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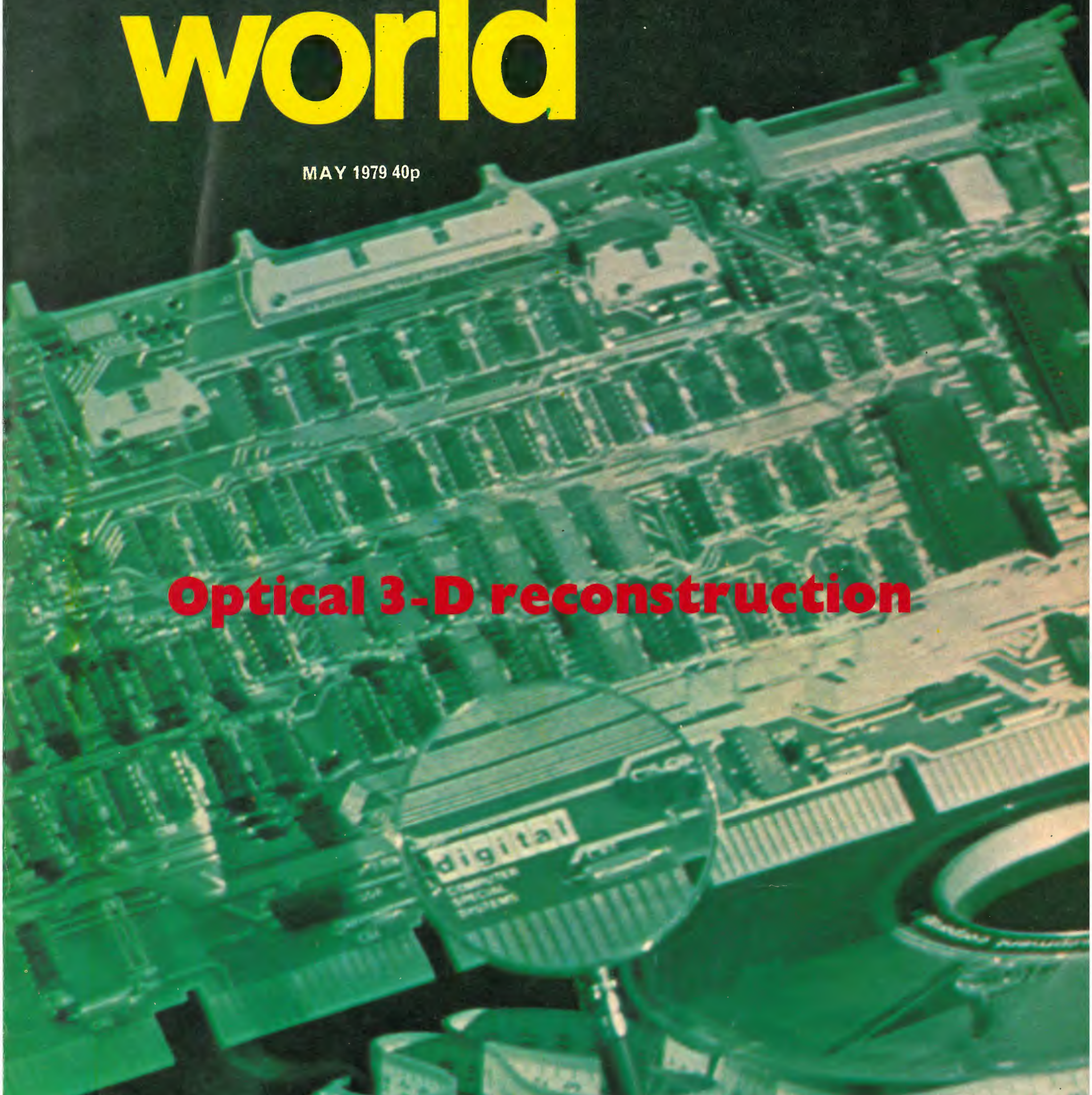
MAY 1979 40p



Optical 3-D reconstruction

Acoustic breakthrough

A-d and d-a converters

Front cover, a 3D image produced by white light holography (including optical magnification), introduces the article by Nick Phillips in this issue. Photo by Theo Bergstrom.

IN OUR NEXT ISSUE

***Bookshelf Loudspeaker Mk II.* Update of 1977 design — lower cabinet resonance, improvements in cross-over circuit and changes for an alternative tweeter.**

***What is an electron?* Examination of its properties and discussion of its connection with radiation precede a proposal for a new model.**

***Weather satellite reception.* Constructing a receiving station for displaying pictures from Meteosat.**

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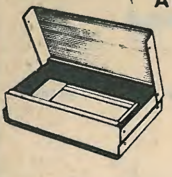
wireless world

ELECTRONICS/TELEVISION/RADIO/AUDIO

MAY 1979 Vol 85 No 1521

YOUR COMPLETE RANGE OF ELECTRONIC HARDWARE...

BIMENCLOSURES



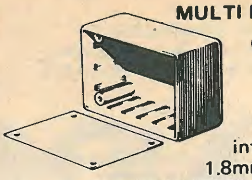
ALL METAL BIMCASES

Red, Grey or Orange 14swg Aluminium removable top and bottom covers. 18 swg black mild steel chassis with fixing support brackets.
BIM 3000 (250x167.5x68.5mm) £14.58

MINI DESK BIMCONSOLES

Orange, Blue, Black or Grey ABS body incorporates 1.8mm pcb guides, stand-off bosses in base with 4 BIMFEET supplied. 1mm Grey Aluminium panel sits recessed with fixing screws into integral brass bushes.

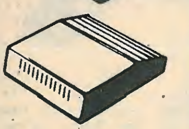
BIM 1005 (161 x 96 x 58mm) £2.18
BIM 1006 (215 x 130 x 75mm) £3.05



MULTI PURPOSE BIMBOXES

Orange, Blue, Black or Grey ABS with 1mm Grey Aluminium recessed front cover held by screws into integral brass bushes. 1.8mm pcb guides incorporated and 4 BIMFEET supplied.

BIM 4003 (85x56x28.5mm) **£1.18**
BIM 4004 (111x71x41.5mm) £1.62
BIM 4005 (161x96x52.5mm) £2.19

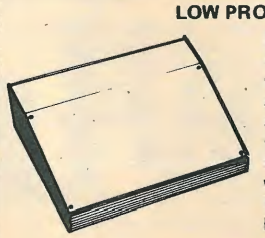


ALL METAL BIMCONSOLES

All aluminium, 2 piece desk consoles with either 15° or 30° sloping fronts, sit on 4 self-adhesive non-slip rubber feet. Ventilation slots in base and rear panel for excellent cooling. See latest catalogue for new styles and sizes

Colour Code	Top Panel	Base
A	Off White	Blue
B	Sand	Green
C	Satin Black	Gold

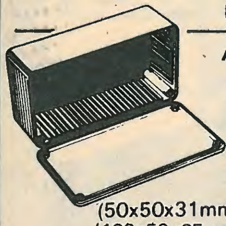
15° Sloping Panel	30° Sloping Panel	
BIM7151 (102x140x51[28] mm)	BIM7301 (102x140x76[28] mm)	£10.67
BIM7152 (165x140x51[28] mm)	BIM7302 (165x140x76[28] mm)	£11.44
BIM7153 (165x216x51[28] mm)	BIM7303 (165x183x102[28] mm)	£12.61
BIM7154 (165x211x76[33] mm)	BIM7304 (254x140x76[28] mm)	£13.82
BIM7155 (254x211x76[33] mm)	BIM7305 (254x183x102[28] mm)	£15.36
BIM7156 (254x287x76[33] mm)	BIM7306 (254x259x102[28] mm)	£16.67
BIM7157 (356x211x76[33] mm)	BIM7307 (356x183x102[28] mm)	£17.58
BIM7158 (356x287x76[33] mm)	BIM7308 (356x259x102[28] mm)	£18.55



LOW PROFILE BIMCONSOLES

Orange, Blue, Black or Grey ABS body has ventilation slots as well as 1.8mm pcb guides and stand-off bosses in base. Double angle recessed front panel with 4 fixing screws into integral brass bushes. 4 BIMFEET supplied.

BIM 6005 (143 x 105 x 55.5 [31.5] mm) £2.37
BIM 6006 (143 x 170 x 55.5 [31.5] mm) £3.08
BIM 6007 (214 x 170 x 82.0 [31.5] mm) £4.12

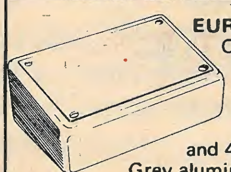


ABS & DIECAST BIMBOXES

6 sizes in ABS or Diecast Aluminium. ABS moulded in Orange, Blue, Black or Grey. Diecast Aluminium in Grey Hammertone or Natural. All boxes incorporate 1.8mm pcb guides, stand-off supports in base and have close fitting flanged lids held by screws into integral brass bushes (ABS) or tapped holes (Diecast).

	ABS		Diecast	Hammertone	Natural
(50x50x31mm)	N/A		BIM5001/11	TBA	£1.02
(100x50x25mm)	BIM2002/12	£0.96	BIM5002/12	£1.46	£1.19
(112x62x31mm)	BIM2003/13	£1.13	BIM5003/13	£1.78	£1.46
(120x65x40mm)	BIM2004/14	£1.35	BIM5004/14	£2.24	£1.82
(150x80x50mm)	BIM2005/15	£1.52	BIM5005/15	£2.84	£2.28
(190x110x60mm)	BIM2006/16	£2.37	BIM5006/16	£3.94	£3.33

Also available in Grey Polystyrene with no slots and self-tapping screws
BIM 2007/17 (112x61x31mm) £1.00



EUROCARD BIMCONSOLES

Orange, Blue, Black or Grey ABS body accepts full or ½ size Eurocards, with bosses in the base for direct fixing. 1.8mm wide pcb guides incorporated and 4 BIMFEET supplied. 1mm Grey aluminium lid sits flush with body top and held by 4 screws into integral brass bushes.

BIM 8005 (169x127x70[45] mm) £4.12
BIM 8007 (243x187x103[66] mm) £6.10

BIMTOOLS + BIMACCESSORIES

MAINS BIMDRILLS

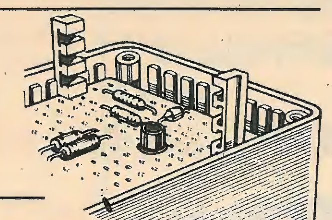
Small, powerful 240V hand drill complete with 2 metres of cable and 2 pin DIN plug. Accepts all tools with 1mm, 2mm or .125" dia. shanks Drills brass, steel, aluminium and pcb's. Under 250g, off load speed 7500 rpm. Orange ABS, high impact, fully insulated body with integral on/off switch £10.53

Mains Accessory Kit 1 includes 1mm, 2mm, .125" twist drills, 5 burrs and 2.4mm collet £2.48

Mains Kit 2 includes Mains BIMDRILL as above, 20 assorted drills, mops, burrs, grinding wheels and mounted points, 1mm, 2mm, 2.4mm and .125" collets. Complete in transparent case measuring 230x130x58mm £22.14

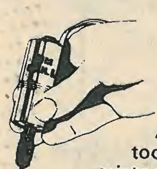
BIMDAPTORS

Allows pcb's to be flat mounted sandwich fashion in BIMBOXES, BIMCONSOLES, and all other enclosures having 1.5mm wide vertical guide slots. One plastic BIMDAPTOR on each corner of pcb(s) enables assembly to be simply slid into place. 54mm long, 10 slots on 5mm spacing and can be simply snipped off to length. £1.08 per pack of 25.



BIMFEET

11mm dia. 3mm high, grey rubber self-adhesive enclosure feet. £0.77 per pack of 24



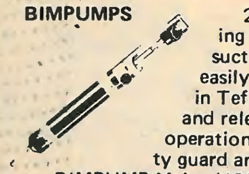
12 VOLT BIMDRILLS

2 small, powerful drills easily hand held or used with lathe/stand adaptor. Integral on/off switch and 1 metre cable.

Mini BIMDRILL with 3 collets up to 2.4mm dia. £ 8.10
Major BIMDRILL with 4 collets up to 3mm dia. £13.60

Accessory Kits 1 have appropriate drills and collets as above plus 20 assorted tools. Mini Kit 1 – £15.12, Major Kit 1 – £19.44. Accessory Kits 2 have appropriate drills, collets plus 40 tools and mains 12V dc adaptor. Mini Kit 2 – £34.02, Major Kit 2 – £39.42. Accessory Kits 3 as appropriate Kits 2 plus stand/lathe unit. Mini Kit 3 – £45.36, Major Kit 3 – £50.76.

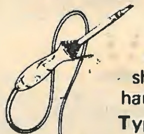
BIMPUMPS



2 all metal desoldering tools provide high suction power and have easily replaceable screw in Teflon tips. Primed and released by thumb operation with in-built safety guard and anti-recoil system.

BIMPUMP Major (180mm long) £7.99
BIMPUMP Minor (150mm long) £6.80

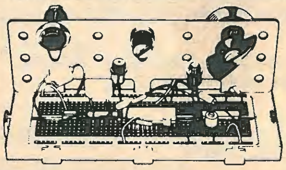
BIMIRONS



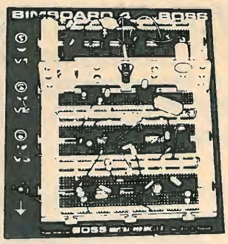
Type 30 General Purpose 27 watt iron with long life, rapid change element, screw on tip, stainless steel shaft and clip on hook. Styled handle with neon. £4.05

Type M3 Precision 17 watt iron, quick change tip, long life element, styled handle with clip on hook. £4.43

BIMBOARDS



DIL COMPATIBLE BIMBOARDS



Accept all sizes (4-50 pin) of DIL IC packages as well as resistors, diodes, capacitors and LEDs. Integral Bus Strips up each side for power lines and Component Support Bracket for holding lamps, switches and fuses etc. Available as single or multiple units, the latter mounted on 1.5mm thick black aluminium back plate which stand on non slip rubber feet and have 4 screw terminals for incoming power.

BIMBOARD 1 has 550 sockets, multiple units utilising 2, 3 and 4 BIMBOARDS incorporate 1100, 1650 and 2200 sockets, all on 2.5mm (0.1") matrix.

BIMBOARD 1 £ 8.83
BIMBOARD 2 £21.01
BIMBOARD 3 £29.84
BIMBOARD 4 £38.79

DESIGNER PROTOTYPING SYSTEM

1, 2, or 3 BIMBOARDS mounted on BIM 6007 BIMCONSOLE with Integral Power Supply (±5 to ±15Vdc @ 100mA and fixed +5Vdc @ 1A) All O/P's fully isolated. Short circuit and fast fold back protection. Power rails brought out to cable clamps that accept stripped wire or 4mm plug.

DESIGNER 1 £55.62
DESIGNER 2 £61.02
DESIGNER 3 £66.42

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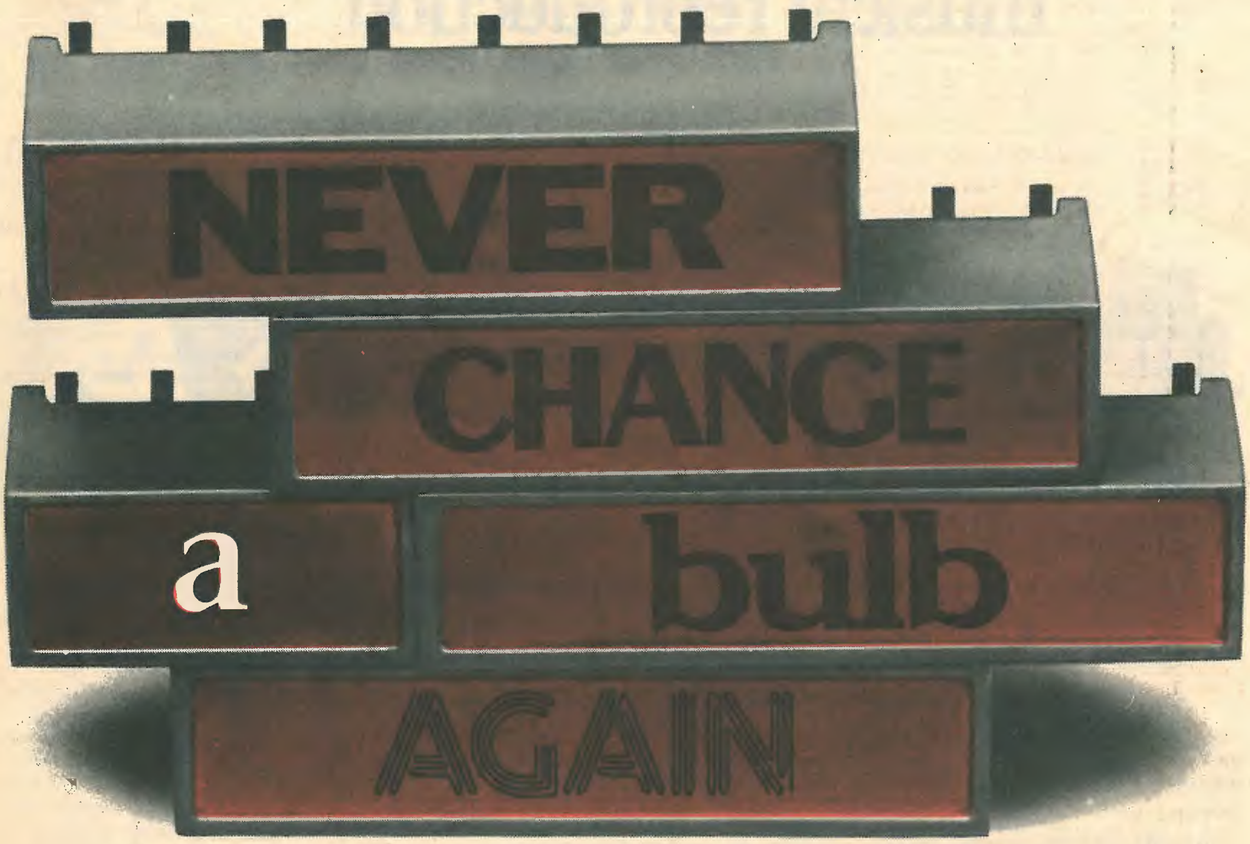
From Crellon: the new Hewlett-Packard Block of Light.



Got the message?

Visualise a bright light source that's as reliable as solid state technology can make it. That can be fitted quickly and easily. That's so versatile it can be used to illuminate switches, indicators, bar graphs and carry any message or symbol.

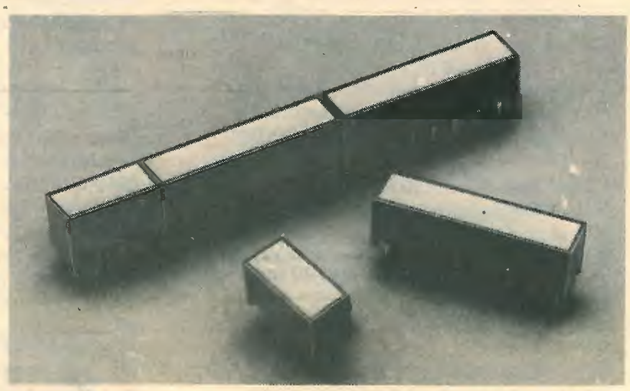
This is Hewlett-Packard's new HLMP-2300/2400/2500 series of light bars. Rectangular panels of light in 9mm, or 19mm bars in high efficiency red, yellow or green.

They utilise LED's that are 100% tested and are catagorised for light output, mounted on standard in-line packages with leads on industry standard (0.1") centres, ideal for PC board mounting.

Additionally they are XY stackable, flush mountable and easy to align. The on-off contrast is excellent, they look very good and the prices are fine. The 9mm package costs £1.02 for 1 off £0.71 for 1000 x. 19mm package costs £1.49 for 1 off £1.08 for 1000 x.

For full details for the Light bar modules contact Crellon Electronics.

We'll make sure you get the message.



HEWLETT hp PACKARD

Crellon Electronics Ltd., 380 Bath Road, Slough, Berks.
Tel: Burnham (06286) 4434.

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". . . Shure guarantees a frequency response of 20 - 20,000 Hz within a tolerance field of 2 dB! Whoever promises something like this, certainly must have production under control!. . . . No wonder that its sound pattern was judged to be on the top end of the spectrum."

Stereo
Germany

"It is a smooth, neutral and analytical cartridge, and therefore best suited to an already neutral system."

"We doubt whether there is any commercially available record it is incapable of tracking."

Records and Recordings
United Kingdom

". . . a sound quality I cannot imagine to be bettered by any cartridge at any price. The art has reached a higher state!"

Cliff Coleman
Honolulu Advertiser
United States

"It seems that a curtain has been raised. . . . This increased definition seems to extend to the entire audible spectrum."

Hi-Fi Conseils
France

"It is, in fact, a superb-sounding and superb-measuring cartridge, which will set a new standard for the industry. . . . This is certainly the flattest response we have yet seen from a cartridge. . . . All in all, when Shure does it, they do it right."

AudioScene Canada
Canada

"In fact, the V15 Type IV wonderfully gets out of the most insidious traps, and, willingly tracks the most strongly modulated records. This, with a precision that no ear can miss, and comparatively better than all the other models tested up-to-date."

Electronique Pour Vous —Hi-Fi Magazine
France

"Its sound is smooth, flat, and clean to a degree that rivals anything on the market, at any price. . . . It should become the pickup of choice for a great many systems owners. It arguably represents the most significant (pickup) cartridge innovation in years."

CBS Technology Center
High Fidelity
United States

"The Super Track V15 Type IV is exactly that, a phenomenal performer that, with the proper associated gear, will provide gorgeous, undistorted sound from the most demanding records—for example the heavily cut direct-to-disk releases that many audiophiles are cultivating to show off their equipment. . . . In performance, it rivals or surpasses fancy, fragile, temperamental moving coil designs that may cost twice the price. . . ."

Robert C. Marsh
Sun-Times
United States

"The Type IV appears to be a cartridge that has the 'most' of every desirable quality and the 'least' of every undesirable quality. It is unsurpassed in the smoothness and flatness of its frequency response, low distortion, high trackability, and neutral sound character."

Hirsch-Houck Lab Report
Popular Electronics
United States

"The sound of the V15 Type IV can be described in much the same way as that of a good amplifier; there is really no particular sound at all that can be attributed to the cartridge. It is, after all, essentially flat, with distortions that seem to be below those inherent in even the best test records, and with far greater tracking ability over the entire audio band than any other cartridge we know of. . . . The Type IV is able to play records that other cartridges cannot."

Stereo Review
United States

"All in all, this is a quality cartridge that sweeps away one's fear of false advertising claims."

Swing
Japan

"It (the V15 Type IV) is superb on all types of music.
The remarkable points are:
—The extreme definition in low frequencies, which outclasses all the cartridges that were compared to it (moving magnet and moving coil).
—A clear mid-range.
—Accurate . . . . open sound.
—A radiant treble without any excess due to artificial addition.
The tonal balance is good without bias of any kind. On percussion instruments, the V15 Type IV reads only what is recorded, without any overbrightness."

La Nouvelle Revue Du Son
France

"This cartridge excels by genuine sound 'neutrality', without any tendency to sound 'shaping'. It is pure pleasure to play direct-cut records of pianos . . . absolutely clean play!"

Radio-TV-Electronic
Switzerland

"I do not intend to allow the Type IV to pass out of my hands. Its stability in the reproduced sound, the rich qualities and harmony of the vocals and strings, as well as the extension in the sound of pianos on direct-to-disc recordings, and others, are truly magnificent."

Masao Miyamoto
Radio Techniques Antenna
Japan

20-E
Please send me your leaflet describing the Shure V15 Type IV and other pickups in the Shure range.

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Address ____________________

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In future, recording the present will be a thing of the past.

What's past is past. And said to be best forgotten.

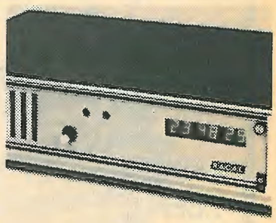
But it's fundamental to the very existence of communications recording to be able to replay a selected portion of tape to find out what was said by who, to whom . . . and when. And 'when' can be vital.

Equally vital, particularly in emergencies when every second counts, is the ability to obtain such replay access rapidly, precisely, automatically. With absolute certainty—and without time-consuming multiple knob-twiddling aided by guesswork.

Racal Recorders has recognized this need and produced TIMESEARCH—designed specifically for its ICR range of multi-channel communications recorders—and providing just these facilities.

TIMESEARCH can generate a coded time reference signal of crystal accuracy and index it onto the tape. It can read and display that signal. It can search a tape at high speed for a pre-selected time signal and automatically initiate replay at that time.

In communications recording, the future becomes the present; the present becomes the past. And when you need to recall the past with precision, you need TIMESEARCH.



And for providing precise time signals every 10 seconds for recording onto magnetic tape: the International Timing Unit.

Racal Recorders always on the right track

Racal Recorders Limited, Hardley Industrial Estate, Hythe, Southampton, Hampshire, SO4 6ZH. Telephone: 0703 843265. Telex 47600.

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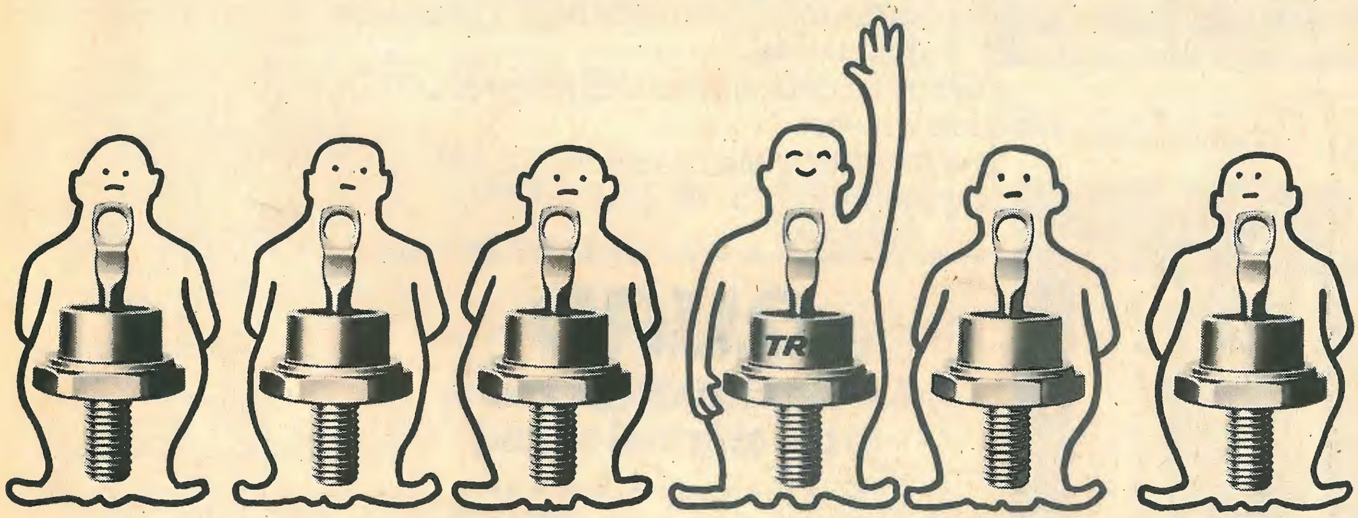
RACAL

OK, which of you Power Schottkys is ready to talk reliability and performance?

(now be honest)



Reliability

TRW supplied its first customer with Power Schottky devices in 1972 and he's still buying. His return rate is still nil. He knows that he doesn't have to worry about them failing in low voltage, high current switching power supply applications. He knows that when he gets a shipment he can use them without any worries. Hundreds of other customers have had the same experience.

Performance

The SD-51 in the DO-5 package has the best overall performance around for switching power supplies with 5.0V @ 60 amps. ($V_F = 0.6V$ @ 60A, P.I.V. – 45V and $T_j = 150°C$.) For 5.0V @ 30 amps the SD-41 in the DO-4 package can cut system size and cost. And both will reduce your need for heat exchangers and cooling devices.

MCP Electronics Ltd.
Alperton, Wembley, Middx.
Tel: 01-902 5941

And that's straight talk. If you'd like help with your low voltage, high current switching power supply designs just call MCP Electronics on 01-902 5941.

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Please send me further information on TRW's Power Schottky Diodes.

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TRW POWER SEMICONDUCTORS

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Peace and quiet

The quietest sound the ear can hear moves the eardrum about 10^{-9}cm, one tenth the diameter of a hydrogen molecule. Movement due to random thermal bombardment of the eardrum by air molecules is around this same level and largely accounts for this limit of sensitivity.*

But the distortion contribution from a QUAD 405 amplifier in normal use (say 85dBa) moves the eardrum less than this amount.

Perhaps sitting in a very quiet room at −100°C and without the music we might nearly hear them ....but "'tis bitter cold."

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*Sensitivity is never made more acute by the presence of other sounds.

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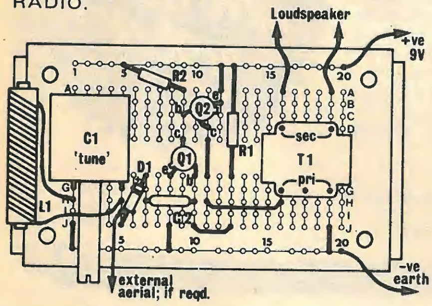
ELECTRONICS BY NUMBERS. TWO-TRANSISTOR RADIO.

Now using Experimentor Breadboards and following the instructions in "Electronics by Numbers" ANYBODY can build electronic projects.
Simply look at the diagram — this has exactly the same type of layout of all EXPERIMENTOR boards. Look at the component list and select the component Q1, this is an NPN transistor type 2N3904, this plugs into holes C10, D11, and B12. Easy isn't it?
Now take C2, which is a .1 uf capacitor, this plugs into holes H7 and H10.
Do the same with all the components, connect a 9 volt battery and you have a perfect working TWO-TRANSISTOR RADIO.



YOU WILL NEED

B1—9 VDC battery
C1—365—pF variable capacitor
C2—.1—uF capacitor
D1—Diode, 1N914 or 4148 or equiv.
L1—Standard broadcast loopstick antenna
Q1—NPN transistor, 2N3904 or equiv.
Q2—PNP transistor, 2N3906 or equiv.
R1—100,000—ohm resistor, ¼ watt
R2—4700—ohm resistor, ¼ watt
S1—SPST switch
T1—500:8—ohm matching transformer
SPKR—8—ohm speaker

Building radios is lots of fun. Here's a loud-speaking crystal set. L1 and C1 form the circuit that tunes the radio. For better performance substitute a germanium diode such as IN34 or IN60.
These projects use components which are readily available from all suppliers and we've made a special effort to design the projects so that in many cases substituting close but wrong component values of different transistors will still result in a working circuit.
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Brings IC leads up from crowded PC boards. Available plain or with cable with clips at one or both ends.

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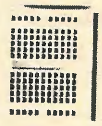

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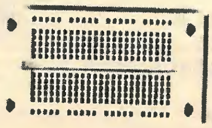

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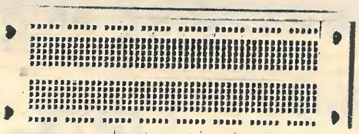

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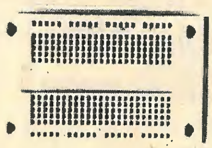

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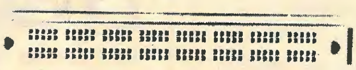

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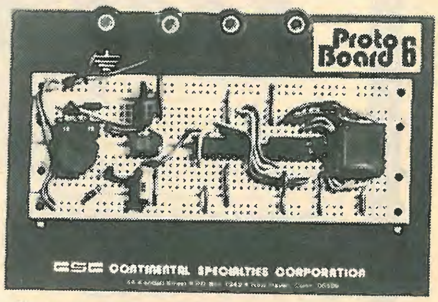

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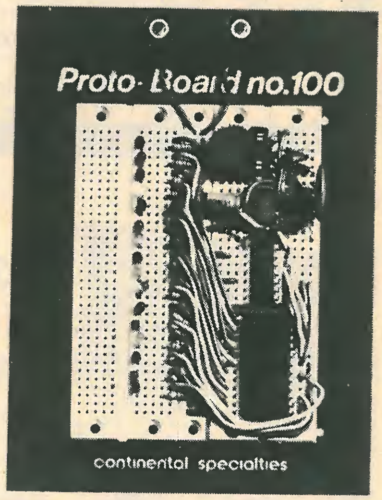

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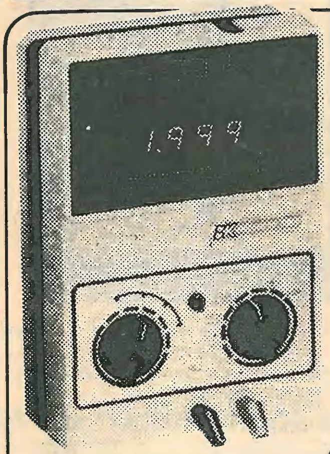

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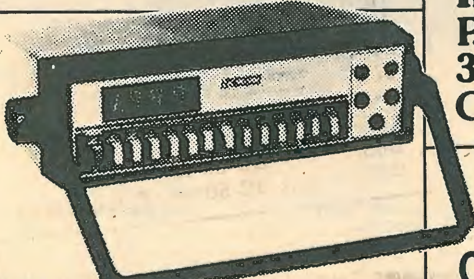

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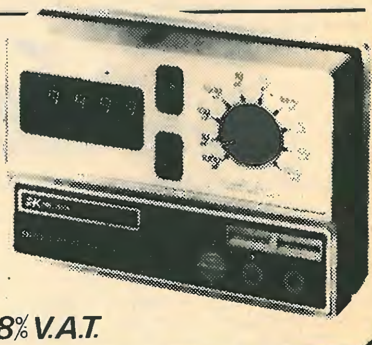

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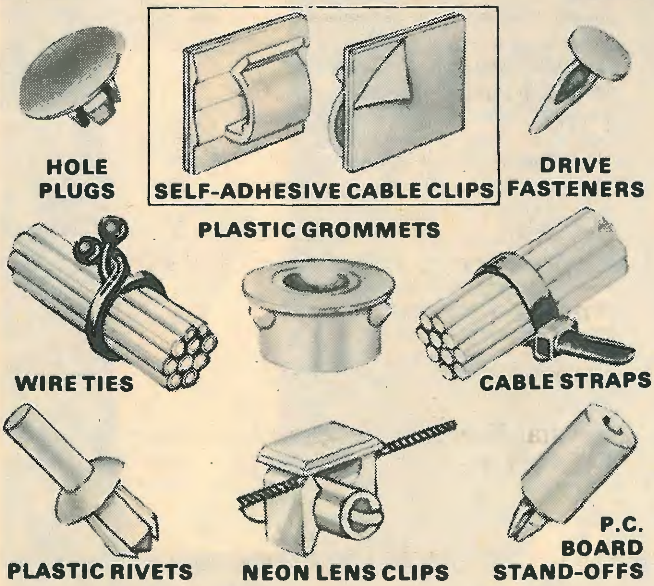

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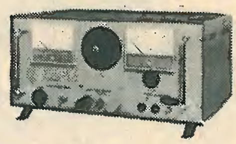

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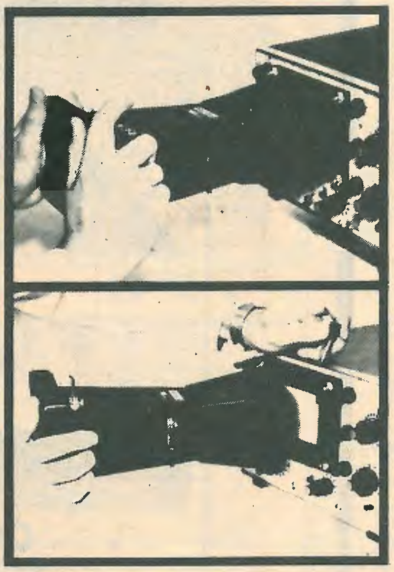

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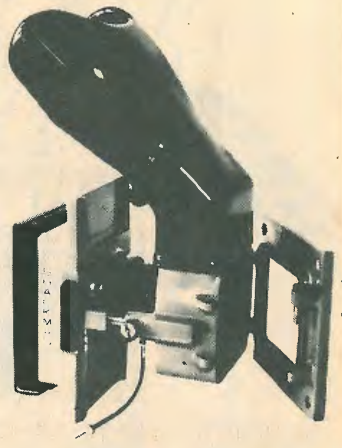

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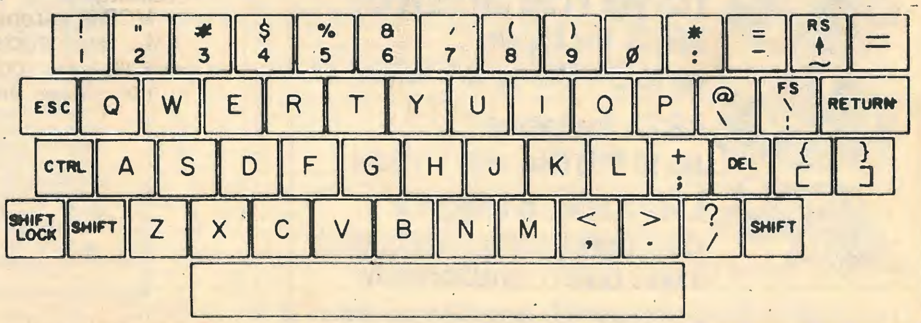

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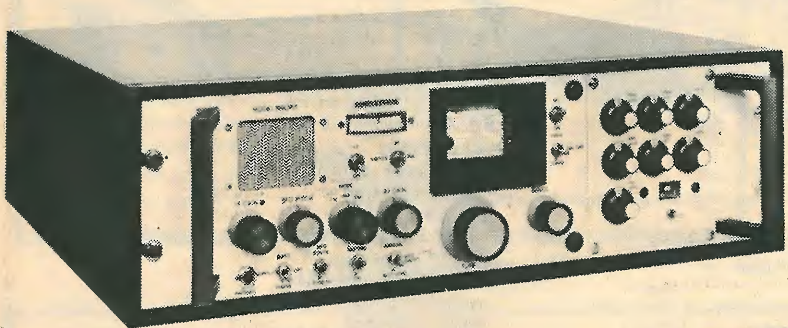

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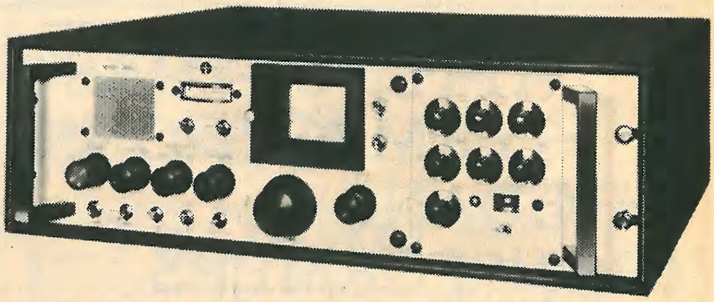

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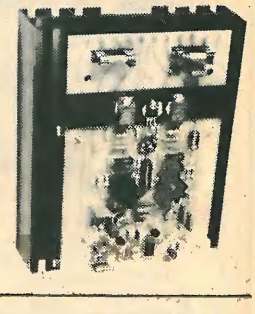

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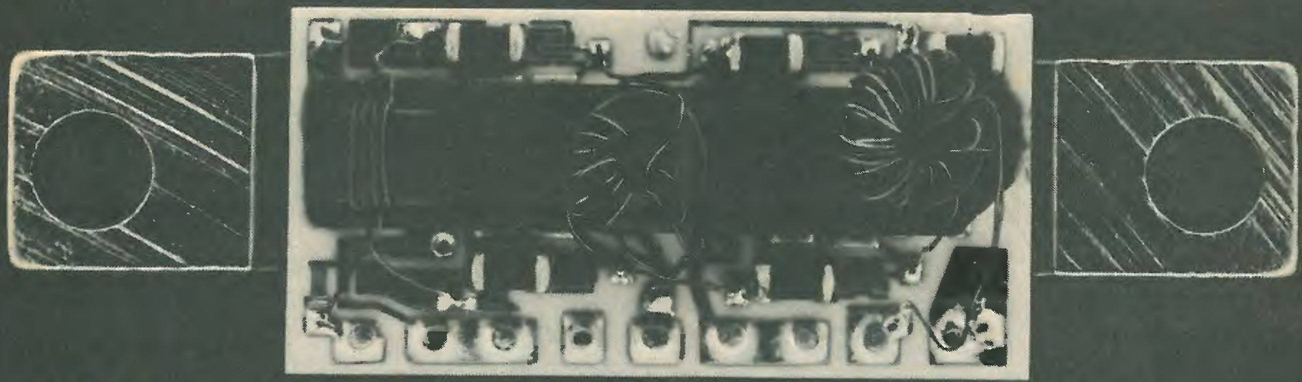

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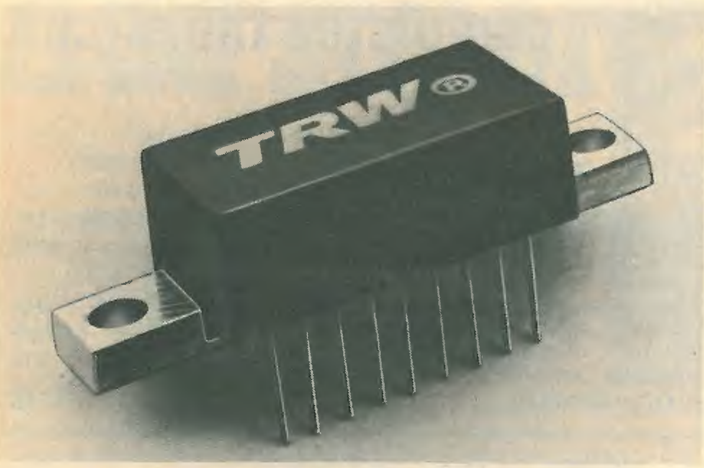

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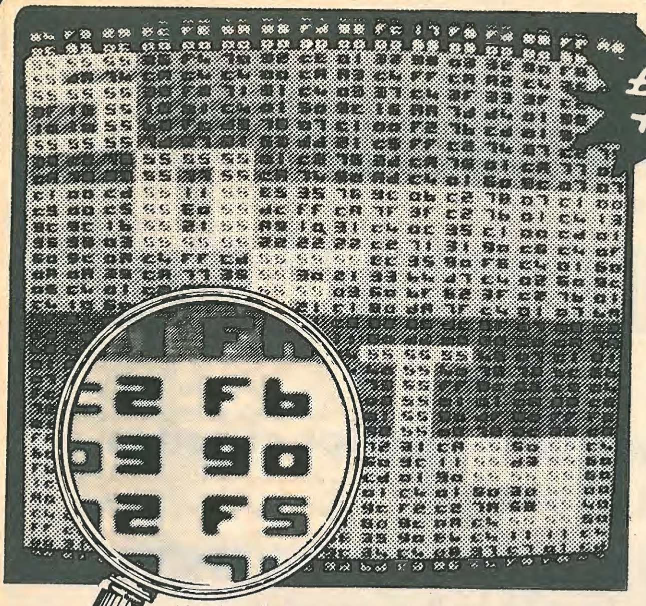

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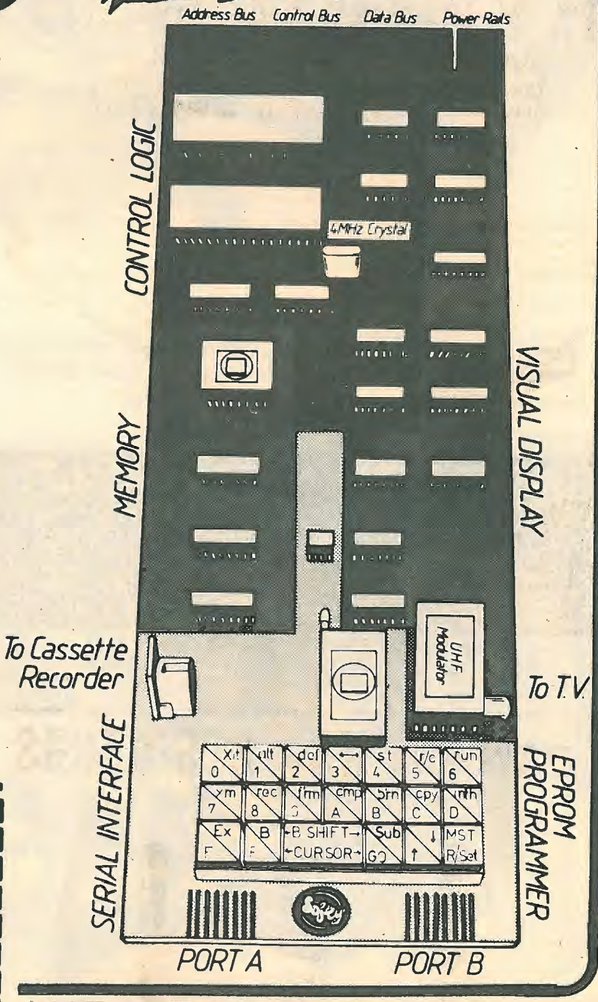

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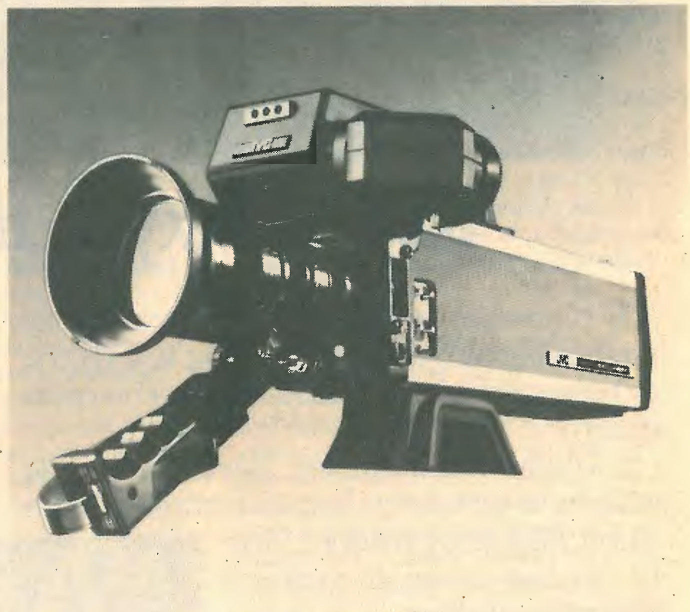

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Education as a meal-ticket

THOSE who design courses in electronic engineering must sometimes wish they had a subject where the rate of accretion of new knowledge wasn't quite so fast — like palaeontology for example. No sooner had they settled down after the change from valves to transistors than the integrated circuit revolution was upon them. Then they had to start thinking in terms of systems rather than circuits and digest related bodies of knowledge such as information theory, control engineering and cybernetics. Digital computers, which started as pieces of hardware made by electronics engineers for use by other people, have turned round and headed back for home to become components of electronic systems, mostly in the form of minicomputers and microprocessors. As a result the education of an electronic engineer or technician is incomplete without a knowledge of how to construct algorithms and write programs. We are already hearing about "software engineers" as a distinct species and a cry is going up that we shall soon need a great many of these to design, manufacture and maintain a multitude of microprocessor-based products and systems.

Faced with a mere three- or four-year course, the task of the educator has become increasingly frustrating. What to leave out has become a more pressing matter than what to put in. And in electronic engineering the software revolution is not likely to be the end. It is, after all, only the modern development of a principle that was already being used in the 18th and 19th centuries. On the horizon for example are such things as artificial intelligence and devices using biological processes. Inevitably the educators must be asking themselves if their task must always be that of hopelessly trying to catch up with the winged Mercury of technology. A more fundamental question is whether this is in fact their proper task.

Ideally the purpose of education is to develop and make the most of what is latent in human beings. The word itself means to bring up, rather than fill up. But ideal education is possible only for rich and leisured people. For those who have to work for their living education means two things: first, what the government deems necessary for its citizens, and so makes available, to keep the country up in front in the economic race of industrial nations; and secondly what the person himself thinks will get him a good job and a high material standard of living. The second usually depends on the first. In both respects education is seen as a meal-ticket. In the scientific and technical sphere if the education doesn't fit you exactly for a job at least it teaches you to think analytically — along certain lines — so that you stand a chance of understanding and controlling what the outside world will throw at you in the future. But this is almost an accidental benefit.

One of our correspondents discussing the impact of software on electronics (M.A.I. Wilson in February letters) made the important observation that "... man has, up to now, survived by being non-specialist; specialism could be the modern ice age, bringing with it stagnation". This surely should be the watchword for education in electronics. Even if it were possible to turn out ready-made specialists it would be very unwise to do so. What seems necessary is to develop analytical thinking and creativity as ends in themselves, not as by-products, and in a way that prepares the student for the fact that he will probably be learning for the rest of his career in electronics.

Converting between analogue and digital quantities — 1

Some digital codes and the reasons for using them

by G. B. Clayton, B.Sc. Liverpool Polytechnic

Many of the electronic processing operations which were once performed using analogue circuit techniques are now accomplished with digital circuitry. The continued emergence of new, inexpensive, digital integrated-circuit devices of increasing complexity has reduced the importance of purely analogue circuits and systems. The upsurge in the use of digital techniques has pushed the role of the conversion element between analogue and digital circuits to the forefront of attention. Microprocessors and their applications in industrial control and measurement are currently at the centre of interest. Microprocessors need data converters if they are to be used to monitor or control analogue processes[1,2].

Newcomers to electronics and purely analogue or digital circuit engineers are perhaps not as familiar as they might like to be with the process of converting between analogue and digital data. In this series of articles the principles underlying the commonly used conversion techniques will be explained. Examples of specific converter devices will be given and experimental investigations will allow the reader to gain a practical familiarity with converter devices.

IN MANY of the real world systems studied by scientists and engineers the system parameters are continuously changing quantities (analogue variables) and, when electronic measurement techniques are employed, data is derived in analogue form as the electrical output signal of a transducer. It is perfectly possible to process, manipulate and store analogue data in a purely analogue electronic system; negative feedback techniques can make analogue systems perform very precisely. However, the accuracy of a purely analogue system is often not usable because of the difficulty of reading, recording and interpreting analogue data with high accuracy. Also, when large amounts of analogue data are involved the task of analysis and storage becomes enormous.

Digital electronic systems can be made to process, manipulate and store large amounts of data rapidly and accurately. Low-cost, digital microprocessor systems have drastically reduced the cost of implementing digital data processing, and make it possible to extend the use of electronic digital techniques into areas where they were formerly not considered economic. However, digital circuits only operate on digital data, and the scientist wishing to avail himself of the power of digital techniques must first transform his analogue data into digital form. A system called an analogue-to-digital converter (a.d.c.) is used to perform this function, the digital-to-analogue converter (d.a.c.) performing the transformation of digital data into analogue form. A.d.cs and d.a.cs provide the essential interface which is required between analogue and digital systems.

Such systems are not new but, until comparatively recently, they have been expensive to implement and have consequently been regarded as rather specialized pieces of equipment. The advent of low-cost, monolithic i.c. converter devices means that a wide range of versatile signal-processing techniques is economically available to the measurement scientist who is prepared to invest time in familiarizing himself with the latest devices and their capabilities. The material which follows is intended to serve as a first step.

Rather than attempting a survey of converter devices, which would be doomed to obsolescence even before it was completed, we concentrate on the principles underlying the most popular conversion techniques. Specific i.c. devices are mentioned, but only as a means of relating the discussion to practical circuits which you can experimentally evaluate for yourself; there is no substitute for 'hands on' practical experience in this type of learning exercise. However, do not assume that the devices referred to are the only ones, nor indeed the 'best' ones available from a cost/performance standpoint. The choice of the 'best' converter for a particular job can only be made from a thorough study of the manufacturers' latest product guides.

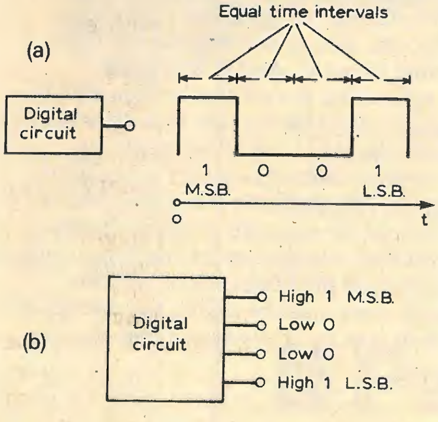

Fig. 1 *Serial and parallel digital data. In the series type shown at (a), the most significant bit (m.s.b.) is transmitted first.*

Digital codes

An understanding of the operation of any converter requires an acquaintance with the techniques which are used to represent digital numbers. In electronic systems, digital numbers are represented by the presence or absence of fixed voltage levels: the numbers used are binary. Each unit of information or 'bit' has one of two possible states; 'off,' false or 0 and 'on' true or 1. The two states are represented by two voltage levels at the inputs or outputs of digital circuits. Groups of levels are called 'words', and may appear simultaneously in parallel on groups of inputs or outputs, or sequentially at a single input or output.

The distinction between series and parallel digital data transmission is shown diagrammatically in Fig. 1. In serial transmission the bit which occurs first in the time sequence is called the most significant bit, m.s.b., the last one being the least significant bit, l.s.b. All bits in the serial word occur on the line for equal periods of time. In parallel data transmission the order of significance of the bits carried by the different lines has to be specified. Serial data transmission has the advantage of economy and simplicity, with only a single line, but it is slow. Parallel transmission is faster, all bits being transmitted and processed simultaneously. In serial transmission, information is transmitted a bit at a time, and the time taken to transmit a word depends upon the number of bits in it.

Natural-binary codes. The number of different words that can be formed from a sequence of bits is clearly dependent upon how many bits there are in the sequence. Thus, four different words can be formed from two bits, eight from three bits, sixteen from four bits, 2^n words from n bits. If a digital word is to represent a number, a code must be used which defines a one-to-one correspondence between each word and a number. It is, of coure, possible to define quite arbitrary codes, but the code which is most commonly used is *natural binary*. In the natural binary code, each bit in a digital word carries a weight or multiplier which is a power of two, the power being determined by the position of the bit in the word. If the digital word 1001 is used to represent a number with the natural binary code, Table 1 shows that the equivalent decimal number is $2^3 + 2^0 = 9$.

Table 1 Bit weights

m.s.b.			l.s.b.
2^3	2^2	2^1	2^0
1	0	0	1

In converter applications, it is convenient to use a fractional code, in which each digital word is used to represent a fraction of full scale, where full scale refers to the maximum value of the analogue quantity. In an *n* bit, natural-binary fractional code, the m.s.b. bit 1, is made to carry a weight of 2^{-1} (½) and the l.s.b. (bit *n*) a weight of 2^{-n}. The decimal fraction corresponding to a particular natural-binary fractional word is found by simply adding up the weights of the non-zero bits: Table 2 shows the sixteen decimal fractions that can be represented by a four-bit binary fraction. Note that in an *n*-bit converter, employing the natural-binary fractional code, a digital word in which all *n* bits are 1 corresponds to $1-2^{-n}$ of full scale; that is, full scale less one.

The relationships which exist between inputs and outputs in ideal converters may be shown graphically. In Fig. 2, the use of the natural binary code is assumed and for simplicity a conversion involving only three bits is considered. In a three-bit d.a.c. the digital input word can take on eight different states, giving rise to eight different analogue output signals from zero to ⅞ full scale. No other levels can exist; the graph in Fig. 2(a) is a bar graph.

The analogue input signal applied to an a.d.c. must be assumed capable of taking on all values up to full scale, but in a three-bit converter only eight different states of the digital output word are possible. The continuum of analogue input values must be partitioned (quantized) into eight discrete ranges, as shown in Fig. 2(b). All values within a particular range give rise to the same digital output word corresponding to the mid-range analogue value. Transitions in the digital output are assumed to take place at analogue input values which are ±½ the least-significant-bit value either side of the midrange value. Because of the necessity for quantization, there is in any analogue-to-digital converter an inherent uncertainty (quantization uncertainty) in the digital output of ±½ l.s.b.

Table 2 Fractional Binary Codes

Decimal fraction	binary fraction	m.s.b. (×½)	bit 2 (×¼)	bit 3 (×⅛)	bit 4 (×1/16)
0	0.0000	0	0	0	0
1/16 = 2^{-4} (l.s.b.)	0.0001	0	0	0	1
2/16 = ⅛	0.0010	0	0	1	0
3/16 = ⅛ + 1/16	0.0011	0	0	1	1
4/16 = ¼	0.0100	0	1	0	0
5/16 = ¼ + 1/16	0.0101	0	1	0	1
6/16 = ¼ + ⅛	0.0110	0	1	1	0
7/16 = ¼ + ⅛ + 1/16	0.0111	0	1	1	1
8/16 = ½ (m.s.b.)	0.1000	1	0	0	0
9/16 = ½ + 1/16	0.1001	1	0	0	1
10/16 = ½ + ⅛	0.1010	1	0	1	0
11/16 = ½ + ⅛ + 1/16	0.1011	1	0	1	1
12/16 = ½ + ¼	0.1100	1	1	0	0
13/16 = ½ + ¼ + 1/16	0.1101	1	1	0	1
14/16 = ½ + ¼ + ⅛	0.1110	1	1	1	0
15/16 = ½ + ¼ + ⅛ + 1/16	0.1111	1	1	1	1

Table 3 Comparison of 4-Bit Binary and Gray Codes

Decimal fraction	Gray code	binary code
0	0 0 0 0	0 0 0 0
1/16	0 0 0 1	0 0 0 1
2/16	0 0 1 1	0 0 1 0
3/16	0 0 1 0	0 0 1 1
4/16	0 1 1 0	0 1 0 0
5/16	0 1 1 1	0 1 0 1
6/16	0 1 0 1	0 1 1 0
7/16	0 1 0 0	0 1 1 1
8/16	1 1 0 0	1 0 0 0
9/16	1 1 0 1	1 0 0 1
10/16	1 1 1 1	1 0 1 0
11/16	1 1 1 0	1 0 1 1
12/16	1 0 1 0	1 1 0 0
13/16	1 0 1 1	1 1 0 1
14/16	1 0 0 1	1 1 1 0
15/16	1 0 0 0	1 1 1 1

The greater the number of bits, the smaller is the weighting of the least significant bit and there is theoretically a corresponding greater resolution and accuracy in the conversion process. There are practical difficulties associated with any conversion which mean that real converters do not accurately attain their theoretical resolution limits. It is convenient to defer a treatment of practical converter errors to later articles which deal with specific conversion techniques.

