SOLID-STATE DISK

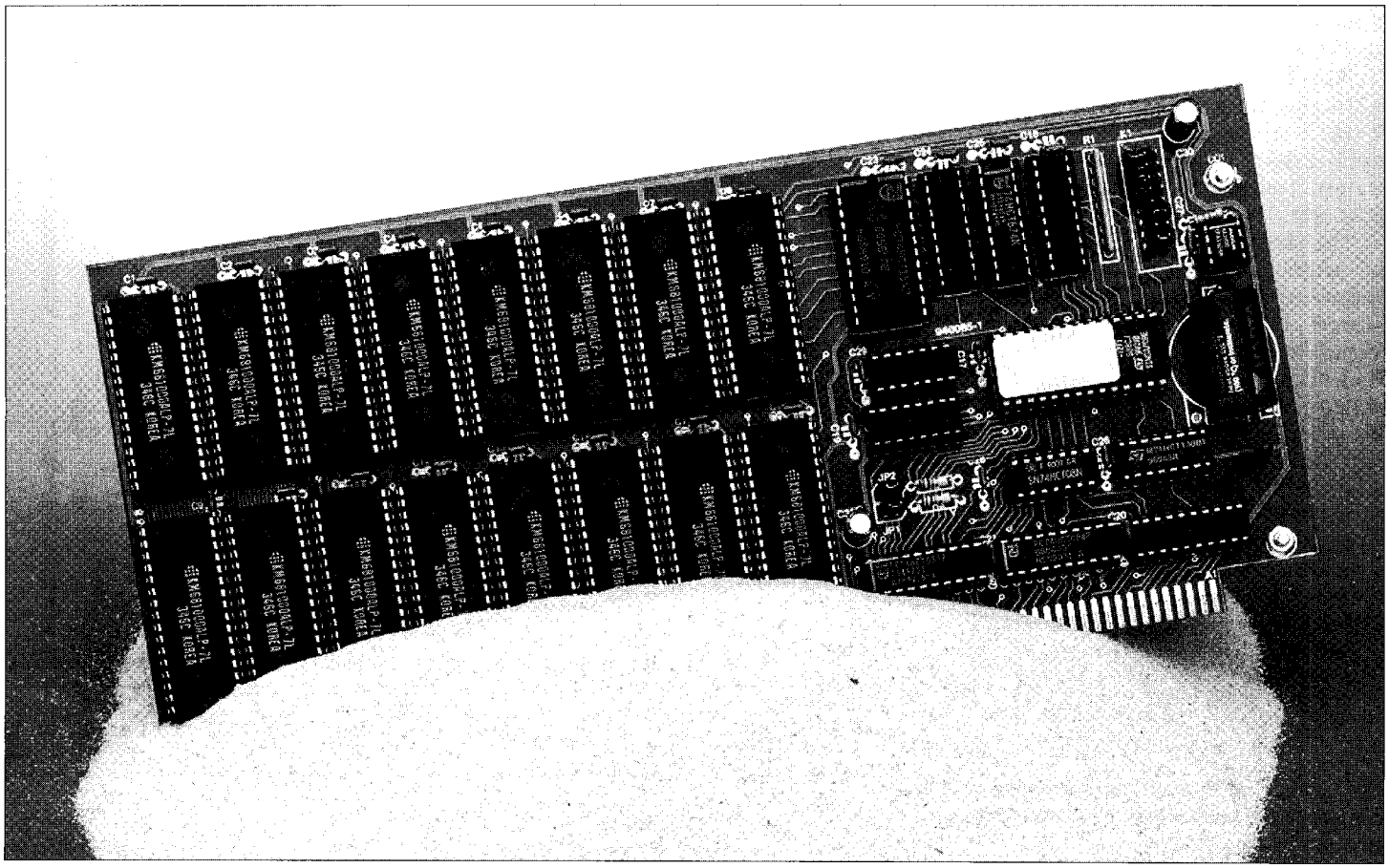
Practically all of today's PCs have a hard disk and one or more floppy disk drives. These 'media' allow the computer to load the files it needs to run a certain program. Unfortunately, there are circumstances in which the use of these magnetic/mechanical media is problematic. In cases where shock, vibration, large temperature variations or an otherwise electrically hostile environment force you to turn away from the 'usual' disk drives, the solid-state disk discussed in this article is a very good alternative.

Design by B. Yahya

ALTHOUGH much larger media are pressing at the gates, the floppy disk is still the most popular portable information carrier. A DOS formatted 3.5-inch floppy disk has a capacity of 1.44 MByte, which is, in principle, enough for the MS-DOS operating system and one or two small application programs. The main disadvantages of the floppy disk are the relatively low data transfer speed, and the risk of data corruption. Also, a diskette is easily lost or stolen. Like the drive unit of a hard disk, the floppy disk drive is a mechanical system with read/write heads and motors. Unfortunately, mechanical parts are subject to wear and tear and eventual breakdown. Furthermore, additional safety precautions have to be taken where a floppy disk drive is used in environments with a high explosion risk. The danger is caused mainly by the tiny sparks which occur in the drive motor.

