FEBRUARY 1974

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20p

SPECIAL POWER CRISIS ISSUE

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FEBRUARY 1974 Vol.3 No. 2

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Due to the power restrictions at the time of going to press, in common with many other publications, we have had to reduce the size of this issue to 68 pages. We apologise to readers for this. Articles which were scheduled will appear as soon as electricity supplies permit us to produce our normal size.

Cover: We hope none of us will need to use candles, but if the mains supply is cut off our special articles on pages 34 and 36 should be of some help.

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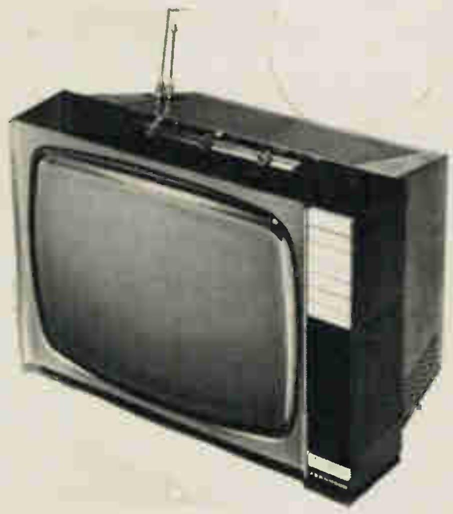

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FROM BOOM TO GLOOM

It seems incredible that in our July editorial we were able to use the title "Boom" and hold out great hopes for the economic future of the country. We were not unique in this.

The situation at the time of writing (mid-December) could hardly be more depressing. Because of the emergency, we don't even know when this issue will be on sale, for the printers and ETI (like many other companies) have electricity for only three days a week. In order to produce the magazine at all we have had to work further ahead and much faster than we would wish. If the production suffers, we apologise in advance to our readers, contributors and advertisers.

What the future holds is anyones guess but it does not look good. Even without industrial troubles, Britain is in a desperate situation and the electronics industry is going to fare as badly as the rest and this comes at a time when the majority have been investing heavily in new plant and premises because of the healthy future that was forseen a few months ago.

We are not arrogant enough to suggest that Dr. Henry Kissinger read last month's editorial 'Power Problems', let alone was influenced by it, but his speech in London on the same subject was encouraging. His proposal that the European Countries, North America and Japan work together to find a solution to the energy crisis must be welcomed. Apart from the USSR and China, this includes nearly all the nations who, 30 years ago, were smashing the hell out of each other and if a tiny part of the effort expended then can be harnessed to finding a solution, then an answer cannot be far away. — HWM.

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SN7475N	0·58	0 55	0·51
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SN74176N	1 44	1 44	1·26
SN74177N	1 44	1 44	1 26
SN74180N	1 44	1 44	1 26
SN74181N	5 18	5 18	4 53
SN74182N	1·44	1 44	1 26
SN74184N	2 16	2 16	1 89
SN74185AN	2 16	2 16	1 89
SN74188N	6 48	6 48	5 67
SN74190N	2·30	2 30	2 01
SN74191N	2 30	2 30	2 01
SN74192N	2 30	2 30	2 01
SN74193N	2 30	2 30	2 01
SN74194N	1 72	1 72	1 51
SN74195N	1·44	1·44	1 26
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CRS 3/10AF	100v	40p
CRS 3/20AF	200v	45p
CRS 3/40AF	400v	55p
CRS 3/60AF	600v	65p
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CRS 5/400	400v	60p
SEVEN AMP (T048)		
CRS 7/100	100v	60p
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CRS 7/400	400v	85p
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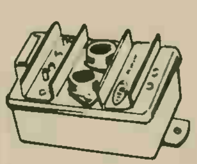

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6 AMPS P.I.V.

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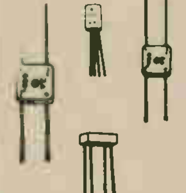
B6/20	200v	80p
B6/40	400v	90p
B6/6x0	600v	£1 00

½H x ¼L x $\frac{3}{16}$" dia.



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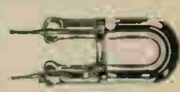

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B20004 2 ch. Stereo mixer		5·95 p & p 15p
PK3 Kit Etch your own printed circuits		1·50 p & p 20p

Henry's RADIO LIMITED

EDGWARE ROAD, W2

ELECTRONICS FOR EVERY PURPOSE

See facing page for addresses

ZENER DIODES

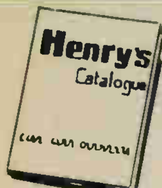
400 m/w BZY88/BZX83. From 3·3 volt – 33 volts 10p each.
1·3 watts 5% Miniature Tubulars IN4700 series From 3·3 volt – 33 volt 18p each
10 watts stnd Mounting. ZS series 6·8 volts – 100 volts 5% 40p each.

SILICON RECTIFIERS

1 amp series IN4001 to IN4007 From 6p each 1·5 amp.
PL4001 to PL4007 From 8p each
3 amp PL7001/IN5400 From 14p each.
Send for full list 36.

Henry's

U.K's LARGEST RANGE OF ELECTRONIC COMPONENTS AND EQUIPMENT AT BARGAIN PRICES
Latest Catalogue price 55p post paid. Complete with Discount Vouchers



BUILD THE TEXAN

20 + 20 WATT IC STEREO AMPLIFIER
As featured by *Practical Wireless* 1972

Now built and used by thousands of satisfied customers. Features slim design overall size in cabinet 15½ x2½ x6½ 6-IC's, 10 transistors, stabilisers Gardners low field transformer. Fibre Glass PC Panel, complete chassis work. Now available built and tested as well as in kit form. HIGH QUALITY AND STABILITY ARE PREDOMINATE FEATURES — DEVELOPED BY TEXAS ENGINEERS FOR PERFORMANCE, RELIABILITY AND EASE OF CONSTRUCTION. FACILITIES. On/off switch indicator, headphones socket, separate treble, bass, volume and balance controls, scratch and rumble filters, mono/stereo switch, input selector; Mag. P.U. Radio Tuner, Aux. Can be altered for Mic., Tape, Tape-head, etc. Constructional details Ref. No. 21 30p. Distributed by Henry's throughout UK

FREE—Teak cabinet with complete kit.

KIT PRICE £28·50
(+VAT+50p carr/packing) or built and tested £35 00 (+ VAT+50p carr/packing) as illustrated.

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Produced to give high performance with a realistic price. (Parts list and constructional details Ref. No. 5 30p). Henry's are sole distributors UK and Europe.

Kit price £21·00 (+ VAT)
OR BUILT AND TESTED £24·95 (+ VAT)

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SDLI (rotary controls)	£49·50
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DJ100 100 watt power amplifier for above	£49·50
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DJ40L as 30L plus built in microphone	£47·50
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Carlsbro reverberation unit	£44·00
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SUPER STROBE £45	
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150 watt QI liquid wheel projector	£50·00
150 watt QI cassette wheel projector	£50·00
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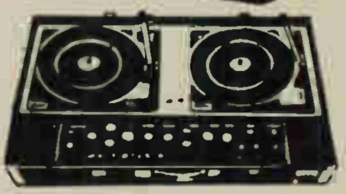

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Mini spot bank fitted 3 lamps	£12·95
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Mixer/Misc/Speakers/Lighting UK's largest range. **FREE** stock list ref No 18 on request
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PLUS PRICE SAVINGS

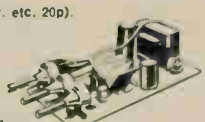
The Texan Stereo Systems include the high quality Texan Stereo amplifier assembled and ready to use. A pair of Type 200 20 watt Speaker-Tweeter systems size 21" x 12" x 10" and a choice of Garrard players built into a plinth with cover with Goldring G800 magnetic cartridge. Systems 25 uses Garrard SP25 Mk III and system 76 the Garrard AP76 de luxe turntable. All necessary leads are supplied.

System 25 (list approx. £109) **£79·50**
System 76 (list approx. £117) **£89·50**

(plus 10% VAT and plus £1·45 carr/packing)

MINIATURE AMPLIFIERS

AMPLIFIERS (carr. etc. 20p).



4-300, 0 3 watt 9 volt	£1·75
104, 1 watt 9 volt	£2·80
304, 3 watt 9 volt	£2·95
555, 3 watt 12 volt	£3·10
E1208, 5 watt 12 volt	£5·10
608, 10 watt 24 volt	£4·10
410, 10 watt 28 volt	£4 95
E1206, 30 watt 45 volt	£9·96
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SAC14, 7 + 7 watt Stereo with controls	£8·70
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SINCLAIR UNITS (carr. 20p) Z30 £3·67,	£4·37
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PZ5 £3 97, PZ6 £6 37, PZ8 (for Z50) (TRANS £2 95)	£4·77

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All items post paid — Best price on request

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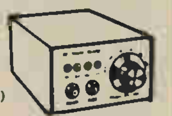
(All cased unless stated chassis)



470C 6/7½/9 volt 300 MA (includes Multi-Adaptor for Tape Recorders, etc.)	£2·15 post 20p
Car Lighter Voltage Adaptors 300mA (State voltage 6v, 7½v, 9v)	£1·95 ea. post 25p
SC202 3/6/7½/9 volt 400mA	£3·35 carr 30p
HC244R Stabilised version	£4·35 carr 30p
P500 9 volt 500mA	£2·90 post 20p
P11 24 volt 500mA (chassis)	£2·90 post 20p
P15 26/28 volt 1 amp (chassis)	£2·90 post 20p
P1080 12v 1 amp (chassis)	£4·25 post 20p
P1081 45v 0 9 amp (chassis)	£7·50 post 20p
P12 4½-12 volt 0 4-1 amp	£7·15 post 30p
SE101A 3/6/9/12 volt 1 amp (Stab.)	£10·30 post 25p
RP164 6/7½/9/12 1 amp (Stab.)	£10·20 post 30p

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SPECIAL OFFER
EMI 13" x 8"—full range speakers (post 20p each or 30p pair)
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*450 10 watt C/o Twin Tweeters 3, 8 or 15 ohms £3·50 each or £6·90 pair.
EW 15 watt 8 ohms C/o Tweeter £4·30 each or £7·90 pair.
350 20 watt C/o Tweeters 8 or 15 ohms £7·50 each or £14·20 pair.
* Polished wood cabinet £4·60 post 35p.

SPEAKER KITS (carr. etc. 35p)

20-2	8"	30 watt	£10 00 each
20-3	8"	40 watt	£15·00 each
LINTON 2	20 watt		£15·95 pair
GLENDALE 3	30 watt		£28·95 pair
DOVEDALE 3	50 watt		£42·00 pair
KEF KK2			£20·40 each
KEF KK3			£32·00 each

TEST EQUIPMENT MULTIMETERS

(carr. etc. 30p)

M210 20K/Volt Slimline £6·75. TLH33D 2K/Volt Robust £7·50. U437 10K/Volt Steel case. AC up to 40KHz £4·95. U4324 20K/Volt with AC current ranges £8·00. AF105 50K/Volt £11·95. U4313 20K/Volt AC current. Steel case £10·50. U4341 Plus Built in transistor tester £10·50. Model 500 30K/Volt £9·95.

OTHER EQUIPMENT

SE250B Pocket Signal Injector 2·10 carr. 15p. SE500 Pocket Signal Tracer £1·70 carr. 15p. TE15 Grid Dip meter 440kHz-280mHz 15·00 carr. 30p. TE40 AC Millivoltmeter 1·2mHz 18·95 carr. 35p. TE65 28 Range valve voltmeter 19·95 carr. 40p. TE20D 120kHz–500mHz RF Generator 17·95 carr. 40p. TE22D 20Hz–200kHz Audio Generator 18·95 carr. 40p. SE350A Deluxe Signal Tracer 12·50 carr. 20p SE400 Volts/ohms/R-C sub./RF field/RF gen. 14·75 carr. 20p.

GARRARD BATTERY TAPE DECK

GARRARD 2 speed 9 volt tape decks. Fitted record/play and oscillator/Erase heads. Wind and rewind controls. Takes up to 4" spools. Brand new complete with head circuits. £9 50 carr. 30p.

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AVOMETER MOVEMENTS
AVO 8 or 9 50MA MOVEMENTS
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Brand new transistorised geared tuners for 625 Line Receiver 1F output. **£2·50** Post 20p

FIBRE OPTICS
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SUPER TESTER 680R — The complete testing system

price £18·50

Volts AC = 11 ranges from 2V to 2500V
Volts DC = 13 ranges from 100mV to 2KV
Amp DC = 12 ranges from 50oA to 10A
Amp AC = 10 ranges from 200µA to 5A
Ohms = 6 ranges from one tenth of Ohm to 100 MO
Reactance = 1 range from 0 to 10MO
Capacity = 6 ranges from 0 to 500pF and from 0 to 0 5µF and from 0 to 50 000pF
Frequency = 2 ranges from 0 to 500Hz and from 0 to 5000Hz
Output Voltage = 9 ranges 10V to 2500V
Decibels = 10 ranges from −24 to + 70dB

Accessories

Transistor tester	£11·00
Electronic voltmeter	£18·00
Ampclamp	£11·95
Temperature probe	£11·95
Guass meter	£11·95
Signal Injector	£5·95
Phase Sequence	£6·95
EHT Probe	£·95
Shunts 25 50/100A	£4·60 each

All types offered subject to availability. Prices correct at time of press E. & O. E. 10% VAT to be added to all orders.

TOP QUALITY SLIDER CONTROLS

60mm stroke high quality controls complete with knobs (post etc 15p any quantity)
Singles Log and Lin 5K 10K 22K 50K 100K 250K 500K 1 Meg 46p each
Ganged Log and Lin 10K 22K 50K 100K 250K 65p each
(Quantity discounts available) Complete with knobs

MARRIOT TAPE HEADS

4 TRACK MONO or 2 TRACK STEREO 17 High Impedance £2·00 18 Medium Impedance £2·00. R730 E73 2 track mono Record Erase low imp 75p pair Erase Heads for 17 and 18 75p. 63 2 track mono Hi imp £1·75. 43 Erase Head for 63 75p. (Post etc. 15p any quantity)

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news digest

CONTACTLESS IGNITION SYSTEM

Jermyn are putting on to the market a new contactless car ignition system which they claim provides greatly increased performance.

The system totally eliminates the contact breaker, the most frequent cause of trouble in conventional ignition systems. Not only is the contact breaker likely to deteriorate in performance due to a build up of dirt and pitting and to gradual changes in timing as well as dwell angle but, more important, the contact breaker is incapable of giving good engine performance at high engine speeds due to such factors as contact bounce.

The new Jermyn electronic ignition system - known as System E - employs a proximity sensor in place of the contact breaker which monitors the precise position of the lobes on the distributor cam and supplies this information to the electronic control unit. At precisely the correct moment, at all engine speeds, the control unit supplies a uniform spark of 30 kV via the existing ignition coil.

