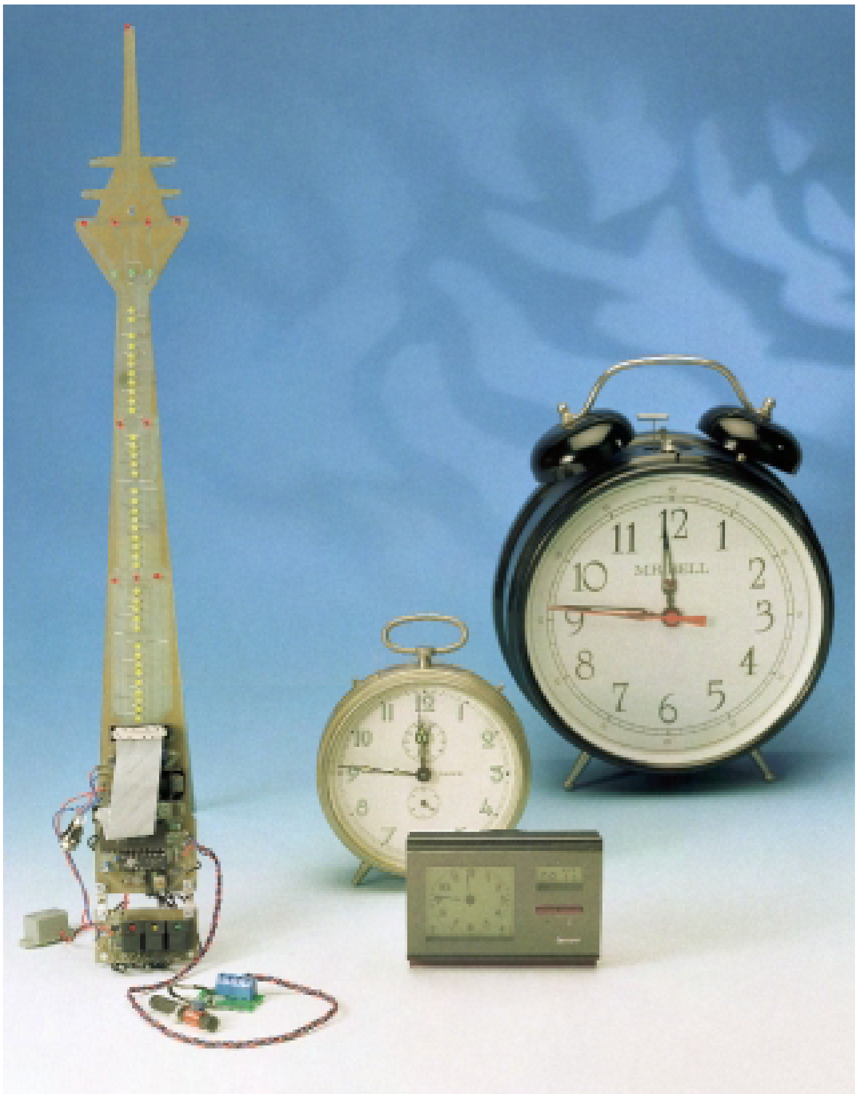
Rhine Tower clock Mk II

a special design, with a circuit board shaped like the tower

The DCF-controlled LED clock design, published in the May 1998 issue of Elektor Electronics, is a radio-controlled electronic version of the clock mounted on the Rhine Tower in Düsseldorf. Inspired by the many positive reactions to this project, its designer has reworked the software to add new features. To make things even nicer, Elektor Electronics has designed a special circuit board in the shape of the actual tower in Düsseldorf.



Design by D. de Mülder

Building a circuit yourself is even more pleasant when the result is something unique. Those of you that have built the original DCF-controlled LED clock will certainly have experienced this first-hand. Anyone who sees such a clock for the first time will undoubtedly wonder what it is and how it works.

The clock that is integrated into Düsseldorf's Rhine Tower consists of a series of lights arranged in a vertical line. The 39 lamps that are used to indicate the time on the tower are replaced in this project by yellow LEDs. The outline of the Rhine Tower can be seen in the drawing of **Figure 1**. The nine LEDs at the very bottom display units of seconds (0 through 9). The four LEDs above them display tens of seconds. The minutes and hours are encoded in a similar manner. Finally, there are two

LEDs that display tens of hours. All of this can be clearly seen from the drawing. At 23:59:59 all lamps are illuminated, and at exactly midnight (00:00:00) all lamps are out. A new 24-hour cycle starts at this point.