Bear in mind that natural binary is but one of many possible digital codes, and in some converter applications the use of an alternative code is more convenient. In the natural-binary code, several bits are required to change simultaneously at various stages of the counting sequence. For example, in the four-bit, natural-binary code of Table 2 all four bits must change simultaneously in the transition between the decimal fraction 7/16 and 8/16. In a practical converter using this code, it is clear that if the m.s.b. involved in this transition were to change slightly before the other, less significant, bits then the code would be grossly in error for a brief

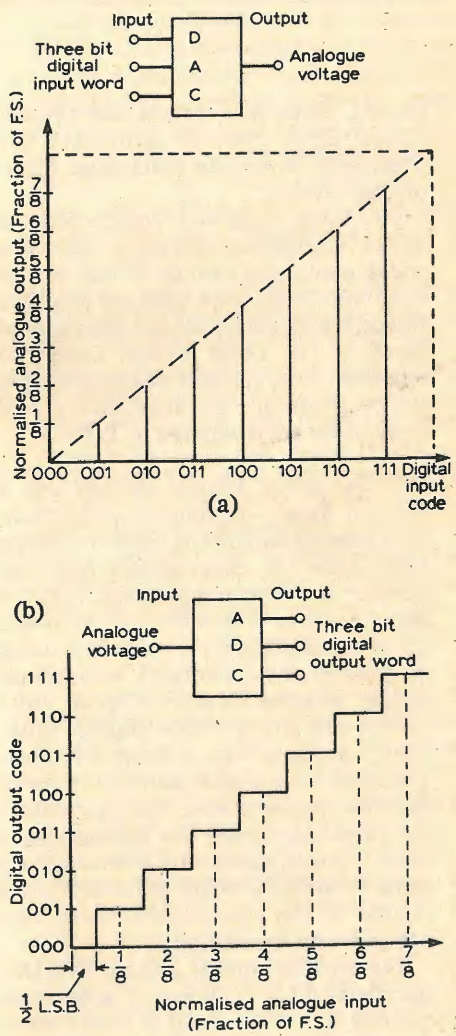

Fig. 2 *Ideal relationships between input and output of converters using, in this case, three bits. In the digital-to-analogue converter at (a) only the analogue outputs corresponding to the vertical bars are possible. Similarly, at (b) the digital output is constrained to the horizontal 'steps'. The difference between the ideal and actual outputs is quantizing error.*

Table 4 The 8.4.2.1. and 2.4.2.1. Decimal Codes

Decimal number	8.4.2.1. b.c.d. (×8) (×4) (×2) (×1)	2.4.2.1. b.c.d. (×2) (×4) (×2) (×1)
0	0 0 0 0	0 0 0 0
1	0 0 0 1	0 0 0 1
2	0 0 1 0	0 0 1 0
3	0 0 1 1	0 0 1 1
4	0 1 0 0	0 1 0 0
5	0 1 0 1	0 1 0 1
6	0 1 1 0	0 1 1 0
7	0 1 1 1	0 1 1 1
8	1 0 0 0	1 1 1 0
9	1 0 0 1	1 1 1 1

Table 5 Examples of 2-Digit BCD Weighting

Decimal fraction	b.c.d. code m.s.q. (× 1/10) ×8×4×2×1	2nd quad (× 1/100) ×8×4×2×1
0.00=0.00+0.00	0 0 0 0	0 0 0 0
0.01=0.00+0.01	0 0 0 0	0 0 0 1
0.02=0.00+0.02	0 0 0 0	0 0 1 0
0.03=0.00+0.03	0 0 0 0	0 0 1 1
.		
.		
0.09=0.00+0.09	0 0 0 0	1 0 0 1
0.10=0.10+0.00	0 0 0 1	0 0 0 0
0.11=0.10+0.01	0 0 0 1	0 0 0 1
.		
.		
0.30=0.30+0.00	0 0 1 1	0 0 0 0
.		
.		
0.90=0.90+0.00	1 0 0 1	0 0 0 0
0.91=0.90+0.01	1 0 0 1	0 0 0 1
.		
.		
0.98=0.90+0.08	1 0 0 1	1 0 0 0
0.99=0.90+0.09	1 0 0 1	1 0 0 1

period. Some converters use the so-called Gray code to eliminate the possibility of grossly inaccurate intermediate codes.

The Gray code is a binary code in which transitions between adjacent codes involve the change of only one bit at a time. Bit position does *not* signify a weighting in Gray code but each digital word in the code is still taken to represent a unique part of the analogue range. Four-bit, natural-binary and Gray codes are compared in Table 3.

Decimal codes. Digital circuits use a form of binary arithmetic – they can only process data if it is coded in binary form. However, most people are only familiar with decimal arithmetic, and a digital code in which decimal numbers are encoded in binary form is often used in systems or instruments with which people interact directly. Digital voltmeters use a.d.cs which employ a decimal code to provide a decimal display. The user of a digital calculator feeds decimal numbers into the calculator, the calculator codes the numbers into binary form, performs calculations using binary arithmetic and decodes the results of the calculations back into decimal form for display.

The decimal number system uses the ten digits 0,1,2 ... 9, and if a decimal number is to be encoded in binary form each digit must be represented by the unique state of a digital word. The smallest number of bits which can be used to form ten different digital words is four. A four-bit word has sixteen possible states, any ten of which can in principle be used to represent the ten digits of the decimal system. The number of possible codes is:

$16 \times 15 \times 14 \times 13 \times 12 \times 11 \times 10 \times 9 \times 8 \times 7 = 16!/6! = 2.9 \times 10^{10}$

or about thirty thousand million possibilities! Do not worry; you do not need to remember this many, since there are only a limited number of decimal codes in use. Indeed, the question may well be asked "why not standardize on one decimal code?" The reasons associated with the development of a variety of codes are to do with the relative ease and efficiency with which available digital devices can perform manipulations on data coded in different ways.

Examples of two decimal codes which are used in converters are given in Table 4. The 8.4.2.1 code is most frequently used in a-to-d converters, and is commonly referred to simply as *binary-coded decimal* (b.c.d.), because the weights of the bits are the same as in the natural-binary number system. Note that the six upper states of the four-bit quad are not used and are simply discarded. In the 2.4.2.1 code, which is used in some converters, the bit in the m.s.b. position has a weight of 2 instead of the usual 8. The code has the advantages of having all 1s for full scale less one and d-to-a converters using the code require a smaller range of resistance values.

A-to-d converters which are designed to give a decimal readout require a binary quad for each output digit. Table 5 shows b.c.d. coding of some of the decimal fractions in the range 0-0.99. Note that in an a-to-d converter which provides two decimal digits at its output, the magnitude of the analogue input corresponding to the l.s.b. of information presented at the output is 0.01 of full scale. The magnitude of the l.s.b. in an eight-bit binary coded converter is $1/(16 \times 16) = 0.0039$. In a sense, b.c.d. is wasteful since it only uses 10 of the possible sixteen states of a quad – a b.c.d. quad provides only $^{10}/_{16}$ the resolution of a natural-binary quad.

Bipolar codes. The converter codes discussed so far have related the normalized magnitudes of an analogue variable (fraction of full scale) to digital words; no regard has been taken of the polarity of the analogue signal. A variety of codes have been devised for use in conversions involving analogue signals of both polarities. In these bipolar codes a digital word is made to carry information about both the magnitude and polarity of the analogue signal.

Example of binary codes which are often used in bipolar conversions are shown in Table 6. At first sight, you may think that the seeming jumble of 0s and 1s is far too complicated to decipher. However, the principles which underly their formulation are not all that complicated.

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Acoustic breakthrough in record players

Measuring their susceptibility to sound feedback from loudspeakers

by James Moir and William R. Stevens James Moir & Associates

In domestic audio equipment the phenomenon of acoustic interference with record reproducers from associated loudspeakers is well known, but very little effort has been made to measure the effect. This article describes a test procedure for quantifying the sensitivity of record players to acoustic breakthrough and presents the results as a range of measurements made under various operating conditions (dust cover up or down, different record support mats etc.). Next month the author suggests a simple test for acoustic breakthrough that can be done in the home without laboratory equipment.

IT HAS long been appreciated that a pickup/tone arm/turntable combination could be acoustically excited by the signal from a loudspeaker and under suitable conditions induce self-oscillation in a record reproducer system. Indeed this was one of the reasons for the demise of the radiogram. The use of a single enclosure to house all the components brought the turntable into close proximity to the loudspeaker and it became difficult to avoid self-oscillation due to acoustic and mechanical feedback. However as far as the writer is aware there were no efforts to quantify the sensitivity of turntables to acoustic pick-up until the publication of a *Hi Fi Choice* survey of turntables and cartridges in 1977.

Our laboratory recently became involved in some assessment tests on several record players and these necessitated an investigation of the relative susceptibility of the various designs to acoustic feedback. This in turn required an investigation of the test technique used to assess the susceptibility and to confirm that the results obtained were not influenced by conditions external to the equipment being assessed. The tests provided much information of sufficient interest to be worth wider discussion.

The assessment technique used for the *Hi Fi Choice* survey was not described in detail, but in outline it took the obvious form of exposing the turntable assembly to the pink noise acoustic output of a loudspeaker and plotting the amplifier output voltage as a function of the excitation frequency with the pickup stylus resting on a stationary record. It was shown that turntable designs vary widely in their sensitivity to acoustic pick-up and that some of the less satisfactory designs were as much as 20dB more sensitive to pick-up than the models where the designer had obviously given some considerable thought to the problem of isolating the pickup and turntable from the loudspeaker. A typical noise induced voltage/frequency response curve taken from the publication is reproduced in Fig. 1 as an indication of the results obtained.

The mechanism by which the noise-induced voltage becomes a problem is easy to follow. Any relative movement of pickup stylus and the record surface due to vibration will generate a noise voltage at the vibration frequency, and this after passing through the amplifier, will be radiated by the loudspeaker either as noise or vibration. Some fraction of this will reach the pickup stylus. If the acoustically excited voltage from the pickup, increased by the amplifier system gain and reduced by the signal attenuation between the loudspeaker and the pickup stylus, exceeds the initiating voltage, the system will burst into self-oscillation. This is the feedback amplifier stability equation in simple words. An amplifier having a gain of g with the feedback ratio of k will be on the verge of instability when gk in the simple gain equation:

$$\text{gain with feedback} = \frac{g}{1-gk}$$

exceeds unity

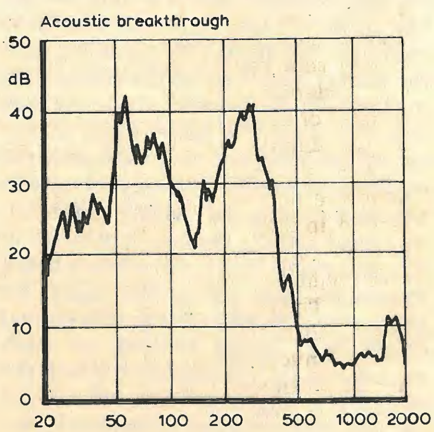


Fig. 1. *Acoustic breakthrough as illustrated in the Hi Fi Choice survey of turntables and cartridges in 1977. Turntable assembly was exposed to acoustic pink noise from a loudspeaker.*

The denominator is then zero and the gain rises to infinity.

The section of the signal loop providing the gain extends from the pickup through the amplifier and up to the current in the speaker voice coil. From that point onwards the signal is reduced by the inefficiency of the conversion from current variations in the voice coil to air pressure changes in the room and by the attenuation of the air path between loudspeaker and turntable. Mechanical vibration from the loudspeaker is attentuated along the parallel path for vibration through the speaker fixings into the speaker enclosure and from this through the supporting table and into the record player and hence up to the stylus tip.

When designing an amplifier with negative feedback the complex forms of both the gain and attenuation paths have to be considered in determining the stability margin, but where, as in the present example, the feedback path includes the room acoustics, the phase of the signal in the feedback path from loudspeaker to stylus tip cannot be controlled or predicted and oscillation is likely to ensue at any frequency at which the product of gain and attenuation approaches unity.

However, it is probable that the subjectively acceptable limit to the effect on sound quality of this feedback will be reached long before sustained oscillation actually occurs. The approach to continuous oscillation is marked by the appearance of a peak in the frequency response of the system and this colours the sound in exactly the way that the presence of any form of resonant circuit adds its own characteristic colour to a signal. This is nicely illustrated by the curves of Fig 2. The lower curve is the frequency response of an ordinary amplifier and it is seen to be flat within about ±1dB from 20Hz to 20,000Hz. The addition of sufficient positive feedback to bring it within about 5dB of sustained oscillation is seen to produce a peak of about 30dB in the frequency response at the frequency at which the amplifier would burst into oscillation if the feedback was further increased.

A system having such a small margin of stability that it is nearing continuous oscillation will have an overload performance that varies continuously with change in the programme spectrum. Each time there is a burst of programme

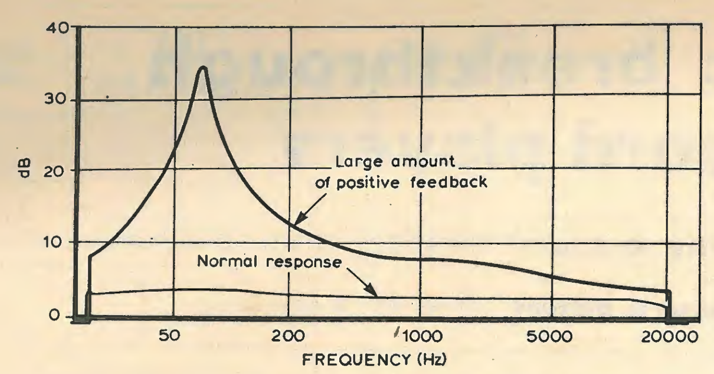


Fig. 2. *Frequency response of an amplifier with heavy positive feedback (upper curve) and without it (lower curve).*

energy in the vicinity of the peak in the frequency response, the amplifier may overload even though the signal amplitudes in other frequency regions are very far from overloading the amplifier. When the burst of programme energy around the peak frequency subsides the performance will revert to that of a system having a flat frequency response. The effects are broadly similar to those obtained when using an amplifier with a bass boost of 30dB. There is a subtle difference in that the bass boost obtained through feedback between the turntable and loudspeaker has a built-in time delay before it is operative. Thus a sound in the programme at the frequency of the peak will be followed by an echo delayed in time by an amount proportional to the spacing between loudspeaker and record player and to the amount by which the reproducer system fails to reach continuous oscillation. This time delay was clearly audible in the listening tests.

The 'noise' voltage that is induced into the pickup by the sound field of the loudspeaker, or by the transmission of vibration from the speaker to the pickup, is a function of the relative movement of stylus tip and record surface. It was initially thought reasonable to assume that the amplitude of movement of the record surface would greatly exceed that of the stylus tip, for the area of the record surface greatly exceeds the area of the tone arm and pickup assembly. To a first approximation the mechanical force exerted on any surface by the acoustic wave is directly proportional to the area of that surface. This neglects such factors as the shape of the surface and the variation in the phase of the incident acoustic wave over the turntable surface, but these are not really relevant in practice.

Acoustic excitation of the turntable and record occurs as a direct result of the mechanical forces exerted on the pickup and turntable enclosure by the sound wave from the loudspeaker, but there may be indirect effects due to acoustically excited vibration of the surface on which the record player stands. These surfaces, such as a table or set of shelves, will be excited into vibration by the incident acoustic wave or by direct mechanical transmission of vibration from the loudspeaker, and the resultant vibration of the table will be transmitted into the record player through the feet on which the unit stands. As the surface area of the shelf or table may greatly exceed the area of the record player the resultant vibration of the table surface transmitted into the player may exceed the amplitude of the vibration directly induced into the turntable by the same acoustic wave.

It is illuminating to consider the multiplicity of resonant elements involved in the simplest situation where the turntable motor and arm are assembled on a single motor board resiliently isolated by springs or rubber from the body of the player unit, which in turn is resiliently isolated from the table or shelf on which the units stand. It is assumed that the system is energised by a pink noise signal from the loudspeaker.

The surface of the turntable and motor mounting board and the unit enclosure will be subject to a driving force due to the impact of the acoustic wave on the turntable surface and on the box in which the turntable system is mounted. We started by assuming that the energy spectrum of the sound field incident on the record player is that characterising pink noise, equal energy per octave band, but the spectrum of the resulting vibration at the stylus tip will almost certainly be widely different. Any mechanically reasonant element in the path along which vibration is being transmitted will colour the signal by tending to concentrate the vibrational energy into bands centred on each resonant mode. The degree to which the energy is concentrated is a function of the Q of each resonant mode, but it also depends upon the length of time that the excitation persists. Resonant elements with high values of Q will require relatively long times to achieve their final amplitude and equally long times for the amplitude to decay to its normal level when the excitation is removed. Each resonant element in the path between the voice coil current and the stylus tip will add its own characteristic colouration to the signal.

The turntable itself will exhibit the resonances inherent in a circular disc, each resonant peak having a Q determined by the construction adopted for the turntable. A single simple circular metal plate will have many resonances of very high Q but a turntable consisting of two separate pieces of metal clamped together will have higher internal frictional losses and a lower value for Q. The addition of a mat to the table may also damp the resonances in the disk, any advantage so gained being a function of the quality and thickness of the mat and the degree of its adhesion to the table surface. The amplitude and frequency of maximum vibration of the turntable surface is a function of the distance of the pickup from the centre pin, but in addition to the resonant modes characteristic of a metal disc there will be others due to the turntable being supported only at its centre and thus free to rock about the centre pin.

The board carrying the motor and turntable will have the series of resonances characteristic of a rectangular plate, modified by the attachment of the motor to the board at several points. At all frequencies except that of the lowest mode of resonance, the point on the motor board at which the tone arm is fixed will move in and out of phase with the centre of the spindle. Thus at any given instant the tone arm base may be moving upwards while the turntable spindle and record surface are moving downwards or sideways.

The tone arm and cartridge assembly provides another group of resonances. The long section of the arm will exhibit both longitudinal resonance and torsional resonance with the rear section of the arm having similar modes of resonance but at other frequencies. There are other modes due to the resonant combination of the vertical compliance of the pickup and arm assembly and the effective mass of the arm. In consequence the movement of the stylus tip is unlikely to mirror the movement of the tone arm base, or that of the motor board to which the tone arm is fixed. The presence of the tone arm and mounting pillar between the motor board and stylus radically alters the frequency spectrum of the vibration at the stylus.

The resilient feet used to isolate the turntable from the table or shelf on which it stands will introduce a prominent peak into the vibration transmission path at some low frequency determined by the compliance of the resilient feet and the mass of the whole turntable unit. As will be shown by the tests to be described, acoustically induced mechanical vibration in the

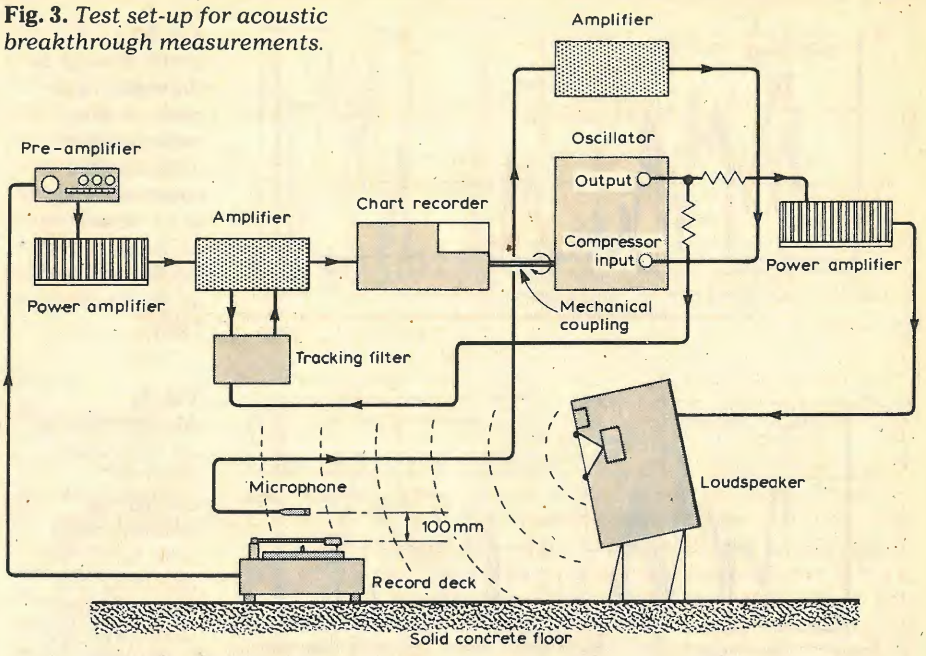


Fig. 3. *Test set-up for acoustic breakthrough measurements.*

table or shelf on which the player stands is often the major cause of serious colouration of the signal from the turntable unit. Finally there is the colouration introduced by the presence of the many acoustic air resonances that are characteristic of every room. In addition to the direct colouration of every sound in the room these acoustic resonances determine to a large extent the attenuation of the path between loudspeaker and record player and the frequency at which the maximum excitation of the record player occurs.

In addition to the basic modes of resonance outlined in the previous paragraphs there are interactions between many of the modes of movement and these interactions result in very complicated patterns of vibration and modulation of the basic modes. In total there may be several tens of resonances in the acoustical and mechanical path between the loudspeaker and the stylus tip.

This all sounds very alarming and the question that springs to mind is: "Just how serious are the effects of all these parasitic vibrations on the sound output from the pickup?"

The experimental procedure adopted to provide objective data on the extent of the trouble was nominally straightforward. In the initial tests the turntable being investigated stood on a laboratory table, having a top 40 inches by 28 inches and incomparably stiffer and more rigid than any shelf system likely to be used in domestic conditions to support a record player unit. A wide range loudspeaker, an Eagle Type 7600 having a particularly flat frequency response, was used to provide acoustic excitation. This was driven by a Quad 405 amplifier from a B & K Type 1014 sine wave signal generator, but as it is necessary to ensure as far as possible that the acoustic signal has constant amplitude at the surface of the turntable, a feedback loop was installed to control the signal generator output, the control circuit microphone being supported at a point about 100mm above the turntable centre pin. This control loop takes out all the peaks and dips due to variations in the loudspeaker output and due to the standing waves that exist in any enclosed space.

The pickup output was amplified and given RIAA correction in a Quad preamplifier and then used to drive a B & K high speed chart recorder mechanically coupled to the 1014 signal generator that provided the drive signal for the loudspeaker. This combination of instruments provided printed charts of the acoustically induced voltages as a function of the exciting frequency. A block diagram of the test equipment is shown in Fig 3.

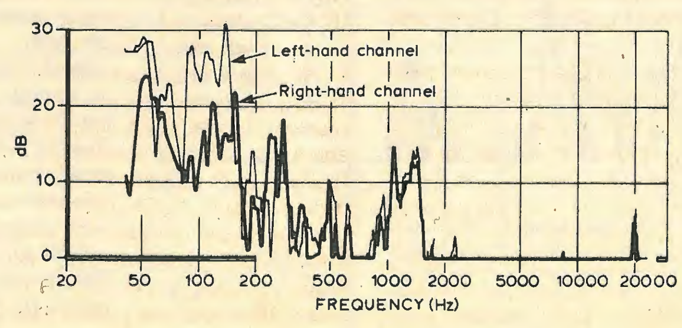
A typical acoustically induced response curve provided by this equipment is illustrated by Fig 4. The top of the chart (not shown) corresponds to 50dB on the vertical scale, and this corresponds to the signal output from a 5cm/second recording of a 1kHz tone. The curves are those obtained when the sound pressure level was held by the control system at a level of 90dB at a point 100mm above the centre pin. However, it should be remembered that the ratio of signal-to-acoustically-induced-noise is independent of the level of the signal on the record that induces the "noise" voltage. A separate check showed that there were no significant amplitude dependent effects, the acoustically induced noise voltage from the pickup decreasing by 10dB each time the loudspeaker drive voltage was reduced by 10dB.

It will be seen from Fig. 4 that there are many prominent peaks in the induced noise voltage at frequencies up to about 300Hz with another group of resonances between 1000Hz and 1500Hz, the peak in the region of 50Hz being some 23dB below the level of the 1kHz reference signal. This chart, Fig 4, also illustrates another feature; in almost all the units tested the noise induced signal in the left hand channel was found to be greater than the signal induced into the right hand channel. Comparison of Fig 4 with Fig. 1 demonstrates the advantage of using sinusoidal tones rather than pink noise as acoustic excitation.

Figures 5 to 7 illustrate an interesting series of results taken while the test set-up was being verified. In Fig 5 the upper curve was obtained with the dust cover lid to the player in the 'up' position while the lower curve resulted when the lid was closed. It will be seen that closing the lid had little effect upon the breakthrough voltage at the lower frequencies, but effected a very significant reduction in the frequency band between 1 and 1.5kHz. This cover was one of the now almost universal Perspex type moulded lids and it is clearly too light in weight to exclude the low frequency components in the acoustic noise.

Fig. 6 compares the breakthrough with the turntable stationary and with it revolving normally, and it will be seen that there is no significant difference. An Audio Technica AT 12XE pickup

Fig. 4. *Example of acoustic breakthrough measurement on a record player made with the Fig. 3 set-up. The top of the chart (not shown) is at 50dB on the vertical scale, and this corresponds to a reference level of the signal output from a 5cm/s recording of a 1kHz tone. Note the difference in breakthrough between the left-hand and right-hand channels. The pickup is in the centre of the record.*



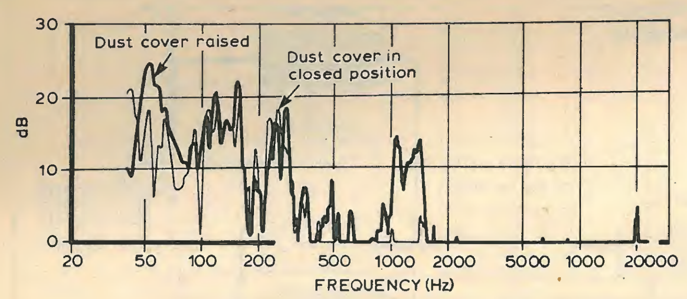


Fig. 5. *Breakthrough in the right-hand channel of a record player with the dust cover raised and in its closed position (50dB=ref. level of 5cm/s at 1kHz).*

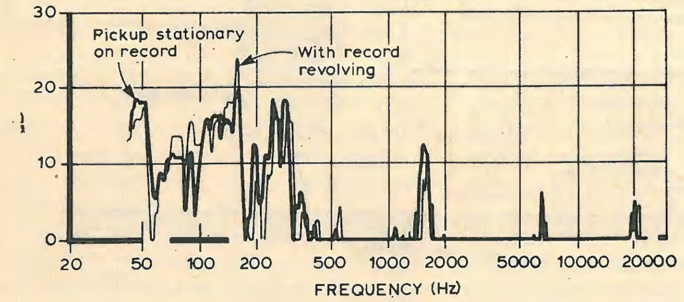


Fig. 6. *Measurements on right-hand channel comparing breakthrough with turntable revolving and breakthrough with turntable stationary (50dB=ref. level 5cm/s at 1kHz).*

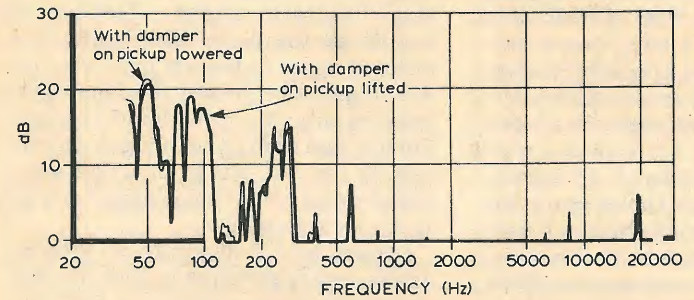


Fig. 7. *Breakthrough in right-hand channel with pickup damper lifted and damper lowered (50dB=ref. level 5cm/s at 1kHz).*

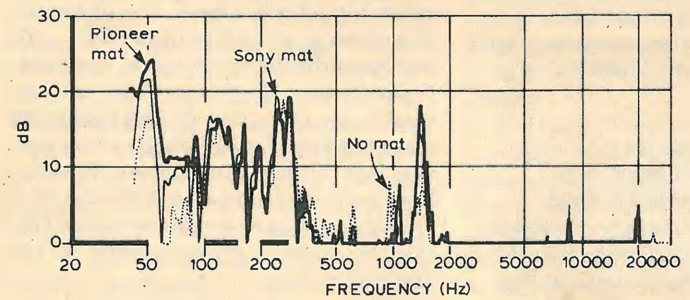


Fig. 8. *Effects of record support mats on breakthrough in right-hand channel (50dB=ref. level 5cm/s at 1kHz).*

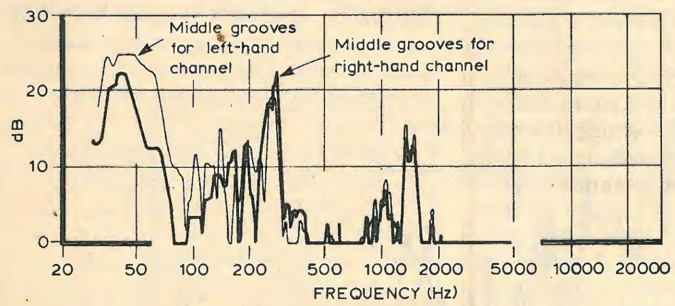


Fig. 9. *Breakthrough when turntable and loudspeaker are both mounted directly on a solid concrete floor. Results for right- and left-hand channel outputs with pickup on middle grooves (50dB=ref. level 5cm/s at 1kHz).*

was used for these preliminary tests, but to check the effect on the acoustic breakthrough of using a damper near the stylus tip a Shure V15 Mk4 pickup was substituted and charts taken with the brush in contact with the record surface and out of contact. It will be seen from Fig. 7 that the brush makes no significant difference to the acoustically induced voltage but Shure claim no advantage in this respect, the brush being added to reduce electrostatically induced charges and to reduce the amplitude of the low frequency arm resonance. It achieves both of these results.

In recent months there have been many claims to the advantages in terms of sound quality of using various types of special record mat, so as a matter of interest we tested about six different types of record support pad or mat that we happened to have available. These mats had many different rib patterns and included mats cut from pieces of soft foam and soft felt, but the differences were only of the order of those obtained by repeating the test on any one type of mat. It is reasonable to suggest that if the design, construction or material of a turntable mat does indeed produce significant differences in sound quality then it is unlikely to be due to their effect in reducing the amount of turntable vibration transmitted to the record surface. Fig 8 illustrates the differences between three of the types of mat we tested.

The first major reduction in the level of the acoustically induced noise appeared when the turntable under test and the exciting loudspeaker were mounted on separate supports, or were both mounted directly on a heavy concrete floor. Figs 4 and 9 illustrate the advantage. Not only did this reduce all the peaks by about 10dB but it substantially eliminated most of the minor peaks above 300Hz. If Fig. 9 is compared with Fig. 4 it will be seen that the improvement is radical, so much so that any method of assessing the amount of acoustic breakthrough must specify that the turntable and exciting loudspeaker are to be mounted on a solid concrete block, or on a solid concrete floor during the test. Standing the units on a timber floor greatly reduces the value of the data and may invalidate the conditions.

It is impossible to reproduce all the data obtained on the many turntables that were tested, but some general conclusions are interesting. In an early paragraph of this contribution it was pointed out that the induced noise voltage generated by the pickup was a function of the stylus velocity and that it should be the same whether the stylus vibrated against a stationary record or the record surface vibrated the stylus in a stationary pickup head. In all the turntables tested the pickup voltage appeared to result from vibration of the pickup against a relatively stationary record surface, vibration from the motor board being transmitted up the tone arm fixings and along the tone arm to the pickup. This is contrary to our first thoughts on the subject. It was earlier noted that wide changes in the softness of the turntable mat had relatively little effect on the noise induced voltage and this is one result to be expected if the pickup is moving with respect to the record surface.

As the evidence suggested that vibration of the tone arm was mainly responsible for the peaks in the acoustically excited frequency response, an attempt was made to separate the peakiness introduced by acoustic excitation of the record player enclosure from the peaks due to resonance in the tone arm. The arm was removed from the record player and mounted on a Goodmans vibration table driven by a separate amplifier and control loop system set to maintain constant the velocity amplitude at the base of the tone arm. The exciting frequency was then swept through the audio range and the RIAA corrected pickup output plotted by the B & K high speed chart recorder. This produced the chart of Fig. 10. It will be seen that this particular arm system introduced two major peaks in the response at frequencies around 60Hz and 250Hz plus a good deal of hash at all frequencies below about 100Hz.

It is interesting to compare this curve with that shown in Fig. 11, the acoustically excited response of the same tone arm system when mounted in the record player. The same two prominent peaks are present at 60Hz and 250Hz but with considerable extra noise produced by the acoustic excitation of the record player housing, particularly at frequencies above about 400Hz where there is little sign of trouble from the pickup arm alone.

Some of the undesirable effects on the sound quality of these acoustically excited peaks have been discussed earlier in the contribution but there are other effects that are equally undesirable. Prominent resonances in the tone arm when acoustically excited by the sounds from the loudspeaker are likely to result in modulation of the signal being reproduced from the record, for the contact of the stylus with the groove is being continually modified by resonant vibration of the arm. Thus any recorded signal is likely to be amplitude modulated at the frequency of these arm resonances. This suggestion was checked experimentally, the results being illustrated by Figs. 12 & 13. The first chart shows a spectrum analyser picture (narrow band analysis from 2kHz to 4kHz) of a 3kHz recording replayed without any signal being applied to the loudspeaker. Thus there can be no acoustically excited distortion and it will be seen that the general random noise is some 50dB below the peak signal. Fig. 13 is a repeat of the same recording when a 250Hz 95dB tone is reproduced by the loudspeaker. It will be seen that two sidebands have appeared having an amplitude about 25dB below the peak signal amplitude due to modulation of the recorded signal by the acoustically excited resonance in the tone arm.

To be continued

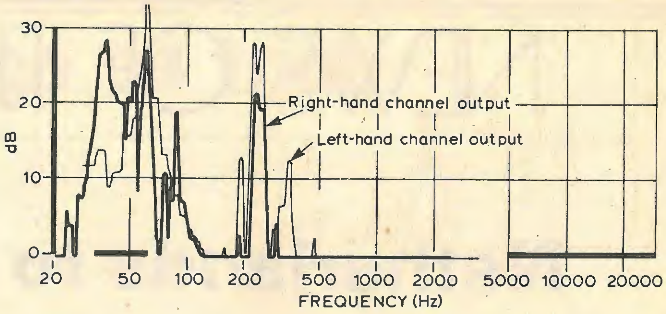


Fig. 10. *Vibration test on tone arm alone. Right- and left-hand channel outputs with pickup on solid object and constant velocity maintained at base of arm.*

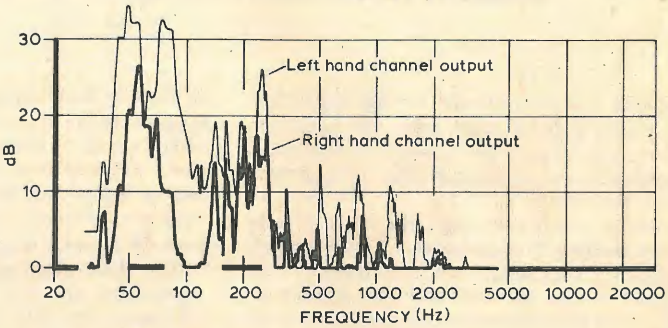


Fig. 11. *Breakthrough with same tone arm system as in Fig. 10 mounted in record player. Right- and left-hand channel outputs with pickup on middle grooves (50dB = ref. level 5cm/s at 1kHz).*

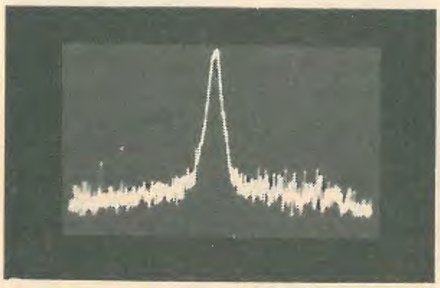


Fig. 12. *Spectrum analyser picture of 3kHz recording replayed without any signal being applied to test loudspeaker (30Hz bandwidth analysis 2kHz-4kHz).*

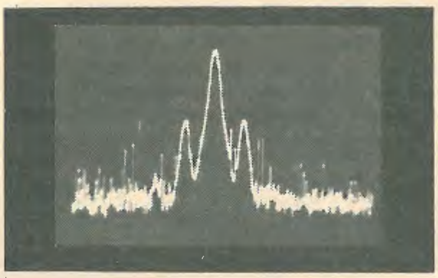


Fig. 13. *Same spectrum analyser test as in Fig 12 but with a 250Hz, 95dB tone coming from the test loudspeaker.*

References

Turntables & Cartridges, *Hi Fi Choice*, 1977.
Audible Effects of Mechanical Resonance in Turntables, Poal Ladegard of B & K, A.E.S. Convention Paper, 1977.

Literature Received

V.h.f., u.h.f. and microwave (4GHz) **ceramic chip capacitors** made by Vitramon and specified in a leaflet, obtainable from Vitramon Ltd, Wycombe Lane, Wooburn Green, High Wycombe, Bucks HP10 0HH. WW 401

Data sheets on T and B Ansley **flat cables** and connectors, and associated components are distributed by Sasco, P.O. Box 2000, Crawley, Sussex RH10 2RU. WW 402

Switched-mode **power supplies** and regulators made by Lambda are described in two leaflets, LSS and LJ/LG, available from Lambda Electronics Co., Abbey Barn Road, High Wycombe, Bucks. WW 403

A leaflet on the Microdata M200 series of **data logging** equipment, designed for portable use, is available from Microdata Ltd, Monitor House, Station Road, Radlett, Herts WD7 8JX. WW 405

For use in laboratories, industry or field to find faults on any IEEE 488 system, the Model 4810 488 **Bus Fault Analyser** is made by ICS, who produce a leaflet, distributed by Amplicon Electronics Ltd, Lion Mews, Hove, BN3 5RA. WW 406

The 1979 catalogue from Measurement Technology is available, containing information on **safety barriers** and intrinsically-safe power supplies, temperature transmitters and trip amplifiers, interface units and application papers. Sales Dept., Measurement Technology Ltd, Power Court, Luton, Beds LU1 3JJ. WW 407

The Computer Bookshop have sent us a list of sixty-nine books on **computing** and fourteen books on computers in education. Transparency masters for teaching are included. Available from Temple House, 43-48 New Street, Birmingham B32 4LH. WW 408

NEWS OF THE MONTH

Netherlands to introduce c.b. —

could it have something to do with a British/Dutch development?

Despite the Netherlands' strong opposition to citizens' band radio over the past few years, the country has now announced new legislation for the introduction of a service early next year.

About three years ago the Netherlands very nearly got c.b. by default. There were so many c.b. sets being used there illegally as a result of the service over the border in Germany and elsewhere, that the Dutch were almost forced to legalize it. Incidentally, this actually happened in Australia. Instead the Dutch brought in heavy legislation saying that one could be prosecuted even for the possession of c.b. equipment. (In the UK one can only be prosecuted for illegal use or importing of c.b. equipment, not for possession.) So why the sudden change of legislation?

Speculating, *Wireless World* suggests that it has something to do with the British/Dutch development of frequency synthesizer and universal divider chips (see p. 48, December 78 issue). Before any decision was made regarding the introduction of c.b., the Secretary of State for the Ministry of Traffic and Waterways, the department responsible for radio communications, ordered a study to be carried out by the Dutch PTT. This study concluded that a 22-channel (the CEPT standard), 27MHz band system should be used. With the two chips, developed by Philips and Mullard, it would be possible to produce a fully-synthesized c.b. set which could not only secure a home market for the Dutch, but could also be the only type-approved equipment acceptable in the legislation. This would stop previously imported, illegal equipment, being used in the new service. It may be significant that the new legislation was announced just two months after the two chips were developed, according to one of our sources. The change of law was announced on Dutch radio on Monday, January 22, according to our contact in the Hague. Strangely enough, the Belgians, who already have a 27MHz business service, started re-examining *their* legislation in December.

The Dutch legislation, which has been given the name MARC (licensing general radio communication) – it is worth noting that most countries avoid using the phrase 'citizens' band radio' and choose other names, such as "general radio" – will permit licences to be granted to individuals of 16 years of age or older who have passed an examination similar to the Radio Amateurs' Examination, required of radio amateurs in the UK. One would assume that this examination will be similar to the first part of the RAE, which deals with licensing conditions and interference, and not the technical section. MARC will carry similar restrictions to those in the amateur radio licences, regarding unlawful or obscene communications, broadcasting of music, and advertising, and there will also be a licence fee. The Dutch service will permit the use of f.m. only and a maximum effective radiated power of 0.5W (the CEPT recommended f.m. in October 1975). Naturally, unlike amateur radio equipment, the c.b. sets will have to be type-approved, with a certificate of registration for the user, and experimenting is limited to the system and location of the antenna.

A brief summary of some of the other c.b. services in the world is given below:

Switzerland: 27MHz, 12 channels, 0.1W e.r.p., handheld radio telephone only — no external power, f.m., a.m., or s.s.b., called general radio, not c.b. Forbid international traffic.

Belgium: Understood to be 27MHz, 0.1W, business radio not c.b.

Denmark: type approved 27MHz for everyone, 22 ch. + maritime channel, small factory-made stations, a.m. or f.m., no s.s.b. 12 years and over or 12 to 15 under supervision.

West Germany: 27MHz, 12 ch., a.m., f.m., no s.s.b., 0.5W output.

Austria: 27MHz, 12 ch., understood to be a.m., f.m. only.

France: 22 ch., + additional from 26.96 to 27.28MHz, no licence — max 5mW output, with licence — 5 to 100mW, exclusively portable.

Italy: 27MHz, 22ch., a.m. or f.m., antenna must be attached to equipment, 1W e.r.p., handheld.

New Zealand: 26MHz, 14ch., 11 for general use, 3 for government departments, public bodies and approved operators, a.m. only.

USA: 27MHz, 40 ch., d.s.b. (suppressed carrier) 4W out, 5W in, s.s.b., 12W p.e.p., also u.h.f. service, 2 blocks of 8 ch., 5MHz duplex repeaters permitted. 50W base stations restricted to one block of 8, mobiles may operate on both blocks.

Norway: 27MHz, 24 ch. + 2 ch., type approved 5W a.m., 4 services, all use calling channel plus others, 10 ch. to private radio — c.b., 8 ch. to sports, scouts, clubs etc, 9 ch. to industry, 9 ch. to public services such as Red Cross, mountain rescue etc.

Sweden: 27MHz, 22 ch. a.m. only, depends on use which of two 11 ch. are allocated, 1-11 max 0.5W, 12-22 max 5W.

Canada: Similar to USA, 40 ch. a.m. s.s.b., 27MHz.

Austria: 27MHz, 12 ch. 0.5W e.r.p. max.

Australia: 27MHz, 18 ch. not equivalent to CEPT standard, s.s.b. only, 12W p.e.p., also 40 ch. of u.h.f., f.m., 5W at 447MHz.

Yugoslavia: permit 27MHz work for individuals.

Poland: permit 27MHz club band — where need is shown.

Israel: community 27MHz for kibbutzim.

S. Africa: 3 bands, 19 ch. of CEPT band, a.m. only, 100mW, 22 ch. 27MHz a.m., 5W or s.s.b., 20W p.e.p., 29MHz a.m. 5W and s.s.b. 20W p.e.p., mostly mobile operation.

Monaco: similar to France.

Finland: 27MHz, 22 ch. + marine ch., a.m. only, 5W.

Ireland: it is suspected that they turn a blind eye to c.b. operation.

Spain, Portugal, Greece: c.b. service legally operates.

Brazil: has legal c.b. service — public general radio.

Cyprus: permit service.

Radio interference document published

A document on radio interference, aimed particularly at importers and exporters of equipment which is likely to cause interference, has been published by the British Standards Institution. The document, PD6485 "Limits of radio interference and leakage currents according to CISPR and national regulations", is not a British Standard – the prefix PD refers to 'published document'. Its contents, according to BSI, are identical with CISPR (International Special Committee on Radio Interference) publication 9.

The information contained in the document is in two parts. The first section gives the limits of radio interference as they apply in different countries, and whether these have legal or voluntary status. This includes ten tables, each covering a different source of interference such as ignition, rf equipment, regulating controls and switch-start fluorescent fittings. The second section gives details, also in tabular form, of national requirements for leakage currents, and the limiting values of capacitance and energy for radio interference suppression capacitors.

Carfax to go on trial

Carfax, the BBC's traffic information system, is to go on trial in London later this year. Five transmitters will transmit experimental broadcasts over a 40-mile radius, and the whole thing will be financed by the Department of Transport, according to an announcement by Secretary of State, William Rodgers. It is estimated that the trial will cost £285,000.

Until now, according to a BBC spokesman, the research work on Carfax has been done "on a shoestring". The transmitters used in the trials so far have been 1930s equipment (salvaged from a BBC storeroom) with a few add-on units. The aerial systems have been built from towers or existing antenna systems already possessed by the BBC.

Three of the transmitting stations at Brookmans Park, Lots Road, Chelsea, and Kingswood Warren, are already operational. The other two transmitters, one at Hoo, near Rochester, Kent, and one at the headquarters of the Transport Road Research Laboratory (TRRL) at Crowthorne, Berkshire, will be new and may well be operational by the time this issue is published.

The trial is expected to last about two years and at the end of this a decision will be made about the value of Carfax. To set the system up nationwide the BBC would need between 50 and 80 transmitters and it would cost about £4 million. The major part of the work involves an examination of the technical and broadcasting aspects of the Carfax scheme. The Corporation expects to receive about £200,000 for this. Although these sums may seem high, it has been suggested by a BBC spokesman that one should compare them with the cost of a single roundabout and look at the benefits to be had from the two cases. A TRRL working party has estimated that the Carfax scheme could save Britain between £5 million and £10 million a year. These savings are difficult to prove, but they are based on tangible and intangible benefits which apparently the TRRL are experts on. Tangible benefits come from reducing the number of cars in jams, petrol used, road accident and hospitalization resulting from accidents. An example of an intangible benefit is the peace of mind which a driver has when he knows that he can obtain the required information for his journey.

Between 100 and 500 test receivers will be used during the trial, but these will not be available to the general public; their allocation will be decided by the Department of Transport and the BBC. If the engineering trial proves successful traffic information will be supplied by police forces in the Home Counties, probably with the help of the AA and RAC, and this could be collated by the BBC Motoring Unit. An initial £85,000 will be spent on investigating ways of improving the method of information collection.

A top-loaded, base-fed mast radiator some 45m high used in a typical Carfax antenna system. The transmitter is adjusted to give an 'effective monopole radiated power' not exceeding 50W. This particular antenna system is a temporary installation at Kingswood Warren near Reigate. The dish antenna in the foreground is not part of the Carfax system.

Ve aff vays

In Europe motorists using the German traffic-information system, ARI, have to watch the roadsigns to find the receiver channel for the area they are travelling through. One wonders if this sign, seen near Oxford, is a preview of what motorists will see if Carfax is adopted. If the BBC's idea of shaping the coverage area of each transmitter to suit a geographical area (see p28, Jan. 1978 issue) works in practice, and no overlap is allowed, a motorist in area A who is about to move into area B could well miss B transmitter's vital announcement just before entering the B zone. For the system to work correctly in this case it may be necessary for drivers to take a route decided by Carfax, not themselves — hence the sign. The driver could, of course, take the "other route", and use ARI.

"Engineers' registration needs teeth" — Redmond

Once again the IEE has emphasized its view that the engineering profession in the UK should be made more exclusive, on a par with those of the doctors and the lawyers. It believes the standards of qualification should be raised — above those at present set nationally by the CEI — and that engineers should be registered by a statutory authority with powers of exclusion, in the manner of some other professions. Speaking at the IEE's annual dinner the president of the Institution, Sir James Redmond (former BBC director of engineering) said: "After 16 years' experience in the CEI we have come sadly but firmly to the conclusion that the present system of setting national standards of qualification does not work, and never will work satisfactorily. The CEI structure is such that its decisions will always lag behind the needs of the day. It depends too much on a concensus of numerous Institutions."

Consequently, Sir James went on, the IEE had strongly recommended to the Finniston committee that national standards of qualification of professional engineers should be taken out of the hands of the institutions and the CEI. They should be set and administered by an independent statutory authority. This authority should be composed mainly of professional engineers acting independently in a personal capacity. It would be similar to the statutory bodies that regulate various other learned professions in the UK. The IEE had also told the Finniston committee that registration by itself was not enough. "The registration authority must have authority, it must have teeth. That means that registered engineers, like members of some other professions, should have certain work reserved to them by law, for instance work in areas affecting public safety and the public purse."

This would make individual engineers publicly and identifiably accountable for their work and hence more mindful of their responsibilities. It would provide effective me means of dealing with misconduct and incompetence since the ultimate sanction of striking a miscreant off the register would limit the scope of his employment.

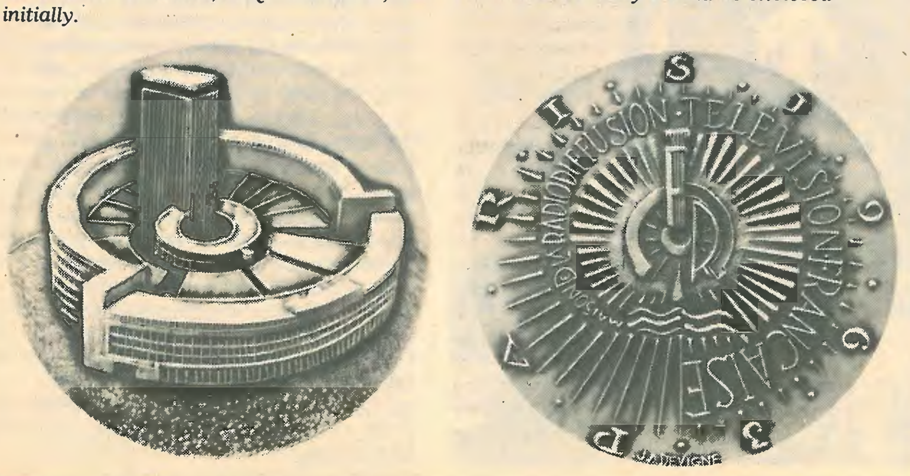
It would ensure that work of significant public interest was either carried out or supervised by engineers qualified to an acceptable standard. It would arm the registering council with significant powers for raising qualification standards because the meeting of these standards would open avenues of employment. And it would make the profession attractive to more of the best school-leavers as a highly qualified, well-disciplined profession to which work of special importance had been entrusted.

"I must emphasize most strongly," continued Sir James, "that we regard the reserving of work of special social importance to the fully-qualified registered engineer as being an essential adjunct to statutory registration. We believe that, without this reservation, the value of statutory regulation of the profession would be very seriously diminished."

New system "finds" babies with poor hearing

Newborn infants with defective hearing can now be identified within the first day of birth. The Mt Diablo Hospital medical Centre (USA) is using a recently developed portable test instrument which measures the threshold of hearing by playing sounds, as a series of clicks varying in number, rate and intensity, through earphones placed over the infant's head. The instrument is known as "Synap 1" (after "synapse," the point at which a nerve impulse passes between neurons), and surface electrodes taped to the scalp pick up the brainwave response and feed it into the test unit's microcomputer. Data thus obtained is used to evaluate changes in the brain's electrical activity by accumulating the amplified analogue signals, converting them into digital information, and then averaging the data into a single wave which is recorded on magnetic tape. A trained operator can detect from the played-back tape the degree to which the infant heard the clicks, and the test, known as the "Brainstem Evoked Response" test (BER) can be performed even while the infant sleeps. Until now, community hospitals, where most babies are born, could not afford the standard BER test, and even severe hearing loss often went undiscovered until children reached school age. Synap 1 overcomes this problem of expense and restriction in the site of operation, previously only possible at major university medical centres. The implications for learning processes are wide — some children, unable to speak by school age, have been diagnosed as "slow" learners, and in some cases as mentally retarded, when the truth was that they were simply unable to hear what was being said. This new portable and inexpensive unit, designed mainly by two volunteers from the Pacific Telephone Company, Gay Sommerville, a digital systems specialist, and Phil Poeschel, an analogue systems engineer, now facilities the widespread screening of the newborn.

Picture shows the two sides of a medal which has been struck by the French Mint in Paris in honour of the capital's radio and television centre. The 68mm medal costs £7.15 in bronze and £48.10 in silver. It may be obtained from Pierre Dehaye, Le Directeur, Monnaies et Medailles, 11 Quai de Conti, 75270 Paris 6e. No money should be enclosed initially.



News in brief

The University of Salford is again running a one-week course, **Electronic Applications for Teachers,** July 16 to 20, to provide teachers who have some basic knowledge of semiconductor electronics with the opportunity to study the subject in greater depth. Material covered will be adequate for the electronics option of the J. M. B. 'A' level physics syllabus, or comparable syllabi. The course is to be devoted primarily to the study of operational amplifiers and integrated-circuit logic applications, and approximately half of the time is to be spent on experimental work. Further information from the Registrar's Department, University of Salford.

Two publications on the subject ot **health hazards facing v.d.u. operators** (see p.76, March 79 issue) are now available. The first 'Eye Tests for v.d.u. operators,' is from the V.d.u. Eye Test Advisory Group and is a discussion document proposing a series of eye tests for v.d.u. operators. For further information contact Tom Steward, VET Advisory Group, Department of Human Sciences, University of Technology, Loughborough, Leicester LE11. The second, 'Visual Display Units — A Nightmare to the Operator?' comes from the Occupational Welfare Committee of the Association of Optical Practitioners. Further information on this publication can be obtained from Joan Chaumeton, Public Relations, 27a Sloane Square, London SW1 8AB.

No major obstacles to Japanese joining association— BREMA director

Applications from three Japanese television manufacturers to join the British Radio Equipment Manufacturers Association (BREMA) will be seriously considered in the next month or so and the director of the Association, Mr O. P. Sutton, sees "no major obstacles ahead". Several Japanese companies have applied for membership in the past, but they have been refused because of opposition from UK companies. However, now that there are links between British and Japanese television manufacturers this opposition appears to have disappeared and the three companies, Toshiba, Matsushita and Sony, are all set to join.

Although Hitachi recently joined forces with GEC it has no plans to join the organization. The other partnership is between Rank and Toshiba, who are together helping to safeguard Rank's tv production in Britain. Sony and National Panasonic are already manufacturing tv sets in Britain but their output is not included in figures for British production.

● Sony, whose assembly plants are in South Wales, is to increase its production by 50%, and provide 250 extra jobs as part of a £5 million expansion programme. A substantial contribution is being made by the government and the Welsh Development Agency towards the cost of extending their plant at Bridgend, which presently employs 250 people. The expansion, say Sony, is due to increased demand. Approximately half of the company's present output is exported and the total capacity of 100,000 sets is to be increased by 50%. Britain supplies 50% of the present output, but this is also to increase.

● A report from NEDC sector working party of the electronic consumer goods industry, sets out a four-point strategy for restructuring and improving production in that industry. It suggests nationalization of British colour tv production into units of a suitable size for low-cost automated assembly; further involvements in existing Japanese technology; the more rapid utilization of new technology and products developed in other countries; and improvements in the quality and supply of British-made components. The industry is expected to spend up to £300 million in the next five years in this improvement programme and a substantial proportion of this will be provided by the Government under existing support schemes, it is reported.

New association for telecommunications consultants

The increasing complexity of telecommunications systems, including digital computer electronics, has resulted in the number of telecommunications consultants growing over recent years. Some of the consultancy firms, according to a public relations document, are acting in a somewhat unethical fashion and are claiming qualifications and expertise they do not possess. In certain cases, it is said, they even act as agents for manufacturers.

In order to give their clients an independent professional service, several consultancy companies combined efforts on January 1 to form the "Association of Telecommunications Consultants," whose members are expected to measure up to a certain level of qualification and capability. Minimum "paper" requirements for example, include HNC or similar in electrical or electronic engineering and City and Guilds certificate in telecommunications, plus seven years' experience in the field, including three as a practising consultant. This last requirement will make it very difficult for newcomers with valid skills to gain the necessary experience to become members of the organisation.

The association insists that advice to clients must be well-informed and financially independent of equipment suppliers or other external influences and intends to form a disciplinary committee which will have the power to investigate complaints and recommend the expulsion of offending members. Further details concerning this association can be obtained from the Association of Telecommunication Consultants, 53-54 King William Street, London, EC4.

Ship-to-shore communications satellites deal

Four British-made communications satellites are scheduled for launching from the ESA's Ariane launch site at Kourou, French Guiana, early in 1980. The manufacturing contract was signed in January between British Aerospace Dynamics and the ESA, valued at £73 million. Two of the satellites will be ECS types (European Communications Satellite) and two will be MAREC (maritime) versions, and it is expected that orders for three more satellites will follow. ECS is a regional communications satellite intended for European telephone, telex and tv traffic. The current contract provides for one satellite in orbit and a spare on the ground. MARECS differ in that the payload will provide direct telephone and telex links between ships and shore stations, offering improvements in quality and capacity. It is anticipated that the MARECS in particular will eventually be used as an element of a global satellite communication system.

Conferences and Exhibitions

The IEE and the IERE are calling for papers for the **9th European Microwave Conference** which is to be held from September 17 to 21 this year at the Brighton Centre in Brighton, England. The two institutions are holding the conference in co-operation with the Convention of National Societies of Electrical Engineering of Western Europe (EUREL), the International Microwave Power Institute (IMPI), the International Union of Radio Science (URSI), and Region 8 of the IEEE, with other societies and groups. Details from Professor Peter Clarricoats, Eu.M.C. Conference Chairman, Department of Electrical & Electronic Engineering, Queen Mary College, Mile End Road, London E.1. 4NS.

A second international **conference on television measurements** is to be held in London from May 21 to 23 this year. The purpose of this conference, which will be run by the IERE, will be to review the progress that has been made in this field since the first conference in 1970, and to consider the latest developments that have taken place. Further details from the Conference Registrar, IERE, 99 Gower Street, London, WC1E 6AZ.