As a result, plugs last up to approximately three times longer, fuel consumption is reduced, more power is available due to better fuel combustion and cold starting is easier. Even when on a cold morning the oil is like treacle and the battery voltage is down, the Jermyn System E supplies a fast rise-time high voltage pulse to the sparking plugs to make cold starting easy. The chance of flat battery through repeated attempts to start the engine is very much reduced.

System E is easy to fit and normally takes under an hour. It costs £22.00 including VAT, and comes complete with instructions. Jermyn need to know the make, model and year of the car.

Jermyn Distribution, Vestry Estate. Sevenoaks, Kent.

EXTENDED RADIO PAGING SYSTEM

Radio paging is in a generally experimental stage, and it is uncertain whether in the long run paging systems will be handled entirely by the Post Office or by private operations. At the moment private operations have separate radio paging systems from the telephone system - an operator interfacing the two.

Now Redifon Telecommunications announce that they are going to market and sell a pocket radio pager suitable for use in a paging system which will be an extension of the telephone network. The pager, called Redipage, could be used equally well in the non-integrated system.

The 4.5oz receiver has an IC 'computer' section to discriminate between any of 2M different incoming codes. In use the caller would dial a 10 digit number to a centrally based computer for broadcasting. The paged person could then hear one of two tones — telling him to phone home or office (or one of any two specified numbers). The central computer, apart from doing the coding and broadcasting, can handle billing for the service.

The actual code system uses FSK (frequency switched keying) digital transmission. To avoid interference between transmitters in the same area, such transmitters would be operated by allocating each of them slots in a transmission cycle. Up to eight transmitters could be used in sequence in an eight second cycle.

With digital coding and transmitter time slotting there should be few problems in extending the system — Redifon estimate that 500 transmitters would cover the whole of the UK!

ELAPSED TIME INDICATOR

This subminiature device, type OFA-1, will provide an indication of the end of a given time interval and has a wide application for all types of electrical and electronic equipment. The indication is provided by a change in

The OFA-1 Elapsed Time Indicators from Photain.

colour from Yellow to Green.

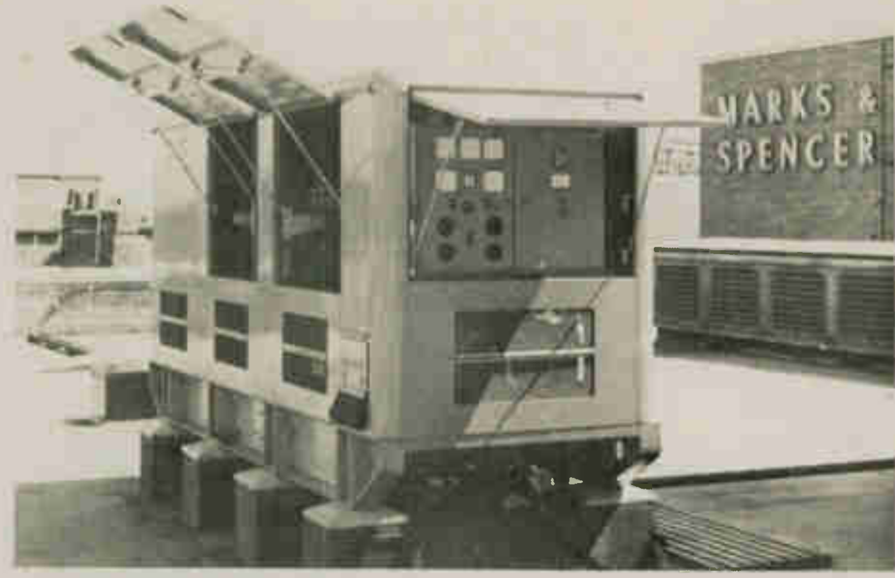
The manufacturers suggest that it can be used for:-

1. Indication of the life of a needle of a Record Player.
2. Indication of the period of guarantee for electrical and electronic equipment.
3. Indication of the period of engine oil changing in motor vehicles.
4. Indication of the expiry of the time of rented machinery.

It is suitable for mounting into a standard lampholder and will operate from any AC or DC voltage for any period up to 1000 hours. To determine the appropriate elapsed time a resistor is wired in series with the indicator so that at the end of the elapsed time the unit will have passed 6mAhrs of electricity. When used for AC operation a silicon diode must be wired in series.

There is a tenfold increase in resistance when the colour change takes place. The corresponding voltage drop can be used to operate a relay to provide automatic contact operation at the end of the elapsed time. Price from £0.30 to £0.50 each according to quantity.

Photain Controls Ltd. Randalls Road, Leatherhead, Surrey.



GENERATING WITH NATURAL GAS

With the shortage of diesel fuel adding to the electricity cuts, Dale Electrics, the manufacturers of stand-by generating sets, have introduced a Natural Gas generating unit designed to run from North Sea Gas. For some years industry has relied on diesel driven generating equipment to keep their production going during the almost annual electricity cuts that are experienced in this country. However, this year another problem has added to the prospect of power cuts, the reduction of supplies of oil from the Arab countries resulting in fuel oil rationing.

Natural Gas alternative emergency power sources are available with outputs from 20 to 255KVA. Advantages are quieter running and cleaner exhaust, also there is no need for fuel storage, saving precious space.

HUMIDITY SENSITIVE SWITCHING ELEMENT

Research Laboratories of Matsushita Electric announce the development of a new switching element. It is sensitive to moisture and is the first of its kind. The Company has also developed a prototype of humidity senser for ultra-small detector, dew-point detector and for air conditioner.

Conventionally, humidity sensitive substances used were human hair, nylon film and high hygroscopic materials. However, their application was limited to the meteorological observation and industrial fields, due to their slow reaction to the moisture.

Matsushita's new elements shut off the electric current immediately when humidity reaches a certain level, because its electric resistance suddenly increases.

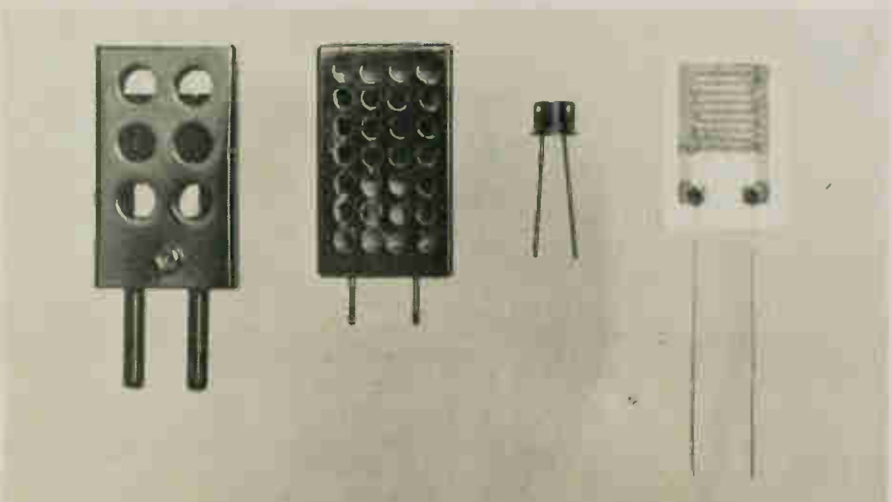
The device works on both AC and DC and can detect the dew-point. The switch function level is adjustable at any humidity level above 50%.

With these features, the following wide range of applications can be expected:

1. Demisting of rear window glass of automobiles.
2. Humidity control in a refrigerator.
3. Air conditioning equipment, such as room air conditioner, central heating equipment and humidifier.
4. In the agricultural field, such as humidity control in a greenhouse.
5. In cold-chain stores for preserving frozen foods.
6. As a device to prevent electronic and precision machineries from dewing.
7. In a dryer for clothes and foods.
8. Meteorological application for measuring rain fall and water level.

The basic structure of the element is as follows: Electrically conductive grains are mixed in a special high-polymer compound and the mixture is coated upon the insulating substrata such as glass, ceramic and plastic film. When the highpolymer compound absorbs humidity contact resistance between conductive grains increases and the electric resistance of the material increases suddenly. Conventional humidity sensors of this kind are good below 75%.

Development of the new switching sensor which works up to 100% of humidity was made possible by the development of special hygroscopic highpolymer compound and selection of optimum size and shape of



Humidity Sensitive Switching Elements from Matsushita.

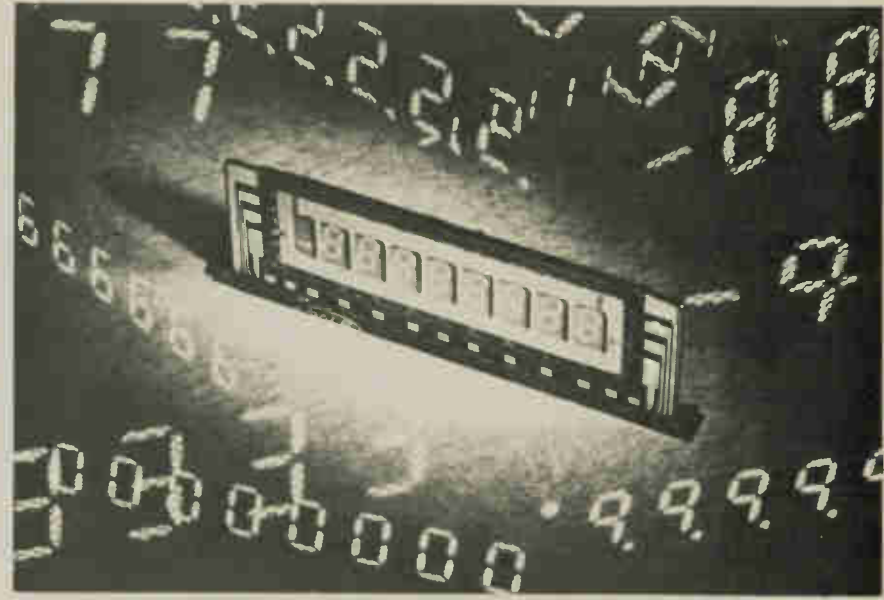
conductive grains to be mixed. By adjusting combination of highpolymer compound and grains, various types of element can be manufactured which work at any humidity level between 50 and 100%.

National Panasonic (UK) Ltd. Whitby Road, Slough, Bucks.

SOUND RADIO FOR ZAIRE

Siemens is soon to supply technical equipment for the construction of a national sound radio network to supply regional, national and international programmes in Zaire (formerly Democratic Rupublic of Congo). The project covers 11 transmitting stations in the medium and short wave bands with a total carrier power of 900kW which will be distributed over the whole country; additionally there is to be a separate communications and programme transmission network in the short wave band consisting of 16 double sideband transmitters (5/10kW) and a central short wave receiving station in Kinshasa.

For regional programme production, 8 broadcasting houses with production and broadcasting studios for music and speech, including a press, film and photo centre will be built. Further short-wave and radio relay links are on schedule for the planned expansion of the broadcasting network.



GAS DISCHARGE DISPLAY

New from ITT is the GN1252·8 cold-cathode gas display panel. The device provides an 8-numeral display with seven-segment characters 6.5mm (quarter-inch) high, plus decimal points and left-hand minus, overflow and dot symbols.

The panel is flat, with edge connectors. The viewing angle is 120°. The anode supply voltage is 190V d.c. and current consumption is typically 0.4mA per segment illuminated.

An optional feature is an eighth seqment to improve the format of character 4. The colour is neon-orange and the width of the display is just over 2in. The ITT GN1252·8 is intended for use in time-share mode. Applications are in instrumentation, frequency counters, calculators, etc.

ITT Component Group Europe, Valve Product Division, Brixham Road, Paignton, Devon.

NEW EQUIPMENT FOR CARGO INSPECTION AT LONDON AIRPORT

A novel form of baggage inspection, installed at London Airport, enables the security authorities to inspect the contents of cases entering the cargo hold of an aircraft without opening the cases or disturbing the contents.

The cases are inspected by Pantak Limited's X-ray equipment and the resulting images are examined by an EMI low light TV camera. The check takes four seconds.

The picture shows a revolver in a false bottom suitcase as seen by the TV operator. A booby trap, which would cause an explosion if the false bottom was incorrectly opened, can also be seen.

THE CHIPS ARE DOWN

Short of giving them away with cornflakes, there seems to be no bottom limit to the cost of both calculator chips and indeed the finished package.

Cal-Tex Semiconductor, an American company are currently negotiating with a British distributor and for a 4-function, 12-digit chip prices of about £2.50 in small quantities and being suggested at only slightly more than twice the price the same company hope to introduce a 'scientific' chip with several additional features.

The £20 calculator that we mentioned only a couple of months back is no longer cheap. The cheapest calculator that we have seen advertised is the Minuteman MM6 sold by G.W. Smith Limited at £12.95 plus VAT.

NEW FORMAT FOR LONDON BROADCASTING?

Representatives of London Broadcasting, Britain's first commercial radio station, say that they cannot afford to continue in the original format of news service plus magazine-style entertainment programmes.

The management have, however, denied that they are in difficulties. Members of the editorial staff, though, have been told they may lose their jobs. It is believed that this is because the overheads are too high and the station is not paying its way.

The station operates on a licence from the Independant Broadcasting Authority. It employs about 20 technical engineers and 115 editorial staff. Capital Radio, London's other commercial station seems to be doing much better with their format of popular music and phone-in programmes. Audience figures have not yet been estimated by Capital, so we cannot give an effective comparison of the popularity of the two stations.

STILL BOOMING

The growth of major public companies during the electronics boom is well known. The recently published "Financial accounts of the British audio industry" show that a wide range of medium sized private companies in consumer electronics have been doing equally well. On the whole, the importers have shown the greatest growth.

Sony (UK) has increased sales from £2,343,000 in the year to October 1970 to £10,954,000 in 1972. Their profits are £101,000. The sales of Bang and Olufsen (UK) rose from £2,336,000 to £6,372,000 between years ending January 1971 and January 1973, while profits leapt from £46,000 to £350,000.

Firms like Sony and B and O have gained greatly from the colour television boom, 1973 colour TV delivery figures being two thirds up on 1972, but more specialist audio importers and manufacturers have shown dramatic gains as well. One of the most spectacular is AMS Trading, which has pushed its sales up from £100,000 in 1970 to £726,000 in 1972, while profits have grown from £1,000 to £61,000. Specialist audio equipment retailers have been profiting from the boom as well, with rapidly growing chains gaining at the expenses of the small independents. Examples include Audiotronic and Dixons Photographic, both public companies, Greens Leisure Centres, and the Lindair chain.

