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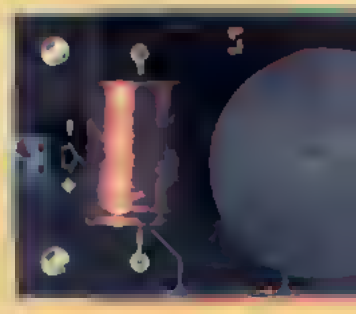

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Volume 3-Number 10

PUBLISHER: C R CHANDARANA
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PRODUCTION: C N MITHAGARI

ADVERTISING & SUBSCRIPTIONS
elektor electronics pvt ltd.
Chotani Building
52 C, Proctor Road Grant Road (E)
Bombay- 400 007.

DISTRIBUTORS.
Blaze Publishers & Distributors Pvt Ltd

PRINTED AT:
TRUPTI OFFSET
103, Vasan Udyog Bhavan,
Off Tulsi Pipe Road,
Lower Parel, BOMBAY 400 013

Elektor India is published monthly under agreement with Elektuur B V Holland. August/September is a double issue

SUBSCRIPTION
INLAND
1 Yr Rs 75/- 2 Yrs Rs 140/- 3 Yrs Rs 200/-
FOREIGN
One year Only
Surface mail Rs 125/- Air mail Rs 210/-

INTERNATIONAL EDITIONS EDITOR P. HOLMES

Dutch edition	Elektuur b.v. 6190 AB Beek (L). The Netherlands
German edition.	Elektor Verlag GmbH, 5133 Gangelt, W Germany
English edition	Elektor Publishers Ltd Elektor House, 10 Longport, Canterbury CT1 1PE, Kent, U.K.
French edition:	Elektor Sarl, Le Seau, 59270 Bailleul, France
Italian edition	Elektor, 20092 Cinisello B., Italy
Spanish edition	Elektor, Av. Alfonso XIII 141, Madrid 16
Greek edition	Elektor, Karaiskaki 14 Voula Athens
Turkish edition	Elektor Yayincilik ve Ticaret A.S. Karakoy Istanbul
Portuguese edition	Ferraire and Bento Lda R D Estefania 32, 1000 Lisbao Portugal

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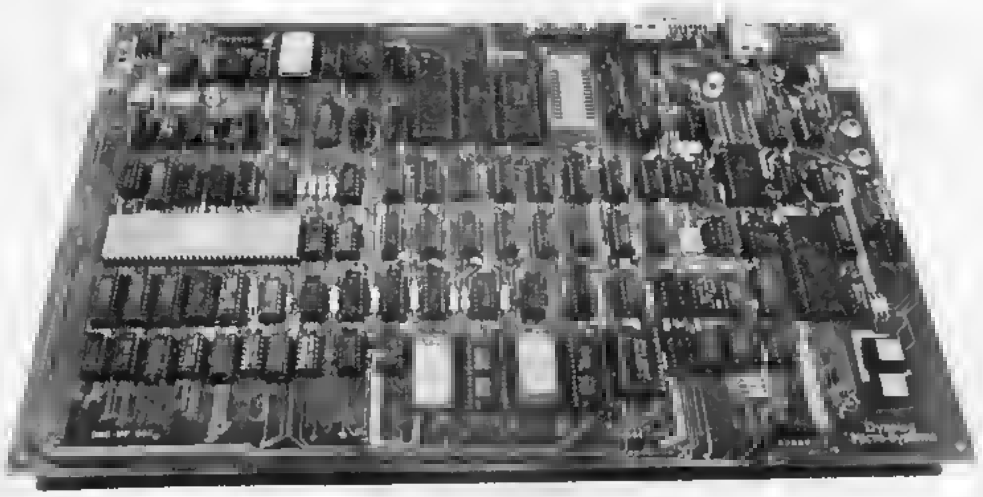

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PISCES/IN/322

electronics scene

ROW OVER NAMES

A controversy has arisen over the use of brand names for the colour television sets manufactured by multinational corporations in India The All-India television manufacturers have opposed the use of brand names by the foreign companies as it would give "an unfair competitive edge and undue marketing advantage to the foreign companies over the domestic manufacturers".

The prime minister himself has intervened in the matter and sought the views of the department of electronics He reportedly cited the example of Japan where foreign brand names were scurpulously avoided even though technology was imported at a very high cost As a result, Japanese brand names have become the household names.

The department of electronics has informed the prime minister that the multinationals cannot be legally prevented from using brand names in TV industry. If TVs are to be mass produced there is no alternative but to allow the use of brand names, says the DOE.

Accepting the views of his department, Mr. Shivraj Patil, minister of state for science and technology, told the Parliament that the policy of allowing foreign companies to use their brand names will not affect the local colour TV manufacturers adversely but "will take better care of consumer through improvement in quality and technology".

Industry sources point out that colour TV marketed under a foreign brand name is priced 60 per cent higher than a similar Indian set. The small manufacturers of colour TV sets, with a capacity to produce 20,000 to 50,000 sets, face stiff conditions from the government. They are not allowed to use foreign brand names and the sets will have to conform to the standards prescribed by the DOE. Repeated representations by the industry over the brand name issue has made the government to have a second thought on the matter.

SCIENTIST'S CONCERN

Liberalised policies on import of technologies announced by the government recently have caused concern among a section of the scientific community as it fears that this step may wipe out industries based on indigenous technology

The Council for Scientific and Industrial Research (CSIR) which has the main task of import substitution and indigenisation may fall on the wayside in the race for acquiring foreign technology

In the field of electronics, which lops in foreign collaboration, every Indian company is frantically searching for new products and partners from abroad to survive. In the view of an electronics expert, employed with a state electronics development corporation, "the new policy has legalised smuggling". His fear is that our companies may give up R & D and turn into traders like in Singapore and Taiwan, thereby transforming screwdriver technology into label technology.

Some private firms and government undertakings like Semiconductor Complex Ltd., are not afraid of losing their business to foreign firms. Dr N Seshagiri, additional secretary in the department of electronics, defended the entry of foreign firms on the ground that it would provide competition, raise quality and bring down prices

KELTRON CHIEF

Mr. Javed Hassan, a laboratory director of International Business Machines Inc., USA, has been appointed executive chairman of the Kerala electronics development corporation. The earlier chairman, Mr.K.P.P. Namibar had relinquished his post to take over the chairmanship of the Indian Telephone Industries, Bangalore. The appointment has been made by the government of Kerala. Mr Hassan graduated from Trivandrum engineering college in mechanical engineering. He is said to be owning a company called Innovations Inc., in U.S.A.

HIGHER DEPRECIATION

The Union finance ministry has cleared a proposal for higher depreciation allowance to the electronics industry Mr. S.R. Vijaykar, secretary to the department of electronics stated that his department sought faster depreciation on machinery and equipment in the electronic units as the technology became obsolete at a faster rate compared to other industries

HARDWARE/SOFTWARE

Mr. Vijaykar, in a recent conference with newsmen discussed the computer policy in detail. A delegation of the Electronics Corporation of India Ltd., has visited Control Data Corporation of the USA and Bull of France for choosing the main frame manufacturing technology. The deal may be finalised by the end of the year

The department has so far approved only one tie-up for the manufacture of super mini computers while another six foreign collaborations are in the pipeline. According to his estimate, the demand for computers this years would be around 10,000 pieces.

On imports of computers, Mr Vijaykar said, popular brands which have been imported in the past few years would be allowed to be brought in and the Computer Maintenance Corporation of India should have the expertise to service them.

The government has recently cleared a proposal of the Texas Instruments to set up a software development unit for 100 per cent export. The unit will have an earth station and satellite links to ensure co-ordination with the master computer installed in the USA

Commenting on the prices of mini computers manufactured indigenously, the DOE secretary said they had come down by 50 per cent but still domestic prices were 30 to 40 per cent higher than the international prices.

Mr. Vijaykar opined that the emphasis should now shift from data processors to process control systems and in the Indian context, investments should be made in the latter category for improving productivity.

VCR PRODUCTION

Five leading companies from Japan and Europe are keen on entering VCR manufacture in India and a high-level team has since returned after evaluating the capabilities of these companies The final choice of the collaborator may be made before the end of the year.

It is learnt that all the five contenders agreed for equity

electronics scene

participation under the FERA guidelines and for the transfar of VCR manufacturing technology Tha government has, in principla, dacidad to manulacture the tapadack centrally by one joint sector company while manufacture of components and assembling may ba givan to other privata units. Earlier indications wara that Hindustan Machine Tools may be asked to manulactura tha tapadack but this decision has not yat baan confirmad

The departmant of alactronics has astimatad that the demand for VCRs would ba around thraa lakh piecas par annum. Initially, the tapedecks would be brought in CKD condition and assambled hera. The Electronics Trada and Technology Devalopmant Corporation has baan antrustad with the job of selecting tha VCR tachnology.

Currently, a large numbar of TV manufacturers are importing the components of VCR, assembling them and salling them under their brand names. The ratail price varias from Rs. 14,000 to Rs. 18,000 per set. The government's intantion is to make the VCRs available at the rate of Rs. 5,000. But, to achieve this, tha axisting customs duty must be drastically revisad for the component industry

WAR OF CHIPS

The chips ara down. The United States and Japan ara angagad in a relentless trada war over the "chips". These two countries produce 90 per cent of tha world's samiconductors.

In an already daprassad market, the two countrias ara fighting to survive now and a dacade hence, in the market of computars and telecommunication equipment, which run on chips

This yaar, tha world sala of samiconductors is likely to shrink by 15 par cant to 22 billion dollars from last yaar's sale of 26 billion dollars, 46 per cant higher than the sale of 1983.

Tha Economist, quoting Mr. Dan Kleshen of Montgomery Securities in San Francisco, says that Amarican salas will be down by 25 per cent to 8.7 billion dollars. The depression has baen caused partly by low demand, particularly from makers of personal computers Falling prices is another big factor.

American chipmakers complain that they are unfairly excluded from the Japanese market and that the Japanese ara investing to buy market share at any cost.

America's trade daficit with Japan in integrated circuits, was 900 million dollars in 1984 as against 350 million dollars in 1983. Once Japanese equivalents become available, hitharto flourishing sales of American chips dwindle. Incidentally, Japanese chipmakers and users are mostly tha same companies. Howaver, Taxas Instruments in Japan has a casa apart as this is an American success story

A new comer in tha field is LSI Logic, a silicon valley manulacturer of semi-custom chips. It has set up a Japanese subsidiary callad Nihon LSI Logic which will build a 100 million dollar silicon wafer plant in collaboration with Kawasaki Steel.

SALES BLOCKED

The proposals of a number of Indian organisations for importing American computers have bean blocked by the US commerce department. Import of 21 large American computers for use by the government departments and public sector undertakings and 17 similar computers for use by the R & D and educational institutions have been cleared by the departmant of electronics, over a period of two years But these are pending for want of axport clearance from the US commarca departmant

The reason for the delay is that tha US government is asking for tha and-user assurances which is under negotiation between the two governmants

AI CONFERENCE

A consortia of Artifical Intelliganca (AI) associations recantly organisad tha International Joint Conference on Artificial Intelligence at tha Univarsity of Califlornia in Los Angales The conference had over 5,000 participants as against 1,500 in the previous conference

Incidentally, the inaugural tutorial for the conference was given by Dr. Raj Reddy of the Carnegie Mellon University The programme chairman of the conference was also an India-born professor of computer science at the University of Pennsylvania, Dr. Arvind K. Joshi.

The largest contingent of participants was from Japan which had 300 membars. Tha conference paved way for a possibla major collaboration betwaan Japan and tha US in machine intalliganca. Over a dozan Indian experts, settled in tha US presented papars during tha conlarance.

LASER PRINTING

Printing industry in India is adopting modarn technologias but rather slowly. Only about six or seven publishing housas in tha country have the latest laser-based printing technology.

Mr. Devak Crockatt, chairman of the British faderation of printing machinery and supplias, who is also the general sales manager of Monotype corporation Ltd , has statad that this company was offering its most succassful and popular Lasercomp-Mk-2 to India. This system can automate typesetting, layout, sub-editing and other functions, apart from providing graphics.

The Winchester-based systam can be modified to handle work in languages like Chinese, Arabic, Urdu, Hindi, Malayalam and others. Over 600 such systems have been installed by tha corporation all over the world and a majority of the usars are newspaper publishers

SOVIET SUPER COMPUTER

The Soviat Union has started commercial production of PS 2000 computers, capabla of performing 200 million oparations per sacond.

Unlike tha Amarican systam basad on the "flow-line lasion", tha Soviats have usad concept of "collactivist principla". In tha lastest computars of the US, procassors responsibla for individual operations ara placed along tha assembly lina, with data passing the whola langth of it irraspective of how many procassors will be at work on it. The Russians proposad tha collactivist principle, enabling all computers to be subordianted to a singla control system, leaving certain amount of freedom and ability to sort out their data. Altar receiving a general command, the processors jointly set about handling a homeogenous operation, then switch ovar to another and so on, until the task is fully resolveo.

electronics select

Radio system signals savings on rural railways

In the far northwest of Scotland, on the single track railway that winds through magnificent mountain scenery to the Kyle of Lochalsh, the installation of electronic signalling will lead to significant improvements in the economics of rural railways. By eliminating the need for 20 signalmen and level crossing keepers on the 103 km line, the new system, known as radio electronic token block (RETB) signalling, will reduce operating costs by some £77 000 a year. This is big money for a railway that depends for most of its income on tourists during a short summer season, and will make all the difference to the line's precarious finances.

Sparsely Populated Region

Britisch Rail is pioneering the new signalling system as part of a major programme to increase traffic and cut costs on the lines running west and north from Inverness. These are routes vital to the economy of a sparsely populated region, and they absorb a hefty slice of the public service obligation subsidy British Rail receives from the government.

Installed at a cost of £415 000, and with a 30% grant from the European Community, the RETB system in practice should cover its investment within two years. In the longer term, its introduction will save British Rail the £500 000 cost of cable renewal that would have been necessary to maintain the existing signalling system.

Modern power signalling has been extended to cover many of British Rail's main lines over the past 20 years, bringing improved safety and reliability, as well as reduced costs. But shortage of investment funds has meant that lightly used rural routes have not felt the benefit of the rapid technological progress recently achieved in signalling installations. Now all this is changing, as the labour intensive mechanical signalling on such lines wears out and new economic pressures demand a reduction in the number of staff needed to operate their sparse services.

On the Kyle of Lochalsh line, RETB equipment replaces the single line key token system, which is a method of ensuring the safe passage of trains on single track railways that dates back to the last century. Under this system, single lines are divided up into sections of varying lengths, with signalboxes at the crossing loops — sections of double track on which trains may pass. Of course, it is essential that only one train at a time is admitted to any single track section, and this is assured by electromechanical apparatus interlocked with the signalling equipment

Authority To Proceed

Before he can proceed into a single track section, the drain driver must receive from the signalmen a metal token or authority. No more than one such token can be released from the key token instruments in the signalboxes at each end of the single track section, and only when that token has been freed electrically from the next signalbox can the signalman clear his signals for tha train to proceed. Until the token is replaced in the machine at tha next crossing loop, no other token can be released, and no train movement can be signalled from either direction.

Communication between signalmen and their key token instruments is achieved electrically by the use of bell codes and currents passing in an openwire pole route. The system has been proved over many years, and is widely used in countries where there was strong British influence in railway development. Its drawbacks are the need for a signalman at every crossing loop, and the burden of maintaining pole routes in unfavourable conditions. Both are costly.

The RETB system was developed by British Rail's Director of Signalling & Telecommunications Engineering, in conjunction with the Research & Development Department at Derby, and with some financial assistance from the European Community. Equipment was supplied by Westinghouse Signals.

Recent developments in microprocessor technology and mobile radio have been harnessed to create a signalling system with built-in safety and security devices that give an overall level of safety as high as that of the key token system it replaces. There is no longer any need for lineside signalling or communications equipment, or for a signalman at each crossing loop. The entire route from Dingwall — to the northwest of Inverness — to the Kyle of Lochalsh is now controlled by one signalman located at Dingwall. Crossing loops at Garve, Achnasheen, Strathcarron, and Kyle of Lochalsh itself are unmanned. In all, a drastic reduction in both staff and infrastructure costs has been achieved.

The signalman at Dingwall communicates with train drivers over a radio link. This also provides communication between the signalbox microprocessor interlocking equipment and the train-borne receiver, which again is microprocessor based. When a train is ready to enter a single treck section, for example from the junction at Dingwall to tha first crossing place at Garve, coded messages are exchanged over the radio between the driver and signalman.

The driver requests authority to proceed to Garve and, once the microprocessor interlocking has proved tha line clear, he recaives it in the form of an elactronic display on the small raceiver mounted in his cab, showing the words "Dingwall" and "Garve". This is his electronic token, which remains illuminated until the driver "returns" it to the signalman when he is safaly inside the loop at Garve. The integrity of the message that passes by radio between signalbox and locomotive, as well as the assurance that the message goes only to the train for which it is intended, is achieved by transmitting the locomotive address and associ-

The signalman at Dingwall with his keyboard and track diagram.

ated information in the form of a data telegram. Each cab receiver unit has a unique, four digit number for verbal recognition and display purposes, and the data telegram is subjected to rigorous and sophisticated coding techniques to ensure that any corruption of the original message causes tha telegram to be rejected by the receiving microprocessor.
The signalman has in front of him a keyboard unit and a visual display of the whola lina. This shows him which sections are occupied, with the four digit receiver number appearing for identification purposes. A teleprinter records all keyboard entries, and voica traffic between signalman and drivers is tape recordad.

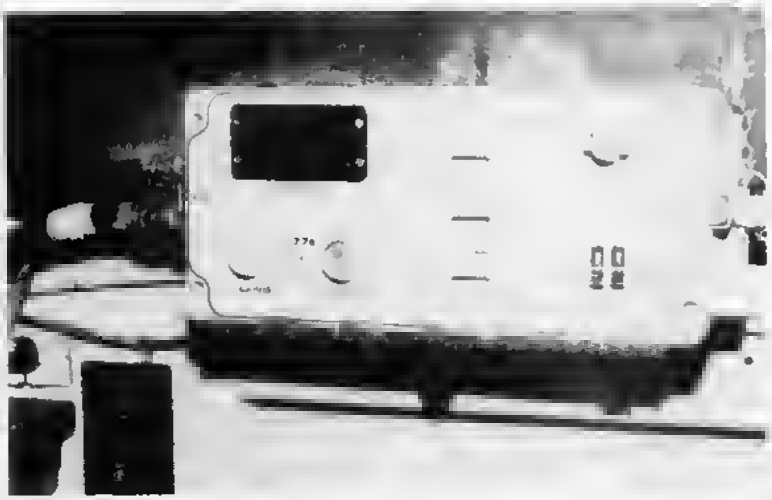
Enormous Benefit

The two way radio, of course, is availabla for communications at any time, and this is likaly to be of enormous benefit on a remote railway where formerly tha only means of communication for drivars was facato-face with signalmen at the crossing stations. As with any radio communications systam, strict attention is paid to tha use of correct — and limitad — terminology in voice traffic.
With the signalman eliminated at crossing loops, one problem remained to tha RETB planners. Who would operate the loop points? In fact, this has been solved in the simplest way, by making the points trailable. Points at each and of tha loop are held securely in position for the direction of travel, eligned for the left-hand track of the doubla lina section.
This is done by pra-pressurized, hydropneumatic rams, which also allow the point bladas to be pushed over, or trailad, by the wheels of a train moving in the opposite direction and leaving the passing loop. When a trailing movement is complete, the ram slowly restores the blades to their correct position for the next incoming train. An electronic detector proves complete closure of the point blades, at the same time actuating a yellow light indication to the driver that the points are correctly set.
As a train on a single line section approaches a passing loop, the driver first sees a reflective warning board, located at braking distance from the points indication signal. This allows him to come to a stop before the points should the signal not be displaying its yellow proceed indication. At the far end of the loop, protacting the trailing points, he encounters a reflective board bearing the words: "STOP obtain token and permission to proceed." Here the token request sequence begins again.

Automatic Crossings

After a trial period of working alongside the key token systam, the RETB equipment took over completely in October 1984 and has proved thoroughly satisfactory in operation. The entire installation will ba completad latar this year with the conversion of tha seven manned level crossings to automatic opan crossings with flashing warning lights. Already British Rail has obtained approval to extend the RETB system to tha line north from Dingwall to Wick and Thurso, which is a much longer route with more crossing loops. A version is elso going into servica later this year on the East Suffolk line in eastern England, whare RETB is providing an economic means of singling e double track route that has more than 20 level crossings.
The ability of the RETB system to cut operating costs is a highly significant development, and should ensure wider application of the equipment over the next few years However, the economic implications extend far beyond British shores. The key token system is still in use on many main lines outside Europe and North America, often in inhospitabla climatic and geographic conditions that make pole routa maintenance a nightmare. British Rail's achievement of a simple, microprocassor based interlocking for single lines should find a ready export market
Once installed, the RETB aquipment allows far greater flexibility in planning train movements than was possible with signalmen working fixed shifts. Although the Kyle of Lochalsh service consists of only thrae trains each way daily, tha new system makes it possible to schedula extra trains to run et any tima, whithout the need to arrange for costly overtime by signalmen.

Chris Bushell LPS (998 ES)



The electronic token eppeers on the duver's cab display

Did you know...

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and also...

.that there is a British Amateur Electronics Club and an Amateur Computer Club? Both clubs publish a regular newsletter and operate a *readers letters* service.

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intruder alarm

P Theunissen

a combination of infra-red and electronics technologies

With burglaries on the increase in most parts of the world, there is a growing demand for good, reliable, yet inexpensive, security equipment. Manufacturers of burglar alarms are convinced that there are many millions of people prepared to spend money — in many instances a great deal — to protect their property. The intruder alarm described in this article is intended for use with a number of infra-red movement detectors featured in the July 1985 issue of *Elektor India*, but can also work with other types of sensor.

The alarm uses a minimum of two printed circuits: one for the control circuits, and the other for the interfaces. The latter may be repeated a number of times if required. The interface board is designed to connect either two infra-red sensors or one infra-red sensor and an anti-tamper circuit to the control board. Other than infra-red sensors may also be used. To this end, each interface offers two operating conditions: (a) NO, in which the switching contact is normally open and closes when the alarm is triggered, and (b) NC, in which the contact is normally closed and opens when the alarm is triggered.
A delay has been incorporated which allows time between setting the alarm and vacating the property and between entering the property and disabling the alarm. In the latter case, a pre-alarm buzzer sounds and an LED lights to indicate that the alarm has been triggered. This arrangement is also very useful for testing the alarm. The LED remains on when the alarm has been set off.
The intruder alarm works off the mains, but a 12 V battery is included as back-up during mains failure.

Basic configuration

As soon as switch S_1 (preferably a key-operated type) in Figure 1 is closed, diode D_4 lights and monostable MMV_1 generates a reset pulse that triggers MMV_2 whose $\overline{Q}$ output then becomes logic 0. This logic level prevents an alarm pulse from interface I reaching monostable MMV_3, at least for the time being. When the alarm is in this delay phase, diode D_9 (see Figure 3) lights, but the alarm is not yet triggered. When MMV_2 toggles, D_9 goes out and MMV_3 is enabled. In this condition a pulse from interface I will trigger MMV_3 which causes its $\overline{Q}$ output to go low. This results in bistable FF_1 being set, diode D_3 commencing to blink, and a buzzer starting to sound: this is the pre-alarm phase. Only when MMV_3 returns to its stable state, i.e., after a further delay, is monostable MMV_4 triggered. The second delay makes it possible to enter the property and switch off the alarm before it has sounded. As soon as S_1 is switched off, D_3 stops blinking, MMV_3 is disabled, and the alarm is reset. The various pulses mentioned here are shown diagrammatically in Figure 2.

Circuit details

The pulses mentioned in the previous paragraph are also shown on the circuit diagram in Figure 3. Terminal 2 on this diagram is the input from the anti-tamper circuit. This line is one of the wires in the multicore connecting cable between the sensor and the interfaces board. This arrangement ensures that cutting this cable by a potential intruder does not disable the alarm, but rather the contrary,

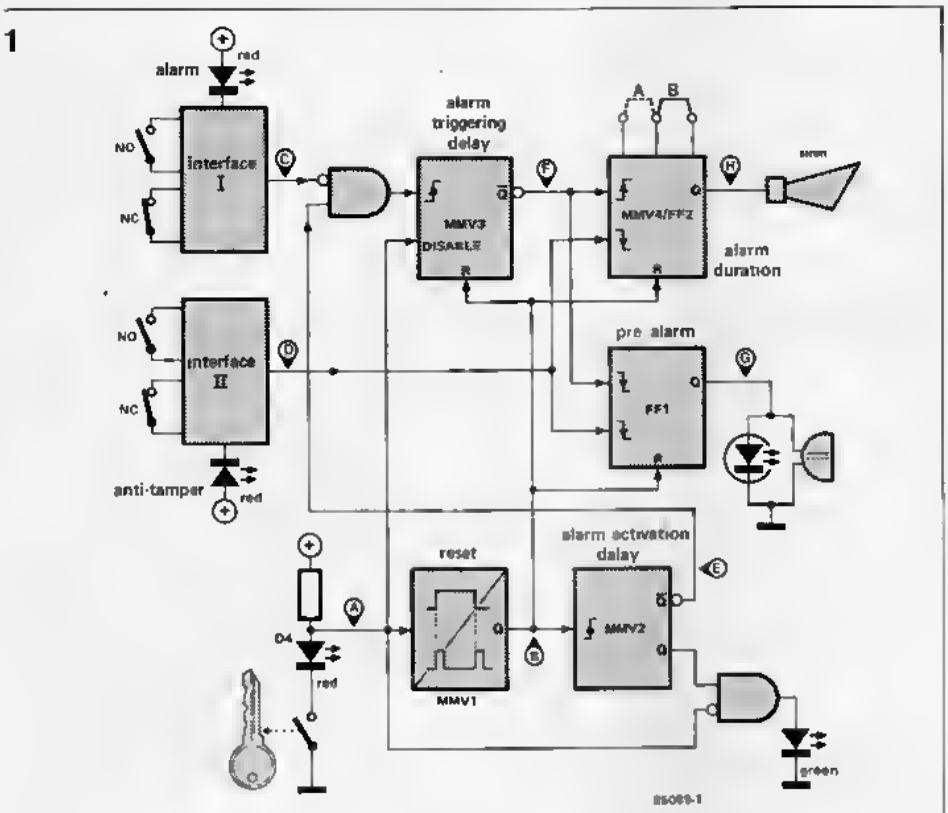
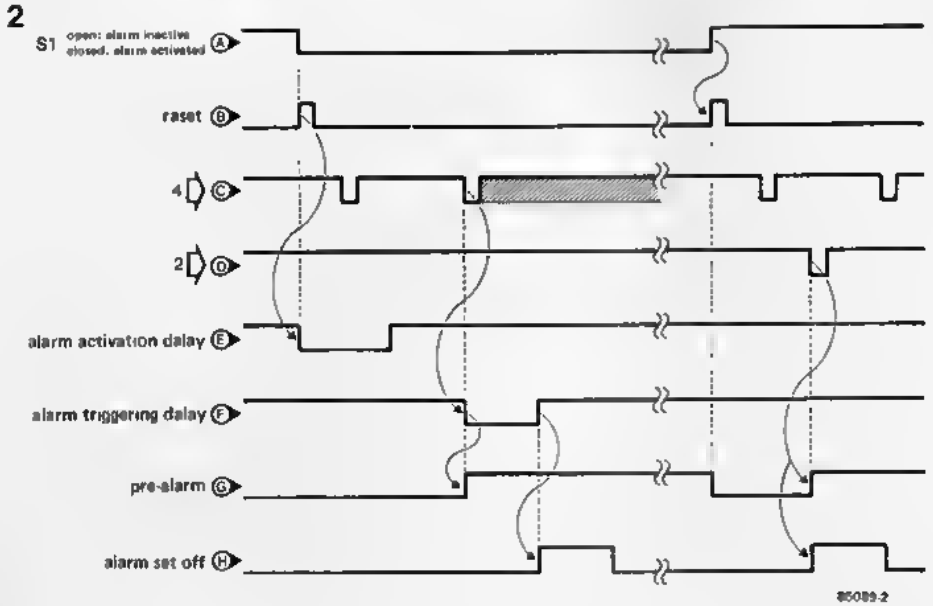


Figure 1 Block diagram of the intruder alarm with two interfaces.



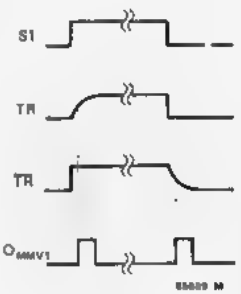


Figure 2 Pulse timing diagram.

because the anti-tamper circuit is connected direct to the board, bypassing switch S_1.

When a pulse from one of the sensors has arrived at the output of MMV_4, or bistable FF_2 has received a clock pulse from MMV_3, bistable FF_2 is set. Output Q then becomes, and remains, logic 1, which prevents MMV_4 being triggered again. At the same time, the output pulse is amplified in T_1 and then used to energize relay Re_1. At this instant the siren will sound.

The length of time that the relay remains energized may be preset between 10 seconds and 4 minutes by P_2. If link B has been made, the siren will switch off after this time has lapsed; the unit can only be reset by switching off S_1 and then closing it again. If, however, link A is used, the alarm will sound again and again until the unit is switched off. This arrangement ensures that the unit conforms to regulations in many areas where an alarm may not sound longer than three minutes and may not automatically switch itself on again.

Reset circuit MMV_1 generates a pulse at its Q output whenever S_1 is opened (rising edge at TR) or closed (falling edge at $\overline{TR}$).