Communications and microprocessors are the two themes of the programme of lectures at this year's **Leeds Electronics Exhibition,** which is to be held from July 3 to 5. The venue for the exhibition is the University of Leeds, and the event is being sponsored by the university's Department of Electrical and Electronic Engineering. This will be the 16th "Leetronix" exhibition.

The **Harrogate International Festival of Sound,** to be held at the Harrogate exhibition complex, will be open to the public on August 18 and 19 and to the trade on 20 and 21. Further information can be obtained from Stan Smith or Peter Hainsworth, Exhibition and Conference Services Ltd, Claremont House, Victoria Avenue, Harrogate, North Yorkshire.

Low-cost digital frequency meter — further notes

The author has informed us that in the articles in the January and February issue, transistors Tr_2 to Tr_5 should be 2N3906 and not 2N3706 as originally stated, and transistor Tr_6 should be 2N3904 rather than 2N3704. Geoffrey Chaplin of Streatham, London, points out that if the wrong devices are used for Tr_2 to Tr_5 the central four digits either remain on, showing the same figure, or will not strobe at all. If the wrong device is used for Tr_6, IC_{18} displays a 1 all the time and the leading zero blanking is defeated. Mr Chaplin used a BC107 in place of the 2N3704 and found that this worked very well.

The p.c.b. component layout, Fig.9, should contain four more connections to earth for satisfactory operation. These are from pin 8 on IC_3, pin 7 on IC_8 and pins 3 and 4 on IC_9. If the latter correction is not made, according to Mr Chaplin, as IC_9 warms up the 'load' inputs float to logic 1 and the least significant digit displays a 5.

The address of Semiconductor Supplies (Croydon) Ltd is Orchard Works, Church Lane, Wallington, Surrey SM6 7NF.

WORLD OF AMATEUR RADIO

144MHz TEP theories challenged

In my February WoAR I reported that "new" theories have been put forward in Europe and America to account for the recent spate of 144MHz contacts (and a 432MHz reception report) over long distances by means of trans-equatorial propagation (TEP): (1) plasma "bubbles" rising to heights well above the normal F-layer; and (2) field-aligned irregularities (FAI) in the ionosphere above the Equator. The FAI theory, published in *QST* as a "newly discovered mode of v.h.f. propagation" has been challenged on several grounds by Roger Harrison, VK2ZTB. He points out that the American account shows confusions between night-time (Class II) TEP phenomena and afternoon-type (Class I) and that emphasis is placed on scattering. He stresses that the importance of field-aligned irregularities has been known since at least 1973 as a result of the work of Dr Leo MacNamara in Sydney (who had earlier shown the influence on TEP of Equatorial Spread-F conditions). Roger Harrison, himself, in 1973 in a survey paper on TEP published both in Australia and Europe discussed in some detail FAI propagation and forecast the possibility of 144MHz TEP contacts as follows: "Class II will support much higher frequencies than Class I; signals have been observed up to 102MHz. This does not imply that 102MHz is the maximum frequency that Class II TEP will support. It is just that *nobody has reported an authentic case at any higher frequency*. Who will be the first to make Australia-Japan on 144MHz via TEP? No upper limit has yet been proposed for Class II TEP."

Well, today one can answer his perceptive question: VK8GB and JH6TEW made contact on 144MHz on February 24, 1978 following the initial TEP breakthrough on this band in South America in late 1977.

Roger Harrison furthermore is not convinced that scatter (suggested also in the plasma-bubble theory) is the primary mode; he accepts that plasma bubbles are large-scale strctures needed to generate the small-scale structures which align with the earth's magnetic field and produce a field-guided mode.

On the evidence available, the Australians, both professional and amateurs, do have at least some reason to feel that their work in the early 1970s has been overlooked in the rush to print theories on the 144MHz super-DX. To my mind, the fascinating world of v.h.f. TEP links neatly and significantly with that of h.f. "chordal hop," the propagation of signals over very long paths without intermediate ground reflection and now believed to account for a significant proportion of all amateur long-distance h.f. contacts.

American WARC proposals

The published American (FCC) proposals for the WARC revision of the frequency table are generally favourable to amateur radio, with support for three new h.f. bands (each 100kHz wide) centred on 10.15, 18.568 and 25.61 MHz and an extra 50kHz to be added to the low end of the 21MHz band. It is also proposed that the 7MHz allocation should be made world-wide exclusive from 6950 to 7250kHz (which would involve shifting a very large number of high-power broadcast stations). There would be a 60kHz loss to broadcasters between 1800 to 1860kHz (FCC is hoping to extend the American medium-wave broadcast band) but 1860 to 1900kHz would become "world-wide exclusive" to amateurs. The American v.h.f.-u.h.f. allocations would remain substantially as at present although Region 2 would have to share 220-225MHz with maritime mobile and amateurs would lose 1215 to 1240MHz to navigational satellites.

The extent to which American proposals are likely to influence WARC remains, of course, uncertain and may well be subject to "horse-trading" and the possibility that the Conference may see virtually an "agreement to disagree" in the form of a proliferation of national footnotes to the main Table and further regionalisation if Africa splits from Europe.

In the news

The two-day RSGB national amateur radio exhibition at Alexandra Palace, North London, on Friday, May 11 and Saturday, May 12 is being supported by major amateur radio retailers and will include a demonstration h.f. station and v.h.f. "talk-in" facilities (GB2AP). A reception/dinner for overseas visitors and RSGB members is being held on the Friday evening.

Over several days in mid-February, a large number of American and Canadian 50MHz transmissions were received at good strength in the UK permitting cross-band working with British stations on 28MHz (50MHz is not normally available to amateurs in Region 1). There remains the possibility that at the peak of the sunspot cycle (possibly October 1979 to March 1980) there may be 50/70MHz cross-band contacts with British stations using 70MHz. Even if this does not happen, there is an excellent chance of UK 70MHz signals being received in South America or southern Africa.

The RSGB's "Open Door" television programme "World at their fingertips" (BBC-2, February 22 and 25) attracted more than 750 requests for more information on the hobby in the week following transmission. Prime mover in getting this programme on the air at short notice was Dave Thomas, GW3RWX, a BBC engineer based in Cardiff and the RSGB's task of putting together, with the help of the BBC Open Door team, an effective programme was much eased by the Society having within its ranks such a highly-professional presenter as Brian Rix, G2DQU. [Pat Hawker modestly omits to mention that he also took part in the programme.—Ed.]

Interest in 24GHz tests is increasing in the UK with the availability of suitable Gunn diodes such as the Plessey GDO33. Stations with equipment for the band include G3BNL, G3EEZ, G3JHM, G4CNV and G8DEK. Cross-channel tests with French amateurs are likely this year.

JX9WT, an amateur on Jan Mayen Island, summoned help by amateur radio when a polar bear lay seige to his remote cabin. He contacted an amateur in Spain, who then contacted Norway and the message was passed to a Norwegian firm whose representatives on the island sent out a rescue party within half an hour of the original call being made!

In Brief

To mark the 50th anniversary of the Swiss society USKA a book "Fascination of the short waves" by Dr Ruedi Stuber, HB9T, will chronicle the story of Swiss radio amateurs from 1911 to 1946. A new certificate Helvetia 26 is being introduced and will supersede the H22 certificate . . . The annual British Amateur Radio Teleprinter Group Convention is being held at the Harpenden Public Hall, Harpenden on Saturday, July 21, 1979 and will include trade stalls, "Bring and buy picture tape factory," demonstrations and lectures. Members and non-members are welcome to attend . . . Hull & District Amateur Radio Society has a mobile rally at Hull University on Spring Bank Holiday Sunday, May 27.

PAT HAWKER, G3VA

Custom designed l.s.i. — man or computer?

Computer aided design of special large scale integrated circuits

by **D. L. Broster,** B.A., GEC Semiconductors Ltd

Because large-scale integrated circuits are becoming more and more complex but customers still expect them to be produced quickly, the manufacturers of custom designed l.s.i. have to make use of computer aided design methods of increasing scope and sophistication. This article describes the methods available for c.a.d. including simulation and how they are used in this field. In particular it deals with a "cellular" approach for the design and manufacture of m.o.s. logic in which the l.s.i. pattern is automatically laid out from a number of standardized cells each of which provides a particular group of functions. In short, logic diagrams are automatically translated into final artwork for the making of photolithographic masks.

THE VAST improvements in m.o.s. manufacturing technology during the past decade have been stimulated primarily by a demand for both higher operational speeds and greater densities of functions on the semiconductor chip. Unfortunately this demand has resulted in a shift in emphasis in standardisation. The previous decade of m.s.i. components had carefully nurtured a standard approach to system design, with the development of families of powerful logic processing elements.

While great advances have been made in the complexity of l.s.i., we are now faced with a multitude of 'standards' for power supplies, interfaces and device speeds. To keep their share of the market the manufacturers of fully custom-designed devices have had to adjust their aims to include a service of supplying custom designed logic systems and also to provide a wide range of custom designed interfaces. This has helped to develop semiconductor technologies such as c.m.o.s., which is a good medium for custom designed devices because of its inherent flexibility. Custom design generally results in a smaller number of packages than the use of standard t.t.l. or c.m.o.s. and this in turn results in: (a) fewer chips, hence smaller board area; (b) fewer inter-chip signals, hence less waste power; and (c) fewer interconnections, hence higher system reliability.

These features are of course highly desirable and have served to make custom designed l.s.i. an attractive method of constructing electronic systems. In development, where the economics of the method adopted are of great importance, and where there is a strong challenge to traditional custom design methods from both microprocessors and uncommitted logic arrays, a manufacturer of custom designed devices must be able to show that he can satisfy the following requirements: (a) first-time success; (b) short time to produce samples and start production; (c) low development costs; and (d) increasing complexity.

Because of these requirements the custom designer needs computer aided design methods of increasing scope and sophistication. Let us now look in some detail at the available c.a.d. tools and how they are used.

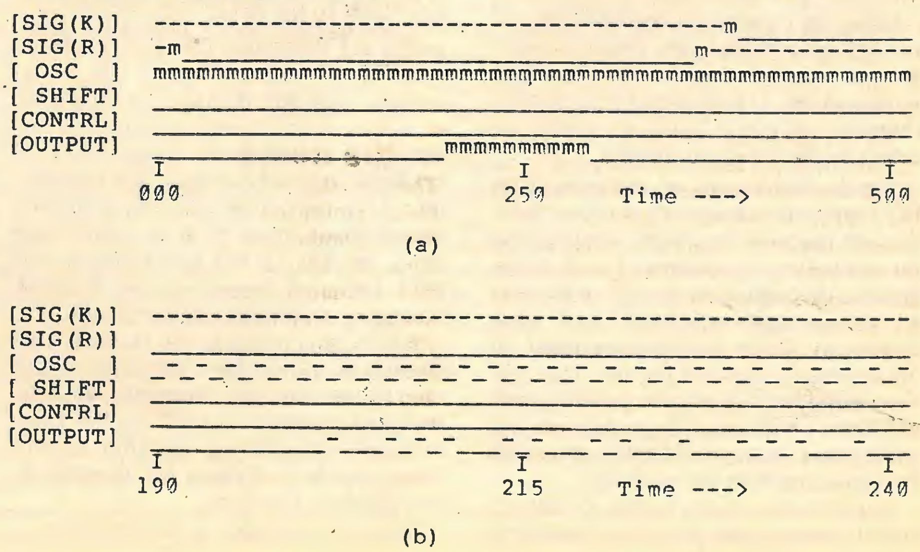
Defining the logic system

The background of customers is, to say the least, varied, ranging from the middle-aged designers most familiar with discrete bipolar technologies to new graduates capable of developing logic systems using the standard logic family approach. In fact l.s.i specifications can vary from brief written descriptions to complete logic specifications based on breadboard developments.

The aim prior to l.s.i implementation must be to define a logic system free from unnecessary redundancy. With increasing complexity it is necessary to achieve a common approach to establishing the final logic system. Breadboard techniques are becoming less realistic as the eventual l.s.i. logic becomes less realisable as a collection of standard logic components. A more exacting technique for checking the logic is required.

Recently the custom designer has started to rely on computer simulations of proposed logic systems as his means of 'breadboarding'. This is often referred to as designing directly onto silicon. The simulation programs are able to offer fast, and therefore semi-interactive, means of logic development. The majority of programs use two-state simulation with fixed propagation delays and have not been able to provide much assistance with the detection of timing problems. More recently 'three-state' simulators have become available (one, zero and don't-know states) thus allowing more representative simulations. Use of these simulators requires information on gate loading conditions within the completed layout. Given

Fig. 1. An example of logic simulation output for five of the pins of a prospective l.s.i. chip. In (a) each character along the horizontal lines represents ten time units and the diagram as a whole embraces some 500 time units (see numbers at bottom). The notation is: (‾) = logic '1', (_) = logic '0' and (m) = unresolved states. An expansion of the output burst in the lowest line of (a) around time 215 is given in (b) where each character represents one time unit.



minimum, maximum and typical propagation delay figures for each gate the programs are able to detect 'race' and 'hazard' conditions. Three-state simulators can give very pessimistic results and some degree of experience is required in their interpretation.

A typical performance for a logic simulation program is approximately 20,000 gate time-steps per minute. Thus a clocked logic system of 500 gates would be simulated at 20 clock cycles per minute (each clock cycle requiring two time-steps). Fig. 1 shows an example of the results of a logic simulation which would normally be displayed on the designer's v.d.u. screen.

It is of course vital to involve the customer in the analysis of the simulation results. In this way both parties can determine that the proposed l.s.i logic realisation is capable of performing to the customer's original specification. It is this involvement which can lead to a better understanding of the logic and thus shed light on the means of deriving the test pattern, which will undoubtedly be required for production testing.

As l.s.i. grows in complexity the problems of providing effective test procedures can become a nightmare. Commercial devices require a test pattern which is as short as possible in order to ensure that the bulk of the selling price is not determined by the cost of testing.

Obviously the simulator program can be used to some advantage as a means of finding the 'cover' provided by any particular test sequence. In order to do this the results of a normal simulation are stored on a magnetic disc file. The program can now re-simulate the circuit whilst applying a deliberate logic fault and compare the faulty simulation results with the stored results. The faulty run is stopped when a discrepancy between the two results is found. Termination of a run implies that automatic test equipment will be able to reject chips with that particular fault. Similarly if a faulty run can proceed to its conclusion then the implication is that if a chip with that particular fault was tested this test would not be able to detect that particular fault.

Some logic contains redundancy by its very nature, and one could not expect to achieve the ultimate goal of testing all the transistors on a particular chip, as this would imply an ability to detect double fault conditions.

The mechanism of test cover analysis has been automated in that the simulator will perform the faulty simulations for all the fault conditions of each of the gates in the logic description. In general an 'n' input gate will have 'n+l' fault conditions. Thus a chip equivalent to 'm' 'n-input' gates will require 'm(n+l)' simulation runs. Typically a 1000 clock cycle test pattern for a chip of 500 three-input gates could take up to 500 hours to complete the analysis.

It is for this reason that designers spend considerable effort in providing themselves with efficient means of testing; e.g., ample reset facilities for long count sequences. Quite often these facilities are beyond the scope of the original logic specification and of course increase the size, and therefore to some extent reduce the yield, of the resulting chips. It can be shown that the trade-off between testability and yield can result in more viable prices when final test costs are taken into consideration.

Layout design

The next part of the design procedure is perhaps even less well defined than the logic definition phase. The designer must now define the structure of a set of m.o.s. transistors interconnected in such a way as to implement the desired logic functions. There is little formality in this procedure and each layout can be as unique as an original painting. The success, or failure, is primarily determined by the rigour of the rules of layout that the designer has to adhere to.

In practice, the logic will be fragmented into manageable segments, each representing a recognisable subsystem of the overall l.s.i, e.g. counters, decoders. Each of these will be defined as a set of patterns of oxide cuts (masks) which when taken together will determine the sizes of the individual m.o.s. devices. Transient analysis will be performed on these individual segments to ensure that with the chosen m.o.s. device sizes the circuits can provide the correct logical functions at the correct speeds and voltages. The circuit is defined to the transient analysis program as a list of p.m.o.s. and n.m.o.s. transistors, resistors, linear and non-linear capacitors. In addition the program needs to know the expected process parameters and, of course, their likely variations. The program will apply input waveforms to the circuits and the designer can request plots of volts against time for monitored nodes.

The task of the designer is to determine a structure which is as small as possible in layout area but which still operates at the desired speed. The cycle of layout and analysis is iterative and is only practicable if the simulation programs are extremely fast in execution. Quite often the exactness of the m.o.s. models used for transient analysis is sacrificed in an attempt to improve the execution speeds of the programs. It is far more valuable to know the capabilities of a particular process/program combination than it is to refine the m.o.s. models to the point where the poor speed of execution could deter designers from using the programs.

When the process of layout and simulation of all the fragments of the chip is complete the fragments have to be fitted together to produce the final artwork. The fitting together of the fragments is performed on an interactive graphics computer.

Before the artwork is handed over to mask making it is plotted and scrutinised by both design and production engineers. It is possible to execute design rule checking programs within the computer-based graphic system. Each method of checking will try to locate possible design rule infringements. Errors can be quickly corrected on the computer and a final plot is produced. Using the final plot a point-to-point check is made to ensure that the interconnection defined by the logic diagram has been correctly implemented.

This 'hand-craft' design technique is expensive in both the engineer's and computer's time, and is most feasible for circuits which push against the limits of a particular technology. The full custom design approach can cost £15,000 or more and can take many months to get a device into production. One must bear in mind that the resulting device will be highly optimised and will perform the intended logic function in the most efficient manner in terms of silicon area. Devices intended for high production volumes are obvious candidates for this technique, because the yield will be higher and the development cost can be amortized over the production life. On the other hand certain customers are prepared to accept the cost of such developments because full custom design is their only means of realising a technical advance in their field.

Cellular approach

The popularity of the international standard t.t.l. and c.m.o.s. logic families has resulted in designers having the freedom to lay out their own custom designed systems on printed circuit boards. Certain semiconductor companies have developed m.o.s. 'micro-cell' equivalents. In theory this means that any logic designer can lay out a chip using these cells and present his layout to the semiconductor company for manufacture. The cells implement the familiar combinational logic elements plus several sequential functions, e.g., D-type flip flops. The cells are intended to be placed side by side in rows. The cells, and therefore rows, are of uniform height and these rows are spaced apart to allow room for the interconnections.

There is one fundamental difference between cell and fully custom designed realisations and that is that the cells must conform to a standard interface specification. Certain cells will be driving their maximum fan-out while in some parts of the circuit there will almost certainly be cells which only drive one other circuit node. This last-mentioned case will be wasteful of silicon area, especially when compared with the full custom design where each node will have been carefully analysed to result in the use of the smallest possible transistors.

In a practical cell design the designer will have to take into account the loading imposed on each cell due to the

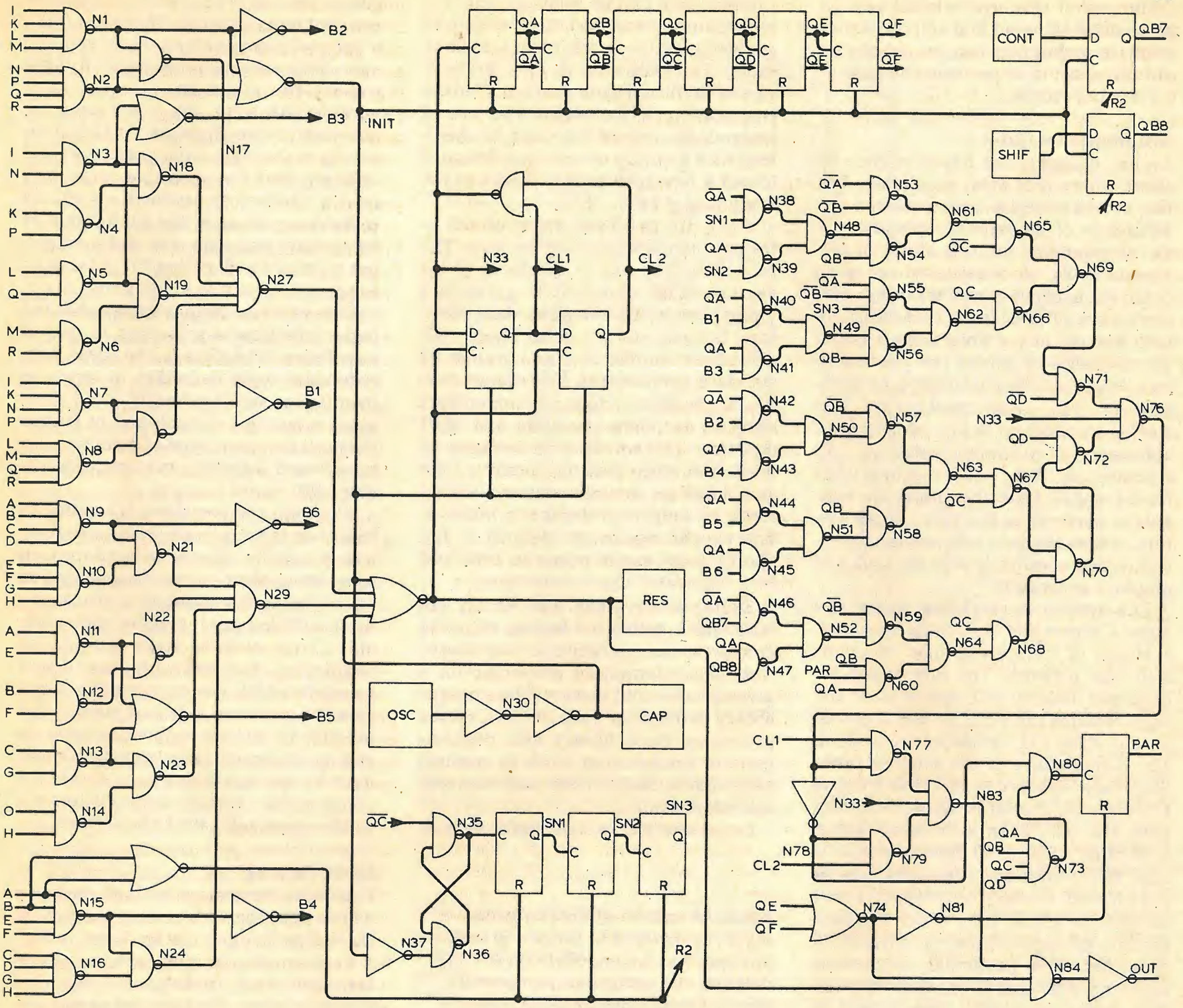


Fig. 2. The logic diagram of a transmitter chip.

routing of the interconnections, as this will serve to reduce the fan-out capability. With care a designer who is familiar with printed circuit board layouts should be capable of completing a medium-complexity custom designed circuit layout in two or three weeks.

The design rules of any particular process have to be adhered to by the user of a cell library, and in general the user is recommended to lay out his interconnections on a fixed grid. In fact the cells are designed to have both their height and width as an integer multiple of this basic grid.

How does one approach the problem of laying out a custom designed logic chip using a cell library? The secret is to determine the best positions for all the cells to give a layout of minimum size. Obviously some parts of a circuit will be more susceptible to interconnection loading than others and facts like these must be considered while the laying out is proceeding.

The situation you are faced with is something like that facing the builder of a dry stone wall, except that not only has the whole thing got to fit together but it must also follow a pattern. An improvement to the analogy would be to instruct the builder to complete the wall in several colours while conforming to a predetermined colour pattern. The wall builder would still have the advantage of being able to break his stones until they fitted, whereas the layout designer cannot alter the size of his cells. The number of ways of placing several hundred cells is of course rather large, and the soundest advice to an intending designer is that trial and error methods coupled with experience are likely to produce the best result.

Surprisingly logic circuits with a random structure are far easier to lay out (once you get started) than those which are formal (i.e., bus oriented). Highly structured logic systems can be laid out using cell libraries but a 'hand-craft' method will always show a great reduction in the area of silicon used. Most companies that offer cell library services started them to help their own designers maintain their sanity when asked to lay out random logic chips. The layout can be performed on graph paper and when it is handed over to the manufacturer he will digitise the information into his graphics process.

Some checking will be done prior to mask making and the ensuing manufacture of devices will be exactly the same as that used for any other design method. The problem of approving the initial logic design is still not well defined for users of cell libraries. Some users will have their own logic simulators but more often than not it is the breadboard techniques discussed earlier that will be used. The cell libraries which have been assembled in c.m.o.s. can of course be breadboarded in the standard '4000' series c.m.o.s., but the arguments stated earlier still apply in that timing problems associated with a breadboard cannot be mapped directly onto silicon. The responsibility for correctness of layout can now be in the hands of the customer. Errors are of course expensive to both the customer and the manufacturer.

The rest of this article is devoted to automation of layout and will show that software techniques can be developed and can assist in or perform the bulk of the layout process.

Automatic layout

An l.s.i. design group has to employ its effort where it is most justifiable. The use of cell libraries has increased the efficiency of medium-complexity l.s.i. developments, but the skills of designers could be better used on tasks other than placing and tracking. The mechanics of placing and tracking are fully defined in the library, so it is not unreasonable to expect the process to be a candidate for automation by computers. GEC Semiconductors Ltd started working on the development of software for automatic placing and tracking in 1972. The programs that have resulted from this effort are capable of performing the tasks of simulation, test evaluation, cell placing, interconnection routing, layout analysis and graphics generation.

The system is marketed under the name Cellmos and is, broadly speaking, a means of translating logic diagrams into final artwork. The time taken for customer liaison and approval of the logic remains the same as that required for any other l.s.i. development method. The manufacture of the samples takes place on a standard production line and there are no special penalties resulting from the use of an automatic layout procedure. The total layout phase is now 99% non-interactive and can be performed in approximately forty seconds of c.p.u. time (two or three minutes of elapsed time) on a GEC4070 computer. This particular machine is used in a time-shared mode by the design group so elapsed time is not an accurate indication of layout speed.

The Cellmos software has been deliberately written to be independent of the manufacturing process and the techniques discussed here could be applied to all the current m.o.s. technologies. The cells used in 1972 were designed in silicon gate p.m.o.s. Current enquiries tend to ask for the use of technologies similar to c.m.o.s.; therefore such a library of cells was designed to suit a new release of software at the beginning of 1978.

There are two basic types of cell — the primitive and the conglomerate. The primitive cells are in the form of inverters, NOR and NAND gates (2-4 inputs), exclusive-OR gates, data selectors, D-types and i/o cells. These cells effectively mimic the s.s.i. range of standard components. The conglomerates are equivalent to m.s.i. components such as decoders, counters and shift registers. The software is designed to work best when placing primitive cells and therefore includes automatic factoring of conglomerates into primitives. The conglomerates are defined in the library as groups of primitive cells and their associated interconnections.

Each primitive has four library entries which define the logical, physical, connective and parametric characteristics. This information is specific for a given process and there will be a unique library defined for each of the Cellmos processes. Each library also contains generic information such as process parameters, design rules and common cell information.

Let us now follow a particular custom design through the system to see how the programs interact. There are three pieces of information required for each proposed development: a logic definition, a set of typical input waveforms and an electrical or parametric specification. If the complexity of the logic is too great, then it is unlikely that the resulting chips will have a satisfactory production yield. As techniques advance the limitations of complexity and chip size will increase, but at the time of writing 300 gates or so is a practical limit in metal-gate c.m.o.s.

Experience so far has shown that the logic definition is presented in one of two forms. The first is the ideal non-redundant logic definition in terms of primitives and optimally used conglomerates. The second, and of course the most common, type of definition is a breadboard definition in terms of available '4000' series c.m.o.s.

Although the computer is capable of resolving the m.s.i. conglomerates their use generally means redundancy in some form. Most companies engaged in breadboard developments stock the most complex m.s.i. components available. This leads to logic definitions requiring, for example, up/down counters which are permanently wired as down counters. It is particularly bad practice to include redundant logic on custom designed chips and agreement must be reached with a customer and a conglomerate specific to the customer's requirement will have to be defined.

Fig. 3. *An extract of the computer input file required to define Fig 2. Each line specifies a component on the logic diagram and comprises: component type, reference number, input names and output names. The file also contains a definition of input signals and a list of monitors (chip pins).*

```
BLOCK CHIP
NAND4      1# I K L M N1
NAND4      2# N P Q R N2
NAND2      3# I N N3
NAND2      4# K P N4
NAND2      5# L Q N5
NAND2      6# M R N6
NAND4      7# I K N P N7
NAND4      8# L M Q R N8
NOR2       9# A B R2
NAND4     10# A B C D N9
NAND4     11# E F G H N10
NAND2     12# A E N11
NAND2     13# B F N12
NAND2     14# C G N13
NAND2     15# D H N14
NAND4     16# A B E F N15
NAND4     17# C D G H N16
NAND2     18# N1 N2 N17
NAND2     19# N3 N4 N18
NAND2     20# N5 N6 N19
      .
      .
      .
      .
NAND2     80# N57 N58 N63
NAND2     81# N59 N60 N64
NAND2     82# QC- N61 N65
NAND2     83# QC N62 N66
NAND2     84# QC- N63 N67
```

```
NAND2     86# N65 N66 N69
NAND2     87# N67 N68 N70
NAND2     88# QD- N69 N71
NAND2     89# QD N70 N72
NAND4     90# QA QB QC QD N73
NOR2      91# QE QF- N74
NAND3     92# N71 N33 N72 N76
NAND2     93# CL1 N76 N77
INVERT    94# N76 N78
NAND2     95# N78 CL2 N79
NAND2     96# N73 N78 N80
INVERT    97# N74 N81
NAND3     98# N77 N79 N33 N83
NAND2     99# N74 N83 N84
TTYPER-  100# N80 N81 PAR- PAR
NOR2     101# N84 RES OUT
SIGNAL A
0 4 0
      .
      .
      .
      .
SIGNAL N
1 12 380 0
SIGNAL OSC
0 1 2 3 4 -4 50 -200 0
MONITOR   A B C D E F G H
MONITOR   OSC CAP RES SHIF
RUN
600
```

Input format

Each logic element on the logic diagram will be represented by one typed line on the computer input file, as shown in Fig. 3. Each line starts with the name of the function and is followed by the reference name. The function names are based on the '4000' series numbers and the reference is a useful tag used by the programs for error reporting. A typical error or warning message will be in the form: " ? missing connection in CM4001 ref: Reset 5." The rest of the entries on the line are the connections to that particular function. In the case of simple NAND or NOR gates the connection list consists of all the input names (in any order) followed by the output name. In the case of a D-type flip flop the order of connections is fixed to be 'data,' 'clock,' 'reset,' 'preset,' 'Q-bar' and 'Q.' Each of the nodes of the circuit must be named and the logic completely defined in terms of this format of one line per logic element. Input waveforms are defined in terms of state change times. The input file contains the names of all i/o signals as specific monitor points. An example of the logic diagram is shown in Fig. 2

Earlier in this article we mentioned first time success as a prime objective. We now find ourselves in a position where a method of achieving this objective can be formalised.

A simulation is performed from the logic description input file. The output waveforms are able to prove two things. If the customer agrees that the outputs satisfy his functional requirement then the implications are that both the logic diagram and the computer listing are correct. On the other hand if agreement cannot be reached, one of the two must be in error. Modifications can be made until the simulated output waveforms agree with the customer's waveform definition.

Until agreement is made the cycle of modifications will continue, and eventually both parties will know that the automatic layout procedure is going to be performed from good input data. The simulator substitutes the library logic definition for each of the cell definitions in order to perform this simulation. If the input waveforms are not capable of testing the logic then this type of logic approval exercise will be pointless. Therefore it is vital that a test cover analysis is performed. This will show that the means for determining the correctness of the logic are in themselves valid. This type of procedure would seem to be a good formal approach to logic definition and can go a long way towards ensuring first-time success.

One by-product of this exercise is the test pattern. The simulator produces a list of the waveforms to be expected at each pin of the chip in a format suitable for use by the automatic test computer. As a front-end to the layout procedure the program also reduces a list of all the cells required for the chip, along with a connections list describing which points of which cells should be connected together. This is the first stage of the layout procedure.

Automatic placing of cells

The placing program deduces from the cell and connections list which cells are best placed in which rows on the basis of efficiency of interconnection. There are three classes of connections. The first contains all connections which can be totally completed local to the row. The second class contains connections to adjacent rows. Finally connections have to be made to non-adjacent rows and i/o cells.

The cells are first collected into groups which are highly connected. These groups have many connections of the first kind and become the basis for inclusion of the cell clusters into rows. The final decision for inclusion of a cell in a particular row is made with respect to connections that are destined to be made in adjacent rows. The program also attempts to make the rows approximately equal in length.

The cells are now fixed within the rows but their exact position within a row is not yet defined. For each row the cells are shuffled until the profile of the interconnection pattern is as flat as possible. This shuffle is based on knowledge of the routing algorithm and of course the flatter the profile for any row then the nearer the row can be

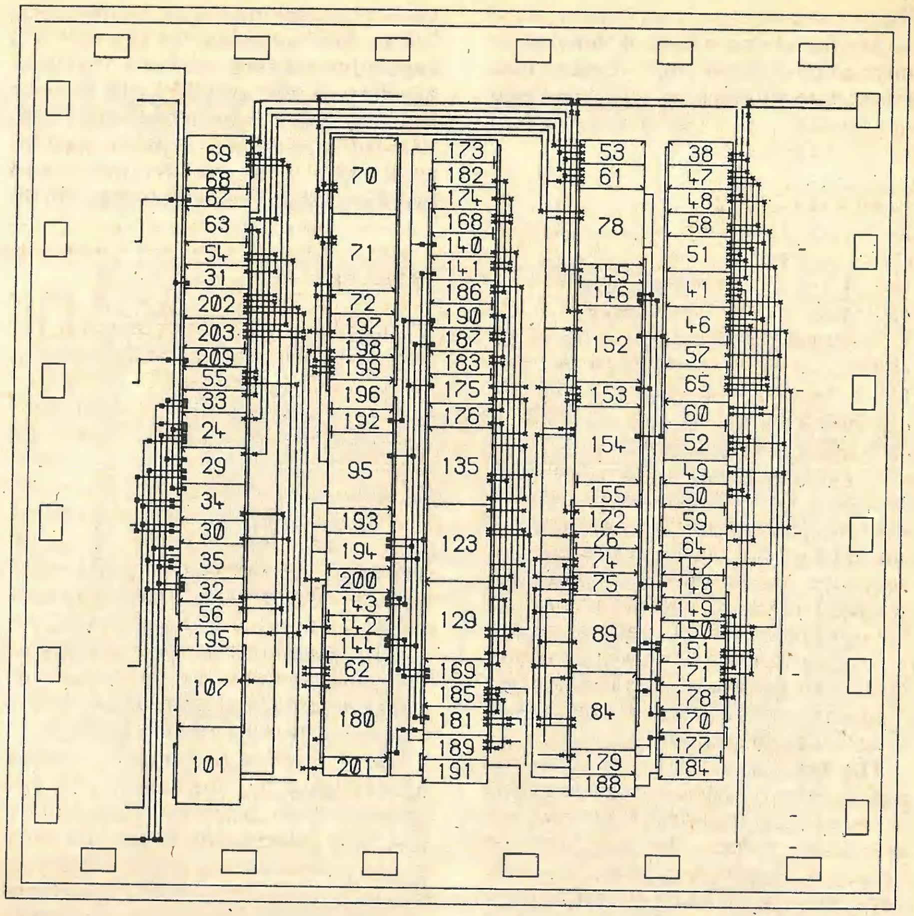


Fig. 4. *Outline plot of transmitter chip showing automatic cell placing and the routing of interconnections.*

placed to its adjacent rows. This procedure is extremely fast and takes about three seconds in the c.p.u. to place up to 300 cells.

There are variants on this basic placing algorithm which can take into account a connection to a particular pin required by the customer. Before such variants are used the customer must be made aware of the effects that such placing restrictions can have on the final size of the chip. This raises the question of whether signal routing is more efficiently performed on the chip or on the printed circuit.

Auto-tracking

The tracking program can never alter the cell placing. It can, however, "mirror" the cell if this improves the efficiency of the tracking. A typical candidate for such a change would be a cell where most of its left-hand connections came from the right and most of the right-hand connections came from the left.

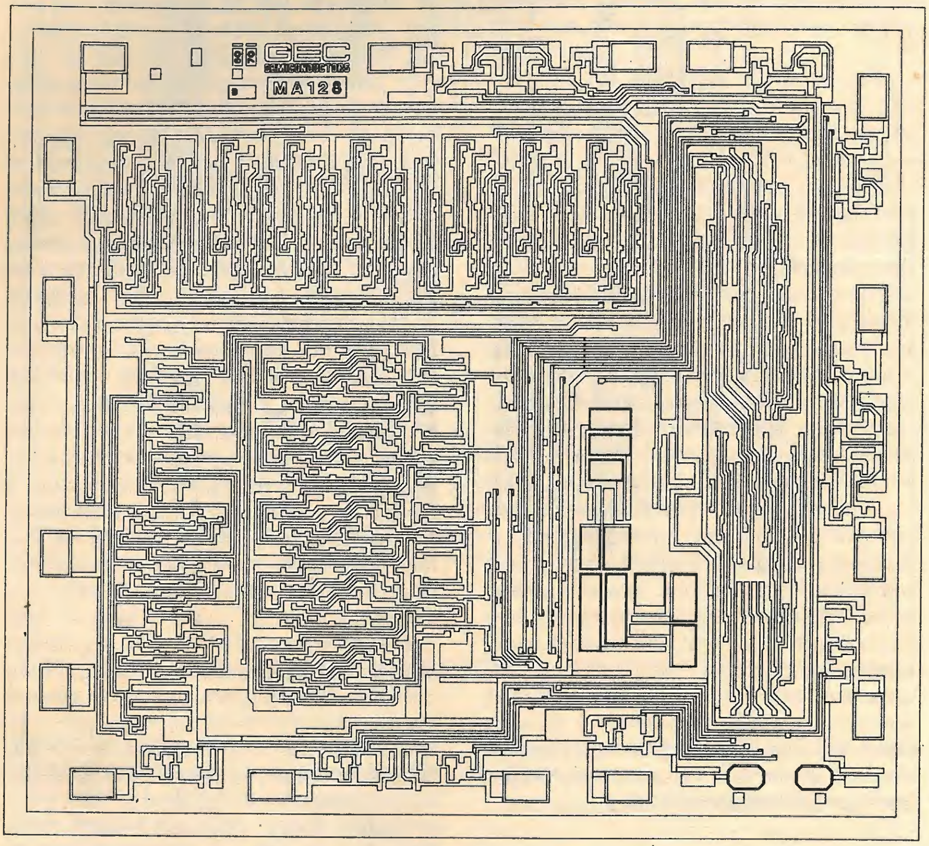
In metal gate c.m.o.s. routing of signals can be made in metal, p-diffusion or n-diffusion. The relative capacitances of these routing methods are 1:2:10. By extracting this information from the library the program will default to making connections via the least capacitive route.

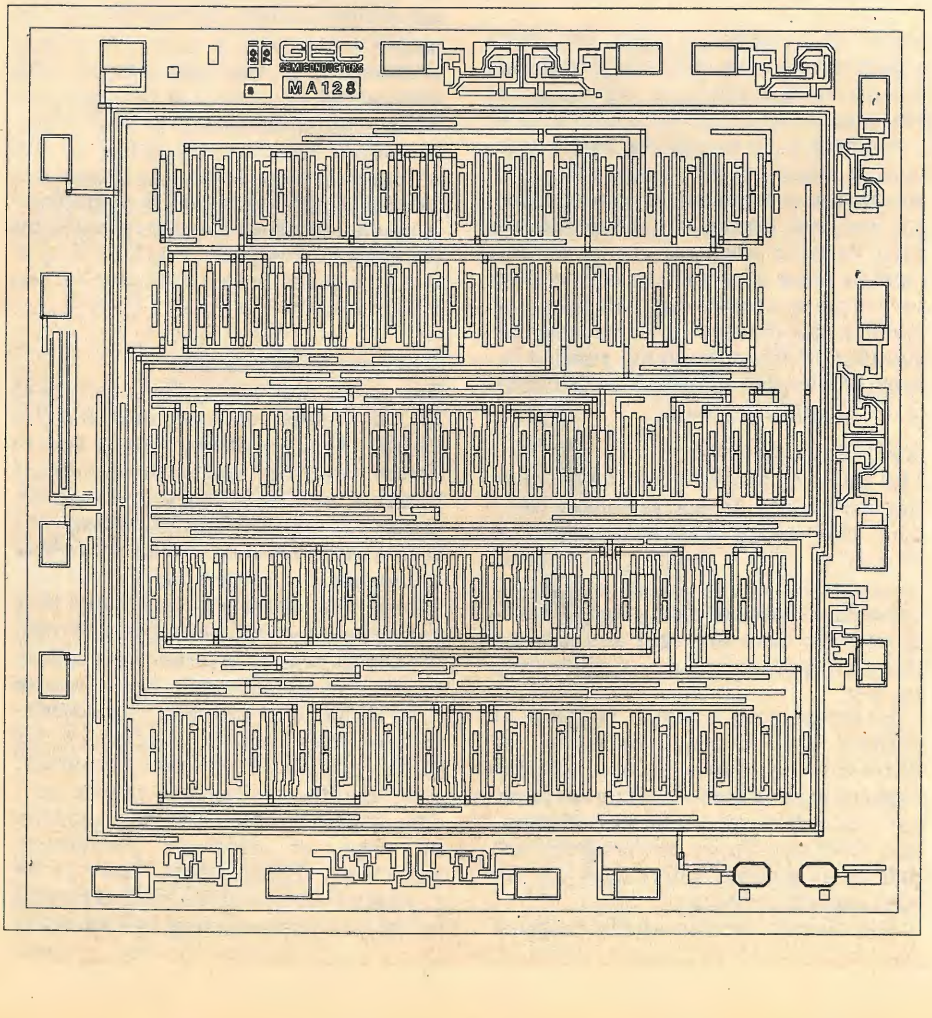
The current version of the program can successfuly make approximately 97% of the connections. Where the connections are left unfinished by the software the 'loose' ends are tagged with the reference label so that the designer can complete the connection on the graphics computer in a manner similar to painting by numbers. The routing takes about 20 seconds in the c.p.u. and the program produces three main types of output. The first is a list of all the unfinished connections. The second is a description of the layout in a graphics language which is directly readable by the graphics computer. The final output is an outline or skeletal plot of the layout as shown in Fig 4.

Designer involvement

The aspect ratio of the chip is governed by the number of rows used for the placing. This number is a guess by the design engineer and if the resulting layout is not the desired shape then the layout package is re-run. Minimum chip area is often produced when the chip is square but the Cellmos logic layout may not be the whole l.s.i. problem. In a number of cases it is desirable to control the aspect ratio to be other than square in order to allow some other structure to be included on the chip. This additional circuitry may be a r.o.m., a r.a.m. or some specialised interface structure. Several different layouts can be produced by using either differing numbers of rows or different placement algorithms. These layouts have to be evaluated in terms of the loading caused by the interconnection or by looking at

Fig. 5. *Comparison of two types of mask layout for a remote control transmitter chip: (top) a 'hand-craft' layout; (bottom) a layout using the Cellmos method.*





the ease of making the i/o connections.

The final program in the set is a capacitive loading analysis. This program reads the graphics file and the process library information and calculates the capacitance (in picofarads) for each node in terms of fan-out and tracking. Using this information in conjunction with the library information relating to cell drive capability, the designer can determine whether a cell is overloaded and could not therefore produce an output at the designed speed.

Alternatively the loading figures can be translated into rise and fall time propagation delays for each gate. These delay figures can become input for a three-state simulation. Using these figures, direct relationships between logic simulation and layout techniques can be established.

The use of such a technique effectively closes the design loop. If a node is discovered to have too great a load a simple solution is to connect an identical gate in parallel. Unfortunately this technique can have a 'snowball' effect by upsetting the loading of preceding stages. If this happens the problems are usually solvable by small changes to the logic diagram.

The role of the design engineer is in effect that of a monitor. He must ensure that each stage of the layout has been satisfactorily completed. The software produces plenty of warnings when things are going wrong and because the re-lay time is only of the order of minutes the designer can try different layouts and quickly evaluate them with respect to some special criterion. When the layout reaches the graphics computer the designer needs to complete the missing connections. Using the printout of the check list this task takes about one hour. The artwork is then plotted and enters the usual checking procedures.

Fig. 5 shows two plots of the metal mask of the layout for a remote control transmitter chip. One plot is of a 'hand-craft' layout, while the other has been generated by the Cellmos software. The two layouts are plotted at the same scale and this example demonstrates the efficiency of the cellular procedure.

Conclusion

The introduction of techniques like Cellmos helps to free designers from the more mundane aspects of layout. The software has in addition allowed a more rigorous approach to be used with custom designed developments.

These two aspects taken together make automated custom designed l.s.i techniques a very attractive proposition both for the customer and the manufacturer. The innate integrity of the computer approach means that far less repetitive checking has to be performed and the design engineer can concentrate on developing the complex interfaces that are now demanded by customers. The wide acceptance of computer-aided design techniques is also enabling engineers to solve problems which, unassisted, would be either too complex or impractical in an economical environment. Who knows, perhaps dry stone wall placement will be performed by a computer in the near future.

White light holography

In memoriam: Dennis Gabor

by **N. J. Phillips,** B.Sc. Loughborough University of Technology

Until recently, holography has suffered from the same "solution in search of a problem" syndrome that the laser originally experienced. However, recent advances in the production of holograms have led to a generation of displays which are easily viewable in white (non-laser) light, and have a good correspondence between the wavelength of the light used to record them and the wavelength at which they replay. This article describes how holograms are produced, and explains some of the problems involved. A concluding section indicates how this breakthrough has created many possible applications and how holography will influence the electronics industry.

WHEN I was a young man, I remember being greatly impressed by the achievements of Dr Roger Bannister when he ran the first four-minute mile. Since then of course, it has been a commonplace event almost expected by the sporting public. Such feelings were again aroused in me when I learned of the sensational white light reflection holographic displays released by Russian workers under Yuri Denisyuk in the autumn of 1977. My own small team of three research students advanced fairly rapidly after this release, but all we would claim is that we are fairly competent at the chemistry of making holograms, and are in a position to provide an alternative and competitive view of the problems involved.

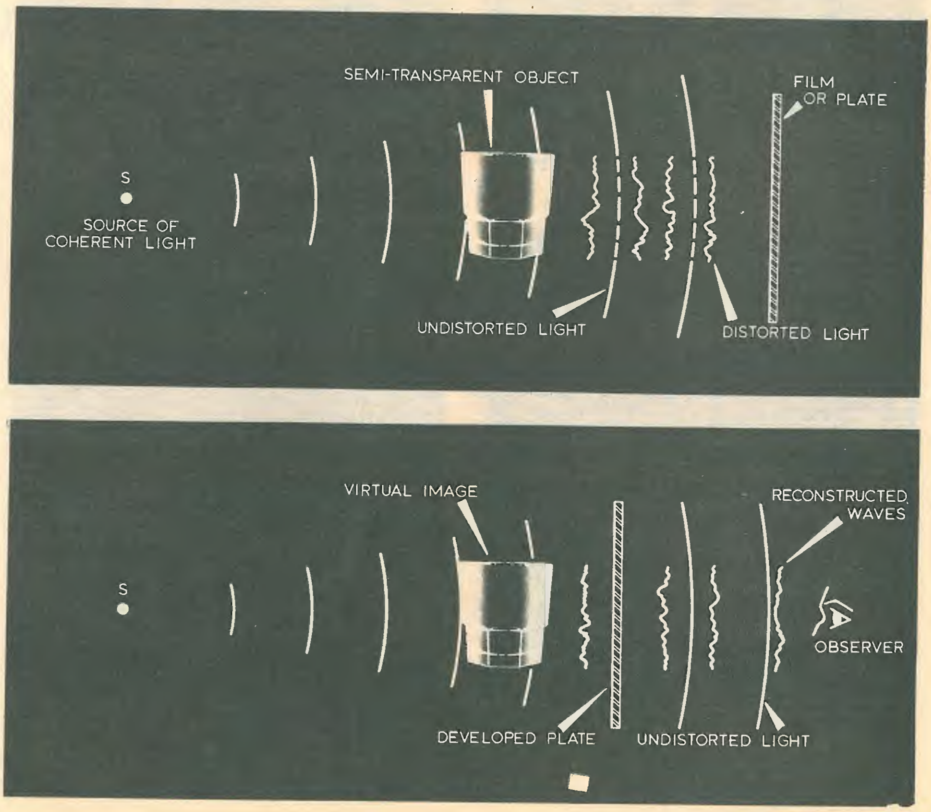
In commercial terms, the only profitable forms of holographic display have resulted from the work of Dr Stephen Benton at the Polaroid Corporation in Massachusetts, and the spin-off work of Lloyd Cross at the Multiplex Corporation. Such displays are indeed viewable in white light, but always suffer from the loss of one of the viewing parallaxes, and usually suffer from a form of chromatic dispersion.

Also, the image produces a novel type of stereoscopic view which is unfortunately a little tiring due to its optical properties. However, the advent of efficient white light reflection holograms may totally alter the commercial view of holography because the viewing requirements are much more relaxed.

To understand where the progress really lies, it is worthwhile briefly covering the early developments. Holography was invented by the ubiquitous Dennis Gabor in 1948, a Hungarian physicist then working at the British Thomson Houston Research Laboratories at Rugby. The invention really concerned electron microscopy, and his original ideas were aimed at trying to produce a recording on a two-dimensional medium using electron waves, and replaying such a recording three dimensionally with X-rays to produce an image magnified in the ratio of the wavelengths, X-ray/electron, i.e. around a million times. Such an idea, although conceptually interesting, was at that time non-realisable and it is a measure of Gabor's intellect that it is only now, some thirty years later that technology has caught up and can exploit his original thoughts. In the absence of a practical system on the exact lines of his theoretical ideas, he used visible light as a method of recording and replaying his holograms. Exposures of his early holograms could take many hours to complete due to the lack of usable coherent light. The basic Gabor method of recording and replaying a hologram is shown in Fig. 1.

The hologram (named after the Greek word holos meaning whole — a hologram contains details of both the amplitude and phase of the incident light) is recorded by mixing light which has been influenced by a semi-transparent object, and undeflected light which hits the plate directly. Gabor concluded that the hologram, if developed and then re-illuminated with the original undistorted light, would recreate the distorted light waves as far as an observer on the far side of the hologram was concerned. In this way, the viewer receives the direct illuminating light during the act of viewing the image. Thus, the general idea of holography is that, given two coherent wavefronts of light arriving on a photographic medium, the medium will record information which can be replayed to reconstruct the weaker

Fig. 1(a) *Gabor experiment for recording a hologram. The point source of light would typically be a mercury vapour discharge lamp. (b) Replaying the hologram.*



wave front by irradiating the hologram with the stronger of the two.

The advent of the laser in 1960 meant that for the first time, coherent light of considerable strength was available to make holographic displays. In 1961, when the first continuous wave laser was produced, Leith and Upatnieks at the University of Michigan produced an off-axis system for making and viewing holograms as shown in Fig. 2.

The object was illuminated by laser light via path 1, and the hologram plate was also illuminated directly along path 2. The arrangement is different from Gabor's original system because the light scattered off the object travels to the plate in a different direction to the direct light. This type of hologram is viewed as show in Fig. 3. The removal of direct illumination from the viewer's line of sight is most important because it stops visual confusion and prevents an optical hazard.

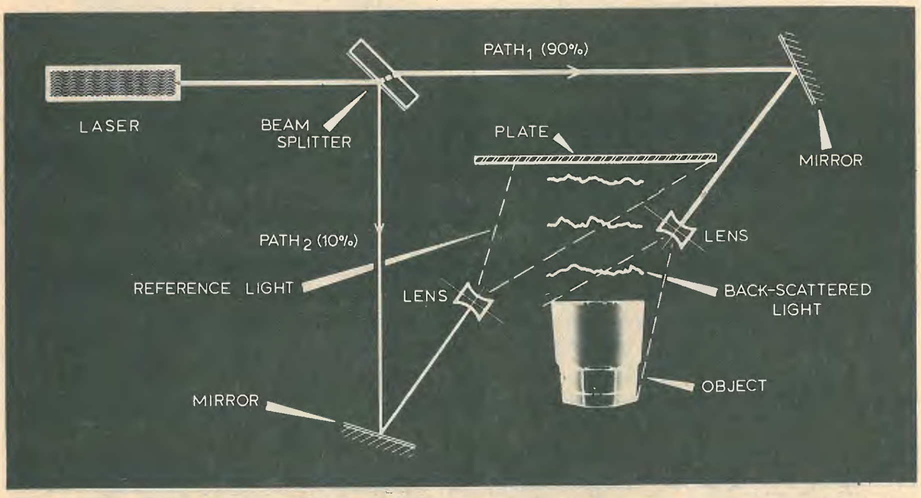


Fig. 2. *Basic Leith and Upatnieks off-axis holographic system.*

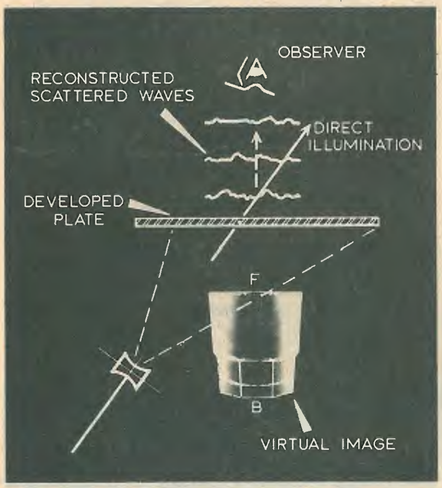


Fig. 3. *Viewing a simple virtual image transmission hologram in the off-axis mode.*

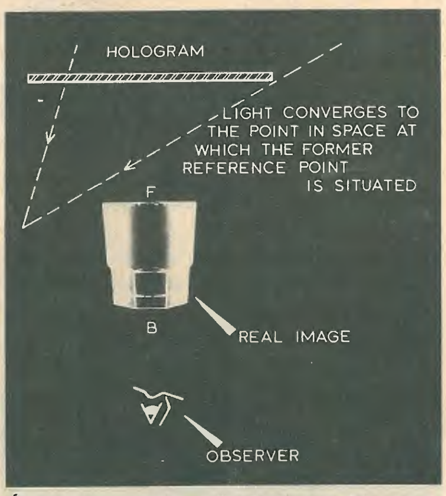


Fig. 4. *Generation of a holographic real image by reversing the light paths, a technique known as time reversal.*

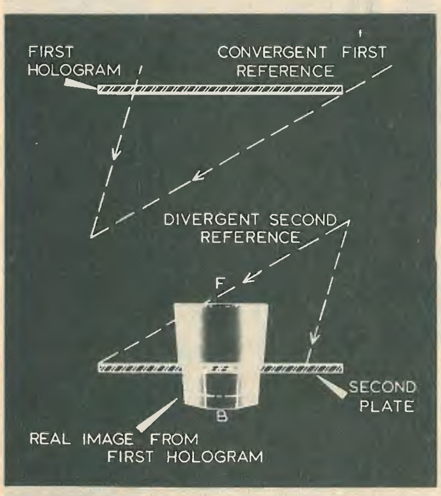


Fig. 5. *Two stage production of a semi-real image hologram from a projection master.*

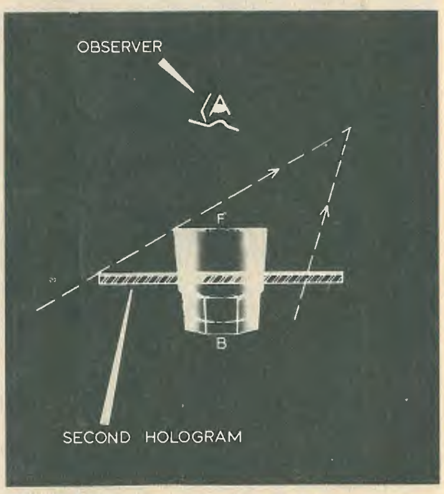


Fig. 6. *Viewing a semi-real image hologram. The image appears to be suspended in mid-air.*

Images may be viewed in front of the hologram by reversing the light path of the illuminating beam as shown in Fig. 4. With this system the viewer sees the background in front of the foreground so that the image is back to front. Such an inversion of the image causes a strange optical effect with the image apparently following the viewer's gaze as he moves his head. Once an image has been projected from a hologram however, it can be captured on a second hologram to avoid the foreground-background anomalies, see Fig. 5. By reversing the light paths through the second hologram, the image now appears suspended in mid-air — part in front of and part behind the hologram as in Fig. 6. The field of view in this secondary image is limited by the effective aperture of the first hologram, i.e. its size and distance from the second plate. Thus, semi-real images with a large angular field of view can only be seen when large holograms are used in the primary position.