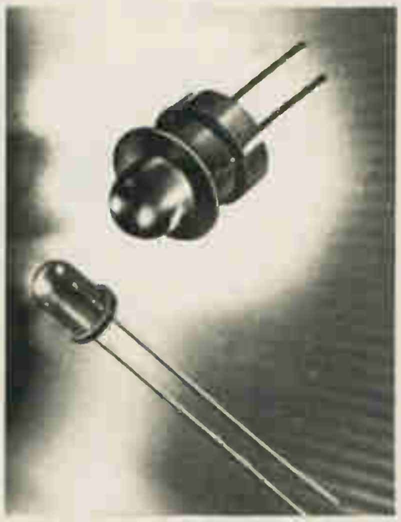
The editor of the publication estimates that three new companies per week have been entering the business over that past two years and if anything the rate has been even higher recently.

We also have news from Advance Electronics on their success of the last few years. The turnover in 1972 was £5½ million; in 1973 it was more than £8 million and a 40% growth rate is expected for 1974. The managing director has announced a new divisional structure - more suitable to the large company than the centralised set-up of previous years. Their are now four autonomous divisions, designed to develop as profit centres in their own right.

This is an audio amplifier — like the one in your pocket transistor radio — only it's 150,000 times as powerful. The 72kW amplifier is one of a new range by Derritron Ltd. Its a pity its not more portable or it would have found a good market in pop music!

ORANGE LED LAMPS

Litronix, have announced the addition of two orange-lit GaAP lamps to their range.



The clip-in, panel mounted OL-30, and the miniature OL-31, both feature high orange brightness of 0.8mcd (min.) at 20mA, and wide angle viewing.

In quantities of 1,000, the lamps are priced at 24p (DL-30) and 17p.

Litronix, Bevan House, Bancroft Court, Hitchin, Herts.

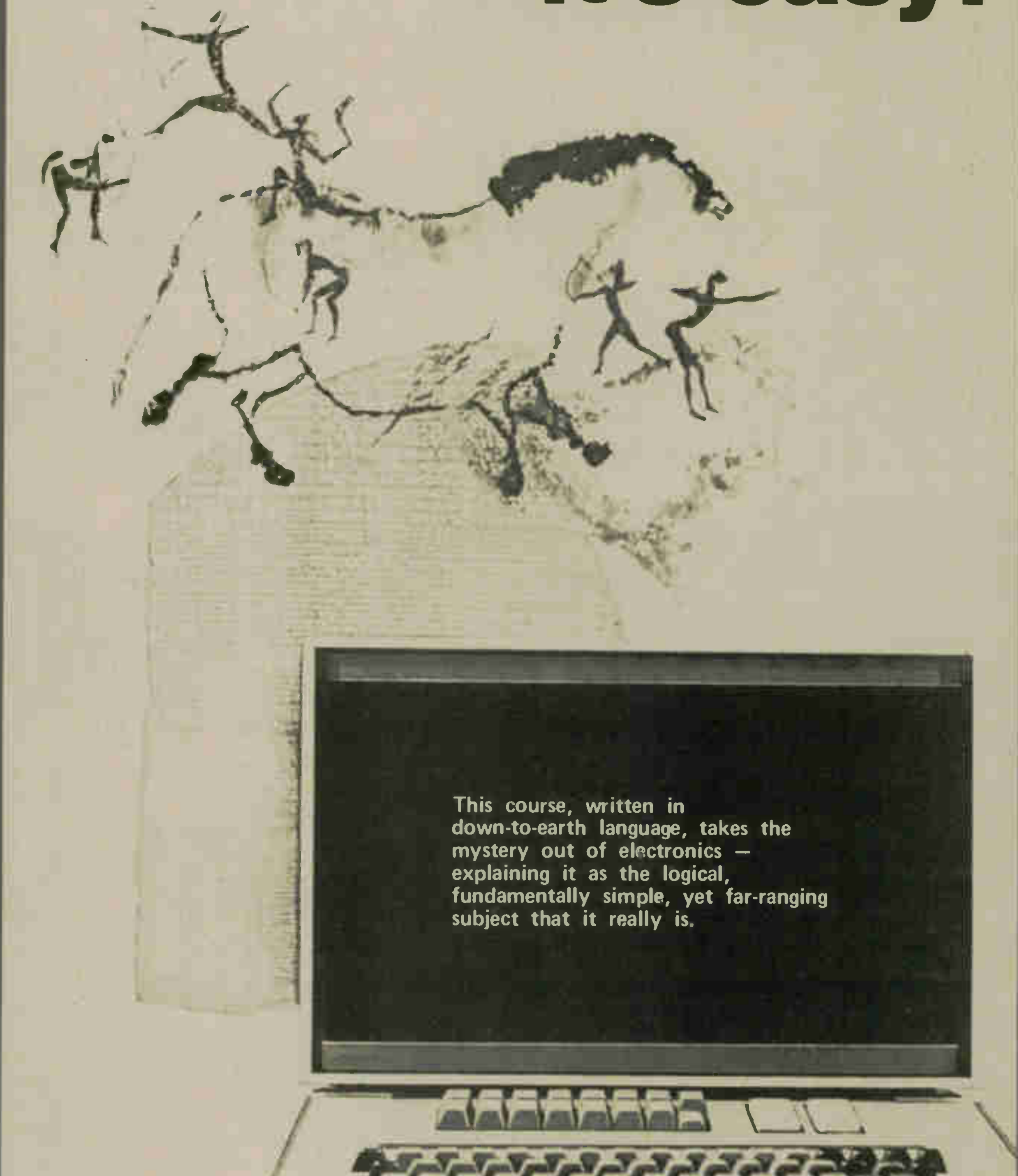
PACKAGED CIRCUITS

Pinnacle Electronic Components have announced that they are marketing two ranges of packaged circuits. The first is a range of transformless audio amplifiers with 800mW and 3W output operating from 9V and 12V respectively designed specifically for workshop intercoms, electronic megaphones and similar high gain applications.

The second is a range of power supplies 9V, 12V and 21V. The 21V model is a double power supply simultaneously providing an unregulated 21V, 300mA d.c. output with a separate isolated 21V, 500mA a.c.

Continued on page 61

ELECTRONICS -it's easy!



A new approach to basic electronics begins with this first article of a series.

TO the unenlightened even the simplest process can be a mystery. Yet with training the mystery vanishes when it is seen how simple logical techniques are combined to fulfil a task.

As we try to further our knowledge of the world about us, we collect facts gained from practical research and a great deal of thinking. Then by further mental effort we construct fundamental concepts that describe the observed facts.

These concepts, are more readily understood and remembered than an enormously long list of individual facts; and, coupled with imagination, provide the power to create and understand processes of great intricacy. Furthermore, by getting down to basics it is possible to build out again in quite new directions.

It is a human habit to try and make all experience black or white, classifying it into distinct compartments having a generally accepted name — medicine, engineering, farming, etc. It seems so tidy and assists information retrieval, but there is an ever-growing awareness that life is not like this, and processes are only understood properly by a multi-disciplinary approach.

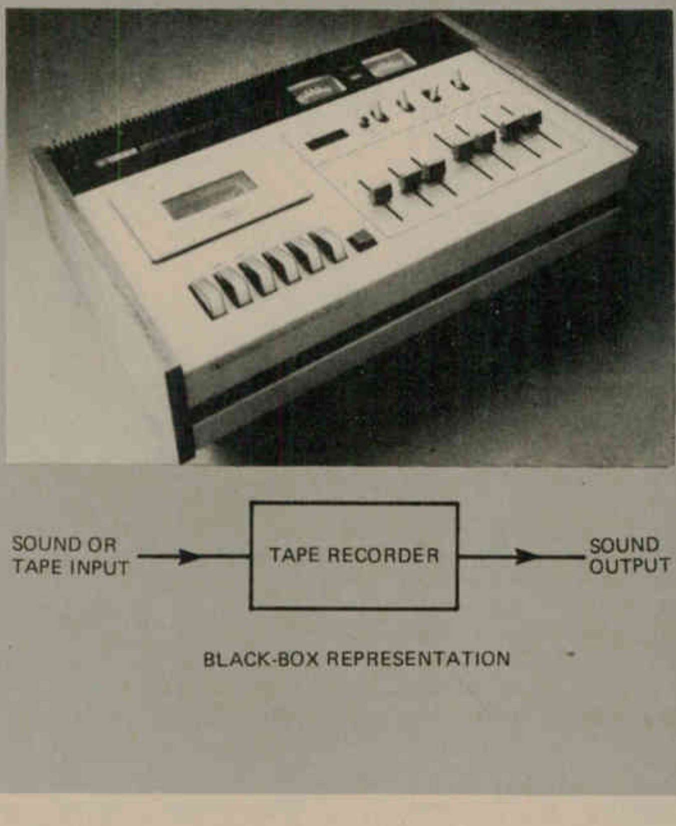
Electronics, although seen by many in the past as a self-contained subject, should, more correctly, be regarded as a universal discipline necessary to a remarkably wide range of endeavour. It is vital to communications, archaeology, medicine, language teaching, banking, education, farming — a complete list would be never ending.

Because of this, thoughout this course, our treatment of electronics will be a general basic approach — known loosely nowadays as a systems study. It will contrast with the more traditional approach, given in books and courses, by placing more emphasis on where a concept fits, rather than on how a manufacturer makes components or how the fundamental particles involved behave.

THE BLACK-BOX APPROACH

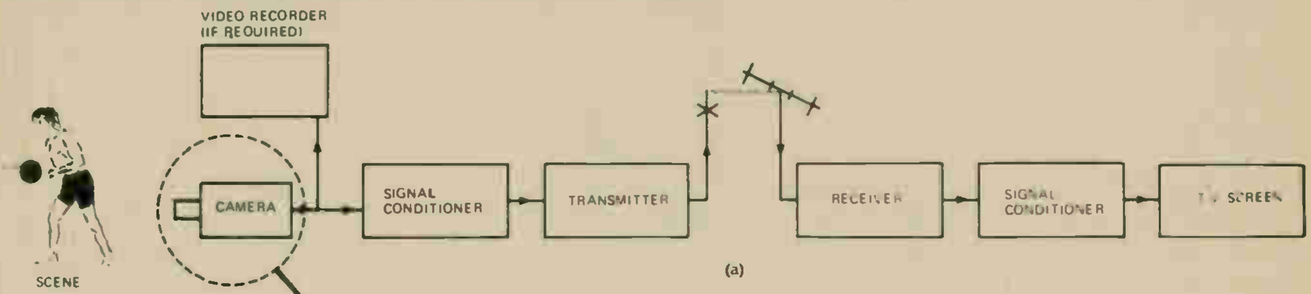
The physical world consists of numerous processes that interact with each other to form a reasonably well-balanced mammoth process. The nature of the individual processes vary enormously. In the natural world they involve such phenomena as biological behaviour and electro-chemical reactions. Man has added processes of his own that function optical and

Fig. 1. As both tape-recorders perform basically similar tasks, their 'black box' representation may be the same.

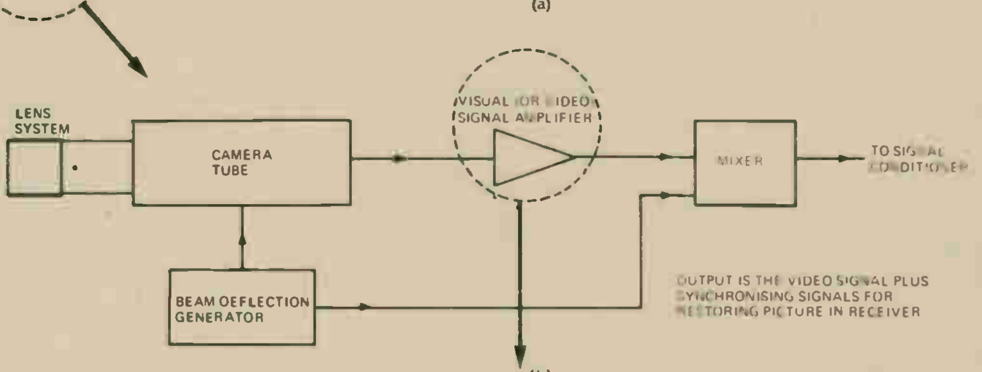


BLACK-BOX REPRESENTATION

ELECTRONICS - it's easy!

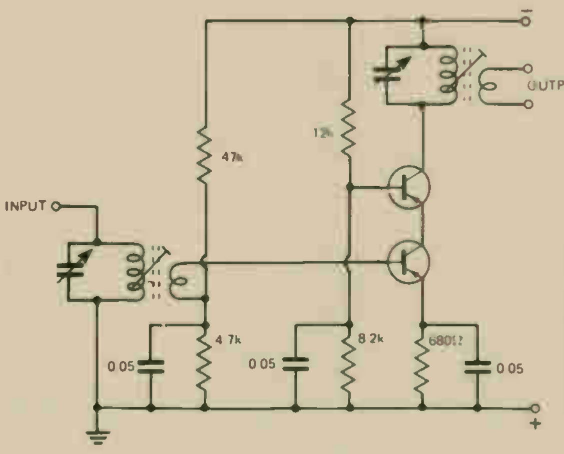


(a)



(b)

TOP: Fig 2a). Complete TV transmitter and receiver — this 'black box' representation shows the rudiments of the system. Each individual 'box' may take one of many forms — yet the system as a whole can always be portrayed as shown here.
CENTRE: (Fig. 2b). Black box representation of the internal workings of the TV camera (shown ringed in drawing above). Here, an elementary knowledge of television techniques would be needed in order to understand the individual 'black boxes' into which the camera has now been broken down.



(c)

BELOW: (Fig. 2c). Final 'breakdown'. This drawing shows the components and their interconnections that collectively form the part of the TV camera in Fig 2b. (As will be explained further in this course, symbols are used to represent components — rather than pictures of the components themsleves).

electronic hardware put together to create the machinery needed to make life easier.

To gain an understanding of the overall function of a system of any type, we need to break it down into recognisable basic blocks that each behave in a way that is comprehensible to us. This approach also enables one to realise what else the total system might do if the circumstances were a little different. Alternatively, it should tell how to modify a block or two to obtain a different behaviour.

Such blocks in electronics are commonly called "black boxes". The behaviour of a given kind of "black box" is always the same (by definition), but the internal mechanism used to achieve the given performance could be quite different (as shown in Fig. 1).

At a systems level of study it does not matter what is *inside* the box; its role is to provide characteristics of a certain kind. Understanding the behaviour of the system needs little knowledge of the inside of such "black boxes". Similarly when designing a new system, it is first realised as a string of "black boxes" picked from one's catalogue of feasible concepts. (There is a catch, however, for technology is changing so rapidly that there is an ever-increasing and apparently never-ending supply of new functions coming into being. A compromise must, therefore, be drawn between being right up-to-date and actually getting on with building a working system).