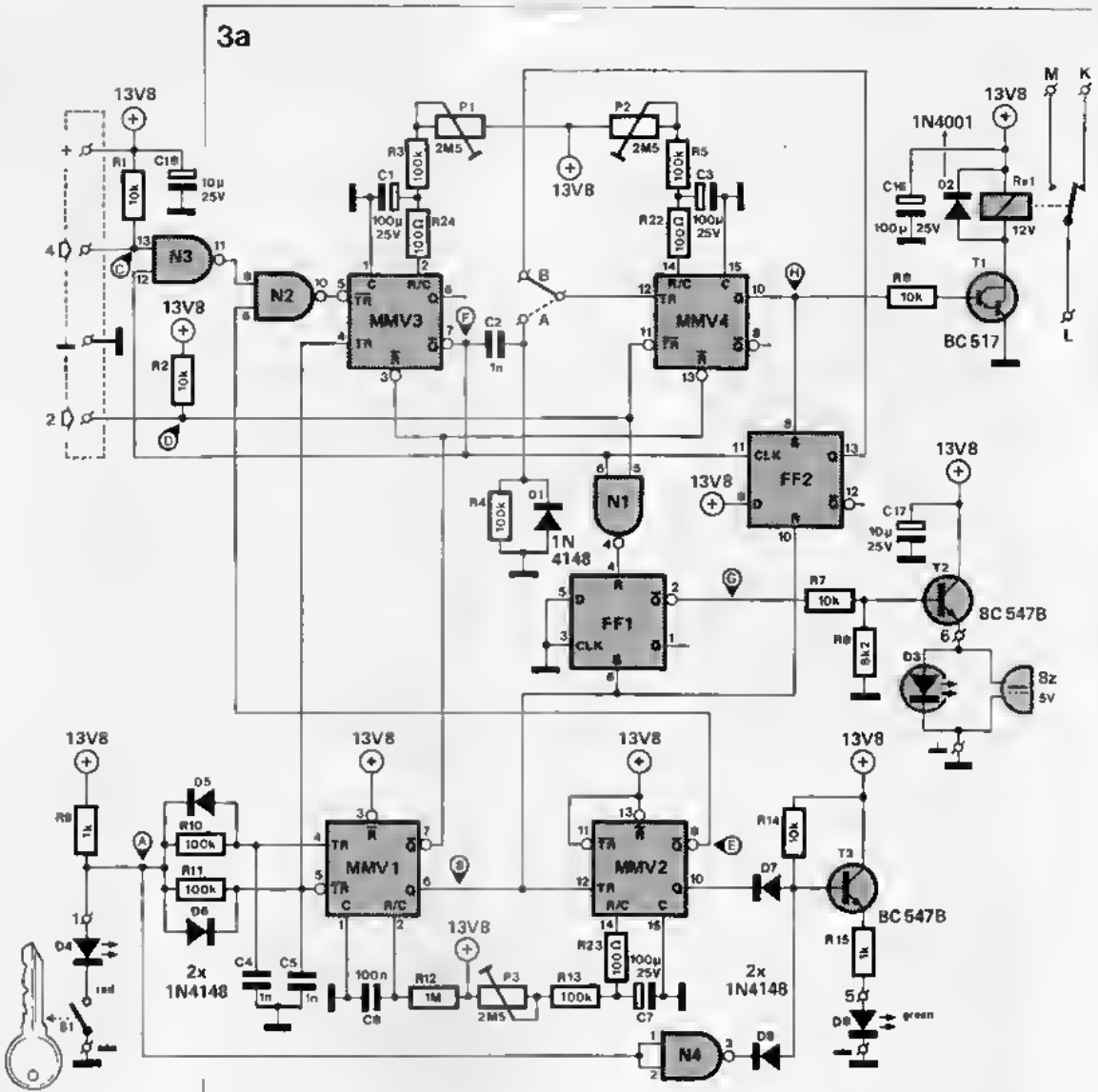
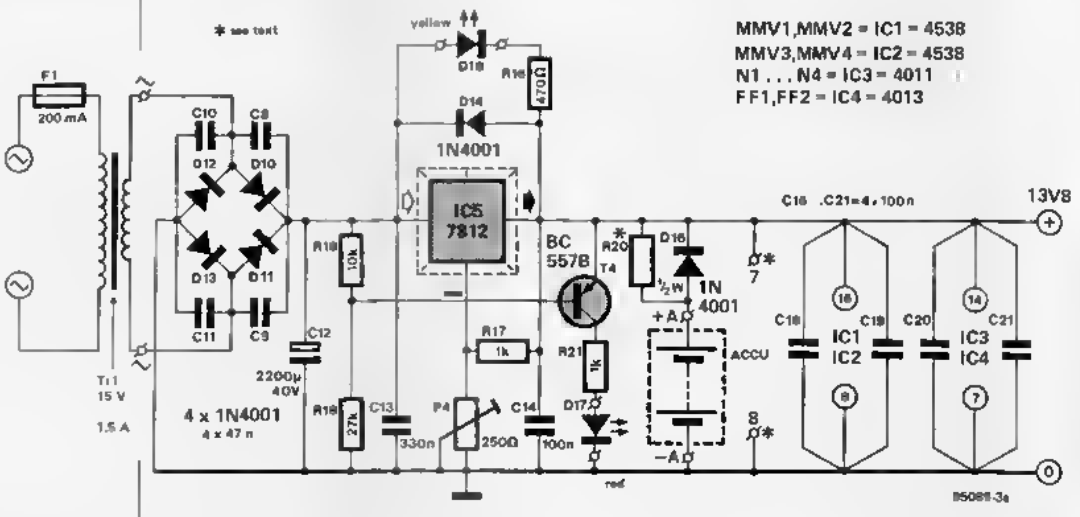
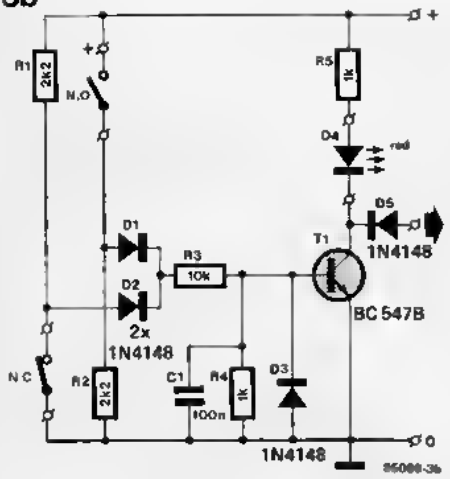


Figure 3a Circuit diagram of the control unit complete with power supply



3b



Power supply

The power supply — see Figure 3a — is rather more elaborate than usual, because it includes protection against mains failure. To this end, it contains two LEDs: an amber one, D_{15}, to indicate operation from the mains, and a red one, D_{17}, to show when the unit works from the battery.

During mains operation, the potential at the input of IC_5 is higher than that at the output, so that D_{15} lights. As the voltage across C_{12} is about 19 V, the potential at the junction of R_{18} and R_{19} is around 14 V; T_4 is then off, and D_{17} does not conduct When the mains fails, T_4 conducts and D_{17} lights.

It is best to use a 12 V lead-acid battery with a capacity of about 1 Ah: diode D_{16} may then be omitted, and R_{20} should be replaced by a wire link. It is, however, also possible to use a 12 V NiCd battery with a capacity of 0.5 Ah: in that case, D_{16} must then be connected as shown, whereas R_{20} should be omitted. When the batteries are not in use, they are trickle charged automatically.

Interfaces

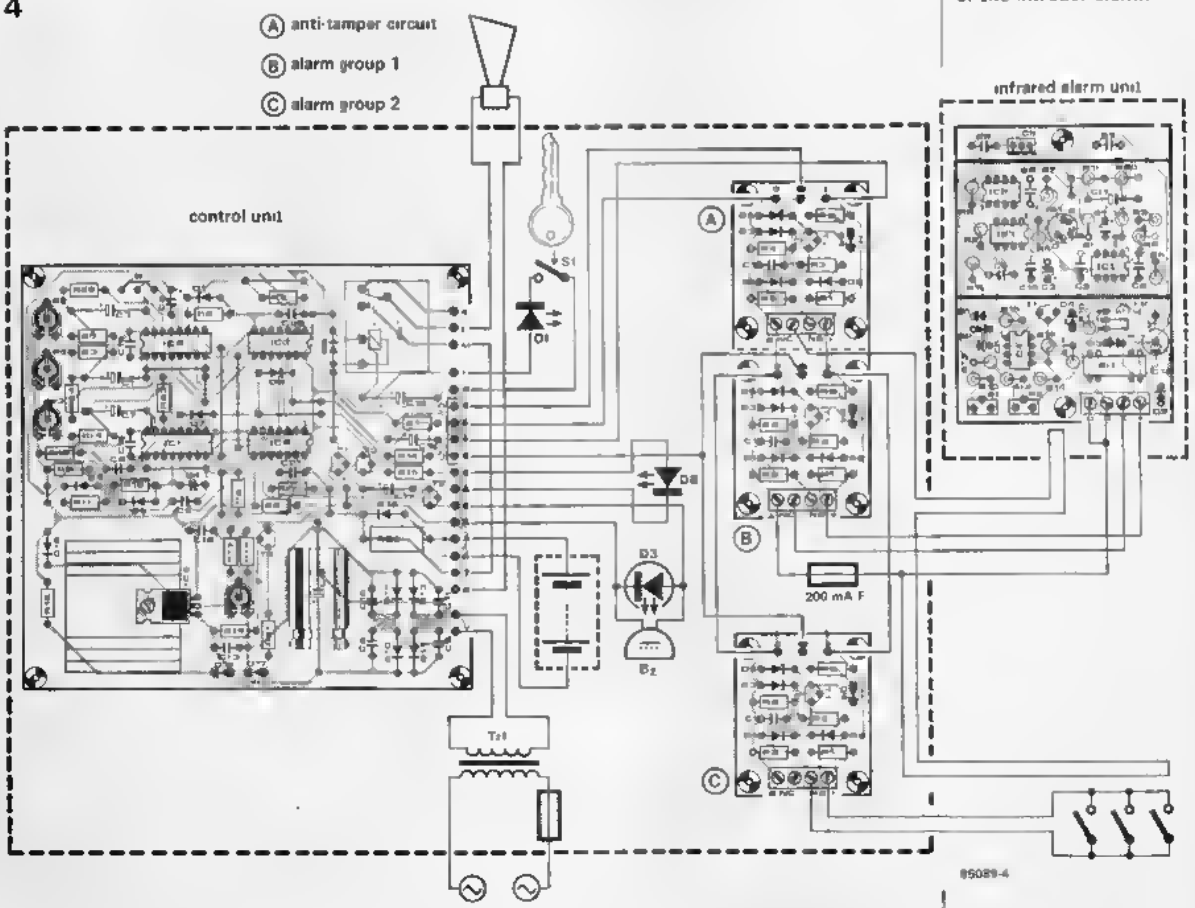
The interfaces, the circuit diagram of which is given in Figure 3b, offer two operating conditions, as stated before. NO contacts should be connected in parallel; NC contacts, in series. A secondary function of the interfaces is to prevent noise generated in long leads from reaching the control circuits.

A number of interface boards may be connected in parallel: an AND gate is then formed by diode D_5 on the interface board and R_1 or R_2, as the case may be, on the control board. This means that when one of the interface boards provides a logic 0, the relevant input of the control board is also logic low. It is thus possible

Figure 3b. Circuit diagram of an interface.

Figure 4. Wiring diagram of the intruder alarm.

4



Parts list

Resistors

$R_1, R_2, R_6; R_7, R_{14}, R_{19}$ 10 k
R_3, $R_5, R_{10}; R_{11}$;
R_{13} = 100 k
R_8 = 8k2
$R_9, R_{15}, R_{17}, R_{21}$ = 1 k
R_{12} = 1 M
R_{16} = 470 Ω
R_{18} = 27 k
R_{20} 120 Ω, ½ W
R_{22} R_{24} = 100 Ω
P_1 P_3 2M5 preset
P_4 250 Ω preset

Capacitors

$C_1, C_3; C_7, C_{16}$ = 100 µ; 25 V
$C_2; C_4; C_5$ = 1 n
$C_6; C_{14}, C_{18}$ C_{21} = 100 n
C_8 C_{11} = 47 n
C_{12} = 2200 µ, 40 V
C_{13} = 330 n
C_{15}, C_{17} = 10 µ; 25 V

Semiconductors

D_1, D_5 , D_8 1N4148
$D_2; D_{10}$.. D_{14},
D_{16}* = 1N4001
D_3 = flashing LED; 5 V*
D_4, D_{17} = LED, 5 mm; red
D_9 = LED, 5 mm; green
D_{15} = LED; 5 mm, amber
T_1 = BC517
T_2, T_3 = BC547B
T_4 = BC557B
$IC_1; IC_2$ = 4538
IC_3 = 4011
IC_4 = 4013
IC_5 = 7812

Miscellaneous

S_1 = SPST switch, preferably key operated
F_1 = miniature fuse; 200 mA; delayed action
Tr_1 = mains transformer, secondary 15 V, 1.5 A*
Re_1 = relay for PCB mounting, e.g., Siemens V23027-A0002-A. (may be available from Electrovalue Ltd, Englefield Green, Egham, Surrey TW20 0HB, telephone 0784 33603 or 680 Burnage Lane, Manchester M19 1NA telephone 061 432 4945)
Bz DC operated piezo buzzer, 5 V, I_{max} 25 mA, with integral oscillator
Heat sink for IC_5, 5 K/W
12 V (nominal) battery*
PCB 85089 1

*See text

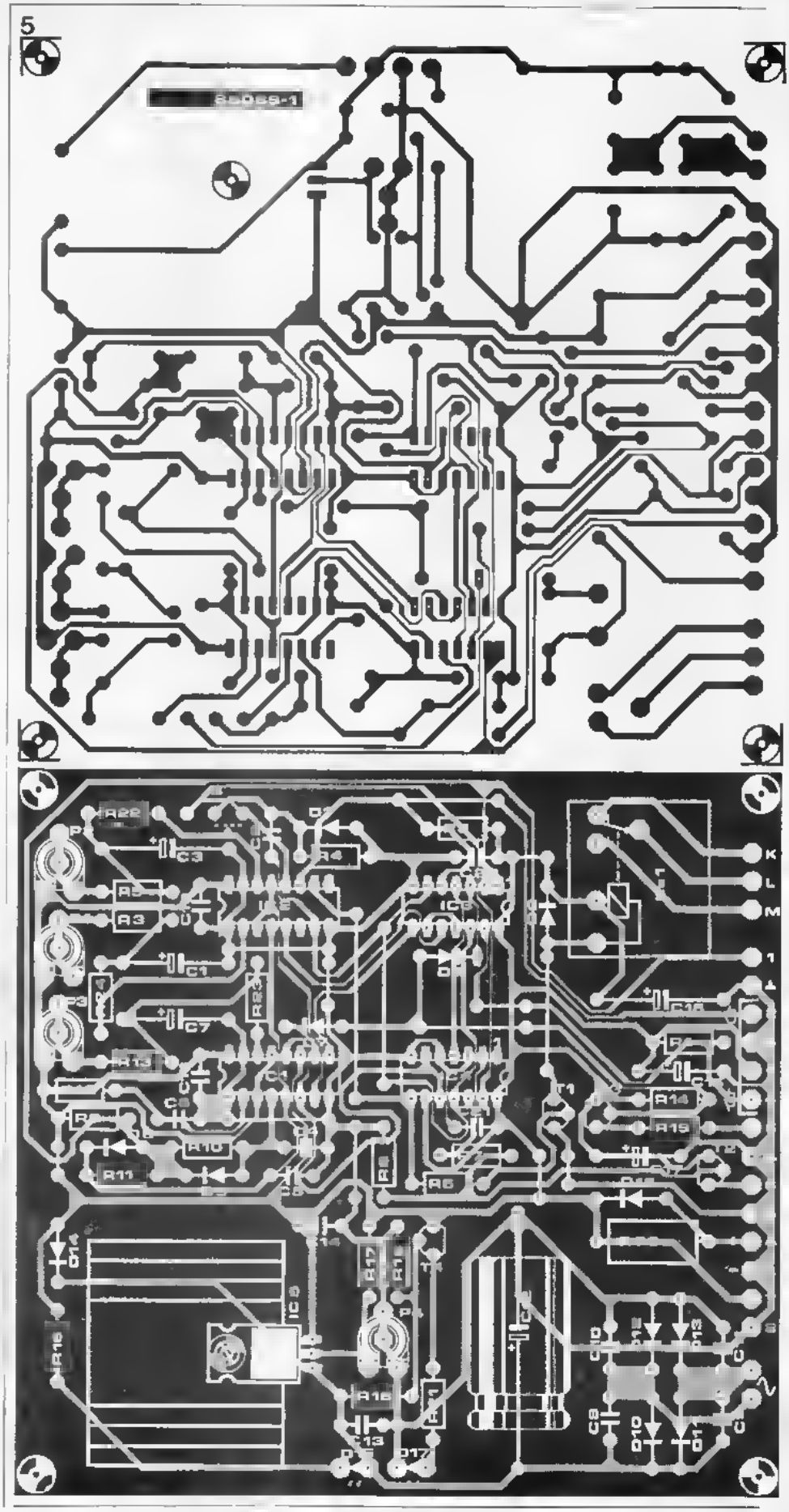
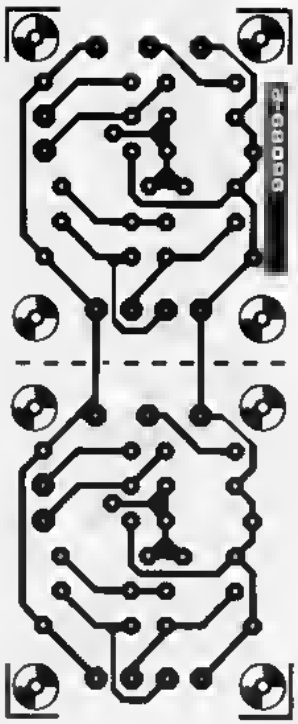
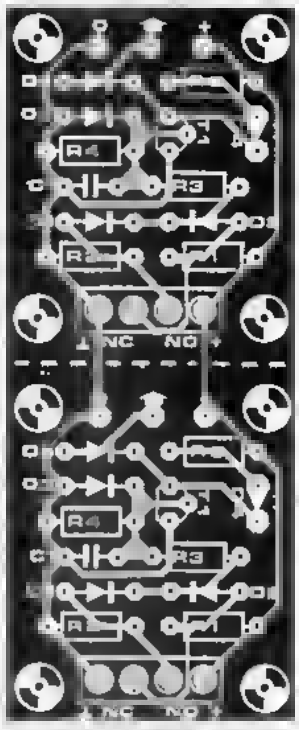


Figure 5. Printed-circuit board of the control unit.





Parts list

Resistors
$R_1;R_2$* = 2k2
R_3 = 10 k
$R_4;R_5$ = 1 k

Capacitor:
C_1 = 100 n

Semiconductors:
$D_1 \ldots D_3;D_5$ = 1N4148
D_4 = LED; 5 mm, red
T_1 = BC547B

Miscellaneous:
4 way PCB terminal block (Verospeed – phone 0703 644555)
PCB 85089-2

Note that these parts are sufficient for one interface only

*See text

Figure 6. Printed-circuit board for two interfaces.

to use quite a number of sensors — see also the wiring diagram in Figure 4. Each interface has its own positive and negative supply connections, which are used in the first instance for the NO or NC contacts. They can, however, also be used for supplying power to the infra-red sensors. It is advisable to fit a 200 mA miniature fuse in the negative supply line to prevent short circuits between the two supply lines in case the cable is cut

Switch S_1 is normally fitted at the control unit; if it is required to be located elsewhere, a separate interface as in Figure 3b has to be used. The switch, still in series with D_4, is then connected between the NO terminals on the interface (anode of D_4 to +). Interface terminals 0, output, and + should be connected to control board terminals 8, 1, and 7 respectively. The value of R_2 in Figure 3b must be lowered to 1 kΩ.

Construction and test

The printed-circuit boards for the control unit and the interfaces are illustrated in Figures 5 and 6 respectively: note that the latter is intended for two identical interfaces.

If diode D_3 is not required to blink, solder a 100 nF capacitor across the buzzer.

The power supply has been designed for use with a 12 V 6 W siren; if a 240 V siren is used, the rating of Tr_1 may be reduced to 15 V; 0.5 A.

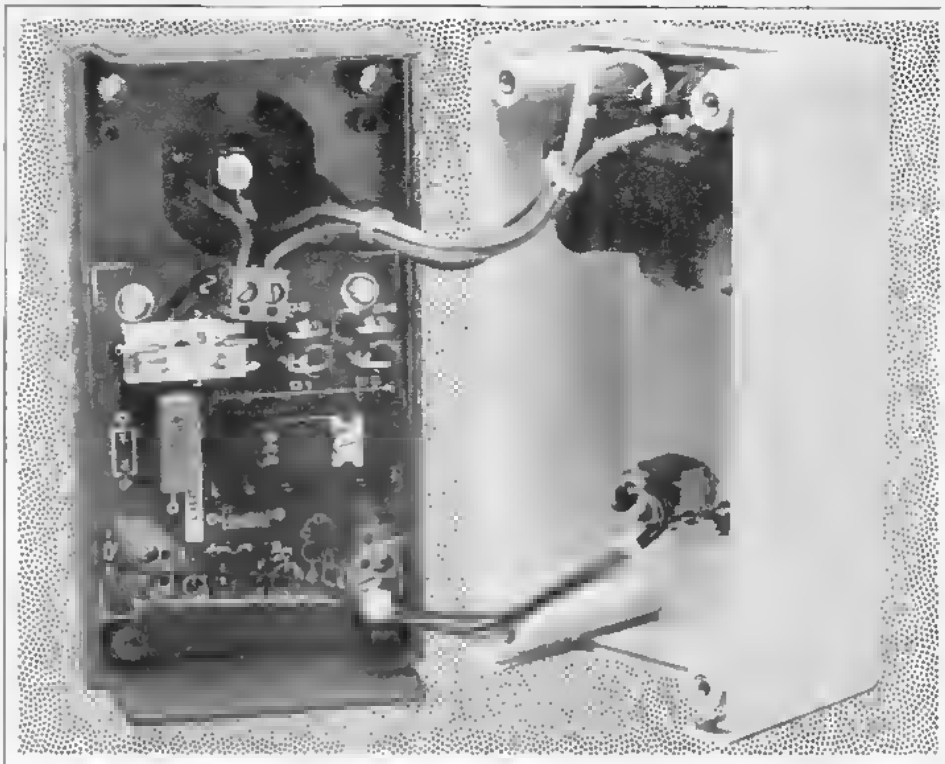
Interconnections between the boards are shown in the wiring diagram of Figure 4 which illustrates the use of 1½ interface board.

The control unit should be housed in a suitable, robust metal case as shown in the photograph.

Before fitting the battery, adjust P_4 to give a voltage of 13.8 V across terminals 7 and 8. Then fit the — fully charged! — battery. Close S_1 when D_9 should light and shortly afterwards go out again. The lighting time is preset between 10 seconds and 4 minutes with P_3

Test the anti-tamper circuit by opening an NC contact or closing a NO contact: relay Re_1 should then be energized; D_3 should blink (unless a 100 nF capacitor has been provided across the buzzer); and the buzzer should sound. The holding period of the relay, i.e., the length of time the alarm sounds, is preset with P_2. Note that $P_1 \ldots P_3$ have minimum value when they are turned fully anticlockwise.

When a normal alarm group receives a pulse from a sensor, nothing should happen immediately; if, however, the anti-tamper circuit receives a pulse, the alarm should be set off immediately. A normal alarm group can only trigger the alarm when S_1 is closed: this happens after a delay of between 10 seconds and 4 minutes — preset with P_1 — when relay Re_1 is energized.



solid-state relay

In general, mains-operated loads are switched by electromagnetic relays. Such relays have been in use for many years and are, in the main, reliable and sometimes ingenious. None the less, they are slowly but surely being superseded by their even more reliable electronic counterparts. A further advantage of these solid-state devices is that they are becoming less expensive than electromagnetic relays. This article describes a simple solid-state relay for switching ohmic loads of up to 600 watts.

J Steeman

Electromagnetic relays have one or several sets of contacts which open or close when a soft-iron core is magnetized by a coil around it.

Solid-state relays involve no mechanical movement whatsoever, as switching is effected by a single silicon-controlled rectifier (SCR) or two SCRs in a common envelope — normally called a triac. This type of relay is of great importance in digital circuits. Note that the SCR was originally called thyristor.

Solid-state relays have a much better lifespan than electromagnetic types, particularly at high rates of switching. They also exhibit far less electrical noise and may be used in explosive environments since there are no contacts across which arcs can form. And, of course, they are completely free of mechanical noise.

The basic concept of a solid-state relay is shown in Figure 1a. The switch may take the form of an SCR in a bridge circuit as in Figure 1b. This configuration enables both the positive and the negative halves of the mains voltage to be switched.

Switching noise

When the moment of switching does not coincide with a zero crossing of the mains, the sudden change in current causes high-frequency impulse noise, which, for instance, may result in unwanted signals appearing on the screen of a television receiver, or becoming audible as clicks in the loudspeaker of a radio receiver.

The magnitude of the noise depends on the frequency of switching, on the instant relative to the zero crossing when switching takes place, and on the type of load being switched: it is generally greater with inductive or capacitive loads than with ohmic loads.

Switching at zero crossing

In a silicon-controlled rectifier, SCR, the forward anode-cathode current is controlled by a signal applied to a third electrode, called the gate. When a positive current is applied to the gate, and the anode is positive with respect to the

cathode, current flows through the SCR from anode to cathode. The magnitude of the gate current determines the breakover point, i.e., the anode voltage at which the SCR switches from the blocking to the conducting state. The SCR conducts as long as the current through it is greater than the so-called holding current.
This means that in a.c. applications the SCR switches off when the mains passes through zero. Consequently, a positive current (pulse) must be supplied to the gate at every half period of the mains voltage to ensure continuous conduction.
For ohmic loads, the correct moment of applying the pulse to the gate is when the mains voltage passes through zero, since for such loads the voltage and current are in phase. With inductive and capacitive loads, voltage and current are not in phase, and it is, therefore, not correct to trigger the gate when the mains voltage passes through zero. The optimum trigger moment for such loads is rather more difficult to determine.

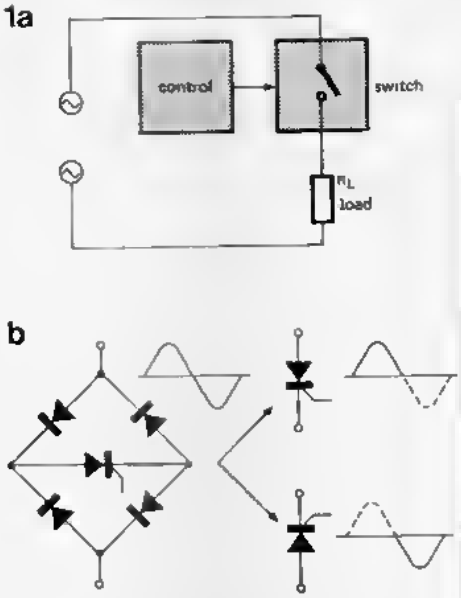


Figure 1. Basic concept of a solid-state relay. The switch in Figure 1a is formed in the prasnt unit by four diodes in a bridge arrangement and a silicon-controlled rectifier as shown in 1b.

Solid-state relay

The circuit of the solid-state relay is given in Figure 2. It is triggered at the zero crossing of the mains voltage and is, therefore, only suitable for use with ohmic loads.
The relay is driven via an opto-isolator, so that the control unit (computer, time switch, and so on) is electrically isolated from the mains.
The main current loop is closed via load La, bridge rectifier $D_1 \ldots D_4$, silicon-controlled rectifier Th_1, and fuse F_1. The maximum forward current through the diodes is 3 A, while the SCR is rated at 5 A.
When the SCR is in the blocking state, the entire full-wave rectified mains voltage is present across it. At every zero crossing of the mains voltage, transistor T_1 produces a positive current pulse, provided switch S_1 is open and the phototransistor in IC_1 is off. When the instantaneous voltage at the gate is sufficient to switch the SCR on, the voltage across the SCR, and consequently that at the gate, drops to zero. As long as the above provisions are met, this action repeats itself at every zero crossing of the mains voltage. The various situations and associated voltages are shown in Figure 3.
With both S_1 and IC_1 off, the SCR conducts, i.e., the relay is actuated. It may be switched off by closing S_1, or by applying a voltage of +5 V to the series combination of R_4 and the LED in IC_1. The opto-

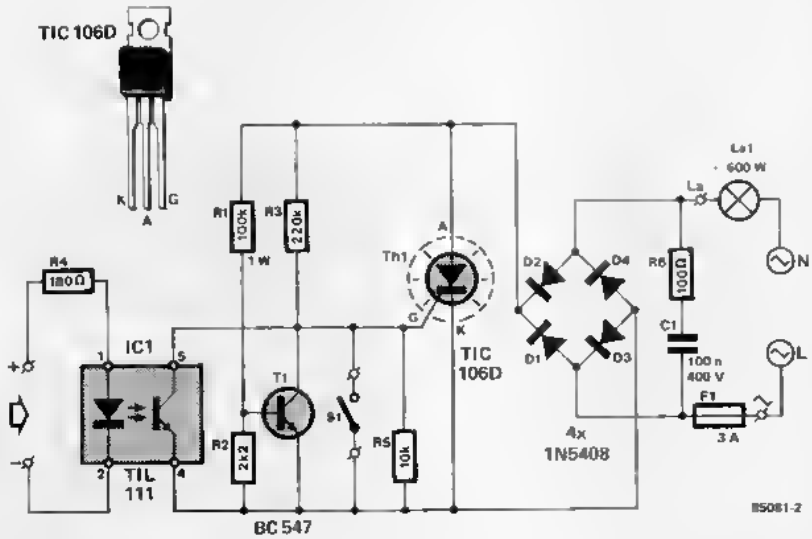


Figure 2. The circuit of the solid-state relay, which, in essence, replaces the usual mains switch. Note that all parts carry the mains voltage!

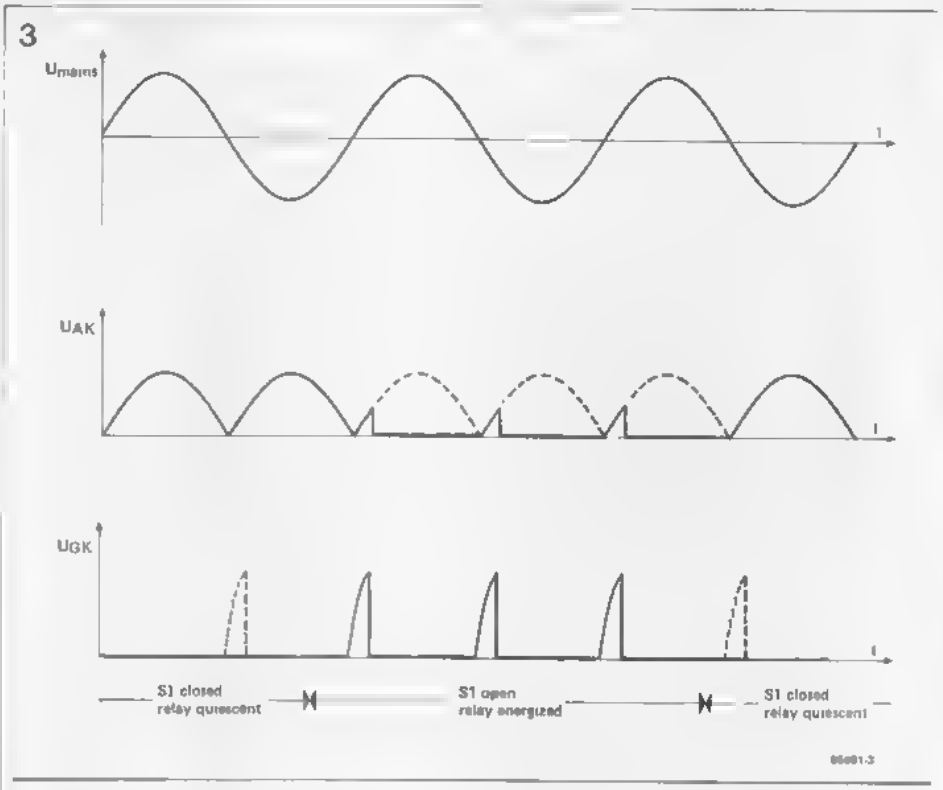


Figure 3. Schematic representation of various operating conditions and associated voltage waveforms.

isolator may be controlled by TTL (transistor-transistor logic), but also by other signals. Note that the maximum forward current through the diode should not exceed 100 mA, while the reverse bias should be not greater than —3 V.

Construction

The relay is most conveniently built on the PCB illustrated in Figure 4. This board is intended for fitting in a 120 × 65 × 55 mm plastic case, which results in a neat and compact unit. The connections to the switch, control unit, mains, and load are best made with the aid of nylon dual terminal blocks. This makes it possible for the PCB to be fitted, or removed, without the need for soldering. The SCR should be mounted on a small heat sink. Because the unit works from, and with, mains voltages and relatively high currents, great care should be taken in the wiring. Do not forget the earth connection between the mains outlet and the unit! Switch S_1 and the input connectors for the control voltage are mounted at the top of the case. Remember that the switch should always be open when external control is used.

Finally

This solid-state relay is intended for use with ohmic loads of up to 600 W. It cannot be used for switching transformers, neon tubes, and other inductive or capacitive loads, because this would upset the triggering system.