In 1969, Benton first showed how to exploit this secondary hologram to make it viewable in white light as opposed to laser light. He illuminated the first hologram using a convergent sheet of light instead of a convergent cone, thus restricting the available vertical parallax in the image, while leaving the horizontal parallax unaffected. The result is a secondary hologram which is effectively viewed via a slit projected into mid-air as shown in Fig. 7. This slit is the illuminated area of the first hologram in the two stage process. As the viewer moves his head up and down he sees a coloured image, appropriate to that part of the visible spectrum coincident with the viewing slit. As he moves his head horizontally, i.e. in the plane of the paper, he sees the normal parallax. This method of constructing holograms is the elementary basis of Lloyd Cross's multiplex system in which an object is first photographed via cinematography on a rotating table with a fixed cine camera at a given

OBITUARY

With the death of Professor Dennis Gabor in February of this year, the scientific world lost one of its truly great inventors. His extraordinary intellect conjured up ideas which were always ahead of their technological time; thus the hologram, invented in 1948-1949 when he was in his fifties, had to wait until the invention of the laser in 1960 before gaining acceptance with the scientific community. His contributions to information theory and communications were at a fundamental level. Those of us who have been involved with holographic science will sadly miss this remarkable man but will be inspired by his example to achieve results to the limit of human imagination and to the very end of their working life. **N.J.P.**

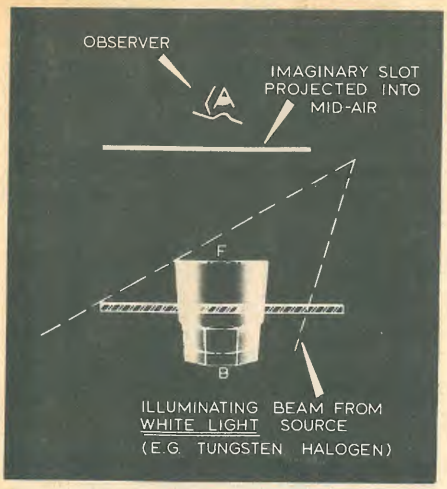


Fig. 7. *Viewing a Benton type hologram. The imaginary slit is the illuminated area of the first hologram in the two stage system.*

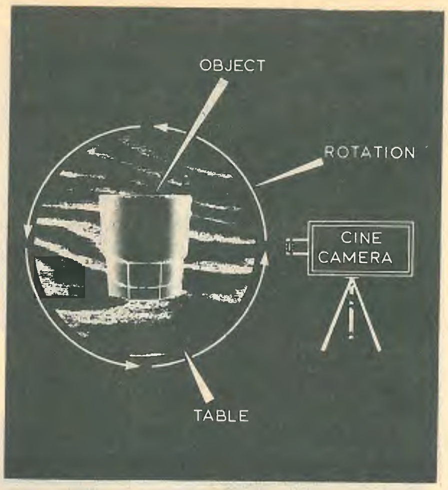


Fig. 8. *Recording a master film prior to the manufacture of a multiplex hologram.*

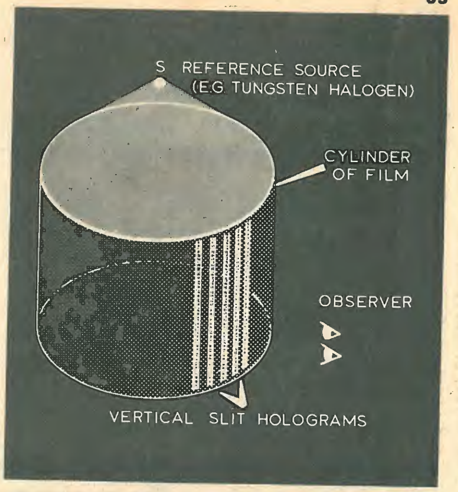


Fig. 9. *Viewing a multiplex hologram. Looking through the vertical slit images produces a stereoscopic view of the original scene.*

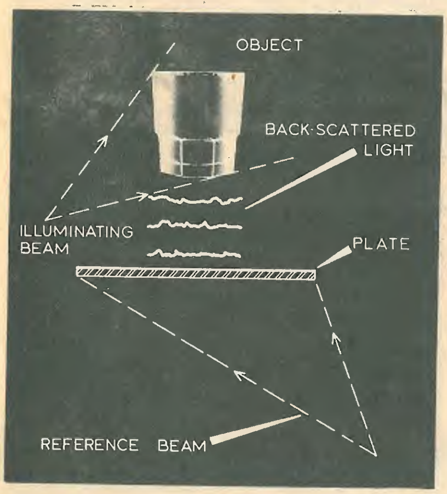


Fig. 10. *Basic arrangement for producing a reflection hologram.*

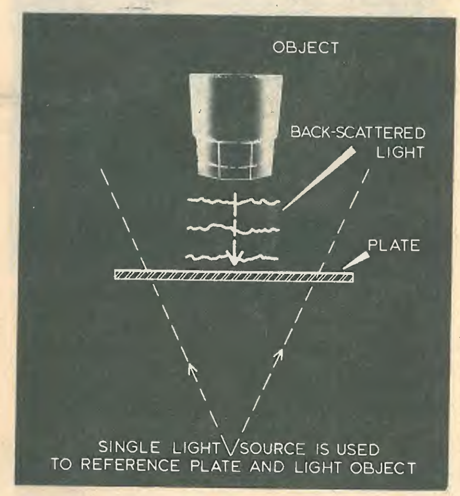


Fig. 11. *Simplified Denisyuk method for producing a reflection hologram.*

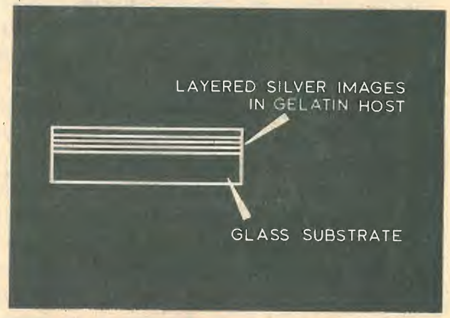


Fig. 12. *Structure of an image in a reflection hologram.*

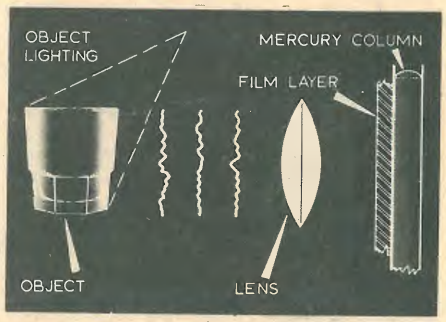


Fig. 13. *Experimental system for the manufacture of a Lippmann photograph.*

vertical height. The camera takes a series of two-dimensional pictures which form a loop of film surrounding the object scene. The information on these frames is then transferred, by means of an anamorphic lens system, to a series of vertical stripe images on a drum of film using laser light through the projector, and feeding a reference beam to each stripe as shown in Fig. 8. The viewer can then look into the drum, which is lit by a single small-source white bulb at the reference source point, and see a Benton-type view of the original scene as illustrated in Fig. 9. The viewer looks through different vertical slit images and sees a stereoscopic view of the original scene. The limited angular viewing range of the image in the vertical plane, and the colour shift as the observer moves his head up and down, compounded with the barred division of the image in the horizontal plane, tend to offset the achievement of the multiplex system. No doubt, there will be advances on the present methods used, and Benton has already achromatised his type of image to make it appear black and white. The great advantage of a multiplex system is its ability to use information recorded by a cine camera, which enables indoor or outdoor scenes, illuminated by normal lighting, and incorporating limited forms of movement, to be encompassed.

The Russian worker Denisyuk pioneered the alternative reflection white light hologram some sixteen years ago. This type is made by recording the hologram using laser light incident from opposite sides of the hologram plate as in Fig. 10. or, alternatively, by the simplified "Denisyuk" method in Fig. 11. The method shown in Fig. 10 works well under all circumstances provided that the reference and back-scattered intensities are reasonably comparable. The simplified "Denisyuk" method, however, can only work well when the object backscatters a high proportion of the incoming light. Metallic objects like the gold Keys of Leningrad, *Wireless World*, April 1978 front cover, are thus ideally suited to the experiment. To view the reflection hologram, the viewer uses a simple point source white lamp at the reference source point, and the hologram should reflect that part of the white light spectrum that roughly corresponds to the wavelength of the laser light used to make the hologram. In practice, the results are usually far from ideal, and for this reason some recent Russian work has stimulated the subject again.

To understand why reflection holograms are so important, and why they are difficult to make, the basic recording and processing mechanisms must be understood. The image formed in the hologram is in fact a volume effect in the gelatin. The counter progressing waves produce an interference pattern that is nearly planar and parallel to the surface of the glass substrate. Layers of image are produced with a separation of approximately $\lambda/2$ where λ is the wavelength of the recording light, see Fig. 12. Unfortunately, a dilemma facing the holographic technician is what to do with the image once the photographic material is exposed. It is easy to develop an image to produce layers of silver, but can enough layers be developed to make the method effective? If enough layers are developed, does the developed grain have the right characteristics, i.e. size and shape? These questions just start a compounded series of problems.

Once the silver image is produced, light can be back reflected off the layers to produce a Bragg effect which is wavelength selective. In fact, by exploring the work of Gabriel Lippmann (c 1891), one begins to wonder whether it hasn't all been seen before, as this is precisely the means by which Lippmann's colour photographs were produced as shown in Fig. 13. The mercury column was used as a reflector to direct light back through the film to interfere with the incoming light. Lippmann's two-dimensional photographs can be replayed in white light by reflection, with the colour roughly corresponding to the colour of the recording. Some fascinating examples of Lippmann's work may be seen at the Science Museum in London.

Unfortunately, the presence of opaque silver in the reflection image causes low brightness during replay and, as a result, all holographic work depends critically on the ability to bleach the silver to a transparent compound, such as silver bromide, after development. Here, there are two choices to make. If the image is developed to produce silver, the residue can be fixed out of the unexposed silver halide. The result is, however, a collapse

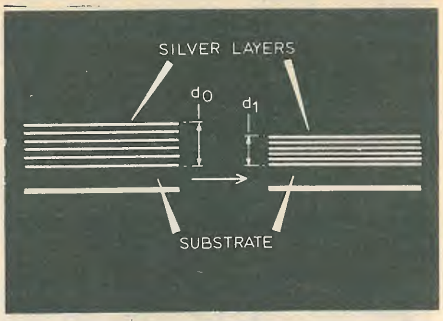


Fig. 14. *Collapse of the gelatin host after fixing.*

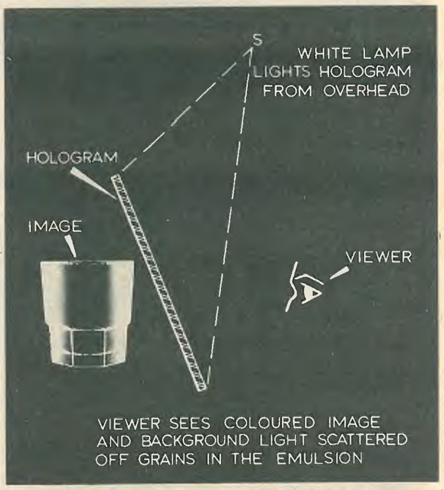


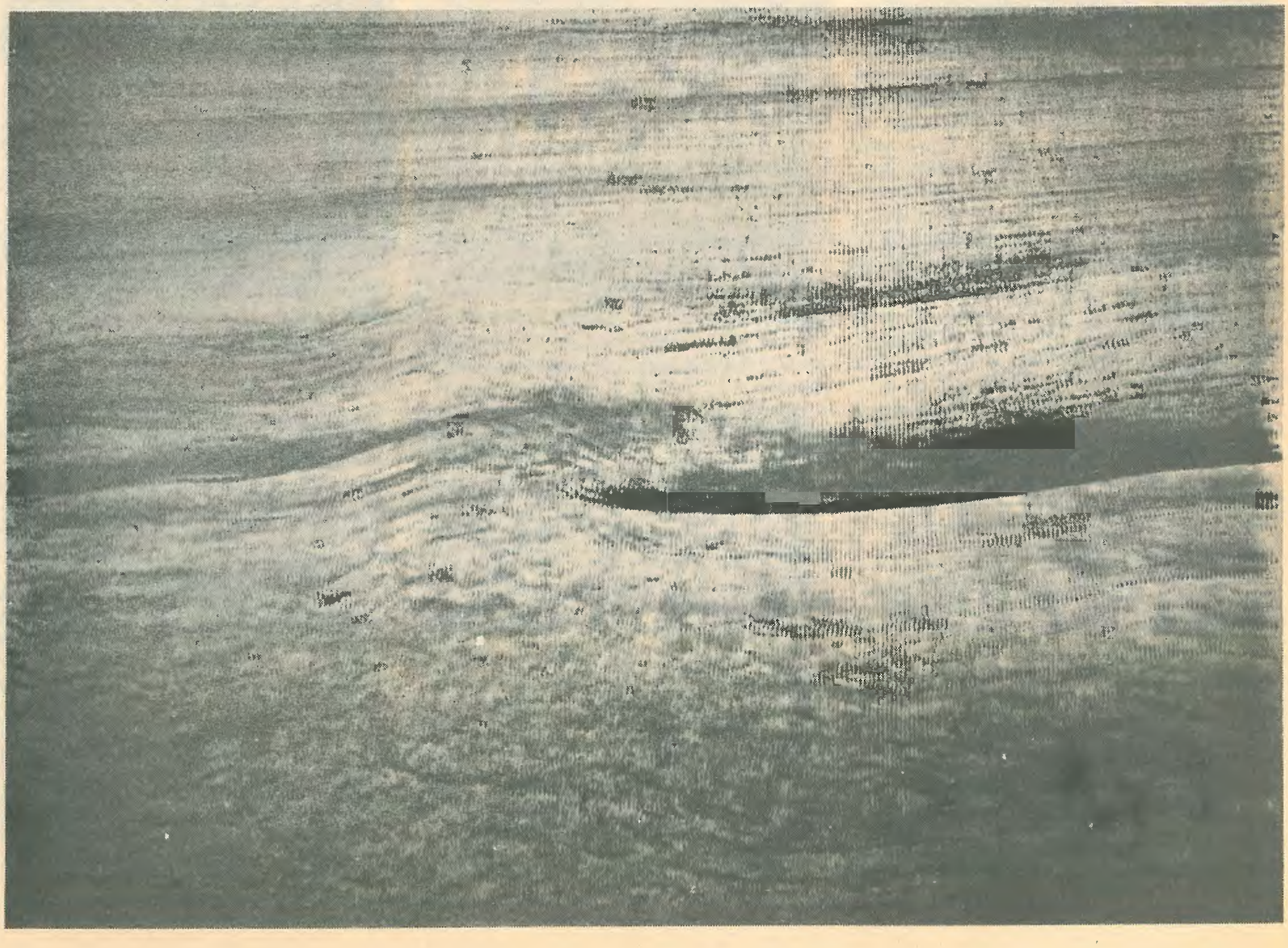
Fig. 15. *Viewing typical white light hologram.*

of the gelatin as shown in Fig. 14. This well known problem is fundamental, and decreases the separation in the layers of the image so that the hologram replays at a shifted wavelength. Thus, a hologram recorded in green will play back in blue-violet, or if recorded in red will play back in green. Furthermore, the highlights of the image, which inevitably lead to greater exposure of the emulsion, will be subject to more intense chemistry and the gelatin collapse may be non-uniform.

An alternative method is to dissolve the silver image and leave the residue of the unexposed silver halide as the hologram. Although the same collapse phenomenon must occur, and the same colour shifts take place, the hologram can then be restored in thickness by using swelling agents. This method is difficult particularly with respect to uniform swelling. Recent progress has circumvented most of these difficulties and chemical packages will shortly be available through Agfa-Gevaert Ltd.

Perhaps the most important area of progress concerns the understanding of light scattering in white light holograms. It was Lord Rayleigh who, in 1870, proposed the theory that small spherical particles scatter light, i.e. redirect light incident upon them, with an intensity proportional to the sixth power of their radius, and inversely proportional to the fourth power of wavelength. The impact of these conclusions on white light holograms

Fig. 16. *Holographic display of seismic data.*



relates to the grains of silver bromide in gelatin, which normally constitute the image, and do scatter light. A viewer looking at a white light hologram, see Fig. 15, sees a coloured image within a range of wavelengths, $\Delta\lambda$ say, which may be around 200nm. At the same time, the unwanted light outside this range can be scattered to the viewer's eye and hence reduce the contrast of the image. This produces images in a grey instead of a black background. In practice, silver bromide grains as small as 50nm in diameter cause this offensive scatter. One chemical trick is to stain the image brown with the developer's oxidation products. This reduces scatter at the short wavelength end of the white light spectrum, and effectively makes the grains of the image appear smaller.

Russian workers have produced special recording materials with grains as small as 5nm in diameter whereas the smallest in the west is 30nm. Thus, the impeccable quality of the best Russian white light holograms is associated with light scatter reduction of potentially 50,000 times. Actually, the story is not quite so damning as western results are now looking very competitive.

Another point to note is that Rayleigh's predicted scattering refers to spherical particles and, unless one is extremely careful with the developer, the developed grains are non-spherical which makes the scatter much worse. New Russian developers, and recent efforts at Polaroid and our own laboratories, have aimed at better control of grain structure. Recording materials such as dichromated gelatin, which produce grainless images, do exist, but the exposure requirements are so high that such media are generally not suitable for large holographic displays.

If a hologram can be made with a given colour of laser, and then replayed at that colour, the inevitable question is, can red, green and blue laser beams be used to achieve a close correspondence between the colours of recording and replay from each elementary image and produce a trichromatic reflection hologram. This idea is certainly not new and elementary attempts have been made in the past. However, with recent advances in the manufacture of holograms, together with the availability of high power dye lasers and new uniformly sensitized emulsions, a convincing trichromatic hologram has become an imminent possibility.

White light holograms were first produced in the Department of Physics at Loughborough University during October 1977 and subsequently exhibited at the Royal Academy of Arts in January 1978. A chemical research programme funded by Holoco has so far enabled us to produce low-noise reflection holograms, an example of which is shown on this month's cover, and laser-lit transmission types. Many thousands of chemical trials have been performed to evaluate the merits of various agents in the production of the holographic image, and it is a little salutary to realise that our most significant work to date has been performed with agents that were under scrutiny before the turn of the century. In fact, the momentum behind research into the holographic image has been late arriving due to the use of convenience packages of developers and other chemicals. Fortunately, monosodium glutamate has no role to play in the production of holograms, at least I don't think so.

Holograms and holography will have a significant influence on the world of electronics. For example, an important application of holographic techniques is in the storage of digital information. One major British electronics firm is very advanced with machinery for the production of micro gratings on photographic film, to store logical ones and zeros in the form of tiny holographically recorded optical elements. Such a storage technique offers up to 1000 times more information for an equivalent volume of magnetic tape, with a very high signal-to-noise ratio. Holograms may also be used as a tool for comparison of engineering objects with a master image and, very importantly, can be used as optical steering and filtering elements for military data transfer applications. As it is not necessary to use photographic processes in the novel electronic speckle holographic methods (pioneered by the Mechanical Engineering Group under Professor John Butters at Loughborough) pictorial information from an engineering object can be absorbed directly by a television camera system, and processed by conventional electronic visual data methods. Another unique application of holography is the three dimensional display of data as in Fig. 16, which shows seismic data (courtesy of Geophysical Services International). This hologram replaces a weighty stack of computer generated data sheets and gives a display measuring 50 × 60cm.

In conclusion, it is important to emphasise the fundamental role of Gabriel Lippmann's work in the production of the modern reflection hologram, but we must all remember that it was Dennis Gabor who truly introduced the third dimension into photography.

The author

After graduating at Imperial College with an honours degree in special mathematics, Nick Philips remained at the university for a year while undertaking research in theoretical physics. During the next six years Nick worked at A.E.R.E. Harwell, A.W.R.E. Aldermaston, and Sperry Rand, Massachusetts on aspects of fusion research. Following a two-year spell with English Electric, he joined Loughborough University as a lecturer in physics and in 1975 was appointed senior lecturer.

As well as his university position, Nick Philips is technical director of Holoco Ltd, a company which was formed to carry out research into holography, and promote possible applications of this science.

Acknowledgement

The author would like to thank those who have contributed to the Holoco enterprise. In particular, research students Ralph Cullen, Andrew Ward and David Porter. Special thanks are due to Duncan Croucher of Agfa-Gevaert Ltd, for his constant help and for the company's support in our collaborative research programme. Thanks are also due to Optical Works in London for their help, and to Professor John Raffle of the Department of Physics at Loughborough University for his help and encouragement.

Further reading

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Acoustics conferences

Two further conferences are being arranged by the Institute of Acoustics as follows:

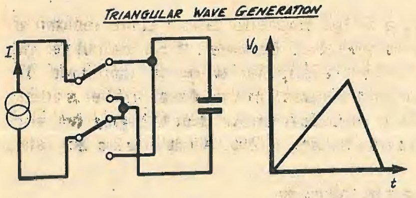
"Room acoustics with emphasis on electro-acoustics" will be held at Heriot-Watt University, Edinburgh, August 23-24, and will include a cultural event in the Edinburgh Festival. Details and accommodation booking: Mr P. I. Newman, Department of Architecture, Heriot-Watt University, Lauriston Place, Edinburgh.

For the Autumn Conference, held jointly with the British Society for Audiology, at the Hydro Hotel, Winderemere, November 4-6, sessions are being arranged on speech research, audiometry, noise in industry, and ships and noise. Organizer: Dr R. Lawrence, Acoustics Group, Liverpool Polytechnic, Byrom Street, Liverpool L3 3AF.

Triangular wave generators: Op amps

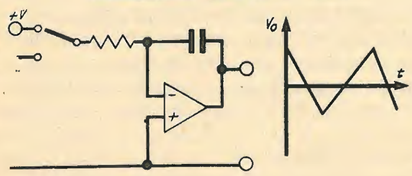
by P. Williams, Ph.D.
Paisley College of Technology

TRIANGULAR WAVE GENERATION



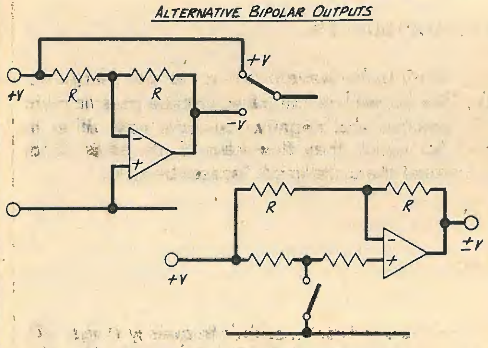
The ramp and sawtooth generators depend on a unidirectional constant current. If the current magnitude is maintained but the direction is reversed then the capacitor voltage changes slope. Provided the time durations of the two slopes are the same the voltage returns to its initial value at the end of the cycle. In practice it is the voltage excursions that are monitored and the durations vary if the currents for the two parts of the cycle are not equal in magnitude. To avoid such current variation the obvious method is to use a single current generator combined with a two-pole changeover switch. This is not easy to implement electronically and there is no common point between the generator and the capacitor — always difficult when the circuit is to form part of a system operated by a common voltage supply. The next alternative would be two generators providing currents equal in magnitude but opposite in sign. Each of these generators might have to be short-circuited when not in use to prevent excessive voltage rise, saturation or other difficulties. This hardly simplifies the switching problems.

OP.AMP. TRIANGULAR WAVE GENERATION



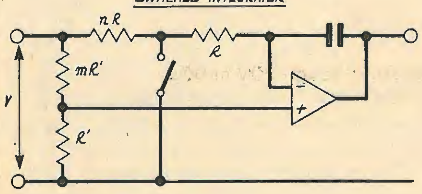
Considerable ingenuity has been exercised in finding ways around this problem. In this and the following section some of these methods are described. The pattern of development appears logical with hindsight, with different methods fitted into a common theme; it must be remembered that no such pattern can be discerned while the development is proceeding, since each proposal is a response to a particular stimulus. Consider first the integrator as used for sawtooth generation, but this time fed consecutively from equal and opposite voltage sources. Assuming an ideal operational amplifier the output consists of successive segments of equal but opposite slopes. If the switching is then repeated a triangular wave results. All the error sources described earlier still exist and the slopes are always non-linear and unequal albeit to a small degree. The problem remains of providing equal and opposite voltage sources, of effecting an electronic changeover function and of activating that switch at the appropriate voltages (free-running) or times (triggered). Note that this is readily solved if it is not required to *control* the voltage and hence the frequency and/or waveform. The integrator is simply interconnected in a closed loop with a Schmitt-trigger such that the square-wave output of the one forces the triangular wave from the other and the vice versa.

ALTERNATIVE BIPOLAR OUTPUTS



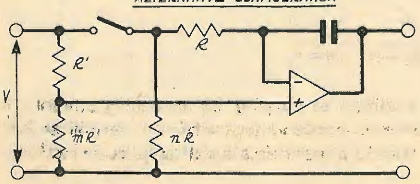
The provision of equal and opposite outputs is simple if an additional amplifier is permitted. It is connected to provide a voltage gain of —1 and the changeover switch selects either the input or the output. It is assumed that the original source is of low enough internal resistance that its terminal voltage is not affected by the presence of the amplifier, nor by the switching action. The changeover switch still presents a problem since it cannot be directly implemented in semiconductor form — two antiphase driven on-off switches are normally used instead. The solution lies in changing the wording of the problem. Ultimately it is the charging-current direction that has to be reversed, the voltage reversal being but a means to that end. As a first step consider the +V and —V can be written as $V_x(+1)$ and $V_x(-1)$. If the bracketed terms are interpreted as amplifier gain then it directs the attention to a means of reversing the gain of an amplifier. There is a well-known way of doing this in which a single grounded on-off switch either permits or prevents the application of the input voltage to the amplifier non-inverting input. In the first case and assuming an ideal op-amp there is no current flow in and hence no voltage dropped across any of the resistors. Hence the output and input voltages are equal with a voltage gain of +1. With the switch closed the non-inverting input is grounded and the amplifier becomes a see-saw amplifier of gain —1.

SWITCHED INTEGRATOR



The last stage in this process eliminates the extra amplifier completely. The input voltage is applied to the integrator input and via a potential divider to the non-inverting input. The single resistor of the integrator is tapped and connected to one side of a switch the other side of which is grounded. Inspection of the circuit for the two cases then shows that the polarity of the voltage across the resistor R is reversed as the switch changes state. Letting the resistor ratios be n and m as shown then there is a relationship between the values of n and m at which the voltages across R are of equal magnitude for the two cases. This condition, for one very close to it allowing for the practical errors, is the condition for equal but opposite slopes. In practice it is usual to replace or modify one of the series pairs of resistors by a potentiometer, which is trimmed to a triangle. The number of amplifiers is reduced to one, the switching is reduced to that of a single grounded on-off switch and the performance is comparable to the earlier proposals needing two amplifiers and/or multiple changeover switches.

ALTERNATIVE CONFIGURATION



As usual there is another related configuration that can provide the same function. It represents a shift in ground point for the input network such that the switch is connected from the free end of the generator to the tapping point of the resistors feeding the integrator. Again the polarity of the voltage across R is reversed leaving a relationship to be derived between m and n for equal but opposite slopes. It is not obvious whether this form has any particular advantage, and it is often easier to provide a grounded switch by using a common-emitter or common-source stage. Either form is easily implemented using analogue gates such as those available in c.m.o.s. form. These have relatively high and variable on-resistances making the circuit more accurate when R,R' are large. This places a greater constriant on the allowable input currents and as for all integrator based circuits, op-amps with f.e.t. input stages are preferred.

Triangular wave generators — 1

THEORY

● For the two states of the switch

(i) $\left(\frac{dV_o}{dt}\right)_1 = \frac{I}{C}$

(ii) $\left(\frac{dV_o}{dt}\right)_2 = -\frac{I}{C} = -\left(\frac{dV_o}{dt}\right)_1$ (1)

● If the input bias current is I_B the slopes are

(i) $\left(\frac{dV_o}{dt}\right)_1 = \frac{\frac{V}{R}+I_B}{C}$

$$\left(\frac{dV_o}{dt}\right)_2 = \frac{-\frac{V}{R}+I_B}{C} = -\left(\frac{dV_o}{dt}\right)_1 - \frac{2I_B}{C} \qquad (2)$$

● For the second circuit, with switch short-circuited to ground the input resistor R_1 and the switch on-resistance R_{ON} the voltage gain is obtained by equating the op-amp input voltages

$$\frac{V+V_o}{2} = \frac{VR_{ON}}{R_1+R_{ON}}$$

$$\frac{V_o}{V} = \left[\frac{2R_{ON}}{R_1+R_{ON}} - 1\right] = -\left[\frac{R_1-R_{ON}}{R_1+R_{ON}}\right] \qquad (3)$$

For $R_{ON}/R_1 \approx 1\%$ the gain is reduced in magnitude by $\approx 2\%$ and this can be corrected for by increasing the feedback resistor by 2%.

● Capacitor current is defined by that in the resistor R. Let the currents be I_1, I_2 for switch open and closed

Switch open $$I_1 = \frac{\left(V-\frac{V}{1+m}\right)}{(n+1)R} = \frac{V}{R}\cdot\frac{m}{(1+m)(1+n)} \qquad (4)$$

Switched closed $$I_2 = -\frac{V}{1+m}\cdot\frac{1}{R} = -\frac{V}{R}\cdot\frac{1}{1+m} \qquad (5)$$

For triangular output i.e. equal but opposite slopes,

$I_1 = -I_2$

$$\frac{m}{(1+m)(1+n)} = \frac{1}{(1+m)} \qquad m = 1+n \qquad (6)$$

For example with $n=1$, $m=2$.

● A similar result obtains for the alternative circuit and again the currents say I_3, I_4 correspond to the switch open and closed respectively

Switch open $$I_3 = -\frac{Vm}{(1+m)}\cdot\frac{1}{(1+n)R} \qquad (7)$$

Switch closed $$I_4 = \frac{V}{(1+m)}\cdot\frac{1}{R} \qquad (8)$$

For triangular-wave output, $I_3 = -I_4$

$$\frac{m}{(1+m)(1+n)} = \frac{1}{1+m} \qquad m = 1+n \qquad (9)$$

Again for $n=1$, $m=2$.

The identity of results for the two circuits should not be surprising. The circuits effectively represent a reversal of input connections to the same passive networks. So the same resistor ratios result in a triangular waveform in each case.

Equations 4, 5 & 7, 8 allow the design of waveforms with different values of positive and negative slope. For example you can see that n affects only one of the currents in each case (I_3 in equation 7 and I_1 in equation 4).

EXAMPLES

1. An op.amp integrator uses a 0.1µF capacitor and a drive resistor of 100kΩ. If the drive voltage is switched between ±5V calculate the switching frequency for an output triangular wave of amplitude 5V peak-peak. Assume for this part of the question that the amplifier is ideal. If the amplifier input current is +0.5µA show that the positive and negative slopes differ in magnitude by about 2%. What mark-space ratio is needed at the input?

(a) During the positive input part of the cycle

ΔV_o is —5V, ΔV_c 5V,
V 5V, R 100kΩ, and C 0.1µF

$$\frac{dV_c}{dt} = \frac{I}{C}$$

$$\Delta t = \Delta V_c \cdot \frac{C}{V/R}$$

$$= \frac{5.10^{-7}}{5/10^5} = 10^{-2}\text{s}$$

∴ Complete period is 2.10^{-2}
Frequency 50Hz

(b) With the amplifier input current as given, the net charging current for positive drive is
50—0.5 = 49.5µA
For negative drive, net charging current is 50.5µA
Slope ∝ I
∴ % change in slope $\approx 1/50 \times 100 \approx 2\%$

(c) With unequal charging currents the waveform is no longer triangular. For it to be at least a repetitive waveform the *mean* voltage must remain constant i.e. because the positive and negative currents now differ in magnitude then the times for which they flow have to be adjusted to compensate. Let the two parts of the cycle (mark/space) be t_1, t_2.

$t_1 \cdot I_1 = t_2 I_2$

$$t_1/t_2 = I_2/I_1 = \frac{50.5}{49.5} \approx 1.02$$

2. The switched integrator is designed for an output frequency range of 0 to 10kHz for an input voltage of 0 to 15V with R 10kΩ, n 1, m 2. Calculate the value of capacitance required if the output amplitude is to be 20V peak-peak.

For input of 15V and switch open, capacitor current is

$$\frac{⅔ \cdot 15}{2 \cdot 10^4} = 5.10^{-4}\text{A}$$

This current must charge capacitor through 20V in 50µs

$$\text{i.e. } \frac{5.10^{-4}}{C} = \frac{20}{½ \cdot 10^4}$$

$$C = \frac{5.10^{-4}}{40.10^{-4}} = \frac{10^{-8}}{8}$$

$= 1.25\text{nF}$

3. What is the input common-mode voltage and why might there be difficulties if the circuit were to be used as an f.m. generator with relatively high modulating frequencies?

$$\text{Common mode voltage} = \frac{V_{in}R'}{mR'+R'} = \frac{V_{in}}{m+1}$$

If V_{in} varies rapidly then in addition to varying the charging currents it provides a high-frequency common-mode voltage which the amplifier will reject only imperfectly. This would appear as a small amplitude modulation term.

Converting between analogue and digital quantities — 1

continued from page 46

In a bipolar code one bit, that in the m.s.b. position in the codes shown, carries the sign information. In the *sign + magnitude* code, the bits after the sign bit give the magnitude coded in natural binary. Sign magnitude b.c.d. is the code used extensively in bipolar digital voltmeters.

The *offset binary* code is simply a natural-binary counting sequence which is interpreted in terms of an offset of the analogue scale which it is used to represent. The zero of the natural-binary counting sequence (0000) is used to represent analogue full-scale negative, the count 1000 represents an analogue zero and the full count 1111 represents $+7/8$ analogue full-scale (full scale -1). Offset binary, as will be shown when converter circuits are discussed, is one of the easiest bipolar codes to implement.

The *two's complement* code is a natural-binary code for values of the analogue variable from zero to full scale positive. The code for the analogue values $-1/8$ full scale to full scale negative is obtained by complementing in turn the codes for the values 0 to $+7/8$ full scale. Complementing means simply changing the state of all bits.

Table 6 gives bipolar codes involving four bits, but each code is readily extended to any number of bits by using the principles on which the codes outlined above are founded. It should be noted that in any n-bit bipolar code one bit is always used for sign information, the remaining $(n-1)$ bits carrying the magnitude information. The analogue range ($\pm$ full scale) of an n-bit unipolar code, but the ratio of the analogue magnitude of l.s.b. to the full scale analogue magnitude is $2^{-(n-1)}$ for the bipolar code, and not 2^{-n} as it is for a unipolar code. The resolution of an n-bit bipolar code is twice as coarse as that of an *n-bit unipolar code.*

Bipolar codes do require rather more care in interpretation than unipolar codes. In Table 6, it has been assumed that an increase in the digital number corresponds to a positive increase in the analogue variable, but this is not always so – it depends upon the details of the converter circuitry. In some converters an increase in the digital numbers corresponds to an increasingly negative value of the analogue variable, and if this is the case the bipolar codes should be reinterpreted by changing the signs of all the decimal fractions.

The treatment of codes has by no means covered all codes in use but it has, it is hoped, demonstrated the essential role of a code in any a-to-d or d-to-a conversion. Readers interested in a more exhaustive treatment of the various codes and their relative advantages and disadvantages are referred elsewhere [3,4]. In any case, advantages and disadvantages can only be understood in relationship to the practical details involved in particular conversion techniques.

To be continued

References

1. Lucinda Mattesa. "Data Converters Latch on to Microprocessors." *Electronics*, p.81, Sept. 1, 1977.
2. D. Fullagar, P. Bradshaw, L. Evans, W. O'Neil. "Interfacing Data Converters and Microprocessors." *Electronics*, p.81, Dec. 9, 1976.
3. D. H. Sheingold. Editor "Analog to Digital Conversion Handbook." Analog Devices Inc. 1972.
4. Herman Schmid. "Electronic Analog/Digital Conversions." Van Nostrand Reinhold Company, 1970.

Table 6 Commonly Used Bipolar Codes

Number	decimal fraction	sign+ magnitude	two's complement	offset binary
+7	$+7/8$	0111	0111	1111
+6	$+6/8$	0110	0110	1110
+5	$+5/8$	0101	0101	1101
+4	$+4/8$	0100	0100	1100
+3	$+3/8$	0011	0011	1011
+2	$+2/8$	0010	0010+1	1010
+1	$+1/8$	0001	0001	1001
1	0+	0000	0000	1000
0	0−	1000	(0000)	(1000)
−1	$-1/8$	1001	1111	0111
−2	$-2/8$	1010	1110	0110
−3	$-3/8$	1011	1101	0101
−4	$-4/8$	1100	1100	0100
−5	$-5/8$	1101	1011	0011
−6	$-6/8$	1110	1010	0010
−7	$-7/8$	1111	1001	0001
−8	$-8/8$		(1000)	(0000)

Letters to the editor

INTERFERENCE FROM ELECTRONIC IGNITION

Many articles and letters have been published both in *Wireless World* and other technical publications on the subject of electronic ignition systems for cars. So far, however, I have not seen any mention of the influence that these systems have upon radio interference. I have installed in my car what is probably the most popular unit, and the result has been an increase in the level of medium-wave interference of about 8dB. Nothing that either the manufacturer's representatives or myself could do, could reduce the interference by more than about 2dB.

I wonder if any other readers have had similar experiences and have succeeded in effecting a cure.

Roy C. Whitehead,
Sutton,
Surrey.

UNIT PREFIXES

I would like to echo G. C. Oxley's complaint (February letters) about the misuse of prefixes in electrical units.

I read recently in a national newspaper that the government of Iran had cancelled an order for a group of French nuclear power stations generating a total of 900 mW. Quite right too!

J. W. Semple
London SW2

Wireless World index and binding

The index for Volume 84 (1978) of **Wireless World** will be available in May, price 50p including postage, from the General Sales Department, IPC Electrical-Electronic Press Ltd, Dorset House, Stamford Street, London SE1 9LU.

Our publishers also offer a service of binding volumes of **Wireless World,** each complete with the appropriate index. If you wish to use this service send your copies to Press Binders Ltd, 4-4a Iliffe Yard, Crampton Street, Walworth, London, SE17 with your name and address enclosed. Confirm your order to the General Sales Department (address in first paragraph) and with this letter to Dorset House send a remittance of £6.65 for each volume (this price includes the index).

In both cases cheques should be made payable to IPC Business Press Ltd.

LETTERS TO THE EDITOR

DISTORTIONLESS CURRENT DUMPING

Readers of your journal are challenged by J. Vanderkooy and S. P. Lipshitz to produce a current dumping circuit without distortion (June 1978, pp.38-40). In that article it is shown that the dumper non-linear voltage-current behaviour may be eliminated from the circuit output by a slight change in the bridge balance. The non-linearity in the base current-collector current relation cannot, with the original circuit, be completely cancelled.

A minor modification of the bridge changes this situation. Consider Fig. 1, an amplifier with voltage amplification A and output impedance Z_0. Signal voltage V_s is applied to the positive input. Then:

$$V_s = V_s' + \frac{Z_0}{A} I_A + \frac{V_2}{A} \qquad (1)$$

Amplifier load will determine the negative input voltage V_s', output current I_A and voltage V_2.

Clearly, if the equation is to represent a linear amplifier, its right hand side must equal a constant times V_0, the circuit output voltage. In the original circuit, current dumper non-linearity will appear both in I_A and V_2, base current being part of I_A and base voltage being equal to V_2. To be eliminated from the equation the terms representing non-linearities must appear at least twice and with different signs. This is true for V_2 and the coefficient for V_2 can be made equal to zero by a change in the bridge balance. The non-linear base current on the other hand appears only in the amplifier current and can produce no additional term to cancel its presence in I_A. A term proportionate to $-I_b$ is needed and can be obtained in several ways.

A simple solution is shown in Fig. 2. Base current is converted to base voltage with the aid of Z_b. The base current non-linearity is now in the V_b term. By working out the equations:

$$V_s'\left(\frac{1}{Z_s}+\frac{1}{Z_1}+\frac{1}{Z_2}\right) = \frac{V_1}{Z_1}+\frac{V_b}{Z_2} \qquad (2)$$

$$V_0\left(\frac{1}{Z_L}+\frac{1}{Z_3}+\frac{1}{Z_4}\right) = \frac{V_1}{Z_4}+\frac{V_2}{Z_3} \qquad (3)$$

$$V_2\left(\frac{1}{Z_3}+\frac{1}{Z_b}\right) = I_A+\frac{V_0}{Z_3}+\frac{V_b}{Z_b} \qquad (4)$$

a solution is obtained for the signal voltage:

$V_s = aV_0 + bV_2 + cV_b$

where $b=0$ if:

$$\frac{Z_4}{Z_3}=\frac{Z_0}{A}\left(\frac{1}{Z_3}+\frac{1}{Z_b}+\frac{1}{Z_0}\right)\left(1+\frac{Z_1}{Z_2}+\frac{Z_1}{Z_s}\right) \qquad (5)$$

and $c=0$ if:

$$Z_b=\frac{Z_0}{A}\left(1+\frac{Z_2}{Z_1}+\frac{Z_2}{Z_s}\right) \qquad (6)$$

It appears that a driving amplifier with a constant and well-defined transconductance ($G_m = A/Z_0$) is best suited for this bridge. With such an amplifier, Z_0 approaches infinity and the balance condition is simply:

$$\frac{Z_3+Z_b}{Z_4}=\frac{Z_2}{Z_1} \qquad (7)$$

when Z_b has been chosen according to:

$$Z_b=\frac{1}{G_m}\left(1+\frac{Z_2}{Z_1}+\frac{Z_2}{Z_s}\right) \qquad (8)$$

Z_b is of course to be kept low.

Balance can still be maintained if Z_2 is a capacitance. Z_b will have to be a R-C series combination and Z_4 a L-R series combination, a fair approximation of a real-life inductor.

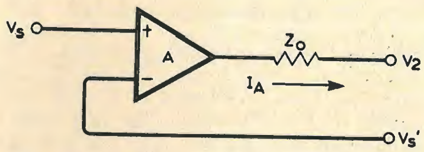


Fig. 1. *Basic driving amplifier*

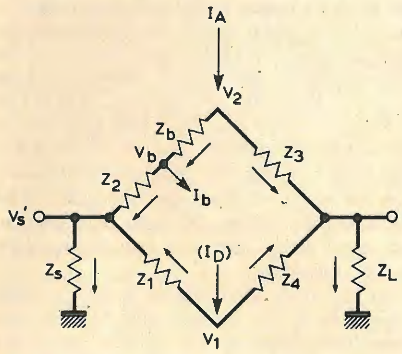


Fig. 2. *Modified bridge*

Tore Hevreng
Stockholm
Sweden

The authors comment:

The contribution of Mr Hevreng does indeed satisfy the requirements of our challenge! We congratulate him on the elegance and conciseness of the exposition. Now that we more fully understand the relationship of voltage and current distortion, several comments are in order.

For a resistive bridge and a constant real A, the four components can be altered to give exact voltage distortion cancellation, and Hevreng shows how a slight change by using an additional component Z_b also removes the current distortion. When A is allowed to become very large, the simple bridge balance condition obtains and the additional component Z_b becomes zero as well. We prefer to view the bridge in Hevreng's Fig. 2 with the node V_b at the top and the class A amplifier current I_A injected into the Z_b–Z_3 arm. The base current through Z_b will generate a compensating signal to the output through Z_3.

We point out that a class A amplifier with infinite output impedance, and specified therefore only by its transconductance, implies an infinite internal gain and current feedback. (However, the collector of a cascode output transistor can have a high output impedance in practical circuits.) It is not necessary to do this, of course, it being then required to use the balance equations 5 and 6. In fact, Hevreng's realization for infinite Z_0 (eqns 7 and 8) actually also applies if Z_0 is finite (eqns 5 and 6); Z_2 is taken to be capacitive and then Z_b can be a series RC and Z_4 a series LR combination. A difficulty with this realization is that now there is no d.c. path to the dumper bases. Any rectification effects due to different upper and lower dumper current gain may cause an offset, which must be cancelled by an increasing current through Z_3. Hence the class A amplifier may saturate. The function of the current dumping concept is to arrange matters such that the power delivered by the class A amplifier is quite small. A practical realization probably needs a d.c. path through Z_b or Z_2, and such realizations are possible. Practical implementation may, however, remain a difficulty.

We note, referring to Mr Hevreng's Fig. 2, that there are two "nodal" points on the generalized bridge circuit where externally applied signals do not influence the output signal V_0. One is at V_1, where the dumper current I_D has no effect on V_0, its only function being to supply most of the load current into Z_L when so demanded by V_s. The other point is V_b, created by the extra bridge component Z_b, (and of course the non-zero value of Z_0), such that current, from this point, namely dumper base current, also generates no signal at V_0. We have built a model circuit which demonstrates these features very clearly. The function of the dumpers is to amplify current, and since V_1 tends to track V_b (and also V_2, approximately) due to the emitter follower action of the dumpers, the load on the class A is minimised.

As a final comment, it is of interest to note that the number of nodal points can be increased ad nauseam by replacing Z_2 and Z_b (or Z_1 and Z_4) by more parallel networks having the same impedance ratios and the same total conductance as the original. This feature may be useful in driving parallel dumper stages. If anyone devises another use for the additional nodes, please inform the readers of this magazine.

J. Vanderkooy and S. P. Lipshitz

MILITARY ELECTRONICS

As a supporter of the Campaign Against Arms Trade, I would like to say how pleased I was to read your editorial in January's issue. Not pleased with the subject matter, of course, but pleased to see some publicity being given to the fact that electronics has been so prostituted from being for the good of mankind to its destruction. It never ceases to amaze me that engineers should allow themselves to be used in this way and at the same time should ask for more recognition for the valuable contribution that engineering makes to the community.

While a large proportion of the world is suffering and starving how can we connive at the continuance or worsening of this situation by our wrong use of resources, and in making and selling that which is intended for death and destruction, and still ask for respect? Respect for what? For our cleverness and ability in technical achievement perhaps, but surely not for our humanity or good sense. Only by a blinkered approach to the excitement of our work, or our own personal progress together with a nationalistic view of Britain's role in the world, can there be any justification for work on weapons or electronics for "defence". But we have been repeatedly told that for an engineer a much wider view is necessary.

I believe that it is the personal responsibility of all those working in electronics, but especially the design engineer, to see that his talents are being used for the good of all mankind. We must not just be the willing servants of those who tell us that they know best what is good for us.

I would be interested to hear from those who agree with all or part of this letter.

Wilfred Laycock
Abingdon
Oxon

DISPLACEMENT CURRENT

I would be grateful, sir, if you would kindly give me some space to point out, and endeavour to correct, certain errors and misconceptions that occur in the article "Displacement current" by Catt, Davidson and Walton in the December 1978 issue.

To say, as they do, that inductance does not exist in a capacitor is just not true: it may be small, but nevertheless it is there. A bifilar resistor has inductance but it is made small by doubling the wire back on itself in the form of a hair pin so as to give a loop enclosing a small area. The same is true when the wire is replaced by a thin conducting sheet doubled back on itself. Snipping the sheet along the folded edge gives, when rolled up, a rolled-foil capacitor – but it still has inductance. In field terms, this inductance represents the magnetic field in the very narrow space occupied by the dielectric. It is quite valid, as the authors do, to consider the capacitor as a transmission line; indeed it is necessary to do so if the length of the foils (or the radius of the circular plates in the authors' Fig. 1) is comparable with a wavelength. In undertaking such an analysis, it is necessary to consider the inductance and capacitance (respectively L_1 and C_1 per unit length) of the equivalent transmission line. The characteristic impedance $Z_0 = \sqrt{(L_1/C_1)} = \sqrt{(\mu/\epsilon)}$ in the loss-free case, needs a non-zero inductance to give it a non-zero value. Likewise the velocity of propagation $v = \sqrt{(1/L_1C_1)} = \sqrt{(1/\mu\epsilon)}$ needs a non-zero inductance to give a finite propagation velocity, a requirement the authors state in their second paragraph. In trying to dispense with this inductance, the authors' analysis in the Appendix becomes confused. In the equation $T=(1-k/n)^n$ it is certainly true to say that, as n increases indefinitely, T tends to the limit exp $(-k)$ *but only if k is fixed.* Since the authors have put $k=2nZ_0/R$ the analysis is immediately suspect and this suspicion is confirmed when n then reappears as a finite number.

In spite of appearances, such as introducing ideas of reflections on a transmission line, the authors' analysis is a quasistatic one and the equation they are deriving is quasistatic also. This being so, it is of little consequence whether one assumes an infinite propagation velocity, which the authors object to, or a zero propagation time which the authors are actually doing. Starting from equation 7 (or 6) and ignoring what follows enables us to redefine T as the time for a double pass: the time for n two-way passes is therefore $t=nT$. Also $t=2l/v=2l\sqrt{L_1C_1}$ (where l is the length of the line) and we can therefore write the characteristic impedance as $Z_0=T/2lC_1=T/2C$ where C is the "total capacitance". Equation 7 now becomes

$$V(t) = V\left[1-\left(\frac{1-T/2RC}{1+T/2RC}\right)^{t/T}\right]$$

where inductance does not appear explicitly, but it is there implicitly since it controls the value of T: if L_1 becomes vanishingly small, so indeed must T. Saying, as the authors do, that L_1 does not exist is tantamount to saying that T is zero. All that is now necessary is for the limit to be taken as T vanishes. To do this, put $n=t/T$, eliminate T and let $n\to\infty$: this gives

$$V(t)=V[1-\exp(-t/RC)]$$

All this has not involved, explicitly, a displacement current simply because the analysis has been conducted in circuit terms rather than field terms. This, of course is quite valid provided that only the dominant mode is involved, which it is because the analysis is quasistatic: indeed a circuit analysis is better suited to this type of solution. A field analysis would have *needed* a displacement current, but it would also have needed a magnetic field. Whether the authors like displacement current or not, their quarrel is not with it but with the magnetic field in the dielectric of the capacitor. The analysis in their Appendix actually gets rid of the magnetic field by declaring that the inductance does not exist: it does *not* get rid of the displacement current (in spite of what the title says) since they use capacitance, its circuit equivalent.

The authors' arguments in the second paragraph do not reveal any flaw in the model presented by Maxwell's equations which need displacement current for consistency. This "mathematical manipulation", no matter how convenient it is from that point of view, would have no value whatsoever if the consequence of a proper application of Maxwell's equations was to produce a result that did not conform with the true state of affairs. The authors have not shown this to be the case in their example, and though I consider Maxwell's equations to be postulates that may be approximations to a more general theory (like Newton's laws are), I do not consider their example to present the sufficiently severe test necessary to the nature of the approximations in those fundamental equations. The flaw, as I see it, is in the authors' understanding rather than in the model, as illustrated by the statements in the second paragraph of the article.

Take first the word "suddenly". Why do we have any need to imagine a "sudden" distribution of charge over the plate any more than we need to explain how a charge moves suddenly from the far end of the wire connected to the capacitor plate to the plate itself? As the authors state, there is a finite velocity by which effects are propagated, but why do the authors imagine (if I understand their statement) that displacement current makes this velocity infinite? It is easy to show that *ignoring* displacement current indicates an infinite velocity, and it could be said that this is a valid reason for including it, not getting rid of it.

Now take the statement that the charge on the plates is uniformly distributed. This is not true if the quantities concerned are varying with time. It is a perfectly general principle that uniform fields varying with time cannot exist: we may be able to produce an approximately uniform field even up to fairly high frequencies but it does not invalidate the principle. The uniformly distributed charge is a quasistatic approximation arising from the small reactive effect of the magnetic field within the dielectric on the electric field distribution. In circuit terms this is equivalent to saying that the effect of inductance is negligible. Maxwell's equations certainly do *not* indicate a uniformly-distributed charge, but maybe this is what the authors imply when they say there is a flaw in the model. But by what argument can it be said that the charge distribution *is* uniform? Indeed, we ought to *expect* a non-uniform distribution, and the greater the radius of the plates, the greater will be the non-uniformity in the radial direction, but then the situation is changing from the quasistatic one to a propagation or travelling wave model.

I would suggest that if there is any paradox, the authors have got the wrong culprit. The model they call faulty works fine and the concept of displacement current is essential to it. I agree with the statement "Work on high speed logic design has shown that the model of a lumped capacitance is faulty", but no further. Any lumping must be faulty since it implies no physical size and/or no time delay. In situations where the time delay is important, quasistatic models will need replacing by those that include propagation effects, but this can only be done by including magnetic flux (or its circuit equivalent, inductance) *and* displacement current (or its circuit equivalent capacitance). Declaring that either one or the other has negligible effect gives a quasistatic model (in the loss free case) and clearly this is not what the authors want.

K. O. Sharples,
Department of Electrical and Electronic Engineering,
The City University,
London, EC1.

The authors reply:
We do not say that (distributed) inductance does not exist in a capacitor. We said that *series inductance* does not exist. The conventional model of a capacitor with stray series inductance is wrong. Thence, the idea of a capacitor's self-resonant frequency is wrong. *Distributed* inductance, such as exists in a transmission line, does exist, and we use the formula $Z_0=\sqrt{(L/C)}$. We feel that the whole of Mr Sharples's letter founders because he confuses series inductance with distributed inductance.

I. Catt, M. F. Davidson and D.S. Walton.

RIDICULOUS UK

I wonder whether your UK readers realize how patently *ridiculous* your country appears to us when we read of opposition to the introduction of citizens' band radio in the UK ("Mobile CB Dangers" — January letters).

We have millions of c.b. radios operating in North America in everything from baby carriages to giant trucks and airplanes and we hear from the UK that it is socially and technically undesirable!

I. Switzer
Switzer Engineering Services Ltd.
Mississauga
Ontario, Canada

A news item in this issue gives a list of countries using c.b. — Ed.

ITALIAN 3D TELEVISION BROADCAST

In your November 1978 issue I read the brief survey of 3D television experiments performed in various parts of the world. On Sunday, 4th February we in Italy also had our first short experimental broadcast. It lasted for five minutes or so and was repeated several times on the following Sunday evenings. The event was described as "experimental", and it really was, but the word "experimental" has an uncommon meaning when referring to RAI, the state broadcasting company. (Fifteen years ago RAI started experimental f.m. stereo broadcasting, for two hours a day, and they are still "experimenting" today.)

In front of the television camera was placed a mirror that completely reflected a range of colours and allowed all the rest to pass through. The mirror produced two images, and these were spaced by 8 centimetres, corresponding to the spacing of the eyes. The two images were then sent to the camera for transmission. At the receiving end of the television link the viewer's eyes, helped by a red and blue coloured lens, 'decoded' the three dimensional information.

Of course, the 3D television broadcast was not compatible with monochrome tv sets and colour sets without lenses because it caused two images, slightly apart, to appear on the screen.

Pierangelo Pensa
Rogena
Italy

A.M. FOR V.H.F. BROADCASTING?

No one will wish to take issue with 'Cathode Ray' about the difficulty of listening to sound radio ("Instant tuning"; September issue), but he seems to miss some essential points.

Firstly, he does not ask why it is that politicians and financiers worry about the fourth television channel while there are insufficient transmitting facilities for the radio services already being provided. Clearly, those who want better radio will have to fight for it. Unfortunately, 'Cathode Ray' suggests only the most obvious improvement, which is to make available more of the 88-108MHz band to accommodate more f.m. transmissions. Apart from its lack of economy, the trouble with this idea is that for a significant proportion of the population our existing f.m. system has none of the advantages he lists. This large city has a local booster, but in many districts the signals are still too weak for ordinary portable sets. The distortion of weak or slightly mistuned f.m. signals has an unpleasant quality which drives listeners to the medium waveband, even after dark. This type of distortion is relatively rare with television sound, suggesting a lack of transmitted power in Band II.

Power is limited by cost, and by the need to avoid interference; it is doubtful whether the money or the bandwidth to improve the system will be provided in the near future. On the other hand, there is no reason why a.m. (or some other form of modulation less profligate in bandwidth than f.m.) should not be used for some v.h.f. broadcasting, f.m. being retained for one or two high quality channels. Dual standard receivers should present fewer problems than current multi-waveband sets, and 'Cathode Ray's' push-buttons could easily be arranged to provide automatic mode switching. In addition, there might well be room for a few slow-scan television channels.

C. R. Lee
Sheffield
South Yorks

THE SOLICITOR'S LOT

Few, if any, of the letters you receive are prompted by your leading article or the other regular features of your publication. May I therefore take the liberty of writing to you in reply to a section of Mixer's Sidebands in the February issue. In particular the paragraph subheaded "Jack and his Master, both". I am a member of the legal profession, a solicitor to be precise, and I take issue with Mixer on his criticism of the "legal brotherhood" which presumably includes me. He says we don't strike because we are "doing very nicely out of [our] clients as it is".

As I say, I am a solicitor. I am also a radio amateur (G3MUX); one of the very few (four I am told) of my profession who are. I take this opportunity of notifying your readers, in case they are under any misapprehension, how we earn our living. We are only able to practise after a long and quite hard training, lasting about five years. We depend for a living on our ability to attract clients from the public. If they don't like me, they can go elsewhere and I starve. If I don't do my job well, I get sued for all I have — and I starve again. But I cannot advertise. I rely for new clients on a reputation I have built up and on that reputation being circulated around the area. I can do little to encourage that process other than to do my job so well that others talk about it to their friends. I have to provide all the not inconsiderable capital I need myself. I receive very little by way of public funds. If I don't work, and work effectively, I starve. I do not go on strike because I do not care for the practice of hari-kari.

If, with all these disadvantages, I can still "do very nicely", is that a criticism — or a compliment? If the average trade unionist had to earn his living under these conditions, he would stop bellyaching and get on with his job. He has a lot to learn from the professions — from mine at any rate.

C. E. H. Benson
Weston-under-Redcastle
Shrewsbury

AUDIO KITS AND MODULES

If a buyer wishes to choose a ready-made item of audio equipment it is not normally too difficult for him to hear comparative demonstrations or to try the unit out in a shop. With kits and modules as advertised in *Wireless World* and other journals this is seldom possible. How is the buyer then to choose? It is beyond argument that figures and specifications are often totally remote from real quality assessments. The reputation of a supplier or a design? Yes, but this would preclude dealing with newly established concerns and newly introduced items. Testimonials? Yes, one advertiser supplies these and they are in glowing terms and often above the signatures of those who can be depended on to know what they are talking about. However, one splendid sounding unit is made bh a concern which has to date noth bothered with testimonials to the extent of making them available to potential buyers but depends on word of mouth recommendations from one satisfied customer to those in the circle of such communication.

In my view the best service that *Wireless World* could do its readers is to review the major items offered as modules or in kits. Such points as inferior socketry, as pointed out by Graham Nalty in the August issue (Letters), could be noted and the suppliers could then offer something better or the buyer could himself substitute the better grade item. Meanwhile it would help if the suppliers would ensure that testimonials were available or, if the item draws no favourable comments, seek to discover why and remedy the position; it could be "a cheap speaker switch acting as a diode"!

Ivor Abelson
Southgate
London N14

COMPUTER BUSES

In his first article on computer buses (February issue), Ian Witten shows in Fig 18 a "fully interlocked bus" which, unfortunately, is almost bound to fail.

Suppose the "address" and "address valid" lines are set up. Then the clock loads the D flip-flop and subsequently the register. This will happen repeatedly until the "address valid" is removed. The next clock pulse will load zero into the flip-flop, but will have also simultaneously clocked the existing value of Q (logic 1) into the load of the register; so whatever rubbish existed on the data bus will have been copied into the register.

A fully interlocked bus would load the register independently of an internal receiver clock, avoiding this difficulty.

Nicholas Honner
Maidstone, Kent

The author replies:

Nicholas Honner points out that in Fig 18 of my article, "data accepted" is asserted by the slave device at the first clock tick after "address valid" has been asserted with the correct values on the address bus, but the "load" operation does not take place until the second clock tick. Thus if the bus master were to remove data from the bus as soon as it sees "data accepted", rubbish would be read. However, under fully-interlocked transmission the bus cycle is not complete until "data accepted" is de-asserted by the slave, and the master is obliged to hold the data on the bus until that time. Under these conditions the transfer will take place correctly.