MAIN SPECIFICATIONS

Application:	in any MS-DOS PC
Capacity:	max. 2 MByte
Disk emulation:	1.44 or 2.88 MByte
Memory type:	static
Data buffer:	Lithium battery
I/O addresses:	300H, 308H, 310H or 318H
BIOS:	in EPROM
Software:	not required
Hardware:	8-bit insertion card



The solid-state version of the floppy disk drive is a plug-in board containing static RAMs and memory backup battery. Arguably, it is totally free from the above disadvantages. It is quiet, fast and easily protected against corruption of data. Also, being secured inside the PC, the solid-state disk is not so easily lost or stolen.

The solid-state disk may be configured such that it can be used to 'boot' the computer, i.e., it acts as a disk from which the PC loads its start-up software. With the correct software installed, the PC starts automatically from the solid-state disk after every reset. A write protect switch on the board makes unauthorized modification of the data contained in RAM far from easy. That also adds to the reliability of the PC, enabling it to log in straight away on a network. Another application where a solid-state disk has the edge over the more traditional magneto-mechanical media is remote logging, for instance, in an automated weather or air quality monitoring system.

Circuit description

The structure of the solid-state disk is relatively simple. Static memory devices are used to create a RAM bank of 2 MByte. A section of 1.44 MByte is allocated to the RAM disk function, the rest is freely available. In principle, it is even possible to use the full 2 MByte simply by configuring the solid-state disk as a diskette with a capacity of 2.88 MByte. This works as long as you, the user, ensure that no more than 2 MByte is written to the disk. Although an error report is generated if the 2-MByte limit is exceeded, many application programs will unfortunately prove unable to handle this properly.

The circuit also contains an EPROM in which all relevant BIOS (basic input/output system) information is stored. These BIOS routines serve to simulate a mechanical diskette station. The solid-state disk is therefore called just like an 'ordinary' disk drive by interrupt routine 13H. That interrupt has three basic functions: reading a sector (02); writing a sector (03); and formatting a sector (05). Those BIOS routines that have no relevance for the solid-state disk contain only a return instruction reporting 'OK' (C=0; AH=0). This enables the computer to actually