Parts list

Resistors:
R_1 = 100 k; ½ W
R_2 = 2k2
R_3 = 220 k; ½ W
R_4 = 180 Ω
R_5 = 10 k
R_6 = 100 Ω

Capacitor
C_1 = 100 n; 400 V

Semiconductors:
D_1 ... D_4 1N5408
IC_1 = TIL111
T_1 = BC547B
Th_1 = TIC106D

Miscellaneous
F_1 = 3 A, delayed action; complete with fuse holder for PCB mounting
Heat sink SK13 or KL105 for Th_1
S_1 = SPST switch
Plastic case, 120 × 65 × 55 mm, e.g., OKW 9022487 (may be available from Velospeed 0703 644555)
3 nylon dual terminal blocks
PCB 85081

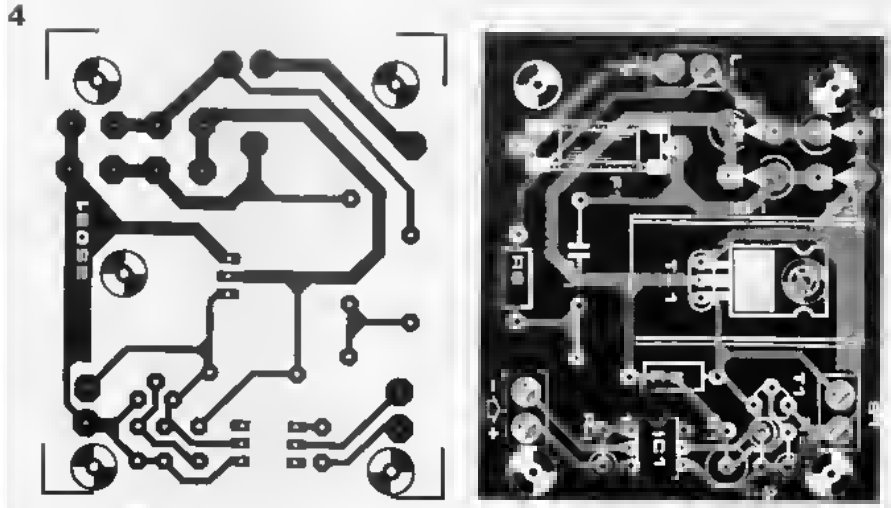


Figure 4. The printed circuit for the solid state relay

fields

In recent years there has been considerable interest in the effects of atmospheric electric and magnetic fields on living organisms, and in particular in their effect upon human health. For example, experiments carried out in West Germany into the effects of electric fields on motoring fatigue seem to indicate that the presence of an electric field inside a motor vehicle can reduce driver error.

The interior of a motor vehicle, because of its metal construction, is largely screened from external electric fields. Researchers from the West German Defence Ministry, the Max Planck Institute, and the Munich Institute for Biomedical Technology co-operated in developing a device to generate an electric field inside a car. It was found that, with the device operating, drivers made 8 to 10% less errors than normal Furthermore, the more fatigued a driver was, the greater was the improvement in his performance when the device was switched on.

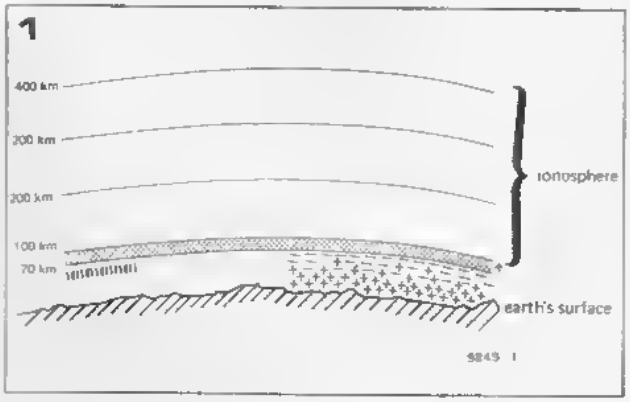
Professor Konig, of the Munich Technical University, writing in the German Motoring magazine 'ADAC-Motorwelt', stated that, ' . . . electric and magnetic fields exert a biological influence upon the human organism'.
On the other hand, Prof. Dr. Ir. Justus Bonzel, director of the Dusseldorf Research Institute of the Cement Industry, in reply to criticisms regarding the screening effect of concrete buildings, wrote, 'The question of the influence of electric fields upon humans and animals still remains unanswered, and most scientists do not accept that a clear link exists. In spite of this, it is often asserted (and even pseudo-scientifically explained) that living in a concrete building has a negative influence on the health of the occupants, as a result of their being screened from electric fields which are present in the open air (. . . .) As far as the screening effect of building materials is concerned, it can be proven that materials such as high-quality concrete, brick, lime/sandstone and wood all screen or let through electric fields to virtually the same extent, and that the interiors of buildings made of these materials contain electric fields similar to those found in the open air.'
Which of these two conflicting viewpoints is true? Certainly, in view of the automobile experiments, it would appear that there is positive evidence that electric fields do have an effect upon health, and that the subject bears further investigation – so exactly what are atmospheric electric fields?
The ionosphere, which is a region of electrically charged air molecules, begins at a height of approximately 70 km above the surface of the earth, and has a positive potential of 300-400 kV with respect to the earth. The ionosphere and the earth's surface thus act as the plates of a gigantic capacitor, which incidentally has a 'leakage current' of about 3×10^{-10} $\mu A/cm^2$ due to movement of ions between the ionosphere and earth.

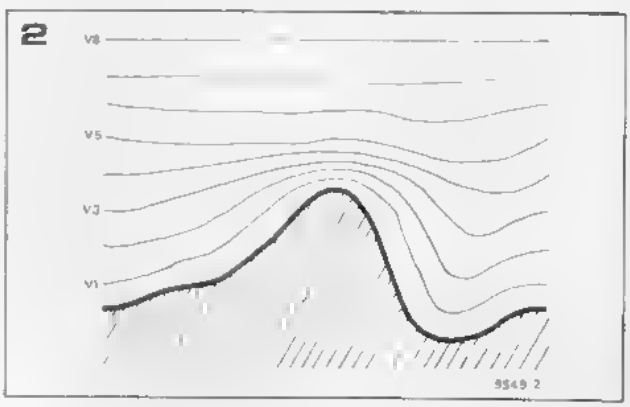
Figure 1. The ionosphere begins at a height of approximately 70 km and extends to about 1000 km. The ionosphere is charged to about 300-400 kV with respect to earth and the electric field causes constant movement of ions.

Figure 2. Electric field strength is greater at the tops of hills than in valleys, as can be seen from the bunching or expansion of the equipotential lines.

Between the ionosphere and earth there naturally exists a DC electric field, and in addition there is an AC field with a frequency of 10 Hz. The field strength is not uniform at all points between the ionosphere and earth, but at ground level in the open air the average field strength is about 130 V/metre. A diagrammatic representation of the ionosphere is given in figure 1.
Terrain and buildings have a considerable effect on local field strength at ground level. Figure 2 shows how the equipotential lines are 'cramped' closer together on hilltops, which means that the potential gradient and hence the field strength is greater there than in the valleys, where the equipotential lines are more widely spaced.

The potential difference between the ionosphere and earth causes a constant movement of ions between the ionospere and earth. Near ground level positive ions predominate, there being approximately 2500 positive and 450 negative ions per cubic centimetre of air, although at sea these figures may be reduced by a factor of 10, and in urban areas may be increased by a factor of 10.
The ion concentration may also vary considerably with weather conditions. For example, before the onset of a thunderstorm there is a heavy ionic concentration with a predominance of positive ions. When rainfall occurs the concentration of ions quickly falls and the negative ions predominate.
It is believed that negative ions have a beneficial effect on health and positive ions a detrimental effect. This may explain the oppressive atmosphere that attends the onset of thunderstorms, and the subsequent relief when the rain begins.
In conclusion it is fair to say that there is sufficient evidence to warrant further research into the effects of electric fields and ions on human and animal health.





The pleasure derived from music is heavily dependent on clarity. Although we may sometimes listen to live music, most of what we hear nowadays is recorded, so that avan tha finest musical sounds will be spoilt if the reproduction lacks fidelity or if they are accompanied by irritating noises and distortion. The item that most often lets the sound reproduction equipment down is the loudspeaker. But not the PL301, which has been designed by KEF Electronics Limited, tha well-known loudspaaker designers and manufacturers from Maidstone. KEF has an international reputation for high-quality products and has, moreover, been activa successfully in the DIY market for many years. This means that their products are readily availabla in most of tha western world. Cogent raasons for building the PL301, which may not be the cheapest KEF design, but is certainly among the best!

a loudspeaker for music lovers

PL 301

The PL301 is a passive, three-way system. Externally, it catches the eye because of its unusual shape. In finished form, it is partly filled with sand, which makes it quite heavy. Its reproduction is characterized by strict neutrality and precision, resulting in a natural, lively sound.

Design considerations

Designing a loudspeaker box is no sinecure, since there is no detail that is not important or does not play a role in the finished product. The loudspeaker frame, the shape of the enclosure, the volume of the box, the positioning of the frame in the box, the damping, the filter, impedance correction networks, filter components — all these have to be carefully matched to one another.
KEF realized all this a long time ago. Their loudspeaker designs never have just one outstanding property, as is often the case with those of other manufacturers: the

KEF Electronics LTD
Tovil, Maidstone,
Kent ME15 6QP
England
Telephone (0622) 672261
Telex: 96140

complete design is good. And that is certainly the case with the PL301: no outstanding strong individual points, but no weak ones either! Technical characteristics are given in Table 1.

The PL301 is a good-size three-way system in, as usual with KEF designs, a closed acoustic box. The cross-over between bass, middle, and treble frequencies is provided by a Linkurtz-Riley filter with an initial slope of 18 dB per octave.

The enclosure contains two separate compartments: one for the bass speaker, and one for the middle frequency speaker and tweeter. At first sight, this basic design looks very similar to the RR105, the most pretentious of KEF's loudspeaker enclosures. Even the speakers themselves are the same as in that model. On that basis you might think that the present design is a sort of updated or perfected (is that possible?) RR105, but you would be wrong, because the PL301 has a number of characteristic details which put it a little outside the normal KEF family. Those details are concerned with the precise positioning of the loudspeakers, the shape of the enclosure, and its freedom of resonance — together resulting in a neutral, uniform reproduction and tightly controlled bass performance.

Building the enclosure(s) takes, of course, quite some time, but this is where the DIY enthusiast has the edge over the industrial producer. The home constructor does not consider the hours he puts into the work as part of the overall cost, and he is, therefore, able to carry out labour-intensive work that a manufacturer could not tackle at a profit.

Drive units

KEF have chosen what is probably their best three-way combination: the T52B tweeter, the B110B for the middle frequencies, and the B300B for the bass. These units are shown in the photograph in figure 1.

The bass speaker is one of the most recent additions to the KEF family. In earlier top-of-the-range designs, the 200 mm Type B200 or the well-known oval Type B139 was normally used. The B300B (SP1071) is a robust 300 mm unit with a resonance frequency of 23 Hz, and is

Table 1.

Technical characteristics	
Frequency range	35 Hz...20 kHz ± 3 dB (see figure 13)
Maximum sound pressure	109 dB
Sensitivity	86 dB (1 watt at 1 metre)
Input power	not less than 15 watt not more than 200 watt
Impedance	8 ohms nominal (see figure 12)
Dividing network	3-way 18 dB per octave, crossover frequencies 400 Hz and 3000 Hz
Drive units	low: KEF B300B (SP1071) middle: KEF B110B (SP1057) high: KEF T52B (SP1072)
Enclosure	closed acoustic box (3rd order)
Volume	bass compartment: 80 litres (0.08 m³) net middle and high compartment: 3 litres (0.003 m³) net
Dimensions	1050 mm high × 465 mm wide × 430 mm deep

Figure 1. Photograph of the three drive units.

2

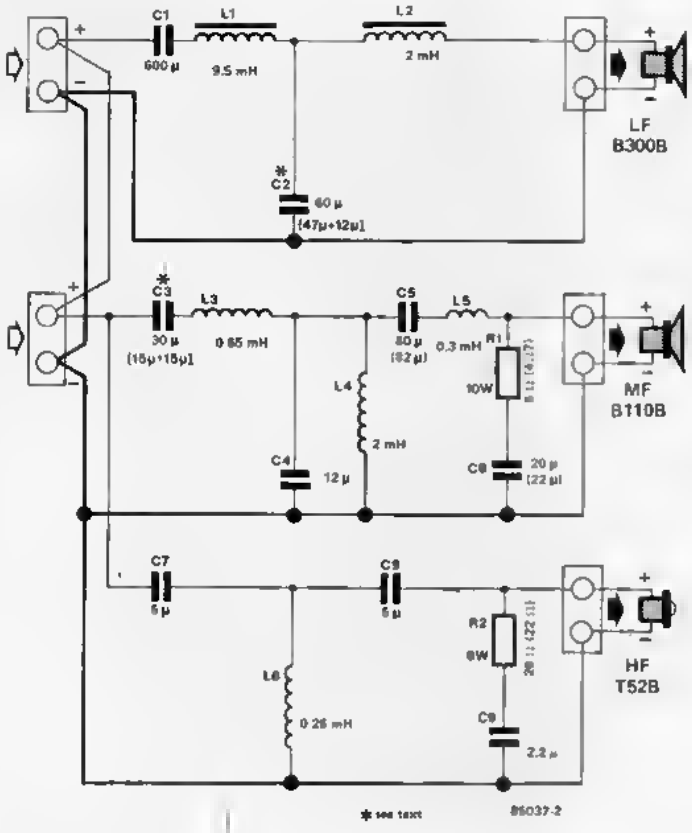


Figure 2. Circuit diagram of the crossover network.

rated at an impressive 150 watt sine wave or 200 watt music.

The T52B (SP1072) tweeter has been in KEF's range rather longer. It has a relatively large cone (52 mm diameter), whereas the speech coil is somewhat smaller (37 mm diameter). Moreover, it has a pleasantly low resonance frequency of 650 Hz.

The old guard of the three is the B110B (SP1057) middle frequency unit. This 130 mm speaker has been produced by KEF for many years, and this makes it all the more amazing how well it still stands up to modern competition. Particularly as regards pulse performance, the B110B is second to none, as our own tests indicate.

Crossover network

Although KEF still used 12 dB loudspeaker dividing networks some years ago, nowadays all crossover networks have an 18 dB per octave characteristic. Modern computer-aided design has made it possible to tune these networks precisely to the relevant loudspeaker combinations. At the same time, these computer calculations give the required frequency and impedance correction factors.

The circuit diagram of the dividing network is shown in figure 2. The crossover points lie at 400 Hz and 3000 Hz respectively. The terminal voltages across the drive units (via the filter) are shown in figure 3.

Although we will revert to this later in the

3

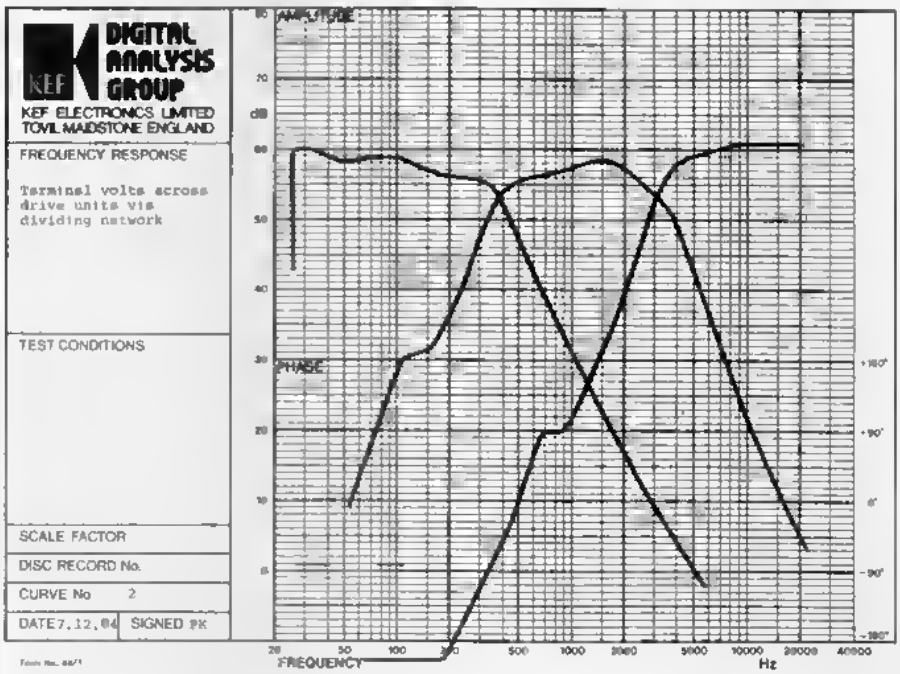


Figure 3 Terminal voltages across the drive units via the dividing network.

article, note that we have designed two different printed circuit boards. The first version is intended for KEF components only, and this board is part of the crossover network kit available from KEF. The second version, shown in figure 6, is of more interest to the pure home constructor, since this is intended for components normally available from most electronics retailers

According to KEF, bipolar electrolytic capacitors are not nearly as bad as is generally believed. Be that as it may, but note that they have taken the properties of such capacitors into account during the design calculations of their networks. This means that it is not possible to just replace these bipolar devices by foil capacitors. At low and middle frequencies, this is not much of a problem, since the audible differences between various types of capacitor in this range are virtually nil. Matters are quite different, however, at high frequencies: in our opinion a good foil capacitor here is definitely better than an electrolytic type.

We feel, therefore, that capacitors C_7 and C_8 should be polyester, polycarbonate, or (best) polypropylene foil types. The smaller losses in these capacitors, as compared with those in electrolytic types, cause the output of the tweeter to rise by almost 20 per cent, while the impedance characteristic descends somewhat at high frequencies. These effects can be negated by connecting a 0.5 ohm, 5 watt resistor in series with both C_7 and C_8.

Enclosure

The enclosure is divided into two compartments: one for the bass speaker, and the other for the middle and high frequency speakers, as shown in figure 7. As stated before, the PL301 is typified by its robustness, the individual placing of the drive units, and the shape of the enclosure.

The strength and rigidity is, of course, vital. Everything possible has been done in this design to prevent disturbing panel resonances. The material chosen is 22 mm plywood; there are numerous reinforcing struts, and, last but not least, the sides are double-panelled and the resulting hollows are filled with sand. It could not be better!

The remaining details worth mentioning reflect, without exception, the aim of obtaining optimum radiation of the sound. Noteworthy in this respect is the placing of the middle frequency speaker above the tweeter. Why this is done is illustrated in figure 4. When both these speakers are mounted in one plane and a line is drawn between the centre of the tweeter cone and the acoustic operating point of the middle frequency speaker, it is seen that in the conventional positioning shown in figure 4b the axis of radiation lies a little below the horizontal, while in the PL301, as shown in figure 4a, it lies above the horizontal. Except when the loudspeaker

4

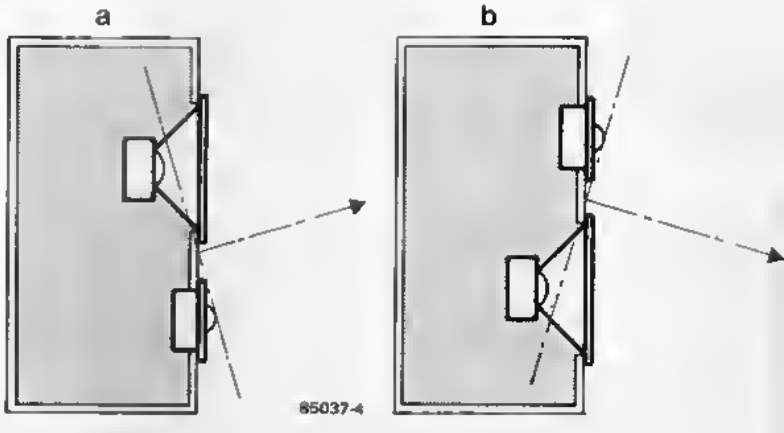


Figure 4. Axis of radiation with (a) middle frequency unit above the tweeter, and (b) the other way around

5

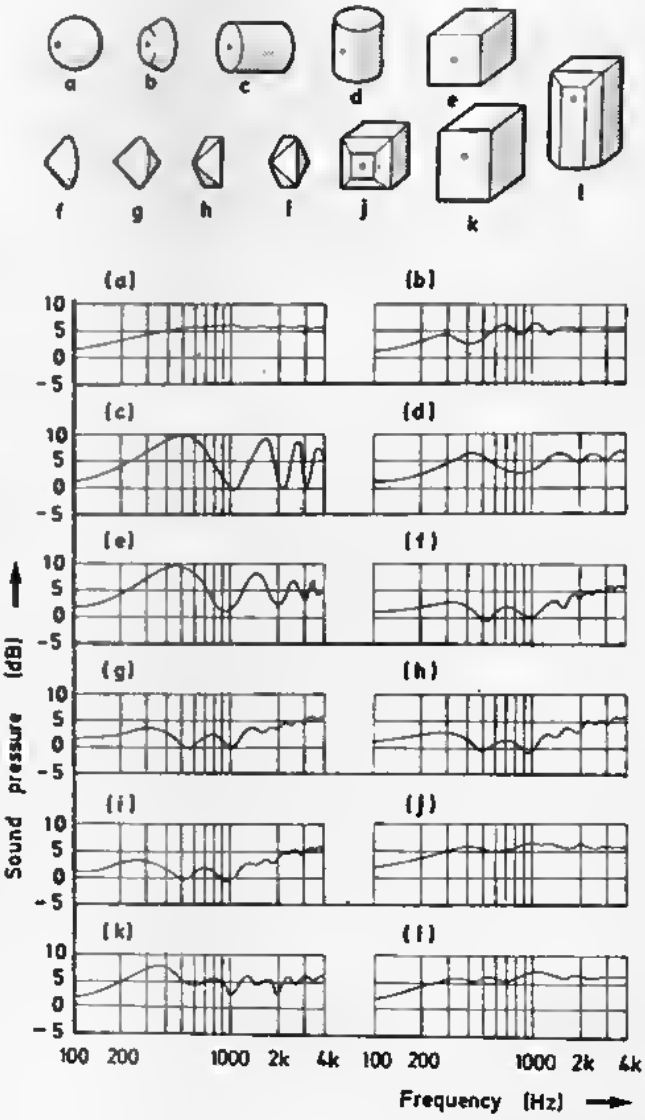


Figure 5. Various enclosure shapes and their characteristic frequency vs sound pressure curves

6

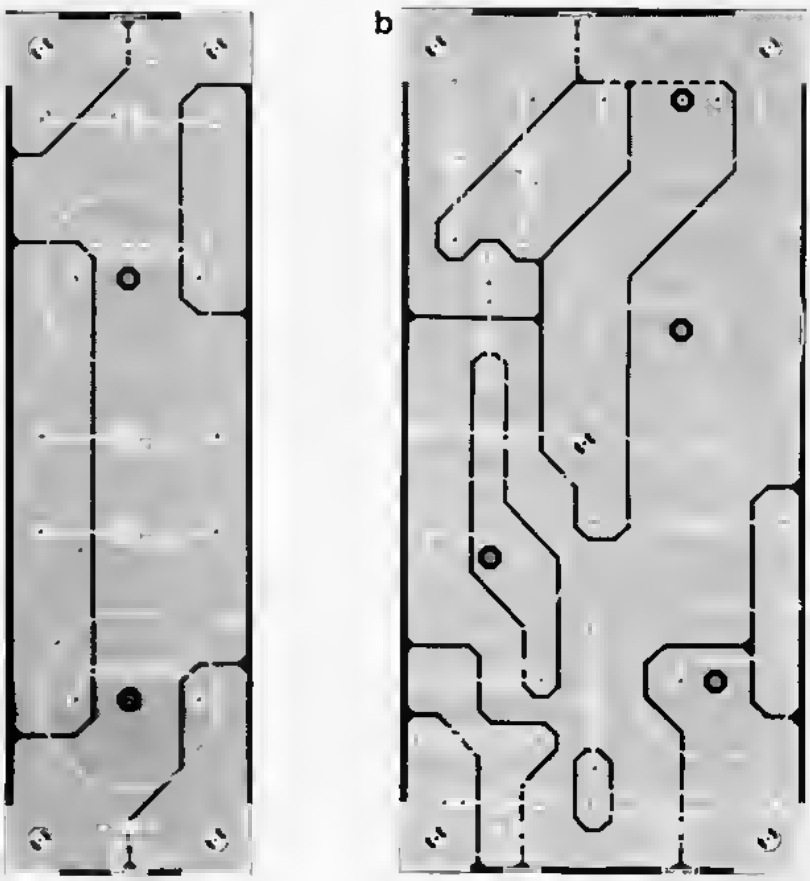


Figure 6. Printed circuit boards for the crossover network: (a) base section; (b) middle and high frequency section. These PCBs are not available ready made.

Parts list

Drive units KEF B300B (SP1071); KEF B100B (SP1057), KEF T52B (SP1072)
Dividing network KEF DN2B or home construction according to figures 2 and 6
6 brass threaded rods M3 × 25 mm
24 nuts size M3
12 spade connectors size M3
2 terminal posts with top socket or a 2-way quick-connection lever terminal
About 2 metres of 1,5 mm² twin flex
Timber 22 mm plywood according to the sawing patterns in figure 8
Sound-deadening material as required (available from motorists retail shops).
Roll of rock wool 30 mm thick
Dr Bailey's longhair or fleece as required
Good quality wood glue
Screws or nails as required
Steel tensioning wire
6 dowels for grille
2 aluminium or steel tubes, 1030 mm long × 10 mm dia
Grille cloth as required
2 brass or steel bolts M6 × 20 mm and two wingnuts size M6 for fastening the middle and high frequency compartment
Dry river sand as required
Four heavy duty castors, if required

Home constructed dividing network:

Resistors.
R_1 = 4.7 (5) Ω/10 watts
R_2 = 22 (20) Ω/5 watts

Capacitors
(all bipolar electrolytic min. 50 V working, but see text in regard of C7 ..C9)
C_1 = 600 µF
C_2 = 60 µF (47 µF + 12 µF)
C_3 = 30 µF (2 × 15 µF)
C_4 = 12 µF
C_5 = 60 or 82 µF
C_6 = 20 or 22 µF
C_7,C_8 = 5 µF
C_9 = 2.2 µF

Inductors:
L_1 = 9.5 mH, ferrite core $R < 1.4\ \Omega$
L_2 = 2.0 mH, ferrite core $R < 0.5\ \Omega$
L_3 = 0.65 mH
L_4 = 2.0 mH air-cored, wire diameter 1 mm
L_5 = 0.3 mH
L_6 = 0.25 mH, air-cored, wire diameter 0.5 mm

Miscellaneous:
5 two-way moulded terminal blocks, 5 A

is at ceiling level, upward radiation is, on the whole, better than downward, because it is along a more direct line to the listening position, so that the detrimental effects of damping by floor covering, particularly carpets, are prevented. It should be mentioned here that in practice the direction of radiation deviates from that shown in figure 4 because of the effects of the phase shift caused by the crossover network.

Another noteworthy feature of the PL301 is that the upper compartment is displaced forward with respect to the bass chamber. This shift of about 450 mm may, dependent on the listening position, be reduced slightly. The forward shift permits the design of the crossover network to be optimized. The necessary phase equalization for inter-unit time delay is incorporated in the crossover design.

The interchanging of the middle and high frequency loudspeakers is closely associated with the shape of the cabinet. Most acoustic engineers are agreed that the shape of the enclosure has a vital bearing on the reproduction. Figure 5 correlates twelve differently shaped cabinets and the associated frequency response characteristics; it is derived from the well-known standard work *Acoustical Engineering* by W H Olson. Spherical shape a is clearly the ideal, but practical spheroids j and l are a good second and third; particularly shape j is hardly inferior to the spherical shape. Noteworthy is that conoids f . . . i score badly, whereas old faithful shape k comes out quite well.

The PL301 uses enclosure shape l, although the forward placing of the upper compartment makes the middle frequency characteristic approach that of shape j very closely. The partly slanting shape of the j and l variants is, therefore, the most conspicuous aspect of the PL301. That shape is continued in the front grille. From a practical point of view, this is an ideally shaped cabinet which has only one disadvantage: you need to be pretty good at woodworking to make it.

Construction

Starting with the dividing network, it seemed sensible to split the PCB, like the cabinet, into two parts: that for the bass section is shown in figure 6a, and that for the middle and high frequencies in 6b. The inputs of the two board are simply connected in parallel. Although building the PCBs is a fairly simple job, it is essential that you stick to the stated component values! Inductors L_1 and L_2 use ferrite cores, but all others are air-cored. The wire diameter for L_3, L_4, and L_5 should be 1 mm, and that for L_6, 0.5 mm.

The capacitors, with the exception of C_6 and possibly C_7 and C_8 (see *crossover network* above) are bipolar electrolytic types. Because values of 60 μF and 30 μF are not always easily available, the board has been designed to accommodate parallel combinations for C_2 and C_3. Normal

Note: these PCBs are not available ready made.

7

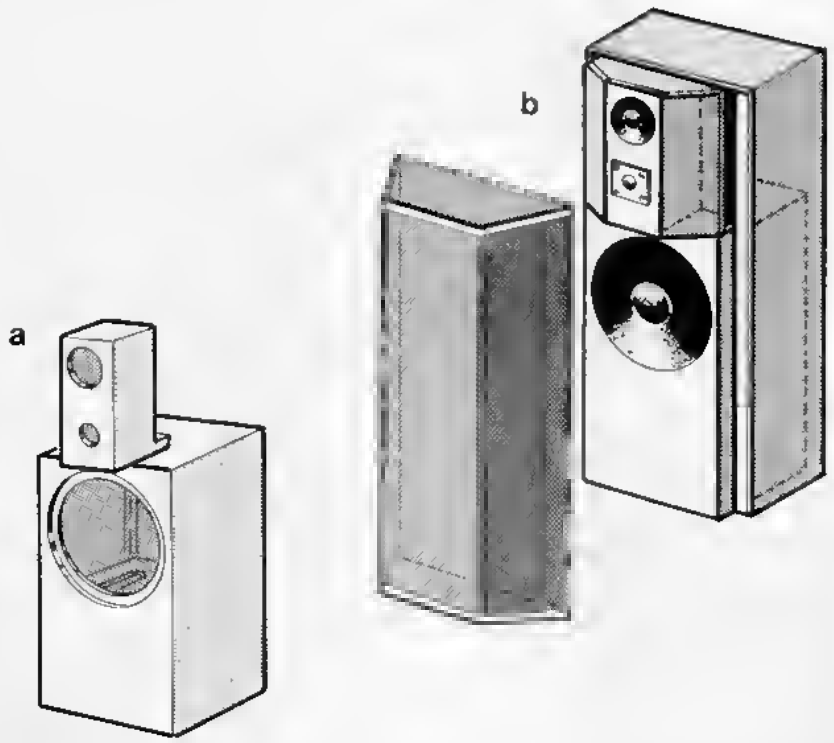


Figure 7. Artist's impression of the enclosure.

8

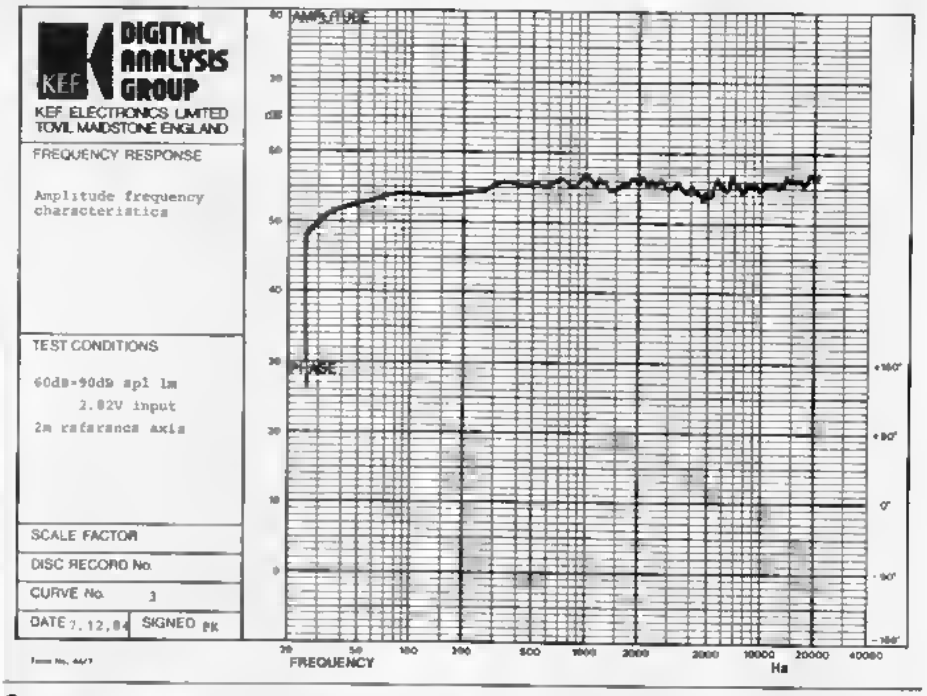


Figure 8. Amplitude vs frequency characteristic.