This correspondence makes the point very clearly that before attaching devices to a bus, one must study timing diagrams for the particular protocol that is being implemented. It often happens that the master is able to guarantee that the address lines have settled fractionally before the data is available, and this is the reason for delaying before loading the register in the circuit. However, it seems to me that a detailed study of transfers on a particular bus, with timing diagrams, would (while interesting) lead to a level of detail which is inappropriate for a tutorial article.

ELECTRONIC ORGANS

The performance of an electronic organ is not to be judged by its circuitry, but by its suitability for the kind of music required of it. A designer for commerce has to adopt many compromises for economic and production reasons, but the enthusiast suffers from no such limitations. We will always have people who say the cinema organ is superior to the concert organ and vice versa, and rightly so because such sentiments are expressions of art, and art has no measurable parameters. Equally, we shall always have devotees of the additive systems as opposed to the subtractive methods (February letters); these are two different schools of thought but, once the main tonal structure has been decided upon, there are certain limitations better overcome by one system than the other. *If* limitation of a pipe organ is the aim, then regulation or the relative value of one note to another is more easily carried out by Dr Ryder's system; it is never really successful with subtractive synthesis and is influenced by quirks of the loudspeaking system at different power levels.

Shall we say that the subtractive method yields quasi-orchestral sounds well suited to domestic tastes and unskilled performers; whilst the additive systems allow of classical and baroque tonal structures (which are of necessity simple voices to obtain the required clarity and definition for contrapuntal music).

Hammond has been quoted; but how many recall that when he first launched his organ he said "Whilst the Hammond organ is played like a pipe organ, it is not made in imitation of one; it is a new musical instrument with a voice of its own"? Instruments of the electro-mechanical type are beyond the power of the amateur to construct and confer no advantages; the Compton generators do have integrated harmonic series rings and some fully-formed tone rings, but they do not seem to have any advantage over semiconductor systems and keying is elaborate and costly.

Domestic organ designs have tended to settle for the simple divider systems yielding square or synthetic sawtooth waves; it is refreshing to see a new design for the home constructor and if my opinion is worth anything, it appears to be the answer to a good many problems.

Alan Douglas
Nottingham.

POST OFFICE MONOPOLY

Some interest has been shown recently in the so-called Post Office monopoly. Mr Chapple, secretary of the EETPU, is quoted as being in favour of people being allowed to connect whatever they like to the ends of PO circuits (your January 1979 issue, page 48).

Alas, as is so often the case, the real restrictions have been overlooked, and attention is unnecessarily being focused on the least important aspect of the monopoly.

The PO is rightly concerned about the safety and interference potential of equipment connected to its plant. It is not really interested in whether or not the equipment is efficient and performs its required function – that is up to the user. It seeks to ensure that equipment connected to its plant will not generate dangerous voltages or produce signals which interfere with other users. Who can blame them for that?

The real problem with the PO, however, is its refusal to allow non-PO organisations to provide certain types of communication systems from their own resources. It will not allow organisations to communicate with each other unless the means of communication is provided by the PO usually at very high cost. It will, for example, insist that you pay perhaps £100,000 for a telephone exchange, refuse to allow you to do what you like with it and then insist that it maintains it for you again at high cost. If you think you can run a piece of wire between your house and your favourite betting shop and rig up a telephone circuit, you have another think coming because the PO monopoly will not permit you to do this. You must have the piece of wire from the PO and pay a rental charge. If you happen to own the betting shop that's a different matter altogether because you would then be legally entitled to provide your own means of communication.

Regulation of the use of the radio spectrum is obviously essential but even when you manage to get a licence and a frequency allocation to enable you to set up a radio network, there are many restrictions arising from the monopoly which negate many of the potential benefits arising from the use of radio communication.

These are among the many aspects of the PO monopoly which must be resisted at every opportunity. Despite what many people say this country has a very efficient public telephone system. It is a great pity that the private sector (i.e. non-PO) is not allowed to develop its own communication systems without having to face petty restrictions, monopolistic attitudes and high costs at every turn.

J. G. Kelly
Edinburgh

LORD KELVIN AND PHILIPS

I was quite touched to see the reference to Thomson and Tait's *Treatise on Natural Philosophy* in the worthy tribute to Professor Bernard Tellegen in the February issue. William Thomson (Lord Kelvin) was the Professor of Natural Philosophy here for 53 years. But I was rather worried by Arthur Garratt's definitions of the "most significant inventions" in radio. These surely have to be the *essential* inventions — the diode, the resonant circuit, the audio transducers, the aerial system, etc?

I would like to comment on two of these items if I may. Firstly there is a letter in the Kelvin Correspondence at Glasgow University, from C. H. Stearn to Thomson in which he describes the effect of embedding a separate wire in a carbon filament bulb, giving measurements of the current between filament and wire and showing the dependence on filament temperature. This was in 1885 and he says he has mentioned his experiments to "Dr Fleming". I do not know if this work was published.

Secondly the resonant circuit — and I have hardly any excuse for mentioning this other than that I suppose it is the father and mother of the gyrator and also that I feel that it is not generally realised that the first investigation into the frequency of an LC circuit, deriving essentially the $f.2\pi\sqrt{LC}=1$ equation, was made by Thomson (*On Transient Currents*, 1853) although the occurrence of an oscillatory behaviour had been anticipated by Helmholtz in 1847.

Perhaps two other items of gossip about Thomson/Kelvin may be of interest. Some two years ago we were asked by Messrs. Philips of Eindhoven if G. L. F. Philips, the co-founder of the firm, could possibly have been a student of Kelvin's. Given the date, 1887, we quickly found that Philips had been a "laboratory student" for one year (he spent two years in Glasgow, partly at the Technical College, partly with Kelvin, and partly working on electric lighting in ships in a Clyde yard). We have a record of what Philips did, including some work on incandescent bulbs. Philips went away to found, with his accountant brother the Gloielampenfabrieken which apparently is the largest enterprise outside the United States. Perhaps, without Kelvin's influence there might have been no Natuurkundig Laboratorium at Eindhoven.

The second item is simply that, most unexpectedly, we now have a recording of Kelvin's voice. We had not known it existed but all this time — since it was made in 1907, the year of Kelvin's death at the age of 83 — the matrix has reposed in the British Museum. Now, the Science Museum has arranged for a pressing to be made and a copy allowed to the Natural Philosophy Collection at Glasgow. Kelvin, reading from one of his papers on radioactivity, shows himself, even at that great age, to be a very able expositionist. His style is vigorous, and both his Scottish upbringing and Irish birth are apparent in the accent.

John T. Lloyd
Department of Natural Philosophy
The University
Glasgow

MOBILE CB DANGERS

I have been following the controversy over citizens' band radio as reported in your publication with great interest. I think my own experience may be useful here.

I must take exception to the experiment reported by C. Riley (January letters). When I first bought c.b. equipment, I quickly learned that there are times when one should not use it while driving. Since then, I have primarily used it to monitor traffic conditions on the road ahead of me, and to report — at my convenience — any unusual conditions.

C. Riley does not mention that it is acceptable in c.b. usage to interrupt one's conversation to devote full attention to a curve of intersection, and then to return to the radio. To properly simulate this condition, the experimenters should have told their subjects that they were to answer questions, *but* that they should only do so when the road did not require their full attention.

The experiment, as reported by C. Riley, did not use drivers accustomed to the use of two way mobile radio.

Rather than citing experiments based on erroneous premises done under laboratory conditions, British opponents of c.b. ought to visit the USA and see it in operation. I am sure that any of the hundreds of c.b. clubs in the USA would be glad to show an observer how c.b. actually works, instead of a theoretical model.

Charles Curley
Los Angeles
USA

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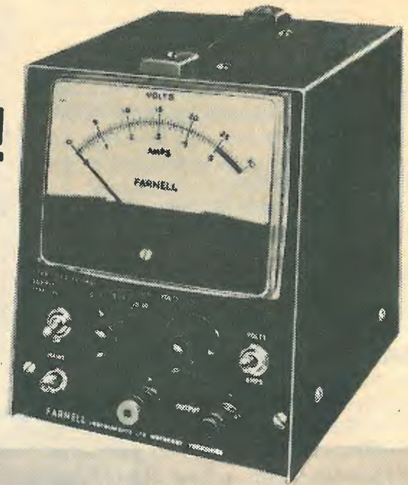

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The role of the specialist in microelectronics

A trade union view

by Ken Gill, Technical, Administrative and Supervisory Section
Amalgamated Union of Engineering Workers

Some trade union leaders argue that the new technology introduced by the silicon chip should be resisted. Here Ken Gill, General Secretary of AUEW-TASS the engineering staff union and a member of the TUC General Council, takes the opposite view. Analysing the special problems faced by the engineers and technicians in inventing, developing, designing, putting into production and applying these new devices, Mr Gill believes that these specialists have a key contribution to make in the battle between conflicting interests for the benefits of the new technology.

THE WORLD is on the threshold of a technological revolution as important as the invention of the wheel, power-looms, electricity and the assembly line. This derives from two related inventions, firstly that of the stored-program computer and secondly that of the silicon chip, or integrated circuit. Commercial interests encourage magic surrounding these developments. This should be removed.

Like previous technological revolutions the computer and silicon chip will create jobs, but equally, as in the first industrial revolution, thousands of jobs will disappear, not just unskilled and semi-skilled, but highly skilled jobs will also be by-passed by the new technology. Engineering will be seriously affected.

To date the silicon chip has destroyed the orthodox watch industry in Germany and has led to Switzerland ceasing to be the pre-eminent watch manufacturer. The electronic calculator produced in millions for a few pounds has displaced electro-mechanical equipment which previously cost several hundred pounds, with the consequent loss of thousands of jobs in that sector.

At present the major impact of the integrated circuit has been on that part of the manufacturing industry which previously made electro-mechanical equipment and this now faces job losses through the change-over to electronic components. The telecommunications industry is now moving belatedly from electromechanical to fully electronic public exchanges. The delay in that transfer has already lost the UK most of its traditional world markets. The combination of these two factors, technological change and a slothful reaction to it, has halved employment in the industry and it is believed that when System X is in full production only one manual worker out of four will have been retained. Electronic systems also require less maintenance and this has led the Post Office Engineering Union to campaign for a shorter working week.

Not unnaturally the implications of electronics technology have been demonstrated most obviously in the field of computer manufacture itself. Over the past decade the total labour force of ICL in the UK has been reduced from 33,000 to 22,000 and the proportion of manual workers in that total has been reduced from one half to one fifth. Similar developments are inevitable in the machine tool industry, and in those parts of the electrical industry that traditionally have used electro-mechanical devices, e.g. switch gear and motor control gear.

The increased use of computers on the assembly line will reduce the number of operatives needed and require fewer inspectors. Maintenance staff will no longer be required to carry out preventive maintenance because a computer can be programmed to carry out its own. Those maintenance staff left will have to be technologists since the traditional functions required of an engineering craftsman would not be appropriate for maintenance of computers.

The new machinery will not only be suitable for continuous processes, but will be sufficiently flexible to cope with the batch production that is currently very much the prerogative of the small and medium sized firms. With the increased cost of equipment the small firms will almost certainly be unable to pay for them; they will go to the wall. The large companies will meet the production loss arising from the collapse of the small firms without necessarily any increase in labour.

Equipment is increasingly becoming available that makes the orthodox tool-room irrelevant since tools and dies can increasingly be produced automatically or by-passed completely.

Because of Britain's backwardness in machine tool technology, equipment is being imported from the United States and Germany. Thus those jobs destroyed by the introduction of new equipment are not being replaced by manufacture of the new equipment. A central demand must be that Britain manufactures the new technology.

A graphic example of the change derived from the new technology is a company like GEC Semiconductors where the factory is installed within a research centre, and the production process is carried out by lines of expensive imported equipment overseen by a few non-manual workers. It is a reminder of the current American joke that an electronics company was so successful it was able to move into smaller premises!

Petro-chemicals and steel manufacture already embody some of the new control technology which has eliminated all but a handful of workers. Whilst it is true that the tiny group of maintenance workers that remain may command high salaries because of their importance to the industry, this is no compensation to the thousands of skilled workers displaced.

Re-training workers

Technological advances will leave thousands of skilled people redundant. Re-training will be more expensive and difficult for those middle-aged workers, like draughtsmen or tool makers, than training for students or school leavers. Disturbing reports are being received that the Government wants educational money associated with the new technology spent not to re-train those currently employed in the industry but used in schools. If this is carried out scores of thousands of workers will be condemned to the scrap heap of the dole for life. It is essential that the responsibility for meeting the new technology should lie not with the Department of Education, but with the Department of Employment and the EITB.

Some trade union leaders argue that the new technology should be resisted. We have already seen what happens if this occurs. The struggle in the printing industry to resist technology simply led to countless print firms going to the wall and the jobs were lost anyway.

Albert Booth, Secretary of State for Employment, has rightly pointed out that if Britain is to remain an important industrial power it has no alternative but to move as rapidly as possible to accept the new technologies in every field. If this is accepted then social demands are required on a scale never known before. Technological change need not cause unemployment. Indeed, Britain should welcome developments that could provide higher standards, less boring work, more leisure and more information so that production can be planned more rationally.

At present, however, workers' demands are surprisingly modest. The dramatic reduction in dock employment, for example, led to a 31-hour week, no compulsory redundancy, and voluntary severance pay up to £7,000. But far greater social benefits could have been achievable as part of the cost of introducing the new technology in dock work.

The 1978 TUC passed overwhelmingly an eight point motion calling for public investment and ownership of the basic production in the UK, training and re-training, planned job creation, research into the social consequences, shorter hours, more holidays, early retirement, and co-operation with trade unions abroad. The General Council is preparing a policy statement for a special conference on this subject.

Vanguard of innovation

Microelectronics will affect all employees. More affected than any, however, will be the technologists and the technicians directly involved in inventing, developing, designing, putting into production and applying these new devices.

History confirms this view. It was the firms which pioneered mass production that were the first to utilise sophisticated office machinery, the first to take industrial engineering into offices, and the first to experiment with new techniques of organisation, management and supervision. Why? Firstly, the profitability of their production breakthroughs provided these companies with the capital — both accumulated and external — to finance costly changes in methods. Secondly, executives right to the top did not suffer from ideological barriers; unlike normally conservative managements, they were themselves in the innovation business.

Thirdly, it is always the sectors of greatest technological change that form the vanguard of trade union organisation. Partly because people in those sectors know they have to defend their conditions, their status and, indeed, their jobs against the new technology. Most importantly because only through trade union organisation can the employees, who feel that they have created the new wealth, share in its benefits.

There is, however, a further factor applying to the technologists and technicians concerned with developing inventions which can harm as well as help mankind. We all know the story of Roger Bacon discovering gunpowder in the 13th century but concealing the formula in a Latin verse so as to prevent mankind doing itself a mischief. As usual, however, the Chinese already had it anyway, and there has been no lack of gunpowder's evil use over the last 400 years.

It was in 1818 — the threshold of the first industrial revolution — that Mary Shelley wrote the fascinating story of the good Doctor Frankenstein and his well-meaning but highly destructive monster. Yet the problems faced by both Bacon and Frankenstein are transcended by those of the specialists in microelectronics today.

Those who innovate *as employees* are in a quite different category from those who innovate as their own bosses. Not only can employees see the harmful effects to which their skills can be put, but also they cannot choose the direction of their work. It is no accident that TASS, the union that set out to organise engineering technologists and technicians, has always given the greatest importance to technology itself. From its foundation in 1913 the union put as much emphasis on what its members do, and the end-products of their labour, as on the money they are paid for their work and the conditions under which they carry it out. Increasingly an added preoccupation has been the effects of technological change on the status of these members, the responsibilities they carry and their influence over the policy decisions that affect their work.

The fact that it is now possible to control a production process 10,000 miles away by satellite, added to all the recent developments in informatics, gives rise to quite new relationships between huge faceless corporations and their employees.

Gone are the days when the specialist enjoyed an elite and secure relationship with his small employer, buttressed by cosy codes of professional ethics. Today's rat-race — really a struggle for survival by the multi-national corporations with their huge overheads and diseconomies of scale — means that technologists in advanced industries need a trade union more than anyone else, more even than the shopfloor!

Collective action

Only by negotiating collectively — from a position of real strength — about much more than just their salaries, can employees in the front-line of innovation hope to escape from this alienation from their own work. And only by joining a national and international trade union movement can these employees strive against their creative work making their fellow-workers in other sectors poorer, unemployed — or perhaps killing them off in war.

Furthermore, unless those technologists and technicians have a direct input into union policy commensurate with their special knowledge of technological development and its potential benefits and dangers, trade unionists as a whole — increasingly influential — will not be able to make correct, balanced decisions.

In recent years a host of public bodies has sprung up, seeking to integrate the conflicting interests between producers and production. Every trade union leader is today involved in committees advising regional authorities, governments, the EEC commission and international bodies upon public interventions in the production process. Yet only if the "rank and file" of technologists and technicians participate in this process — effectively possible only as part of collective bargaining — can their knowledgeable voices be heard where it counts.

The Council of Engineering Institutions and its affiliated organisations has — albeit belatedly — recommended all qualified engineers to join a trade union. It is equally important that the professional institutions do not themselves try to duplicate the role that unions were created to perform. Technical employees whether qualified or unqualified need to speak with a united voice on industrial relations issues in the widest sense.

Chains on thought

If specialists in microelectronics accept a role in which they are told what to think, how to think, when to think and, above all, what *not* to think about, they will become increasingly poor — physically and spiritually — in a theoretically richer and richer world. Even more importantly, the men and women who share this earth with them will fail to realise the better quality of life made possible by the sane use of microelectronics.

Technology must be our slave and not our master. The multi-national corporations see this new technology as a means for greater profits and greater controls over employees and consumers. The trade union movement sees it as presenting opportunities for more employment, higher living standards and more leisure for workers of all kinds. The massive increases in productivity arising from these developments must be made to benefit ordinary people. But this will only happen if the specialists directly involved play their full roles.

Related publications:

Qualified Engineers: The Way Forward. Published by AUEW-TASS, Onslow Hall, Little Green, Richmond, Surrey TW9 1QN. 40p inc. p & p.

Computer Technology & Employment. Proceedings of AUEW-TASS Conference, published by National Computing Centre, Oxford Road, Manchester M1 7ED. £6 inc. p & p.

Sync pulses from the TIROS-N satellite

Detection circuits for a weather-satellite picture facsimile machine

by A. G. Trusler, B.Ed.

On October 13, 1978, the first of the third generation of US polar orbiting weather satellites, TIROS-N, was launched into orbit. Although the satellite's facsimile picture format is basically the same as that of the previous generation of weather satellites, NOAA's 1 to 5, there are some differences and these necessitate certain modifications to the receiving stations. One important alteration made was that the line rate was changed from 48 rev/min to 120 rev/min. The synchronizing frequencies were also altered to remove an ambiguity that had existed on the previous generation of weather satellites.

IN THE January 1975[1] issue of *Wireless World*, G. R. Kennedy put forward a synchronizing start circuit based on the picture format of the first generation of weather satellites. For the NOAA 1-5 series, he made some suggestions as to how his basic circuit could be modified so that detection of the infrared (IR) sync could take place, but it meant that the counters would have to be forced. Although the sync detection circuit in the author's station is not the same as that put forward by Mr Kennedy, the change in the sync frequencies with TIROS-N would not allow either of the circuits to work correctly.

Figure 1 shows how the TIROS-N facsimile picture appears on the author's D611 Mufax* facsimile machine. Both syncs A and B are inserted into their relevant slots of width 9.37ms. The space (meaning interplanetary space) section following sync A is at the video white level and contains black minute markers indicating divisions of one minute of satellite movement. On the visual side the space section following sync B is black and the minute markers are white. This can be seen clearly on the sample picture for orbit 1653.

*The Mufax D611 facsimile machine used by the author at the school where he teaches, produces a picture on a chemically sensitized paper which passes between a helix (rotating synchronously with the automatic picture transmission (APT) image) and a blade. The picture modulation produces a varying current that passes through the paper. When the current is high it darkens the paper and so produces the picture.

The new sync frequencies provided too short a period of time for a given number of pulses to guarantee that a tone decoder would be able to consistently detect either of them. Further, the two frequencies were too close for a normal band-pass filter, with a reasonable number of components, to satisfactorily detect only one of them. The following circuits were kept simple because they were to be fitted to a weather satellite station which is used by a school to provide information for, and as part of, a C.S.E. environmental science course. The circuit in Fig. 2 enables the detection of sync A and provides a trigger voltage to start the facsimile machine – or to release the helix in the case of the author's Mufax machine. The author's unit is driven by a phase-lock-loop circuit in the i.f. stage of his facsimile receiver, and it is the low-pass output (3dB down point at 3.2kHz) of this which is fed to the circuit of Fig. 2. The circuitry associated with IC_1 acts in a similar way to a Bi-quad active filter[3] which has the advantages that its Q value can be set independently from the frequency determining components, and the bandwidth remains constant for all values of Q. The bandpass response is set by R_{22}, R_{23} and R_{24} together with C_1 and C_2. Relationships for the cutoff frequencies and Q values are $f_c = 1/(2\pi R_A C)$ and $Q = R_B/R_A$. Variable resistances R_{21}, R_{22}, R_{23} and R_{24} should be adjusted so that the value of R_A is the same in all three cases for the centre frequency of 1040Hz. Because the Q is high the response decay is enough to provide a detectable number of pulses. It takes a minimum of 9.37ms to obtain enough pulses for correct detection.

The bandpass output at X is fed to a halfwave rectifier, IC_4 in Fig. 3, which has a voltage gain of 10. This part of the circuit just limits the sync pulses while keeping the rest of the line information

Fig. 1. *Diagram shows how Tiros-N picture appears when printed on facsimile machine. Line scan takes 0.5s to provide all infrared and visual information. Telemetry section carries 'housekeeping' and grey scale details. See text.*

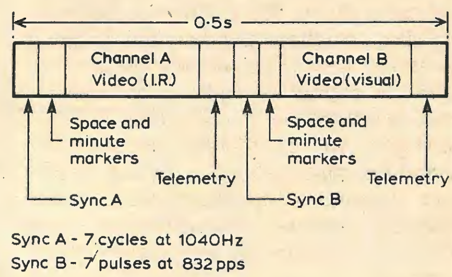
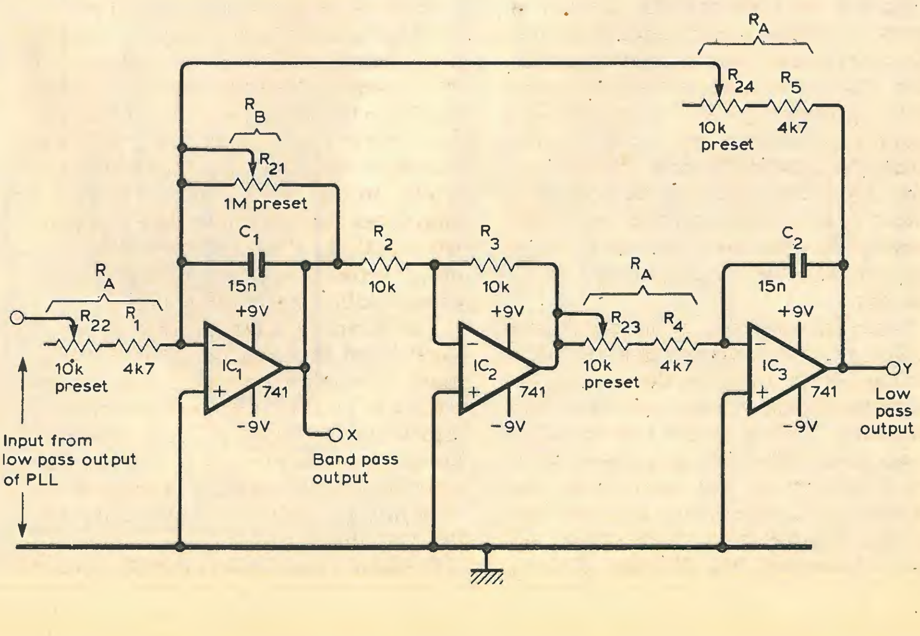


Fig. 2. *Detection circuit. See text.*



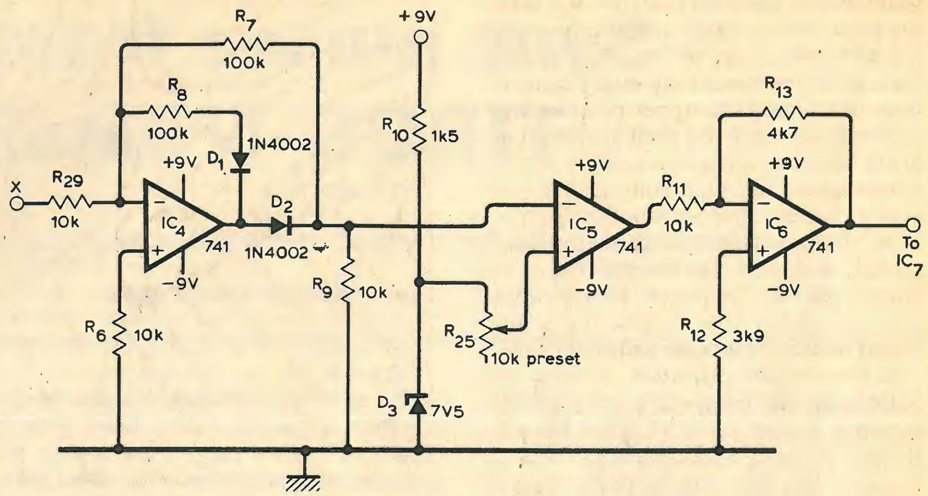


Fig. 3. *Squaring circuit, produces logic 1 output to drive trigger circuit.*

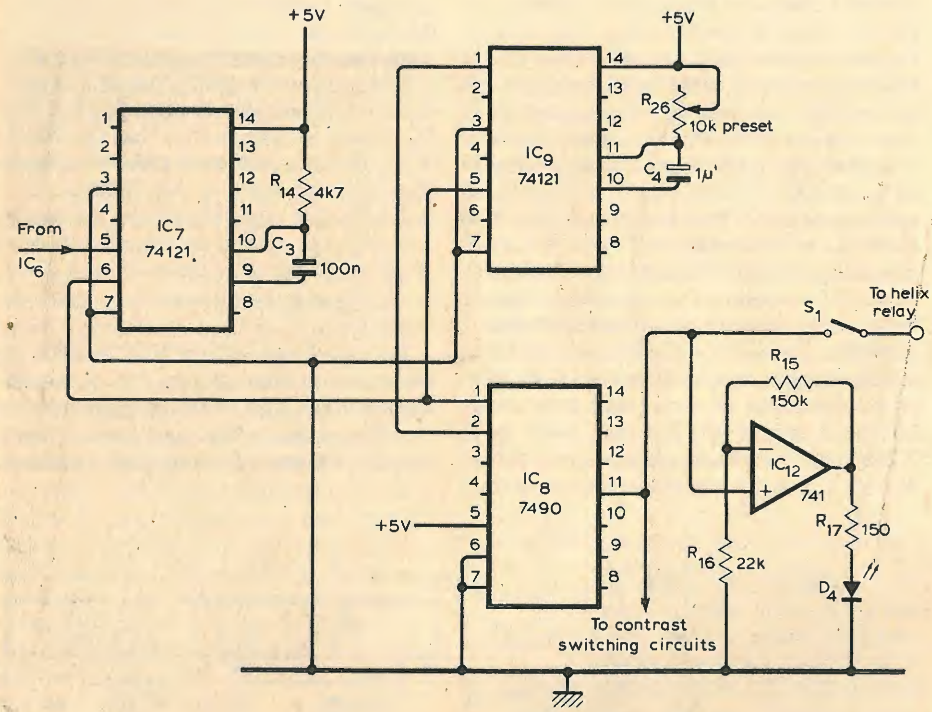


Fig. 4. *Trigger circuit, controls pulse trains for each picture line.*

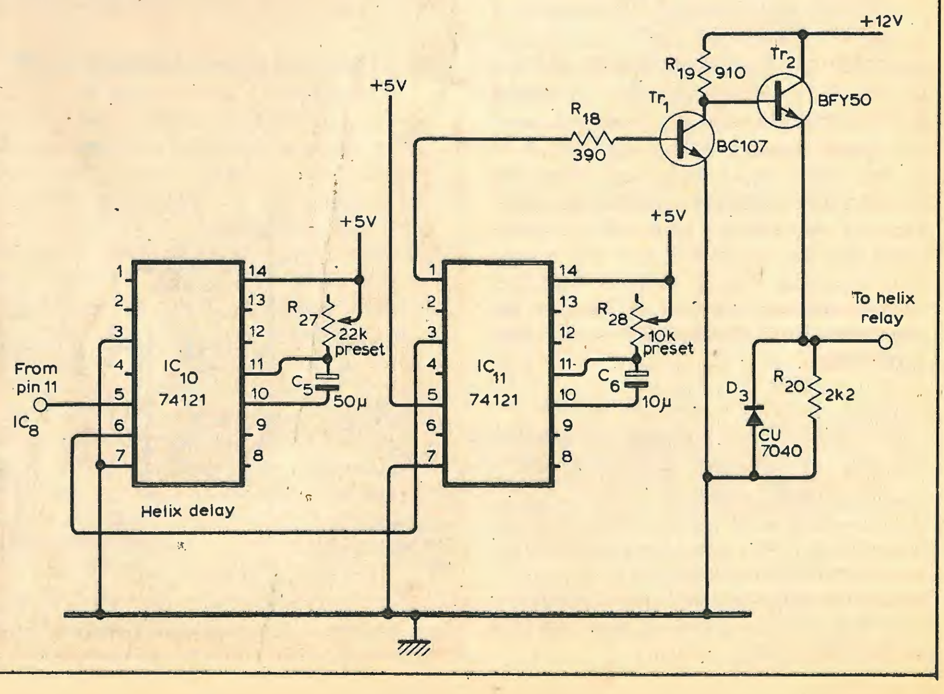


Fig. 5. *Line delay circuit, ensures correct positioning of helix wire (in case of D611 facsimile machine) at start of each line.*

at a reasonably low level. The output is positive d.c., limited at +6.0V. IC_5 then removes all the signal information below the voltage set by R_{25}. This resistance is adjusted so that everything is removed except the upper parts of the sync pulses, which are then amplified to provide a negative output with the pulses appearing reasonably square. IC_6 acts as an inverter and decreases the level of these pulses so that they can provide a logic 1 for feeding into the monostable IC_7, in Fig. 4, for the final squaring of the sync pulses. R_{26} is adjusted to provide a pulse width of 0.9ms.

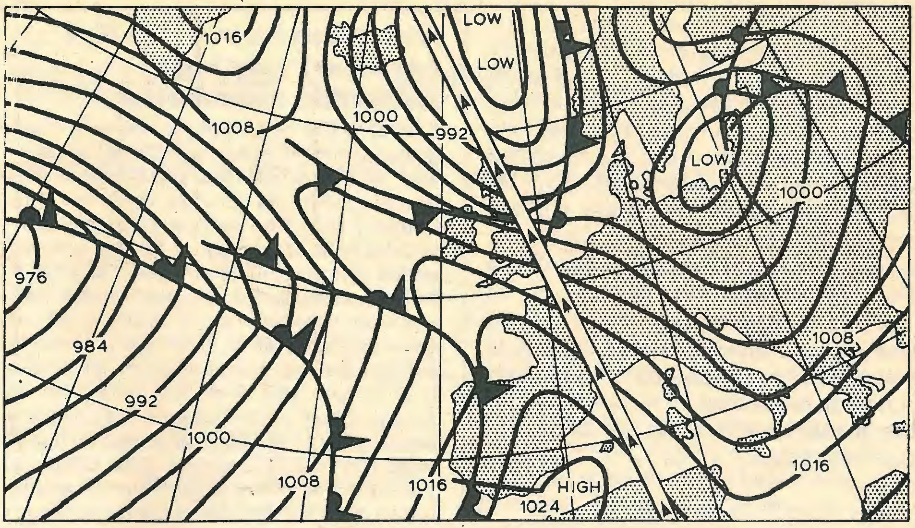
A reasonable number of square pulses, at the frequency of sync A, appear at the output of IC_7 and these are passed on to a divide-by-five decade counter, IC_8, and the Schmitt trigger input of IC_9. The reset line of IC_8 is connected to the $\overline{Q}$ output of IC_9. The pulse width of this output is such that after 4.8ms, it resets the counter. If during this period, five pulses are counted in, the output at pin 11 of IC_8 goes to logic 1, which is the basic voltage pulse required by the D611 facsimile machine. At this stage, R_{21} is adjusted so that the required number of pulses are available for IC_8, with any extras being cleared by IC_9 before the arrival of the next pulse train from sync A on the next picture line. This also ensures that any

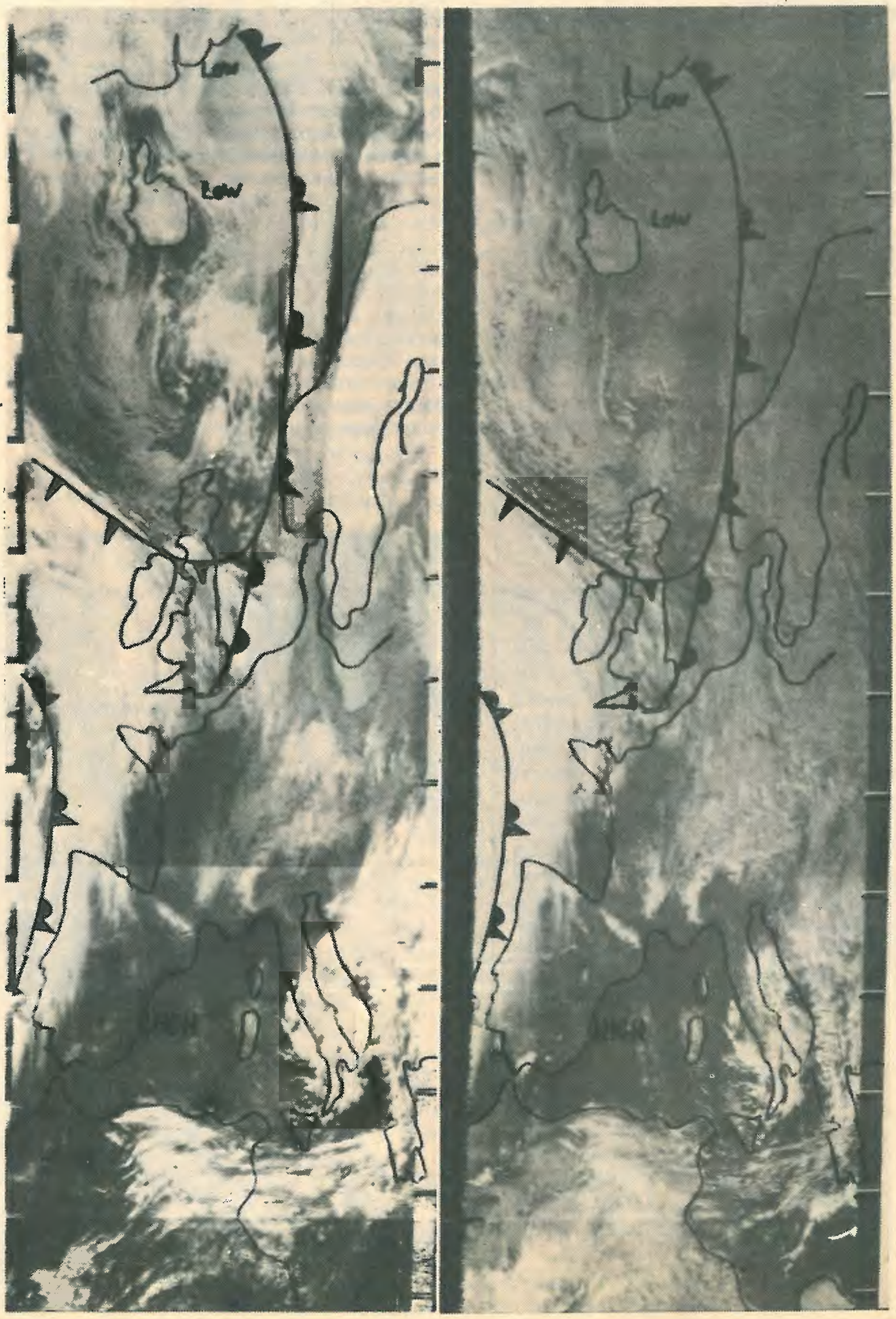
Spectral intervals

The spectral intervals available on TIROS-N and the subsequent satellites of this series, NOAA-A to G, are as follows:

- Interval 1 covers the electromagnetic spectrum from 0.55 to 0.9μm and yields more meteorologically significant land information.
- Interval 2, from 0.725 to 1.0μm, is the best for land to water contrast.
- Interval 3, from 3.55 to 3.93μm, is somewhat noisy and does not provide good temperature definition in winter conditions.
- Interval 4, from 10.5 to 11.5μm, offers better information than 3.
- Interval 5 is still to be allocated.

Channel B, which carries visual information, is switched to spectral interval 1 for day and spectral interval 3 for night.





This picture was received on 31st January 1979 during orbit 1653, northbound ECT 13h. 57m. 36s. GMT, longitude 16.29°E. Channel A is infrared, spectral interval 4, and channel B is visual, spectral interval 1, see inset. An overlay has been placed on the picture to show the land masses. The overlay also includes the high and low pressure areas and the cold and warm fronts corresponding to the accompanying weather chart for that day. Picture clearly shows how the cloud forms along the fronts.

noise spikes that get through are removed from the counter. From pin 11 of IC_8 the pulse is fed to IC_{10}, Fig. 5, which acts as a line delay ensuring that the helix wire (in the case of the D611) is on the left hand side of the line when the next sync A pulse is received. IC_{11}, Tr_1 and Tr_2 provide the necessary current to operate the solenoid to start the facsimile machine. In the case of the D611 this releases the helix stop.

A l.e.d. is included with IC_{12}, Fig. 4, to give a visual indication that sync A is being received correctly. When this condition is satisfied S_1 is closed so that the machine will start on the next received sync A.

Acknowledgements
The author wishes to thank Mr B. Jeffrey for his encouragement and Mr J. A. Molineaux for his help in running the school's station.

References

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3. Orr, T., Designing and using active filters, part 2, *Electronics Today International*, Aug., 1977.

The author

Alan Trusler is the head of the physics department at a comprehensive school in Essex. While his hobby has long been the study of natural science his current interest in satellite meteorology was, he says, originally influenced by the articles by J. M. Osborne in *Wireless World* (Oct. and Nov. 1971). Alan saw in this an excellent opportunity to study weather and introduce to the pupils at his school a limited amount of electronic technology and natural science. This proved so successful that in 1972 he devised a scheme whereby the study became part of a CSE mode-3, environmental science course at the school. His aim was to demonstrate technology which reflected some of the natural science of the world, and how systems which appear to be very complicated are in fact based on very simple principles. He considered the weather to be an obvious subject for this kind of study and the station permitted him to demonstrate how weather information was acquired and predictions made. Mr Osborne's cross-dipole antenna (WW, July 1972) greatly simplified the construction of the school station.

Reception from Tiros-N's advanced very-high-resolution radiometer

TIROS-N, the prototype of the new third generation of US polar meteorological satellites, was launched from the Western Test Range, California at 1123 GMT on 13th October, 1978. The spacecraft is in a near circular orbit at a height of 854 km with an orbital period of 102.12 minutes. The orbit is sun synchronous with a local northbound equator crossing at a solar time of approximately 1500 hr. Drift rate is about 10 minutes later per year. Longitude increment is 25.52° per orbit. Real time data from its advanced very-high-resolution radiometer is broadcast as a 665.4 kb/s bit stream on one of three selectable frequencies, 1698, 1702.5, or 1707 MHz. Data from all the other spacecraft instruments are included in the bit stream.

The transmitted carrier is modulated by the data in p.s.k.-biphase (L)* mode with carrier phase deviations of $\pm 67°$. For reception a receiver front end with a G/T ratio of about 8-10 dB/°K is required. This can be achieved with a 12′ diameter reflector and a low-noise microwave, transistor preamplifier with a noise figure of 2 dB or less. The receiver bandwidth should be in the range 3 to 5 MHz. For demodulation a phase lock loop with a loop bandwidth of less than 1 kHz is used to lock on to the residual carrier in the received signal spectrum. The demodulated output is obtained from the loop phase detector with suitable low pass filtering. At this point the data is in the form of a bi-ϕ-L serial bit stream. The base-band spectrum does not contain the clock frequency, but if passed through a squaring circuit spectral components appear at the clock and double clock rate. Another narrow band loop can be used to extract either clock or double clock. Simple logic circuiots combine double clock and biphase (L) to produce n.r.z. and clock.

Data are transmitted in frames of 11,090 10 bit binary words. One frame corresponds to one scan line of the imaging radiometer. Each frame commences with 6 10-bit sync words followed by data from all spacecraft instruments and output from the five channels of the radiometer. To extract the required channel the serial data stream is clocked into a shift register large enough to accommodate the 60-bit sync word. As soon as a sync word is detected word counters are reset which are arranged to select the required words from the frame and dump them in a line memory buffer. Data in the buffer can be read out at a variable rate to compensate for earth curvature distortion. Each channel of the radiometer is allocated 2048 words per scan line and the scan rate is 360 lines per minute.

Geocentric angle covered by each scan is 28° equivalent to an image width of 3000 km. Data transmitted do not extend to the cross track horizons. For an overhead pass the along-track horizon-to-horizon time is approximately 16 minutes equivalent to a distance of 6200 km. The five channels of the radiometer cover various parts of the visible and infrared (IR) spectrum.

*In biphase (L) '1' is represented by a (+, −) sequence and zero by a (−, +) sequence. Each pulse is half a symbol wide.

The picture and the accompanying text were provided by Mr Peter Baylis of the Department of Electrical Engineering and Electronics at the University of Dundee.

This sample image is an electronic sectorised enlargement of thermal IR Channel 4 (spectral interval 4) as received at the University of Dundee on 19th December, 1978. White areas represent cold and dark areas warmth. The picture quality using the very-high-resolution radiometer is, of course, better than that obtainable using Mr Trusler's APT system.

Teletext remote control — 2

Interfacing the remote control receiver with the original decoder

by R. T. Russell

The first part of this article described the design of an ultrasonic transmitter and receiver for the remote control of most of the functions of the *Wireless World* teletext decoder, originally published in 1976. Several additions have been described since then, and this article brings the design up to the standard of commercial units.

The most complex part of the remote control system is the interface board which mounts inside the teletext decoder cabinet and interfaces the serial signal from the ultrasonic receiver (or directly from the keypad unit) with the original decoder circuitry. Before setting out a detailed circuit description it will be helpful to list the facilities provided and the operating procedure for the remote control.

All the original front-panel controls are remotely operated, with the exception of Roll, which is principally a diagnostic aid. In addition the "newsflash" and "subtitle" modes are combined, because a small modification to the original decoder (described later) renders the distinction irrelevant.

The sixteen keys on the keypad and their functions are as follows:

0-9	Numeric entry. Used in conjunction with the Page and Time keys.
TV	Pressing this key removes all text display, including newsflash and subtitle. It corresponds to the TV button on the original switch bank.
REVEAL	If "new facilities" are fitted this causes concealed parts of the display to be revealed. Pressing any other key restores the concealed condition.
TEXT	This key has a toggle action. When pressed it selects, alternately, a text-only display (original TELETEXT button) or the "boxed" mode (SUBTITLE or NEWSFLASH).
CLEAR	Clears the entire text display, except for the header. Used principally to clear newsflashes.
PAGE	Pressing this key causes the page number display to change to "p.—". A new three digit page number can now be entered, the digits being displayed one-by-one as they are keyed.
TIME	Pressing this key enables the 'time select' mode and the page number display changes to a four-digit clock time. A new time may be entered if required by keying in four digits. Only at this specified time will a page, with the previously selected page number, be captured and stored by the decoder. This function is normally used with the special time-coded pages (page 160 on Ceefax, on which an 'alarm clock' facility is currently provided). The normal "time off" mode can be restored by selecting a new page.

A seventeenth, spare, function is provided for general-purpose use. It could be used, for example, as a sound mute or a sequential channel change.

Circuit description

The serial data input from the ultrasonic receiver (or from the keypad unit) is fed to pin 20 of IC_{304} (Figure 5). This device is a universal asynchronous receiver/transmitter (u.a.r.t.), the function of which in this application is to detect the start bit of the serial data, sample and store the data bits and check the parity and stop bits as they are received. After the stop bit has been received the seven data bits are present, in parallel form, at pins 6 to 12 of IC_{304}. A positive-going pulse is produced at pin 19 to indicate that the data are ready, and this pulse is gated in (305,3) with a combined signal from IC_{304}, pins 13 and 14. In the event of the u.a.r.t. having detected an incorrect parity bit or a missing stop bit in the input signal, one or both of these pins will be at logic 1. In this case the pulse at pin 19 is prevented from reaching the rest of the circuitry and the command is ignored.

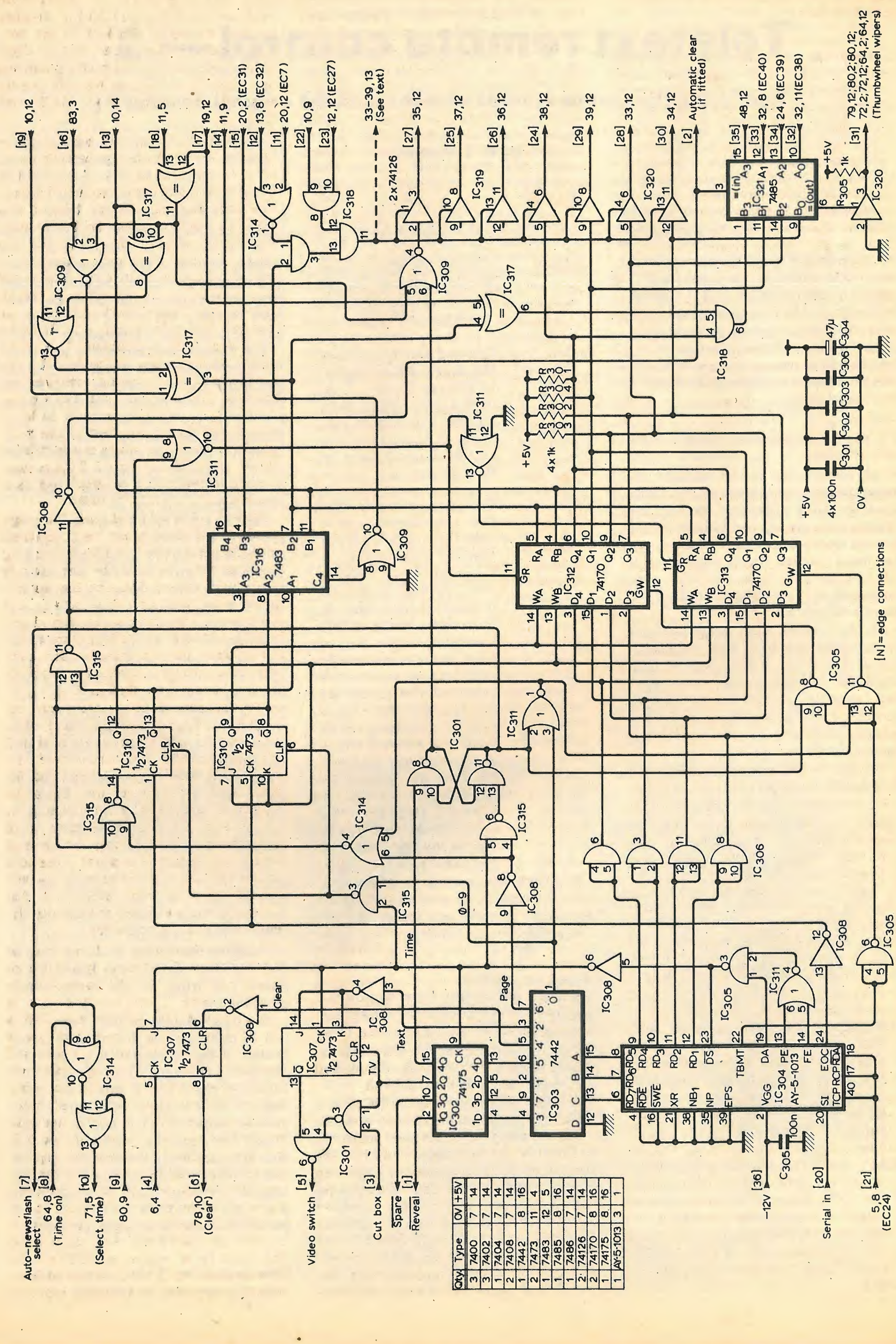
The transmit section of the u.a.r.t. is not used as such but is instead used to generate some conveniently-timed pulses for use in the decoder. The gated pulse from pin 19 is fed to pin 23, the transmitter data strobe. This causes a short, negative-going pulse to appear at pin 22, followed by another negative-going pulse, this time of approximately 100ms duration, at pin 24.

Data bits 5, 6 and 7 from the u.a.r.t. are fed to the decoder IC_{303}, one output of which will be low at any given time, depending on the last command received (in this context the numeric keys 0-9 are treated as one command and cause pin 1 to go low). In the event of the Reveal key being pressed, (303,4) will go to logic 0 and the pulse from (304,19), inverted in (308,6), will clock this 0 onto the output of four-bit latch IC_{302}. This signal is fed to digital board 3 to perform the reveal function. The 'spare' command is processed in the same way.

When the "TV" key is pressed, (302,7) goes to logic 0. In so doing it forces IC_{301}, pin 6 to a continuous logic 0, which causes the video switch in the tv receiver to select the off-air picture. When, subsequently, any key other than "TV" or "Text" is pressed (302,7) goes to logic 1 but, by virtue of being previously reset, (307,13) remains at logic 1. This condition corresponds to the subtitle/newsflash mode in which the "cut-box" signal from Board 2 (or Board 3 if fitted) is fed to the video switch in the tv.

The toggle-action of the "Text" button is achieved as follows. On the receipt of any command IC_{307}, pin 1 is clocked by the signal from IC_{304}, pin 19. However, the J and K inputs are normally held at logic 0, resulting in no change (307,13). On receipt of the "Text" command the J and K inputs are both at logic 1 when the lock occurs and this is the condition for the flip-flop to toggle (i.e. change state). When (307,13) is at logic 0 (301,6) is forced to a 1 and the video switch selects the text signal.

Clear page. The "Clear" key is somewhat different from those dealt with so



Qty.	Type	0V	+5V
3	7400	7	14
3	7402	7	14
1	7404	7	14
2	7408	7	14
1	7442	8	16
2	7473	11	4
1	7483	12	5
1	7485	8	16
1	7486	7	14
2	74126	7	14
2	74170	8	16
1	74175	8	16
1	AY-5-1013	3	1

Fig. 5 *Circuit diagram of the decoder interface board.*

far in that is must not produce a steady signal, which would cause continual clearing of the screen and inhibit acquisition of a new page, but instead must generate a single negative-going pulse. To ensure that the entire page is cleared this pulse must be at least one field period (20ms) in duration. A monostable could have been used but instead a feed is taken from IC_6, pin 4 (digital board 1) which is a once-per-field, negative-going pulse. On receipt of the "Clear" command IC_{307}, pin 6 goes to logic 1 and a positive-going pulse is applied to its J input, pin 7. This "primes" the flip-flop so that when the next field pulse arrives from (6,4) the output (307,8) will change to a logic 0 to initiate the clear page action. When the next clock pulse occurs, 20ms later, the flip-flop returns to its quiescent state and, as its J input is now at logic 0, remains there until the "Clear" key is pressed again.

Page number selection. The previous sections have dealt with the general decoder controls, but the main function of the remote control board is the selection and display of page number and time code. The current page number and selected time are stored in two 16-bit register files, IC_{312} and IC_{313}. Each digit of the page number or time is in the range 0-9 and requires four bits to represent it in binary. IC_{312} and IC_{313} can therefore hold four digits each, the three digit page number in IC_{312} and the time in IC_{313}. The fourth digit in IC_{312} is always zero. These stores are written into by applying the 4-bit digit to the four data inputs, the appropriate digit number (0, 1, 2 or 3) in binary to the two write-address pins and pulsing the write enable (pin 12) to logic 0. Similarly the data are read out by applying the correct digit address to the read-address pins and taking the read enable (pin 11) to logic 0, whereupon the appropriate digit is present at the four (open-collector) data outputs.

The write address for both IC_{312} and IC_{313} is provided by the 2-bit counter IC_{310}. Normally this counter remains in the 00 state, because when any non-numeric key is pressed on the keypad unit the pulse from (304, 19), inverted in (315,3), feeds the clear pins of both flip-flops. Although subsequently the flip-flops are clocked by the signal from IC_{304}, pin 24, their J inputs are both at logic 0, resulting in no change at the outputs. When the "Page" key is pressed, IC_{310} is cleared as usual but, via (314,4) and (315,8), the J input (310,14) is held at logic 1. On receipt of the clock pulse 100ms later the write-address changes from 00 to 01. Pressing the "Page" key also presets the page/time latch comprising (301,8) and (301,11) into the "page" condition (i.e. (301,11) high).

When the write-address changes from 00 to 01 a number of things happen; (315,11) goes to logic 1 and, inverted in (308,10), initiates an automatic page clear and inhibits acquisition of a new page (see later). By virtue of the signals fed to 4-bit adder IC_{316}, which controls the display blanking, the page number indication is changed to "p.—" in anticipation of the new page number to be entered. Also the page number store IC_{312} is correctly addressed ready for the first digit (hundreds). In this condition the decoder is primed to accept a new page number. If any key other than 0-9 is pressed next, the decoder reverts to its normal state and the previous page number is restored.

Assuming that a new page number is now entered, each digit is loaded into the store IC_{312} by being fed to its data inputs and the write enable pin being pulsed. Following this the write address is incremented by virtue of IC_{310} being clocked, the normal clearing action being inhibited by IC_{303}, pin 1 being low. The display blanking controlled by IC_{316} allows each digit to be displayed as it is entered, only those digits not yet entered being blanked. When the three digits have been entered, the counter IC_{310} is back to the 00 state and the J and K signals are arranged so as to inhibit further changes until the "Page" key is pressed once again.

Page number display. As mentioned previously, the selected page number (or time when appropriate) is displayed in the top left corner of the page of text. This is achieved by paralleling the date outputs of the r.a.m. page store ($IC_{33\text{-}39}$) with the outputs of seven tri-state buffers on the remote control board. When it is desired to display the page number, these buffers are enabled and the appropriate data are fed into the display circuitry as if they had come from the page store in the normal way. As the t.t.l. tri-state outputs have considerably greater driving capacity than the m.o.s. r.a.ms it was found unnecessary to inhibit the r.a.m. outputs, the t.t.l. outputs forcing the data lines to the correct levels when enabled. This occurs for such a small proportion of the time that no damage will occur to the r.a.ms or buffers, although a suitable signal for driving the r.a.m. chip-select pins is provided if preferred. Unfortunately these pins are very inaccessible on the original Board One layouts and is for this reason that the somewhat unethical approach described was adopted.

The seven tri-state buffers (IC_{319} and IC_{320}) are normally enabled to a signal corresponding to character positions 1-4 on row 0 (the header row) but are additionally disabled when it is desired to blank one or more digits. This enable signal is derived by gating together signals from the clock and line dividers in (314,1) (318,3), (318,8), (318,11) and IC_{316}. The function of IC_{316} is to compare the current display address with the number of digits which have been entered and therefore to determine whether or not a particular display position should be blanked. In the normal condition (i.e. when not in digit entry mode) all four character positions are enabled and IC_{316} serves only to gate together the signals from (11,9) and (20,2).

In order to display the page number or time, the character generator must be presented with the 7-bit ASCII representation of the appropriate digits. The four least-significant bits of the ASCII number correspond directly with the binary value of the digit and the inputs of the tri-state buffers are therefore fed directly from the outputs of IC_{312} and IC_{313}. These open-collector outputs are "wire-ORed" together so that the data correspond to whichever IC (312 or 313) is enabled. The most significant three bits of the ASCII code are 011, the two 1s being achieved by leaving (319,9) and (319,12) open-circuit. IC_{319}, pin 2 is normally held at logic 0, but during the first of the four character positions, when not in "time-select" mode, it is at logic 1. This causes the first character to be displayed as a lower-case "p" (ASCII 1110000).

As well as being displayed, the page number and time must be compared with those present in the incoming teletext data so that the decoder is enabled to accept data for the appropriate page (and time if selected) and store them. This function is carried out by IC_{321}, which is a four-bit comparator. It compares the Hamming-coded data extracted from the incoming video with the page and time stored in $IC_{312, 313}$. If, at any instant, these are the same, its output (pin 6) goes to logic 1 and, after inversion in (320,3), provides a signal which replaces the outputs of the original thumbwheel switches used for page and time selection. Because magazine eight is denoted by zero, gate (318,6) holds the most significant bit of the digit at logic 0 during the time at which the magazine number is present on the outputs of the Hamming corrector. (321,3) is fed from (308,10) so that the comparator is inhibited during the entry of a new page number.

To allow the display and checking of page/time to take place properly it is of course necessary that the correct digits from IC_{312} (or IC_{313}) are selected onto its outputs at the appropriate times. This is the function of the network of gates which feeds the read-address inputs and enables of $IC_{312, 313}$. The page and time information is present in the incoming teletext data as Hamming coded bytes which replace what would otherwise be the first eight characters of row 0. It is in this region of row 0 that the page or time is displayed but the character display positions do not correspond to those positions in the incoming data at which the equivalent digits are present in their encoded form. For this reason the "lines 11-21" signal at (83,3) on the Analogue Board is fed into the address selection circuitry so that the order in which the various digits are selected onto the outputs of ICs $_{312,313}$ is different for the acquisition and display periods. Fig. 6 shows the waveforms present in these two cases.