In contrast to the previously published design, the beacon lights are also included in the present design. In addition to the four lamps that indicate the wind direction (N, E, S and W), there is also a beacon lamp at the top of the tower. The result is a faithful reproduction of the Rhine Tower (clock).

In addition to these cosmetic modifications, a number of new functions have been added in the software. It is thus no longer necessary to use a DCF receiver (although this simplifies operation and gives better results). The new clock can function without the radio time reference signal, although it will naturally not be as accurate over an extended period of time.

Since the DCF receiver is no longer essential, a number of pushbuttons have been added to allow the clock to be set.

An additional new function is the extraction of the day of the week from the DCF signal. It can also be manually entered using the pushbuttons. With this additional information, it is possible to use the clock as an alarm that takes the day of the week into account. Naturally, an electronic buzzer is also included to generate the wake-up signal.

In order to accommodate all these functions, it is of course necessary to use a somewhat bigger processor. This is the price that must be paid for the extra features.

Controlling lamps with bits and bytes

The schematic diagram of the LED clock is shown in **Figure 2**. A large part of this is the same as the schematic of the 1998 design. The same type of microcontroller is still used, as well as the same LED-driver IC and power supply. These parts of the circuit are all straightforward. The driver for the piezo buzzer is new. With the specified components, any buzzer that works with a 5 V supply voltage and a current not exceeding 50 mA can be used for Bz1. The three pushbutton switches are connected to processor inputs that were not used in the previous design. The extra LEDs fit into previously unused positions in the matrix.

As before, an additional LED that lights whenever the supply voltage is present can be connected via jumper JP1. Resistors R4 and R5 are provided to allow experiments with other displays to be carried out. Under normal circumstances, these resistors are not necessary, and in most cases they may be omitted (along with R7, which is connected to JP1).

It goes almost without saying that, while the hardware is almost the same as in the earlier design, the controller software has been extensively modified. In order to use the new functions, it is thus necessary to acquire a new controller. It is possible to use the new circuit board with the old controller, if you wish, but the additional LEDs will not function in that case.

Construction

The printed circuit board track layout and component layout are shown in **Figure 3**. As is immediately apparent, this is no ordinary circuit board. Not only does it have an unusual form, its size is also special, which is why the illustration is only 55% of the actual size. If you want to etch your own circuit board, you must first enlarge the layout drawing by 182%. Alternatively, you can find the full-scale layout drawing as a PDF document at Elektor's Internet site (http://www.elektor-electronics.co.uk). Of course, none of this matters if you buy the circuit board ready made. In addition, the ready-made circuit board is milled to the shape of the Rhine Tower by the board manufacturer, saving you the trouble of doing this yourself. If you make your own circuit board, a bit of exercise with a coping saw will be necessary to give the board its proper shape.

If you wish, you can colour the board by applying a thin coat of spray paint to the component side of the circuit, board before fitting the components (but take care to avoid clogging the holes!).

The foot of the tower consists of two circuit board sections that can be separated from the rest of the board if desired. The bottom-most section accommodatees the pushbuttons, while the middle section holds the processor that drives the whole circuit. It is a question of taste whether to leave everything in one piece or divide it into two or three separate boards. It's up to you to decide, and the choice will depend in part on how the finished unit will be set up.

Since the three portions of the printed circuit board are electrically separate, a number of interconnections must be made, regardless of the final configuration. You should first fit the wire jumpers and all necessary pins. It's a good idea to used sockets for IC1 and IC2. When fitting the LEDs, pay good attention to the polarization. With so many LEDs, it's easy to make a mistake.