9

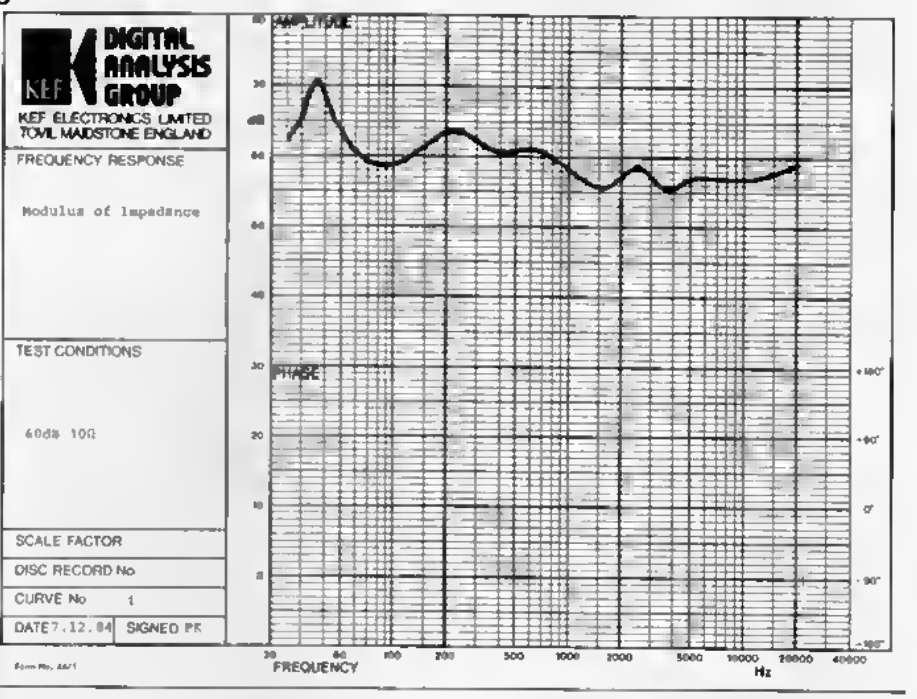


Figure 9. Modulus of impedance vs frequency characteristic.

1.5 mm² flex may be used for the (fairly short) connections between the boards and the inputs sockets and between the boards and the drive units.

We have already touched briefly on the enclosure proper, and figure 7 illustrates how it consists, as it were, of an inner and outer cabinet. Figure 7a shows the basis, comprising the bass chamber with the compartment for the middle and high frequency units mounted on top. The bottom of the smaller compartment has been extended to the back and provided with sunken holes to enable the box to be fastened to the bass compartment with a couple of heavy bolts and wingnuts. Figure 7b shows what the construction looks like when the slanting side panels of the middle and high frequency chamber and the outer enclosure have been added. The spaces between the side panels of the bass chamber and the outer enclosure are filled with sand. There is sufficient space left behind the upper compartment to accommodate not only the crossover network, but also a power amplifier.

The three drive units are sunk into the front panels. This does not require any milling or chiselling, because we have used a sandwich construction of two separate sheets of plywood that are glued together. The forernost sheet has a cut-out

(continued on page 47)

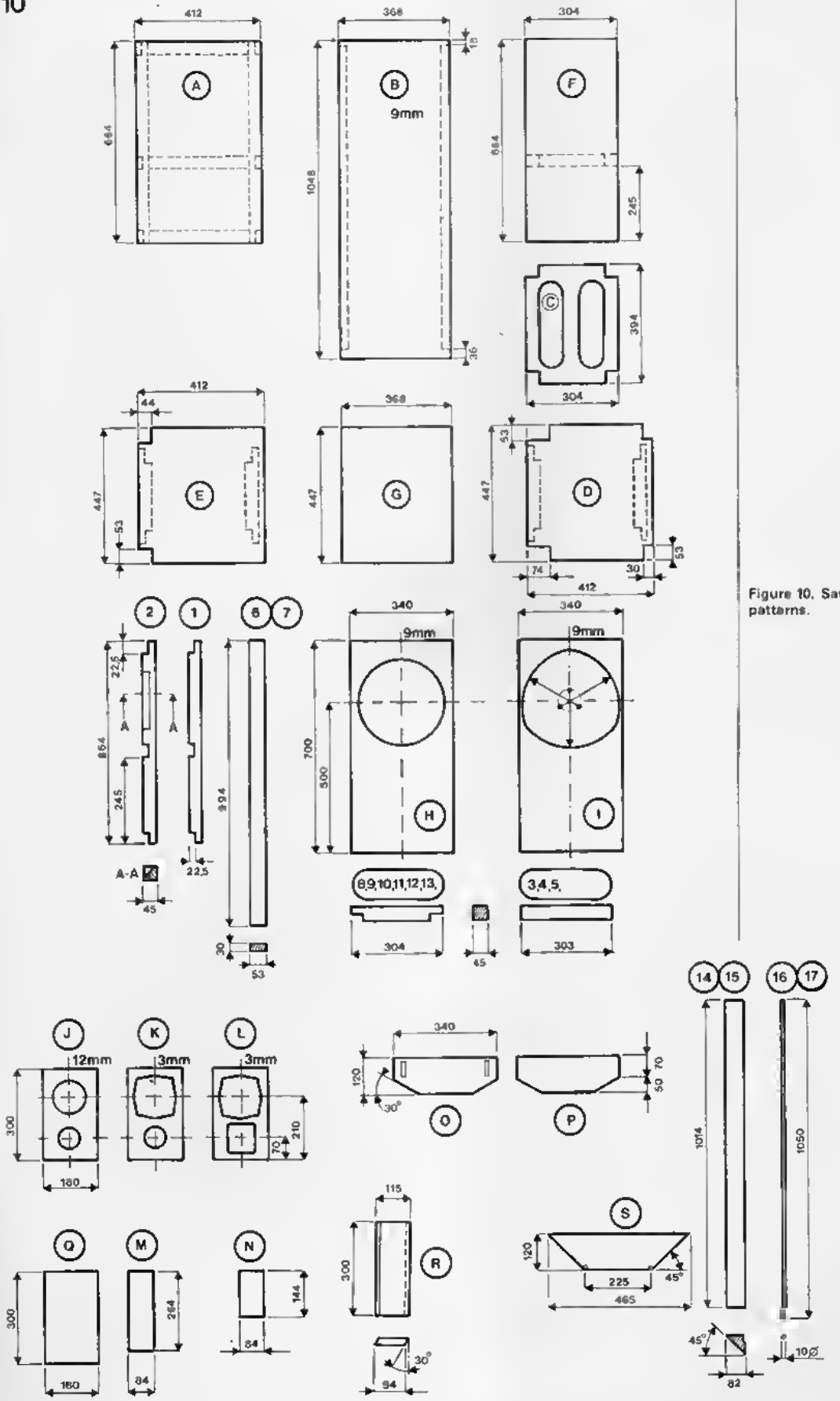
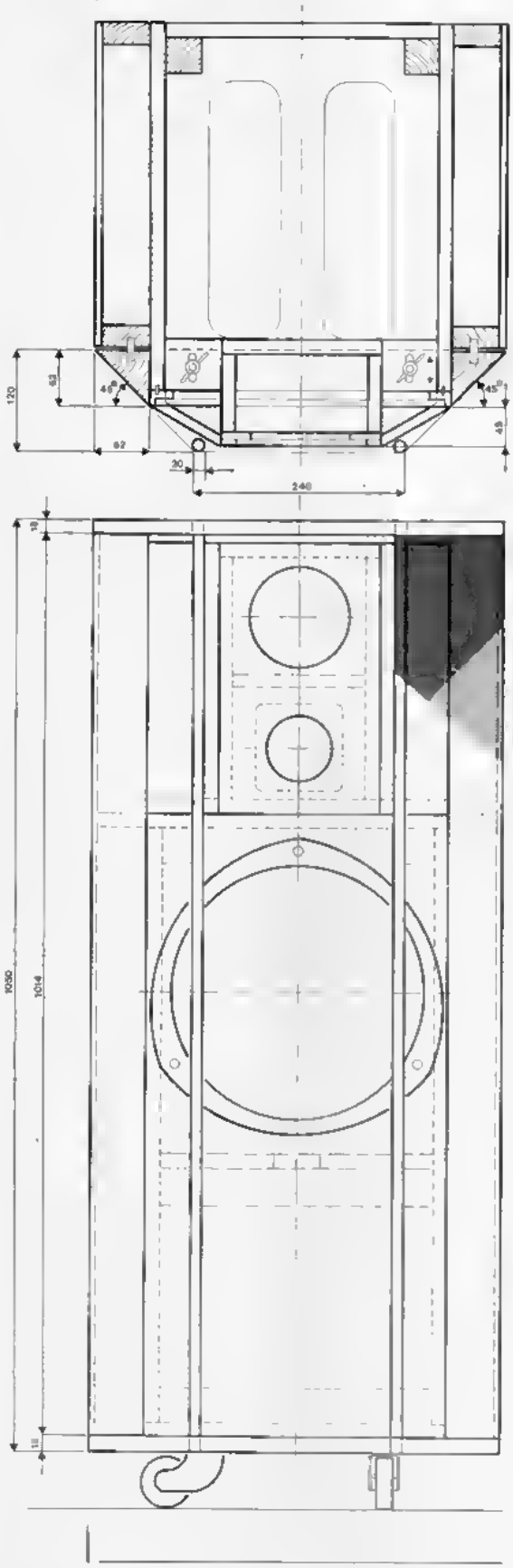


Figure 10. Sawing patterns.

Constructional details



The bass chamber

- Fit battens 1...5, and then 6 and 7, to side panels A and A'. Next, fix panels B and B' to the side panels.
- Fit anti-boom panels to the inside of those parts of B and B' that protrude above the bass compartment. This is best done with floor covering adhesive.
- Mount partition C between side panels A and A'.
- Glue batten 12 to rear panel F and then fasten this panel in place.
- Glue battens 8 and 9 to lid D of the bass compartment.
- Glue battens 10 and 11 to floor panel E of the bass compartment.
- Fit floor panel E and lid D to side panels A and A'.
- Fit anti-boom panels to the inside of panel G and then fasten this top lid to panels A-B and A'B'.
- Cut holes as indicated in panels H and I and then glue these panels together securely.
- Fit centre batten 13 between battens 2 and 2' at the front.
- Make all electrical connections to the bass drive unit.
- Fit 30 mm thick sheets of rock-wool to the inside of all panels and then fill the space behind the woofer loosely with Dr Bailey's longhair or fleece.
- Mount front panel H-I in place.
- Fill the space between panels A and B and that between A' and B' with (dry!) sand.
- Mount the bass drive unit in place with nuts, bolts, and washers.
- Finish the compartment as required with varnish, veneer, and so on.

Middle and high frequency compartment

- The front panel consists of J, K, and L; cut holes as indicated, and glue the three sections firmly together.
- Fit sides M and M' to the front panel, and at the same time fix partition N.
- Glue lower panel O and lid P to the compartment, and then fix back panel Q.
- Fit slanting panels R and R' at the front.
- Make all electrical connections to the two speakers.
- Fit the drive units in the compartment.
- Fill the compartment loosely with Dr Bailey's longhair or fleece.
- Finish the compartment as required (varnish, veneer, and so on).
- Screw the compartment to the bass unit.

Grille

- Drill holes in the top and bottom of the grille, i.e., panels S and S', for the cloth tensioning bars.
- Assemble panels S and S', together with battens 14 and 15 and cloth tensioning bars 16 and 17.

11b

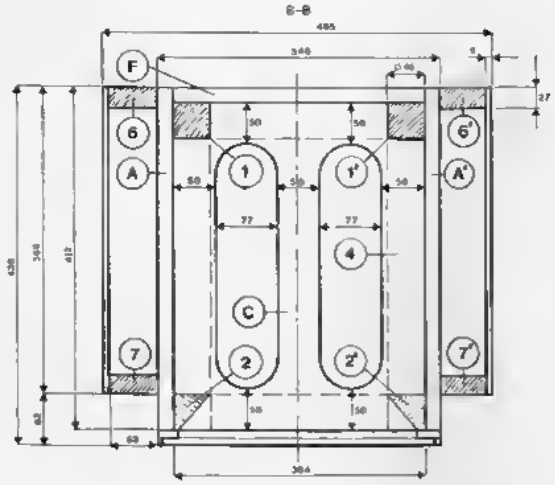
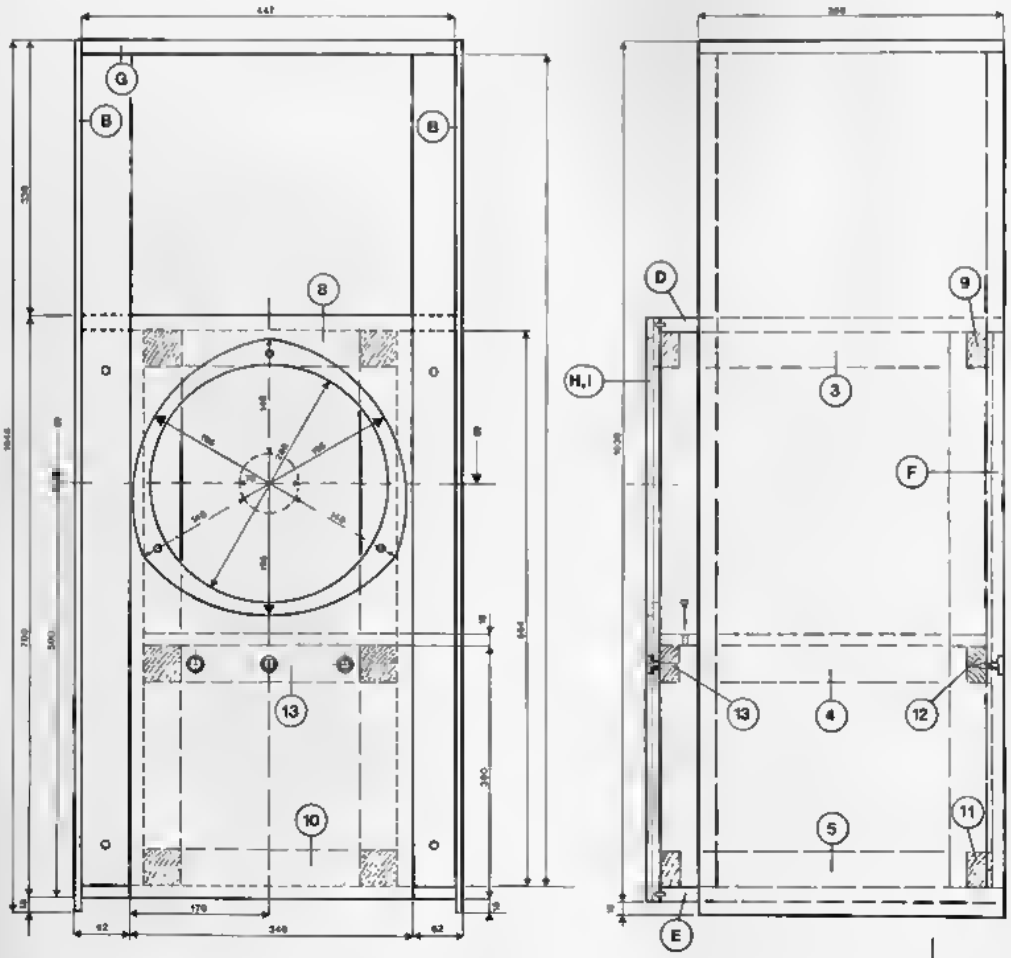
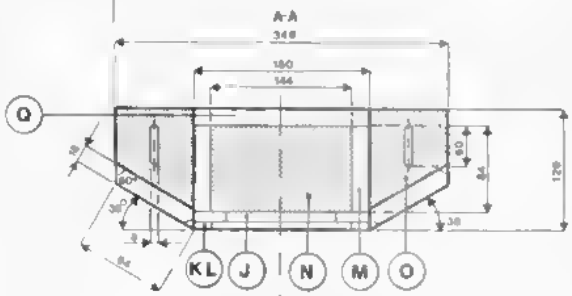
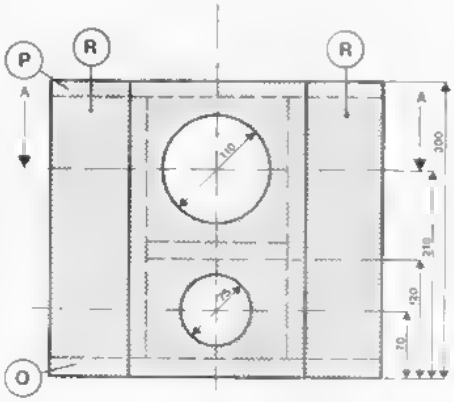


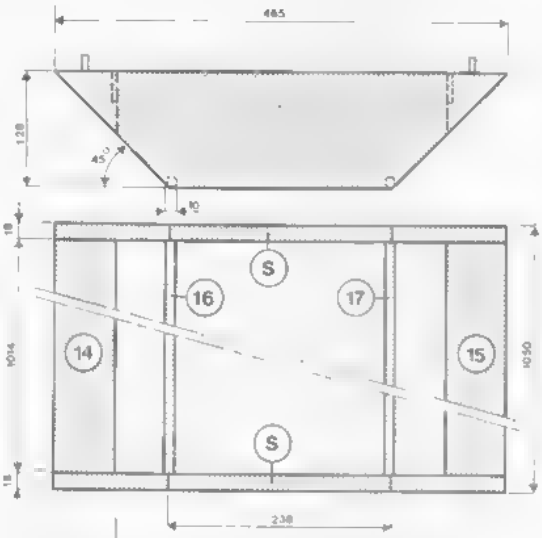
Figure 11. Construction plan.



11c







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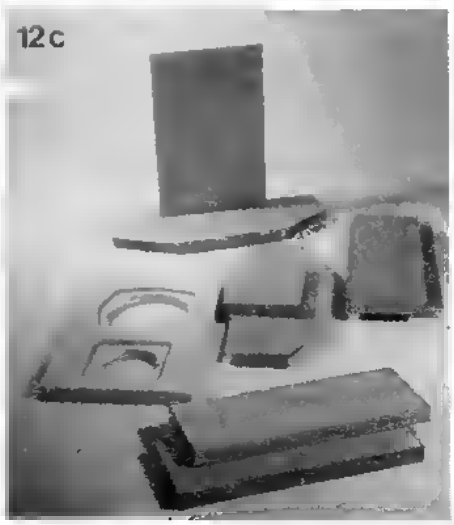
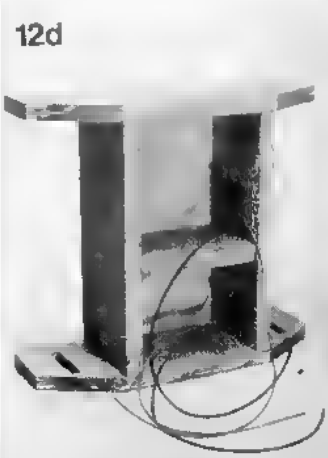
- Finish the grille as required (varnish, veneer, and so on).
- Fit dowels in the side battens — 14 and 15 — to enable the grille to be fastened to the enclosure.
- Fasten the grille cloth to the top and bottom of the grille with steel tensioning wires. The protruding edges of the cloth should be stapled to the back of the side battens.
- Fit the grille to the enclosure.

the same size as the outer diameter of the loudspeaker, while the second panel has a slightly smaller cut-out. KEF provides a paper template for cutting the holes for the drive units.
The complete cutting pattern of the enclosure with all dimensions is given in figure 10. It has been designed in a manner by which standard available sheets of wood are utilized as economically as possible. If your carpentry skills are suspect, it is wise to have the material sawn by an experienced carpenter to ensure that all parts are the right size and straight!
For the rest, you need a good quantity of first class wood glue and an assortment of screws and/or nails. Since this is in any case a project for experienced handymen, we will not go into details as to what types and sizes of screws and/or nails, or, indeed, whether you screw or nail the cabinet together. As long as all panels are fastened together securely, and the cabinet is airtight on completion, it does not matter how you do it.
The construction plan is given in figure 11. a shows the complete enclosure with outside dimensions, b shows the bass chamber complete with outer enclosure, and c gives all the details of the middle and high frequency speakers compartment complete with grille. Construction can thus be sub-divided into three different phases, detailed on pages 39, 40 and 45, 46, which can conveniently be lifted out if desired

Finally
As stated before, the crossover network may be housed in the empty space behind the middle and high frequency compartment.
The various interconnecting wires can be taken through the (back) panels via 3 mm diameter brass threaded rods and heavy-duty spade terminals
The photographs in figure 12 show various stages of the construction.
Impedance and frequency curves are given in figures 9 and 8 respectively, while the technical characteristics are summarized in table 1.

Figure 12 Photographs of various stages in the construction.





12e

12g

12f

12h

FET millivoltmeter

J. Borgman

FET opamps have high gain, low input offset and an extremely high input impedance. These three characteristics make them eminently suitable for use in a millivoltmeter. The circuit presented here can measure both voltages and currents.

Figures 1a and 1b show the basic circuits for voltage and current measurement respectively. In figure 1a, the opamp is used in a virtual earth configuration and the gain is therefore determined by the ratio Ra/Rb and by the voltage divider circuit Rc/Rd. The exact formula is given in the diagram. The current measurement circuit, figure 1b, is also basically a virtual earth configuration; the opamp will maintain an output voltage such that the left-hand (input) end of Ra is at zero potential and, since the input current must flow through this resistor, the voltage drop across Ra equals I x Ra. Therefore, the output voltage must be −I x Ra.

The complete circuit (figure 2) combines these two functions. The range switch S3 selects the required feedback resistor (Ra in figure 1) and the voltage divider (Rc and Rd) if the latter is required. The resulting ranges are listed in Table 1. The polarity of the meter can be reversed by means of switch S2.

A symmetrical +/−3 V supply is required, capable of delivering 1 mA. This low voltage and low current consumption means that the FET millivoltmeter can be battery-powered. This is a highly desirable feature, since the meter can then be used for so-called 'floating' measurement. A higher supply voltage is permissible, if it is easier to obtain (4.5 V flat batteries, for instance); the maximum for these opamps is a symmetrical +/− 16 V supply.

It is advisable to use 1% resistors, and P1 and P2 should preferably by high-quality preset potentiometers. R1, R2 and R3 may prove difficult to obtain, in which case a series-chain of 1 M resistors must be used.

Preset P1 is for offset compensation. With the meter input shorted, this preset is adjusted until the meter reads zero. P2 is the calibration potentiometer: a known voltage (or current) is applied and P2 is set so that the meter reads correctly.

Figure 3 shows an optional extra, the 'universal shunt'. This consists of nothing more than a chain of resistors that can be connected across the voltage input terminals of the meter. If current is passed through any one of these resistors, a corresponding voltage drop will appear across this resistor. Since there is no voltage drop across any of the other resistors, this voltage will be indicated by the meter, Table 2 lists the resulting current measurement ranges. As before, 1% resistors should be used for the actual measuring chain (R19 . . . R24).

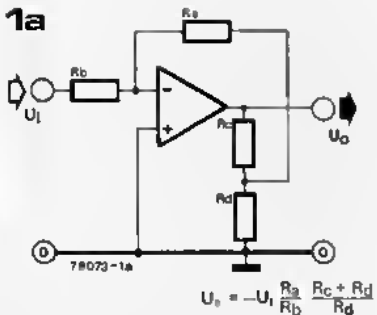
Table 1

S3	U_i (f.s.d.)	I_i (f.s.d.)
a	10 mV	1 nA
b	50 mV	5 nA
c	100 mV	10 nA
d	500 mV	50 nA
e	1 V	100 nA
f	5 V	500 nA
g	10 V	1 µA
h	50 V	5 µA
i	100 V	10 µA
j	500 V	50 µA
k	1000 V	100 µA

Table 2

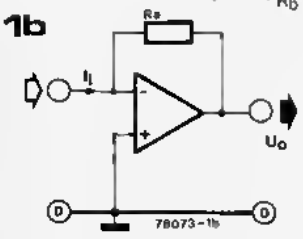
S3 in position	a	b	c
I_a (f.s.d.)	1 µA	5 µA	10 µA
I_b (f.s.d.)	10 µA	50 µA	100 µA
I_c (f.s.d.)	100 µA	500 µA	1 mA
I_d (f.s.d.)	1 mA	5 mA	10 mA
I_e (f.s.d.)	10 mA	50 mA	100 mA
I_f (f.s.d.)	100 mA	500 mA	1 A

1a



$$U_o = -U_i \frac{Ra}{Rb} \frac{Rc + Rd}{Rd}$$

1b



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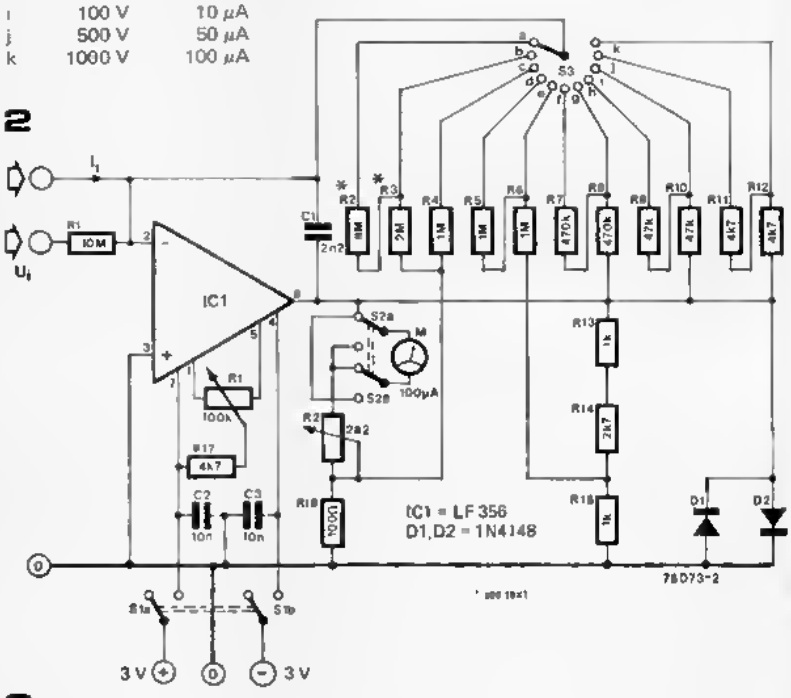

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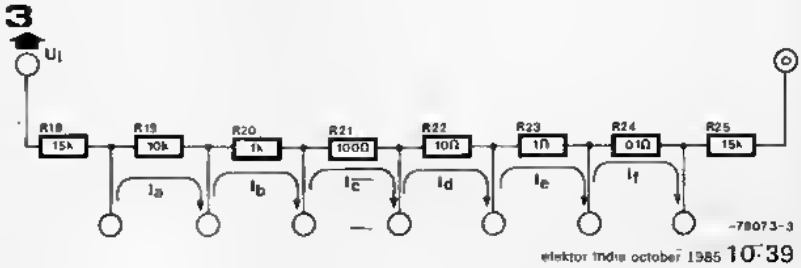


One of the most common sales ploys in the computer world is to demonstrate a machine's capability for graphics. Unfortunately, the graphics card is often an optional extra or so basic that it needs very powerful programs to control it. In general, it is far better to use a separate graphics card. The one described in this series of articles offers a range of options rarely found together in one project. It is very efficient due to the clever balance of software and hardware: a balance achieved only after many months of design and tests. The major characteristics of both the hardware and the software are summarized in Table 1.

1 high-resolution colour graphics card

the first in a series of articles describing a 512×512 or 512×256 pixel, black & white or colour graphics card, complete with software

P Lavigne &
D Meyer

Basically, a graphics card is an autonomous terminal that generates graphic video images based on instructions received and decoded by the software. In a sense, it is similar to a printer receiving ASCII codes and converting these into control signals for driving its print head. The difference between a printer or *x-y* plotter and a graphics card is that the latter does not need a separate CPU to interpret the instructions, since it makes use of the host system's microprocessor. The processor on the graphics card is used to generate the screen memory and to make traces.

ASCII is the acronym for American Standard Code for Information Interchange. It is a 7-bit code that gives 128 unique combinations of characters, of which 32 are reserved for special control functions

Design considerations

A graphics card has a number of advantages over a VDU card: it provides dot-by-dot (rather than block-by-block) graphics; its results have a high resolution; and it can support colour. In addition, a graphics card enables text to be included in the picture, so that, with the associated software, it is also an alphanumeric video terminal with a resolution of 32 lines of 80 columns. This latter property is more important than may appear at first sight, since it enables both the colour and the size of the characters to be easily changed, to the obvious benefit of versatility.

pixel is short for picture element. It is also called a pel or a dot

All pixels on the screen are accessible on an *x-y* matrix when the coordinates are presented to the graphics processor. The origin, $x=0$; $y=0$, is found at the top left-hand corner in text mode and at the bottom left of the graphics screen.

The complete card, with colour extension, uses only 19 addresses in the host's memory. This makes it simple to include the card in any system, particularly a

Table 1. Technical characteristics of the graphics card

Table 1.

HARDWARE	
Processor	GDP9366 (9365) or GDP9367
Databus	8-bit, buffered
Addresses decoded	19 (XX50 XX5F, XX64 XX66) The screen memory is autonomous with automatic refresh (16K per page and per colour)
Synchronization.	composite, normal or inverted (buffered TTL output)
Video:	monochrome RGB or RGBI (buffered TTL outputs)
Lightpen	negative pulse (buffered TTL input)
Resolution:	4 pages of 512 × 256 pixels (9366/9367) 2 pages of 512 × 512 pixels (interlaced only/9367)
Colours	monochrome on the main board / RGB on the extension (8 or 16 colours) **Note** The number of colours does not restrict the resolution in any way Several extension cards may be added
Scrolling	vertical scroll (the software changes the display addresses sent by the GDP to the video memory)
RWM	read/modify/write mode (EXOR data between pen and paper)
Communication with the screen memory	pixel by pixel reading (the microprocessor uses a special instruction to feed the pixel coordinates into the GDP)
Interrupts	IRQ (3 programmable modes)
Generators:	■ alphanumeric characters (on a 5 × 8 matrix) The number of characters is individually programmable for *x* and *y* axes ■ programmable vectors (four types of trace) – see software

SOFTWARE

The graphics card is supplied complete with software (a little less than 4K of 6502 object code). This is sub divided into two programs one of which generates all the text (and is a sort of ASCII video terminal) and the other handles all the **graphics**. The software is completely autonomous and acts almost like a super reception routine for the contents of the accumulator. Note how concise the instructions are

6502-based one, since the control interpreter was designed around this processor. The software can, of course, be changed to suit a different processor, or to enable the graphics card to be driven direct, but this involves some more work, which will be considered at a later stage. The colour extension and mother boards are both of eurocard format. The latter is completely independent and monochrome; its input is linked to the microprocessor bus, while the output provides the video signals that are fed direct to a monitor. Apart from the graphics processor and TTL circuitry, this card contains 64 K of dynamic RAM.