When a system fails to operate, the faulty "black box" can be isolated for repair; this is achieved by applying carefully thought-out tests to the system to diagnose the fault, or in the case of small systems, by simply replacing "black boxes" one by one until the system works again. Designing and repairing "black boxes" needs a knowledge of more basic electronic design — we will be mainly concerned with this level in the early stages of the course.

At a stage more basic again, are scientists, research engineers and circuit designers who each have a specialized knowledge of the many individual facets of the basic components — it is they who invent and develop new devices.

To illustrate this hierarchy, consider the system used to transmit visual information to other places — television. In Fig. 2a a television system is depicted as a number of interconnected black boxes. The names in this form of portrayal (called a schematic) tell even the untrained the purpose of each box. The next stage of complexity is another schematic (still drawn as boxes, for we are not yet at the component level) that uses commonly available functions. The camera only, of Fig. 2a is drawn in Fig. 2b to illustrate this — the complete system diagram would need a great deal of space. If we wished actually to construct or fault-find the camera, we would need to know about the inside of each box,

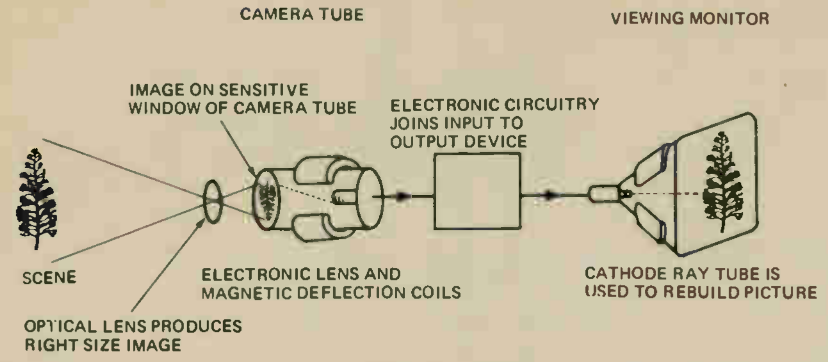


Fig. 3. Electronic circuits invariably need to be used in conjunction with 'bits' from other disciplines. Television, for example, utilises a number of mechanical and optical components — as our drawing shows.

and here we use circuit diagrams that show the actual connections made between components.

In electronic circuit diagrams, symbols are used to represent the various components — thus a battery is shown as —|||— regardless of its actual size or shape, a resistor is usually shown as —ww—, and a capacitor as —||—. Circuit diagrams are in fact a shorthand way of showing components and their interconnections.

The circuit shown in Fig 2c is that of the video signal amplifier (Fig. 2b). Given a circuit diagram and a little basic knowledge, it is relatively easy to assemble the circuit to form a more complicated black box.

Occasionally, especially when designing new circuits, it helps to have more fundamental details of the operation, manufacturing process and material properties of components, but that stage is not entirely essential if the need is only to make designs already detailed by a designer, in application notes, or an electronic magazine. (A point to remember when studying schematics is that the supply of power necessary to operate the circuit is often omitted to simplify the drawing).

The systems approach to a problem is not restricted to use in electronics alone. It is just as useable in the study and design of mechanical and optical systems, as well as a host of non-physical processes. The electronic worker cannot avoid becoming involved with other disciplines — in the study of television for example, he or she would need to know something of optical techniques, photography and acoustics (as shown in Fig. 3).

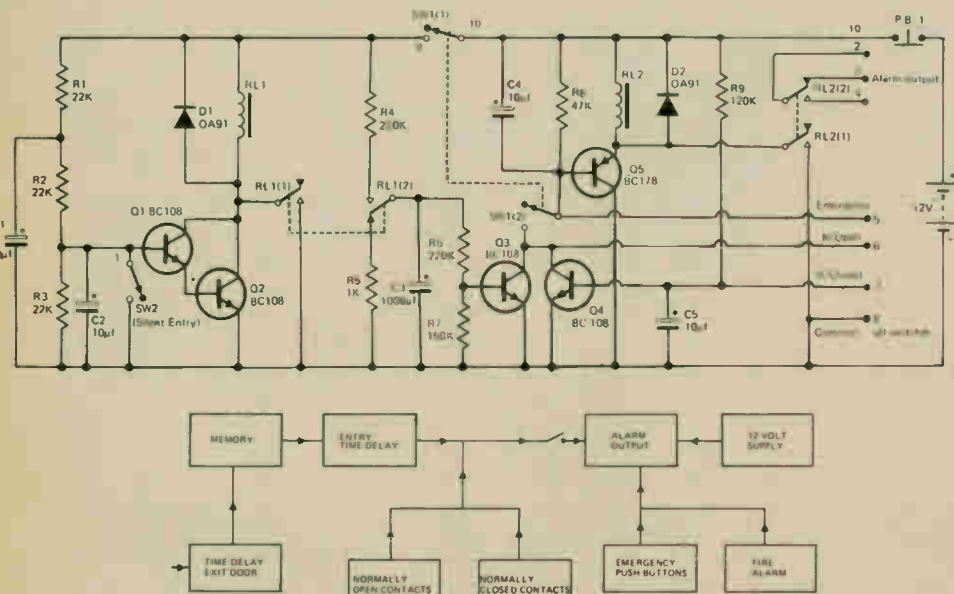
When systems are studied as boxes at the various levels described in this brief introductory article, a seemingly incomprehensible device (like that shown in Fig. 4) crumbles, slowly perhaps, but assuredly, to a stage where it is almost obvious — the mystery has vanished. With training and experience, that this course will provide, it will become possible to recognise the individual blocks in an intricate circuit diagram and thus realise its behaviour.

In electronics that which was regarded as a complex system component a decade or so ago, might now be merely a sub-system of another larger system. Twenty years ago it was a major project to design and build a stable amplifier for precision applications. (This is a device commonly used in many branches of electronics. Its function is to enlarge signals, and will be studied later). Today, they are of fingernail size, consume only a minute amount of power, perform equally as well as the best of yesteryear, yet sell at a price that enables them to be used with little regard for their cost. The earlier units used a thousand times more power, cost a hundred times as much, and were at least the size of a shoe box. The old and the new forms are contrasted in Fig. 5.

This trend towards the sale of complete inexpensive sub-systems as the most basic building block enables even the learner of today to build sophisticated devices speedily and at reasonable cost. It is because of this development that this particular course is different from most others on electronics.

So much for the way in which we treat a system to gain an understanding of its operations. Let us now concentrate on the fundamental nature of black boxes.

Fig. 4. Complex devices may appear baffling — until broken down to show the actual functions: a/ Circuit diagram of a complex burglar alarm. b/ It's operation is much clearer as shown here.



POWER FLOW IN ELECTRONIC BLACK-BOXES

For a system to operate, it usually must have an energy or power supply. The law of conservation of energy says there must be an energy balance (Fig. 6) — energy given out by a system as useful output, plus the energy losses of components, must equal the input energy from the supply.

Black boxes, therefore, have inputs and outputs of energy. For example, there might be an input of power to drive it and an input to operate the output. The relationship between the input and the output is called the transfer function of the box, for it expresses how the input is effectively transferred to the output. In boxes

ELECTRONICS - it's easy!

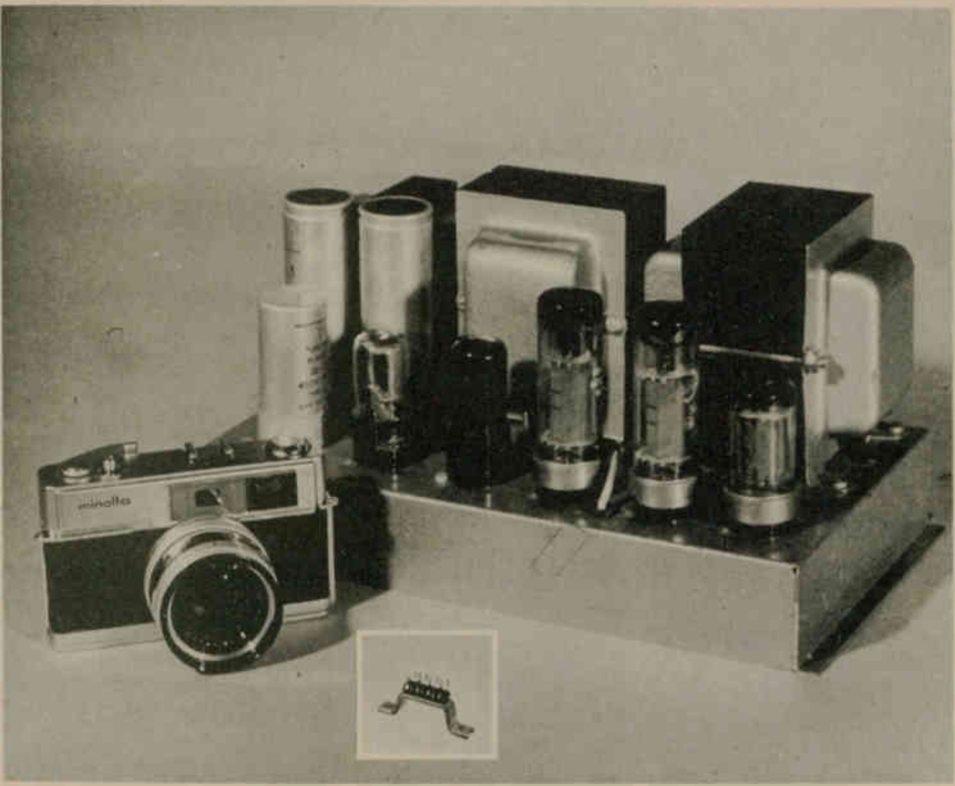


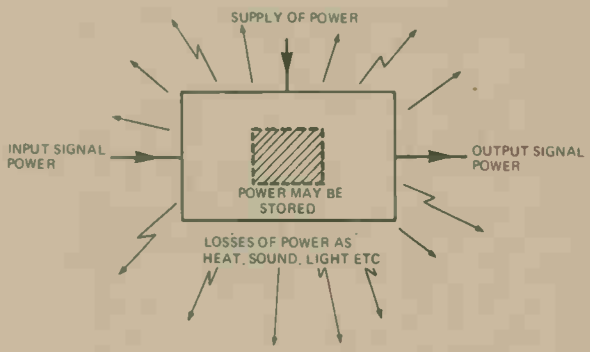
Fig. 5. Dramatically illustrating the rapidly changing nature of electronic techniques, the tiny module (below) has virtually identical performance as the massive unit shown above it. Both are high power audio amplifiers.

consuming small powers we refer to the input and output energies as signals. The input signal to a black box invariably controls the power flow to the output – like a tap controls water flow. There are a few electronic systems that derive their power from the input signal, but they are not common. The old-fashioned crystal radio set of our grandfather's day was an example of this. The energy used to drive the headphones was actually derived from the signal transmitted by the broadcasting station, and no battery or other form of power supply was required.

Black boxes connected to the power supply will be constructed from two classes of component. They can either dissipate (or waste) the energy as losses (for example, the heating of a resistor) or they can store energy giving it back later. An example of this – explained in detail later in this course – is a coil of wire forming an inductor. This can store electrical energy by virtue of a magnetic field. Another example is that of two close, but not touching, metal plates (known as a capacitor) that can store energy as an electric charge.

Resistors (often abbreviated when written, to (R)), inductors (L) and capacitors (C) are the basic elements of electronics. In practice, each has some degree of unwanted power-loss or storage and this may be important, as will be seen later. Basic resistors, inductors, or capacitors have a wire

Fig. 6. The total amount of energy flowing into any system will always be the same as the total amount of energy flowing out of that system.



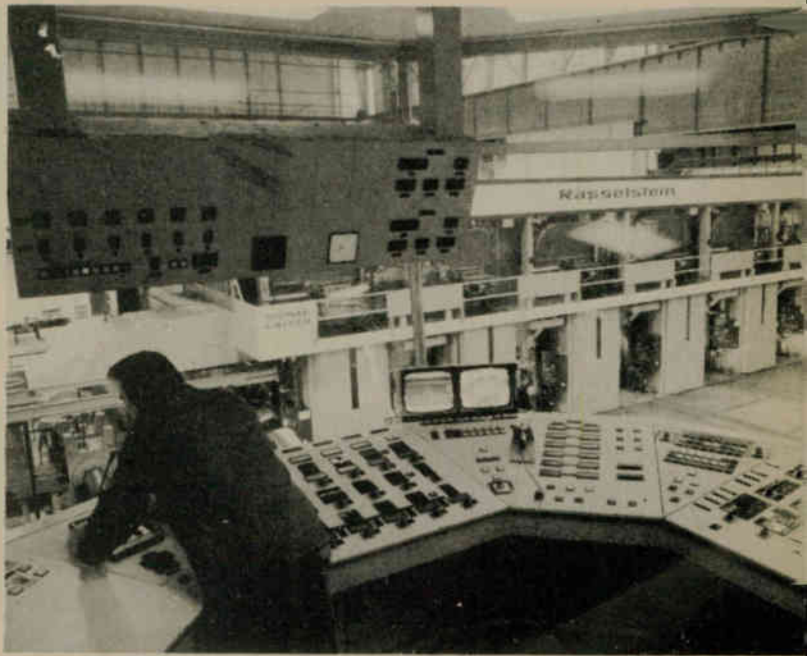


Fig. 7. Signals from many processes may not be in a form suitable for electronic processing. Transducers, are used to make the necessary transformations. Here, information from many different parts of this mammoth steel rolling mill is transduced into electrical form and displayed on this control desk.

going into them, and another leading from them. (They are 'passive elements' in that they are unable to increase (amplify) the power level of input signals transferred to the output. They can be used to set the flow-rate of power but cannot produce a higher power at their output than that at their input.

THE AMPLIFIER

Another class of basic element, the amplifier, by contrast, has three terminals (at least) – input signal, power input and output signal, and with these an output signal can be made much larger than the input signal.

An amplifier does not increase power in a mysterious way. It merely acts as a device whereby a small input power can control a large output power by allowing it to flow (under control) from the power supply – just as a small hydraulic tap is operated to control the lift of a car-hoist in a service station. Such devices are known as 'active elements'. Individual passive elements are often combined to produce a passive circuit; these circuits can then be combined with active elements to form larger circuits.

THE NEED FOR TRANSDUCER BLACK BOXES

Some black boxes serve the purpose of interfacing an electronic system with the physical world, and vice versa. They change (or in electronic parlance, 'transduce') physical variables, such as sound, brightness and length into an electrical equivalent signal that is compatible with electronic techniques.

These are the 'sensors' of man-made systems, acting much as eyes, ears, etc do in other ways in humans.

The television camera, for example, changes visual images into electronic signals suitable for broadcasting. Once the electronic signals are processed, it will eventually be necessary to change them back to a non-electronic form (which may, for example, be the output of a record player).

The loudspeaker is one such output transducer, for it converts electric currents to the motion of a diaphragm, thus producing sound pressure waves in the air that we recognise as music or speech.