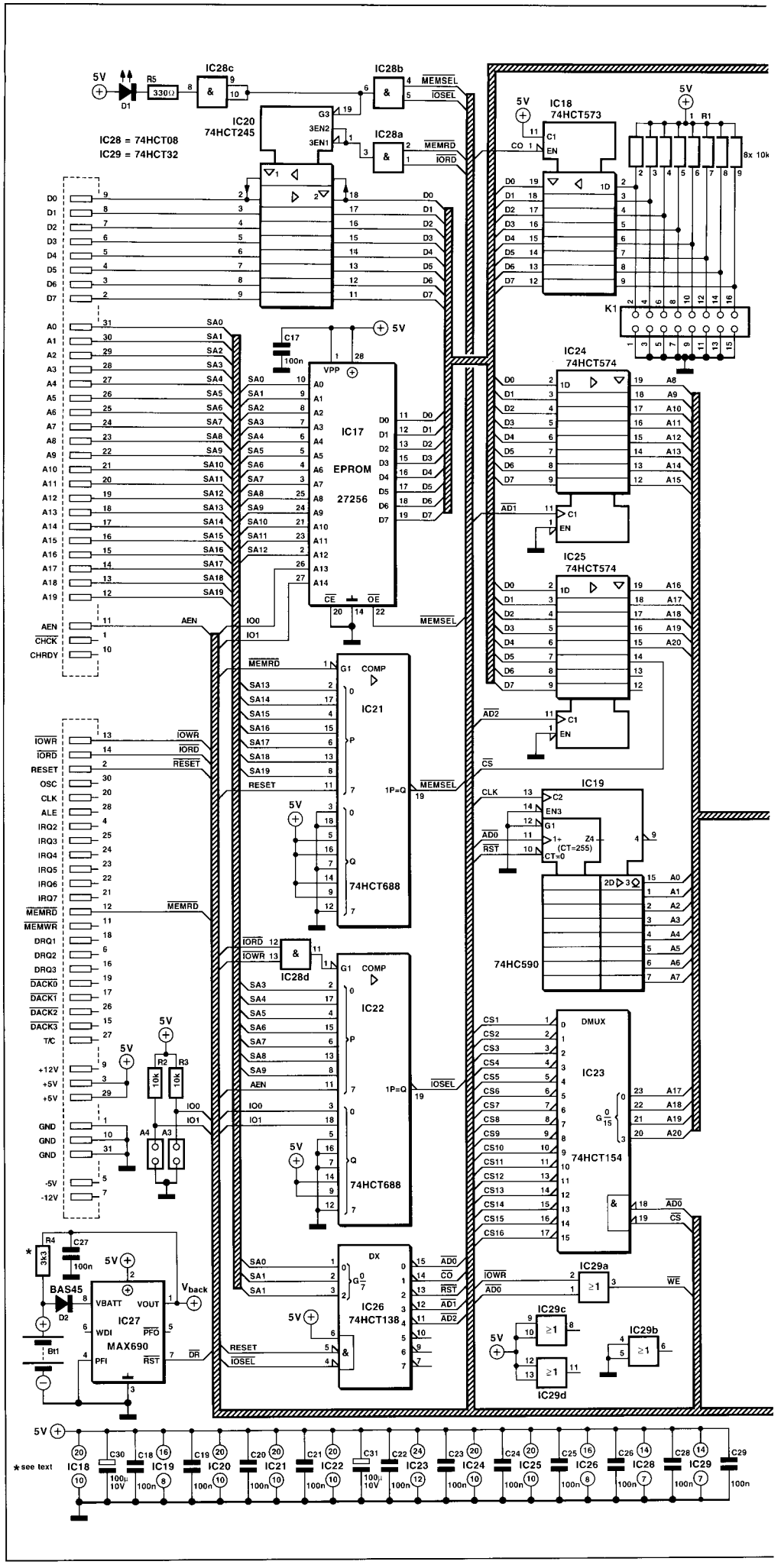
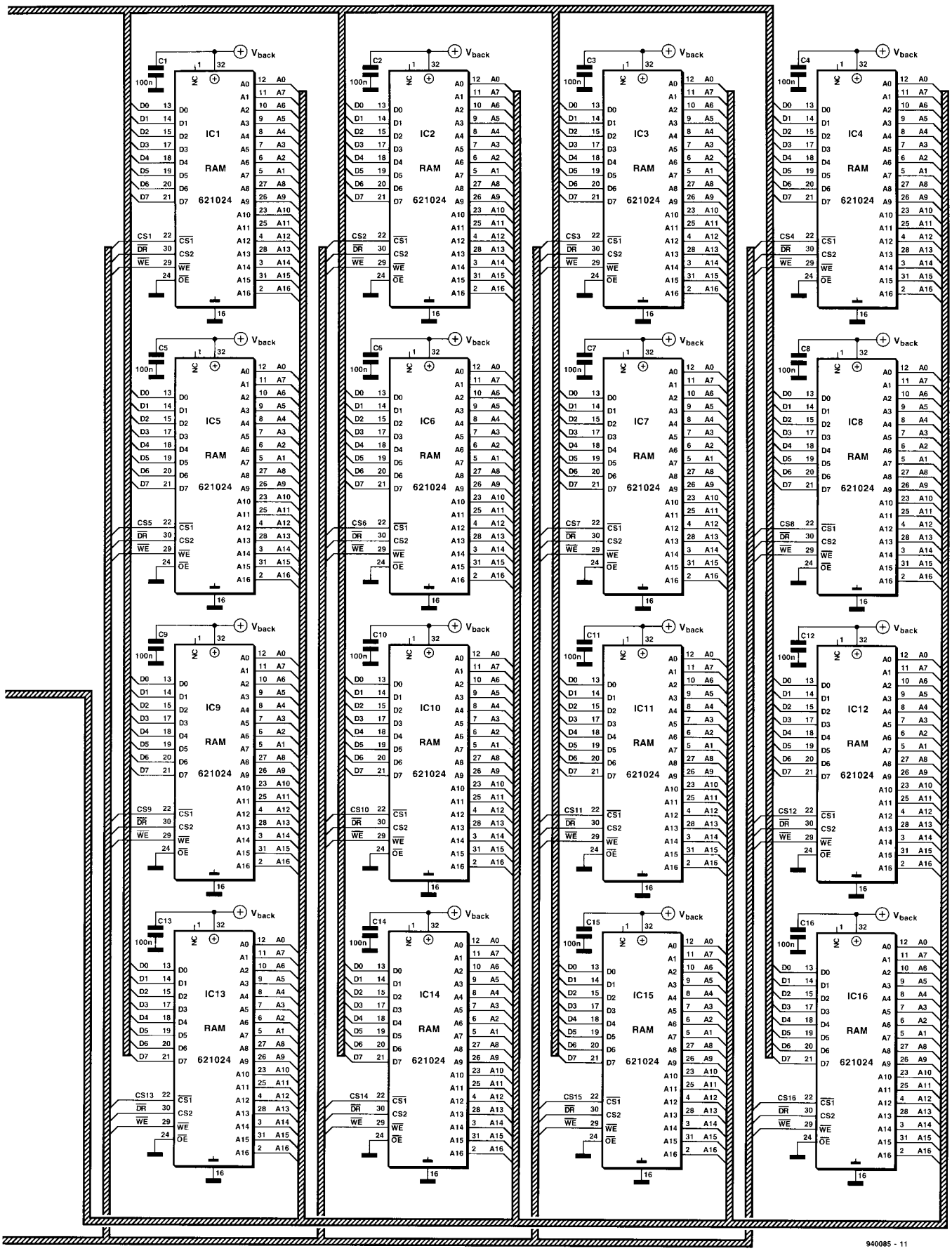


Fig. 1. Circuit diagram of the solid-state disk card. Note the huge memory bank consisting of static RAMs.


