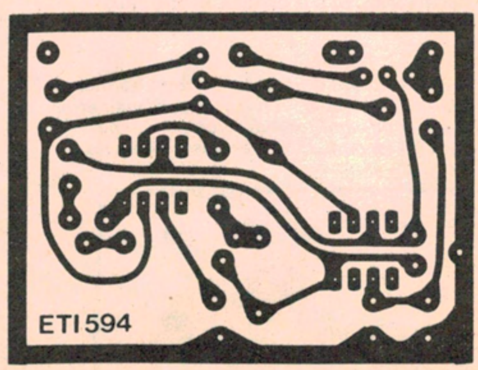
Summary

The theory behind the use of this unit needs development. It should make a fascinating study for any photographer, amateur or professional. This device will make an interesting addition to any darkroom.



Component overlay, including the front panel switch and potentiometer arrangements

PCB artwork shown full size.



HOW IT WORKS - ETI 594

The Watkins Factor is the ratio of two time periods. A timing circuit having one variable period, which you set, and one fixed period is arranged to indicate when the correct ratio of time periods has been reached.

This is achieved by charging and then discharging a capacitor. The time taken to charge the capacitor is varied while the discharge time is fixed. The control used to vary the charging time is calibrated in terms of the Watkins Factor.

When a capacitor is charged at a constant current, the voltage across it will rise linearly with time – or 'ramp' upwards. Similarly, when it is discharged at a constant current, the voltage across it will 'ramp' downwards. This technique allows good accuracy to be obtained in timing applications.

In this circuit, the current at which the timing capacitance is charged is varied by means of a potentiometer control.

Q1 is connected as a 'constant current' source; that is, it will only allow a constant current to pass, the amount being determined by R1 and RV1. The potentiometer RV1 sets the Watkins Factor.

When SW2 is set to START, C1/C2 will charge via Q1/R1/RV1, the voltage across it ramping upwards at a linear rate The lower the resistance of RV1, the higher the charging current causing C1/C2 to charge at a faster rate. The converse is also true.

Q2 is connected as a 'constant current' sink – when SW2 is set to TIME, C1/C2 will discharge via Q2/RV2, these components 'sinking' the current. The discharge current will be constant and the voltage across C1/C2 will ramp down at a linear rate.

A Watkins Factor of '2' requires equal charge/discharge times for C1/C2. So that the currents through Q1 and Q2 will be equal when RV1 is set for a Watkins Factor of 2, RV2 (a trimpot) is provided to set the current through Q2. This is used to calibrate the timer.

When the timer is switched on initially, with SW2 in the TIME position, any positive voltage on C1/C2 will cause the output of IC1 to go negative, drawing current through Q2/RV2, discharging the capacitors. Any negative voltage that may appear on C1/C2 will cause the output of IC1 to go positive. This will forward-bias D1 and 'pull up' the voltage across the capacitors. The combined action of these processes ensures that the voltage across C1/C2 stabilises at zero volts.

When the timing period is commenced at the start of developing a print, SW2 is set to START. As C1/C2 charge, the output of IC1 will go negative. When the image first appears on the paper, SW2 is set to TIME. C1/C2 will then discharge, as previously explained, and the voltage across the capacitors will go to zero. At this time, the buzzer will sound.

IC2 is arranged as a 'trigger'. When C1/C2 first begin to charge, the output of IC1 goes negative. When this negative voltage passes the value of the negative voltage applied to the inverting input of IC2, set by RV3, the output of IC2 will go very rapidly to about -7 V. At the end of the timing period, the output of IC1 goes to zero volts. As this drives the non-inverting input of IC2, the output will swing rapidly from about -7 V to +7V.

This will force a pulse of current through C3/R2, forward-biasing the base of Q3. When Q3 turns on the buzzer will sound.

C3 will take about one second to charge, Q3 will not receive sufficient base current and the buzzer will cease its cacophony. It sounds not unlike the wheeze from expiring bagpipes! This project was designed by a homesick scotsman.

D2 discharges C3 when the output of IC2 goes low when next you turn SW2 to START.

A pushbutton, PB1, allows you to abort a timing sequence by shorting C1/C2.

Note that the buzzer will sound whenever the unit is turned on. IC2 will trigger as the output of IC1 will initially be zero and the output of IC2 will thus jump to about + 7 V, setting off the buzzer.

PARTS LIST – ETI 594

Resistors

R1 . . . . 27k
R2 . . . . 12k

Potentiometers

RV1 . . . . 1M log
RV2 . . . . 1M trim
RV3 . . . . 250k trim

Capacitors

C1, 2 . . . . 33μ 10V tantalum
C3. . . . . 10μ 25V electrolytic
C4. . . . . 470μ 25V electrolytic

Semiconductors

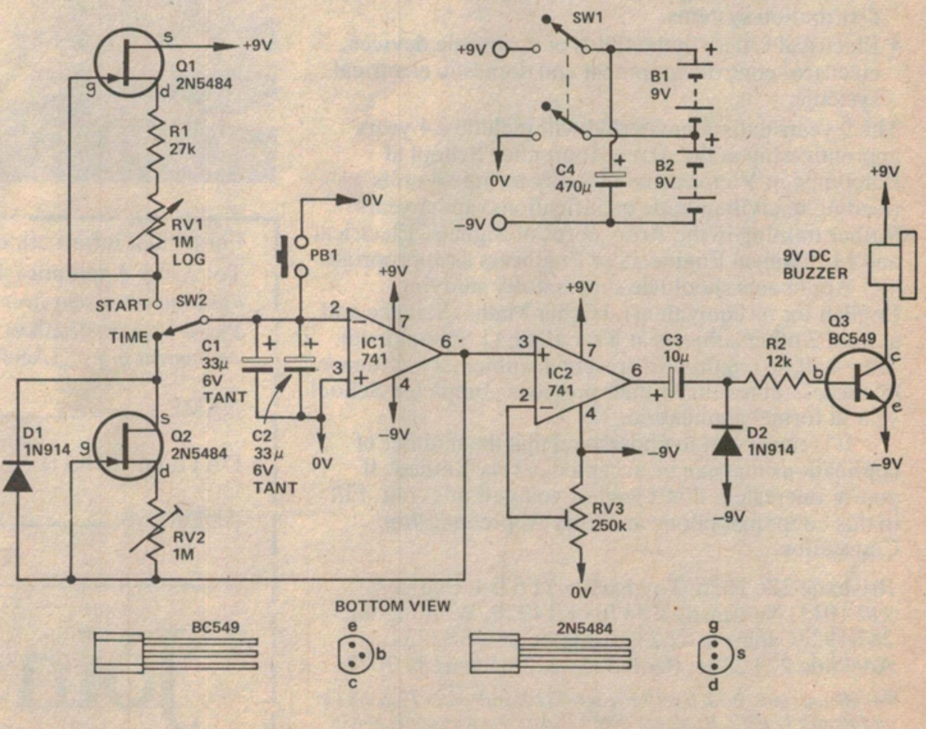
IC1, 2. 741

Q1, 2 . . . . 2N5484
Q3 . . . . BC549

D1, 2 . . . . 1N914

Miscellaneous

pcb . . . . ETI 594
SW1. . . . . miniature dpdt toggle
SW2. . . . . miniature spdt toggle
2 off 9V batteries with clips; case to suit; 9V dc buzzer and mounting bolts; knob with pointer.



The circuit diagram. C1 and C2 are in parallel to achieve the required total capacitance and voltage rating.