After all the components have been fitted, the three portions of the circuit board must be connected to each other using a number of bits of wire and a piece of flatcable, even if they are not

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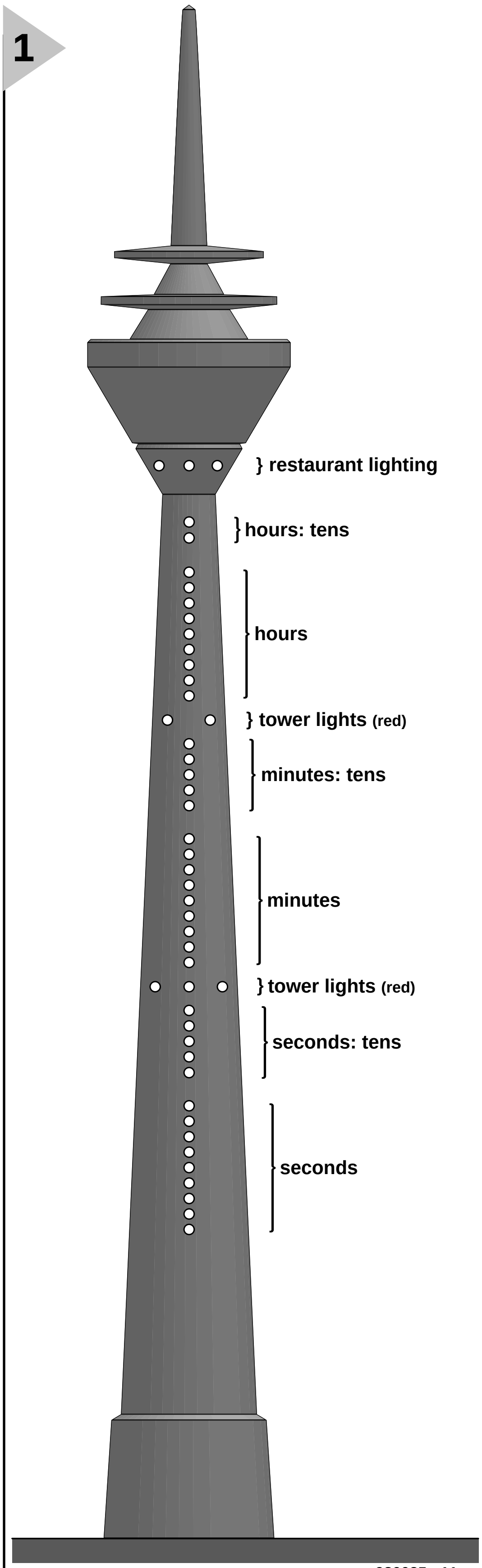

Figure 1. This drawing shows the configuration of the clock on the Rhine Tower in Düsseldorf, Germany.

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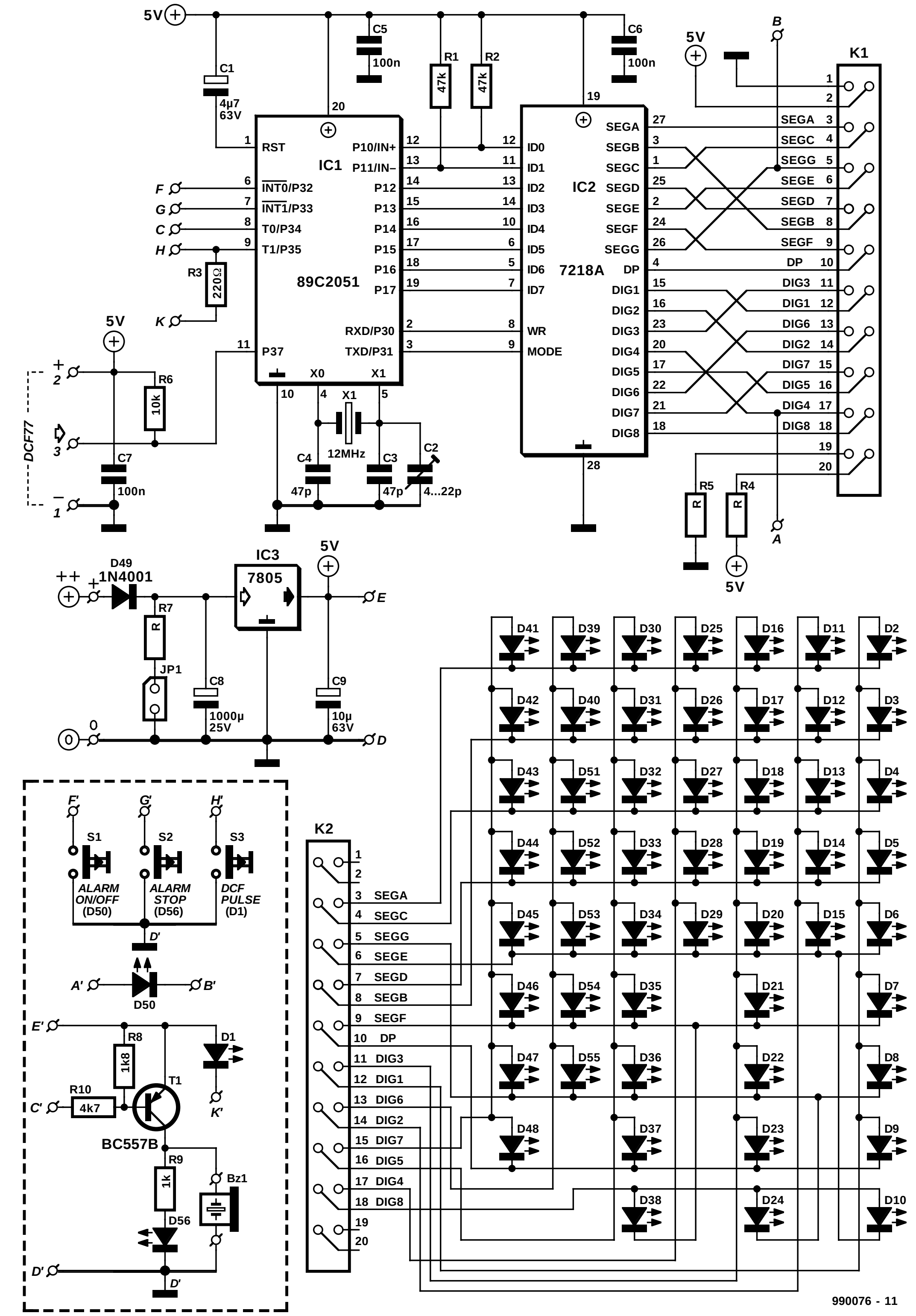