Vback
100n
IC1
IC2
IC3
IC4
IC5
IC6
IC7
IC8
IC9
IC10
IC11
IC12
IC13
IC14
IC15
IC16
RAM
621024
940085 - 11

'boot' from the solid-state disk.

The circuit diagram of the solid-state disk is given in **Fig. 1**. The striking element in the drawing is, of course, the RAM bank which consists of 16 ICs with a capacity of 128-KByte each.

With the exception of the BIOS ROM, the entire circuit is addressed in the I/O range. The base address of the card may be set to 300H, 308H, 310H or 318H with the aid of jumpers. In addition to the space occupied by the BIOS ROM, the card uses five memory locations, namely (base) through (base+4). The BIOS ROM is addressed in the memory block between D8000H through D9FFFH.

Nine ICs are used to couple to card to the PC's extension bus. Three of these, IC_{21}, IC_{22} and IC_{26}, perform the address selection. IC_{21} and IC_{22} are comparators type 74HCT688. The databus is buffered by IC_{20}, a 74HCT245. The BIOS ROM address is selected by IC_{21}, while IC_{22} and IC_{26} fix the I/O address assigned to the card.

Some tricks are in order to be able to read the memory bank whilst emulating a mechanical (floppy) disk drive. A floppy disk is usually partitioned in sectors of 256 bytes each (each of the 80 tracks on a 3.5-inch diskette has either 18 or 36 sectors). These 256 bytes are read in succession by issuing an equal number of read pulses. This system is mimicked on the solid-state disk. The 256 read pulses are used to enable IC_{19}, a synchronous 8-bit counter, to drive the lower-order eight address lines. The higher-order address lines are supplied by IC_{24} and IC_{25}.

Circuit IC_{18} has a key function in the circuit, because it reads the eight configuration bits set by the user with the aid of jumpers. Note, however, that the software set-up uses only four of these eight bits.

To address a memory location on the solid-state disk, the desired address is copied into two latches, IC_{24} and IC_{25}. Addresses (base+3) and (base+4) are available for that purpose.

Base:	read/write to/from RAM memory; increment sector counter
Base+1:	read configuration bits
Base+2:	reset sector counter
Base+3:	set A8-A15
Base+4:	set A16-A20 and CS

Table 1. Solid-state disk card addresses.