The colour card, which will be discussed later, has four banks of 64 K memory that form an extension mounted parallel to the mother board. This card communicates with the host's microprocessor via its data bus, and with the mother board by a separate bus. It provides RGB (red, green, blue) signals that are combined with the base board's video signal to obtain 2, 4, 8, or 16 colours (or shades of grey) on a monitor with RGB or RGBI (I = intensity) inputs. It is possible to add a second extension card (for which provision has been made) and generate, 32, 64, or 128 colours.

Functional diagram

The basic functional diagram is given in Figure 1a; that in the Figure 1b is complete with the colour extension card. The graphics card is based on the Thomson Type EF9365, EF9366, or EF9367 **graphics display processor (GDP)**. The processor generates 64 K of dynamic video RAM, which is completely separate from the memory of the computer with which the graphics card is used. The timing and clock stages control the timing of the internal signals and are in turn driven by the dot clock, which is either a 12 MHz or 14 MHz version.

The graphics card can access the microprocessor data bus either via the GDP or via the read/write latch. An internal address decoding circuit handles all communications and the graphics card, therefore, needs only nineteen addresses from the host system.

Table 1

CHR$	Text mode commands		Graphic mode commands
(1)	Transfer video buffer contents to screen	A	Set text mode
(2)	Open the video buffer	B n	Set background color to color "n"
(3)	Close the video buffer	B −n	Combine the background color with color "n"
(4)	Use graphic commands in text mode	C n	Set pen color to color "n"
(5)		C −n	Combine the pen color with color "n"
(6)		D x,y	Draw from current position to x,y destination
(7)		D x,y,x,y,...	D may be followed by several x,y destinations
(8)	Backspace (cursor left)		X,Y coordinates are given from absolute origin
(9)	Horizontal tabulation (cursor right)	E	
(10)	Line Feed (cursor down)	F	
(11)	Vertical tabulation (cursor up)	G ±n,x,y	n = 1 , n = 2 ; n = −1 , n = −2
(12)	Clear screen&home cursor	H	Home pen to current origin (without drawing)
(13)	Carriage Return	I	Set current location as new absolute origin
(14)		J x,y	Draw from current pen location to **relative position** x,y
(15)			
(16)		J x,y,x,y,...	J may be followed by several x,y destinations
(17)	Set text mode	K	
(18)	Set graphic mode	L n	Set line type n, n = 0 ; n = 1 . ; n = 2, ..., n = 3, ...
(19)			
(20)	Reset the character size	M x,y	Move to absolute location x,y without drawing
(21)		N	
(22)		O e,r,i	Draw a circle or a disk with current absolute origin as center
(23)			
(24)			s = sectors i = **radius**, t = **thickness**
(25)			
(26)	Erase current line		
(27)	Escape		
(28)	Home cursor	P characters	Print alphanumeric characters without leaving graphic mode
(29)	Clear to end of line	Q d	Set the print direction; d = 0 **horizontal**
(30)			d = 1: **vertical**
(31)		R x,y	Move to relative x,y position from current pen location (without drawing)
		S x,y	Set character size x on X axis / y on Y axis
Examples in BASIC:		T t	Set character type t, t = 0 normal,
PRINT CHR$(18) "M0,127,I"			t = 1 tilted
PRINT "B6,C4,D255,127,255,0"		U p,u	Select pen/eraser up/down; p = 1: pen; p = 0: eraser; u = 1: down; u = 0 up
PRINT "C2,M127,63,I"		V x,y	Get pixel status at specified x,y location
PRINT "0255,60,2"		W m	Set Read Modify Write mode; m = 0, **no RMW mode**, m = 1, **RMW**
etc..		X a,s,i	Draw a coordinate axis from current location in direction "a" using increments "s"(teps) (+ or −) and marking "i"(ntervals)
.		Z p	Select page "p"

Table 1 gives the instructions that are accepted by the command interpreter, which will be discussed later. These instructions are not directly intended for the GDP, which cannot interpret them either in the form given. Note that the majority of the instructions end their syntax are the same as those used with a number of plotters, such as, for instance, the Tandy.

Before the command interpreter can be dealt with, it is necessary to study the mother board, followed by the colour extension card.

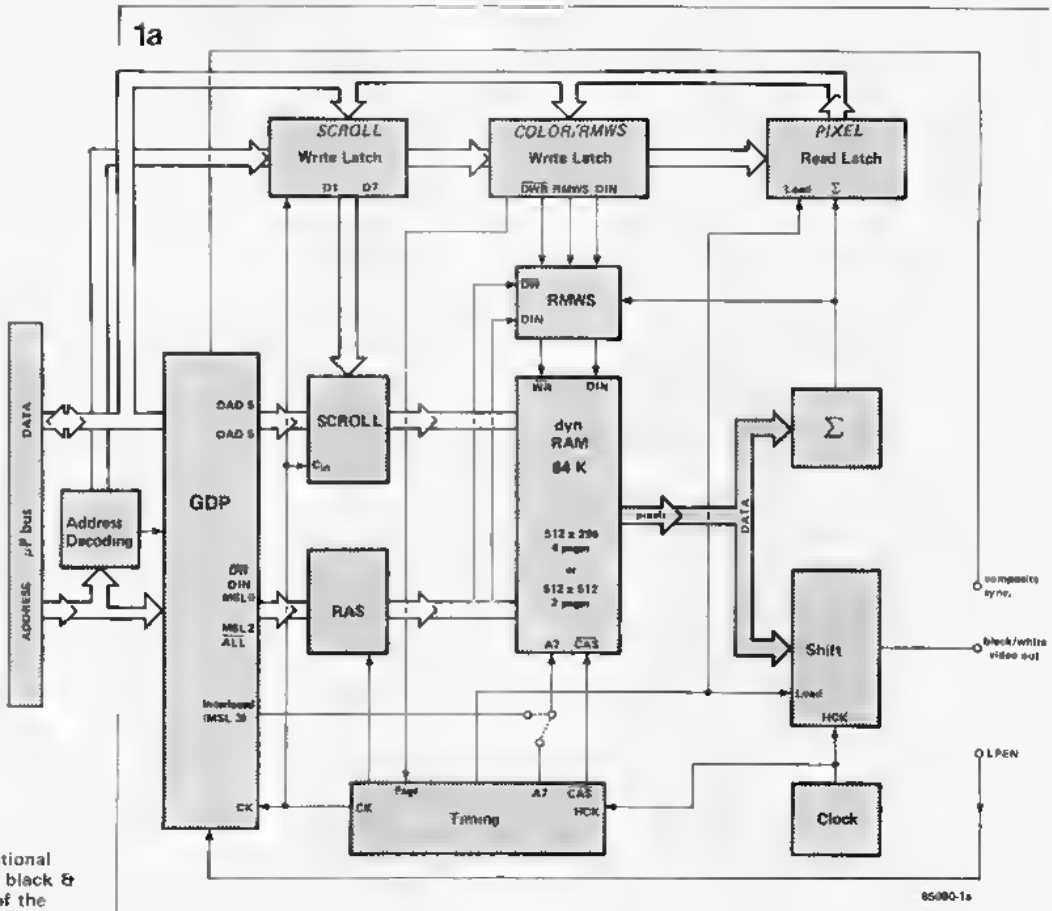


Figure 1a. Functional diagram of the black & white version of the graphics card.

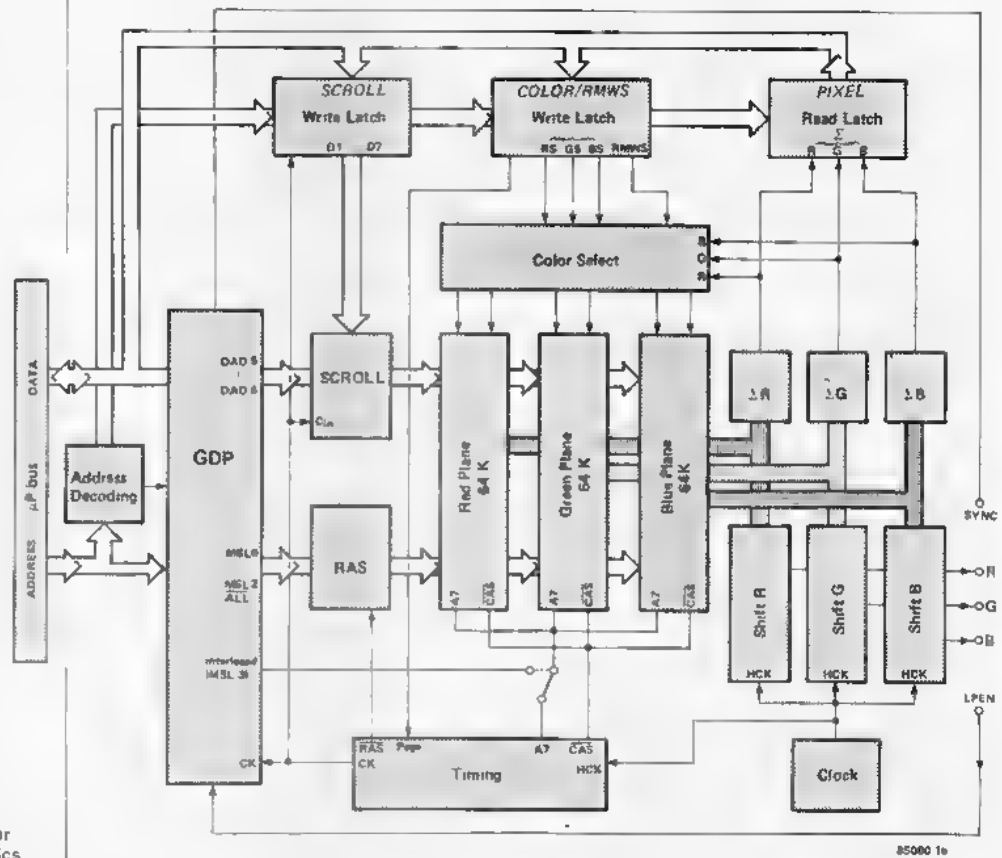


Figure 1b Functional diagram of the colour version of the graphics card

The ***SCROLL* register** enables the microprocessor to shift the addresses supplied by the GDP to the video memory in order to move the entire screen image vertically. This is particularly interesting when there is text on the screen.
The ***COLOUR* register** allows the colour of the pixels to be changed, and also permits the shift of the screen memory from the 512 x 256 (non-interlaced; four pages) mode to the 512 x 512 (interlaced; two pages) mode.
The ***RMWS* (read-modify-write select) register** enables the contents of the screen to be altered without the need of memorizing the original, which can, however, be recalled afterwards. This will be dealt with in more detail later.
The ***PIXEL* register** makes it possible for the microprocessor to examine the state of a pixel, the coordinates of which it has fed to the GDP. It is, of course, a read only latch.
The **second SCROLL** function (in association with the ***SCROLL* register**) alters the addresses sent by the GDP to the video memory so as to shift the entire image vertically.
The **RAS (row address strobe)** simply distinguishes between the two different access modes of the GDP to the video memory. In the first of these modes, eight ICs in the memory are accessed simultaneously to refresh or change the background colour or any other aspect of the addressed byte. In the other mode a single IC is accessed to read or write a single point, i.e., when only one bit of the relevant byte is addressed.
The complete functional diagram in Figure 1b includes the extension for 8 colours, which will be reverted to later.

Black & white picture production

The image on the fluorescent screen of the cathode-ray tube (CRT) in the monitor display unit comprises hundreds of thousands of pixels. The screen is scanned in both the horizontal and the vertical direction by an electron beam moving at a rate of 64 µs per line. The horizontal direction is termed the line, and the vertical direction, the field (also called the raster). Sawtooth waveforms are used to deflect the beam: the flyback period is blanked out.
Pulses are used to synchronize the original signal and the screen image. The line synchronizing pulses are generated during the line flyback period, and the field synchronizing pulses during the field flyback.
For optimum performance, the number of horizontal scans is made larger than the number of vertical scans. The number of lines traversed per second is the line frequency; the number of vertical scans per second is the field frequency.

2a

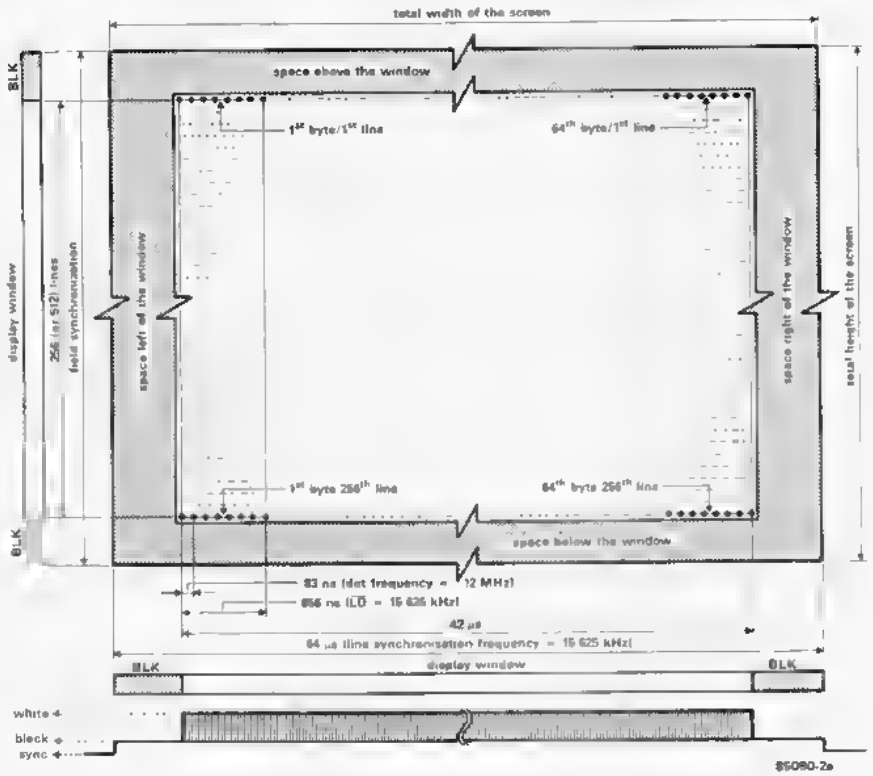


Figure 2a. Picture size and image production

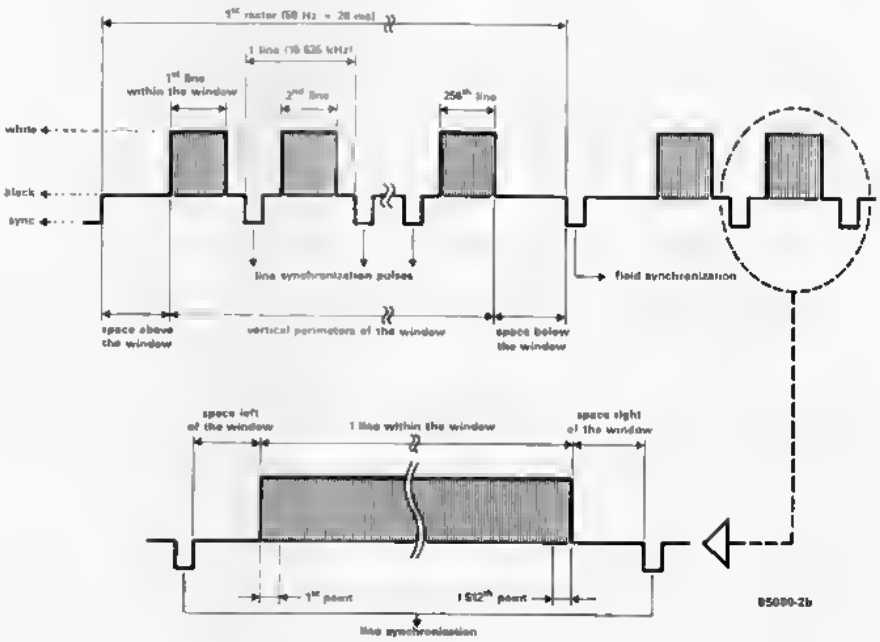
Generally, interlaced scanning is used, in which the lines of successive fields are not superimposed on each other, but are interlaced; two rasters form a complete picture or frame. The number of complete pictures per second is the frame frequency, which is, therefore, half the field frequency. The field frequency is slow enough to allow a great number of horizontal lines, and fast enough to eliminate flicker. European systems invariably use the 625 lines per frame standard recommended by the CCIR, and a field frequency of 50 Hz, whereas the system in North America uses a 60 Hz field frequency and 525 lines per frame.
A graphics card defines a rectangular window within the screen area as one in which lines are scanned in 42.667 μs (see Figure 2a). If each line contains 512 pixels, it is about 83 ns wide. A complete scanning line (from one edge of the screen to the other) then contains 768 pixels. This gives a pixel frequency of 12 MHz, which is applied as a clock to a shift register. If this is an 8-bit type, the bits are input at a frequency of 1.5 MHz.
At the start of a scanning line nothing happens until it reaches the left window frame: the shift register then loads the first byte and outputs one pixel every 83 ns (see Figure 2b). After 8×83 ns, the first eight bits at the top left-hand side of the screen are either on or off. The shift register then loads the second byte, and continues outputting bits. This goes on until it has output the last bit of the 64th byte for this line, when the line reaches the right-hand frame of the display window. Nothing happens then until the line sync(hronization) pulse, when the electron beam flies back to start scanning the next line. This process continues until the end of the last line at the bottom of the window has been reached. Note that the top and bottom of the screen fall outside the window.
Next, the field synchronizing pulse causes the electron beam to fly back to the point of origin at the top left-hand corner of the screen, and the whole process starts afresh.
It is clear that there are three factors determining the picture: the sync pulses, which have fixed frequencies irrespective of the contents of the picture, and the video signal proper. The latter may be considered as composed of all the pulses corresponding to the dots making up the picture. It is derived from the dot clock, which provides the timing for the output shift register. This register receives information as to brightness of the pixel in packets of eight bits — the **luminance** signal — that are loaded simultaneously to the video memory. The pulse indicating "load the next byte" arrives while the previous eight bits are being read, provided the beam of electrons is within the window. A blanking signal ensures that the screen outside the window remains completely dark.

Colour pictures

The colour information is contained in the **chrominance** signal, which is obtained by combining three binary signals, each of which represents one of the primary

Figure 2b. Composition of the video signal

2b



3

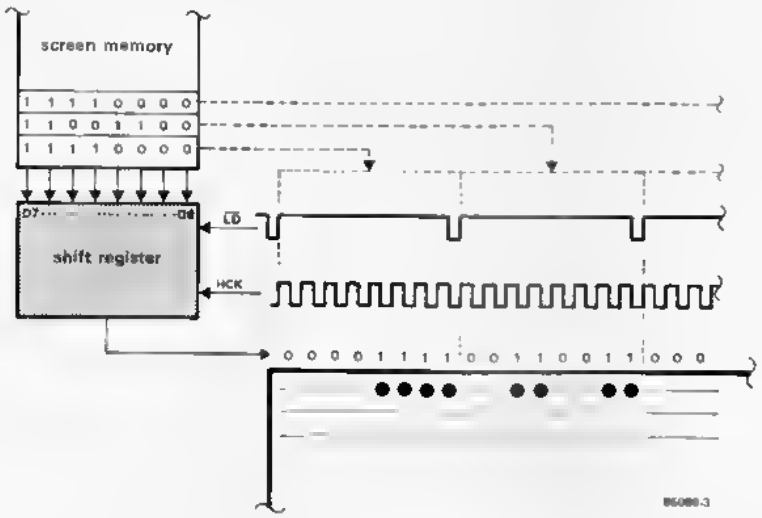


Figure 3. Production of a single-colour signal, three registers as shown are needed for a colour graphics card.

colours red, R, green, G, and blue, B. Any three primary colours can be mixed, in suitable proportions, to produce any other colour, except black. In other words, the colour is determined by the binary word formed by a combination of the three binary colour signals; this combination is also known as pel or pixel, both short forms of picture element.
The three colour signals are usually applied to the RGB inputs of the monitor. When the R input is high, and the other two low, the pixel will show up red; similarly, a high blue input and low R and G inputs will result in a blue pixel. Further primary colours are produced under the following conditions.

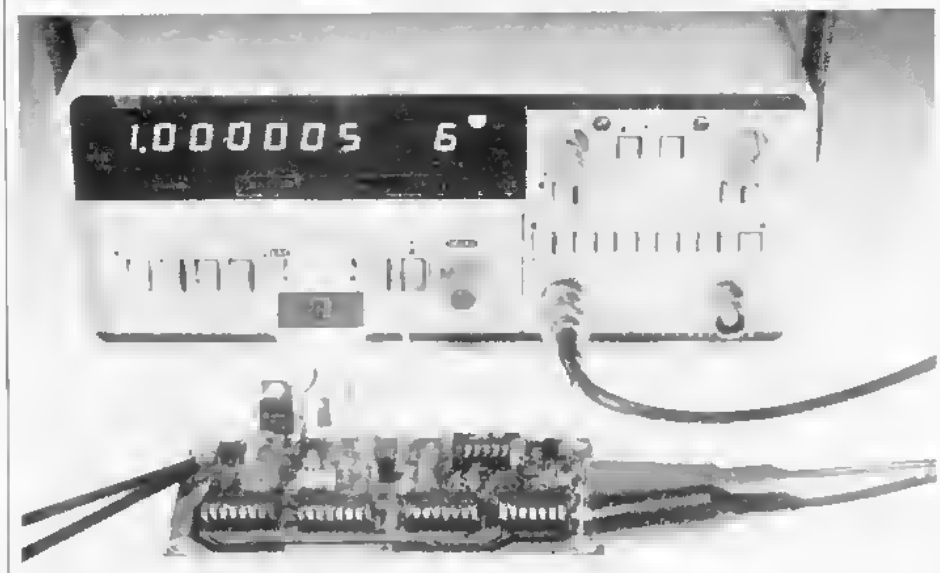
R (high) + G (high) + B (low) = yellow
R (low) + G (high) + B (high) = cyan (greenish blue)
R (high) + G (low) + B (high) = magenta (reddish blue)
R (high) + G (high) + B (high) = white
R (low) + G (low) + B (low) = black

The colour signals are output by three separate shift registers; this situation is shown for black and white or one colour in Figure 3. The registers are fed by three parallel banks of memories: each channel carries a signal as shown in Figure 2b.
The line and field sync signals, the dot clock, and the load shift register are, of course, common to the three channels.
Reiterating, there are thus **three bits with the same address** (but each in a distinct memory bank) for each pixel on the screen.
If the screen is black and its colour is required to be changed to, say, red, the R memory must be written to; if a yellow screen is required, the red and green memories should be accessed. This is, of course, true of not only the entire screen, but also of each individual pixel.
The graphics card must, therefore, have a dataline and a write select line common to the three memory banks, and also an individual select line. In practice, this requires two signals: one to indicate whether a bank is accessed or not; and the other to specify what is being done there. When the writing is green on a red background, for example, the pixels that are written must be accessed in both the green and the red memory. However, when the bit in the G memory is actuated, the same address in the red memory must be disabled. If this were not done, the pixel in the example just described would be green + red = yellow on a red background.
Note that a pixel being lit on the screen has a logic low level on the graphics card, and a high level when it is dark.

Part 2 will appear in our November 1985 issue. ■

Did you know...

...that FORTH is currently the hottest high-level computer programming in the language industry?
Though still relatively new, FORTH is rapidly gaining in popularity because of its reduced memory requirements, modular structure, inter-active nature, and ability to be extended to a problem-solving language.
Prime areas of application for the language are in data acquisition, process control, robotics, or any other application that requires high speed with low software overheads.



G E Dunning

A frequency standard is a stable and precise oscillator that is calibrated against national or international reference frequencies which are often broadcast as time signals throughout the day; in many countries, such reference signals are also available over the telephone. These reference frequencies deviate by not more than 1 second per 3170 years. The clock used in the SI definition of the second is 100 times better still! A frequency standard is used, for instance, to check the calibration accuracy of various measuring instruments. For this purpose, an accuracy of about 1 p.p.m. is normally perfectly adequate.

frequency standard

A quartz-controlled digital watch, synchronized to a radio or telephone reference time signal over a period of time, is a convenient and inexpensive basis for a frequency standard. Such a watch commonly deviates not more than 1...2 seconds per month from true time, which is an accuracy of better than 1 p.p.m.
The quartz-crystal oscillator in a digital watch has a frequency of 32.768 kHz, which is divided by 2^{10} (=1024) to obtain a 32 Hz signal for maintaining the LCD (liquid crystal display). It is not possible to tap the basic oscillator frequency without upsetting its accuracy, but the 32 Hz signal may be tapped with impunity

Functional details

Phase-locked loop. The operation of the frequency standard is illustrated in the functional diagram of Figure 1. The circuit receives a reference signal of 32 Hz from the digital watch, and this is compared in a phase detector with a signal derived from a VCO (voltage-controlled oscillator). If the VCO signal differs from the reference signal in phase or frequency, the phase detector generates an error signal, which is fed to the VCO via a low-pass filter. In this way, the VCO becomes a self-adjusting stage that provides a stable and accurate 16 MHz signal. This signal is divided by 16 and 16×10^6 to give output frequencies of 1 MHz and 1 Hz respectively.
Note that the 1 MHz signal has a 32 Hz ripple caused by the control signal to the VCO. However, the peak value of this ripple is so small that it will hardly ever be noticeable in practice.
Voltage-controlled oscillator. The oscillator formed by gates N_1 and N_2 in Figure 2 is a conventional crystal-operated circuit. If, however, a variable reactor, here formed by a VMOSFET Type BS170, is added, it becomes possible to vary the frequency with the control voltage provided by the phase detector via R_7. The use of a MOSFET as varactor (acronym of **variable reactor**), instead of the more usual semiconductor diode, has the advantage of a relatively large change in

capacitance — from 80 pF to 30 pF — for a voltage swing of 0 V to 2.5 V (see Figure 6). The maximum control voltage of 2.5 V arises when the output signal of the phase detector is symmetrical. These values enable the output frequency of the VCO to be varied from 15.999 to 16.000 MHz. The correlation between the output frequency and the control voltage is shown in Figure 7. The characteristic shows that the wanted frequency of 16 MHz is obtained with a control voltage of 1.2 V.

Phase detector. Correct operation of the frequency standard depends essentially on the proper functioning of phase detector N_3-N_4 (see Figure 2). Assuming that the inputs to N_4 are square wave signals, the duty factor, by definition, is 1:1. Slight variations in the duty factor will result from small differences in phase between the two inputs, and this will cause a change in the output voltage of the detector. The control voltage for the VCO is derived from this output: the correlation between the control voltage and the phase differ-

1

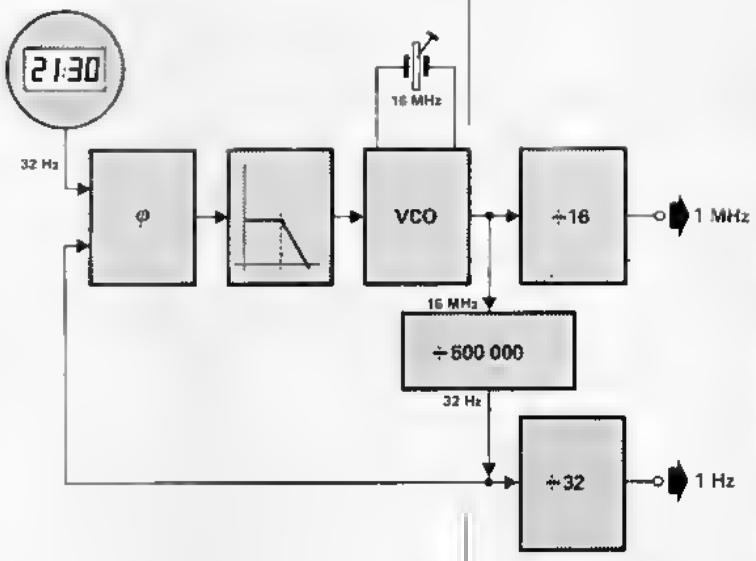


Figure 1. Functional diagram of the frequency standard.

2

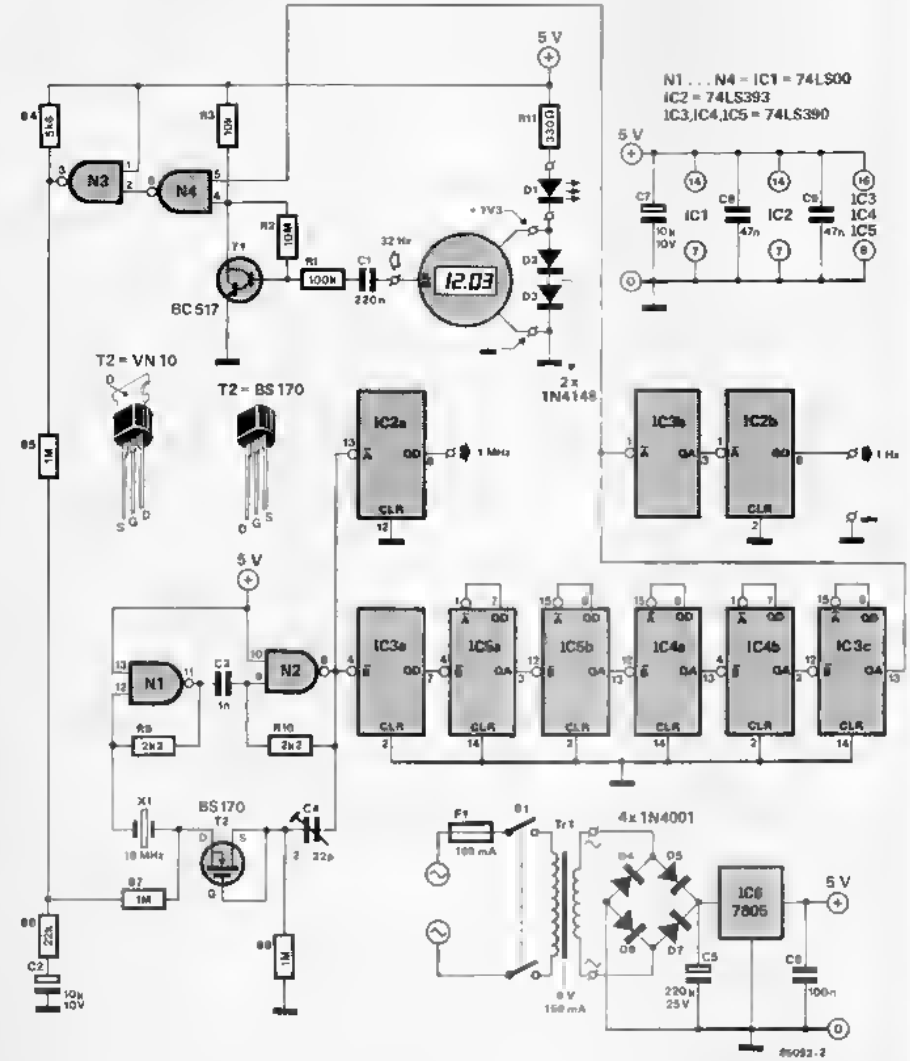


Figure 2. Circuit diagram of the frequency standard.