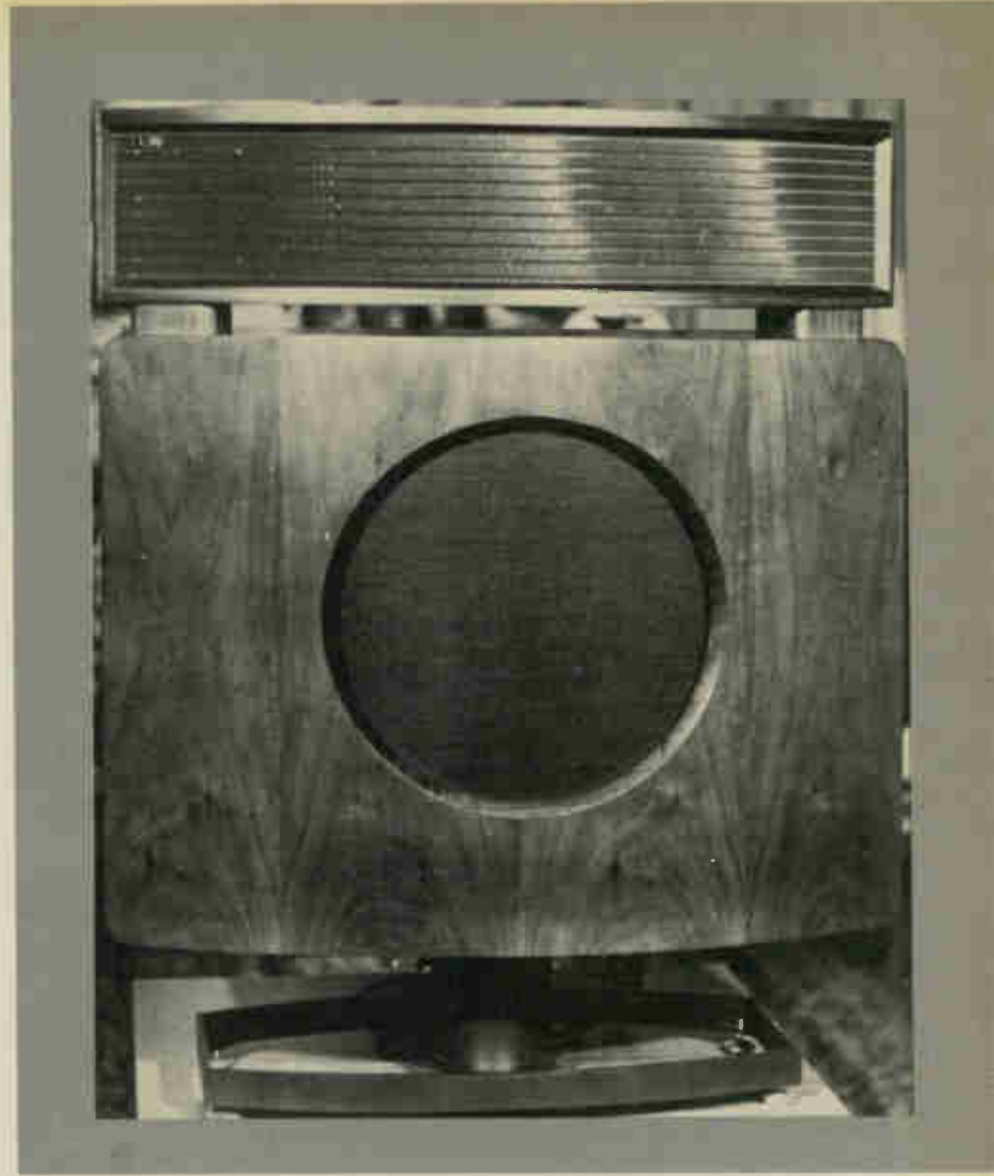
Electronic systems then, are built up from passive elements (resistors, inductors and capacitors in the main) that can either store or lose energy, and active elements (amplifiers) that enable energy flow to be regulated from a main supply. A proper understanding of these basic differences greatly assists comprehension of the operations of circuits that are encountered as we proceed.

As it is too early to start practical work, find out if you really understand the systems approach by sketching the black-box diagrams of common processes around you – they need not be electronic.

Examples worth trying are a motor-car, or bicycle system with a rider, the movie film process from scene to screen, automatic street lighting where the sun is used to switch the lamp off during the day, and traffic lights controlling vehicles at an intersection. Remember to identify where the power is coming from and going to, and which are the active and passive elements of each system. ●

Perhaps the most complex electric systems yet devised are those used in space – typifing such applications is this NASA model of the USSR's Soyuz and the US Apollo spacecrafts in simulated rendezvous and docking in Earth orbit.

Two transducers used in everyday life. The microphone (left) transduces sound energy into electrical energy, conversely the loudspeakers (below) transduces electrical energy back into sound.



Recommended price, including VAT: £194.98.

BOWERS AND WILKINS DM 70 LOUDSPEAKERS

BOWERS and Wilkins have been producing speakers since the mid 1960s and in a short space of some seven years have captured a significant portion of both the European and international markets for top quality equipment.

It is this emphasis on top quality equipment that characterizes Bowers and Wilkins' products — for unlike many other manufacturers, who provide a range of speakers from cheap to expensive, Bowers and Wilkins cater solely for the 'purist' market.

The company has expanded rapidly and in keeping with other world leaders in their field, have placed a very great emphasis on research and development. It is not surprising that 60% of their production is exported, and even then the demand grossly exceeds their ability to supply.

The Model 70's reviewed in this article are the second Bowers and Wilkins speakers that we have tested (the first were the company's type DM2 (Oct '72) — these had one of the best frequency responses of any speaker system we have ever tested in the range from 100 Hz to 20 kHz).

Whilst the DM2, and most previous systems produced by Bowers and Wilkins, have used electro-dynamic components, the series 70 uses an excellent eleven element wide dispersion electrostatic unit.

The series 70 system consists of a large bass enclosure, the front of which is curved, surmounted by an electrostatic tweeter assembly. Both units are mounted on a metal stand.

With an overall height of 820 mm, width of 680 mm and a total depth of 390 mm, the bass unit is physically large. It incorporates a 305 mm diameter model DW 13/70 driver. This driver has a free air resonance of 28 Hz that increases to 45 Hz when mounted in the enclosure. An unusual feature of the DW 13/70 driver is a series of special rubber damping pads on the face of the heavy speaker cone to reduce cone break-up under high power drive conditions.

The designers have used a very long throw voice coil — together with a linear suspension system — to produce, as far as possible, true linear piston drive in the sealed enclosure.

The purpose of this is to reduce distortion at high power inputs, and in this respect the designers have been particularly successful.

The electrostatic unit is really the heart of the system, for it covers the frequency range 500 Hz through to 20 kHz. By using a series of individual electrostatic drive units arranged in a curve, the designers have avoided the high frequency beaming effect that is a fault of so many other electrostatic loudspeakers.

The power unit required to supply the polarising voltage for the electrostatic units, together with the cross-over networks, is located within the main bass enclosure. Access to these is provided from the rear.

MEASURED PERFORMANCE

Our first measurements were of the free field frequency response, on direct axis. The results showed that response was within ±6 dB from 35 Hz to 15 kHz. We then moved the recording microphone through a 30° arc to check the polar response of the electrostatic units — and were pleasantly surprised to find that there *was* no effective change. In this respect the designers have achieved an outstanding result.

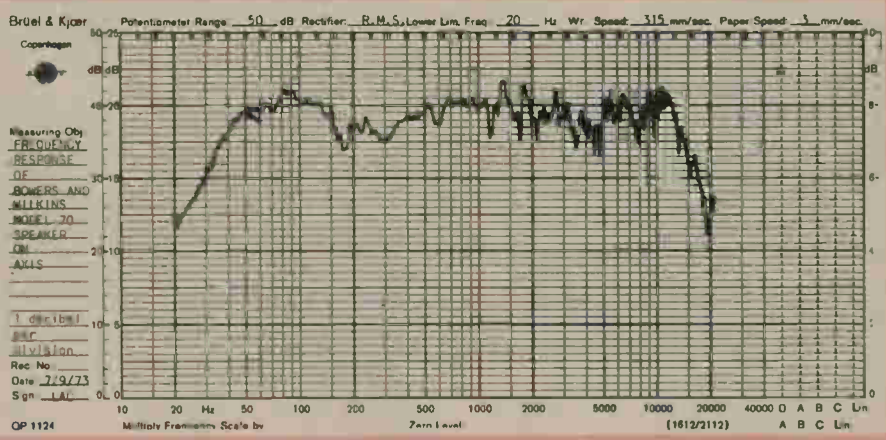
Having completed free-field measurements we next measured sound output power, with the speakers in our 340 cubic metre reverberant chamber, using white noise excitation and a 1/3rd octave filter test set. The results were highly commendable and, as can be seen from the relevant Bruel and Kjaer level recording (reproduced within this review) the sound output power level was commendably flat from 40 Hz to beyond 17 kHz. This is extremely good and equal to the best that we have measured.

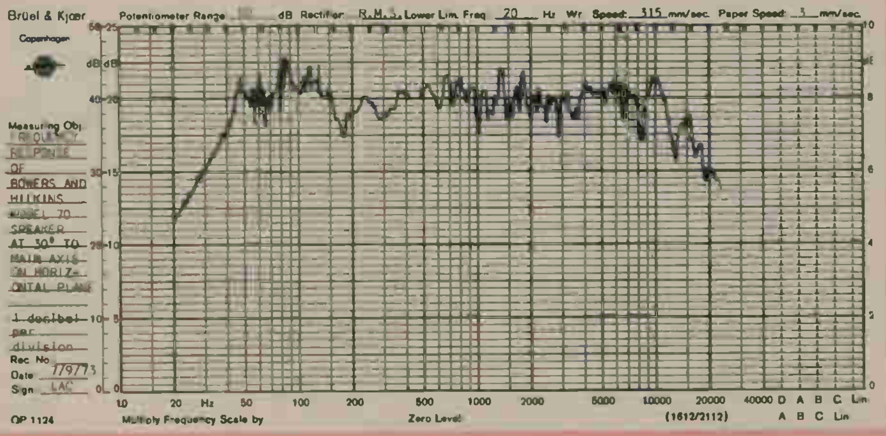
Measured distortion was generally low, particularly from the bass unit. At 25 watts input, distortion at 100 Hz was only 2%; at 500 Hz it was 1%, and at 10 kHz it was 0.7%. However with 50 watts input, the distortion at 100 Hz had risen to 5% and was audible.

As our impedance curve shows, the impedance characteristics of this speaker are rather unusual. In fact above 10 kHz the impedance is so low

MEASURED PERFORMANCE OF BOWERS & WILKINS LOUDSPEAKER MODEL DM 70,

Frequency Response (on axis)	35 Hz to 15 kHz ±6 dB	
(30° to axis)	35 Hz to 18 kHz ±6 dB	
Total Harmonic Distortion (for 90 dB at 2 m on axis)	Frequency (Hz)	Distortion (%)
	40	4%
	63	1.8%
	80	1.2%
	125	1%
	250	0.8%
	500	0.4%
Sensitivity (for 90 dB at 2 m on axis)	15 watts	
Woofer Resonance	45 Hz	
Measured Impedance	(see curve)	
Dimensions	680 mm wide 390 mm deep 820 mm high.	





that it rather disturbs us, for at these frequencies the speaker as 'seen' by the amplifier is virtually a short circuit.

Whilst it can be argued that, generally speaking, there is not a high level of content above 10 kHz, there is always the exception. If the manufacturers' recommendation — that a 30 watt (minimum) amplifier be used — then there should not be any problem, but, in our opinion if an *unsuitable* amplifier were to be used then there would be a strong possibility of damaging the output stages.

SUBJECTIVE IMPRESSIONS

Our next series of tests involved direct A-B comparisons, against a series of studio monitor loudspeakers, using high quality programme content.

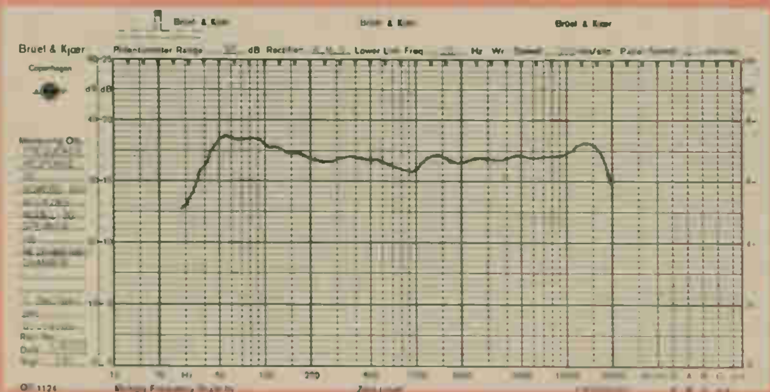
The first record used had every conceivable percussion instrument (and quite a few that are only barely conceivable — Ed!) — from cowbells to glockenspiels, maracas to jawbones.

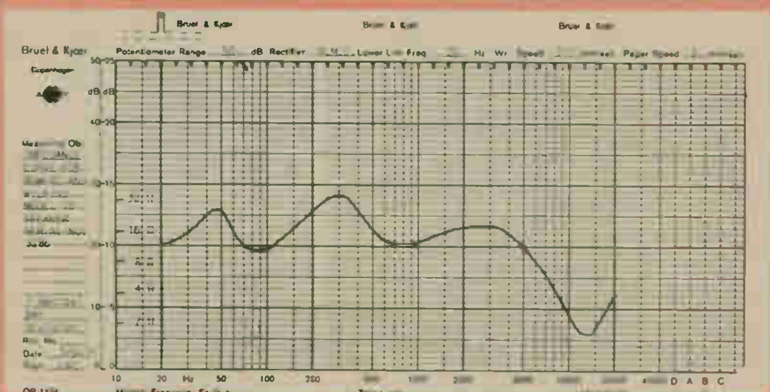
On this type of material the top end performance of the DM 70's is superb. There are only two other speaker systems that we have tested that have a better top end performance and both of these are substantially more expensive.

Transient response, on both scales and pulse inputs was exemplary, and low frequency performance proved to be equal to any other speakers previously tested (or heard).

Bowers and Wilkins have produced a speaker system that is exemplary. The DM 70's point the way to the forthcoming trend in loudspeakers — namely a move away from wholly electro-dynamic systems of conventional albeit refined design — to hybrid transducers and to the quite revolutionary transducers currently under development both in Europe and the USA.

In keeping with their smaller brothers, the DM 2's, the DM 70's are truly worthy of the title 'Monitor Loudspeakers'. ●





SONAB P4000 AMPLIFIER

First-rate Swedish amplifier uses latest technology to provide excellent performance.