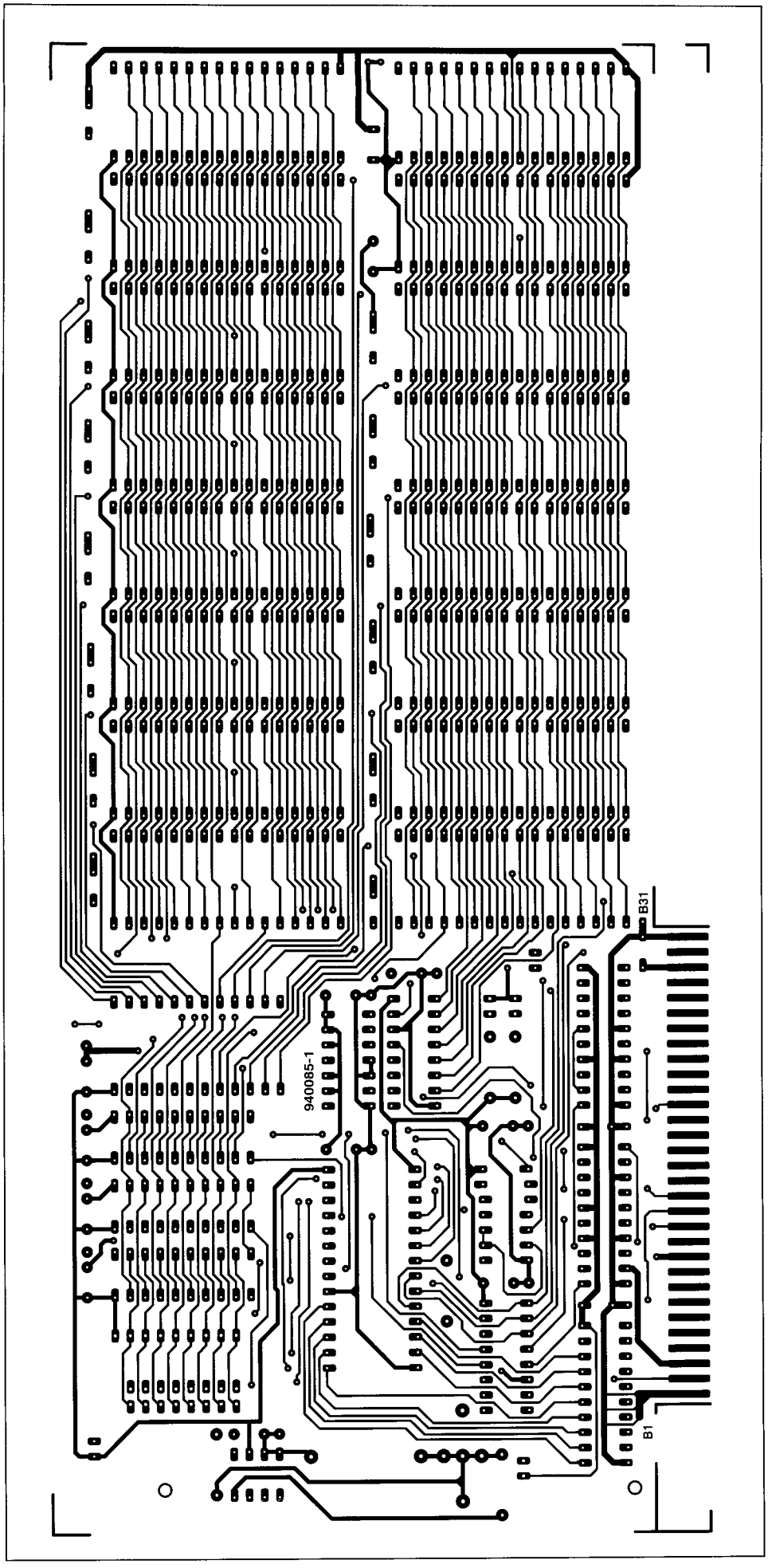
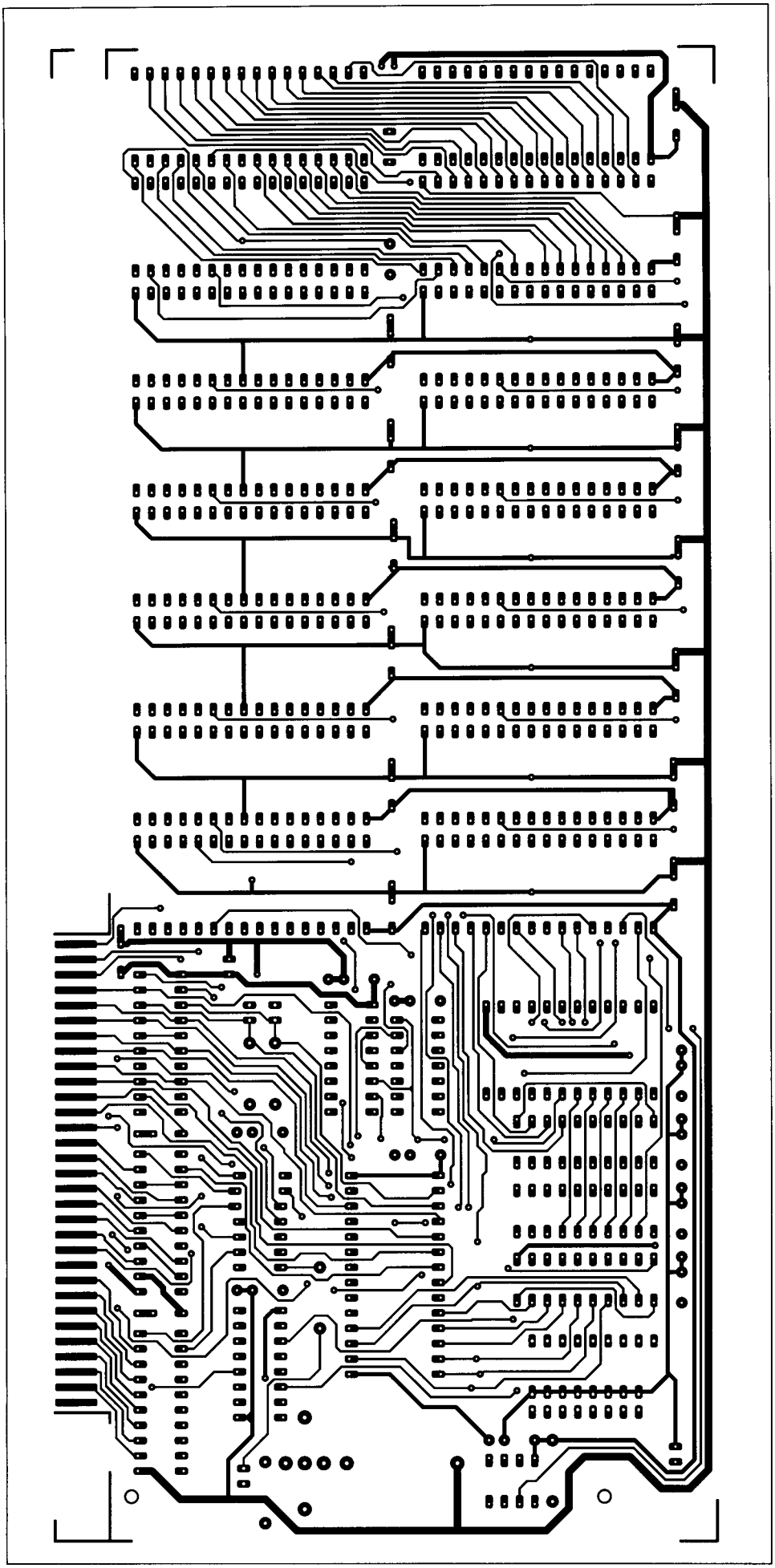


Fig. 2a. Track layouts of the double-sided, through-plated printed circuit board. This board is



available ready-made, see page 70.