Figure 2. The schematic diagram of the clock. The similarity to the original DCF-controlled LED clock circuit is readily apparent.

separated. Connect corresponding points to each other (A to A', B to B' and so on, finishing with K to K'). After this, connect a length of 20-lead flatcable between K1 and K2. The optional DCF receiver can be connected to PC1, PC2 and PC3. The CPU generates interference that can affect the operation of the DCF receiver, so the receiver should be located 20 to 30 cm away from the CPU. Use a piece of screened cable for the connection.

A wall adapter that can deliver around 250 mA at a d.c. voltage between 8 and 12 V can be used to supply power to the circuit.

Once all interconnections have been made and all components installed, the mains adapter can be plugged in. If a DCF module is used and the signal reception is adequate, LED D50 should flash once per second. This is also true for some of the beacon lamps. If signal reception is good (as indicated by D50 flashing), the exact time should be displayed after two to three minutes.

DCF77 reception should be possible within a radius of 1500 km (just under 1000 miles) from the transmitter location in Mainflingen, Germany. From previous projects employing the DCF77 signal we know that reception is just about adequate in South-Eastern parts of England, South Scandinavia and most of Central Europe. If you live in a fringe area, remember that the radio signal is not required all the time! Also remember that DCF77 transmits CET (Central

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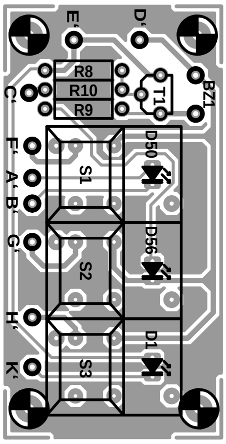