Recommended retail price £149.93 inc. VAT.

WHILST the Swedish Sonab organisation are best known for their range of omni-directional speakers, the company also market amplifiers, headphones etc. that are comparable in quality to their speakers.

The Sonab type P4000 amplifier has a number of features that to some extent indicate a family relationship with Sonab speakers. The appearance for example is quite different from most present-day amplifiers. It is very striking with bold white control designations on a matt black front panel.

The cabinet too is quite unusual. It is made of ¼" extruded aluminium construction featuring a number of fins that at first sight can be mistaken for finned heat sinks. A closer examination shows that they are nothing of the sort. In fact fully adequate heat sinks are provided internally, and the cabinet has ventilation slots at both top and bottom. The fins seem to be a styling feature intended to remove the visual impact of the ventilation holes.

Controls and facilities provided are, from left to right:— Function selector for, tuner, auxiliary input, phono 1, microphone, phono 2.

Two microphone jack inputs for standard tip and sleeve plugs, two headphone outputs for ring tip and sleeve plugs.

In the lower section of the fascia are five black push buttons, these are for:— Power on, tape monitor, mono-stereo high cut filter, linear/loudness selector.

Above each of these controls is a clear green plastic bezel, illuminated from the rear, to indicate that the control function has been selected.

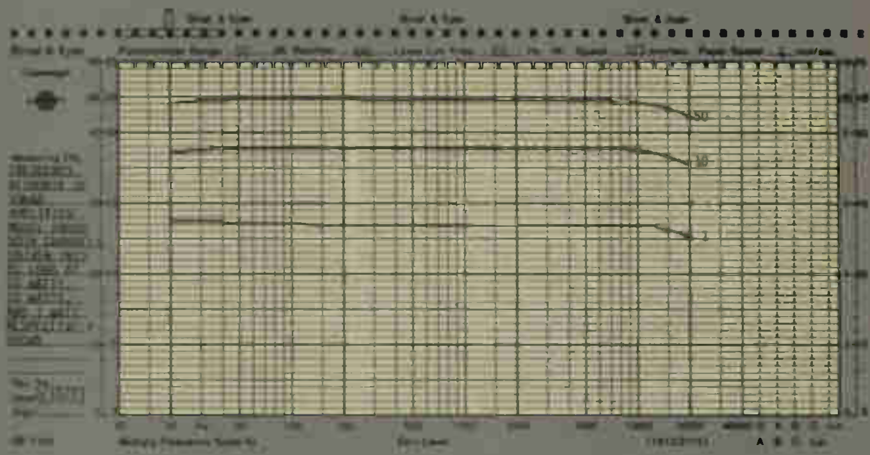
The four remaining controls, on the right hand side of the unit, are:—

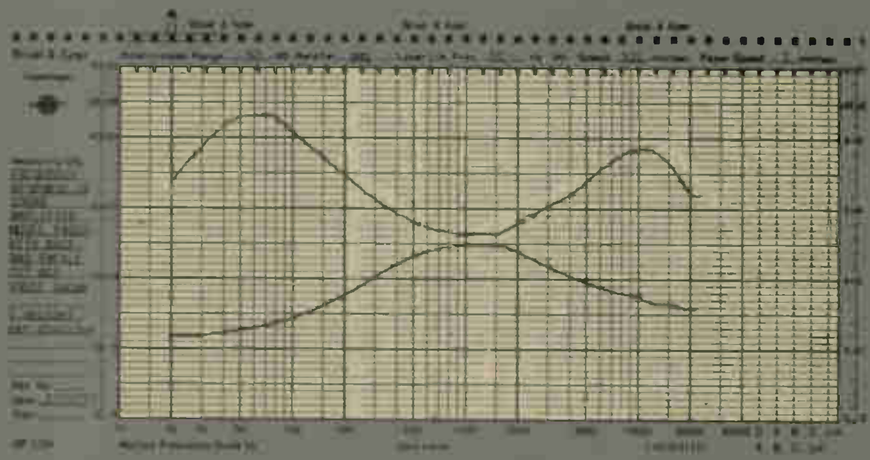
Volume control, bass cut and boost, treble cut and boost, balance control.

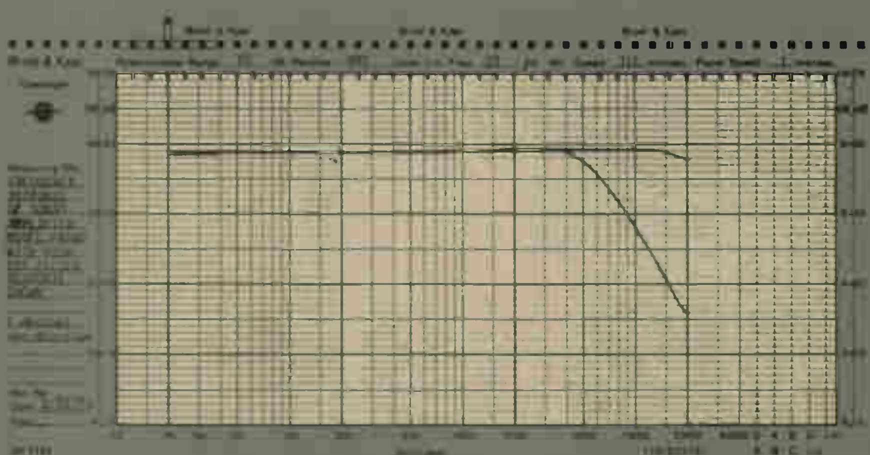
The grouping of all controls is good. They fall immediately to hand after a few minutes — it is probable that an ergonomist has had some part in planning this amplifier.

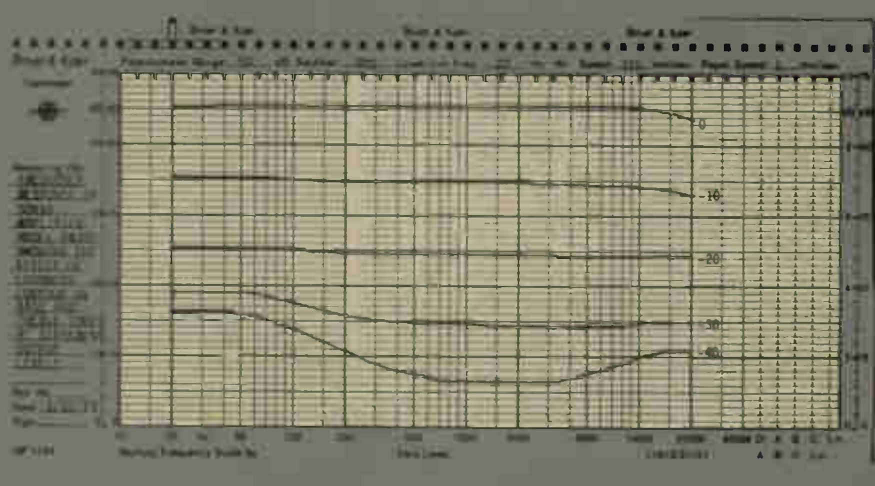
The rear panel of the P4000 amplifier is, like the rest of the unit, slightly unusual.

All inputs are made via DIN sockets (although the unit reviewed was supplied with a double DIN to RCA









electronics TODAY INTERNATIONAL

product test

adaptor to facilitate inter-connection with the more usual RCA type coaxial plugs — we understand however that this is not normally supplied).

Controls and inputs etc on the rear panel are, from left to right:—

Mains voltage selector — for 110, 130, 220 and 240 volts, ar either 50 Hz or 60 Hz.

External, switched, power outlet complete with its own three amp fuse.

This outlet is of the European two-pin type, but fortunately the amplifier is supplied complete with a matching (white) plug.

Next in line are two pairs of DIN speaker sockets, each with separate ON-OFF switch for A and B speaker systems.

Above the mains lead in the centre are two separate fuses — one for each side of the stereo amplifier.

On the right of these is a DIN socket that enables an output to be taken from the inbuilt preamplifier — or to feed an external signal into the main amplifier. A switch is also provided to enable the preamplifier and main amplifier to be directly connected — as the great majority of units would in fact be.

Further DIN sockets are provided for tape, auxiliary input, tuner, phono 1 and phono 2.

Both phono and microphone inputs are 68 k impedance RIAA equalized. Sonab claim that this impedance provides a flatter response with most better-known cartridges. Whilst this may well be so, the small but measurable droop in the high frequency response of the amplifier partly negates any advantage otherwise obtainable from this technique.

The amplifier is well constructed and finished internally. Power amplifier stages are well designed, with large finned heat sinks, each incorporating special slots to support the integral printed circuit boards on which are mounted associated components. Each drive transistor has a section of black anodised aluminium attached, to further enhance thermal dissipation.

The bridge rectifier module is large

and conservatively rated, and the whole of the power supply is screened from the remainder of the unit by a steel enclosure.

Particularly noticeable are the printed circuit boards, which, with their well labelled circuit designations, quality of components and general finish, are quite outstanding.

The amplifier is supplied with a twenty page handbook, written in both Swedish and English. This handbook provides full installation details together with a quite invaluable section on room acoustics. This section is sensibly written and sets an example for other manufacturers to follow. A circuit diagram is adhered to the inside of the amplifier top plate.

MEASURED PERFORMANCE

Whilst Sonab claim that the P4000 is rated at 50 watts (continuous power) on a single channel basis — or 40 + 40 watts into eight ohms loads — our measurements showed this rating to be conservative. We found that the amplifier will produce 50 + 50 watts (continuous power) into eight ohms loads at 0.35% total harmonic distortion. This is significantly better than Sonab's claim.

Frequency response is slightly unusual in that, unlike most present day amplifiers, the output falls off below 20 Hz and above 20 kHz. Nevertheless this characteristic has particular merits at the low end in that it reduces the effects of turntable rumble. The small droop in response between 12 kHz and 20 kHz is of no importance.

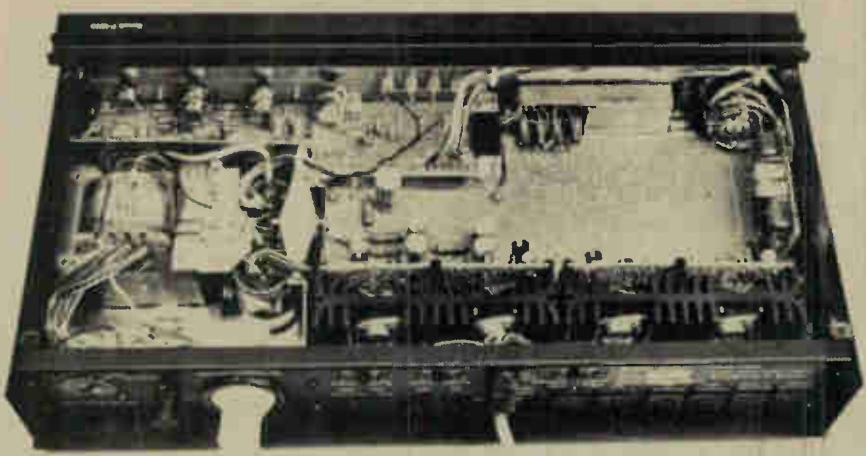
It is pleasing to find an amplifier in which not only is the power output greater than claimed, but one in which *all* manufacturer's rating are adequately met — in fact many of the more important ones are exceeded. In particular, power bandwidth, total harmonic distortion and intermodulation distortion are equal to or exceed the manufacturer's specification, and channel separation and signal/noise ratio are substantially better.

In use, the amplifier is readily incorporated in a hi-fi system. It is basically a 'no vice' unit in that it can accept many different types of speaker with no harmful effects. To check this we connected electrostatic speakers, and also speakers of a lower impedance than Sonab recommend. But in all cases the unit performed faultlessly and added no significant colouration to the programme content — compared against our reference amplifiers.

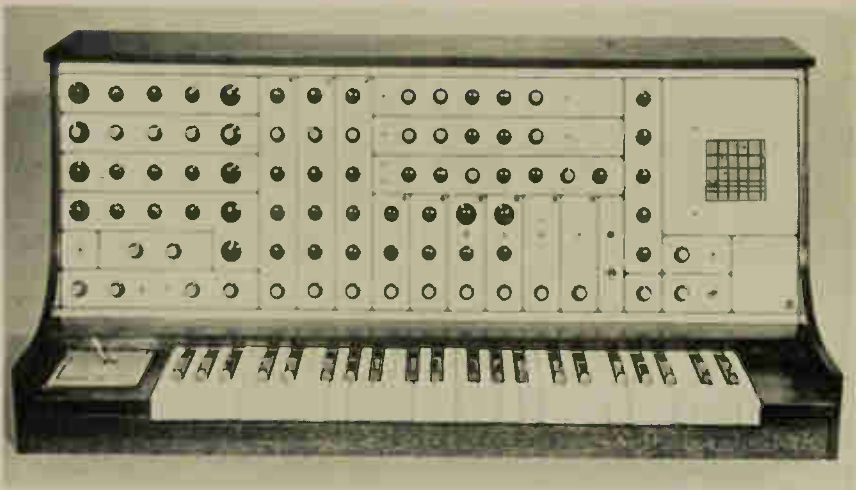
The Sonab P4000 is a particularly good amplifier. The quality of manufacture and degree of care in provision of protection circuitry should provide long, trouble-free operation. ●

MEASURED PERFORMANCE OF SONAB P4000 AMPLIFIER
SERIAL No. 002372

Power Output (at rated input)	50 + 50 watts ('rms') into 8 ohms.	
Frequency Response		
at 1 watt output	20 Hz — 15 kHz	
at 10 watts output	25 Hz — 15 kHz — all ±1/2 dB	
at rated output	25 Hz — 15 kHz	
Channel Separation (at rated output)	100 Hz — 47 dB 1 kHz — 45.5 dB	
Hum and Noise (with respect to rated power output)	— 76 dB (unweighted) — 85 dBA (weighted)	
Input Sensitivities (for rated power)		
Auxiliary	85 mV —	>100 k
Tape	87 mV	>100 k
Tuner	88 mV	>100 k
Phono 1	1.6 mV	68 k
Phono 2	1.6 mV	68 k
Power Amp.	500 mV	47 k
Mic.	1.8 mV	68 k
Total Harmonic Distortion (at 50 watts 'rms', both channels driven)	100 Hz — 0.35% 1 kHz — 0.33% 6.3 kHz — 0.33%	
Intermodulation Distortion	0.2%	
Tone Controls		
Bass	16.5 dB boost at 50 Hz 14.0 dB cut at 50 Hz	
Treble	12.5 dB boost at 10 kHz 9.0 dB cut at 10 kHz	
Loudness Control	15 dB boost at 50 Hz 12 dB boost at 10 kHz	
Dimensions	475 mm wide x 250 mm x 110 mm high.	
Weight	8.5 kg	



INTERNATIONAL MUSIC SYNTHESIZERS



Constructional details of the voltage controlled oscillators and the keyboard controller are provided in this second article in the series.