Writing to address (base+2) causes 8-bit counter IC_{19} to be reset. As soon as the address is copied into the latches via the PC's I/O connection, the information from the selected sector can be requested by sending out a series of read pulses.

The individual memory components are selected via IC_{23}, a type 74HCT154. This IC generates a selection signal on the basis of the highest address lines of the memory chips.

An important function is reserved for IC_{27}, a type MAX690. This 'watchdog' IC continuously monitors the supply voltage, and ensures that the write protection is actuated via the $\overline{DR}$ signal when the supply voltage drops below a certain minimum level. The write protection then prevents the contents of the memory being changed. Next, battery Bt_1 takes over the supply of the memory via diode D_2. The specified battery guarantees a safe storage period of three years. The watchdog IC also ensures that all memory components are enabled again when the supply voltage is restored. Resistor R_4 has a function if a NiCd (Nickel-Cadmium) battery is used for Bt_1. It is omitted if a Lithium battery is used.

Finally, LED D_1 has the same function as the light on the front panel of any diskette station. The LED lights whenever the solid-state disk is selected, indicating that the computer is busy with a read or write operation on the RAM disk. If you use a high-efficiency LED in this position, you are sure not to miss even the shortest read/write pulses.

Construction

Although the circuit looks quite sizeable, construction is by no means a long-winded affair. Anyone capable of soldering accurately should be able to produce a working copy of the card. The track layouts and component mounting plan of the printed circuit board are shown in **Fig. 2**. Since the board is double-sided and through-plated, it is not recommended to make it yourself. Moreover, to prevent serious problems, the integrated connector should fit very accurately into the PC's extension bus slot. The ready-made board supplied through our Readers Services comes with gold-plated contact fingers for the best possible connection to the extension slot contacts.

In view of the cost of the memory components on the board it is recommended to use IC sockets for the RAMs and the BIOS EPROM. Start the construction by fitting these sockets. Next, do the passive parts, taking good care to observe the polarity of the electrolytic capacitors. The ICs are fitted

COMPONENTS LIST

Resistors:
R_1 = 8-way 10kΩ SIL resistor-array
R_2,R_3 = 10kΩ
R_4 = 3kΩ3
R_5 = 330Ω

Capacitors:
C_1-C_{29} = 100nF
C_{30},C_{31} = 100µF/10 V

Semiconductors:
D_1 = high-efficiency-LED, dia 3 mm
D_2 = BAS45
IC_1-IC_{16} = 621024 or KM681000 (1 Mbit static RAM)
IC_{17} = 27256 (order code 946641-1)
IC_{18} = 74HCT573
IC_{19} = 74HC590
IC_{20} = 74HCT245
IC_{21},IC_{22} = 74HCT688
IC_{23} = 74HCT154
IC_{24},IC_{25} = 74HCT574
IC_{26} = 74HCT138
IC_{27} = MAX690
IC_{28} = 74HCT08
IC_{29} = 74HCT32

Miscellaneous:
K_1 = double-row 16-pin header. Jumpers as required.
Bt_1 = ER 1/2 AA (Varta).
1 cover bracket type KHPC L22833 (Eurodis Texim).
Printed circuit board plus BIOS EPROM: order code 940085 (see page 70).