Time selection. When the "Time" key is pressed on the remote keypad IC_{302}, pin 15 goes to logic 0 and sets the latch (301,8), (301,11) to the "time select" condition. The connexion from (301,8) to (309,6) causes the first of the four digits displayed to change the letter "p" to a number. The feed from (301,11) to (311,9) causes IC_{313} to be enabled during the display period rather than IC_{312}. This results in the page number display being replaced by the four-digit time code stored in IC_{313}. At the same time the feed to (314,8) causes the time selection circuitry in the original decoder to become active, thereby inhibiting acquisition of a new page unless its time code agrees with that selected. This is equivalent to selecting "time on" with the original front-panel control. A new time may be entered when in this condition by keying the appropriate digits. The digits are stored in exactly the same way as the page number except that they are written into IC_{313} rather than IC_{312}. The page number remains unchanged in IC_{312} and, although not displayed, is still active in selecting which page is captured by the decoder.

Decoder modifications

Although the remote control will work with an unmodified decoder, the following modification is recommended to enhance its operation. With the original decoder, after selecting a new page number it is necessary to manually clear the display so that parts of the previous page do not remain when a new page is read in. This is because blank lines on the new page may not be transmitted or characters may be missing due to a parity error, in which case the previous characters in these positions would remain. It would be better for this clearing action to take place automatically, preferably immediately before the new page is received to minimise the period during which a blank screen is displayed.

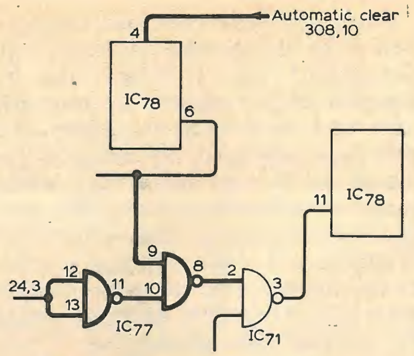


Fig. 7 *New circuitry to provide 'automatic clear' shown in bold.*

Luckily the Teletext specification guarantees that, after the header row of a page is transmitted, one complete field will elapse before further rows for that page are sent. This allows an automatic clear action to take place following reception of the header. The circuit of Figure 7, which requires a 7400 to be added to digital board 2, performs this function.

When a new page is selected, a logic 0 from the remote control board is fed to IC_{78}, pin 4, which causes the page header to start "rolling". The signal from (78,6) is additionally fed to the new IC_{77}, pin 9, which in effect simulates the presence of a "clear page" control bit in the incoming headers. When the appropriate page number is detected an automatic clear takes place just as if the clear page bit had been set. IC_{78} is reset to its normal state in the usual way and the header stops rolling.

The original "auto newsflash" mode was designed to inhibit the acquisition of a page unless the clear-page control bit is set. This was to prevent the display of a newsflash until a "new newsflash" was transmitted. By virtue of the automatic clear modification described above, any new page selected effectively has the clear page bit set so the decoder may be operated permanently in the "auto newsflash" mode. The only exception to this is when the 'time select' mode is active, in which case the automatic clear function is inhibited (because the clear page bit is present in the page header before the entire time code has been received and checked). For this reason, a feed from the remote control board disables the "auto newsflash" mode during time-select.

To carry out the modification to board two a 7400 must be fitted in the IC_{77} position, there being no i.c. with this number in the original design. This may be done neatly by drilling 14 small holes to accept the i.c. pins. The original tracks to (78,4) and (71,2) should be cut and the circuit of Fig. 7 wired, not forgetting pins 7 and 14 of the new i.c. which should be connected to 0V and +V respectively.

To be continued

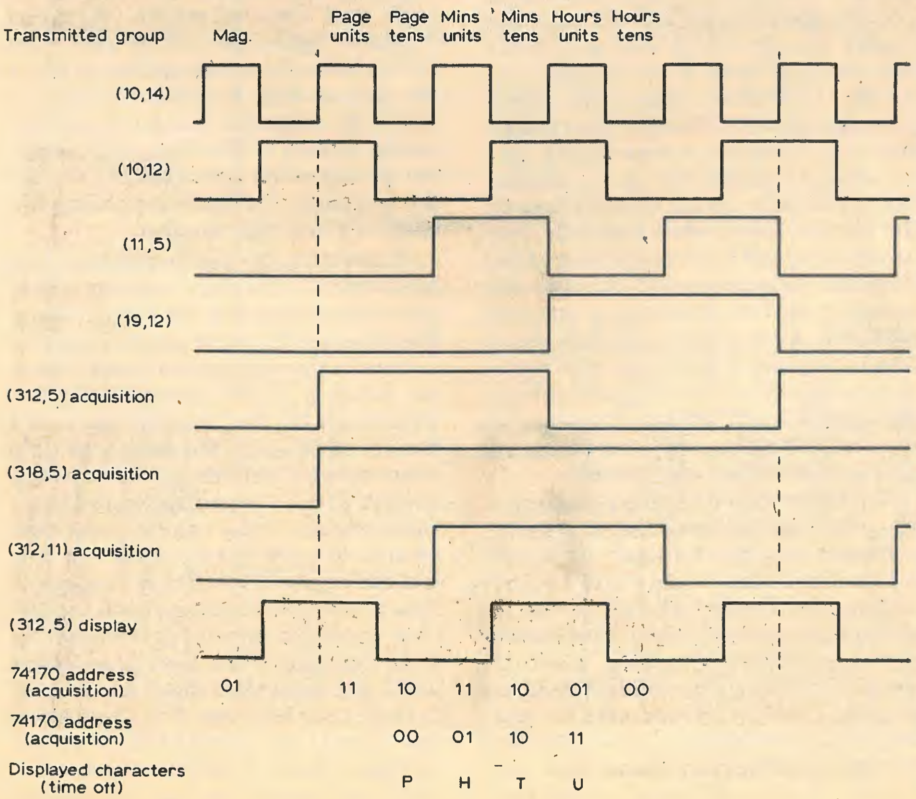


Fig. 6 *Timing of events in the page number and time stores, $IC_{312,313}$ for both data acquisition and display.*

Computers to monitor IBA television network

The IBA's UK network of unattended transmitting stations is to be supplied with computerized systems which will enable the four IBA regional operations-centres to control and supervise it remotely by telemetry. The centres involved are Emley Moor in Yorkshire, St Hilary in South Wales, Black Hill in Central Scotland and Croydon.

A contract for the systems, valued at £½ million, has been awarded to Ferranti Computer Systems Ltd. At each regional operations centre the company plans to install dual Argus 700G minicomputers with semiconductor memory and cartridge disc backing stores. Ferranti are going to use special equipment of their own manufacture to interface the new systems with the existing telemetry and to provide the necessary control. They will also use their own standard software system.

When the computer systems are installed, operators will be able to monitor the states of the network equipment and control them remotely when necessary, and where remedial action is required, pass appropriate information to the relevant bodies.

A scientific computer — 2

Memory, v.d.u., tape and teleprinter interface

by J. H. Adams, M.Sc.

THE STANDARD COMPUTER holds up to 8 kilobytes of memory, but this can be expanded up to 32 kilobytes if necessary. Of this memory, 3K are 2708 r.o.ms which are mapped, or located, at the hexadecimal addresses 0000 to 0BFF. The first 2708 contains a monitor program using hexadecimal data, and responds to commands entered in English. The remaining two r.o.ms hold the more complex BURP monitor and interpreter.

Addresses 0C00 to 1FFF accommodate up to 5K of 21L02 read/write memory and these i.cs are grouped in eights, each one being the store for one bit in an 8-bit byte as shown in Fig. 6. The computer will operate with only 2K of r/w.m., these being IC_{22} and IC_{26}, but, for greater program storage, further blocks starting with IC_{23} should be added. Pin 12 of IC_{17} should be wired to pin 13 of IC_{22} and the position for IC_{21} left blank. This has been provided for any future development which may require more r.o.m. space.

The data outputs of IC_{18} to IC_{26} are wired to an eight-line bus which feeds into the main data bus through the tri-state buffer IC_{27}. Parallel wiring of the outputs is possible because the memory devices also have tri-state outputs. The chip-enable, CE, inputs are enabled by the outputs of a 3 to 8-line decoder, IC_{17}, which is, itself, only selected when $\overline{MREQ}$ and address line 15 are low, i.e. the Z80 must be requesting a memory operation in the lower half of the memory. Similarly, IC_{27} is only enabled when both $\overline{MREQ}$ and $\overline{RD}$ are low, i.e. a memory read is requested. A link has been placed in the $\overline{MREQ}$ line so that the system may be expanded as shown in Fig. 7. The $\overline{MREQ}$ is connected to a 74LS139 2 to 4-line decoder which is fed by A_{13}, A_{14} and the original $\overline{MREQ}$. This modification generates four new $\overline{MREQ}$ signals, one for each quarter of a 32K memory. If the expanded memory is used, $\overline{MREQ_1}$ will take the place of $\overline{MREQ}$ on the original board.

As there are many devices to be

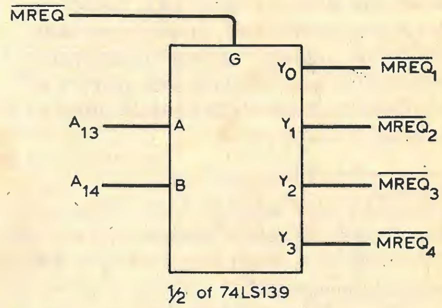
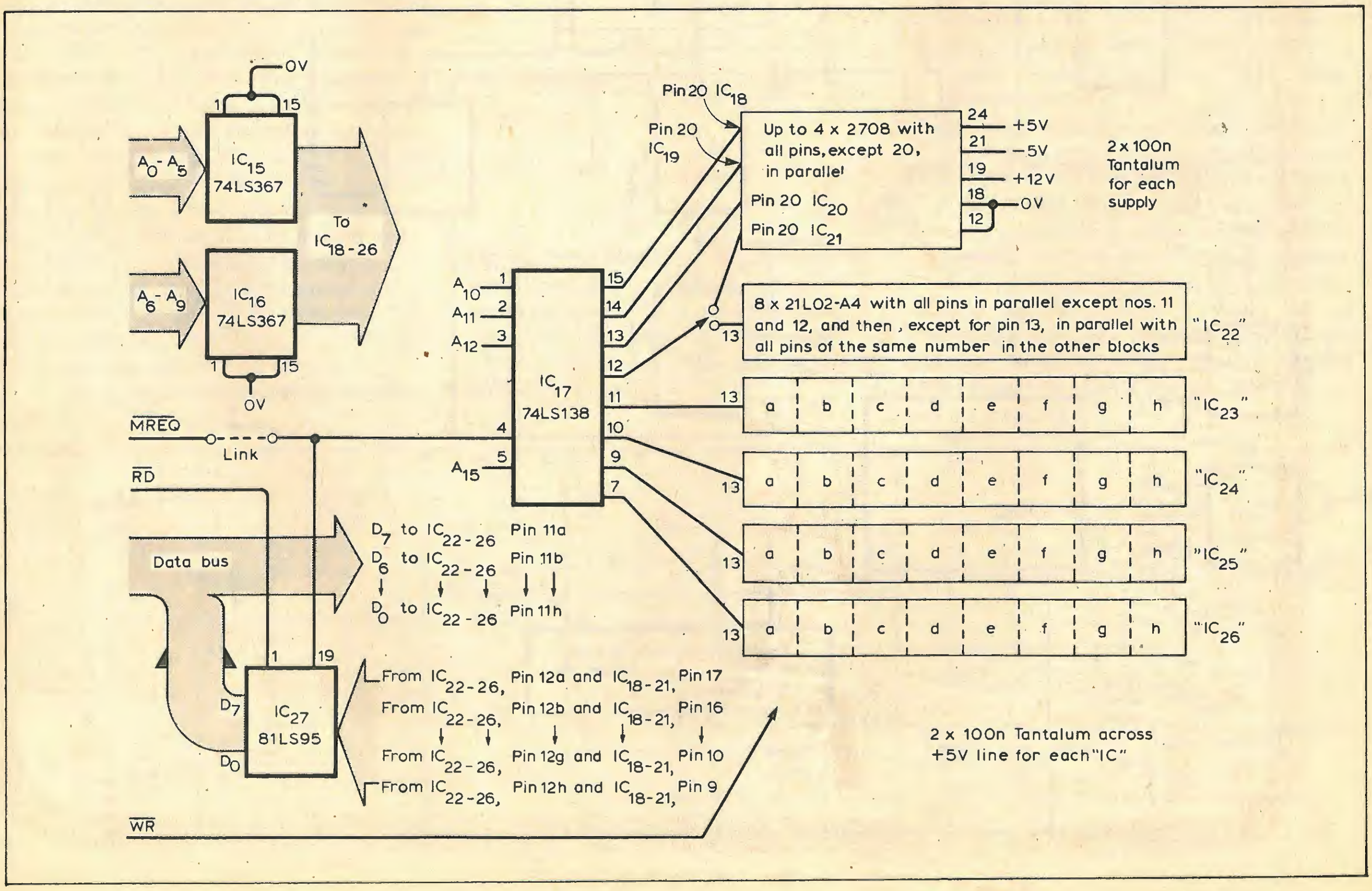


Fig. 7. *Modification to achieve four $\overline{MREQ}$ lines for the control of up to 32K of memory.*

Fig. 6. *Memory circuit. 3K of r.o.m. contains the monitor program, BURP monitor, and interpreter. 5K of r.a.m. accommodates user program storage. The memory can be extended in blocks of 8K up to 32K.*



driven from A_0 to A_9, these lines are buffered by IC_{15} and IC_{16}, which are permanently enabled. Although adding buffering increases the time delay between a memory request, and the data being ready for the Z80 to read in, the most critical 'reads' have 750ns to access the memory, therefore 21L02s with a 450ns access time are quite adequate.

Visual display

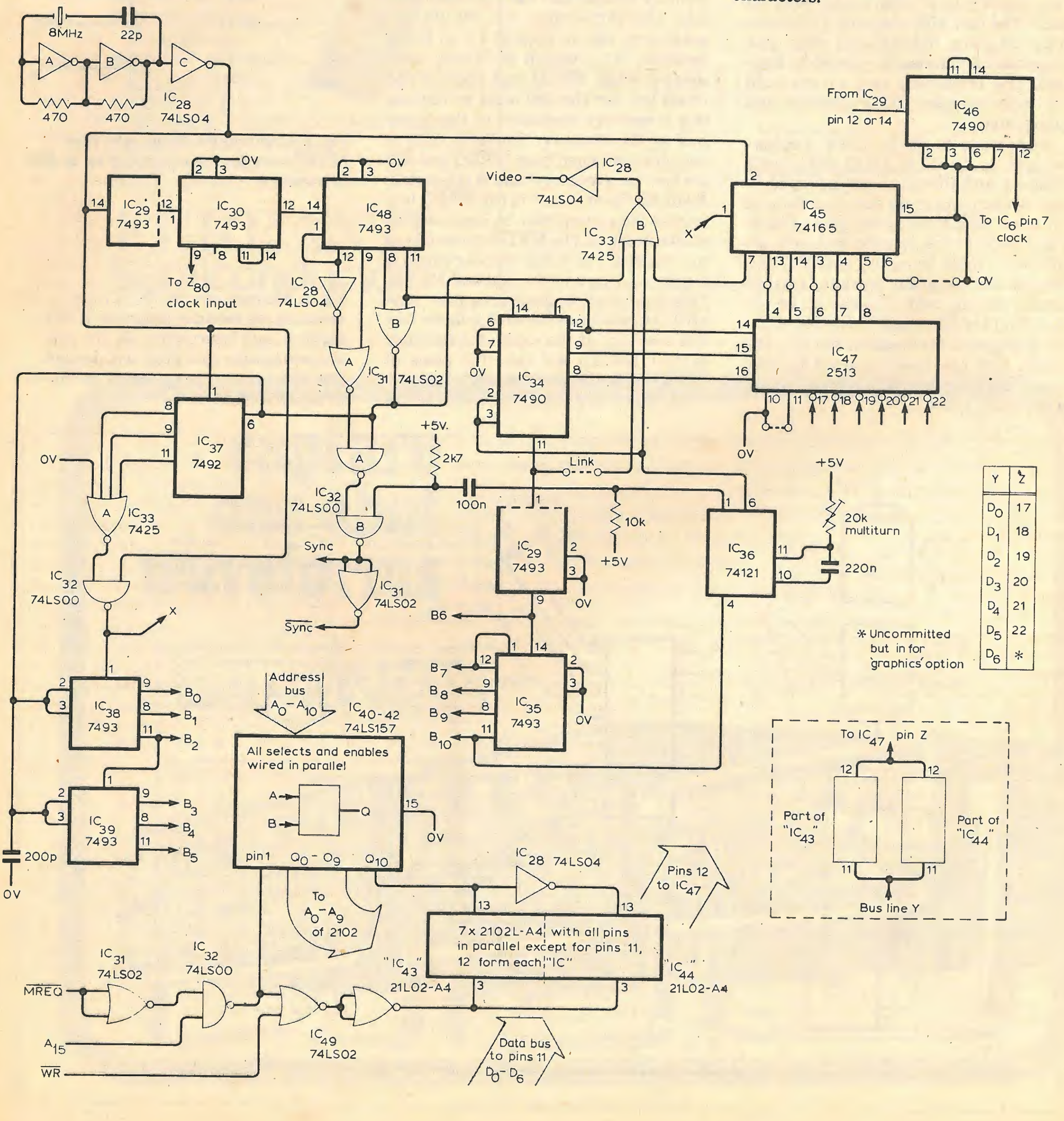
The visual display circuitry in Fig. 8 is constructed using standard t.t.l. i.cs instead of one of the recent l.s.i. controllers. This approach was chosen because the only suitable l.s.i. device is rather expensive, and, more important, the t.t.l. design gives maximum flexibility and allows an optional graphics system to be easily implemented.

Each line scan takes 64μs and is thus compatible with standard 625 signals and, with 320 instead of 312.5 lines per picture frame, the frame scan, although slightly longer, will easily be within the range of a television set to be used as a v.d.u.

In Fig. 8., IC_{28} generates a signal at 8MHz from which all of the clocks within the computer are obtained. Part of IC_{29} divides the clock to 4MHz, and either the input or output of this i.c. is fed to IC_{46} which produces a true square wave at either 800 or 400kHz for the MM57109. The 4MHz is further divided by IC_{30} to provide a 2MHz clock for the Z80, and an output at 250kHz for IC_{48},

Fig. 8. *Visual display circuitry. This discrete t.t.l. version reduces cost and improves flexibility.*

which produces 16 states of 4μs each. State 0001 is decoded and used as the line synchronizing pulse. The output at pin 11 of this i.c. is at 15.625kHz, and clocks IC_{34} at the standard 625-line rate. Part of the line sync. decoder, IC_{31b}, provides a signal which is active low during states 0100 to 1111 inclusive. This produces a 48μs burst during which IC_{33} and IC_{37} to IC_{39} are enabled, and allows a video display to occur, see Fig. 9. Division of the 64μs line scan into a 4μs sync. pulse, an 8μs pause, a 48μs display, and then a 4μs pause, allows for the overscan that occurs in commercial televisions. If the displayed video runs off the end of the screen, even with the width and shift controls adjusted correctly, omitting the inverter on pin 12 of IC_{48} will shift the displayed video 4μs to the left which corresponds to about five characters.



The dividers described so far are free-running with their reset inputs taken low. The decade counter IC_{34} is fed with pulses at the line frequency and divides these to provide 10 row addresses for each line of displayed characters. Outputs Q_1 to Q_3 go directly to the character generator, IC_{47}, but Q_4 is connected to IC_{33} and is high during the ninth and tenth lines, i.e. the two lines to be blanked between character rows. A divide-by-32 counter, formed by IC_{29} and IC_{35}, provides an address for each line of characters on the screen. At the end of a display page, monostable IC_{36} is triggered by this counter to provide a reset pulse for IC_{34}. This holds the divider chain, IC_{34} to IC_{39}, at the first row of the first character of the first character row until frame flyback has occurred and line sync. has been regained. The monostable pulse is also used to blank the video during the flyback via IC_{33}, and through a differentiator, to provide a field synchronising pulse to IC_{32}.

A third divider chain remains reset except during the 48μs display time defined by IC_{48} and its associated gates. IC_{37} is clocked at 8MHz, and divides-by-6 to provide a character-rate pulse, which, when gated with the 8MHz clock, is used to load data from the character generator into the shift register IC_{45}. This gated pulse is also used to clock a character counter divide by 64 circuit, comprising IC_{38} and IC_{39}. Data loaded into IC_{46} comprises five bits of the row of the character which the character generator is being asked to supply, together with one blank bit on pin 6 to complete the 10 × 6 character format. These bits are loaded in parallel and clocked out serially, via pin 7, to the video gate, IC_{33}. The three lower address bits for the character generator, IC_{47}, are supplied by IC_{34} as previously explained. The upper six come from the r/w.m. comprising IC_{43} and IC_{44}. Addresses for this block of r/w.m. are supplied by the 2 to 1-line multiplexers IC_{40} to IC_{42}, which are switched between addresses supplied by the main address bus of the Z80 and those being generated by the v.d.u. dividers by the decoded $\overline{MREQ}$, $\overline{WR}$ and A_{15} signals. Because this signal also switches the $R/\overline{W}$ inputs of the memory, the conditions are either; multiplexer connects Z80 address bus to r/w.m., Z80 writes into r/w.m., or multiplexer connects v.d.u. circuitry to r/w.m., data inputs to r/w.m. disabled.

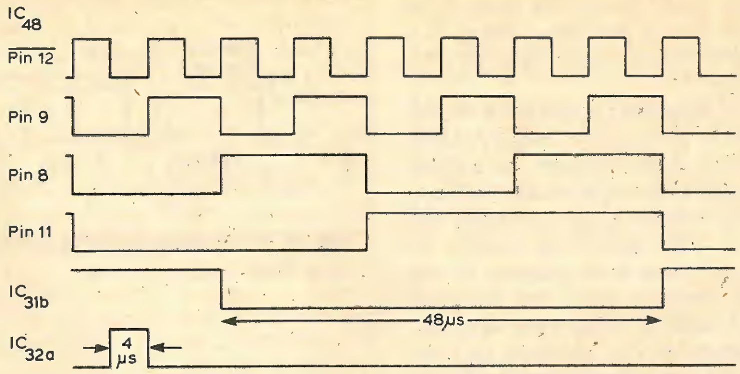


Fig. 9. *Divisions of the 64μs line scan.*

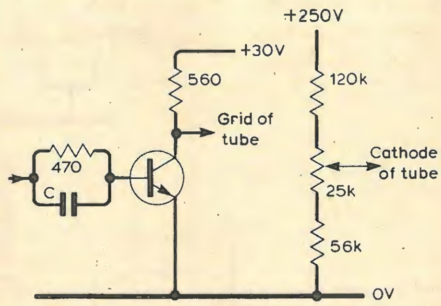


Fig. 10. *Typical television interface.*

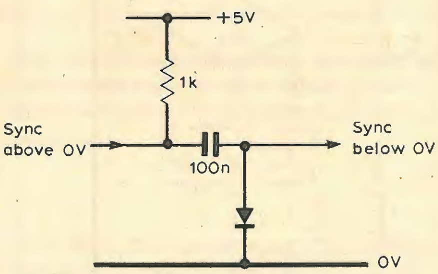


Fig. 11. *Positive to negative sync. converter.*

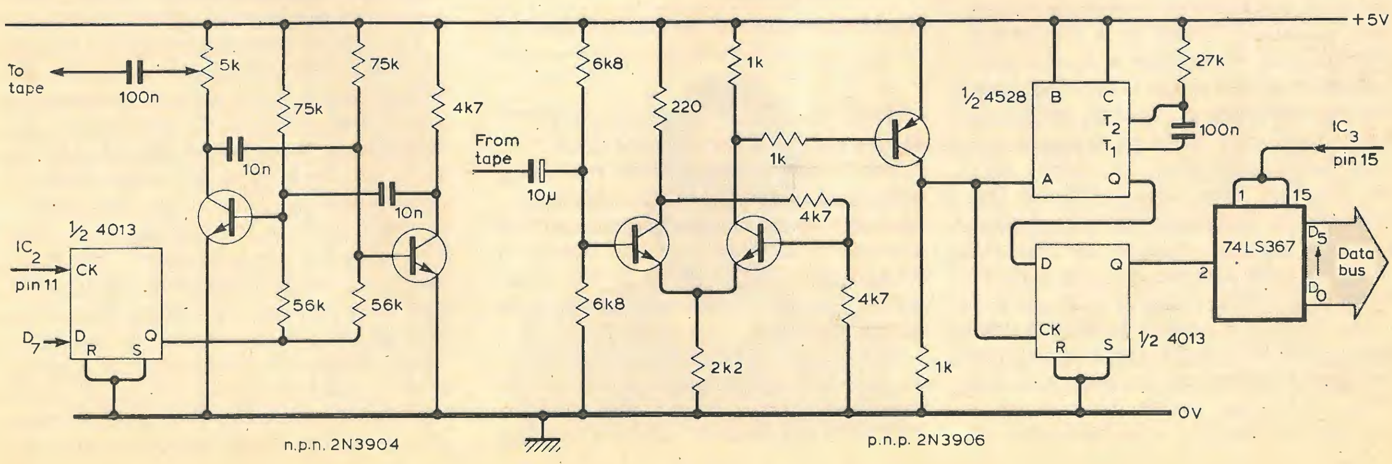
Fig. 12. *Tape interface. The receiver is not susceptible to changes in tape speed because it does not detect a particular frequency, but recognises whether the signal is above or below a certain frequency.*

Each i.c. block in the r/w.m. consists of seven 21L02A4 devices, six of which are used as stores for ASCII character codes. The seventh is for an extension of the v.d.u. to graphical displays and may be omitted. The 2 kilobytes of memory contained in the v.d.u. is mapped at the addresses 8000 to 87FF, but, due to the simple decoding used to address the v.d.u., it may also be "found" at 8800 to 8FFF, 9000 to 97FF etc., up to F800 to FFFF, i.e. 16 blocks in all. This provides a simple method of extending the v.d.u. display so that, after printing out a full screen of results, the next line will automatically start at 8800, i.e. the top of the screen, and so on, which effectively gives over 500 lines of display.

Tv interfacing

The v.d.u. circuit produces approximately 4V of video information and a separate 4V synchronization signal consisting of 4μs and, approximately, 100μs pulses. If a dedicated monitor is not available, perfectly good results can be obtained with a modified 625 line television as follows.

To obtain a high quality display, the video amplifier in the tv set should be ignored, and the v.d.u. signal applied, via a buffer, directly onto the grid of the tube. As the chassis of most sets is connected to one side of the mains, an isolation transformer must be placed between the mains supply and the tv/



computer. Apart from the danger to yourself if this is not done, there is a great risk of destroying several i.cs with one mistake.

A typical interface for a tv set is shown in Fig. 10. If a 30V supply is not available in the set it can be obtained, via a diode and smoothing circuit, from the cathode of the line output stage, or from the computer. The interface should be mounted as close as is possible to the tube base, and the video fed via good quality r.f. coaxial cable from the computer. Capacitor C is selected to compensate for the particular length of coax used, 50pF being a typical value for 1 to 2m of miniature cable.

The best place to inject a sync. signal is where the sync. is taken from the i.f./video section to the timebase. An oscilloscope should be used, with the set operating normally, to identify where the voltage level of the sync. pulses best matches that of the computer. When this has been ascertained it is important to note whether the pulses are positive or negative going, and whether, as is common in valve sets, the entire sync. signal is negative. The first point will determine which sync. output is used, and Fig. 11 shows a simple method of dropping the entire sync. signal below 0V.

Tape interface

It is useful to have a cheap means of storing data and, at present, recording on ordinary cassette tape is the most acceptable method. Blocks of data are recorded onto, or read off tape via the interface shown in Fig. 12.

Data is recorded at 300 baud, with 0s and 1s represented by tones at approximately 1200 and 2400Hz. The Z80 calls the byte to be recorded into register A and sends it out, bit 7 first, along data bus line D_7. The byte is pre fixed by a 0, known as a start bit, and immediately followed by 1½ bits, in duration, of a 1, which is known as a stop bit, see Fig. 13. Thus, the recorded word is 10½ bits long, i.e. 35ms. A time delay is generated by the Z80 (its fastest rate being over 100 Kilobaud) and latches the bits from line D_7 into the D type flip-flop, whose Q output switches a multivibrator to generate the tones.

The receiver consists of a Schmitt trigger and buffer, which produce a 5V pk-to-pk square wave from the tape deck output, followed by a frequency discriminator formed by a monostable and the other half of the D type flip-flop. The square wave at 1200 or 2400Hz is simultaneously used to trigger the monostable, and clock its output into the flip-flop. The pulse width of the monostable has been chosen so that with a triggering rate of 2400Hz, its output is continuously at 1, i.e. a pulse width > 1/2400s. Therefore, the output of the flip-flop is also at 1. With a triggering rate of 1200Hz, the monostable has time to complete its pulse, so the next clocking pulse clocks a 0 into the flip-flop, i.e. a pulse width < 1/1200s. The circuit requires a 2 to 3V pk-to-pk signal from the tape deck.

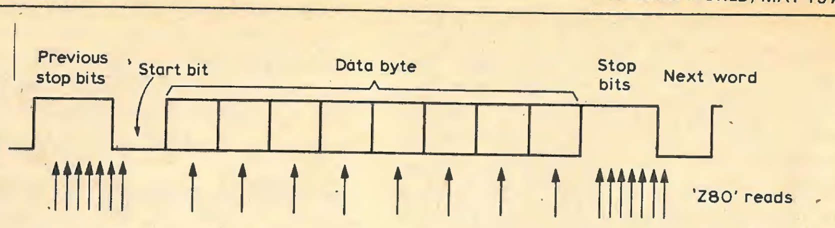


Fig. 13. *Word structure of a software recording.*

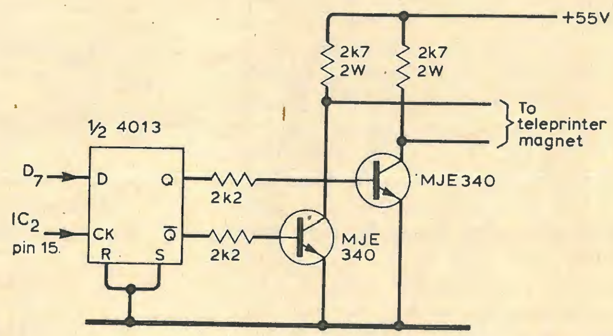


Fig. 15. *Teleprinter interface. This circuit is kept simple because software in the r.o.m. carries out most of the operations.*

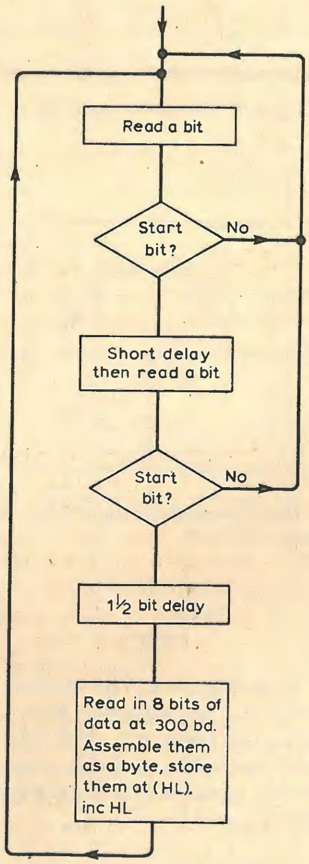


Fig. 14. *Operation of the read software.*

The firmware starts each recording with several seconds of stop bits before the transmission of data begins, and this allows the tape to be cued before a READ command is given to the computer. The read software operates as shown in Fig. 14.

The bit from the interface is read in through a 6-bit buffer and then masked, i.e. the other bits are blanked off by a Z80 AND instruction, before checking takes place. To give error protection, two checks must indicate that a 0 is being read in before the routine proceeds, and a byte of data is then read in.

Teleprinter interface

A teleprinter is a very useful addition to any computing system, but, in a low cost design such as this, a new machine would be prohibitively expensive. The supplies of second-hand machines seem to split into two groups; 7/8-bit machines using ASCII coding, and 5-bit machines using modified ASCII or Baudot coding. The advantage of the first type is that they hold the full ASCII set of characters but, they are still reasonably expensive. The 5-bit, modified ASCII machines, such as the Creed 75s, can be purchased for as little as £5, but only have 32 possible codes. Almost 60 different characters can be generated by using two of the code words, 1B and 1F, to switch a mechanical flip-flop, within the teleprinter, between two sets of characters, letters or figures and punctuation. The two shift characters, line feed, carriage return, blank and space remain common to both shifts.

This type of machine requires a serial input at 75 baud which means that, with a 7½-bit word, it will print 10 characters per second. Coding for the letters is identical to the lower 5 bits of ASCII code, but the figures, although similar, require translating from the 6-bit subset of ASCII used in the computer, to the 5-bit code for the teleprinter. The formation of words comprising a start bit, five data bits and two stop bits, the interspersing of figure and letter shifts where necessary, the storage of a byte which mirrors the state of the mechanical shift flip-flop in the teleprinter so that shift characters are only

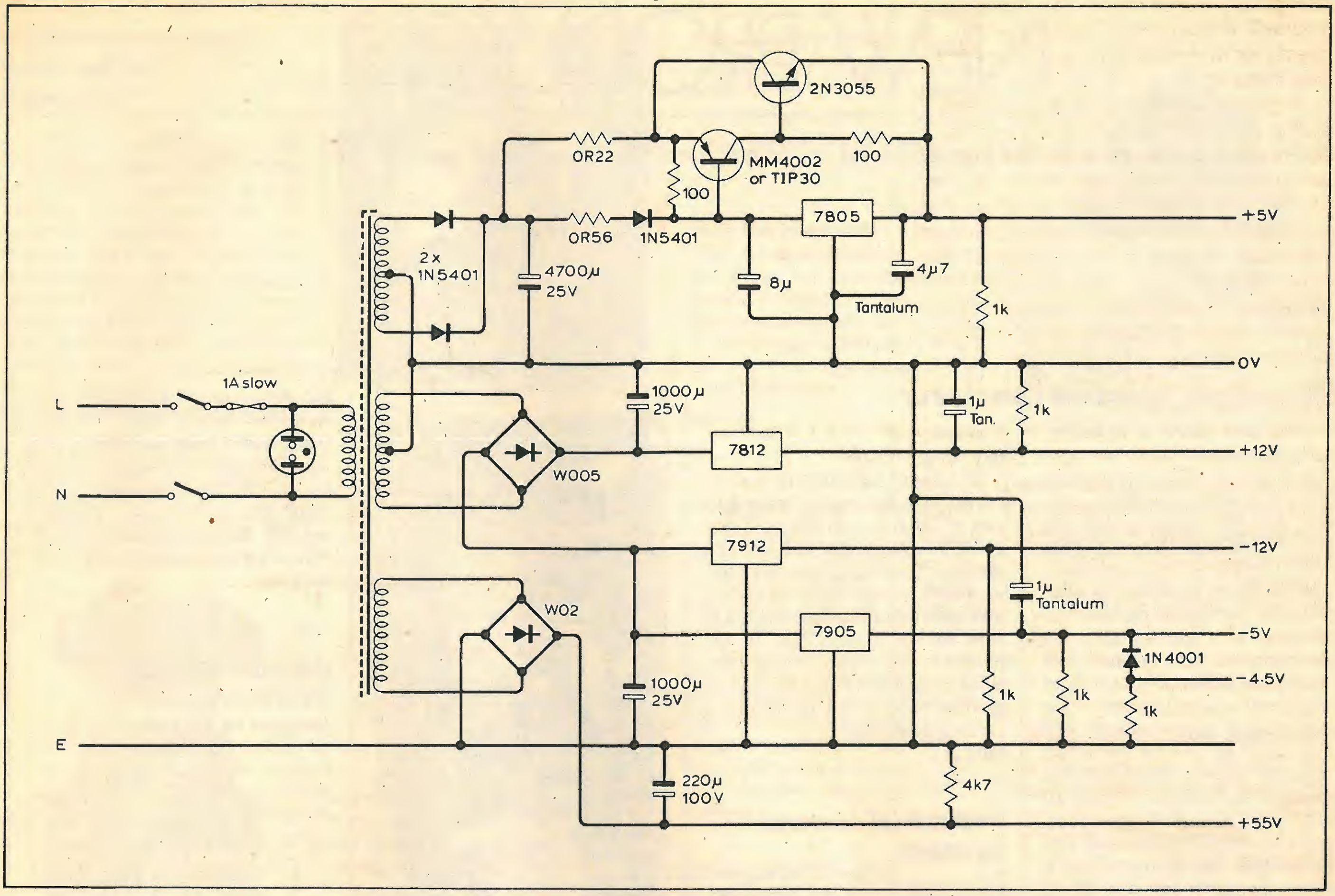


Fig. 16. *Power supply. A 1A regulator in parallel with a general purpose power transistor gives a regulated output of up to 3.5A.*

sent when necessary, and the time delays required to slow the computer down to 75 baud, are all accomplished by software stored in part of the monitor r.o.m. The hardware involved in interfacing the teleprinter, Fig.15, is therefore very simple.

Power supplies

The power supply provides stabilized outputs of +5V at 3.5A, −5V and ±12V at 1A, and an unstabilized output of approximately + 55V at 100mA. The +5V supply in Fig. 16 is the only unusual part of the circuit as it uses a 1A regulator i.c. with a pseudo p-n-p pass transistor instead of a more expensive 3A regulator. The circuit operates by dividing the current passing through the regulator and the transistor in the ratio of the two series resistors. In this case, 56/22 times as much current passes through the 2N3055, which gives a 3.5A regulated output for 1A through the 7805. It is important that the regulator, transistors, and the diode which mirrors the voltage drop across the base-emitter junction of the p-n-p transistor are in good thermal contact.

The −4.4V supply is for the MM57109 which is specified to operate from a maximum overall supply of 9.5V. The +55V supply is for the teleprinter magnet. Although the Creed magnets, in common with others, are designed to operate with a current of 20mA, and have a resistance of 200Ω, switching 4V into the coil is not satisfactory due to the inductance in the magnet's coil. Therefore, current driving, rather than voltage supplying, is required to produce a quick action from the magnets, and a high voltage supply fed through 2.7kΩ resistors is used. If a teleprinter is not going to be used, it is still worth including this supply as it may be needed for the tv interface, and will be required for the r.o.m. programmer to be described later.

The transformer used in the prototype was an RS Components 50VA d.i.y. type 207-554 with windings to give open-circuit voltages of 9.5-0-9.5V for the +5V supply, 13V for the −5V and ±12V supply, and 40V for the teleprinter supply, the last mentioned being wound with 36 s.w.g. wire and the other two with 22 s.w.g. wire.

No filtering has been included at the mains input as the processor is relatively insensitive to interference from the mains cable. The computer has been used to receive radioteleprinter messages via a communications receiver with an interface, and tests showed that negligible interference leaves the computer by the mains cable.

To be continued

A kit of parts for constructing a computer on this design is available from Powertran Computers, Portway Industrial Estate, Andover, Hants SP10 3NN (tel: Andover (0264) 64455).

The author
John Adams read for a B.Sc. in electronic engineering and for an M.Sc. in materials science, at the University College of North Wales, before becoming a teacher. His involvement in electronics is, therefore, primarily as an amateur, and the design for this computer started 18 months ago as an exercise to gain familiarity with microprocessors. John operates the amateur radio station G3VZF, and in his spare time claims to be a very amateur musician.

NEW PRODUCTS

Professional readers are invited to enter codes on the reply-paid card bound in at pages 112/3

Microwave spectrum analyser

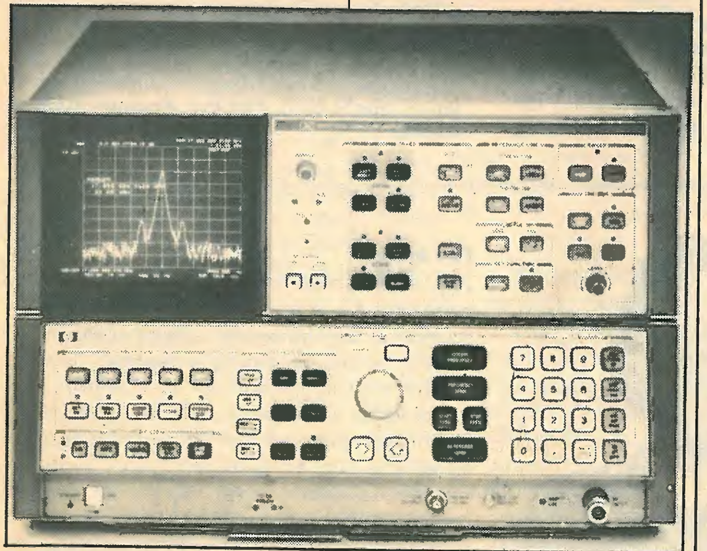
AFTER five years of development, Hewlett Packard has now introduced its 8566A programmable microwave spectrum analyser. This instrument covers the range 100Hz to 22GHz with 10Hz resolution, is microprocessor-controlled and requires no add-on units for basic operation. Frequency selection is automatic. All data is presented on the instrument's c.r.t. and control settings may be stored for later recall if measurements are to be repeated. In addition to this "memory" facility, full automatic operation is possible, while all functions are remotely programmable via the interface bus and the analyser can be instructed to feed its measurements out via the bus for interpretation and interaction by a computing controller.

Alternative features include automatic peak search, preselector peak, zoom, setting storage, and a "single sweep" facility from zero to 24GHz.

Using the 10Hz resolution bandwidth, the analyser's sensitivity is —137dBm to 1GHz, —134dBm to 5.8GHz, and —115dBm at 22GHz. Related attributes are 80dB dynamic range and full frequency range amplitude variations of ±2dB, permitting direct measurement of line-related sidebands that are 50dB down. Frequency error is virtually that of the internal frequency reference, 1×10^{-9} per day being possible.

The basic instrument is contained in a two-deck casing and the total net weight is 50kg (112lb). At a price of £29,500, the analyser (excluding options such as 400Hz power line operation and rack mounting kit), which is now in full production, is expected to sell largely to organisations such as the Post Office or to groups interested in satellite communications.

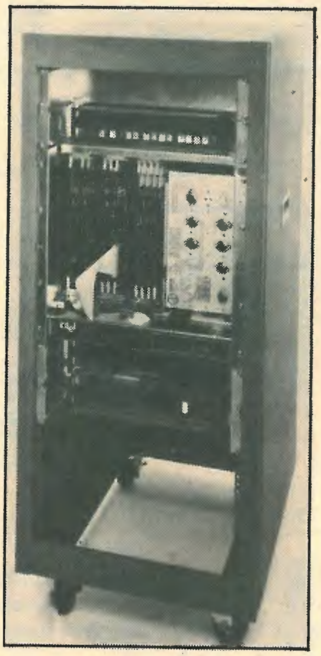
WW301



WW301

Industrial control system

The ICS-80 industrial controller which is linked to Intel's multibus system, accepts the complete range of iSBC single board computers and the full range of Intel's software, including PL/M-80, PL/M-86, Fortran-80, Basic-80, and RMX-80, all on boards. Principal applications of the system will be as industrial process timers on production lines, as data acquisition systems or as test fixtures. The chassis is air-cooled and power supplies can be fitted to suit application, signal conditioning and termination panels. The needs of a system can be matched to a particular processor board, eight-bit word length by the 8080A or the higher



performance 8085A and 16-bit by use of the 8086-based iSBC-86/12. A system can contain several processors, and 8-bit and 16-bit processors can be intermixed in the same system. Memory can be extended to over a megabyte, and a variety of disc systems and controllers is available from the manufacturer to provide bulk storage facilities. Intel Corporation (U.K.) Ltd., 4 Between Towns Road, Cowley, Oxford OX4 3NB.

WW302

Miniature microphone amplifier

Improved transient and frequency response when compared with a typical balancing transformer and associated circuitry, is claimed by Kelsey Acoustics for their miniature microphone amplifier, designated K102m. The amplifier measures 40mm × 40mm × 20mm and has been in use in Kelsey audio mixers following its development over the past two years. Specifications include frequency response 10Hz to 50kHz ±0.5dB, harmonic distortion better than 0.03% ref 1kHz, and equivalent input noise (unweighted) better than −125dBV (DIN/audio band weighted). The input impedance of each terminal (+ or −) is 5kΩ, maximum gain is 43dB and the + and − supplies are 15V. Kelsey Acoustics Ltd, 28 Powis Terrace, London W11 1JH.

WW303

Instant-heat soldering iron

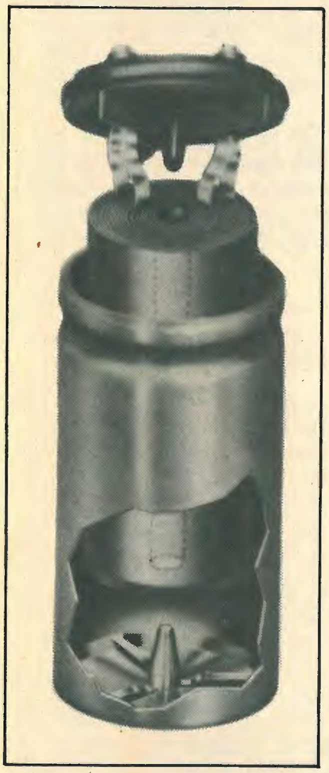
Designed for both the professional and the amateur user, the Kelgray Products S.50 "Instant Heat" soldering iron offers the impatient engineer a 10 second warm-up time to reach a tip temperature of 350°C. This iron is a mains-powered version of the B.50, has a consumption of 35W, and a permanent soldering tip with protection against oxidation and erosion. Illumination of the workpiece is included, as is an indicator lamp to show when the iron is switched on. The standard bit is suitable for soldering materials up to 2.5mm², although the iron exists in a larger kit form including two extra tips (one for 1.5mm² and one for 6mm² material). In both forms the iron is packaged in a transparent

container complete with tip cover, cleaning pad and a screwdriver. The standard package with one tip costs £9.50 and the larger one with three tips £11.80. Quantity discounts are applicable to larger users. Kelgray Products Ltd, Kelgray House, Sandy Lane, Crawley Down, West Sussex RH10 4HS.

WW304

High temperature electrolytic capacitor

Primarily designed for high frequency filtering applications in switching regulator power supplies, the Sangamo type 125 capacitor, according to its distributor Waycom, is the first large computer grade aluminium electrolytic capacitor to operate for extended periods at temperatures from —55°C to 125°C. In test situations this capacitor has passed 2000-hour life tests and the projected life is estimated as 5 years at +85°C, 10 years at +75°C and more than 20 years at +65°C. Capacitance ranges are from 1400μF to 72000μF at working voltages of 5V (d.c.) to 40V



(d.c.). Current ripple capability is a maximum of 35A at +85°C and 10Khz. Standard threated insert terminals are used and the capacitor is available in nine length sizes between 41mm and 143mm. Waycom Ltd., Wokingham Road, Bracknell, Berkshire RG12 1ND.

WW305

Fast comparator chip

Claiming that their SP9685 and SP9750 circuits are the fastest in the world today, Plessey Semiconductors assert that conventional propagation delay is twice that of the SP9685's 2.2 nanoseconds. The SP9750 possesses additional decoding logic suitable for 4 bit a-to-d and 8 bit d-to-a converters, operating with a clock rate of 100MHz. An appropriate number of such devices may be used in parallel,

eliminating the need for further decoding logic and saving space, time and costs. A dual version, the SP9687, will soon be available. Plessey Semiconductors Ltd., Cheney Manor, Swindon, Wiltshire SN2 2QW.

WW306

Short circuit locator

The "Tone Ohm 400A" provides an audible tone which is directly related to a resistance level under test, providing an instant check for short circuits on p.c. boards, wiring harnesses or cableforms. Microscopic "whiskers" or solder bridges can be located in seconds by moving the test probes along the tracks or cables until the highest pitch tone is heard, corresponding to the actual location of the short. Audio volume is adjustable, and there is a meter readout extending from 30mΩ to 3Ω over five ranges. The instrument is mains operated (120V or 240V) and costs £98 + V.A.T. Omnitest Ltd., 119 Old Christchurch Road, Bournemouth, Dorset, BH1 1EP.

WW307

Proximity detector

A proximity detector which could help to reduce accidents in industrial situations is available from Bulgin Electronics. This unit has a matched counterpart which operates from a 12V d.c. supply and which activates the main unit when within a range of 1.5in. It can be useful in warning of excess movement in suspended vehicles or crane jib systems and measures 5in × 2.75in × 1in. Bulgin Electronics Soundex Ltd., Park Lane, Broxbourne, Herts EN10 7NQ.

WW308

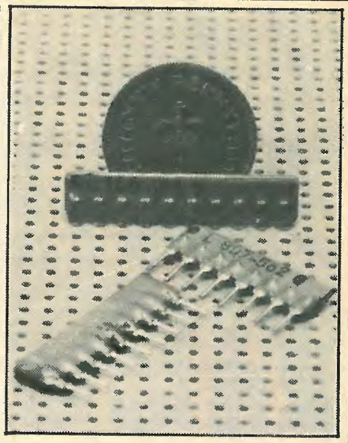
Power f.e.t. device

A further item in the growing power f.e.t. family has been introduced by Siliconix. Featuring turn-on and turn-off speeds of 5ns (typical) this V-m.o.s. device has a maximum source-to-drain and source-to-gate voltage of 60, and a maximum power dissipation of IW at 25°C. The item is designated VN10KM and is TO-237 packaged. Siliconix Ltd., Morriston, Swansea SA66 NE.

WW309

Low-profile SIL resistors

The recent introduction of standard profile SIL cermet resistor networks by Hitech Electronics has now been followed by a "lo-profile" range in which the overall maximum seated height from the p.c. board is only 6.35mm. Each network is available in 6, 8, 9 and 10 pin, 0.1in pitch versions, with two basic options available offering all resistors commoned to pin 1 or each resistor brought out to a separate pin. Over 50 resistor values are avail-



able, ranging from 33Ω to 2MΩ with 0.125W or 0.2W ratings and tolerances of ±2%, and some at tolerances of ±0.1%. NSL, Stamford House, Stamford New Road, Altrincham, Cheshire WA14 1DR.

WW310

Micro crystal packs

A range of micro-miniature crystal packages intended for applications such as microprocessors, portable communications equipment, computers and pagers is now being marketed by Rastra Electronics. The Crystek type HC45 is available in the frequency range 6 to 22.9MHz and it is claimed that the operating temperature can be within the limits of —55°C to +105°C. Rastra Electronics Ltd., 275-281 King Street, Hammersmith, London W6 9NF.

WW311

Music generator

"Jingle" machines using tape mechanisms to produce short tunes or Morse code sequences are by no means new to the market, but Crow of Reading have just introduced a similar unit, the "Ident and Music Generator", model MMB32, which uses no moving parts. Primarily intended for establishing and verifying long-line audio networks, outside broadcast lines and telephone links, this item is claimed to represent a competitive price (against conventional machines), and to require a minimum of maintenance. Thirteen semitones of a complete octave are derived by frequency division from a single master oscillator, which can be pre-tuned to locate the octave in use anywhere within the 100 to 1000Hz range. A further circuit provides timing or rhythm information, and the unit can be delivered ready programmed or may be programmed by the user. Audio output is 1mW into 600 with transformer isolation. Crow of Reading Ltd., P.O. Box 36, Reading, RG1 2NB.

WW312

SIDEBANDS by Mixer

Living room

How would you rate the relative importance, in terms of domestic bliss and harmonious cohabitation, of a set of hi-fi 'separates' and of unimpeded access to one's own dining-room? I ask the question because it is becoming increasingly clear to me that those of us who possess such a collection of gear are harbouring a cuckoo which, if given its head, will eventually take over the house completely and leave us, whining unhappily, listening to the Who in the loo.

These bitter thoughts, foreign as they are to my normally sunny nature, originated in frustrated attempts to fit the assorted boxes I have collected into a new bit we have tacked onto the house. It is supposed to be a new dining room, but when I had decided on the position of the hi-fi (there's no space in the living room) the room was fit only for Japanese-style meals, without the geishas.

I do realize that some minor writer once came up with the crack that music might be called the food of love, but when I want to get at my steak, chips and mushy peas I don't want to find I have to balance them on a speaker. Looking at the constitutent boxes of a set of audio 'separates', it seems to me that, although the cassette deck is pretty tightly packed with its transport mechanism, and a turntable box has to be at least the size of the turntable with a bit of space for the arm, amplifiers and tuners contain a lot more fresh air than they ought to. The 'long, low' look is all very well, but unless your family is a sight less acquisitive than mine, its demand for lebensraum can upset the even tenor of domestic tolerance.

Shrinking the electronics would help, as I've indicated, but the real problem is the speakers. There can't be many more inconvenient lumps of technology than the average hi-fi speaker enclosure: with a piano you can put the aspidistra and family photographs on it; the television set has already got all my pipes and a daft little toy dog grinning like a lunatic; and practically every other horizontal surface carries its share of household embarrassments. But not the speakers. For one thing, they're omnidirectional and the treble driver fires straight up at the ceiling, so a pot of Busy Lizzie artistically placed on top of it would not do a lot for the frequency response.

No, I think electrostatic speakers, flush with the wall when not in use, or even when they are, would be the solution. They could be designed with this in mind and made specially resistant to plaster, cement and fag ends with a view to surviving the attentions of builders. If the manufacturers could manage to reproduce a Lowry, or perhaps one of the livelier Canalettos — maybe even a Mondriaan for the geometrically inclined — on the front of the units, I feel sure that their cause would thrive. One might then hear, in the local hi-fi shop, customers demanding "An 8-ohm, 50W 'Monarch of the Glen', please".

Software engineering

Have you noticed the way a system has changed from being something to get things out of to being the generic term for everything from office furniture to a network of computers? Since a system is a complex whole or organized body of ... things (Concise Oxford) that's fine for computers and even office furniture at a pinch, but my normally alert mind, finely tuned to spot the links between apparently unrelated remarks and items of general chit-chat, has so far failed utterly to detect the relevance of the word 'system' in relation to a towel. A handout that came in today asserts that a new, disposable towel provides a comfortable and hygienic system, needing no 'complex dispensing system'. It is also blue. I'm not grumbling, though; if we get them here they'll be useful for decontaminating my tobacco incineration system.

Chip trip

This unseemly, though belated, passion for electronics by which government and quangos have lately been overcome is going to lead to some queer goings-on in some of the smaller companies. As *WW* points out in last month's leader, sending the chap who mends the office fuses for a fortnight's brainwashing is unlikely to revolutionize the way they make tin-openers. When he comes back from the cramming, trailing clouds of glory and data sheets, unkind directors will probably wish to know of him when they can expect to see his first, hesitant steps towards revitalizing British industry. Whereupon he will collect the relevant i.cs and a white coat, upgrade his assistant Sparks to fuse-mending status, and retire to reflect on what on earth he has let himself in for.

Some works electricians I have known are extremely bright. They will re-wire a factory while an electronics whizz is still wondering what size cable to use. Being perspicacious, they will have realized in the course of the brain-pickling session that tying a microprocessor chip onto the bed of a milling machine is not going to make it fully automatic at a stroke. All the little bits and pieces which allow the creature to communicate its deliberations, and the means whereby something useful can be done with this intelligence when it emerges, not to mention the software, firmware and brainwear needed to attain this happy state, are mentioned only rarely in the general hysteria.

What the aforementioned director is going to say when told that the chips cost £50 and, after a well-timed pause, that the bits and pieces and the bill for software will come to around £1000, can only be imagined by one whose request to spend £5 on a better soldering iron was met by a suggestion that he borrow the electrician's 60W monster.

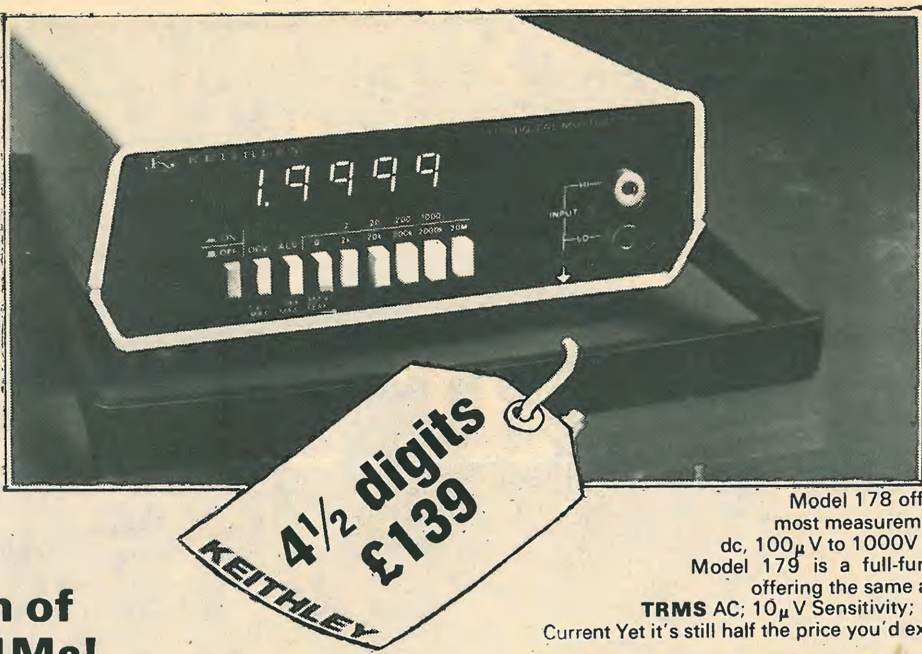
Some of these lance-corporals of industry are all for making more profit by the use of new ideas, but if the increased profit doesn't materialize by next Thursday, it is branded as pie in the sky and discounted.

Capital depreciation

So long as the pervasive computer was content with the mismanagement of life in general, I didn't complain too loudly. People's driving licences can go astray and they can receive electricity bills for three and a half million pounds without a murmur from me. But when, having found precious space for descriptions of computers and similar contraptions, they begin to ruin the look of our pages, then I reckon it's time someone said something.

It's all to do with the way instructions and statements are printed in capitals. If you come across a paragraph with WRITE in the middle of it or, worse, one of those Czechoslovakian words, like MREQ or IORQ, your eye leaps straight to it and, having got there, discovers that it is no more important than the rest of the words in the paragraph. And yet these words must be set in a different way to the rest of the text, or they might be confused with ordinary words and their significance be lost; one can imagine a command to print print on the screen, for example.

To differentiate between text and these special words, without over-emphasizing them and making the eyes tired with continually jumping to the capital word and back to the start of the sentence, perhaps one could set them out as :read: or /mreq/ or even (goto). It would also be a help to printers if to no one else, if, when all instructions are of the 'active low' variety, the negating bar could be omitted; a simple statement of explanation at the beginning of the article should then suffice.