PART 2

IN THE first part of this series last month specifications were given for the 3600 and 4600 units and a brief description of module operation. This month we begin construction of the oscillator and keyboard-control modules. Full constructional details will take about 5 months to present, but with the power supply (next month) sounds can be generated immediately. Modules will be described in a logical sequence such that each month further capability will be added.

The description will concentrate on construction of the larger unit and although many of the modules may be used in the smaller version this will not be described until the end of the series.

For ease of construction and greater reliability and stability of the synthesizer, extensive use has been made of integrated circuits of both analog (operational amplifiers) and digital (CMOS). Hence this is not a recommended project for the beginner unless he has available the help of someone with experience.

Although the synthesizer can be built without the aid of test equipment, correct operation can only be assured by the use of some equipment.

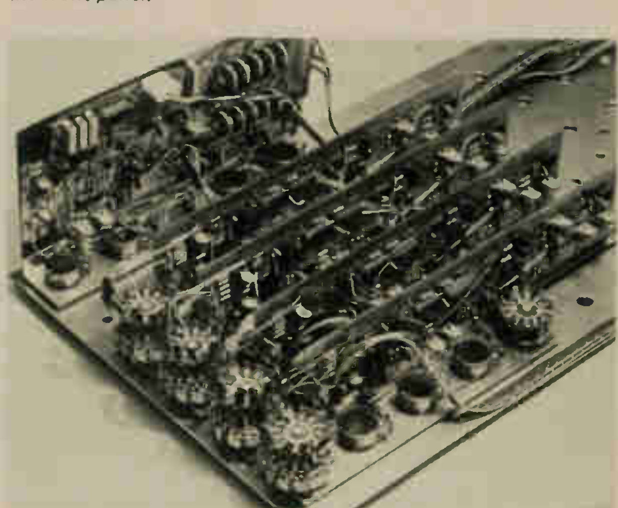
The most important instrument is most certainly an oscilloscope together with an organ tuner or digital frequency meter (an organ tuner project will be described soon) and an accurate dc voltmeter (preferably digital).

Components have been selected for use in the synthesizer on the basis of availability, price and performance. In most cases the components should be available from a number of suppliers. However certain components are either specialised or are available from only a limited number of suppliers. Where we envisage that problems will arise, we shall be mentioning a supplier but please bear in mind that there is a serious components shortage world-wide and there may be some delays.

Since the publication of last month's article much interest has been shown and we have had many telephone calls. From these it has become obvious that many people do not understand that this is a monophonic (one note at a time) instrument. That is, only one voltage at a time can be generated from the keyboard. Although a polyphonic instrument could be designed it would be considerably more complex and would virtually require a complete synthesizer for

The voltage controlled oscillator, showing the assembly of board potentiometers and switches to the sub panel.

The four oscillators and the keyboard controller shown assembled to the front panel.



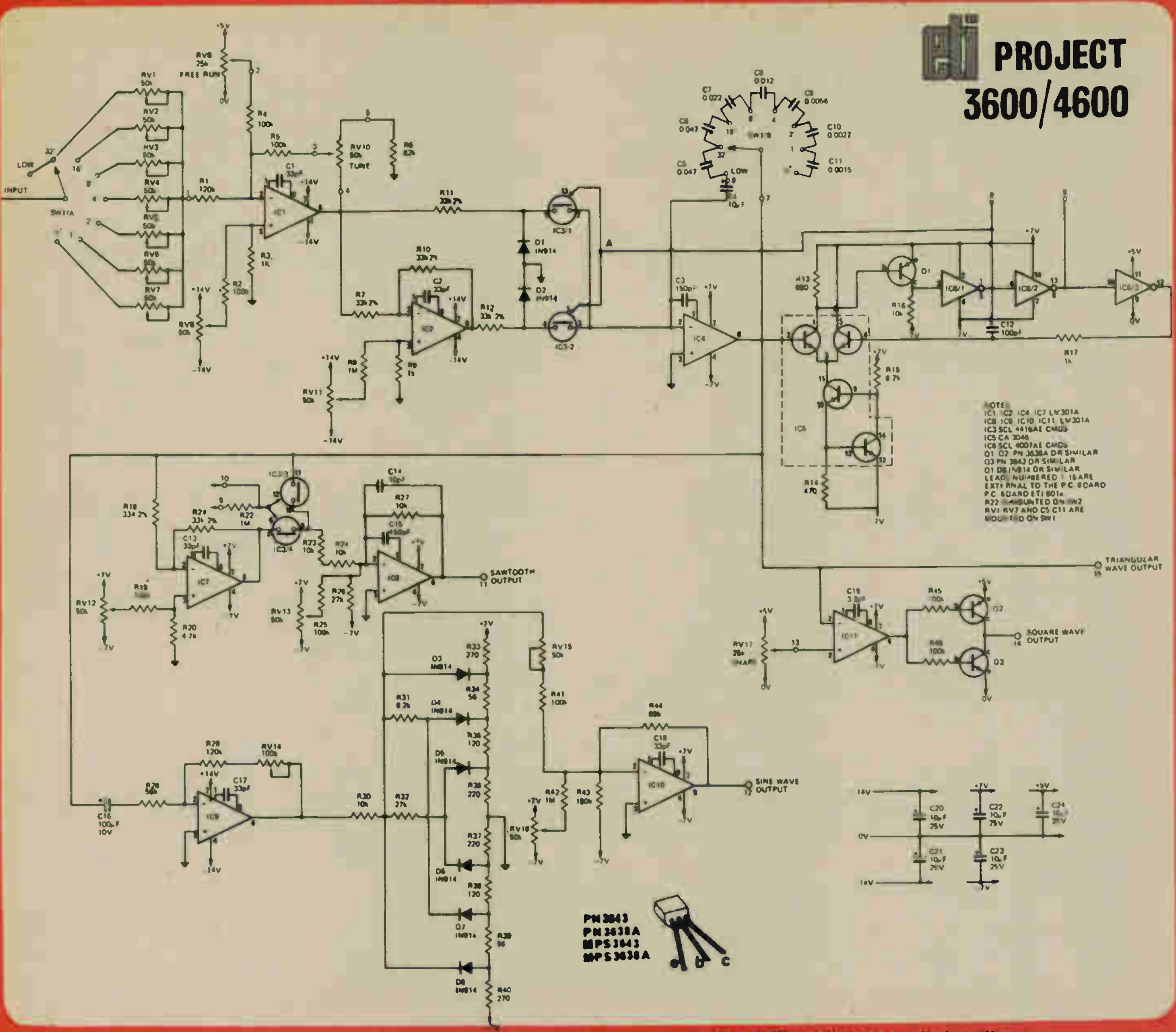


Fig. 1. The voltage-controlled oscillator.

each note to be played simultaneously.

CONSTRUCTION

General

Each separate synthesizer module is constructed as an individual subassembly, and these subassemblies are mounted onto a common front panel. It is recommended that plugs and sockets are used for all inter-wiring between modules, as this enables individual modules to be completely aligned and tested before installation on the front panel. It also, of course, facilitates later servicing.

With circuitry as complex as that in the synthesizer it is normal to use double-sided PC board. However, since this doubles the price of the boards we have elected to use single sided board with wire links where necessary. These have been kept as short, and as straight, as possible.

Oscillators

Before mounting any components on the PC board install the links as shown in Fig. 2. Note that some of the links, due to the proximity of other components, must be insulated. Make sure when mounting the components that the orientation of IC's, transistors, capacitors and diodes is correct. It is recommended that IC sockets be used for IC3 and IC6. These ICs should not be fitted until ready for testing and should not be handled excessively. Leads leaving the PC board are numbered on the overlay and these numbers correspond to leads on the circuit diagram and Fig. 12.

The external potentiometers and switches are mounted on a small aluminium bracket (Fig. 9) which also holds the PC board (see photo). The metal bracket is fitted to the PC board on the component side and not the copper side.

Except for the power supply which has 6 wires (+14V, +7V, +5V, OV -7V, -14V) only two other wires leave the board. These are the input and the output.

It is recommended that a plug and socket be used to connect the power supply from each module to the power supply board. Provision is made for this on the power supply board and the parts list contains the necessary part numbers.

Before switching on double check all soldering, component selection and orientation, and power supply connections.

Keyboard Controller

Construction of this module follows the same line as specified for the oscillator. Provided the links are kept straight no insulated links' need be used. It is recommended that IC sockets be used on IC3, IC4, IC5 and IC7 which are the CMOS devices.

It is recommended that a plug and socket be used to connect the keyboard to this module as it allows easy removal of the front panel. The layout of the PC board allows for the

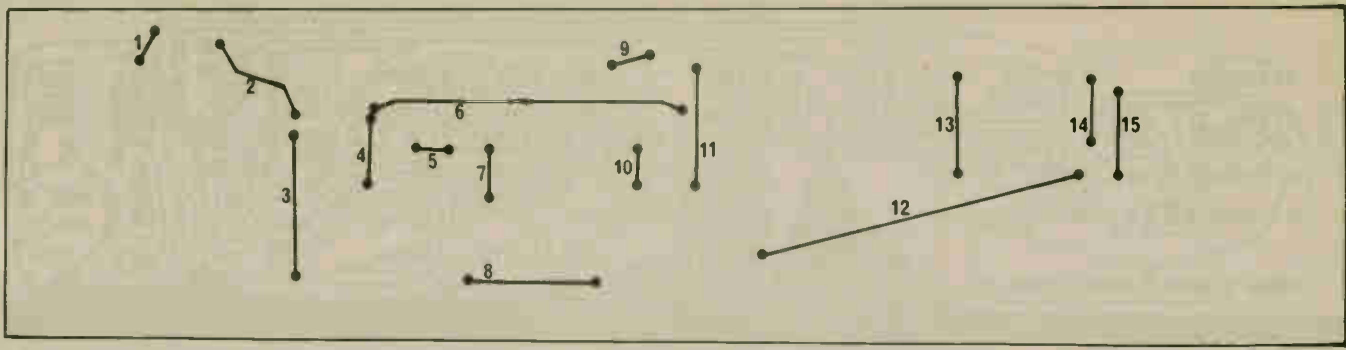


Fig. 2. Linking required on the oscillator board. This should be installed before components are fitted.

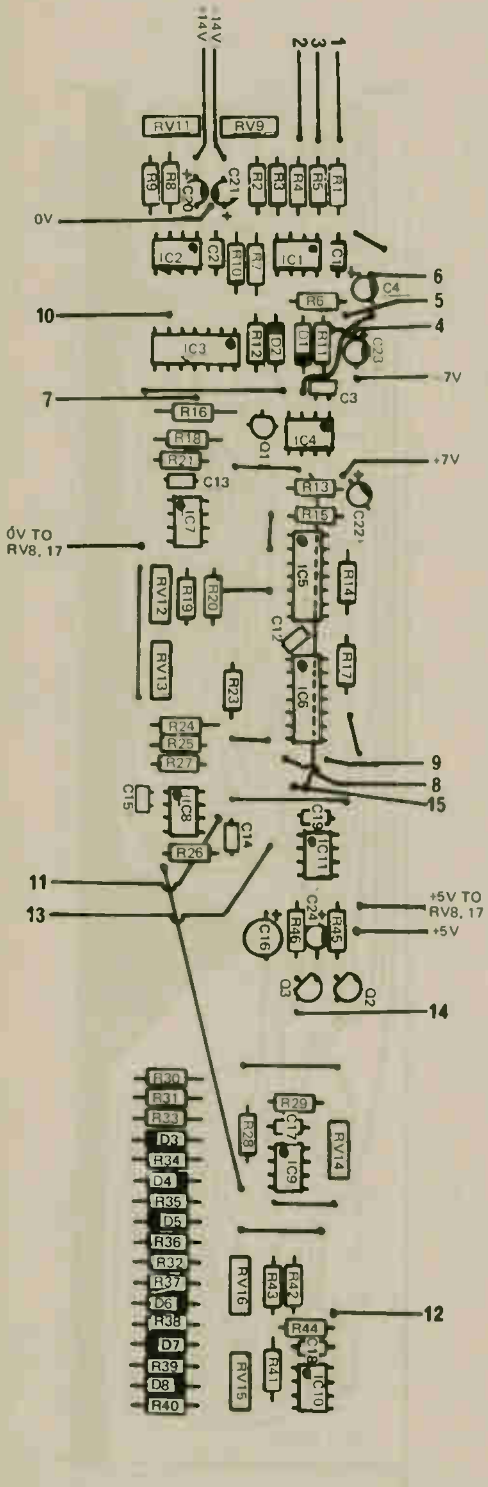


Fig. 3. Component overlay for the oscillator.

use of a plug.

ALIGNMENT
Oscillator

This procedure will require the use of an oscilloscope and a digital frequency meter or organ tuner.

Procedure:

1. Connect all power rails to the power supply and, without any input connected to SW1, switch on.

2. Select the 8 foot range and turn free run control fully clockwise.

3. Select triangular waveform and observe the output waveform. This should be as per Fig. 4a and go from 0 to +5 volts.

4. Select sawtooth waveform and observe the output. It will probably be similar to either Fig. 4b or Fig. 4c. Adjust RV12 to obtain a straight line as in Fig. 4d.

5. Select the ½foot range and turn the free run anti clockwise until the oscillator is just running. The waveform will appear as in Fig. 4e or Fig. 4f. Adjust RV11 to obtain a straight line as in Fig. 4d.

6. Adjust RV9 such that the oscillator is just running when "Freerun" is at zero.

7. Select 8 foot, maximum free run and sine-wave output. Adjust RV14 for best waveform as per Fig. 4h. Incorrect waveforms are shown in Fig. 4g and Fig. 4j.