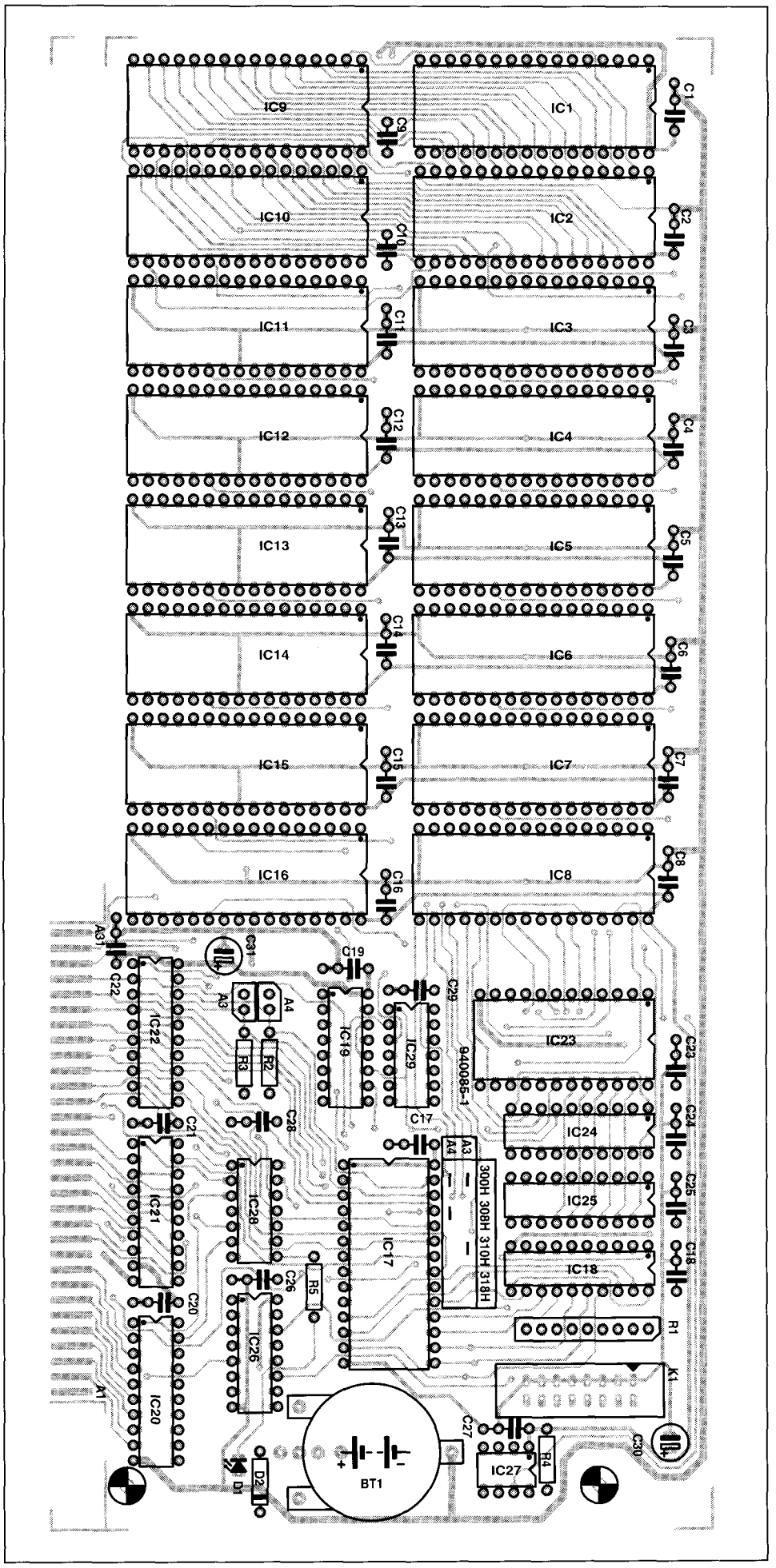


Fig. 2b. Component mounting plan.

last. Here, too, mind the polarity, because errors are easier made than found, paid for and corrected (in that order). Next, check for errors in your soldering work. If you are convinced that everything is in order, the mounting bracket may be fitted on to the PCB.

Setting up

The functions of the jumper options offered by K_1 are listed in **Table 2**. The default base address of the card (no jumpers fitted) is 318H. That address range is reserved for experimental circuits, and is usually free. If 318H is already occupied by another extension card in your system, relocate the solid-state disk to an alternative base address using the A3 and A4 jumpers. Alternatives are indicated on the component overlay printed on the circuit

B7	B6	B5	B4	B3	B2	B1	B0	
x	x	x	x	x	x	0	0	drive A:
x	x	x	x	x	x	0	1	drive B:
x	x	x	x	x	x	1	x	DOS selects number
x	x	x	x	x	1	x	x	18 sectors/track
x	x	x	x	x	0	x	x	36 sectors/track
x	x	x	x	1	x	x	x	read/write
x	x	x	x	0	x	x	x	write protect

x = don't care
1 = jumper not fitted
0 = jumper fitted

Table 2. Configuration bit functions.

board. A dash indicates that a jumper must be fitted.

Once the card address has been set up, the board is put aside for a moment. Do not yet insert into the PC.

Start the software configuration by informing the PC about an additional drive. Enter the structure of the drive into the CONFIG.SYS file. Use one of the following commands to do so:

```
driveparm=/D:00/F:07/H:2/S:xx/T:80
```

to assign the solid-state disk to drive A:, or

```
driveparm=/D:01/F:07/H:2/S:xx/T:80
```

to assign it to drive B:.

The parameter 'xx' indicates the number of sectors per track. It should be set to '18' to emulate a 1.44-MByte disk, or '36' for a 2.88-MByte disk.

If the computer already has two diskette drives, and you wish to add the solid-state disk, a DOS driver must be started. That can be achieved by adding the following line to the CONFIG.SYS file:

```
Device=\<DOS directory>\driver.sys
/D:n/F:07/H:2/S:xx/T:80
```

where n takes a value between 0 and 3.

Having added these lines, switch the computer off. Insert the solid-state disk card, secure the bracket, and close the case. The solid-state disk is not usable yet, because it has to be formatted first. That is done with the aid of the familiar 'FORMAT' command available under DOS. Despite the fact that the capacity of the drive has been fixed by the 'driveparm' instruction, it is still recommended to repeat the desired capacity. Do this by using the /F: parameter offered by the FORMAT command, as follows:

```
FORMAT B:/F:1440
FORMAT B:/F:2880
```

for a 1.44-Mbyte or 2.88-MByte emulation of disk drive B:, respectively. Evidently, the 'station' letter (B: in the examples) must be changed in accordance with the identification assigned to the solid-state disk.