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For complete specifications on the 178 and 179, call Keithley Instruments, 1 Boulton Road, Reading. Phone 0734 861287

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Overshoot:	less than 3%
Sweep time:	100 nS/cm - 0.5S/cm
Linearity:	better than 3%
Calibrator:	1 KHz 100 mV square wave
Trigger bandwidth:	DC - 40 MHz
Trace rotation:	Electrical
Phosphor:	P31
Power:	AC 100/120// 220/240V 50/60 Hz 40W
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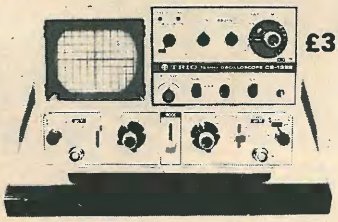
Weight:	10 Kg

CS1352 DUAL TRACE 15 MHz/2mV PORTABLE



£350 + 8%

The CS1352 oscilloscope offers you not only dual trace, 15MHz bandwidth operation at sensitivities down to 2mV/cm but also use from 100-240 Vac mains **and** portable operation using the optional rechargeable battery pack. Automatic charging is carried out when the CS1352 is plugged into a mains supply. Now you can have top performance both on the bench and out in the field — and at an affordable price.

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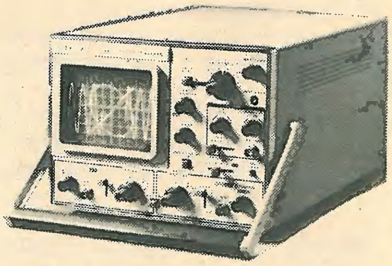
The CS1575 is a unique tool for the audio engineer. It features the normal facility of dual trace display with sensitivity to 1 mV/cm but not only can it display the input signals on two channels, it can **simultaneously** display the phase angle between them and measure the phase angle referenced to a zero phase calibration display. In addition to these unique features, you also have independent triggering from each channel to give stable displays even with widely differing input frequencies.

Absolutely indispensable to the professional audio engineer, the CS1575 is now in use all over the world. See it in action or send for complete details.



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BC108B	.12	.11	.09
BC108C	.12	.11	.09
BC109	.12	.11	.09
BC109A	.12	.11	.09
BC109B	.12	.11	.09
BC109C	.12	.11	.09
BC142	.24	.22	.17
BC143	.26	.24	.19
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BC301	.23	.22	.17
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BC461	.27	.25	.20
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BCY59	.15	.14	.11
BCY70	.18	.17	.13
BCY71	.18	.17	.13
BCY72	.18	.17	.13
BD131	.30	.34	.26
BD132	.37	.35	.28
BD142	.69	.65	.51
BD222	.42	.40	.31
BD234	.51	.49	.38
BD242	.33	.32	.24
BF257	.23	.22	.17
BF258	.24	.23	.18
BF259	.25	.24	.19
BF337	.24	.23	.18
BFY50	.21	.20	.16
BFY51	.21	.20	.16
BFY52	.21	.20	.18
BFX84	.21	.20	.16
BFX85	.21	.20	.18
BFX86	.21	.20	.16
BFX87	.23	.22	.17
BFX88	.23	.22	.17
C1509	.38	.28	.28
MJE340	.71	.67	.52
R2008B	1.35	1.28	1.00
R2010B	1.15	1.09	.85
TIP29	.30	.28	.22
TIP29A	.32	.30	.24
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TIP30A	.32	.30	.24
TIP30B	.32	.30	.24
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TIP31A	.32	.30	.24
TIP31A	.32	.30	.24
TIP31B	.32	.30	.24
TIP31C	.35	.33	.28
TIP32	.32	.30	.24
TIP32A	.32	.30	.24
TIP32B	.32	.30	.24
TIP32C	.35	.33	.26
TIP33	.53	.51	.39
TIP33A	.56	.53	.41
TIP33B	.61	.58	.45
TIP33C	.67	.64	.50
TIP34	.59	.56	.44
TIP34A	.62	.59	.46
TIP34B	.68	.64	.50
TIP34C	.75	.71	.56
TIP35	1.18	1.12	.87
TIP35A	1.24	1.18	.92
TIP35B	1.36	1.28	1.09
TIP35C	1.49	1.41	1.18
TIP36	1.28	1.22	.95
TIP36A	1.35	1.27	.99
TIP36B	1.47	1.39	1.09
TIP36C	1.62	1.53	1.19
TIP41	.46	.44	.34
TIP41A	.46	.44	.34
TIP41B	.52	.49	.38
TIP41C	.52	.49	.38
TIP42	.48	.45	.35
TIP42A	.48	.45	.35
TIP42B	.46	.45	.35
TIP42C	.52	.49	.38
TIP47	1.32	1.25	.97
TIP48	1.39	1.32	1.09
TIP2955	.56	.54	.42
TIP3055	.56	.54	.42
2N918	.35	.33	.25
2N1131	.24	.23	.18
2N1132	.23	.22	.17
2N1893	.33	.31	.24
2N1613	.19	.18	.14
2N1711	.24	.23	.18
2N2102	.34	.33	.25
2N2218	.21	.20	.18
2N2218A	.21	.20	.16
2N2219	.21	.20	.16
2N2219A	.21	.20	.16
2N2221A	.16	.15	.12
2N2222	.14	.13	.10
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2N2904	.21	.20	.16
2N2904A	.22	.21	.17
2N2905	.21	.20	.16
2N2905A	.22	.21	.17
2N2906	.14	.13	.10
2N2906A	.15	.14	.11
2N2907	.14	.13	.10
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2N3054	.60	.57	.45
2N3055	.61	.58	.45
2N3442	1.30	1.23	.96
2N3771	1.87	1.77	1.38
2N3772	1.09	1.78	1.39
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2N4037	.22	.21	.17
2N4058	.10	.09	07
2N4059	.10	.09	.07
2N4061	.10	.09	.07
2N4236	.28	.26	.21
2N4239	1.19	1.12	.87
2N5294	.42	.40	.31
2N5296	.37	.35	.27
2N5298	.45	.42	.33
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7404	.15	.14	.11
7405	.18	.17	.14
7406	.24	.23	.18
7407	.24	.23	.18
7408	.15	.14	.11
7409	.18	.17	.14
7410	.15	.14	.11
7412	.19	.18	.14
7413	.29	.28	.22

TTL	1+	25+	100+
7416	.22	.21	.18
7417	.22	.21	.18
7420	.15	.14	.11
7422	.18	.17	.14
7423	.18	.17	.14
7425	.19	.18	.14
7426	.19	.18	.14
7427	.19	.18	.14
7428	.19	.18	.14
7430	.15	.14	.11
7432	.18	.15	.12
7433	.21	.20	.15
7437	.19	.18	.14
7438	.19	.18	.14
7440	.15	.14	.11
7442	.25	.24	.19
7443	.40	.37	.29
7444	.40	.30	.30
7445	.19	.18	.14
7446	.45	.43	.33
7447	.36	.34	.27
7448	.45	.43	.33
7450	.17	.16	.13
7451	.17	.16	.13
7453	.17	.18	.13
7454	.17	.16	.13
7460	.17	.16	.13
7470	.30	.29	.23
7472	.30	.29	.23
7473	.23	.22	.17
7474	.23	.22	.17
7475	.19	.18	.14
7476	.28	.26	.21
7480	.33	.31	.24
7481	.52	.49	.38
7482	.52	.49	.38
7483	.28	.26	.21
7484	.40	.38	.30
7485	.42	.40	.31
7486	.18	.17	.13
7489	2.20	2.08	1.62
7490	.18	.17	.14
7491	.18	.17	.14
7492	.28	.27	.21
7493	.18	.17	.14
7494	.36	.34	.27
7495	.21	.20	.16
7496	.31	.30	.23
7497	.94	.89	.69
74100	.65	.61	.48
74104	.65	.61	.48
74105	.78	.74	.57
74107	.32	.30	.24
74109	.32	.30	.24

TTL	1+	25+	100+
74110	.38	.36	.28
74111	.25	.23	.18
74116	.25	.23	.18
74118	.81	.77	.60
74119	.54	.51	.40
74120	.54	.51	.40
74121	.35	.33	.26
74122	.40	.38	.29
74123	.38	.36	.28
74125	.38	.36	.28
74126	.38	.36	.28
74128	.40	.38	.30
74132	.55	.52	.41
74136	.22	.21	.16
74137	.23	.21	.17
74141	.22	.21	.16
74142	1.34	1.27	.99
74145	.33	.31	.24
74147	.85	.81	.63
74148	.67	.64	.50
74150	.40	.38	.30
74151	.26	.25	.20
74153	.26	.25	.20
74154	.63	.60	.46
74155	.26	.24	.19
74156	.33	.31	.24
74157	.26	.25	.19
74159	.70	.66	.52
74160	.33	.31	.24
74161	.33	.31	.24
74162	.36	.34	.27
74163	.33	.31	.24
74164	.33	.31	.24
74165	.33	.31	.24
74166	.47	.45	.35
74167	1.15	1.09	.85
74170	.99	.94	.73
74172	1.88	1.78	1.39
74173	.65	.61	.48
74174	.49	.47	.36
74175	.76	.72	.56
74176	.35	.33	.26
74177	.35	.33	.26
74180	.36	.34	.27
74181	.90	.85	.66
74182	.36	.34	.27
74184	.85	.80	.63
74185	.85	.80	.63
74190	.28	.27	.21
74191	.28	.27	.21
74192	.33	.31	.24
74193	.33	.31	.24
74194	.45	.43	.33
74195	.24	.23	.18

TTL	1+	25+	100+
74196	.35	.33	.26
74197	.35	.33	.26
74198	.54	.51	.40
74199	.33	.31	.25
74221	.82	.78	.61
74H00	.26	.24	.19
74H05	.29	.28	.22
74H10	.26	.24	.19
74H11	.26	.24	.19
74H20	.26	.24	.19
74S10	.28	.27	.21
74LS11	.19	.18	.14
74LS21	.19	.18	.14
74LS153	.46	.44	.34

DIL Sockets			
8 pin	.12	.11	.09
14 pin	.13	.12	.10
16 pin	.14	.13	.11
18 pin	.20	.19	.15
20 pin	.21	.20	.16
22 pin	.23	.22	.17
24 pin	.24	.22	.18
28 pin	.31	.30	.23
40 pin	.44	.42	.33

Triacs T0220	1+	25+	100+
2A 100v	.41	.39	.30
2A 200v	.42	.40	.31
2A 400v	.45	.43	.33
6A 100v	.46	.44	.34
6A 400v	.51	.48	.38
8A 200v	.47	.45	.35
10A 100v	.74	.70	.55
10A 200v	.76	.72	.56
10A 400v	.82	.78	.61

Thyristors T0220			
3A 50v	.34	.32	.25
3A 400v	.37	.35	.28
5A 100v	.34	.32	.25
5A 600v	.46	.43	.34
7A 400v	.51	.48	.38
10A 200v	.57	.54	.42

Bridge Rec	1+	25+	100+
2A 50v	.34	.33	.26
2A 100v	.38	.36	.28
2A 200v	.42	.39	.31
2A 400v	.54	.51	.40

Voltage regs T0220 1A			
7805	.67	.63	.49
7812	.67	.63	.49
7905	.78	.74	.56
7912	.78	.74	.56

Diodes	
IN914 100s only	.013
IN916 100s only	.014
IN4001 100s only	.034
IN4002 100s only	.036
IN4003	.037
IN4004	.04
IN4005	.04
IN4006	.044
IN4007	.047
IN4148	.013
IN4149	.014
BAX13	.014

LEDS	1+	25+	100+
TIL 209 Red 0.120"	.11	.10	.085
TIL 212 Yel 0.120"	.16	.15	.12
TIL 220 Red 0.200"	.12	.11	.095
TIL 232 Grn 0.120"	.16	.15	.12
TIL 234 Grn 0.200"	.17	.16	.14

Linear ICs	1+	25+	100+
555	.24	.23	.17
709-8	.26	.26	.20
709-14	.33	.31	.24
710	.40	.38	.29
741	.20	.19	.15
747	.35	.33	.25
748	.33	.31	.24
CA3130E	.81	.77	.59
CA3130T	.89	.84	.64
CA3140E	.36	.34	.26
LM301AN	.24	.23	.17
LM301AJ	.62	.58	.45
MC1310P	.80	.76	.56
MC3340P	1.00	.95	.73
NE556	.42	.39	.29
TBA800	1.08	1.02	.78
TBA820	.72	.68	.52
TCA940	1.53	1.44	1.10

Memories	1+	10+	25+
2102 1k x 1			
4114 1k x 4			
4116 16k x 1	11.70	9.75	8.70
4140 4k x 1			
2708 1k x 8			
2716 2k x 8			
Z-80	18.00	16.00	13.00

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.022uF	.025
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BP226	Build Advanced Short-wave Receivers	£1.20†
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ORDER NO.	DESCRIPTION	PRICE
	QUESTIONS & ANSWERS:	
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C26 4 places 8" x 3¼" (approx.) Single-sided fibreglass 80p

C27 3 pieces 7" x 3¼" (approx.) Double-sided fibreglass 60p

SWITCHES

Description	No.	Price
DPDT maniature slide	1973	£0.14*
DPDT standard slide	1974	£0.15*
Toggle switch SPST 1½ amp 250V a.c.	1975	£0.33*
Toggle switch DPDT 1 amp 250V a.c.	1976	£0.42*
Rotary on-off mains switch	1977	£0.50*
Push switch — Push to make	1978	£0.14*
Push switch — Push to break	1979	£0.18*

ROCKER SWITCH

A range of rocker switches SPST — moulded in high insulation. material available in a choice of colours ideal for small apparatus.

Colour	No.	Price
RED	1980	£0.30*
BLACK	1981	£0.30*
WHITE	1982	£0.30*
BLUE	1983	£0.30*
YELLOW	1984	£0.30*
LUMINOUS	1985	£0.30*

Description	No.	Price
Miniature SPST toggle, 2 amp 250V a.c.	1958	£0.70*
Miniature SPST toggle, 2 amp 250V a.c.	1959	£0.75*
Miniature DPDT toggle, 2 amp 250V a.c.	1960	£0.80*
Miniature DPDT toggle, centre off, 2 amp 250V a.c.	1961	£0.95*
Push-button SPST, 2 amp 250V a.c.	1962	£0.90*
Push-button SPST, 2 amp 250V a.c.	1963	£0.95*
Push-button DPDT, 2 amp 250V a.c.	1964	£1.20*

MIDGET WAFER SWITCHES

Single-bank wafer type — suitable for switching at 250V a.c. 100mA or 150V d.c. in non-reactive loads make-before-break contacts. These switches have a spindle 0.25in dia. and 30° indexing.

Description		Order No.	Price
1 pole	12 way	1965	£0.48*
2 pole	6 way	1966	£0.48*
3 pole	4 way	1967	£0.48*
4 pole	3 way	1968	£0.48*

MICRO SWITCHES

	Order No.	Price
Plastic button gives simple 1 pole change over action Rating 10 amp 250V a.c.	1970	£0.25

FUSE HOLDERS AND FUSES

Description	Order No.	Price
20mm x 5mm chassis mounting	506	£0.16*
1¼in x ¼in chassis mounting	507	£0.12*
1¼in car inline type	508	£0.16*
Panel mounting 20mm	509	£0.20*
Panel mounting 1¼in	510	£0.32*

QUICK BLOW 20mm

Type	No.		Type	No.		Type	No.	
150mA	611	6p	1A	615	5p	3A	619	5p
250mA	612	5p	1.5A	616	6p	4A	620	9p
550mA	613	5p	2A	617	5p	5A	621	5p
800mA	614	7p	2.5A	618	6p			

ANTI-SURGE 20mm

Type	No.	Type	No.	Type	No.
100mA	622	1A	625	2.5A	628
250mA	623	2A	626	3.15A	629
500mA	624	1.6A	627	5A	630

All 7p each

QUICK BLOW 1¼in

Type	No.	Type	No.	Type	No.
250mA	631	500mA	632	800mA	634

All 7p each

Type	No.	Type	No.	Type	No.
1A	635	2.5A	638	4A	641
2A	637	3A	639	5A	642

All 6p each

NUTS AND BOLTS

BA BOLTS — packs of BA threaded cadmium plated screws slotted cheese head
Supplied in multiples of 50

Type	No	Price	Type	No	Price
1in OBA	839	£1.20	½in 4BA	846	£0.32
½in OBA	840	£0.75	¼in 4BA	847	£0.25
1in 2BA	842	£0.65	1in 6BA	848	£0.40
½in 2BA	843	£0.45	½in 6BA	849	£0.21
¼in 2BA	844	£0.52	¼in 6BA	850	£0.25
1in 4BA	845	£0.44			

BA NUTS — packs of cadmium plated full nuts in multiples of 50

Type	No	Price	Type	No	Price
OBA	855	£0.72	4BA	857	£0.30
2BA	856	£0.48	6BA	858	£0.24

BA WASHERS — flat cadmium plated plain stamped washers supplied in multiples of 50

Type	No	Price	Type	No	Price
OBA	859	£0.14	4BA	861	£0.12
2BA	860	£0.12	6BA	862	£0.12

SOLDER TAGS — hot tinned supplied in multiples of 50

Type	No	Price	Type	No	Price
OBA	851	£0.40	4BA	853	£0.22
2BA	852	£0.28	6BA	854	£0.22

TRANSFORMERS

MINIATURE MAINS Primary 240V

No.	Secondary	Price
2021	6V-0-6V 100mA	90p*
2022	9V-0-9V 100mA	90p*
2023	12V-0-12V 100mA	£1.12*

MINIATURE MAINS Primary 240V
with two independent secondary windings

No.	Type	Price
2024	MT280-0-6V. 0-6V RMS	£1.60*
2025	MT150-0-12V. 0-12V RMS	£1.60*

1 AMP MAINS Primary 240V

No.	Secondary	Price	
2026	6V-0-6V 1 amp	£2.50*	P.&P. 45p
2027	9V-0-9V 1 amp	£2.00*	P.&P. 45p
2028	12V-0-12V 1 amp	£2.60*	P.&P. 55p
2029	15V-0-15V 1 amp	£2.75*	P.&P. 66p
2030	30V-0-30V 1 amp	£3.45*	P.&P. 86p

STANDARD MAINS Primary 240V
Multi-tapped secondary mains transformers available in ½ amp, 1 amp and 2 amp current rating. Secondary taps are 0-19-25-33-40-50V.

Voltages available by use of taps:
4, 7, 8, 10, 14, 15, 17, 19, 25, 31, 33, 40, 25-0-25V.

No.	Rating	Price	
2031	½ amp	£3.40*	P.&P. 86p
2032	1 amp	£4.40*	P.&P. 86p
2033	2 amp	£5.45*	P.&P. £1.10

AUDIO LEADS

107	FM Indoor Ribbon Aerial	£0.60*
113	3.5mm Jack plug to 3.5mm Jack plug. Length 1.5m	£0.75*
114	5 pin DIN plug to 3.5mm Jack connected to pins 3 & 5. Length 1.5m	£0.85*
115	5 pin DIN plug to 3.5mm. Jack connected to pins 1 & 4. Length 1.5m	£0.85*
116	Car aerial extension. Screened insulated lead. Fitted plug & skt.	£1.25*
117	AC mains connecting lead for cassette recorders & radios, 2 metres	£0.68*
118	5 pin DIN phono plug to stereo headphone Jack socket	£1.05*
119	2+2 pin DIN plugs to stereo Jack socket with attenuation network for stereo headphones. Length 0.2m	£0.90*
120	Car stereo connector. Variable geometry plug to fit most car cassette, 8-track cartridge & combination units. Supplied with inline fused power lead and instructions	£0.80*
123	6.6m Coiled Guitar Lead Mono Jack Plug to Mono Jack Plug BLACK	£1.50*
124	3 pin DIN plug to 3 pin DIN plug. Length 1.5m	£0.75*
125	5 pin DIN plug to 5 pin DIN plug. Length 1.5m	£0.75*
126	5 pin DIN plug to Tinned open end. Length 1.5m	£0.75*
127	5 pin DIN plug to 4 Phono Plugs. All colour coded. Length 1.5m	£1.30*
128	5 pin DIN plug to 5 pin DIN socket. Length 1.5m	£0.80*
129	5 pin DIN plug to 5 pin DIN plug mirror image. Length 1.5m	£1.05*
130	2 pin DIN plug to 2 pin DIN inline socket. Length 5m	£0.68*
131	5 pin DIN plug to 3 pin DIN plug. 1 & 4 and 3 & 5. Length 1.5m	£0.83*
132	2 pin DIN plug to 2 pin DIN socket. Length 10m	£0.98*
133	5 pin DIN plug to 2 phono plugs. Connected pins 3 & 5. Length 1.5m	£0.75*
134	5 pin DIN plug to 2 phono sockets. Connected pins 3 & 5. Length 23cm	£0.68*
135	5 pin DIN socket to 2 phono plugs. Connected pins 3 & 5. Length 23cm	£0.68*
136	Coiled stereo headphone extension lead. Black. Length 6m	£1.75*
17B	AC mains lead for calculators, etc.	£0.45*

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157	6in	4¾in	1¾in	£1.30
158	9in	5¼in	2½in	£1.76

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No.	Length	Width	Height	Price
159	5¼in	2¼in	1½in	62p
160	4in	4in	1½in	62p
161	4in	2¼in	1½in	62p
162	5¼in	4in	1½in	70p
163	4in	2½in	2in	64p
164	3in	2in	1in	44p
165	7in	5in	2½in	£1.04
166	8in	6in	3in	£1.32
167	6in	4in	2in	86p

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INTEGREX

S-2020TA STEREO TUNER/AMPLIFIER KIT

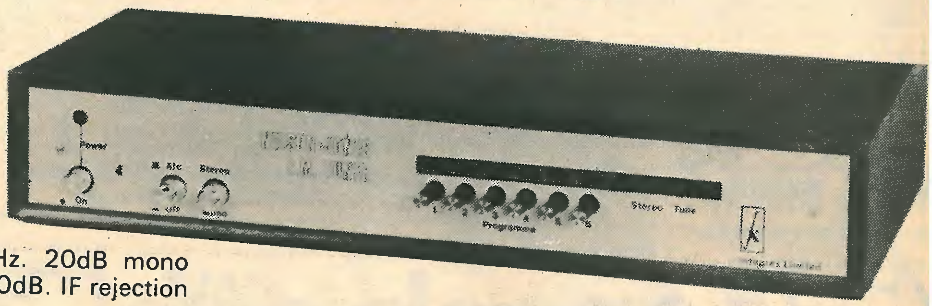
SOLID MAHOGANY CABINET

A high-quality push-button FM Varicap Stereo Tuner combined with a 24W r.m.s. per channel Stereo Amplifier.

Brief Spec. Amplifier Low field Toroidal transformer, Mag, input, Tape In/Out facility (for noise reduction unit, etc.), THD less than 0.1% at 20W into 8 ohms. Power on/off FET transient protection. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section uses 3302 FET module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC stereo decoder. LED tuning and stereo indicators. Tuning range 88—104MHz. 30dB mono S/N @ 1.2μV. THD 0.3%. Pre-decoder 'birdy' filter. **PRICE: £59.95** + VAT

Nelson-Jones Mk. 2 Stereo FM Tuner Kit. Price: **£69.95** + VAT.

NELSON-JONES MK. I STEREO FM TUNER KIT



A very high performance tuner with dual gate MOSFET RF and Mixer front end, triple gang varicap tuning, and dual ceramic filter/dual IC IF amp.

Brief Spec. Tuning range 88—104MHz. 20dB mono quieting @ 0.75μV. Image rejection — 70dB. IF rejection — 85dB. THD typically 0.4%.
IC stabilized PSU and LED tuning indicators. Push-button tuning and AFC unit. Choice of either mono or stereo with a choice of stereo decoders.

Compare this spec. with tuners costing twice the price.

Mono £36.40 + VAT
With ICPL Decoder £40.67 + VAT
With Portus-Haywood Decoder £44.20 + VAT

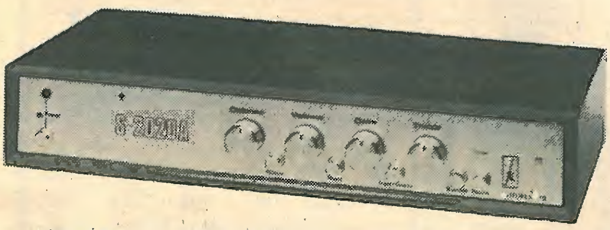
Sens. 30dB S/N mono @ 1.2μV
THD typically 0.3%
Tuning range 88—104MHz
LED sig. strength and stereo indicator

STEREO MODULE TUNER KIT

A low-cost Stereo Tuner based on the 3302 FET RF module requiring no alignment. The IF comprises a ceramic filter and high-performance IC Variable INTERSTATION MUTE. PLL stereo decoder IC. Pre-decoder 'birdy' filter Push-button tuning

PRICE: Stereo £33.95 + VAT

S-2020A AMPLIFIER KIT



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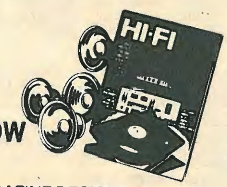

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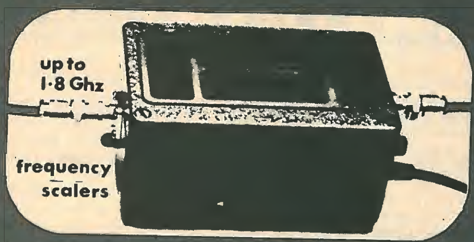

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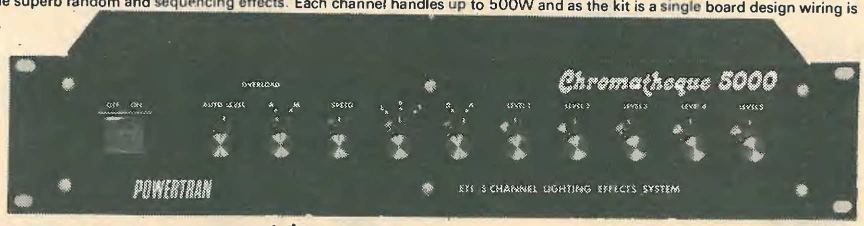

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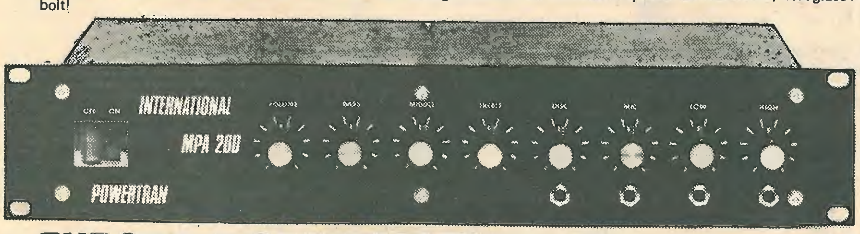

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Our Export Department can readily despatch orders of any size to any country in the world. Some of the countries to which we sent kits last year are shown in this advertisement. To assist in estimating postal costs our catalogue gives the weights of all packs and kits. This will be sent free on request, by airmail, together with our "Export Postal Guide" which gives current postage prices. There is no minimum order charge. Prices same as for U.K. customers but no Value Added Tax charged. Postage charged at actual cost plus 50p documentaton and handling. Please send payment with order by Bank Draft, Postal Order, International Money Order or cheque drawn on an account in the U.K. Alternatively for orders over £500 we will accept Irrevocable Letter of Credit payable at sight in London.

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PRICE STABILITY. Order with confidence! Irrespective of any price changes we will honour all prices in this advertisement until June 30th, 1979, if this month's advertisement is mentioned with your order. Errors and VAT rate changes excluded.

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SECURICOR DELIVERY: For this optional service (U.K. mainland only) add £2.50 (VAT inclusive) per kit.

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QUALITY: All components are brand new first grade full specification guaranteed devices. All resistors (except where stated as metal oxide) are low noise carbon film types. All printed circuit boards are fibreglass, drilled roller tinned and supplied with circuit diagrams and construction layouts.

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ALBOL ALBOL ALBOL

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PPM2: IEC268-10A; draft BS5428

The latest refinements of BBC programme monitoring philosophy are now embodied in an International Standard.

The new IEC Standard defines considerably closer tolerances than BS4297 for temperature stability and specifies for the first time the frequency response at all signal levels as well as requiring a wider response than previously. Performance to isolated tone bursts is defined in a more stringent way and a new clause specifies the reading to be given when very low levels of signal are applied.

PPM2 is a standard performance drive circuit which can be mounted on the rear of a meter movement or by separate fixing holes. Connections are to a gold plated edge connector, with terminals also provided if direct wiring is preferred. It is manufactured under licence from the BBC and meets the requirements of the BPO, IBA, EBU and broadcasting organisations of other countries. *Ernest Turner* meter movements 642, 643 and TWIN are available from stock, as are flush mounting adaptors and illumination kits.

The coaxial red and green pointers of the TWIN offer an unrivalled method of monitoring stereo. PPM2 drive circuits are aligned for decay tracking such that any two boards will produce pointer overlay on a TWIN during Fall-Back. This allows accurate checking of channel balance during items of programme intended to be centre stage.

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149	60	**6.70**	.96
150	100	**7.62**	1.14
151	200	**11.16**	1.14
152	250	**13.28**	1.50
153	350	**16.43**	1.84
154	500	**20.47**	2.15
155	750	**29.06**	OA
156	1000	**37.20**	OA
157	1500	**51.38**	OA
158	2000	**81.81**	OA
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★115 or 240 sec only. State volts required. Pri 0.220-240V.

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Separate 12V windings Pri 220-240V

Ref	Amps 12v	Amps 24v	£	P&P
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213	1.0	0.5	**2.64**	.78
71	2	1	**3.51**	.78
18	4	2	**4.03**	.96
85	5	2.5	**5.00**	.79
70	6	3	**6.35**	.96
108	8	4	**7.42**	1.14
72	10	5	**8.12**	1.14
116	12	6	**8.99**	1.32
17	16	8	**10.72**	1.32
115	20	10	**13.98**	2.08
187	30	15	**17.93**	2.08
226	60	30	**36.14**	OA

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Ref.	Amps	£	P&P
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103	1.0	**4.57**	.96
104	2.0	**7.16**	1.14
105	3.0	**8.56**	1.32
106	4.0	**15.06**	1.50
107	6.0	**14.62**	1.64
118	8.0	**20.26**	2.08
119	10.0	**24.98**	OA
109	12.0	**28.90**	OA

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Voltages available 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24. 30V or 12V-0-12V and 15V-0-15V.

Ref.	Amps	£	P&P
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21	4.0	**7.99**	1.14
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117	6.0	**11.17**	1.45
88	8.0	**14.95**	1.64
89	10.0	**17.25**	1.84
90	12.0	**19.17**	1.95
91	15.0	**21.96**	2.08
92	20.0	**29.45**	OA

60 VOLT RANGE

Pri 220-240V
Sec 0-24-30-40-48-60V. Voltages available 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48. 60V, or 24V-0-24V and 30V-0-30V

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127	2.0	**7.60**	1.14
125	3.0	**11.00**	1.32
123	4.0	**12.52**	1.84
40	5.0	**15.84**	1.64
120	6.0	**18.06**	1.84
121	8.0	**25.56**	OA
122	10.0	**29.55**	OA
189	12.0	**34.06**	OA

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212	1A, 1A	0-6, 0-6	**2.85**	.78
13	100	9-0-9	**2.14**	.38
235	330, 330	0-9, 0-9	**1.99**	.38
207	500, 500	0-8-9, 0-8-9	**2.77**	.71
208	1A, 1A	0-8-9, 0-8-9	**3.53**	.78
236	200, 200	0-15, 0-15	**1.99**	.38
239	50MA	12-0-12	**2.57**	.38
214	300, 300	0-20, 2-20	**2.80**	.78
221	700 (DC)	20-12-0-12-20	**3.41**	.78
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203	500, 500	0-15-27, 0-15-27	**3.99**	.96
204	1A, 1A	0-15-27, 0-15-27	**6.04**	.96

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64	75	0-115-210-240V	**4.01**	.96
4	150	0-115-200-220-240V	**5.35**	.96
69	250	" "	**7.04**	1.14
67	500	" "	**10.99**	1.64
84	1000	" "	**18.76**	2.08
93	1500	" "	**23.28**	OA
95	2000	" "	**34.82**	OA
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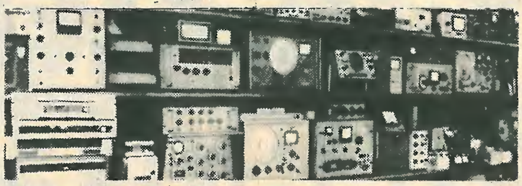
HEWLETT-PACKARD 695A Sweep oscillator
HEWLETT-PACKARD Sweep oscillator **£350**
DERRITRON. Digital Wheatstone Bridge **£110**
MUIRHEAD K-134-A Battery op. wave analyser
WEINSHEL Power Supply Modulator MO3



BRUEL & KJOER Vibration equipment 1018
BRUEL & KJOER Frequency analyser 2105
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TEKTRONIX 555 scope with plug-ins types CA (2 off), 21, 22
TEKTRONIX 515A Oscilloscope
TEKTRONIX 545 main frames. **£210.** Choice of plug-in units extra
TEKTRONIX 585A oscilloscope with '82' P.I. DC-80MHz
TEKTRONIX type 561A DC-10MHz **£350**
TELEQUIPMENT DM53A Storage oscilloscope
TEKTRONIX 556. 50MHz oscilloscope

NOTICE. All the pre-owned equipment shown has been carefully tested in our workshop and reconditioned where necessary. It is sold in first-class operational condition and most items carry our three months' guarantee. Calibration and certificates can be arranged at cost. Overseas enquiries welcome. Prices quoted are subject to an additional 8% VAT.

ROHDE & SCHWARZ EQUIPMENT

HUZ Field Strength Meter. 47-225MHz.
AMF TV. Demodulator 55-90MHz.
Selective UHF v/meter, bands 4&5 USVF.
Selectomat. RF Voltmeter. USWV. BN 15221
.... **£450**
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UHF Signal generator type SCH. **£175**
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POLYSKOP SWOB 1.

KROHN-HITE 10-Watt Amplifier DC-1MHz

GR Impedance Bridge type 1650A **£175**

SPECTRAL DYNAMICS SD104/5 SWEEP GENERATOR
Sine/Square/Triangle outputs. Linear & Log Sweeps. Sweep rate 0.001Hz/sec to 1KHz/sec. Metered frequency indication **£250**

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Made by Rotron Holland. These are very high quality, quiet running fans, specially designed for the cooling of all types of electronic equipment. Measures 4.5 x 4.5 x 1.5in. 115V AC. 11 Watts. The list price of these is over £10 each.
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OSCILLOSCOPE WITH TYPES 1A1 and 1A2 PLUG-IN UNITS. First-class condition throughout.

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GREEN	£0.19	
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Plastic TO 220

Positive	
7805	£0.85
7612	£0.95
7815	£0.85
7824	£0.85
Negative	
7905	£1.19
7912	£1.19
7915	£1.19
7924	£1.19

Plastic TO 92

Positive	
78L05	£0.40
78L12	£0.40
78L15	£0.40
78L24	£0.40
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79L05	£0.50
79L12	£0.50
79L15	£0.50
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301	8 Pin DIL	£0.30
308	8 Pin DIL	£0.90
377	14 Pin DIL	£1.40
378	14 Pin DIL	£1.90
379	14 Pin DIL	£2.20
380	14 Pin DIL	£1.05
381	14 Pin DIL	£0.00
387	8 Pin DIL	£0.75
555	8 Pin DIL	£0.30
565	14 Pin DIL	£1.10
567	8 Pin DIL	£1.40
741	8 Pin DIL	£0.20
741	TO5	£0.25
748	8 Pin DIL	£0.35
3046	14 Pin DIL	£0.75
3130	8 Pin DIL	£0.95
3140	8 Pin DIL	£0.85
3140	TO5	£0.80
3900	14 Pin DIL	£0.60

74 Series TTL

7400	0.12	7473	0.27	74153	0.65
7401	0.12	7474	0.27	74154	1.05
7402	0.15	7475	0.33	74155	0.70
7403	0.12	7476	0.25	74156	0.70
7404	0.15	7480	0.50	74157	0.65
7406	0.25	7482	0.73	74160	0.70
7407	0.25	7483	0.60	74161	0.75
7408	0.14	7485	1.05	74162	0.75
7409	0.18	7486	0.30	74163	0.75
7410	0.12	7489	2.45	74164	0.85
7411	0.18	7490	0.34	74165	0.85
7412	0.20	7491	0.75	74166	1.25
7413	0.36	7492	0.45	74167	2.95
7420	0.12	7493	0.45	74173	1.45
7425	0.25	7494	0.90	74174	1.05
7427	0.25	7495	0.55	74175	0.90
7430	0.12	7496	0.55	74176	1.05
7432	0.27	74100	1.35	74177	0.95
7437	0.27	74104	0.45	74180	1.10
7438	0.27	74105	0.45	74181	2.10
7440	0.12	74107	0.35	74182	1.20
7441	0.49	74121	0.30	74185	2.10
7442	0.50	74122	0.40	74190	1.05
7445	0.60	74123	0.52	74191	1.05
7446	0.60	74125	0.45	74192	0.95
7447	0.55	74126	0.55	74193	0.95
7448	0.50	74132	0.65	74194	0.95
7450	0.12	74136	0.75	74195	0.95
7451	0.15	74141	0.60	74196	0.95
7453	0.15	74145	0.70	74197	0.95
7460	0.15	74150	0.90	74198	1.95
7472	0.27	74151	0.55	74199	1.95

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Literature + Prices on request

C7205EN MULTITESTER 20,000 OPV

£9.75
P&P 75p

AC volts:	0 to 10, 50, 250, 1000
DC volts:	0 to 5, 25, 125, 500, 1000
DC current:	0 to 50 ua, 250 ma
Resistance:	0 to 300 ohms, 6K, 30K 6 meg ohms
Decibels:	— 20 to + 22 db
Size:	115 × 78 × 33mm

IT 1/2 20,000 OPV

£11.95
P&P 75p

AC volts:	0 to 10, 50, 100, 500, 1000
DC volts:	0 to 5, 25, 50, 250, 500, 2500
CD current:	0 to 50 ua, 2.5 ma, 250 ma
Resistance:	0 to 6K ohms, 6 meg ohms
Decibels	—20 to + 22 db
Capacitance:	10 pf, 0.01 uf, 0.1 uf
Size:	4½ × 3¼ × 1 inch

TMK500 MULTITESTER 30,000 OPV

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A sturdy and reliable instrument. Has internal buzzer.

AC volts:	0 to 2.5, 10, 25, 100, 250, 500, 1000
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Resistance:	0 to 6K, 60K, 6 meg, 60 meg.
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Accurately covers 120 KCS. To 500 MCS in 6 bands.
Directly calibrated. Variable R.F. Attenuator. 240v AC.
Dimens: 140 × 215 × 170mm

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DC volts:	0 to 10, 50, 250, 1000
DC current:	0 to 1 ma, 100 ma
Resistance:	0 to 3K ohms 0 to 150K ohms
Size:	2 x 3½ x 1 inch

20p P&P unless otherwise shown
All prices include V.A.T.

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The No. 1 Personal Computer in the U.K. Affordable £499 + VAT SAVE £50
for the first time user and the professional check out the PET, the world's most popular personal computer. **8K**

TRS 80 SOFTWARE *NEW* £39.00 (incl. VAT)

100 MIXED PROGRAMMES on cassette
Educational Games, Graphics, Finance, etc. on 5 cassettes plus Full Documentation.

NEW! THE ITT APPLE (2020)

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LOW PRICE MEMORY UPGRADE PURCHASED AT TIME OF ORDER

16K £49 + VAT

* Full colour - UHF output * Audio cassette tape interface * Up to 48K RAM on board * BASIC in ROM (graphics commands include COLOUR = VLIN, HLIN, PLOT and SCRN) * Built in Loudspeaker *Buckets of software already available *disk system (110 K byte per drive — includes controller) only £425 + VAT

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THIS COMPUTER HAS ALL OF THE FACILITIES NEEDED TO FORM THE NUCLEUS OF A SMALL BUSINESS SYSTEM FOR AN EXCEPTIONALLY SMALL OUTLAY.

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Are you looking for a PERSONAL or SMALL BUSINESS Computer? Look at these features for only £850 + VAT

- 256 Character Graphics Set includes 128 that you can define.
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- 32K of RAM on board.
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- Excellent bit-mapped graphics (512 x 240 point resolution)
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- Serial I/O ports for cassette/RS232 etc (300 or 1200 Baud)
- Parallel I/O port for printer (Centronics Compatable)
- Z80 bus available at the rear for connection to the optional 6 slot S100 expansion box (e.g. S100 Floppy disk drives, graphics boards, extra memory etc.)

EXIDY SORCERER 32K RAM computer £850
(Add £9 for UHF output) 16K RAM computer £751
12" Video monitor £69
S100 expansion box (includes 6 Slot Motherboard and power supply) £210

DISK SYSTEM as shown
MICROPOLIS S100 disks — 315 K bytes per drive
Drive 1 (includes S100 controller, Micropolis M DOS and BASIC software) £649
Additional 315 K bytes drives (up to 4 per controller) £349
Cables and regulators for 2 disk system £41

PRINTER as shown
ANADEX DP8000
80 columns, 112 char/sec 5 x 7 dot matric head
Connects to parallel or serial ports £575

ADDITIONAL SOFTWARE FOR SORCERER PLUS DISK SYSTEM
CP/M operating system £145
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MICROPOLIS BASIC PACKAGES FROM COMPUMAX: STOCK CONTROL (INVENTORY), PAYROLL, ACCOUNTS RECEIVABLE, LEDGER, PERSONNEL — £99 each

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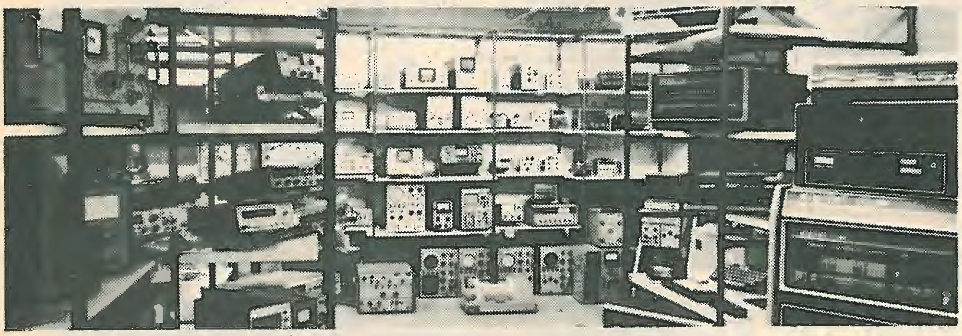
Our background

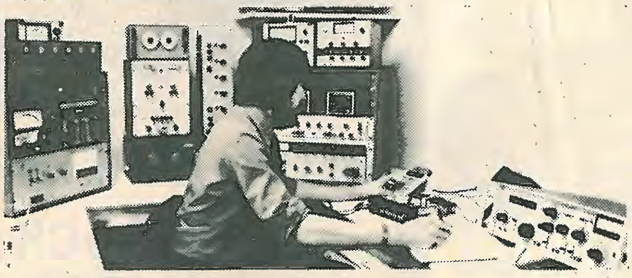
Electronic Brokers is Europe's largest specialist in quality, second user test equipment, mini-computers and associated peripherals. Established 11 years ago, we have pioneered the second user concept in Britain, and many overseas territories.

One reason for our success is the company's policy of continually updating the type of equipment we sell. So from selling to private users, the business has rapidly developed, and today, our customer list includes leading international companies, research establishments, universities, colleges and government institutions throughout the world.



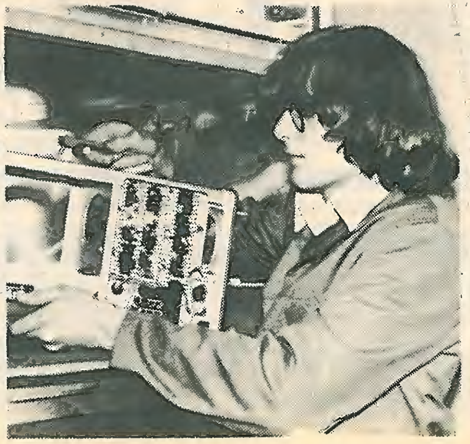
Back up

To support our growth we have a skilled team. This includes trained sales staff, whose role is not only to sell, but provide a helpful information service to our many customers. Backing this team is our own service laboratory where technicians monitor each item of equipment we sell. Our maxim is *service*, and those who have dealt with us will know that we endeavour to always live up to our reputation. Equipment can be configured to customer's exact requirement, and a number of options can be made available — almost like custom-tailoring.



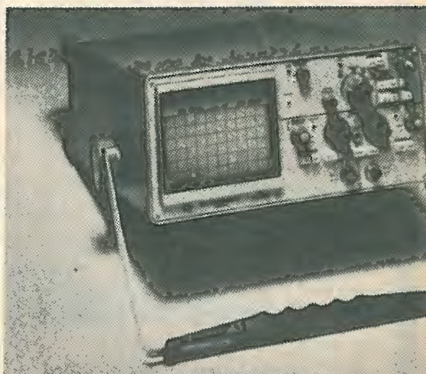
Refurbishing

Our own service laboratory checks each item that arrives at our Pancras Road headquarters. Electronic test equipment is then thoroughly cleaned and a schedule prepared for any work which needs to be carried out to meet customer's requirements. Whether it is new test equipment or used, all items pass through the service laboratory where they are given final tests to ensure they meet manufacturers' specifications, before delivery to the customer.



SEND FOR NEW 86 PAGE CATALOGUE

Containing latest information on our stocks of test equipment, mini computers, computer peripherals, stroboscopes and tachometers. Airmail to overseas addresses £2.



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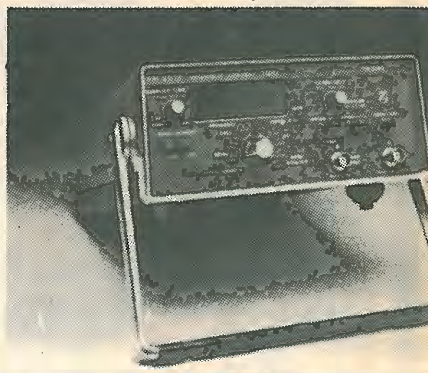
DUAL TRACE PORTABLE OSCILLOSCOPE 432
DC-25MHz 1mV-10V/div
Self-setting mains i/p
A superb unit for the service engineer

£495



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10mV sensitivity
9 digit display
Superb condition.

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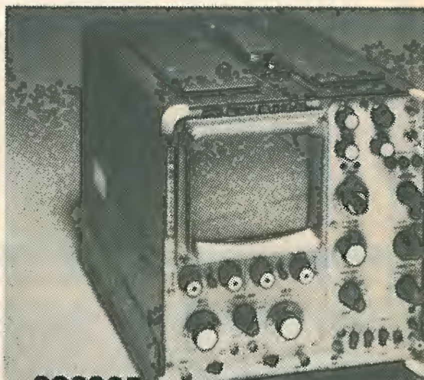

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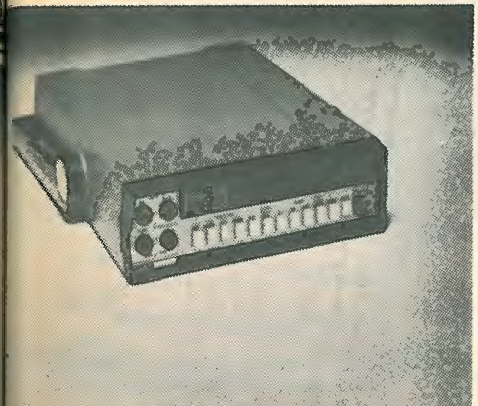
DUAL TRACE
OSCILLOSCOPE
CDU150
DC-35MHz 5mV-20V sensitivity
Delayed Sweep. Quantities available. Superb value.

£4

sNo.1 in Second User Test Equipment

94

Add 8% VAT to all prices



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resolution
C/DC Volts
y mains operation.

£335.00
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PORTABLE SOUND
LEVEL METER 1981
70-120dB. A weighting Digital and analogue readout. Peak hold facility.

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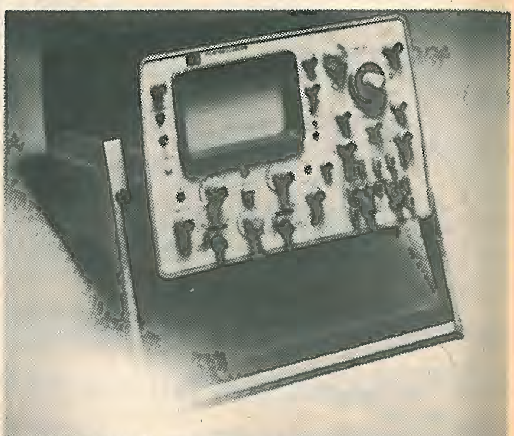

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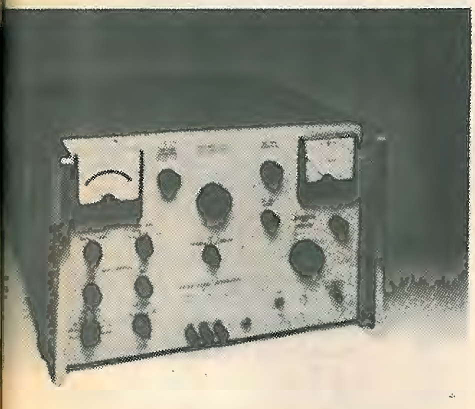
DUAL TRACE PORTABLE
OSCILLOSCOPE 1707B
DC-75MHz. 10mV-10V sensitivity.
Delayed Sweep. Vary
High Quality.

£895.00



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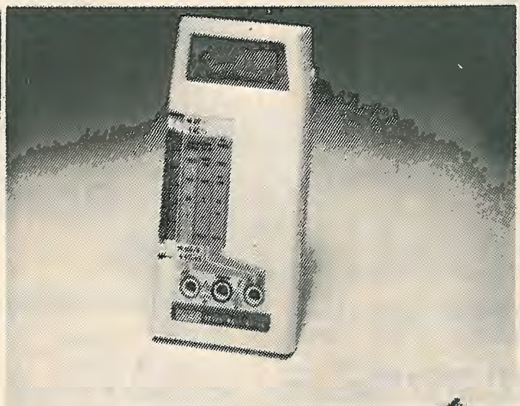
16MHz. AM 0-50%.
–±250kHz
V–0.2V into 50Ω

£515.00



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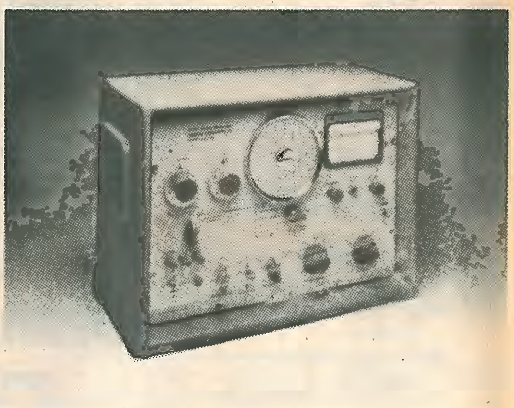
PORTABLE LCD 3½ DIGIT D.M.M. 8020A
AC-DC Volts and
Current, Resistance.
100μV resolution on AC & DC

£99.00
Current new price £112.00



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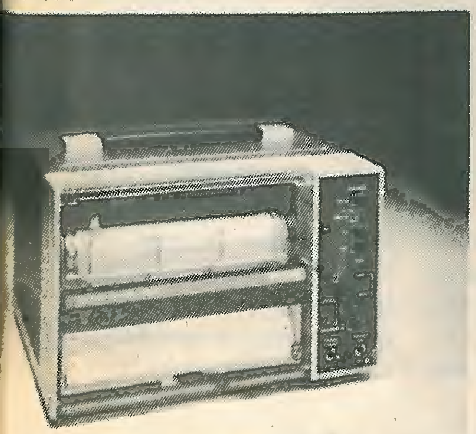
AM/FM SIGNAL GENERATOR TF995B/2
200kHz-220MHz.
0– ± 75kHz
0.1μV –200mV
into 75 or 52Ω

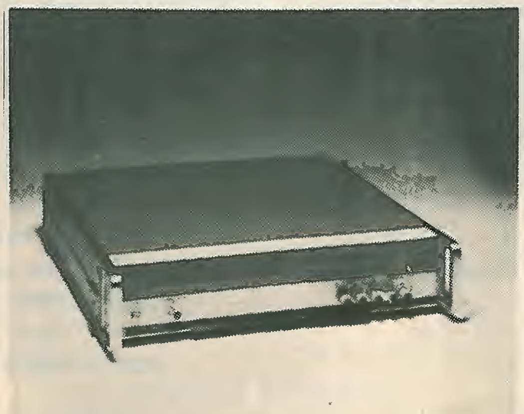
from £675.00



PHILIPS

GLE CHANNEL
ART RECORDER PM8110
sitivity 10mV-10V
rt width 12cm
w condition. Excellent value.

£285.00



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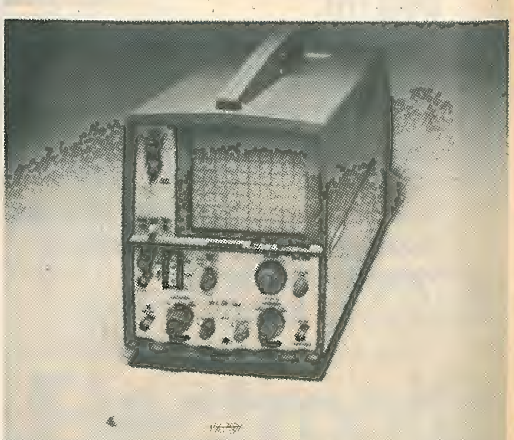
5½ DIGIT D.M.M. 3490A
AC-DC volts
and resistance
Self check facility.

only £550.00
Current new price £1,679.00

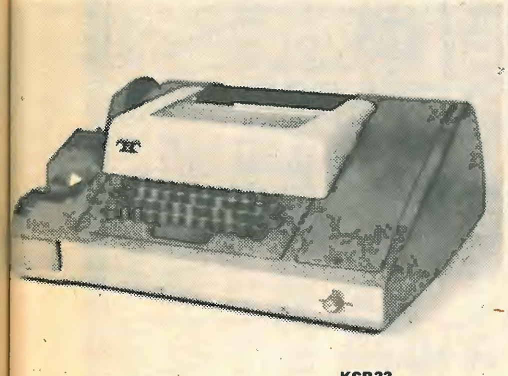


TEKTRONIX

DUAL TRACE PORTABLE OSCILLOSCOPE T932
DC-35MHz 2mV-10V
sensitivity
Trigger Hold off
Superb condition

£495.00

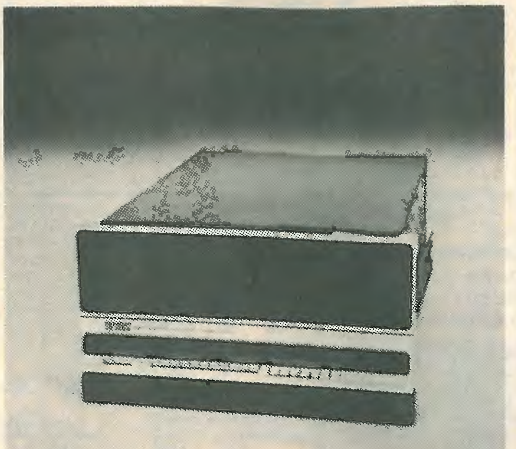
No.1 in Second User Minis & Peripherals



ASR33 and KSR33 TELETYPES

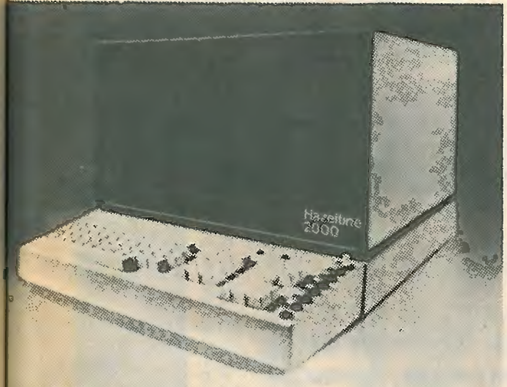
Input/Output terminals with 64 ASCII character set. 110 baud operation. Paper tape punch and reader (ASR33 only). Choice of interface (20mA or RS232).

KSR33
£425.00
ASR33
£650.00
Pedestal
£30.00



DEC

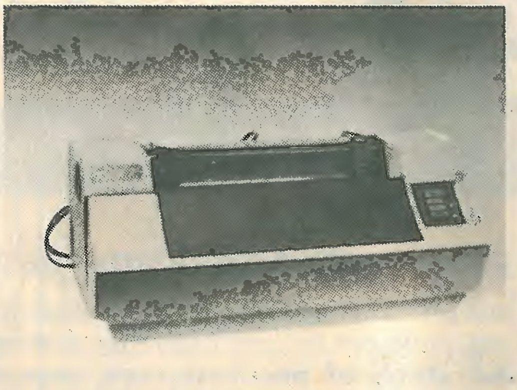
Big savings on our large stocks of processors, peripherals, add-on memory, options and logic modules (see next column for an extract from our current stocklist)



HAZELTINE VDUs

The Superb H-2000A terminal with full editing and XY cursor addressing, detachable keyboard, printer port, RS232 Interface. ONLY £495.00

Also available:
H-2000
£350.00
H-1200
£425.00



CENTRONICS 101 MATRIX PRINTER

64 ASCII uppercase character set. 165 characters per second 132 print columns. 5x7 dot matrix. Parallel input.

PRICE **£750.00**

SHUGART FLOPPY DISC DRIVES

SA400 Minifloppy — 110KB capacity, 35 tracks, transfer rate 125bits/sec, AV access time 550msec. Power requirements +5VDC+12VDC.

PRICE **£195.00**

SA800 Floppy — 400KB capacity, 77 tracks, transfer rate 250Kbits/sec AV. access time 260msec. Power requirements +24VDC, +5VDC — 5VDC.