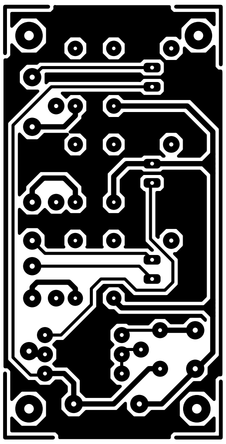

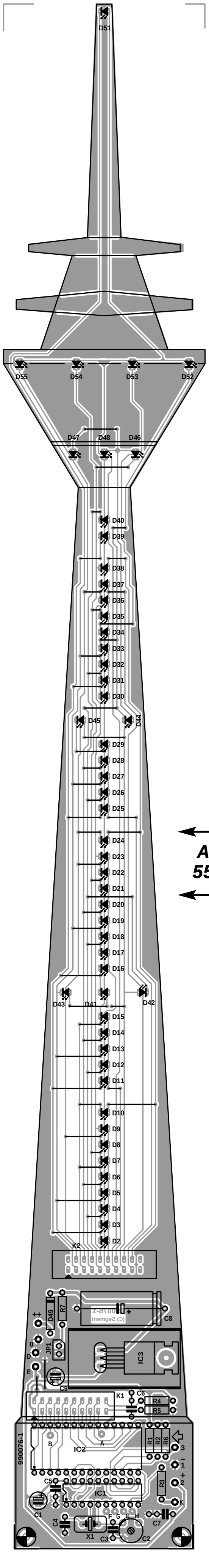

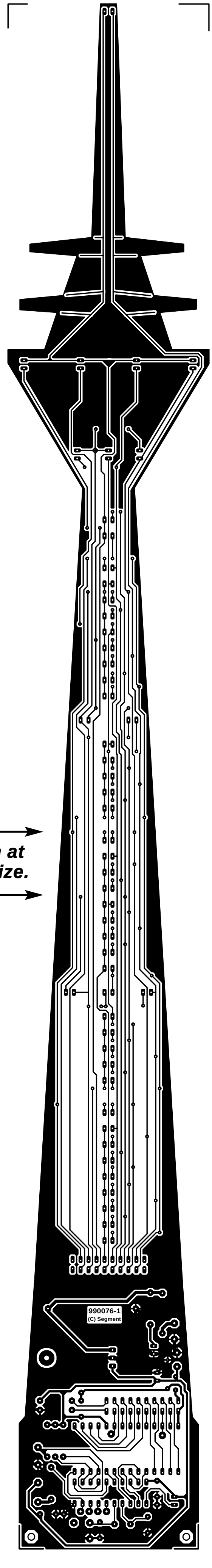

Artwork shown at 55% of actual size.

Figure 3. This may not be the largest circuit board ever offered by Elektor Readers' Services, but it is certainly one of the most attractive.

European Time).

None the less, if you do not use a DCF module, you will have to set the time manually and initialize the non-DCF operating mode. To do this, press S3 at the same time as power is applied. The restaurant lamps will come on, while all other lamps will remain off. Release S3 and start with setting the time. Use S1 to set the hour. The hours count is increased by one each time S1 is pressed. After this, use S2 to set the minutes. Note that there is an automatic 'rollover' from the minutes setting to the hours setting.

Use S3 to set the day of the week. It has a double function in this regard. Press it briefly (0.1 to 1 second) to set the day of the week; the count increases by one each time the button is pressed. While the day of the week is being set, the first seconds LED indicates Monday, the second LED Tuesday and so on. After Sunday (all seven LEDs on), the day automatically

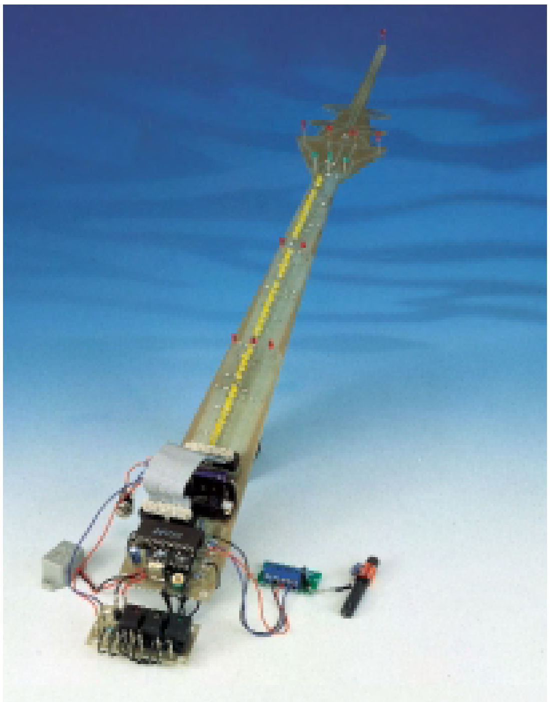

Figure 4. The assembled prototype of the clock.

returns to Monday (one LED on).

After everything has been set, you can start the clock using S3. If S3 is held pressed for longer than one second, the clock will start, and it starts exactly on the minute. You should therefore press S3 at the 59th second of the minute, so that the clock will start exactly when the minute changes. After a bit of practice, you should find the operation of the clock very simple. Those of you that use a DCF module need not be concerned about all this, since clock synchronization is fully automatic with a DCF module!