3

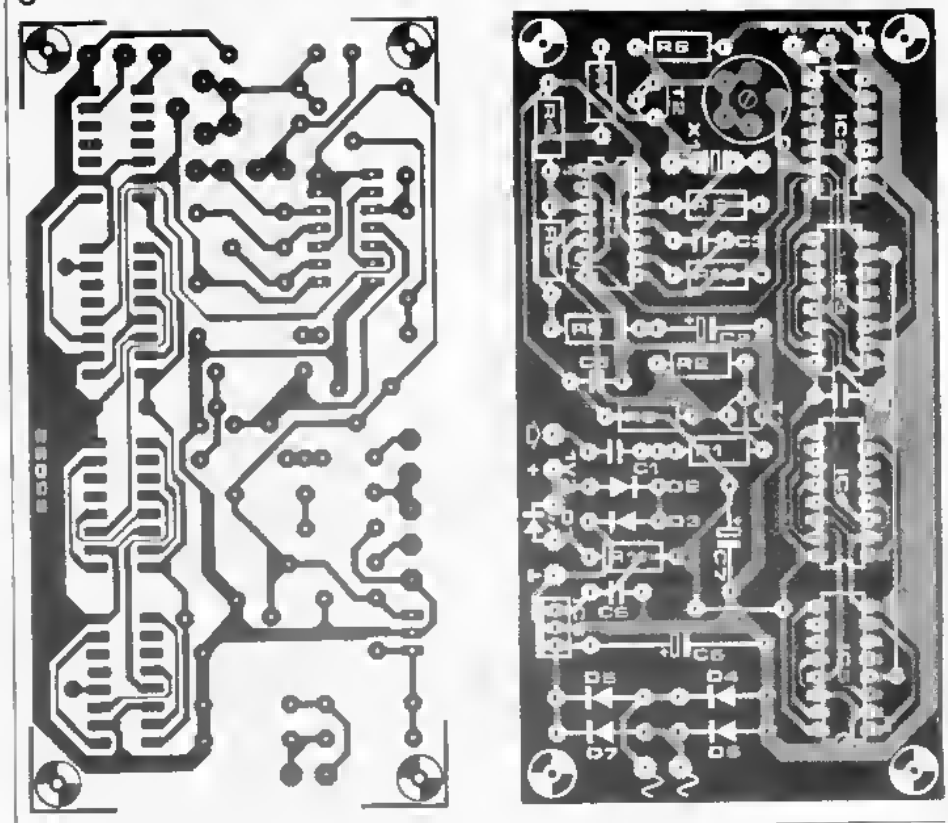


Figure 3. Printed-circuit board for the frequency standard

Parts list

Resistors.
R_1 = 100 k
R_2 = 10 M
R_3 = 10 k
R_4 = 5k6
R_5,R_7;R_8 = 1 M
R_6 = 22 k
R_9,R_{10} = 2k2
R_{11} = 330 Ω

Capacitors
C_1 = 220 n
C_2,C_7 = 10 µ, 10 V
C_3 = 1 n
C_4 = 2 ... 22 p; variable
C_5 = 220 µ, 25 V
C_6 = 100 n
C_8,C_9 = 47 n

Semiconductors
D_1 = LED, as required
D_2;D_3 = 1N4148
D_4,D_7 = 1N4001
T_1 = BC517
T_2 = BS170; VN10KE, VN10LE
IC_1 = 74LS00
IC_2 = 74LS393
IC_3;IC_4,IC_5 = 74LS390
IC_6 = 7805

Miscellaneous
X_1 = quartz crystal 16 MHz
F_1 = miniature fuse; 100 mA, delayed action; with carrier
Tr_1 = mains transformer, secondary 9 V; 150 mA
S_1 = DPST mains switch
LCD quartz digital watch
PCB 85092

ence at the inputs of the detector is shown in Figure 8. The circled cross indicates an operating point where the frequency of the signal at pin 5 of N_4 is a little lower than that at pin 4. This means that the phase difference between the two signals becomes larger, and this causes the operating point to slowly move towards the *x*-axis. This does not mean more stable operation, however! When the operating point has reached the turn-over point at 180°, the control voltage to the VCO begins to rise. This causes the VCO frequency, and consequently that at pin 5 of N_4, to increase. The widening phase difference is then slowed down until an equilibrium is reached, and this happens when the frequencies at pin 4 and pin 5 of N_4 are equal. The phase-locked loop is then operating correctly.

If the output frequency of the VCO drops a little due to a temperature variation, the phase difference widens again. The control voltage increases, and the VCO output frequency rises to its correct value.

Figure 7 shows that the maximum possible frequency correction is ±1000 Hz. After division by 500 000, this becomes ±0.002 Hz, which means that it takes the VCO a maximum of 1/0.002 = 500 s to correct itself.

Circuit details

The 32 Hz signal from the watch is fed to the phase detector, consisting of gates N_3 and N_4, via MOSFET amplifier T_1. The error signal from the detector is applied to the voltage-controlled oscillator, composed of MOSFET T_2 and gates N_1 and N_2, via low-pass filter R_5-R_6-C_2. MOSFET T_2 functions as a varactor, so that the oscillator frequency varies with the control voltage as mentioned. The output of the VCO is divided by 16 in IC_{2a}, and by 16×10^6 in the chain $IC_{3a} \ldots IC_{2b}$.

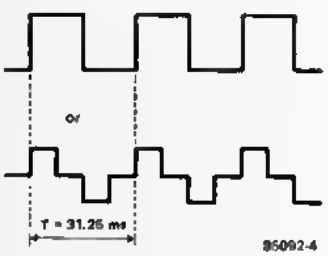
The power supply is of conventional configuration: transformer, rectifier, smoothing capacitor, and voltage regulator. If desired, the battery in the watch may be replaced by a direct supply via stabilizing diodes D_2 and D_3.

Construction and calibration

The frequency standard has been designed for construction on the printed-circuit board in Figure 3. Voltage regulator IC_6 does not need a heat sink. Once the board has been completed, connect the negative supply (earth) line to the watch. If the watch battery is replaced by a direct power supply, the +5 V line should now also be connected via R_{11} and D_1.

The trickiest part is to solder (with a very fine soldering tip!) a length of wire to the track of the PCB in the watch at which the back plate signal is present. This is normally at the top left (seen from the front of the board) of the LCD display. It is necessary to use an oscilloscope to determine which track carries the back plate signal. This signal has either a single- or double-step rectangular waveform with a period of 1/32 s as shown in Figure 4. The watch should be set for seconds display, which makes it easier to distinguish between the constant back plate signal

4



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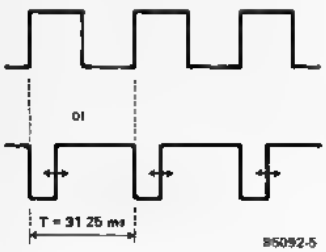

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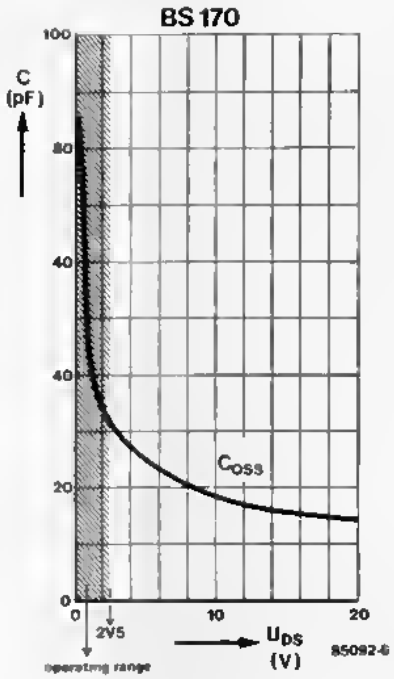


Figure 4. Back plate signal in a digital watch

Figure 5. Signal at the junction of R_2 and R_3.

Figure 6. Capacitance vs drain-source voltage in a BS170.

and the varying segment signal. Once the watch is connected to the main board, the signal at the junction of R_2 and R_3 should be as illustrated in Figure 5.
Connect an analogue voltmeter, set to the 3 V DC range, to the junction of R_4 and R_5. This instrument should have an input impedance of not less than 20 kΩ/V. When the standard is switched on, the pointer of the voltmeter will move to and fro at a speed which is dependent on the setting of capacitor C_4. Wait till it indicates 1.2 V or 1.8 V, depending on whether the waveform at junction R_2-R_3 is symmetrical or asymmetrical respectively — see Figure 5. Once this situation has been reached, quickly adjust C_4 until the meter reading is constant or changes only very slowly, i.e., less than 0.1 V per 10 seconds. The phase-locked loop is then calibrated. It may happen that the voltmeter indicates 0 V or 2.5 V after a few minutes and then returns to 1.2 V or 1.8 V, as the case may be, after which it remains stable. This is perfectly normal as explained under *phase detector*.

Application

Both the 1 Hz and 1 MHz outputs are, in the first instance, intended for the calibration of a frequency counter or similar instrument: it has, for example, been used to calibrate the *µP-controlled frequency meter* featured in the February 1985 issue of *Elektor India*
The 1 Hz signal may, of course, also be used as the clock for time pieces, which then hardly ever need to be adjusted.

7

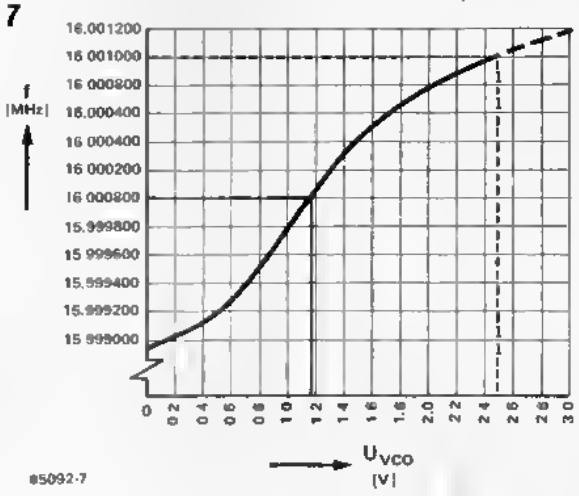


Figure 7. Frequency vs control voltage characteristic.

8

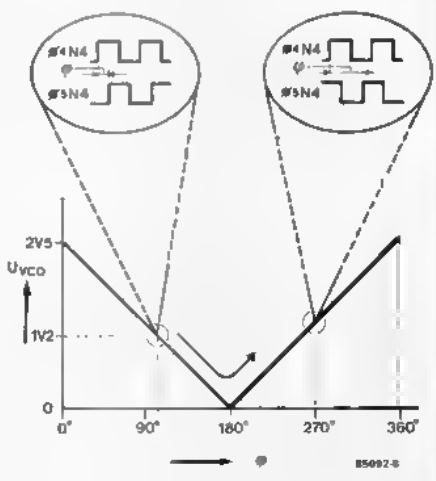
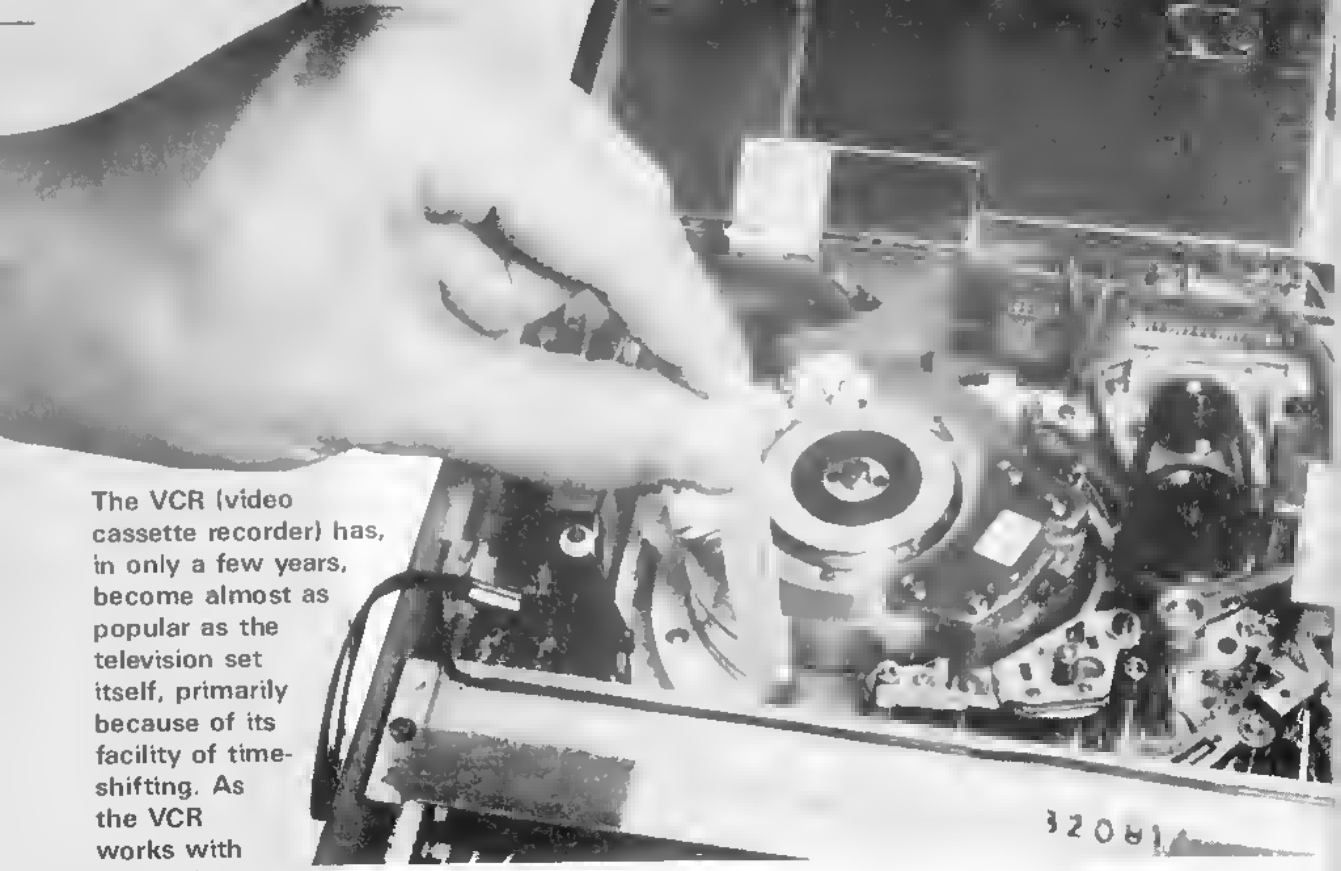


Figure 8. Control voltage vs phase difference characteristic.



The VCR (video cassette recorder) has, in only a few years, become almost as popular as the television set itself, primarily because of its facility of time-shifting. As the VCR works with magnetic tape, the mechanism of the machine will become dirty after a time, in the same way as in a sound cassette recorder. Regular cleaning of particularly the recording and playback heads is, therefore, essential to ensure optimum picture and sound quality, and to minimize wear of these heads. Unfortunately, the heads are very sensitive precision parts, which do not stand up to a brushing with some alcohol. And there are other aspects of the VCR mechanism that require particular attention. This article aims at explaining what you can do yourself, and what should better be left to properly trained service engineers.

cleaning video recorders

H. Baggen

Although much has been written about the cleaning of a video recorder, there is little that makes the operation clear in a practical way. Cleaning tapes as well as complete cleaning outfits for VCRs have come onto the market over the past few years, but most appear to be almost completely ineffective.
Distributors, importers, and manufacturers alike are generally of the opinion that VCRs should only be cleaned in their service department. No doubt, this feeling is based on the assumption that the owner of the recorder knows little or nothing of electronic and mechanical engineering Yet, with some technical insight, dexterity, and care, it is possible to clean your own VCR and save the not inconsiderable charge made by professional service departments for this operation. But care is the word, because video heads are very easily damaged, and replacing them is, of course, a great deal more expensive than having them cleaned!

Where does the dirt come from?

Dirt in the video recorder is an accumulation of dust and microscopically small particles of iron oxide and base material. The iron oxide is the magnetizable basic substance used for coating the base, which, incidentally, gives the finished tape its brown colour. The base material is most likely to be polyester (more correctly polyethylene terephtalate — called mylar in the USA), but may also be polyvinylchloride (PVC), or cellulose acetate.
Base particles form the largest proportion of the accumulated dirt This is because the tape follows quite an intricate path in the machine, running along a variety of

guide rollers and pinch rollers, as well as the capstan and the recording, playback, and erase heads. Although the keying (firmness of adhesion of the coating to the base) and the abrasion resistance of modern tapes are very good, minute particles are worn off over a period of time and left in the machine. Therefore, the better the tape quality, the less frequent there is a need for cleaning the heads. Dust on the tapes (which is left behind in the machine) can be minimized by storing the tapes in closed boxes. The recorder itself should also be placed in as dust-free a position as possible. Note that the television receiver because of the strong static field around the picture tube is a dust trap.

Figure 1. Everything revolves around this: the picture scanning drum with the video heads. The thin line in the hole of the drum is the video head, which rotates at 1500 rev/min.

When is cleaning necessary?

Even if the VCR stands in a dust-free position and high-quality tapes are used, there comes a time when the machine — and not just the heads — needs cleaning. Fortunately, the heads tend to keep themselves cleaner than other parts of the guidance because of their relatively high rotational speed. Cleaning of the VCR becomes necessary when the picture becomes "snowy" (as if a poor signal had been recorded), or the sound quality deteriorates (in which case the video heads need not be attended to).

How to clean

Before cleaning is contemplated, several important aspects of the operation should be noted

- The video heads are extremely vulnerable; one false move or treatment can destroy them. And replacement costs are high!
- Use correct materials: no cotton buds; no cleaning spirit; no so-called cleaning tapes; no spray cans with head cleaner. The video heads should be cleaned with head cleaning sticks with a chamois leather tip, and other parts of the guidance with the same type of stick or non-fluffy tipped sticks or cloths. These sticks or cloths should be soaked in pure alcohol or cleaning spirit, which are available from good video dealers or chemists. Wearing of rubber gloves is recommended, because skin grease and perspiration contain acids which may affect certain guidance parts.
- If you have any hesitation about cleaning the VCR yourself, have the work done by an authorized dealer.

Before cleaning can be commenced, it is essential to know the location of the various parts of the guidance system. The three current systems, VHS, Betamax, and V2000 are shown in figures 2, 3, and 4, which clearly indicate the position of the various heads and other parts. The V2000 system is either of the M-loading (= Philips), or the U-loading (= Grundig) type, as shown in figures 4a and 4b respectively. When there is no tape in the machine, guide rollers may be in a slightly different position from those shown in the figures.

First, remove the mains lead from the mains, and any cassette from the machine. Stand the recorder in a well-lit position and remove the top cover. In some older top-loading machines, it may be necessary to first remove the cassette compartment as detailed in the relevant service notes or manual. After the top cover has been

removed, it is normally quite clear what else needs to be undone to gain free access to the guidance.

The following parts can then be cleaned with a chamois leather tipped stick or cloth soaked in alcohol or cleaning spirit: all normal (i.e., not video) heads, the capstan, all guide rollers, and pinch rollers (the material of which these latter rollers are made may, however, be affected by alcohol or cleaning spirit, so make sure that this is not the case before cleaning the rollers).

Next, carefully clean the outside of the picture scanning drum with a chamois-leather tipped stick. **Never touch this drum with bare hands!** Pay particular attention to the slant track at the underside of the drum, and to persistent dirt particles on the surface of the drum. **Take**

2

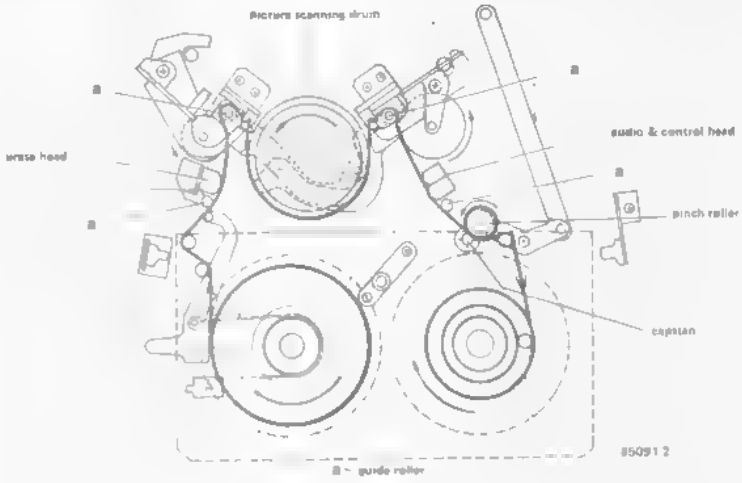


Figure 2. The guidance system of a JVC VHS recorder; that in other VHS machines is virtually identical. (Courtesy JVC)

Figure 3. The guidance system in a Betamax vidao racorder. (Courtesy Sony)

3

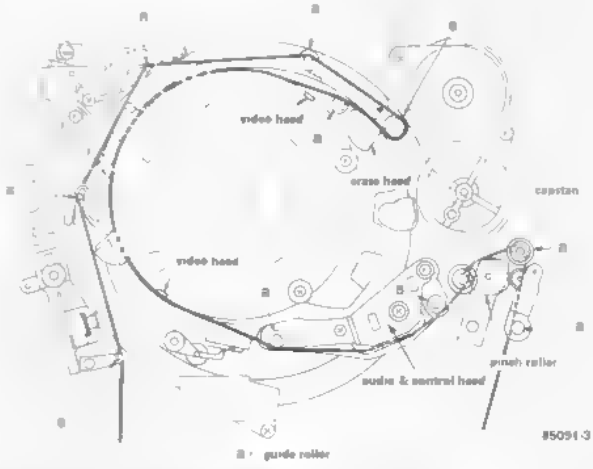


Figure 5. The photograph of a Betamax picture scanning drum shows in the centre of the drum the gap in which the heads revolve; in V2000 and VHS machines the entire upper half of the drum rotates. At the bottom is the slant track which ensures correct guidance of the tape along the drum.

5

great care not to touch the video heads! Take a clean chamois-leather tipped stick, soak this in alcohol, and, as shown in Figure 6, press it lightly against the gap at the circumference of the drum in which the heads rotate. Hold the stick steady, and turn each of the heads a few times by hand (rubber glove!). Often this can be done by turning the spindle of the drum at the top; this is, however, not possible with the V2000 system, because the top of the drum contains some sliding contacts and a contact bridge. **Do not, under any circumstances, loosen this bridge during cleaning!** In this type of recorder, therefore, carefully turn the top of the drum by hand (rubber gloves!). Do not touch the heads and do not move the stick vertically! One false move here could cause the head to snap off.

Take care not to displace any guidance parts during the cleaning. For instance, do not attempt to move the tape-slack take up mechanism. In short, only do what is strictly necessary and then put the covers on again.

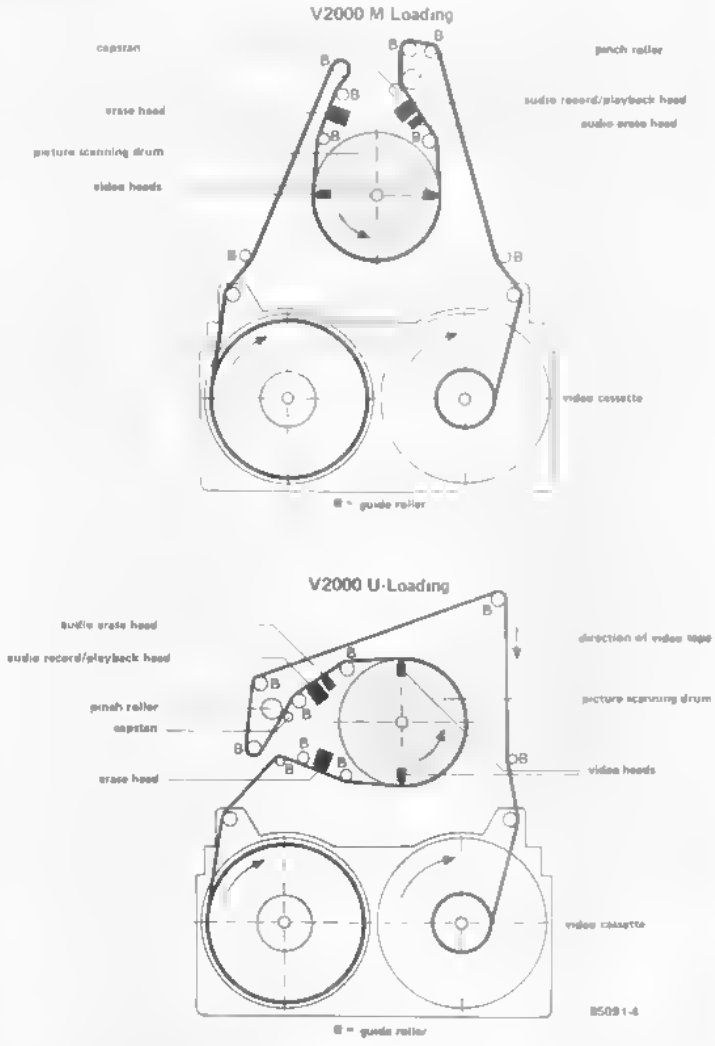


Figure 4. The guidance system in a V2000 M-loading (Philips) recorder (a), and that in a U-loading (Grundig) machine (b).

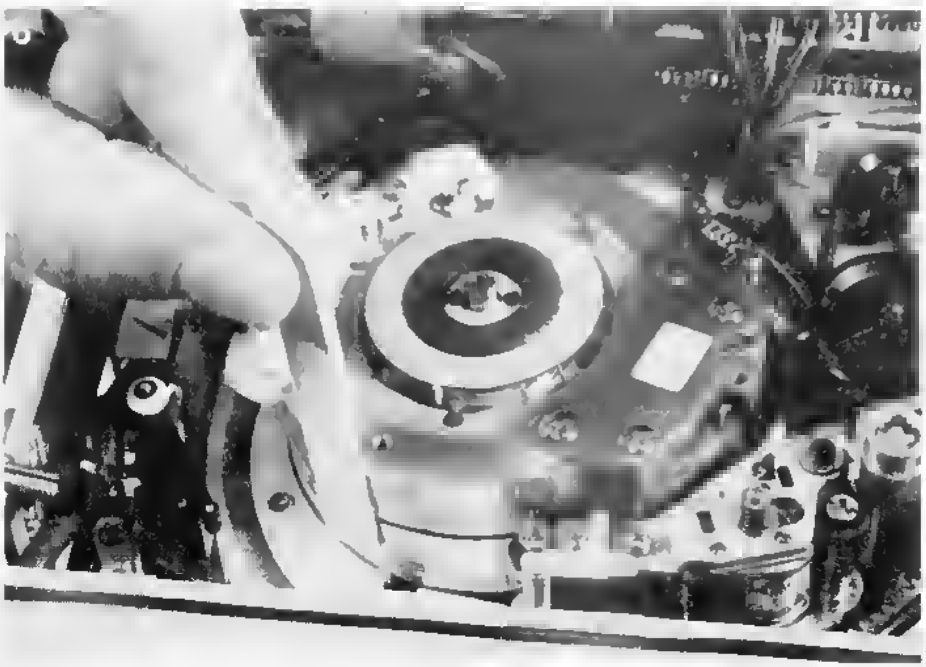


Figure 6. The critical moment, the chamois leather tippad stick is pressed gently against the drum, after which the heads are moved by turning the disc protruding at the top of the drum by (rubber gloved) hand.

J Steeman

The name RS232 represents a number of standard conventions that aim to ensure the correct transfer of data irrespective of the individual characteristics of a computer. Most computers have a serial input & output port for connecting a printer, a DCE (Data Circuit Terminating Equipment), or even another computer. To marry the two, we have designed an RS232 card, which is intended for the universal I/O bus featured in the June 1985 issue of *Elektor India*. There is a choice of TTL or RS232 line levels.

RS232 interface

serial transfer via the universal I/O bus

Parallel transfer of data, whereby all bits of a character are transferred simultaneously, is normally used where the distance between the computer and the peripheral equipment is relatively short. This means that a wire connection is required for each of these bits. This is a very reliable method of transfer, but if longer distances are involved, it becomes prohibitively expensive.

Another form of data transfer is used where other than relatively short distances are involved: serial, whereby all data are transferred in sequence over one transmission line. Compared with parallel transfer, the serial form requires a rather more complex receiver and transmitter, but the connection between the various parts of the computer system remains simple. And, of course, in case of wireless data transfer, serial transmission and reception remain the most practical method.

RS232 protocol

Transfer of data between a computer and a public network or in-plant installation is carried out by a Data Terminal Equipment <DTE> which is part of the computer system and a Data Circuit Terminating Equipment <DCE> popularly called a modem, which is connected to a transmission line See Figure 1.

The exchange of data between the DTE and DCE must be governed by clear agreements as to their format. For instance, as the bits are transmitted sequentially, their timing and that of the complete characters must be accurately known.

There are two types of transfer: synchronous and asynchronous. In the former, a continuous data stream is transmitted, and the receiver is synchronized to the transmitter by a clock signal derived from the data, or by a specially transmitted clock signal. Asynchronous transmission is, however, far more commonly met. This method has its origin in telex engineering. Since the drive motors of the transmit and receive terminals could not be synchronized precisely over long periods, each group of data bits was preceded by a start bit and closed by a stop bit. This type of

1

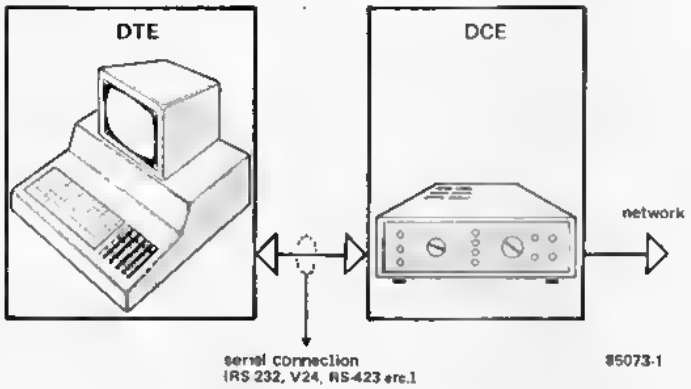


Figure 1. Generally, an RS232 or a V24 connection is used for communication between a DTE (Data Terminal Equipment) and a DCE (Data Circuit Terminating Equipment).

2

Figure 2. General shape of a serial data word, here preceded by a start bit and followed by a parity bit and optional stop bit

synchronization is perfectly satisfactory for the relatively short duration of the data word.

An example of such a serial signal is shown in Figure 2. First is the start bit, followed by eight data bits (for instance, an ASCII character), a parity bit for error control, and finally the stop bit. The stop bit enables checking whether the transmission and reception speeds are the same.

The correct processing of the data stream exchanged between the DTE and DCE is based on a protocol, i.e., a set of conventions or regulations. The two most common, official protocols are the RS232 and the V24

Apart from the data, there is a number of signals for the individual control of the DTE and the DCE. All these and the relevant connection to a standard D-type connector are shown in Figure 3.

DTR, DSR, and DCD are typical signals used for the establishing and terminating of a communication. The remaining signals are used, as required, during the exchange.

Assuming the communication is full duplex, i.e., both the T×D and R×D lines are in use, the DTE activates the DTR line to indicate a request for communication. The modem responds to this by activating the DSR line. If the DTE is to transmit, it activates the RTS line. The DCE acknowledges that it can process the data by activating the CTS line. Note that in full duplex operation the DTE can also receive at all times, provided that the modem has activated the DCD line. This takes place during the establishment of the communication. See also *data communication by telephone* and *direct-coupled modem* in the September and October 1984 issues of *elektor electronics* respectively. The "secondary" connections are relevant to the main channel — back channel separation in modems.

Translating all these actions to a ready-to-use serial connection to a computer is effected by an intelligent peripheral chip: asynchronous communications interface adapter (ACIA) Type 6551. This device is simply accommodated in the microprocessor system to provide complete RS232 and V24 compatible communication with the outside world.

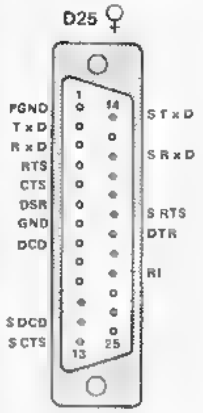
Interface circuit

As may be seen from Figure 4, the ACIA does not need much more than a crystal and a number of gates for signal level matching to carry out its task. To the left of it are shown the usual connections to the computer system: here, the slot connections of the I/O bus.