PRICE **£395.00**

NEW ASCII KEYBOARDS

Illustrated is the KB771, latest addition to our range of top-quality ASCII keyboards. See next column for full details of prices and range of accessories.

DEC EQUIPMENT

PDP8A Add-on RAM Read/Write Memory:

MS8AA 1K	**£225**
MS8AB 2K	**£375**
MS8AD 4K	**£550**

PDP11-04/11-34 Add-on MOS Memory:

MS11FP 8K	**£550**
MS11JP 16K	**£1,200**

PDP11-05/11-40/11-45 Add-on Parity Core Memory:

MM11LP 8K	**£1,000**
MM11UP 16K	**£1,250**
MF11UP 16K complete with backplane	**£1,500**
PC81 High Speed Reader/Punch & Control for PDP81	**£895**
DD11A 4 SPC-slot backplane	**£195**
DR11B DMA Interface complete with backplane	**£750**
KW11P Programmable Clock	**£345**
PR11 High-speed paper tape reader and control	**£1,450**
RTO1AB Single-line data entry terminal with hex keyboard and 20mA interface	**£150**
TC11 TU56 DECtape drive and control	**£1,395**

DATA GENERAL NOVA
Special Purchase of these popular 16-bit minis. Prices from £995.00 (4K 1200 series CPU) to £3,500.00 (32K 800 series CPU with 2.5 Meg disc.)

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240 cps. 80 column receiver-only matrix printer. Full upper and lower case ASC11 character set. Standard RS232 interface. Electro-sensitivity printing ensuring quiet operation. BRAND NEW SURPLUS. ONLY £695.00

TEXAS SILENT 700
Model 725KSR Terminal mounted in integral carrying case complete with built-in acoustic coupler. 64 ASC11 character set with 5x8 dot matrix. 30 cps. Weight 35 lbs. Dimensions 21½"x19"x6½". £695.00

SEALECTRO PATCH BOARDS
Programme boards for switching and interconnecting input/output circuits. 11 x 20 XY matrix. Interconnection is by means of shorting. Skip and component holding pins (not included). Dimensions: 7½" x 5¾" x 1".
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BURROUGHS SELF-SCAN ALPHANUMERIC DISPLAYS
Single line panel display with 16 or 18 5 x 7 dot matrix positions and a repertoire of 64 characters. Input requirements: a six-bit (binary) code must be present at the data input terminal during the first five clock pulses of each character position. Power requirements: Positive logic supply 4.75-5.25V, 160mA. Negative logic supply —11.4 - —12.6V —50mA. Display power supply 237.5-262.5V 30mA. Supplied with full technical data.
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CALCOMP 565 DIGITAL DRUM PLOTTER Y-Axis 11", X-Axis 120'. Maximum speed 900 increments (6.3") per second. Input: Positive or negative polarity pulses, amplitude greater than 10V, rise time less than 10 microsec., minimum pulse with 4 microsec. Source impedance less than 500 ohms.
PRICE £1,250

BADGE READER MATRIX TYPE MODEL 161
AMP Model 161 split matrix type (6x14) + 6x14). Gold plated contact spring and interposer buss. Dimensions: 3½" x 4" x 2¾".
PRICE £25 (mail order total £28.08)

NEW KEYBOARDS

		(mail order total)
KB756 key-stations mounted on PCB	**£49.50**	**£55.08**
KB756MF, as above, fitted with metal mounting frame for extra rigidity	**£55.00**	**£61.02**
Optional Extras:		
KB15P Edge Connector	**£3.25**	**£4.05**
KB701 Plastic Enclosure	**£12.50**	**£14.31**
KB702 Steel Enclosure	**£25.00**	**£28.62**
KB710 Numeric Pad	**£8.00**	**£9.18**
KB2376 Spare ROM Encoder	**£12.50**	**£14.04**

LATEST ADDITION TO THE RANGE
KB771 71 Station keyboard incorporating separate numeric/cursor control pad and installed in custom-built steel enclosure with textured enamel finish. Case dimensions: 17¼"x7½"x3⅝". Total weight 4Kg.
PRICE £95 (mail order total **£108**)
Quantity Discounts available.

NEW KEYTOP/KEYSWITCH KITS—ASCII CHARACTER SET BRAND NEW SURPLUS
Pack of 58 keytops and keyswitches comprising 49 "Qwerty" set, TTY format + 9 Edit/Function keys.
PRICE £15 (mail order total **£17.28**)

SURPLUS KEYBOARDS

KB3 ROM-encoded ASCII keyboard with 63 push-button key stations. Selectable mode—either full ASCII or TTY. Selectable parity. TTL-compatible. Power requirements: +5V-12V. Constructed on rugged PCB with metal mounting plate. Supplied with full technical data. Manufacturers surplus.
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Plays 12", 10" or 7" records, Auto or Manual. A high quality unit backed by BSR reliability. Stereo Ceramic Cartridge. AC 200/250V. Size 13½-11¼in. 3 speeds. Above motor board 3¾in. Below motor board 2½in. with Ceramic Stereo/Mono cartridge.

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HEAVY METAL PLINTHS ONLY

Cut out for most BSR or Garrard decks. Silver grey finish. Post £1.00
Model "A" Size 14½ x 12½ x 3in. **£3.50**
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Sizes: 14½ × 12½ × 4¼in. **£3.**
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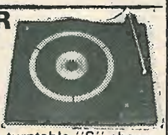
Ideal for record decks, tape decks, etc.

BSR SINGLE PLAYER

Ideal replacement or disco deck with cueing device and stereo ceramic cartridge. 3 speeds. Large turntable, modern design



£19.50 Post £1

BSR P182 3 speeds flared aluminium turntable "S" shape arm, cueing device, ceramic cartridge **£22.50.** Post £1. BSR MP60/P128 Stereo Ceramic, balanced arm, cueing device. Bias compensator **£24.50. Magnetic £5** extra. P&P £1.

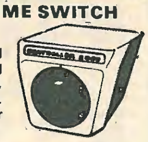
GARRARD HI-FI AUTO CHANGER Model 5-300

3-speed stereo cartridge. Cueing devices **£14.95** Post £1

SMITH'S CLOCKWORK 15A TIME SWITCH

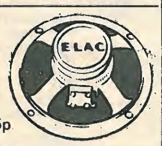
0-6 HOURS £3.30 Post 35p

Single pole two-way. Surface mounting with fixing screws. Will replace existing wall switch to give light for return home, garage, automatic anti-burglar lights, etc. Variable knob. Turn on or off at full or intermediate settings. Brand new.



ELAC HI-FI SPEAKER 8in. TWIN CONE

Large ceramic magnet. 50-16,000 c/s. Bass resonance 40 c/s. 8 ohm impedance. 10 watts. RMS. **£5.95** Post 35p
20 watt model **£8.95** Post 45p



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Stereo L/S **85p** D.P. **£1.**
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Transistor **45p.**

80 Ohm Coax

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With tweeter and crossover. 20 watt. **£11.50**
15 ohm. 20 to 20,000 c.p.s. Post 75p

Suitable Bookshelf Cabinet
Teak finish. For EMI 13 x 8 speakers. Size 16 x 11 x 8 inches approximately. **£8.50** Post £1.00

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Suitable for cassettes, and all sizes of tape reels. A.C. mains 200/250V. Leaflet S.A.E. Will also demagnetise small tools **£5.50** Post 50p
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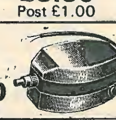

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All parts and instructions with Zener diode, printed circuit rectifiers and double wound mains transformer. Input 200/240V a.c. Output voltages available, 6 or 7.5 or 9 or 12V d.c. up to 100mA or less. Size 3 x 2½ x 1½in. Please state voltage required. **£2.95** Post 45p

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12 VOLT, 750mA. Complete with printed circuit board and assembly instructions. **£3.35** Post 30p
12 VOLT 300mA KIT, **£3.15.**

R.C.S. "MINOR" 10 watt AMPLIFIER KIT

This kit is suitable for record players, guitars, tape playback, electronic instruments or small P.A. systems. Two versions available: Mono, **£12.50;** Stereo, **£20.** Post 45p. Specification 10W per channel; input 100mV; size 9½ x 3 x 2in. approx. S.A.E. details. Full instructions supplied. A.C. mains powered.

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Easy to build kit. Printed circuit. Will control up to 480 watts AC mains **£3.25** Post 35p

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2 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	**£8.50**
3 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	**£11.00**
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AUTO TRANSFORMERS, 115V to 230V or 230V to 115V 150W . **£7.00**
250W . . . **£8.00** 400W . . . **£9.00** 500W . . . **£10**
FULL WAVE BRIDGE CHARGER RECTIFIERS.
6 or 12V outputs, 2 amp.....**75p.** 4 amp.....**£1.25**
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12V, 1½ amp Half Wave Selenium Rectifier **25p**

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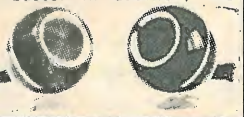
Teak 4 or 8 ohm White 4 ohm only 13 × 10 × 6in. approx. 50 to 14,000 cps. 10 watts.
£16 pair Post £1.30

EXTENSION SPEAKERS £3.95 ea.

Globe shaped cases in high gloss mouldings of red or green, are finished with chrome frontal trim and provided with screw-on rubber inset protective bases. In addition, 2½ metres of strong lead already fitted with phono plug is supplied. Full Range Quality Frequency Response Impedance: 8 ohms Power Peak: 5 watts



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500mF 12V **15p;** 25V **20p;** 50V **30p;**
1000mF 12V **17p;** 25V **35p;** 50V **47p;** 100V **70p.**
2000mF 6V **25p;** 25V **42p;** 420mF/500V **£1.30.**
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5000mF 6V **25p;** 12V **42p;** 35V **85p.** 5600mF/76V **£1.75**

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8/350V	**22p**	8+8/450V	**50p**	50+50/300V	**50p**
16/350V	**30p**	8+16/450V	**50p**	32+32/450V	**75p**
32/500V	**75p**	16+16/450V	**50p**	100+100/275V	**65p**
50/350V	**50p**	32+32/350V	**50p**	150+200/275V	**70p**

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RESISTORS. 10Ω to 10M. ¼W, ½W, 1W, 20% **2p;** 2W, **10p.**
HIGH STABILITY. ½W 2% 10 ohms to 1 meg., **12p.**
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1.5V DC operation over 300 hours continuous on SP2 battery, fully adjustable swing and speed. Ideal displays, teaching electro magnetism or metronome, strobe, etc.

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High Fidelity — Twin Cone
Quality loudspeaker, low cone resonance ensures clear reproduction of the deepest bass. Special copper drive and concentric tweeter cone. Full range reproduction with remarkable efficiency in the upper register.
Bass resonance 25 cps Useful response 20-17,000 cps Flux Density 16,500 gauss 8 or 16 ohms models.

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'Group 25'	'Group 35'	'Group 50/15'
12 inch 30 watt **£12** 4 or 8 or 16 ohm	12 inch 40 watt **£14** 4 or 8 or 16 ohm	15 inch 75 watt **£33** 8 or 16 ohm

BAKER LOUDSPEAKER, 12 INCH. 60 WATT.
GROUP 50/12, 4 OR 8 OR 16 OHM HIGH POWER.
FULL RANGE PROFESSIONAL QUALITY.
RESPONSE 30-16,000 CPS **£21**
MASSIVE CERAMIC MAGNET Post £1.60
WITH ALUMINIUM PRESENCE CENTRE DOME.

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For 13x8in. or 8in. speaker **£8.50** Post £1
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SPEAKER COVERING MATERIALS. Samples Large S.A.E.
LOUDSPEAKER CABINET WADDING 18in wide **20p** ft.

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Four inputs. Four way mixing, master volume, treble and bass controls. Suits all speakers. This professional quality amplifier chassis is suitable for all groups, disco, PA, where high quality power is required. 5 speaker outputs. AC mains operated. Slave output socket. Produced by demand for a quality valve amplifier. 100V line output to order £10 extra. Send for leaflet. Suitable carrying cab **£21** Price **£99** carr. £6.00

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Handles up to 100 watts. No crossover required.
BLACK PLASTIC CONSTRUCTION BOX with brushed aluminium facia. Sturdy job. Size 6¼ x 4¾ x 2in. **£1.50**

BAKER 150 WATT PROFESSIONAL MIXER AMPLIFIER

All purpose transistorised. Ideal for Groups, Disco and P.A. 4 inputs speech and music. 4 way mixing. Output 4 8/16 ohms. A.C. Mains. Separate treble and bass controls. Master volume control.
100 volt line model **£99** **£79** £1.50 carr.

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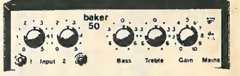
£59 Post £1



Superior quality ideal for Halls/PA systems, Disco's and Groups. Two inputs with Mixer Volume Controls. Master Bass, Treble and Gain Controls. 50 watts RMS. Three loudspeaker outlets 4, 8, 16 ohm. AC 240V (120V available). Blue wording on black cabinet.

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Standard 12in. diameter fixing with cut sides 12" x 10". 14,000 Gauss magnet. 20 watts R.M.S. 4 ohm imp. Bass resonance = 30 c.p.s. Frequency response 30-8000 c.p.s.
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ALUMINIUM HEAT SINKS. FINNED TYPE.
Sizes 5" × 4" × 1" **95p.** 6½" × 2" × 2¼" **65p.**
JACK PLUGS. Plastic 25p; Metal 30p.
JACK PLUGS Stereo Plastic 30p; Metal 35p.
JACK SOCKETS. Open 20p; Closed 25p.
JACK SOCKETS Stereo Open 25p; Closed 30p.
FREE SOCKETS — Cable end 30p.
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Plugs 3-pin 20p; 5-pin 25p.
PHONO PLUGS and SOCKETS ea. 10p.
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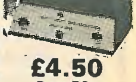
TV CONVERGENCE POTS **15p each**
Values = 5, 7, 10, 20, 50, 100, 200, 250, 470, 2000 ohms.

MONO PRE-AMPLIFIER. Mains operated solid state pre-amplifier unit designed to complement amplifiers without low level phono and tape input stages. This free-standing cabinet incorporates circuitry for automatic R.I.A.A. equalisation on magnetic phono input and N.A.B. equalisation for tape heads. **£4.50** Post 50p



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		CD4017	0.79	CD4034	1.71	CD4051	0.82	CD4075	0.20	CD4510	1.01
		CD4018	0.83	CD4035	1.06	CD4052	0.82	CD4076	1.17	CD4511	1.25
		CD4019	0.50	CD4036	2.86	CD4053	0.82	CD4077	0.39	CD4514	2.47
CD4000	0.15	CD4020	1.11	CD4037	0.85	CD4054	1.04	CD4078	0.20	CD4515	2.82
CD4001	0.17	CD4021	0.90	CD4038	0.96	CD4055	1.18	CD4081	0.20	CD4516	1.01
CD4002	0.17	CD4022	0.82	CD4039	2.78	CD4056	1.18	CD4082	0.20	CD4518	0.97
CD4006	1.04	CD4023	0.18	CD4040	0.97	CD4059	4.29	CD4085	0.64	CD4520	1.04
CD4007	0.18	CD4024	0.70	CD4041	0.75	CD4060	1.00	CD4086	0.64	CD4527	1.43
CD4008	0.87	CD4025	0.20	CD4042	0.69	CD4063	0.98	CD4089	1.39	CD4532	1.21
CD4009	0.50	CD4026	1.55	CD4043	0.88	CD4066	0.55	CD4093	0.80	CD4555	0.78
CD4010	0.50	CD4027	0.44	CD4044	0.84	CD4067	3.35	CD4094	1.69	CD4556	0.78
CD4011	0.18	CD4028	0.77	CD4045	1.26	CD4068	0.20	CD4095	0.94	MC14528	0.93
CD4012	0.20	CD4029	1.03	CD4046	1.20	CD4069	0.20	CD4096	0.94	MC14553	4.43
CD4013	0.43	CD4030	0.50	CD4047	0.89	CD4070	0.46	CD4097	3.35		
CD4014	0.83	CD4031	2.00	CD4048	0.50	CD4071	0.20	CD4098	0.98		

COMPONENTS

SOLDERCON PINS		CLOCK CHIPS		DISPLAYS		CRYSTALS			
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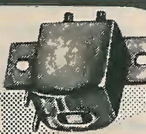

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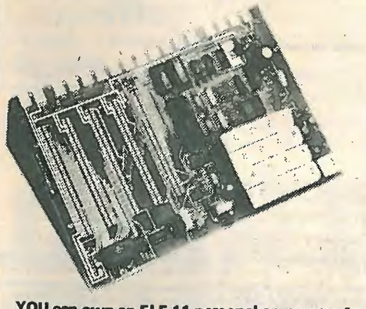

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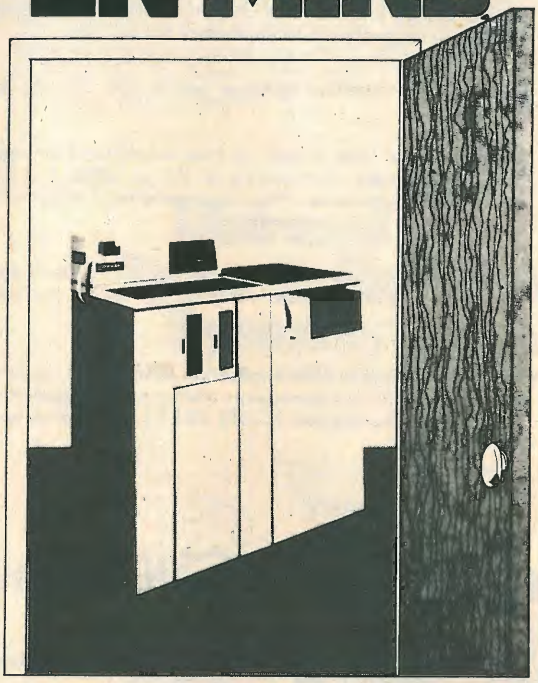

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(9109)

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Interested applicants should writ giving full details of previous ex perience etc, to: **Assistant Registra (Staff), Royal College of Art, Ken sington Gore SW7 2EU.**

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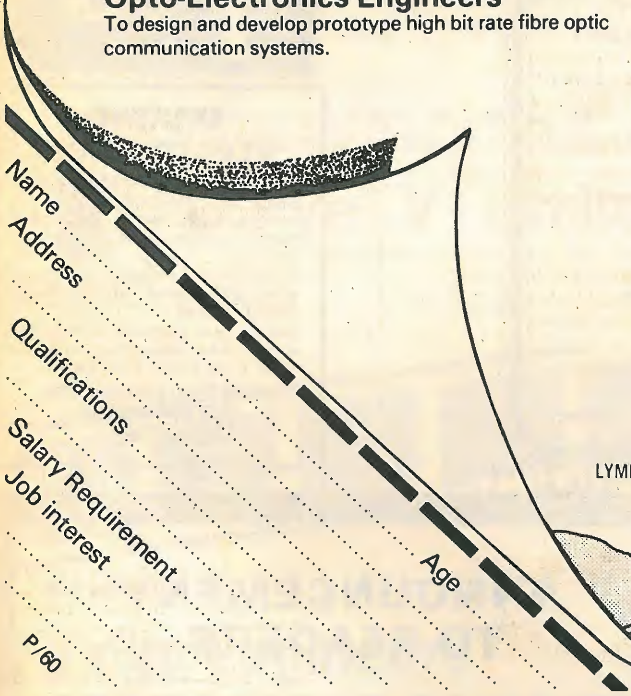

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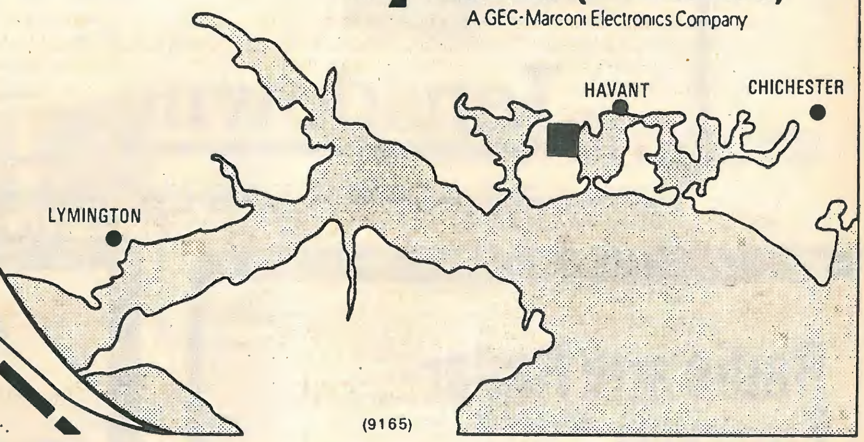

(9165)

UNIVERSITY OF LEEDS

Vacancies have arisen for the Department of Physiology for the following technical staff:

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To assist with the general routine tasks in the teaching/research laboratories. Applicants must be of sound education and some knowledge of biology would be an advantage. Salary on the scale £2346-£2499 p.a. (under review).

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LONDON TRANSPORT

(9167)

ANNOUNCEMENT TO READERS

Readers will have noticed an advertisement for the Independent Broadcasting Authority in the April issue of Wireless World inviting applications for the position of Senior Engineer-Service Continuity Section.

The IBA have informed us that this advertisement was not placed by them, and the position advertised does not exist. We can only come to the conclusion that the advertisement was therefore an unfortunate hoax. The IBA and Wireless World wish to apologise to any applicants for this position and for any inconvenience they have been caused.

(9143)

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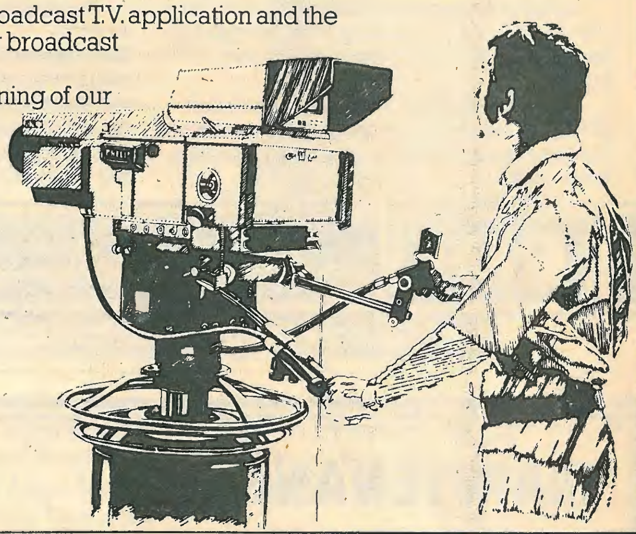

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GCHQ

For further details apply to:
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£3186-£3720 (under review)

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Closing date: 4th May, 1979. (9121)

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Full details and application forms from:
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70 London Road
Kingston-upon-Thames
Surrey KT2 6PY

(9125)

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Experience in audio/visual electronic installation and a knowledge of light engineering/fabrication techniques would be an advantage.

You should have at least seven years' experience and be qualified to ONC level.

Salary within the scale £3,675-£4,212.

Application form from the Staffing Officer, Polytechnic of the South Bank, Borough Road, London SE1 0AA. (01-928 8989) quoting ref. ETS5.

Polytechnic of the South Bank

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We have vacancies for technicians on duties involving the testing, maintenance and repair of machine telegraph and associated electronic equipment in London, and also on the installation of PABX telephone systems in British Government offices overseas. Staff employed on the latter duties are based at Hanslope, near Milton Keynes in Buckinghamshire. Applicants should possess a sound knowledge of basic principles and preferably have some experience with the appropriate equipment. Some knowledge of Radio would be an advantage.

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QUALIFICATIONS REQUIRED:

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SALARY: is: £2,627-£4,252 according to age.

The additional allowance of £524 is paid for working in London. The apoointments attract four weeks' paid annual holiday and there are prospects of pensionable employment.

For an application form apply to:

Foreign and Commonwealth Office
Hanslope Park, Hanslope
Milton Keynes
MK19 7BH

(9107)

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SWINDON, Wiltshire

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Product Manager, Computer Systems
TANN SYNCHRONOME LTD.,
Station Road, Westbury, Wiltshire

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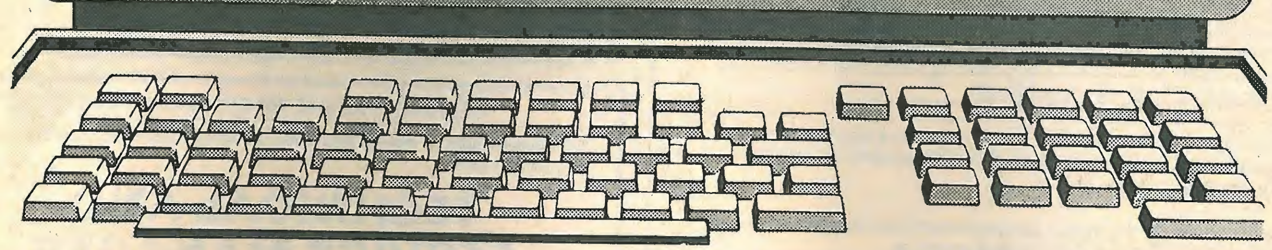
Mike Gernat (Ref. ME3), Technomark, King House, 5-11 Westbourne Grove, London W2 4UA. Phone: 01-229 9239

(9189)



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MICROPROCESSOR SOFTWARE ENGINEER for new generation of ATE. Experience in Assembler level software essential. Knowledge of high level language capabilities and a hardware background preferred. Salary negotiable — up to £10,000 if self-employed.

DESIGN DEVELOPMENT ENGINEER — instrumentation-transient recorders, correlators, etc. Experience in high speed analogue and digital techniques essential. Surrey — to £9,500.

DESIGN ENGINEER for advanced projects group working on application of state of the art to a wide range of products including satellite communications, TV display and ranging equipment. To £8,500.

COMPUTER ENGINEERS for: Technical Support, Field Service, Permanent Site and Systems Test. Vacancies in Home Counties, Sussex, Yorkshire, Suffolk, Midlands, Hampshire and South Wales. Salaries vary with area and experience.

YOUNG GRADUATES for industrially sponsored research in a University. Experience in one or more of the following: physical electronics, instrumentation, microprocessor applications and peripheral interfacing. South Coast — to £6,000.

ALSO REQUIRED

ELECTRONIC BLOKES — all shapes, sizes, with or without warts — for literally thousands of unfilled vacancies.

(9166)

Charles Airey Associates

"PROBABLY THE BEST KNOWN SUPPLIER OF ELECTRONICS ENGINEERS IN THE COUNTRY" — FINANCIAL TIMES

155 KNIGHTSBRIDGE, LONDON, SW1. TEL: 01-581 0286

British Forces Broadcasting Service

ENGINEERS Radio and T.V.

. . . to join the BFBS which provides a radio service for H.M. Forces and their dependants abroad, offering entertainment, information and education, as well as a link with home. A service of U.K. television programmes has also been started in Germany.

Their work (mostly overseas) includes the installation, operation and first line maintenance and repair of MF, HF and VHF sound broadcasting equipment and receiving and studio equipment, and the operation and maintenance of T.V. equipment, including video-tape recorders, vision mixers, slide scanners and character generators.

Candidates (preferably aged 22-30) must have ONC in Electrical Engineering **or** an appropriate C & G Certificate **or** an equivalent qualification. They should have received appropriate training and have at least 2 years' relevant experience together with a knowledge of the fundamental principles of the PAL colour TV system.

Starting salary will be between £4,475 and £5,660, depending on qualifications and experience, **plus** generous overseas allowances. Salaries are under review. Promotion prospects. Appointments are pensionable and will be for a period of 2 to 3 years initially with prospects of an extension or permanency.

For further details and an application form (to be returned by 10 May, 1979) write to Civil Service Commission, Alencon Link, Basingstoke, Hants RG21 1JB, or telephone Basingstoke (0256) 68551 (answering service operates outside office hours). **Please quote T/5104.**

Ministry of Defence (Army Department)

(9160)

CHIEF ENGINEER

Enfield

Our expanding RFI/EMC Division provides a comprehensive design, manufacturing and installation service for customers throughout the world.

As part of the Divisional reorganisation necessitated by increased business we are looking for a man or woman with the appropriate engineering background to lead a small design and development team involved with a wide range of electrical power filters, signal and control line circuits. As well as actively participating in the design and manufacturing of our specialised products you will also act as consultant to our clients on a worldwide basis, provide expertise to our sales and marketing team and be expected to make a positive contribution to technical development in this highly competitive field. Reporting to the Divisional Manager you will have the status of Chief Engineer and will need to be experienced in either the power, radio or microwave engineering fields and be qualified to Chartered Engineering standard.

In addition to any attractive salary we offer a benefits package appropriate to a large company which includes life assurance and pension scheme etc.

Applications for the above position which will be treated in the strictest confidence should be addressed to:

Mr. J. D. Bostock, Personnel Manager, Belling & Lee Limited, Great Cambridge Road, Enfield, Middlesex. Phone 01-363 5393 ext. 214.

Belling-Lee
Better by design

(9110)

We are a rapidly growing Company, supplying technical communication systems to the Hotel industry in the UK and abroad. We require additional staff at our base near Oxford.

PROJECT ENGINEERS

Experienced in VHF/UHF/HF distribution, Public Address Systems and colour TV, for the planning and installation of Audio-Visual Systems.

TELEVISION ENGINEER

Able to install, inspect and maintain TV Systems.

CABLE INSTALLATION WIREMEN

Approved Electricians with cable installation experience or Relay Wiremen.

All applicants must be willing to go abroad at short notice and be prepared to undergo training. Good remuneration and excellent prospects.

Write, giving details of education and employment record to:

TSR SYSTEMS

Stanley Linden, TSR Systems
The Old Post House
London End, Beaconsfield, Bucks.
HP9 2JH. Tel. 049-46 71706

(9148)

KEM ELECTRONIC MECHANISMS LTD.

We have an immediate vacancy for a capable and responsible person for position as a

TECHNICAL AND SERVICE MANAGER

Good practical knowledge of electronics, both analogue and digital required, mechanical aptitude vital. Current driving licence essential. Salary negotiable, company car will be supplied.

We are also looking for a keen

TECHNICIAN

for both workshop and field work

KEM import, sell and maintain motion picture film equipment for education, film and T.V. industries.

For further information please contact:
Mr M. Sherman
KEM ELECTRONIC MECHANISMS LTD.
24 Vivian Avenue, Hendon, London, NW4 3XP
Tel: 01-202 0244

(9196)

THE POLYTECHNIC OF CENTRAL LONDON
Division of Engineering

ELECTRONIC TECHNICIAN SUPERVISION

Grade 6

Technician required for working supervision of Electronics Workshop. Circuit design/development ability desired together with knowledge/experience in troubleshooting and modification of instruments. Qualifications required: H.N.C./H.N.D. or equivalent, and 9-10 years experience including training period. Consideration in respect of industrial experience would be given in lieu of academic qualifications. Salary: £4143-£4851 inclusive of £465 London Allowance.

ELECTRONICS TECHNICIAN

Grade 3

Technician required in workshop group involved in electronics and computer fields. Experience in electronics and workshop practice necessary.
Qualifications required: O.N.C./O.N.D. or equivalent, and 3-5 years' experience including training period. Consideration in respect of industrial experience would be given in lieu of academic qualifications. Salary: £3162-£3549 inclusive of £465 London Allowance.

ELECTRONICS TECHNICIAN

Grade 3

Technician required for electronics laboratory group to assist in the construction and maintenance of electronic equipment for student projects and general laboratory development.
Qualifications required: O.N.C./O.N.D. or equivalent, and 3-5 years experience including training period. Experience/interest in the manufacture of P.C.B.'s would be advantageous. Consideration in respect of industrial experience would be given in lieu of academic qualifications.
Salary: £3162-£3549 inclusive of £465 London Allowance.

Application forms and further details from The Establishment Officer, P.C.L., 309 Regent Street, London W1R 8AL. Tel: 01-580 2020 ext 212.

(9170)

Inner London Education Authority
HACKNEY COLLEGE

LECTURER I

Department of Electrical Engineering

Suitably qualified person required to teach theory and craft processes to ELECTRICAL AND ELECTRONIC ENGINEERING CRAFT AND TECHNICIAN apprentices. Applicants should hold a City and Guilds of London Institute Advanced Craft or Full Technician Certificate and have suitable industrial experience.

Salary on an incremental scale within the range £3,192-£5,334 plus £474 Inner London Allowance. Starting point will depend on qualifications and experience.

Applications obtainable from/returnable to Senior Administrative Officer, Hackney College, Dalston Lane E8 1LJ (Tel. 01-985 8484).

Closing date 14 days from appearance of this advertisement. (9154)

UNIVERSITY OF SHEFFIELD

RESEARCH TECHNICIAN

(Grade 5)

required for duties in the Space Physics Group within the Department of Physics for an initial period of three years from the 1st April 1979. The successful applicant will be primarily concerned with the design, development, operation and maintenance of complex and sophisticated apparatus, equipment and instruments used in research into phenomena associated with the propagation of very low frequency radio waves.

Qualifications or experience should be o H.N.C. or equivalent standard. A curren driving licence is essential and duties may include some travel both within the U.K. and abroad for periods of up to several weeks.

Salary on scale £3186-£3720 p.a. (unde review).

Please write to the Administrative Officer (Personnel), (Ref. S1214/WW) The University, Sheffield S10 2TN.
(9146

RADIO TECHNICIANS

At the Government Communications Headquarters we carry out research and development in radio communications and their security, including related computer applications. Practically every type of system is under investigation, including long-range radio, satellite, microwave and telephony.

Your job as a Radio Technician will concern you in developing, constructing, installing, commissioning, testing, and maintaining our equipment. In performing these tasks you will become familiar with a wide range of processing equipment in the audio to microwave range, involving modern logic techniques, microprocessors, and computer systems. Such work will take you to the frontiers of technology on a broad front and widen your area of expertise — positive career assets whatever the future brings.

Training is comprehensive: special courses, both in-house and with manufacturers, will develop particular aspects of your knowledge and you will be encouraged to take advantage of appropriate day release facilities.

You could travel — we are based in Cheltenham but we have other centres in the UK, most of which, like Cheltenham are situated in environmentally attractive locations. All our centres require resident Radio Technicians and can call for others to make working visits. There will also be some opportunities for short trips abroad, or for longer periods of service overseas.

You should be at least 19 years of age, hold or expect to obtain shortly the City and Guilds Telecommunications Technician Certificate Part I (Intermediate), or its equivalent, and have a sound knowledge of the principles of telecommunications and radio, together with experience of maintenance and the use of test equipment. If you are or have been in HM Forces your Service trade may allow us to dispense with the need for formal qualifications.

WORK IN COMMUNICATIONS R&D AND ADD TO YOUR SKILLS

You start on £2,927 at 19, up to £3,700 if you are 25 or over, rising to £4,252, and promotion will put you on the road to posts carrying substantially more. There are also opportunities for overtime and on-call work paying good rates.

Get full details from our Recruitment Officer, Robby Robinson, on Cheltenham (0242) 21491, Ext. 2269, or write to him at GCHQ, Oakley, Priors Road, Cheltenham, Glos. GL52 5AJ. If you seem suitable we'll invite you to interview in Cheltenham — at our expense, of course.

(9106)

SERVICE ENGINEERS

EARN UP TO £7,000 p.a.
PLUS EXCITING VARIETY OF WORK

Electronic Brokers Limited are Europe's leading suppliers of refurbished test and computer equipment. Due to our continued expansion programme we have immediate vacancies for the following experienced personnel within our organisation which is situated within easy reach of King's Cross and St. Pancras stations.

SERVICE ENGINEERS

Capable of repairing and recalibrating a wide variety of test equipment by well-known manufacturers, with the opportunity to progress on to digital equipment i.e. VDUs, printers, etc. Salary up to £5,500 p.a. basic plus bonus, LVs and overtime.

PDP11 ENGINEERS

Able to reconfigure computer systems. Salary negotiable depending on experience. Plus bonus, LVs and overtime.

TELETYPE ENGINEERS

For complete refurbishing of teletypes. Opportunity to progress on to other computer peripherals. Salary circa £5,000 p.a. basic plus bonus, LVs and overtime.

ELECTRONIC BROKERS LIMITED

Phone Mike Jones on 01-837 7781 or write to him at Electronic Brokers Limited, 49-53 Pancras Road, London, NW1.

(9203)

ELECTRONICS TECHNICIANS

We are a small rapidly growing company looking for 2 Technicians to join us. One job involves working on production, fault finding and servicing of our 380Z micro computer boards. The other vacancy exists in our R+D Department and involves working on the development of new products for the 380Z.

We are looking for highly responsible and hardworking people who are able to work without supervision and although no previous microprocessor experience is required, both candidates will need to be very conversant with TTL logic circuitry.

The company is situated in East Oxford within walking distance of the town centre.

Above average salaries will be awarded to the right people according to experience and ability rather than a rigid grade structure.

Phone or write:
RESEARCH MACHINES LTD.
Chapel Street, Oxford.
Tel: 0865 43244

(9183)

SCIENCE RESEARCH COUNCIL
APPLETON LABORATORY

ELECTRONIC ENGINEERS

to work on instrumentation for space research

There are two vacancies for Electronic Engineers at Appleton Laboratory for work on instrumentation required for rocket, balloon and satellite payloads, and on the associated ground station equipment.

The successful candidates will assist in the layout, building, testing, integration and maintenance of encoding and decoding equipment and R.F. links. They will be involved in preparing a transportable telemetry station for use in Australia which will contain digital decommutation and display equipment, U.V. recorders, and tape recorders.

Periods of duty abroad, usually not exceeding two months' may be required to support launch campaigns.

The posts will initially be based at Slough, with a move to Chilton, Oxfordshire at a later date.

The posts will be at Professional and Technology Officer Grade III level. Salary will be in the range £4601 to £5144, which includes outer London Weighting Allowance.

The minimum qualification is ONC or equivalent, but possession of a Higher National Certificate is desirable. Experience of high quality electronic construction techniques used for digital analogue and R.F. circuits is required, together with a desire to make original contributions to the work. Previous experience of telemetry, telecommand, position finding, transducers, environmental testing or systems maintenance would be an advantage.

Non-contributory pension scheme.

Please request an application form from:
The Secretary
SCIENCE RESEARCH COUNCIL
Appleton Laboratory, Ditton Park
Slough SL3 9JX. Telephone: Slough 44234. Ext. 153

Closing date: May 9th, 1979

(9176)

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF GEOLOGY

Grade 5

ELECTRONICS TECHNICIAN

for maintenance and development to work in the Department of Geology. Applicants should have ONC Electrical or equivalent. Salary scale £3,651-£4,185 (under review). Superannuation, generous sick pay scheme, plus additional days at Christmas and Easter. Five weeks' annual leave. Application form and job details from: J. R. Blount, Departmental Superintendent, Geology Department, Imperial College, Prince Consort Road, London SW7 2BP or phone 01-589 5111 ext. 1685.

Closing date for applications 30 April, 1979.

(9112)

A leading London Recording Studio requires a

JUNIOR TECHNICAL ENGINEER

To assist in the development and maintenance of its operation. Position requires good technical background and practical abilities.

Please reply Box No. W.W. 9116

(9116)

SENIOR ELECTRONIC ENGINEER

Newcastle-upon-Tyne up to £6774

As a result of an expansion of work in the electronics area following a recent re-organisation, a vacancy has been created within the Electronics and Instruments Division at the Engineering Research Station in Killingworth.

The post is in the recently created Electronics Development Section in which new applications within British Gas for modern electronics, including microprocessors, are being developed. Work is proceeding on a number of applications of digital electronics in gas transmission and distribution. The section is also developing new techniques for the control and monitoring of experiments both in the field and the laboratory.

Salary range with initial placing according to age and experience. £5253-£6774 plus current self-financing productivity payment, plus the benefits normally expected of a large progressive organisation.

Applicants should have a good degree in electrical/electronic engineering and at least three years' experience in R&D in industry or an academic institution. Preference will be given to applicants who have already had experience in the design and development of microprocessor-based systems.

Please write or phone for an application form, quoting reference ERS/203/WW to the Personnel Division, Engineering Research Station, PO Box 1LH, Killingworth, Newcastle-upon-Tyne. Tel: (0632) 684828.

(9168)

BRITISH GAS

MINISTRY OF DEFENCE

RADIO TECHNICIANS

The Ministry of Defence has vacancies at RAF Sealand for Radio Technicians to work on the repair and maintenance of radio communications/radar equipment. Applicants must be experienced technicians in the radio field.

Starting pay according to age, up to £3,700 a year (at age 25) rising to £4,252 a year.

Five-day week—4 weeks' paid holiday in addition to Public Holidays — prospects of promotion — pension scheme.

Applicants must be United Kingdon residents.

Write for further details to:
Officer Commanding
No. 30 Maintenance Unit
RAF Sealand
Deeside, Clwyd CH5 2LS

(9111)

CITY OF LONDON POLYTECHNIC

ELECTRONICS TECHNICIAN

The Library and Learning Resources Service

A keen young electronics technician is required to join a team engaged in providing a Media Service for the Polytechnic.

The successful candidate will be required to assist with the provision of a basic repair service for a wide range of audio-visual and TV equipment.

Applicants should have a sound practical knowledge of relevant electronics, together with some experience in the field. Ability to drive an advantage.

The job is based in our premises at Old Castle Street, London E1, close to Aldgate and Aldgate East Underground stations.

Salary on the scale of Technician Grade 3, currently £3162-£3549.

For further details and an application form please write quoting reference number 79/19 to the Staff Records Officer, City of London Polytechnic, 117/119 Houndsditch, London EC3A 7BU.

(9155)

QUEEN ELIZABETH COLLEGE
Kensington
(University of London)

ELECTRONICS DEVELOPMENT ENGINEER

We can offer:

- Technological challenges
- Extensive experience
- Good holidays
- A pleasant working environment

The College is situated between Holland Park and Kensington Gardens. You would work in a small group designing specialised instrumentation for research projects. Your work would include linear (d.c. to v.h.f.), and digital circuits plus microprocessor systems, and thick-film techniques.

The post offered has a salary (under review) plus London weighting in the range £3651-£4185 (Technician Grade 5 scale). We would like you to have had some design and development experience and to hold an HNC or equivalent. If you are interested write or telephone for an application form to Mrs. G. M. Howard, Queen Elizabeth College, Campden Hill Road, London W8 7AH. Tel. 01-937 5411 ext. 499. Alternatively talk it over with Mr. Webb on ext. 306.

(9156)

Electronic Test Engineers

Peterborough **£4,000+**

These vacancies are the direct result of substantial expansion by a leading manufacturer of sophisticated electronic equipment. Their export achievements are a matter of record and the future is assured.

Working on a project basis, you will mainly be responsible for implementing a wide range of test methods on completed machinery and sub-assemblies.

There will also be parts testing, fault diagnosis and repair work.

Ideally qualified to HNC or equivalent, you should have gained Test or Quality experience, probably in the computer or similar electronic industries.

Alternatively, technical expertise in electronics gained in the Regular Forces could be ideal.

Help will be given for moving to the low cost housing area.

Contact: Lynne Green
Leicester (0533) 27581 PER
Northampton House
177 Charles Street, Leicester LE1 1LT

Applications are welcome from both men and women.

PER
Professional & Executive Recruitment

(9188)

CHARING CROSS HOSPITAL
Medical School
(University of London)

ELECTRONICS TECHNICIAN

Dept. of Physiology

Applications are invited for the post of Technician to work on the design, development, construction and repair of scientific electronics equipment used in teaching and research. Fault finding and repair will form a significant part of the job and experience in this type of work would be useful.

Applicants must be qualified to H.N.C. or degree standard or equivalent. Salary on the incremental Whitney Scale £3261-£4680 + £354 London Weighting Allowance (under review).

Applications on forms obtainable from the Secretary, Charing Cross Hospital, Medical School, The Reynolds Building, St Dunstans Road, London W6 8RP. Tel: 01-748 2040 ext. 2067, quoting ref. 402-3.

Closing date: 30th April. (9202)

ELECTRONICS TECHNICIAN

required to assist in electronic equipment development work in the Respiratory Division of the Department of Medicine.

Experience in analogue, digital and software techniques desirable, together with an interest in instrumentation development.

Salary on scale £3646 to £5086, initial placing dependent on qualifications and experience.

Application forms and further particulars may be obtained from the Personnel Office, Royal Postgraduate Medical School, 150 Du Cane Road, London W12 OHS, quoting reference number 2/120WW.

(9128)

Sony Broadcast Limited

are engaged in marketing SONY professional broadcast equipment throughout Europe, Africa and the Middle East.
Currently we have an opening for a

Service Engineer

Candidates are required to have a minimum of five years experience maintaining broadcast television equipment. Academic qualifications whilst not essential are preferred, as the successful candidate will work on highly sophisticated VTR, Camera and support equipment. Normal colour vision is also required for this position.
The successful candidate would be based at our Company's merchandise control unit at Crockford Lane, Basingstoke.
A highly competitive and attractive salary is offered to the right person, together with the usual benefits of a large multi-national company.
Please write in confidence giving career history and essential details to the

Personnel Manager

SONY® Broadcast

Sony Broadcast Ltd.
City Wall House
Basing View, Basingstoke
Hampshire UK RG21 2LA

(9162)

Electronic Engineers

Worldwide Airborne Surveys

Our Engineers prepare electronic sensing and digital recording systems at U.K. base for eventual in-flight operation by themselves in fixed and rotary winged aircraft engaged on overseas geophysical projects. Typical overseas project duration is between 2 to 6 months.

A wide spectrum of electronics is covered with a growing emphasis on microprocessor based devices. Qualifications or experience to HNC standard together with a flair for fault diagnosis, solving interfacing problems and mechanical packaging ability is desired.

Persons interested in joining our teams or who require further information should apply to:

The Personnel Manager,
Hunting Surveys
& Consultants Limited,
Elstree Way, Borehamwood,
Herts, WD6 1SB.

1977

(9127)

ELECTRONIC PICTURE HOUSE LIMITED

Our expanding duplication and telecine department requires:

AN EXPERIENCED ENGINEER

with the following:

(1) Understanding and service knowledge of colour cameras and telecine maintenance.

(2) Full service knowledge of all types of Videocassette Recorders and related equipment.

(3) System design capabilities (including R.F. Distribution networks).

The high degree of responsibility and the ability of the candidate to meet it will of course ensure that the resulting rewards in terms of salary and personal advancement should be attractive.

Apply in writing or phone:

The Managing Director
Electronic Picture House Limited
191 Wardour Street, London, W.1
Tel: 01-734 6525/6

(9201)

FIELD SERVICE ENGINEER

A Field Service Engineer is required in Our Birmingham Service Centre. To service and maintain our Tanncard Access Control Equipment.

Applicants should have a sound knowledge of Digital Techniques and possess a clean driving licence.

Apply with full details of qualifications to: E. E. Shribbs, Tann Synchronome Ltd., Stirling Corner, Borehamwood, Herts.

(9164)

CITY OF LONDON POLYTECHNIC
SCHOOL OF NAVIGATION

ELECTRONICS TECHNICIAN (Grade 5)

Applications are invited for the post of Technician in the above school which is located at 100 Minories, London, EC3, close to Tower Hill Underground Station.
The person appointed will be required to assist in the maintenance of a digital marine radar simulator, live radars and other electronic navigational aids.
Applicants should have practical experience in digital computing and possess a national certificate or equivalent qualification in electronics.
Salary scale: £3,675 p.a. to £4,212 p.a.

Application forms and further particulars can be obtained from the Staff Records Officer, 117/119 Houndsditch, London EC3A 7BU quoting reference number 79/22.

THE OPEN UNIVERSITY
FACULTY OF SCIENCE

RESEARCH ASSISTANT
(in Physics)

Applications are invited for the above post, which is available immediately, starting date negotiable. The successful candidate will be required to develop electronic circuitry including interfaces for various data acquisition systems used in experiments in the Physics Discipline, which include work on biomagnetism, solar flux, semiconductor physics and nanosecond spectroscopy.

Applicants should hold a degree (or equivalent) in Physics, Electronics or Electrical Engineering and be competent in modern electronics.

The post is available for three years in the first instance and is reviewed annually thereafter to ascertain whether the Research Assistant meets agreed criteria for promotion to Research Fellow. Commencing salary will be within the Research Assistant 1B scale £3,384-£4,882 p.a. with U.S.S. benefits.

Application forms and further particulars are available from The Recruitment Officer (JD3773/3), The Open University, P.O. Box 75, Walton Hall, Milton Keynes MK7 6AL or telephone Milton Keynes 63404: there is a 24 hour answering service on 63868.

Closing date for applications: 4th May. (9169)

University of Surrey
Dept. of Linguistic and International Studies

TECHNICIAN GRADE 4

A vacancy exists for a Technician to assist with the day to day running of the Dept. Language Laboratories and associated equipment.

General adaptability and flexibility is necessary.

Technical experience in Radio or T.V. service or maintenance of Language Laboratories and ancillary equipment.

Educational requirements: C&G Radio and T.V. Tech Certificate or C&G Audio Visual Tech Certificate, or 5 years' experience in similar posts.

Application forms may be obtained from the Staff Office, University of Surrey, Guildford, Surrey GU2 5XH, or telephone Guildford 71281, ext. 452.

Closing date: 20th May, 1979. (9197)

ROYAL COLLEGE OF ART

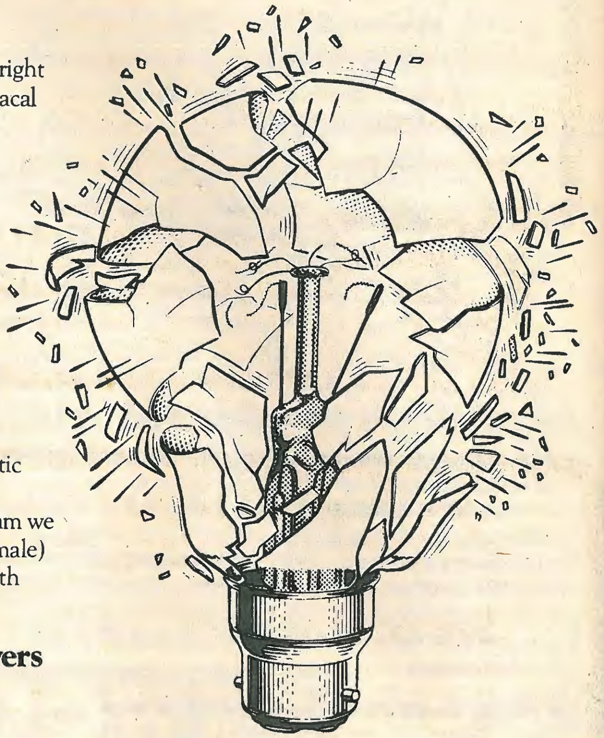
ELECTRONIC TECHNICIAN

is required in the Department of Environmental Media to assist and advise students on the creative use of equipment; design and construct 'one-off' pieces of equipment to interfacer or modulate standard facilities; have an overall view of the technical aspects of the department, control all aspects of maintenance of equipment.

Applicants should have a thorough working knowledge of Sony video recording and editing facilities (½" open reel and U-matic) sound recording and synthesising equipment, film and slides cameras and projectors (including cross-fade and multi-screen units).

Starting salary on scale £3651-£4185 under review. Please write giving full details of age, qualifications and experience to: Assistant Registrar (Staff), Royal College of Art, Kensington Gore, London SW7 2EU. (9186)

Design Engineers
What do you think will happen to your next bright idea?
Will it receive the serious consideration it deserves?



At Racal you can be sure that no bright idea goes unrecognised and indeed the Racal Group's performance is due in no small measure to the ideas and achievements of our unrivalled design teams.

Racal Communications Limited has established a world-wide reputation as a supplier of high quality communications equipment. We are now expanding our activities to encompass exciting new products at the forefront of technology. Current projects embrace H.F. and V.H.F. Equipment Direction Finding Systems, Radio Surveillance, Software Systems, Automatic Test Equipment and Special Projects.

To complement our established team we are seeking qualified engineers (male/female) and would particularly welcome those with experience of: –

- **High performance receivers**
- **High power transmitters**
- **Advanced mechanical engineering and packaging**
- **Antenna design**
- **Advanced digital techniques**
- **Microprocessors**
- **Software development for control of communications systems**

Vacancies exist at all levels from graduate engineers to project managers able to take responsibility for a complete design team.

For the right people, Racal's fantastic growth offers real career opportunities. The rewards can be high – both in terms of the initial offer and of the prospects of responsibility for high technology – where ability is the only requirement.

Racal's reputation and success is based on the people who work in the Group, where the working conditions and benefits reflect a firm belief in the people – and in the future of the electronics industry.

Please write giving brief details of qualifications and previous experience, or telephone for an application form, to: The Personnel Manager, Racal Communications Equipment Limited, Brants Bridge, Broad Lane, Bracknell, Berkshire. Telephone: Bracknell 24747.

Britain's fastest growing electronics group

RACAL

DESIGN AND DEVELOPMENT ENGINEER required with sound all round capability. To work on digital and analogue design as well as video cameras and monitors. Apply: Mr E. A. Falkner, R.C.S. Electronics, 6 Wolsey Road, Ashford, Middlesex. Tel. No. Ashford 53661. (9132

CAPITAL APPTS.

29, Windmill St. London, W.1.

FREE LISTS

101 Design/Development and Test Jobs

Permanent and Contract

To £6,000

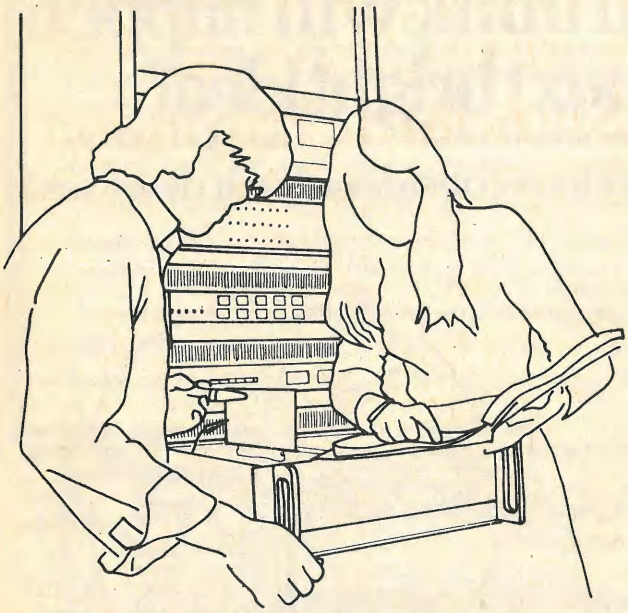
(8782)

637 5551 day: 636 9659 eve.

RADIO TELEPHONE service engineer required. Proven ability to repair VHF/UHF equipment more important than formal qualifications. — Phone London Car Telephones on 01-680 1010. (9124

PCB AGENT WANTED. Very generous commission offered on all PCB work obtained. Please reply Box No WW 9093. (9093

Professional Careers in Electronics



All the others are measured by us...

At Marconi Instruments we ensure that the very best of innovative design is used on our range of communications test instruments and A.T.E. We have a number of interesting opportunities in our Design, Production and Service Departments and we can offer attractive salaries, productivity bonus, pension and sick pay schemes together with help over relocation.
If you are interested to hear more, please fill in the following details:-

Name ______________________ Age ______

Address ______________________________

____

Telephone Work/Home (if convenient) ______

Years of experience	0-1 ☐	1-3 ☐	3-6 ☐	Over 6 ☐
Present salary	£2,500-3,500 ☐	£3,500-4,500 ☐	£4,500-5,500 ☐	over £5,500 ☐
Qualifications	None ☐	C & G ☐	HNC ☐	Degree ☐

Present job ______________________________

____

Return this coupon to John Prodger, Marconi Instruments Limited, FREEPOST, St. Albans, Herts, AL4 0BR. Tel: St Albans 59292

Marconi Instruments

A GEC MARCONI ELECTRONICS COMPANY

(9200)

ELECTRONIC MAINTENANCE SUPERVISOR

ENGINEERING TRAINING DEPT., EVESHAM, WORCS.

Duties Directing a team of Broadcasting Engineers responsible for maintaining the full range of professional radio and television broadcasting equipment. Irregular hours of working are involved.

Requirements Ability to motivate and lead other Engineers in such a way as to provide an efficient maintenance facility. Recent experience of maintaining electronic equipment. A good technical knowledge of audio and/or video equipment.

One of the following qualifications is essential:–

a) A degree from a British University in electronics or Electrical Engineering.
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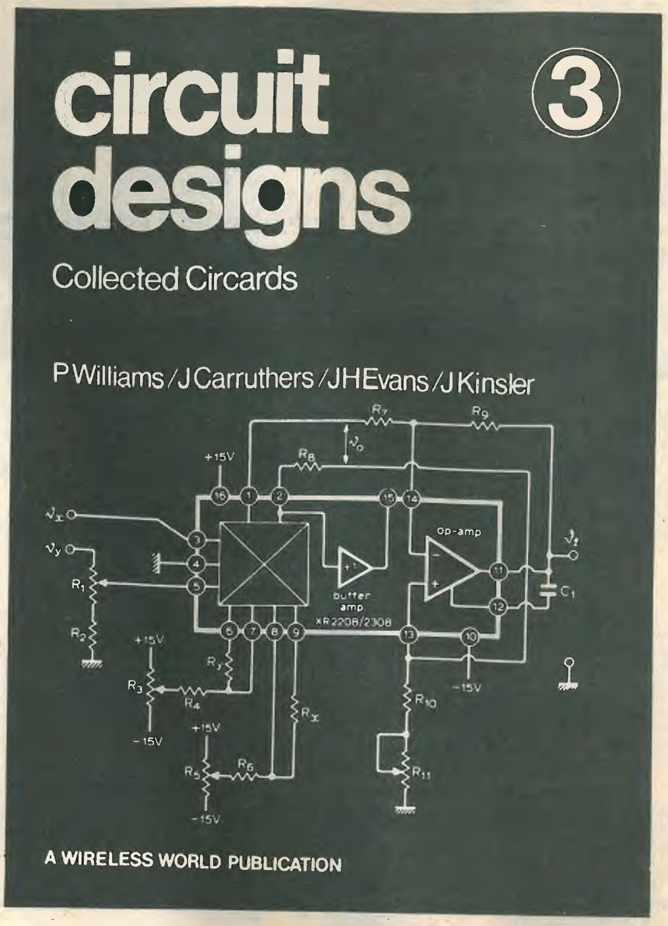

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