Setting the alarm

After the clock is set and is running, the alarm time can be set. The clock continues to run in the background while the alarm is being set. However, the DCF module is temporarily not used as long as the alarm is being set. This is not a problem, since the clock is crystal-controlled and thus runs quite accurately using its own internal timing. (Note that many battery-operated DCF clocks synchronize themselves with the DCF time only once per day, in order to save energy. This is usually sufficient to maintain the desired level of accuracy.)

To set the alarm time, first press S3. Either all LEDs will go out, or they will indicate the last-entered setting for the alarm time (including the day of the week).

All three pushbuttons have double functions for setting the alarm time, depending on how long they are pressed — either briefly (up to 0.6 second) or longer (more than 0.6 second). The alarm time is specified in hours and minutes. The functions of the switches are as follows:

S1 short:	increment the hour
S2 short:	increment the minute
S3 short:	increment the weekday
S1 long:	switch the alarm on or off
S2 long:	program the weekday
S3 long:	return to the time display

Each time S1 is pressed, the alarm time in increased by one hour. S2 sets the minute of the alarm time in a similar manner, and S3 the day to which the alarm time applies. The first time S3 is pressed, the LED belonging to Monday starts to flash. If the alarm should only be active on this day, press S2 until the flashing weekday lamp stays on continuously. To program more than one day in the week, use S3 to increment the weekday count and then S2 to select the day. If the weekday count rolls over from Sunday to Monday, all daily programming is erased and you will have to start over with selecting the day(s).

The last position of the cursor is saved when the clock is returned to the time display mode. This makes it possible to add other days to the program at some later time. Finally, press and hold S1 to activate the alarm function. The lamp built into S1 will illuminate. To terminate the alarm setup procedure and return to the normal time display, press and hold S3. When the alarm goes off, you can silence it by pressing S3.

The alarm output itself is a logic-level output that is connected to a switching transistor and a d.c. beeper. If desired, a sound-effects generator, a relay or some other type of circuit could be connected to this output. In some cases it may be necessary to connect a buffer to the output. There are lots of ways you can experiment with this unusual clock.

(990076-1)

Text (Dutch original): H. Steeman
Design editing: K. Walraven

COMPONENTS LIST

Resistors:
R1,R2 = 47kΩ
R3=220Ω
R4,R5,R7 = see text
R6 =10kΩ
R8 = 1kΩ8
R9 = 1kΩ
R10 = 4kΩ7

Capacitors:
C1 = 4µF7 63V radial
C2 = 4-22 pF trimmer
C3,C4 = 47pF
C5,C6,C7 = 100nF
C8 = 1000µF 25V
C9 = 10µF 25V radial

Semiconductors:
D1,D46,D47,D48 = LED, high eff., green
D2-D40,D56 = LED, high eff., yellow
D41-D45,D50-D55 = LED, high eff., red
D49 = 1N4001
T1 = BC557B
IC1 = AT89C2051-12PC (order code **996519-1**)
IC2 = ICM7218**A** IJI
IC3 = 7805

Miscellaneous:
JP1 = 2-way jumper
K1,K2 = 20-way boxheader
Two 20-way sockets and a piece of flatcable
S1,S2,S3 = pushbutton ,type ‘Digitast’ with integral LED (ITT Schadow)
X1 = 12 MHz quartz crystal
Bz1 = dc buzzer, 5 or 6 V
Heatsink for IC3 (15 K/W, e.g., ICK35)
PCB, order code **990076-1**
Optional: DCF-module (Conrad Electronics order code 64 11 38-55)

The Rhine Tower clock on the Internet

If you are interested in the Rhine Tower and its clock you may find a lot of interesting information on the Internet. For example, a Windows screensaver based on the Rhine Tower can be found at http://www.duesseldorf.de/tourist/download/index.html.

A site that is based on the theme of clocks can be found at http://www.hsp.de/~wiegels/programm/uhren.htm. Naturally, software that emulates the Rhine Tower clock is available at this site.

If you want to know more about the Rhine Tower itself, the site ‘Höhe Türme’ (‘high towers’) is certainly something for you. Go to http://www.hsp.de/~wiegels/tuerme/hoch.htm to see all the information that is available regarding this high tower (and others).