The 1843.2 kHz crystal connected to pins 6 and 7 is used to provide a number of baud-rates, which are selected by the software. The R×C pin (5) is a bidirectional input and output respectively for an external clock to provide non-standard baud-rates, and for outputting the internal baud-rate generator. In either case, the clock frequency amounts to sixteen times the baud-rate.

To the right of IC_1 are the familiar RS232 lines with buffered inputs and outputs. Seen from the IC, all signals are inverted, which means that all control signals: DTR, RTS, CTS, DCD, and DSR are active high, whereas data signals $\overline{T \times D}$ and $\overline{R \times D}$ are active low. These levels are standard for

3



PGND	protective ground
T×D	transmit data
R×D	receive data
RTS	request to send
CTS	clear to send
DSR	data-set ready
GND	ground
DCD	data carrier detect
DTR	data terminal ready

S DCD	secondary data carrier detect
S CTS	secondary clear to send
S T×D	secondary transmitted data
S R×D	secondary received data
S RTS	secondary request to send
RI	ring indicator

Figure 3. Standardized RS232 connections to a 25-way D-type connector. The "secondary" connections and the RI connection are only used at the DCE side

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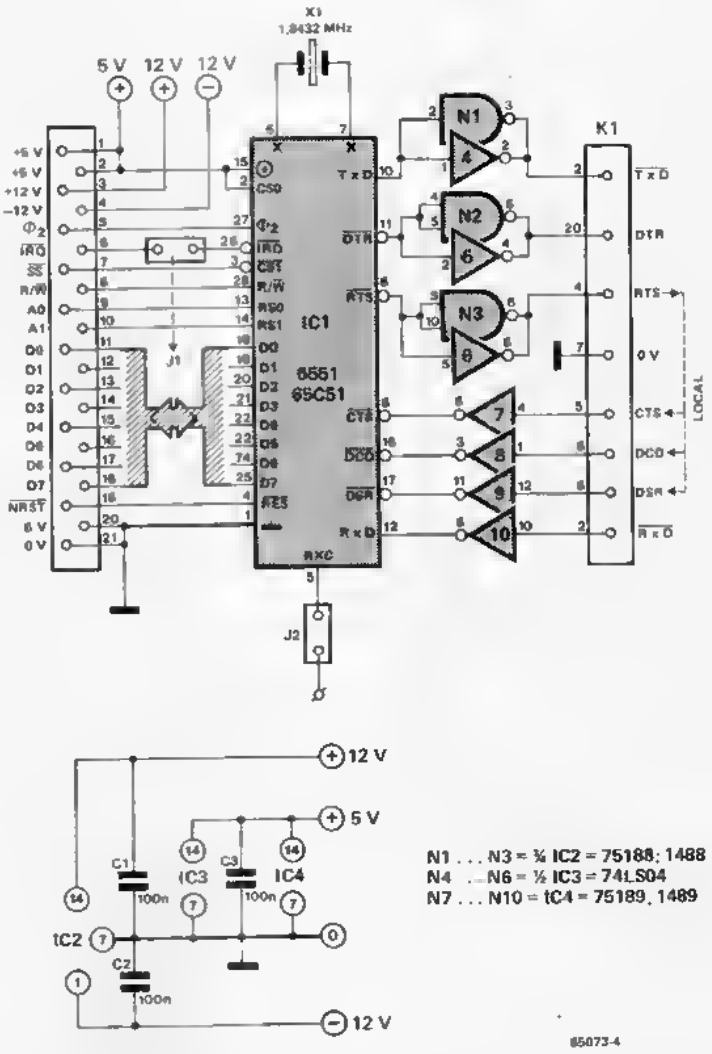


Figure 4. Circuit diagram of the RS232 card. Links J_1 and J_2 are optional. Either RS232 drivers N_1 . . . N_3 or TTL drivers N_4 . . . N_6 are used.

RS232 connections. There are two possible, corresponding voltage levels: TTL, i.e., high = +5 V; low = 0 V, and RS232, i.e., high = +3 . . . +25 V (nominally 12 V) and low = −3 . . . −25 V (nominally −12 V). It is intended that one of the groups of parallel-connected ports is selected: $N_1 \ldots N_3$ provide RS232 levels, and $N_4 \ldots N_6$, TTL levels. The receive buffers are suitable for both TTL and RS232 levels. It is, therefore, necessary to check with which levels the system to be connected operates. The printed-circuit board in Figure 5 shows both IC_2 and IC_3, which are required for TTL or RS232 levels respectively. The ±12 V supply is not needed in TTL operation.

Operation

As stated, the circuit is based on a Type 6551 ACIA, a block diagram of which is given in Figure 6. Communication at the DTE end is effected by five registers, four of which are detailed in Figure 7. Since the inputs are connected to address lines A_0 and A_1, the registers are located sequentially in the address range of the I/O bus. If, for instance, the interface card is placed in slot 1 of the universal I/O bus, and the start address of the I/O range is set to 4000_{hex}, the Transmit and Receive Data Registers are at 4000_{hex}, the Status Register at 4001_{hex}, the Command register at 4002_{hex}, and the Control Register at 4003_{hex}.

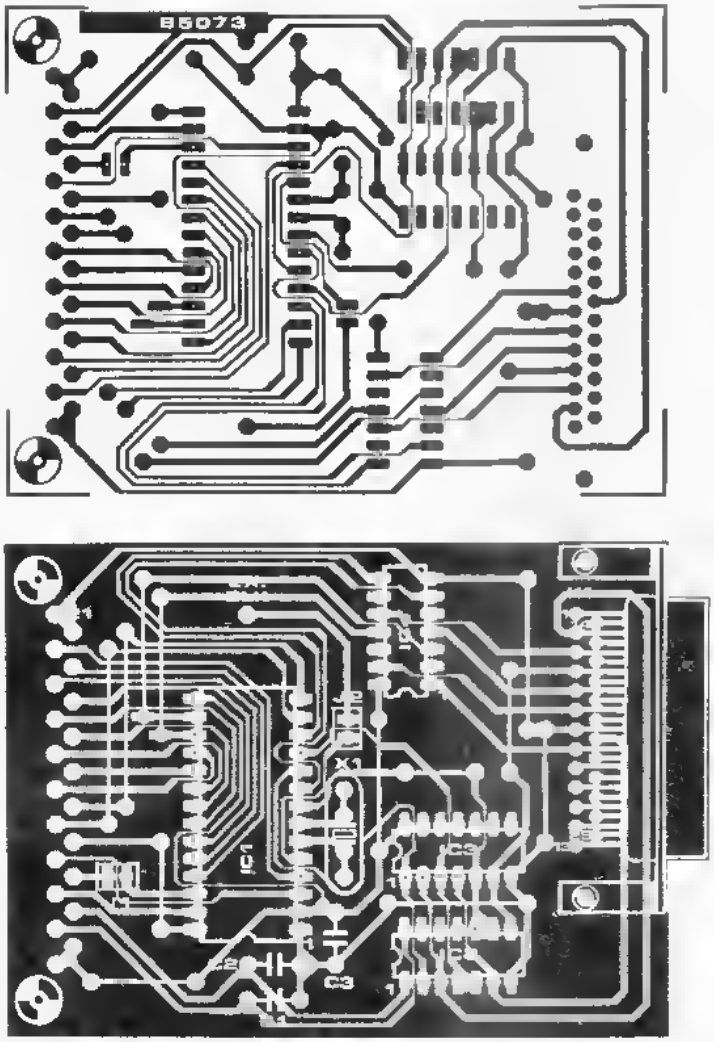
Transmit and Receive Data Registers

During transmission, bit 0 (LSB) is sent first. The bits not used, for instance, 5 . . . 7 where a 5-bit format has been chosen, are treated as "don't care". In the receive mode, the first received bit goes to location 0, and subsequent bits to 1, 2, and so on. The highest, not used, locations are given a 0.

Status Register

This register can only be read. Bits 0, 1, and 2 indicate respectively whether during reception errors in parity, framing, or overrun occurred. The more important bits

5



Parts list

Capacitors:
C_1 – C_3 = 100 n

Semiconductors
IC_1 = 6551, 65C51
IC_2 = 75188, 1488
IC_3 = 74LS04
IC_4 = 75189, 1489

Miscellaneous:
X_1 = crystal, 1843.2 kHz
K_1 = 25-way D-type subminiature connector, right angled; female
21-way right-angled connector; male; to DIN41617
two 2-pin pcb type terminal block

Figure 5. The printed-circuit board of the RS232 card with at one side the connector that slots into the universal I/O bus, and at the other side the standard D-type RS232 connector.

6

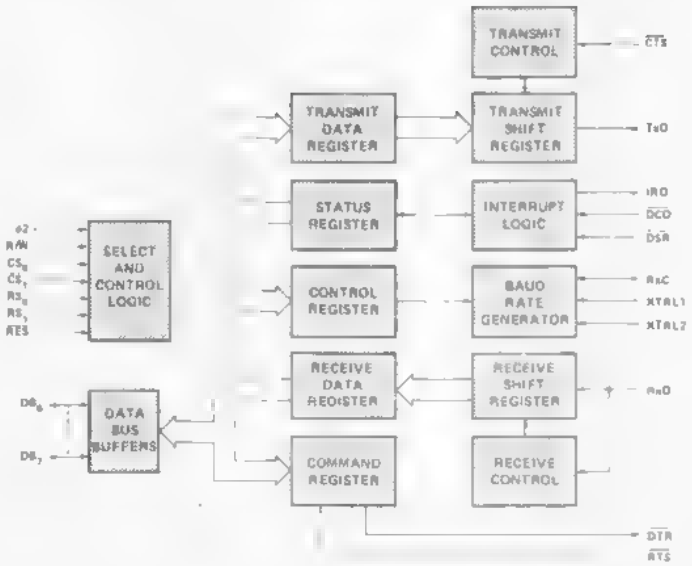


Figure 6. Block diagram of ACIA Type 6551

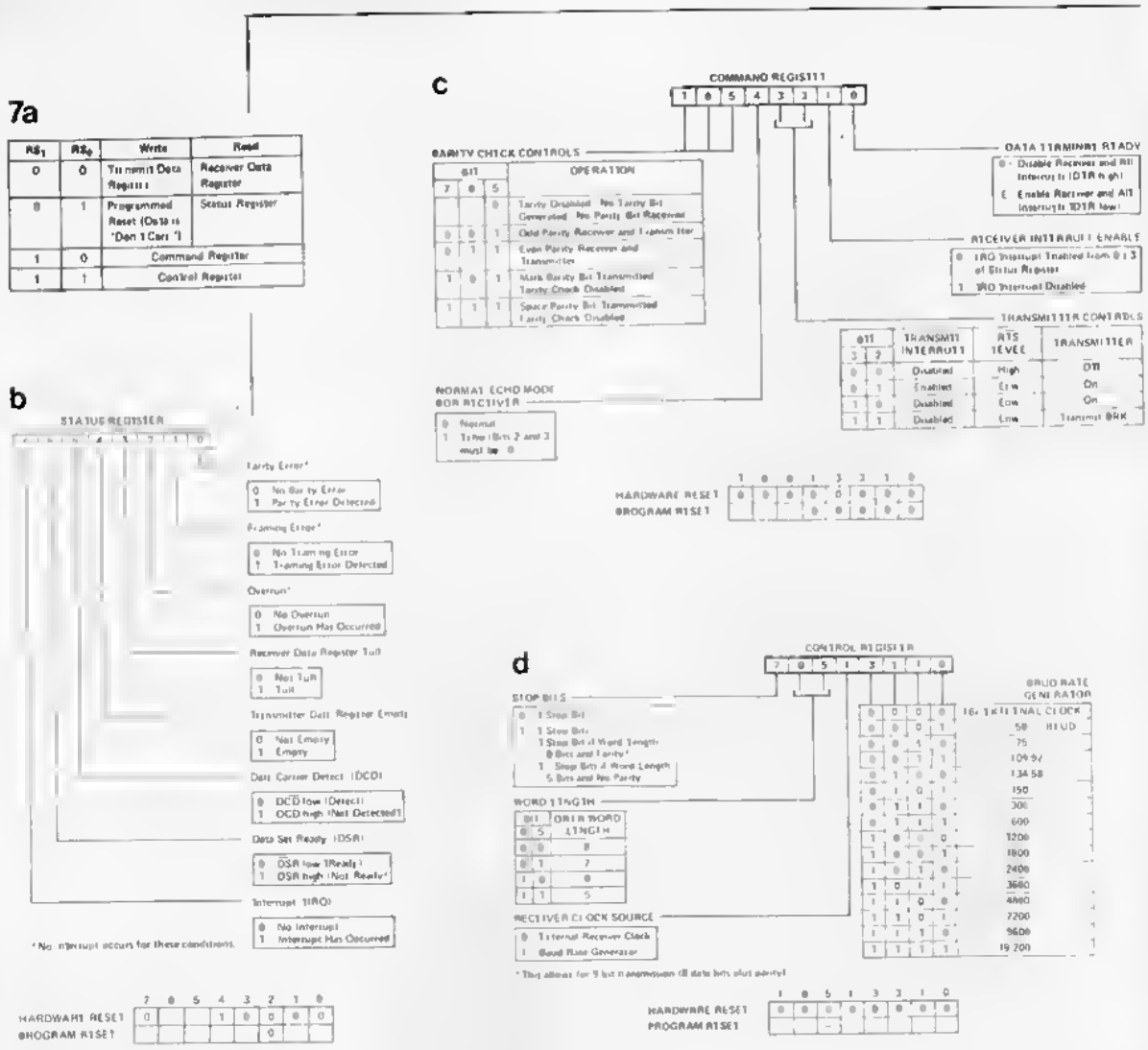


Figure 7. Details of the registers used to program the ACIA

are, however, 3 and 4, which indicate whether a complete character has been sent or received. These bits determine in the control program whether the next character can be processed. The final three bits enable the reading of the DCD and DSR lines and of the interrupt status. If an interrupt structure is used for the control of the interface card, the status register must be checked after detection of an interrupt to decide what the next operation should be. If such a structure is not used, link J_1 should be left open; the interrupt is then still generated but not passed on to the computer system.
An arbitrary write operation to the Status Register gives rise to a program reset. The effect of such a reset is indicated in Figure 7 for each register. A dash indicates indeterminate.

Command Register
Bit 0 determines the DTR signal and the receiver status. Bit 1 is used to decide whether an interrupt indicating a full Receive Data Register should be given or not. Bits 2 and 3 control the RTS signal and, therefore, the operation of the transmitter. They are also used to decide whether an interrupt indicating an empty Transmit Data Register should be given or not. Bit 4 is normally 0. Bits 5...7 are used for parity control and control of the transmitter and the receiver.

Control Register
This register determines the format of the serial data. Bits 0...3 determine the baud-rate: there is a choice of a number of standard baud-rates, all derived from the crystal frequency. In position 16× external clock, an external clock signal may be applied to pin 6 of IC_1 (pin 7 open): the baud-rate will be one sixteenth of the external frequency. The internal baud-rate generator is connected to the receiver when bit 4 is logic 1: transmitter and receiver then work at the same baud-rate, while pin 5 of IC_1 functions as the output terminal of the internal generator; the frequency is sixteen times the selected baud-rate. This arrangement makes it possible to connect several ACIAs in tandem. When bit 4 is logic 0, pin 5 functions as the input for the receiver clock via bridge J_2. Bits 5 and 6 determine the

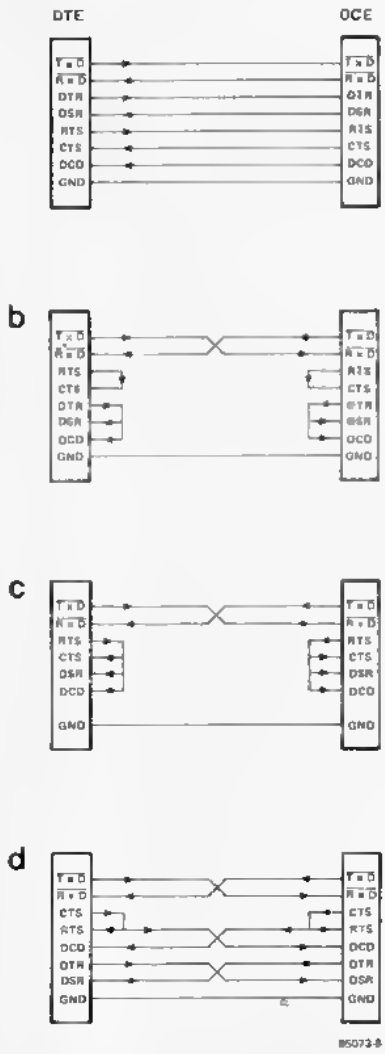


Figure 8 Some examples of RS232 connections: b. d are intended for use between two DTEs

their own control signals. Any control characters are exchanged via the data lines. The local mode connection illustrated in 8c is most suitable for the present 6551 card. Rather more control signals are used in the arrangement shown in 8d. The mutual DTR-DSR interchange is effected at start-up. When one unit gives RTS, thereby effecting its own CTS, the other activates DCD, so that it switches to the receive mode. How the various connections are made is, therefore, entirely a matter of application. The sample program shown is a simple RTTY receive program for the present card. It was originally intended for the Acorn Atom, but is easily adapted for use with any 6502 computer (which must, of course, be fitted with the universal I/O bus and the present interface).

A simple RTTY receive program for the Acorn Atom.

```
 10 REM RTTY-ONTVANGPROGRAMMA VOOR ACORN ATOM
 20 REM 6551-BASIS-ADRES=#4800...#4803
 30 DIM%14:FORA=0TO13:%A=-1:N.
 40 DIMLL8:FORB=0TO7:LL8=-1:N.
 50 P.$12:P.$21
 60 F.C=0TO1:P=#3500
 70
 80 [
 90:LL0 LDA#08:STA#4002 \initialise
100     LDA#F1:STA#4003
110     LDA#0:STA#89:STA#81:STA#85:STA#90
120     LDA#C0:STA#91
130     LDA#81:STA#92
140:LL1 JSR#FE71        \keyscan
150     CPY#11:BNE P+7
160     LDA#F1:STA#4003
170     CPY#12:BNE P+7
180     LDA#F2:STA#4003
190     CPY#2E:BNE P+6
200     LDA#00:STA#80
210     CPY#33:BNE P+6
220     LDA#01:STA#80
230     CPY#35:BNE P+6
240     LDA#FF:STA#80
250:LL2 LDA#4001:AND#08:BEQ LL2 \receive-register full?
260     LDA#4000:TAY
270     CMP#02:BEQ LL3:CMP#08: BEQ LL3 \cr or lf?
280     CMP#1F:BEQ LL4 \lets?
290     CMP#00:BEQ LL4 \3rd shift?
300     CMP#10:BEQ LL5 \figs?
310     CMP#04:BNE LL6 \space?
320     LDA#80:BEQ LL6
330     CMP#01:BNE LL7
340     LDA#20:STA#81:JMP LL6
350:LL7 LDA#80:STA#81
360:LL6 TYA:CLC:ADC#81:TAY
370     LDA#8400,Y:JSR%V5:JMP LL1 \output to video-driver(%V5)
380:LL3 CLC:INC#85:LDA#85:CMP#02:BNE LL1 \cr/lf-loop
390     LDA#00:STA#85:LDA#00:JSR%V5:JMP LL1
400:LL4 LDA#00:STA#81:JMP LL1 \skiet
410:LL5 LDA#20:STA#81:JMP LL1 \setfig
411
412 \V10E0-DRIVER
413
420:%V5 TAY:BEQ%V11:CMP#0D:BNE%V15:LDX#020:STX#90:LDY#20:TYA
430:%V13:JSR%V11:JSR%V2
440:%V1 RTS
450:%V11:TAX:CLC:ADC#C0:BCC%V12:TXA:EOR#040:RTS
460:%V12:TXA:RTS
470:%V2 LDY#90:STA(#91),Y:INY:CPY#020:BCC%V3:JSR%V4:LDY#80
480:%V3 STY#90:RTS
490:%V4 LDA#91:LDY#92:CPY#81:BCC%V6:CMP#0E:BCC%V6:LDY#20
500:%V7 LDA#8000,Y:STA#7FE0,Y:INY:BNE%V7
510:%V8 LDA#8100,Y:STA#80E0,Y:INY:BNC%V8:LDY#1F
520:%V9 STA(#91),Y:DEY:BPL%V9:RTS
530.%V6 ADC#20:STA#91:BNC%V10:INC#92
540:%V10:RTS
560
570]
580 N.C:P.$6
590 REM lookup-table
600 D=#8400
610 D' 0=#416A4500:D' 4=#55495320:D' 8=#4A524400:D'12=#4643464E
620 D'16=#574C5A54:D'20=#5150594B:D'24=#0047424F:D'28=#80565840
630 D'32=#2D0A3300:D'36=#37382720:D'40=#8734240D:D'44=#283A002C
640 D'48=#32292B35:D'52=#31303600:D'56=#00003F39:D'60=#80302F2E
650P.''' RTTY" " ====":"1=50 8D":"2=75 B0":"N=NORMAL"
660 P.'"U=U.0.S":"S=S.0.S"'
670 P."--------------------------------"
680 LINK LL0
```

length of the data word. Bit 7 enables selection of 1, 1½, or 2 stop bits.

It is clear that there are a great number of programming possibilities. With a little knowledge of machine language and some experience in this type of work, almost anyone can establish his own specific serial connections.

As far as connections to peripheral equipment are concerned, distinction should be made between DTE-DCE (interface card — modem) and DTE-DTE (interface card — another computer, terminal, or printer) combinations. In the latter, the connecting cable must make it possible that the function of the DCE is simulated as far as feasible. Figure 8 gives a number of examples of the connection between the interface card and peripheral equipment; in a the peripheral equipment is a modem; in b.. .d the modem function of the connected unit is more or less simulated by the cable connection.

Figures 8b and 8c are simple versions of the so-called cross or zero-modem connections, whereby the transmit and receive data lines are interconnected crossways, while the two systems generate

design ideas

voice recognition & speech processing

The subject of "speech and computers" has been discussed in these pages on several occasions, the last one being in the April 1985 issue. The accent then was mainly on the speech processing aspect, which is technically easier than voice recognition. It is, therefore, fascinating for all those interested in this subject that General Instrument now have available two chips — the SP1000 and the VSR1000 — that, in combination, tackle the problems of both speech processing and voice recognition. The SP1000 is a voice recognition and synthesis IC, and the VRS1000 is an 8 bit microcomputer to control the SP1000.

The combination of the two chips provides the designer with complex, ready-to-use recognition and synthesis algorithms. Typical applications include robotics, aids for the handicapped, security devices, and voice-dial telephones.

The nucleus of the SP1000 is a lattice filter that can be programmed for synthesis and recognition modes. In the synthesis mode, the VRS1000 feeds the filter speech data it has computed: these data control the filter characteristics. In the recognition mode, the filter extracts from an incoming audio signal the LPC (linear predictive coding) information required for the digital speech processing.

To this end, the audio signal is scanned every 160 µs by an 8-bit analogue-to-digital converter; the resulting eight bits are fed to the SP1000, as shown in Figure 1. The filter extracts eight significant audio coefficients as well as relevant information as to audio signal amplitude: all this information is then stored on board the SP1000 and sent to the microprocessor every 20 ms.

Each spoken word is divided by the SP1000 into twelve frames, for each of which a time-weighted average of the coefficient is calculated and stored. This means that for each word a storage requirement of 108 bytes is required.

A single word should last no more than 2 seconds, and the space between two words should be not less than 200 ms. In this context, it is important that the audio signal level is matched to the input of the analogue-to-digital converter, so that the latter works under optimum conditions. To this end, the SP1000 has three "gain" outputs, which are fed to an external analogue gain control.

The LPC coefficients calculated by the VRS1000 are converted by the filter in the SP1000 into a digitally speech-modulated signal. Only a low-pass filter and a power amplifier are then required at the output to complete the synthesis process.

The VRS1000 is functionally equivalent and pin-by-pin compatible with the General Instrument Type PIC7040, which is a licensed, second-source of the Texas Type TMS7040. These ICs are 8-bit microprocessors with internal 4 K ROM. This ROM contains the entire program for the control of the SP1000.

During speech processing, the VRS1000 deals with the computation of the LPC coefficients extracted from the text provided by the host computer; during voice recognition, it compares the LPC coefficients provided by the SP1000 with the stored vocabulary. The VRS1000 can recognize twenty words simultaneously.

Other functions of the VRS1000 are: retraining of the vocabulary; creating vocabulary subsets; storing templates on disc; and rejecting a word that is found not to be a member of the recognition vocabulary.

Accuracy of voice recognition is claimed to be better than ninety-eight per cent according to the Doddington-Schalk standard test.

The search time, i.e., the time required to recognize or reject a word, depends on the size of the vocabulary: as a guide, 45 ms per word. It seems, therefore, sensible to sub-divide a vocabulary of, say, 100 words into five subsets of 20 words each; the search time will then always be less than 1 second.

It should be borne in mind that the recognition accuracy is bound to suffer with large vocabularies, since the likelihood of similar sounding words is then greater.

An advantage of the system is that a vocabulary has to be learnt. It is specific to a speaker, but can, none the less, be modified at any time. Furthermore, a number of speakers may enter their own specific vocabulary.

Since articulation, depth of voice, and speed of speech even in the same word spoken by the same speaker vary from time to time, it is possible to enter a word up to 255 times, and store the average. This, of course, results in very high recognition accuracy.

Characteristics - recognition mode	Characteristics — processing mode
• direct access to a 20 word vocabulary • 6.25 kHz sampling, 8 bits per sample • extraction of 8 LPC and 1 amplitude coefficient • maximum word duration 2 seconds • minimum pause between words of 200 ms • correction of temporary deviations in each of the twelve frames of a word • storage of 108 bytes per word • search time 45 ms per word • recognition accuracy 98 per cent • programmable rejection threshold • selectable number of training passes during the loading of the vocabulary	• 10 kHz sampling rate • variable frame rate • synthesis of 10 LPC coefficients • synthesis of sound effects and music • real-time interpolation of energy, pitch, and filter coefficients

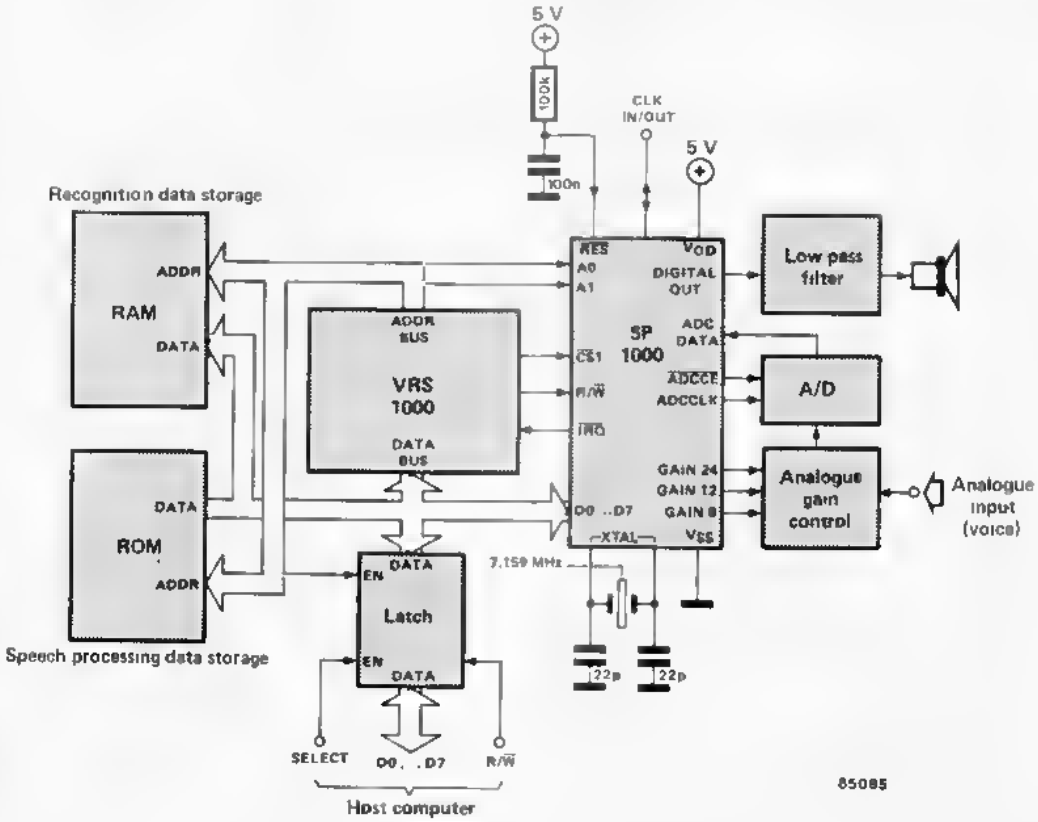
Communication with the host computer is kept simple by the use of the ASCII code, so that it will normally not be a problem for individual control programs to be used. ■

Literature:
SP1000. preliminary information
Application note AN-0504
General Instrument
Times House
Ruislip HA4 8LE
Telephone: (089 56) 33355

General Instrument Corporation
International:
600 West John Street
Hicksville
New York 11802
Telephone: 516-733-3107

Figure 1. The functional diagram of the SP1000/VRS1000 combination shows that only a few peripheral devices are required to design a complete voice recognition & speech processing unit for use with a microcomputer.

1



Moving Coil Meters.

A moving coil meter basically consists of a coil through which the test current flows, end a modified horse shoe magnet.

The current flowing through the coil produces a magnectic field. As the coil is pivoted between the two feces of the permanent magnet, (modified horse shoe) it tries to realign itself by rotating about its own axis

Figure 1 shows a most commonly used design of the meter movement. In order to keep e uniform end minimum eir gap, the coil is wound around a cylindricel piece of magnetic meterial. The test current is supplied to the coil through spiral springs, which also serve to return the moving coil to its orignel position as soon as the current flowing through it becomes zero. All the forces acting on the moving coil are balanced in such a way that the deflection of the coil is proportional to the current flowing through it.

To indicate this deflection of the moving coil, an indicator is directly connected to the coil and indicates the deflection on the scale A damping paddle is sometimes connected to the moving coil to prevent sudden movement of the coil and indicator This paddle moves in a damping chamber, which appears at the bottom of the illustretion of figure 1.

1

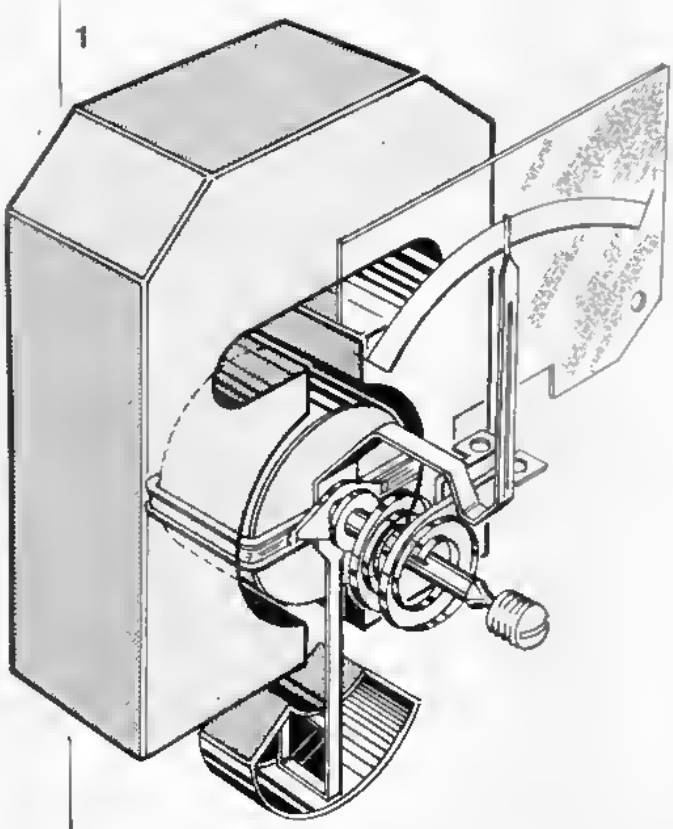
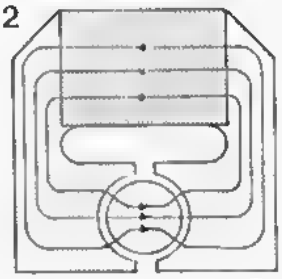


Figure 2 shows the schematic diegram and lines of the magnetic field.