If the solid-state disk is to be used in a PC which has no disk drives at all, it has to be formatted in another PC, and then loaded with the application software. Note that this requires the disk to be made 'bootable', which is achieved using FORMAT /S.

Finally, we repeat our warning that only 2 Mbyte of memory capacity is available even if the disk card is formatted for 2.88 Mbyte.

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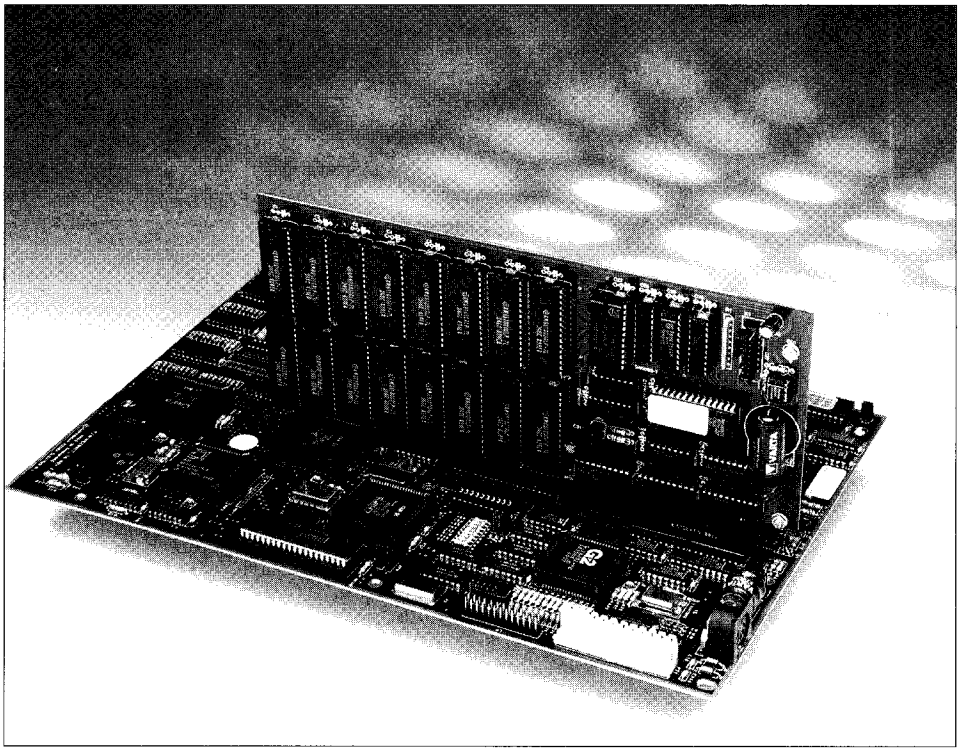

Fig. 3. Completed prototype of the solid-state disk card. mounted into an extension slot of a 386 motherboard. The key words are: no wear and tear, quiet operation, high speed and excellent reliability.

```
% md5sum 9466411.BIN
cc8fb396f51064f7469f6ad7547350d3  9466411.BIN
% zip -r 9466411.zip 9466411.BIN
  adding: 9466411.BIN (deflated 98%)
% base64 -i 9466411.zip
UEsDBBQAAAAIAJa0klqD0n9DJgMAAACAAAALABwAOTQ2NjQxMS5CSU5VVAkAA+vFAmj4xQJod
XgLAAEE9QEAAAQUAAAA7dndS1NhHAfw59lZe4kazrpoEXku1Cxo1OhGISptlDnWnE63ScpQyZ
Wo7OWim0gsCRexm/4A8UYiqGAXuou0tKTCyC7M6CYl8sjRFRQ6NVxnL5ZtC0Ud0/
h+Dpxt5zzn9z08V4Ov6b6Yp94eQu6OLXTqSBcRdepJl0jUo6BdOnJHoSeLT44QLoe8tthcjuY
mey1bZm+01zY3HT1rd15lKzTqY2xe7WH2eH6+hvxUP7jZ75L4FMMZ/
I8Bg9FPmelusVvG673OHXyJ12ouNXieZvc/
lrzj2gc9QbPms+ebpW381MikZ6h9VDPLPPNnkrmJPiKam/
Rwxh7hc9wa3PPcSQuNhvCvLx6uumZgLXOy1zDHL2I8L756hvxiJuAnzMBi9JWzGWvBW5fEPHz
jlYiYy0oPVlSajBJDx2BOFhn51FclCjJBszqUE/
SRqd00fJZSLiPEPQz1Ejqde1taNDHfOkOoWxK+x5Ng6yihDkU0TcgRVvFjbe8Jdz38AD8c2yi
ZW2Y1+5j5qV4SFHaNzlvN3NASZwkvyu2QBv6aeu/fU/OiU4M+Md/
iFdbyVyLnusi52huXxuu8y2mal1zlEje1JDz+aFaIW/gdxx/yJov7EI7rDa/n34RXUa/
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QAABBQAAABQSwUGAAAAAAEAAQBRAAAAawMAAAA
%
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