2

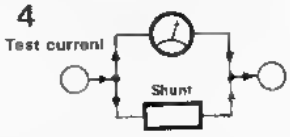


83636X-2

Figure 3 shows the symbol of the circuit element "Moving coil meter". The moving coil instruments are so sensitive, they can be seldom used alone. A sensitive meter movement needs just 25 uA current for full scale deflection of the indicator. For most of the applications, these meter movements must be supplemented by resistances.

Parallel Resistance (Shunt)

4



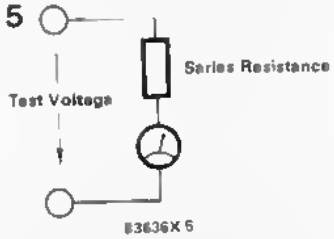
3

83636X-4

Figure 4 shows the function of the parallel resistance (shunt). It bypasses a part of the test current away from the measuring instrument and thus protects it from overload. The amount of current passing through the shunt depends on its value The remaining current passing through the movement decides the amount of deflection of the indicator. The meter scale must be accordingly marked to read the test current

Series Resistance

5



83636X 5

Voltage measurement with a moving coil meter is possible only with an additional series resistance When a resistance is connected across a voltage source, the current flowing through it is governed by the Ohms law Since we have introduced a fixed resistance in series with the test voltage and meter movement, the current varies with the voltage. This produces a deflection of the meter movement proportional to the test voltage The measuring instrument in figure 5 measures the current flowing through the moving coil, but the scale can be marked in Volts!

Resistors

". You know a lot about pocket redios, isn't it?"

"Well yes, what do you want to know?"

"This afternoon I had taken apart the old pocket radio. From thet I have brough along a few parts, look here!"

And now you certainly want to kn- what it is?"

"Right!"

"These things with the coloureo -re resistors. These resistors work as brakes fo ne current As the material of which these are made is a poor conductor, the current cannot flow through these resistors without obstacles".

"You mean they resist the flow of current?"

"Yes, but rather it is Voltage that they resist when it tries to drive current through the resistors. When a voltage is applied across a resistor — a specific current flows, not more, nor less The current depends upon the level of resistance offered by the resistor "

"So all these resistors allow the same current to pass through"

"How do you say that?"

"Because they are all of equal size"

"No, it has no relation to the size By level of resistance I mean the braking power of the resistor, if we imagine a resistor as a brake applied against the current. A resistor has resistance, and how much resistance a resistor can offer is expressed in Ohms. Ohm is the unit of resistance. Do you understand now?"

"That was a little too much resistance for me! If I understand you correctly, this is similar to the word "conductor". Cables, Wires and stranded wires are called conductors. That is because they "Conduct" the current."

"Quite right. These resistors are also conductors, but poor ones. The poorer they are in conducting current, the better they are es resistors and higher is the Ohms value "

"Why is the resistance value not expressed in Amperes?"

"Why should this be done?"

"Because each resistor allows only a specific current to pass through and current is measured in Amperes".

"No, the current is not dependant on the resistance value alone, it also depends on the voltage across the resistor."

The resistor brakes the current by offering resistance to the voltage The higher the voltage, the lesser is the effect of resistance and the more is the current which is allowed to flow through the resistor. Let us take an example of e car on a downhill roed The driver must apply the brakes, otherwise the car would run fester end faster and come off the road. The speed of car depends on how hard is the breking. The seme thing is true about the current. The higher the resistance, the lower is the current.

As the slope of the road is important to decide the speed of the car, level of voltege is importent to decide the flow of current through e resistor. A high voltage level is like a steep road and a higher resistance level is like breking herder."

Current Paths

In our June '85 issue, we had seen that current can flow only in a circle (a circuit) and that it can no longer flow through this path if it is interrupted at any position.

What happens when more than one path are available for the current to flow?

We can see what happens, with a small experiment. For this we need the following

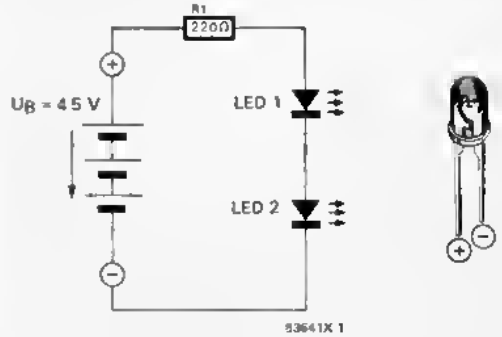
— 2 Flat batteries of 4.5 V each
— 2 Resistors of 220Ω 1/8 Watt
— 2 LEDs

All these components can be obtained from any electronics component shop.

First, connect the circuit as shown in figure 1. A battery, a resistance and two LEDs are connected in the circuit. The LEDs glow when current flows through them

The brightness of glow depends on the level of current flowing through them. The series resistance serves only to limit the current flow in the circuit so that LEDs are not damaged due to excessive current. The components cen be connected by twisting the leeds together. Polarity of LEDs must be observed correctly. The shorter lead of the LEDs is the cathode (minus pole)

1



When the circuit is connected, a current flows through it as shown in figure 2. Both LEDs glow with aqual brightness because tha sama level of current flows through both.

Now with the ramaining components, the circuit is connected es shown in figure 3. Will the second battery elso drive currant through the LEDs? and if so, through which path will it flow? Observe the circuit properly and it will give us the answer. LED 3 elso glows, end this means that the second battery is also driving current through the circuit. To complete the circuit the current which flows through LED3 must also flow through LED2, which is confirmed by the fact that LED2 glows more brightly then LED1 or LED3.

2

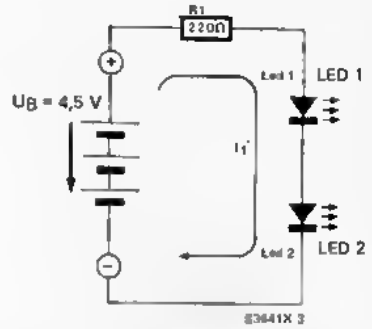


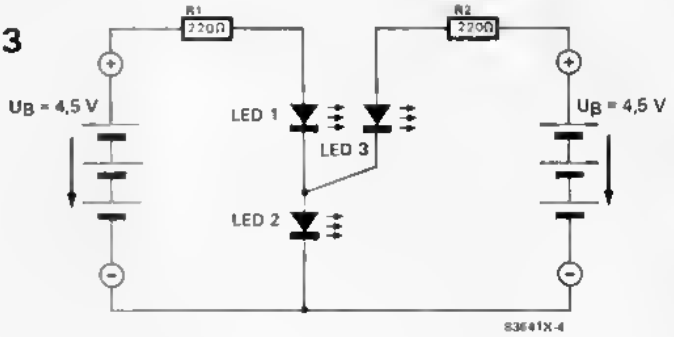
Figure 1.
The two LEDs light up, showing the presence of current in the circuit

Figure 2.
The current path in the simple circuit.

Figure 3.
A second circuit is added, LED 2 is included in both the circuits.

Figure 4.
Currents of both the circuits flow through LED 2.

3



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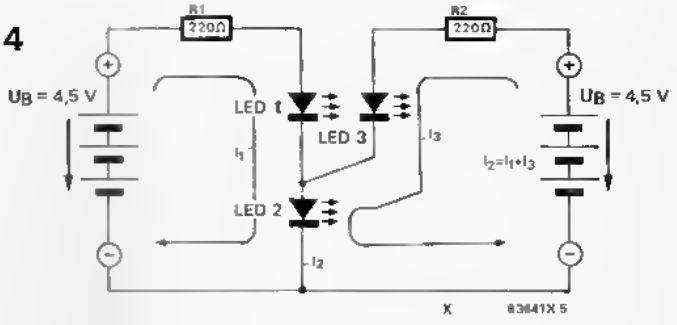


As a double check, disconnect the circuit at point x in figura 4 This extinguishas LED3 and LED2 glows less brightly than before. This also proves our observation that both the batteries drive current through the circuit paths aveileble to them, indapandantly of each other They taka up exactly the same current at the minus pole which they discherge or drive out through the plus pole. Both the currents find the correct paths beck to the voltage sources from which thay amerge

This fact wes established by the scientist Gustav Robert Kirchhoff (1824-1887) who proposed the thaorem that all the currents which flow into a nodal point, must always flow out of the same nodal point egain.

This is known as the Kirchhoff's Lew

Let us examine the two nodal points in our circuit of figure 3 & 4 Figura 5 shows the currant paths meating at the first nodal point. Currents I1 end I3 flow into this noda and currant I2 leaves this node This gives us the relation I2 = I1 + I3

Besed on this theoretical relation, we can explain tha fact that LED2 must glow with more brightness compared to LED1 and LED3 es the current flowing through LED2 is the sum of two individual currents flowing through LED1 and LED3 respectively.

Although the terms "theoram", "nodal point" etc sound theoratical, we can sae the practical importance of the Kirchhoff's Law in studying various current paths in e circuit. A complex circuit can be understood eesily when individual current paths ara studied

5

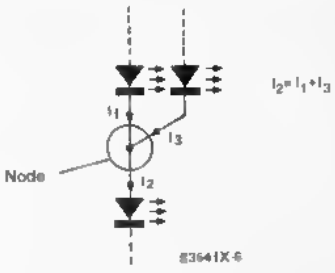


Figure 5.
The node between LED 1, and 2 and LED 3. Currents I1 and I3 flow into the node and current I2 flows out of the node.

The Ohm's Law

"Resistors" as we have just seen, are the brakes for the current. In fect these resistors can be also thought of as the intermediate levels between good conductors (like copper wires) and non-conductors (insulators like glass, ceremics, plastics etc.) These intermediate levels are of great importance lo the Electronics Engineer, since he can control currents and voltages with their help We already know - "When a voltage is applied ecross e resistor, a specific current flows, not more, not less The current depends upon the level of resistence offered by the resistor."

Greg Simom Ohm (1787 to 1854), the discoverer of this interrelation, formulated from this the law which was later named after him as Ohm's Law:

The voltage (U) across a resistor is equal lo the product of the resistance value (R) and the current (I) flowing through the resistor

$U = R \cdot I$

Which is also stated es

$E = R \cdot I$

This was once called the "8asic law of Electrical Engineering". Without going into the theoretical background the significance and utility of the Ohm's law can be seen with the help of a few examples.

Figure 1 shows a 4 5 V battery connected across a 100 Ohms resistor. As the circuit is complete, the current flows through the resistor By substituting the values of voltage and resistance into the Ohm's formula, the unknown current can be calculated as follows·

$4\,5\ V = I \times 100\Omega$

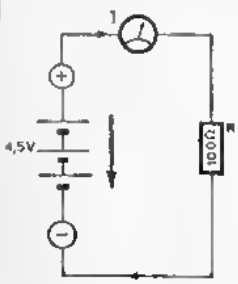
$$\text{or } I = \frac{4\,5\ V}{100\Omega} = 0.045\ A = 45\ mA$$

A milliampere (mA) is one thousandth of an Ampere We can practicelly confirm this result by measuring the current on a multimeter in the 100 mA DC range

This small experiment makes clear, how a resistor can set the current in a circuit for a given voltage value. Another interesting detail can be studied from a similiar experiment by adding one more 1.5 V cell lo the circuit in series with the 4 5 V which is already there Now the voltege increases to 6 V and the Ohm's Law tells us that the current flowing in the circuit should be

$$I = \frac{6\ V}{100\Omega} = 0.06\ A = 60\ mA$$

1



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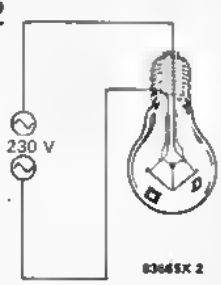
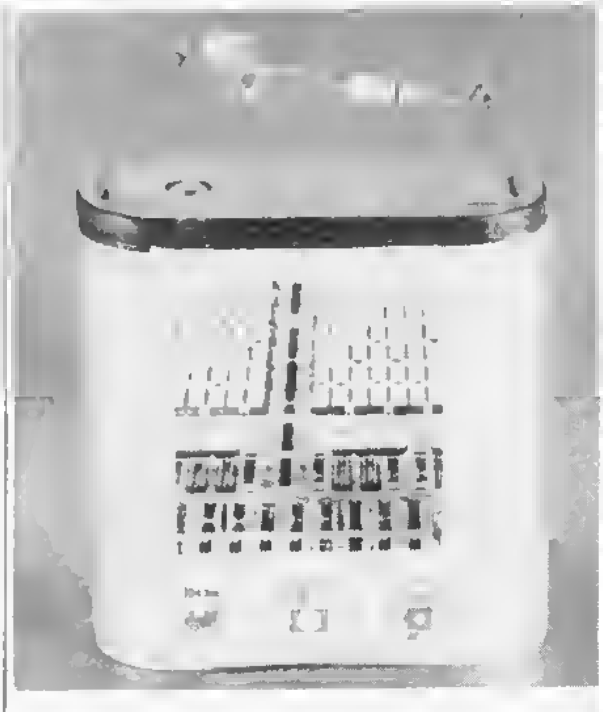




This result can again be practically confirmed by measuring with a multimeter The current increases with increase in voltage level, for a fixed value of resistance

Now try another variation. Increase the resistance value to 120 Ohms by substituting the 100 Ohms resistor by a 120 Ohms resistor Keep the voltage fixed at 6 volts The current should now be

$$I = \frac{6\ V}{120\Omega} = 0\,05A = 50\ mA$$

The current decreases with increase in resistance, for a fixed value of voltage

Let us once again go back to the example of a car on e downhill road The steeper the slope, the faster is the speed of the car. The same is true for the circuit the higher the voltaga, greater is the current. When the brakes are applied harder, speed of the cer goes down. In cese of the circuit, increase the resistance and current goes down.

When the voltage in a circuit is fixed, the resistence regulates the flow of current. A 100 W bulb consumes about 0 45 A current, when it is lighted (see figure 2). The Ohm's law gives the value of resistence.

$$R\ (Bulb) = \frac{230\ V}{0.45A} = 511\Omega$$

Unfortunately this indicates the resistance of the filament in the lighted condition. (When it is hot.) When we switch on the bulb, it is still cold, and the filament resistance at this time is approximately 40 Ohms This gives us the velue of current that passes through the bulb for a moment at the time of switching it on as:

$$I = \frac{230\ V}{40\Omega} = 5.75\ A$$

This is more than 10 times the steedy state current in the lighted condition. It is not surprising, that most of the bulbs ere lost while switching them on.

Note thet in our calculations so fer we have not used the original form of the Ohm's law U = R . I, but we heve used the variations.

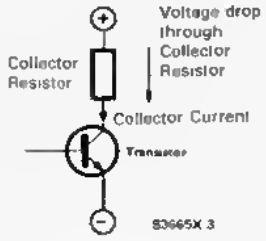
$$I = \frac{U}{R} \quad \text{and} \quad R = \frac{U}{I}$$

The original stetement of the Ohm's lew is used when we know the current flowing through a brench of the circuit, end the resistance in that brench, for exemple the collector current of a transistor, and the collector resistance (See figure 3)

The voltege drop ecross the resistor cen be calculeted using the original statement of the Ohm's law.

U = R . I

3



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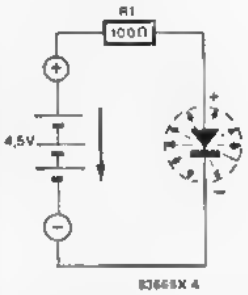

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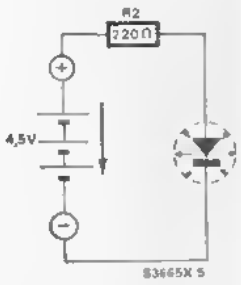


Figure 4
Resistor R1 prevents the current in the circuit from becoming very high. The current is limited to 20 to 30mA.

Figure 5
Increasing the resistence reduces the current, thus reducing the glow of the LED.

6

7

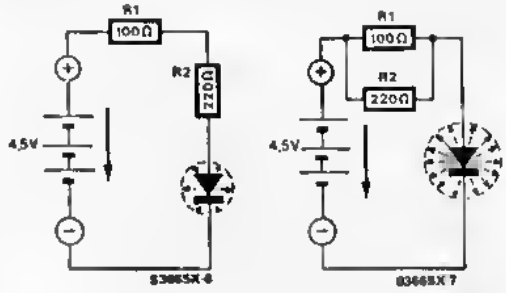


Figure 6.
Two resistors in series offer more resistence to the current then e single resistor.

Figure 7.
Two resistors in perellel offer less resistence to the current then e single resistor.

Experiments:

Experimenting is better then so much of theoryl Let's turn our attention to some interesting experiments based on the Ohm's lew. For this we need.

- 1 Flet bettery of 4.5 V
- 1 Resistor, 100Ω
- 1 Resistor, 220Ω
- 1 LED

All these will be eveileble in an electronic components shop. Colour of the LED is immaterial for these experiments.

Figure 4 shows the first circuit with the 4 5 V battery, 100Ω resistor and the LED. All connected in series (Be careful about the LED polerity) The resistor is used for limiting the current through the LED within the allowed limits In absence of this resistor the full 4 5 V battery voltage will be epplied directly ecross the LED and it will be destroyed as e high current will pass through.

The LED is used in these experiments to give a visual indicetion of the level of current flowing through the circuit, beceuse the LED glows more brightly when more current flows through it

Observe the brightness of the glow of the LED in the first experiment end then substitute the 100Ω resistor by e 220Ω resistor. (See figure 5) Now observe the brightness of glow, it is less than thet in the first experiment. Neturally so, beceuse with increased resistence, the current has reduced Connecting both the resistors together in series in the circuit es shown in figure 6 will further reduce the current end the LED glow will be dim.

A further possibility is connecting both the resistors in perallel as shown in figure 7. In this cese the LED glows more brightly than all the previous combinetions. The result initielly appears surprising However as the two resistors in parallel offer two paths to the current end effectivelt the totel current driven by the battery increases, end LED glows more brightly.

The distinction between the series and perellel connection of resistors must be noted here - a series connection strengthens the effect of resistance, wherees e perellel connection reduces the effect

Digi-Course

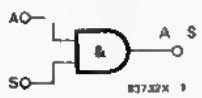
Chapter 5

Gates, Logic Circuits,

The Previous chapters in our Digi-Course series mainly covered the basic gates and the possibilities of processing logicel signels

In this chapter we shall look into circuits based on gates, which allow the signals (logical signals) to pass through or block them, depanding upon the circuit conditions The gates can be said to be some kind of "Logic Switches" The Truth teble of an AND gate also shows this feature.

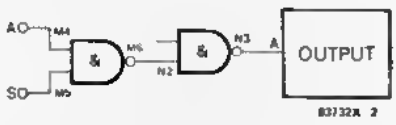
1



S	A	AND A · S	
0	0	0	OFF
0	1	0	
1	0	0	ON
1	1	1	

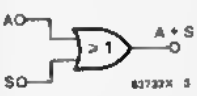
One of the inputs, designated here with S, can be considered to be the control input. With S = 1 the AND gate output is same as the input A, where as with S=0 the output is constantly "0" With S = 1 the AND gate allows the signel at input A to pass through to the output. With S=0 the gate blocks whatever signal may be at input A To try this on Digilex-Board, use a NAND gete with an inverter (a NAND gets with one input unconnected).

2



An OR gets also behaves in the same manner

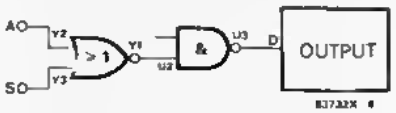
3



S	A	OR A + S	
0	0	0	ON
0	1	1	
1	0	1	OFF
1	1	1	

With en OR gate, e 0 on the S input ellows the signal et A to pass through to the output, and e 1 on the S input blocks the gate end makes the output constantly "1". This also cen be tried on the Digilex-Board, using a NOR and a NAND gete.

4

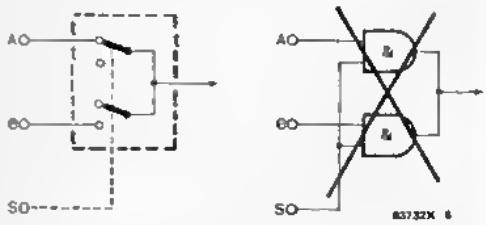


NAND end NOR gates, when individuelly used in this feshion, elso beheve es logic switchas with invartad outputs.

Changeover Switch

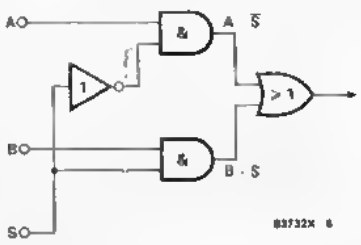
A mechanical change over switch can be constructed from two switches with common actuating lever Unfortunetely this is not possible with the digital switches directly (Sea figure 5)

5



The digitel equivalent needs an extra OR gate and end Inverter in addition to the two "AND-switches"

6



We have seen how an AND gate with a control input S behaves as an ON/OFF switch. Here the control signal S is teken through an invertar to the first AND gata and is directly connected to the second AND gate This prevents the condition that both the "AND-switches" are ON and OFF at the sama time The outputs of the two AND gates ere taken through an OR gate The truth table of the entire circuit is given below

Truth Tabla

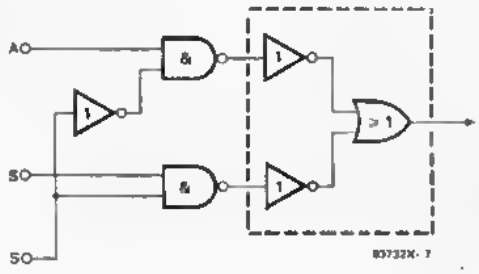
A	B	S	A · S̄	B · S	OUTPUT	
0	0	0	0	0	0	A ON
0	1	0	0	0	0	
1	0	0	1	0	1	
1	1	0	1	0	1	
0	0	1	0	0	0	B ON
0	1	1	0	1	1	
1	0	1	0	0	0	
1	1	1	0	1	1	

selex

Unfortunately the circuit of figure 6 cannot be directly wired on the Digilex-Board, which has only NAND and NOR gates. But there is no reason to panic! We already know how to use NAND and NOR gates to simulate the required circuits.

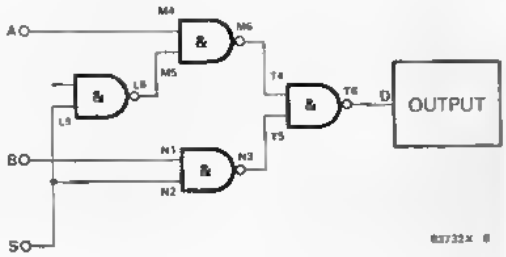
Replacing the AND gates with NAND and Inverter combination, we obtain the circuit shown in figure 7.

7

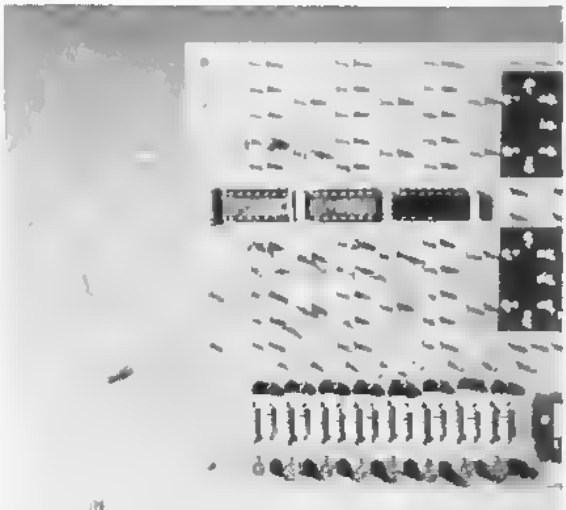


Compare the circuit enclosed in the dotted lines with the AND equivalent, we had derived in chapter 3. A NOR gate was used there instead of the OR in the present circuit. This means that the present circuit is the "NAND" equivalent.

8



Now this circuit can be easily wired up on our Digilex-Board.



Input A : M4
Input B : N1
Control Input S : L9

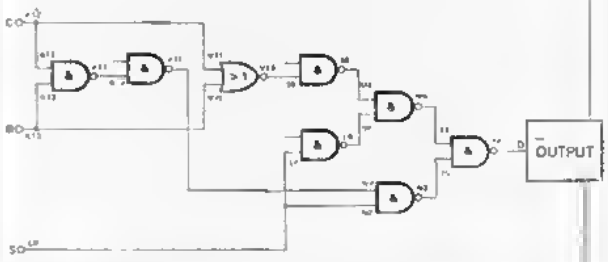
N2 — L9
N3 — T5
M5 — L8
M6 — T4
T6 — D

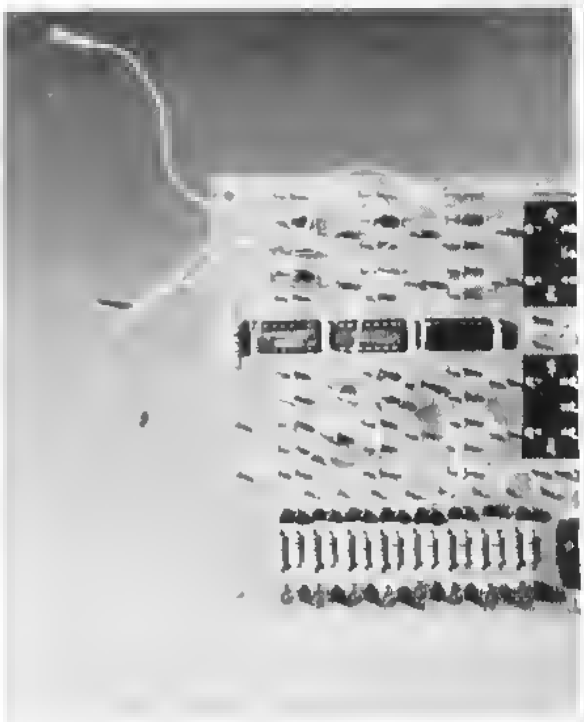
AND-OR universal gate

Figure 9 illustretes the possibility of epplication for the logical Changeover Switch, an AND-OR universal gete.

Inputs are named as C end D for the purpose of differentiating the circuit from the previous one

9





Here we heve two NAND—NOR equivalent combinations for the AND and OR functions followed by the circuit of figure 8. Thus we have deviced a circuit which beheves es an "OR" gate when there is a "0" on S input. The same circuit behaves as an "AND" gate when there is a "1" on the S input.

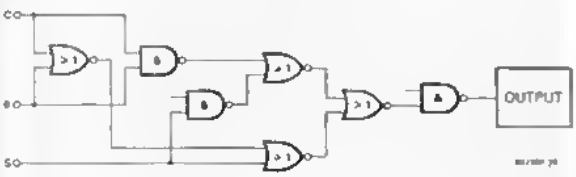
The connections on the Digilex-Board are as follows:

Input C : K13
Input D : K12

K11 — R13
R11 — N1 (Input B)
K13 — V12
K12 — V11
V13 — S9
S8 — M4 (Input A)

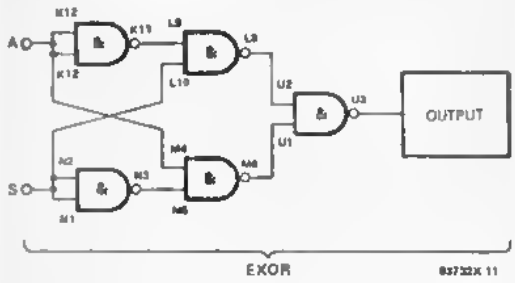
Tha Changeover switch can also be raalised as shown in figura 10. We shall not go into tha datailad explanation of this circuit. It is laft to the reader to prove the aquivalance.

10



Incidentally, it will be of interest to go back to chapter 3 again, where we had studied a circuit with reversing logic: The EXOR—circuit.

11



Truth Tabla

S	A	S⊕A	
0	0	0	Non inverted
0	1	1	
1	0	1	Inverted
1	1	0	

The truth table shows clearly that the signal on input A appears on the output in an inverted form, when there is a "1" on the control input S. In case of a "0" on the control input S, the signal on A appears directly on the output. This is also known as a controlled inverter.

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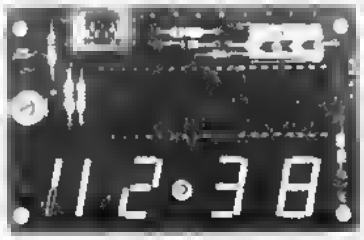

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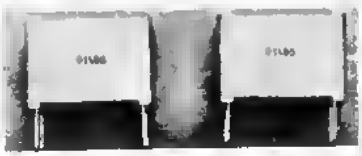

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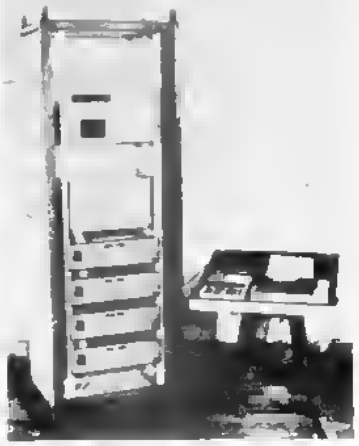

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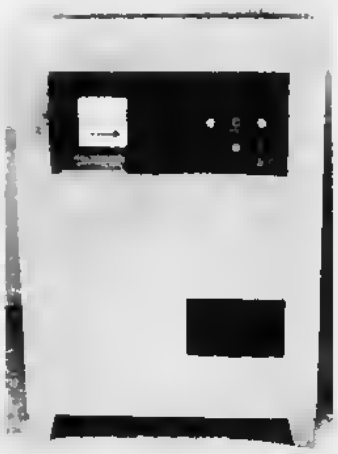

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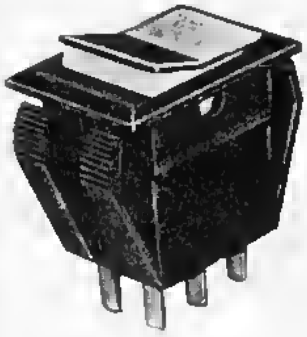

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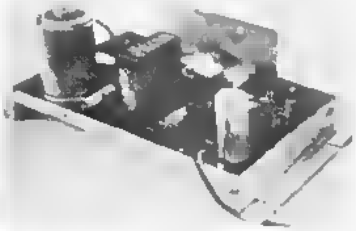

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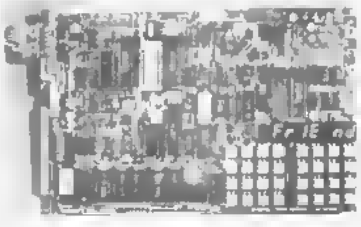

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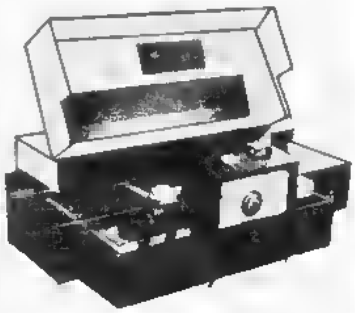

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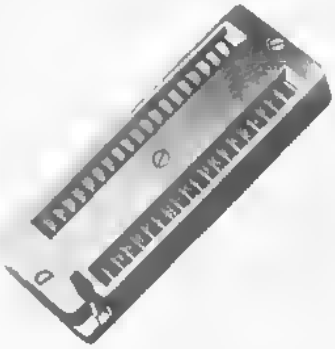

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