8. Adjust RV15 such that the waveform is 5 volts peak-to-peak.

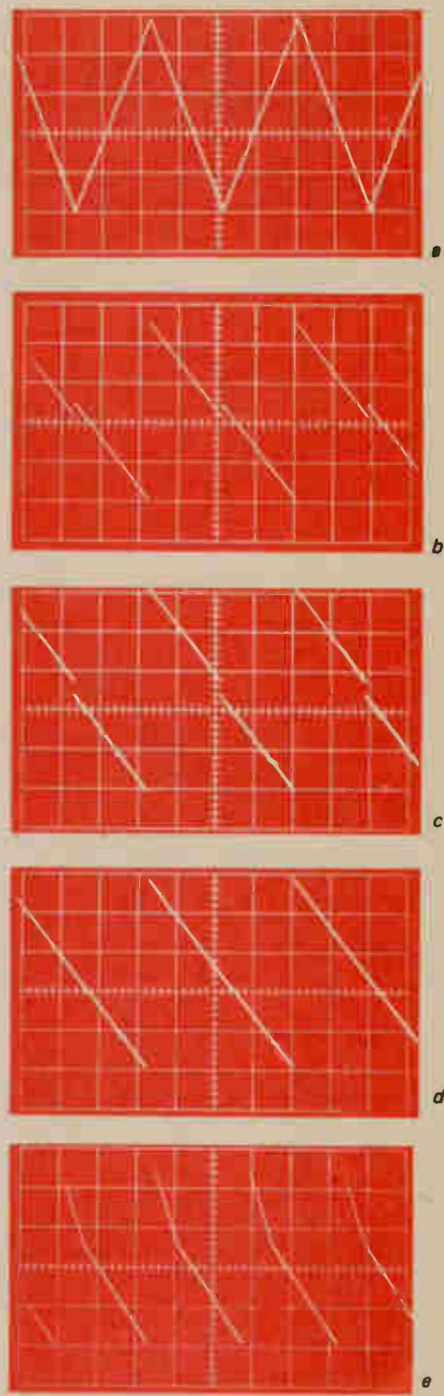


Fig. 4.

OSCILLATOR – HOW IT WORKS

The basic waveform generated by the oscillator is triangular. All other waveforms are generated by modification of this basic waveform.

The input voltage, normally between zero and + 5 volts, is amplified in IC1. The tune control, RV10, controls the gain and can vary the output by a 2 to 1 ratio. With this control set at mid position, the output of IC1 is approximately equal to, but in antiphase with, the input voltage. That is, the stage has a gain of -1. Individual potentiometers on each switch position allow the ranges to be adjusted an exact number of octaves apart. Control RV9 adjusts the offset of IC7 and RV8 is the free run control. The output of IC1 is therefore normally in the range zero to -5 volts, but can range up to -12 volts if the modulated output from the keyboard is being used. (See keyboard controller).

The output of IC1 is inverted by IC2 to provide an identical voltage of opposite polarity, the offset of IC2 being adjusted by RV11.

Integrated circuit IC3 is a solid state, dual, double-throw switch. If the input at A is high (+7 volts) IC3/1 will be on and IC3/2 will be off, and vice versa if the input at A is low (-7 volts). The on resistance is between 200 and 500 ohms and the off resistance is of the order of 10^{12} ohms. Diodes D1 and D2 protect the input of the switch against the application of excessive voltage.

An integrator is constructed with IC4 and an integrating capacitor selected by SW1. If IC3/1 is on, the output of the integrator will be a linearly increasing voltage. Hence if IC3/1, 2 are switched alternately on and off, the output of IC4 will be a triangular wave.

Transistor array IC5 when connected to Q1 and IC6 acts as Schmitt trigger; where IC6 is simply a CMOS inverter with IC6/1 and IC6/2 connected to +7 and -7 volts and IC6/3 connected to zero and +5 volts. The output of IC6/3 provides feedback to the comparator section of the Schmitt trigger, and being a 0 to +5 volt level, makes the Schmitt points 0 and +5 volts. The output of IC6/1 controls the CMOS switches IC3/1 and IC3/2 which hence derive a triangular wave from the integrator of 0 to +5 volt amplitude.

To generate a square wave of variable mark/space ratio, the triangular wave is simply compared to a dc level as set by the shape potentiometer (R17) by IC11, the output of which is buffered by Q2 and Q3 which ensure that the output has the correct levels of '0' and +5 volts.

The sawtooth waveform is generated by inverting the triangular waveform in IC7 and level shifting to produce a waveform 180° out of phase having 0 to -5 volts levels. The output of these two waveforms is selected in turn by CMOS switches IC3/3 and IC3/4. These switches are controlled by either IC6/1 or IC6/2 dependant on the position of SW2 (reverse or normal sawtooth). The correct amplitude and level of the sawtooth is maintained by IC8.

The sinewave output is generated by amplifying the triangular wave in IC9 to about 15 volts peak-to-peak, symmetrical about zero. This signal is then clipped by the diode-resistor matrix to approximate a sinewave. This is then level shifted and amplitude controlled by IC10.

PARTS LIST OSCILLATOR

R1,29	Resistor	120k ½ watt 5%
R2,4,5,19,25		
41,45,46	"	100k " "
R3,9,17	"	1k " "
R6	"	82k " "
R7,10,11,12,18,21	"	33k " 2%
R8,22,42	"	1M " 5%
R13	"	680 " "
R14	"	470 " "
R15	"	8.2k " "
R16,23,24,27,30	"	10k " "
R20	"	4.7k " "
R26,32	"	27k " "
R28	"	56k " "
R31	"	8.2k " "
R33,40	"	270 " "
R34,39	"	56 " "
R35,38	"	120 " "
R36,37	"	220 " "
R43	"	180k " "
R44	"	68k " "
RV1,2,3,4,5,6,7	Potentiometer	50k trimpot
9,11,12,13,15,16	"	(or similar)
RV8	"	25k log rotary
RV10	"	50k lin rotary
RV14	"	100k trimpot
RV17	"	25k lin rotary
C1,2,13,17,18	Capacitor	33pF ceramic
C3,15	"	150pF ceramic
C4,20,21,22	"	10μF 25V tag tantalum
23,24		
C5,6	"	0.047μF polyester
C7	"	0.022μF polyester
C8	"	0.012μF polyester
C9	"	0.0056μF polyester
C10	"	0.0027μF polyester
C11	"	0.0015μF polyester
C12	"	100pF ceramic
C14	"	10pF ceramic
C16	"	100μF 10V PC mount electrolytic
C19	"	3.3pF ceramic
Q1,2	Transistor	PN3638A or similar
Q3	"	PN3643 "
IC1,2,4,7,8 9,10,11	integrated circuit	LM301A minidip case
IC3	" "	SCL4416AE CMOS*
IC5	" "	CA3046
IC6	" "	SCL4007AE CMOS*

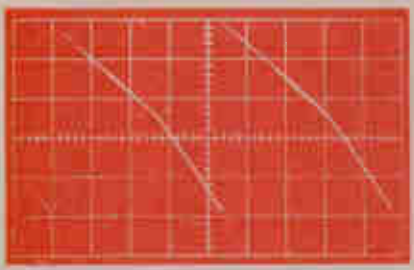
*prefix and suffix varies with manufacturer

D1-D8	Diode	IN914 or similar
SW1	Rotary switch	2 pole 11 position (8 only used)
SW2	" "	2 pole 5 position

PC board ETI 601a, metal bracket, 5 knobs, 2 extra potentiometer nuts (to retain module), 2 of 1/8" x 3/8" long screws and nuts

Recommended extras
2 off 14 pin IC sockets (for CMOS)
1 off 8 way plug.
8 contacts for above plug

ETI have made arrangements with Maplin Electronic Supplies, P.O. Box 3, Rayleigh, Essex for the supply of the I.C's, transistors and certain other components.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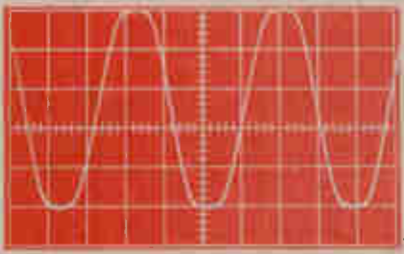
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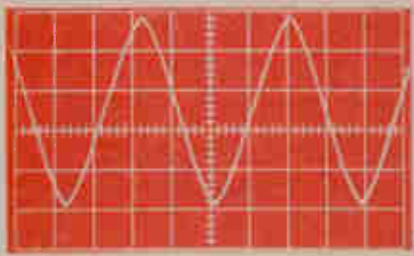
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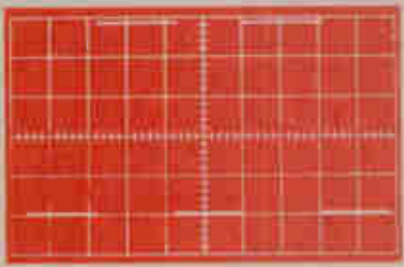
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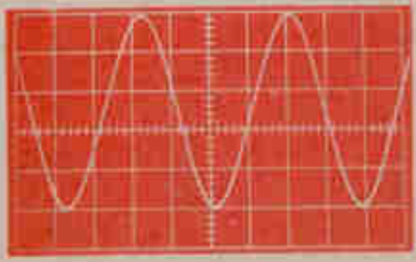
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Fig. 4.

9. Adjust RV16 such that the lowest edge of the waveform is at zero volts.

10. Check that all waveforms are selectable by SW2 and that the square wave output is correct as per Fig. 4k.

TABLE 1.

Adjust	RV1	RV2	RV3	RV4	RV5	RV6	RV7
Range	32'	16'	8'	4'	2'	1'	½'
Frequency	329.6	659.3	1318.5	2637	5274	10548	21096

The calibration of each range is best performed in conjunction with the keyboard controller. With the keyboard controller connected, select the top note of the keyboard, or if no keyboard is available, link pins 21 and 33 on the keyboard controller. Hold this connection closed to eliminate drift and set keyboard tune, oscillator tune and free run controls all to zero. Adjust potentiometers RV1-RV7 to obtain the frequencies appropriate to the range as per table 1.

That completes the oscillator alignment.

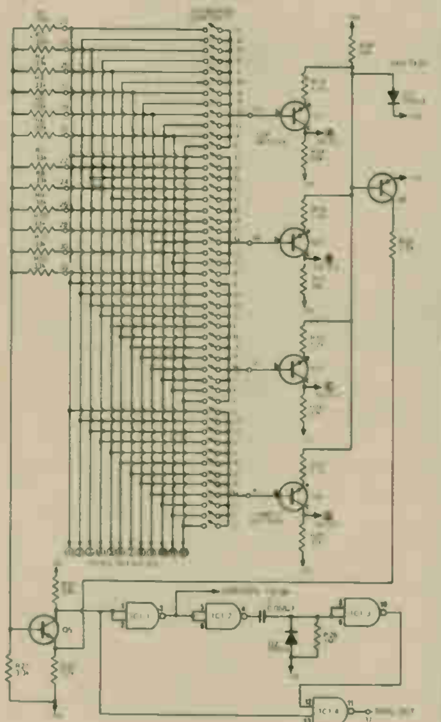

Fig. 5. Keyboard matrix and trigger generator components are mounted on keyboard controller board.

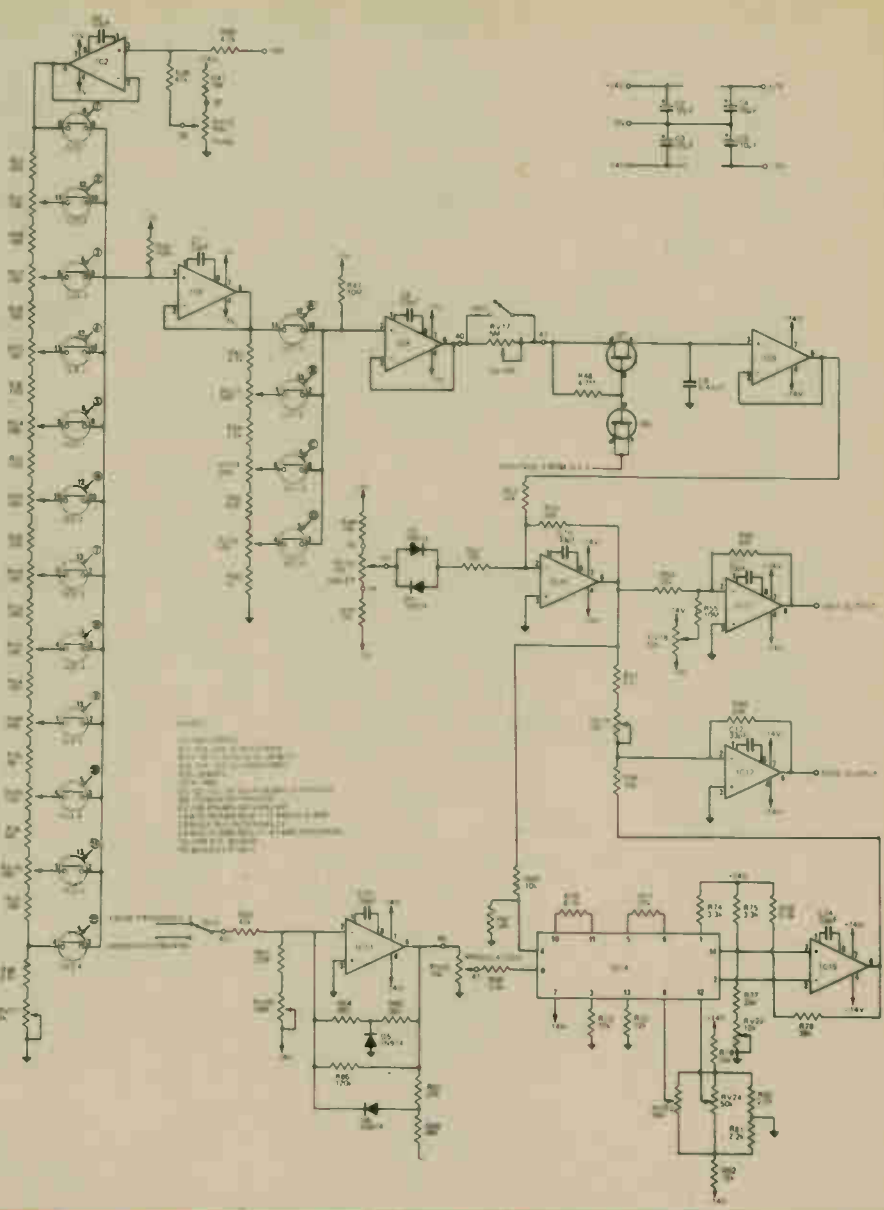

Fig. 6. Keyboard controller circuit.

Keyboard Controller

The equipment required is an oscilloscope, organ tuner or digital frequency meter and an oscillator module type ET1 601a.

Procedure:

1. Connect power supply, oscillator (to key output) and a keyboard if available.

2. Set keyboard tune and sweep controls to centre, glide to 'off', modulation to zero and oscillator free run to zero.

3. Switch on and press the top note of keyboard, or link pin 33 to pin 21 in the keyboard controller.

4. Select ½ foot on the oscillator and check that it is running.

5. Turn the sweep control and check that it varies the output frequency. It will be found that there is a dead region in approximately the centre of rotation where the oscillator frequency does not change. Set the knob such that zero on the scale occurs in the centre of this band.

6. Release the key (or link) and short capacitor C9 to ground. Turn the sweep control to zero and then adjust RV18 until the oscillator is just running. This compensates for offsets in the ICs.

7. Remove the short on C9, select the 4 foot range and depress the top note again.

8. Adjust the output frequency by use of the oscillator tune control to 2637 Hz. Calibration of the rest of the notes is then carried out in accordance with the order given in table 2.

9. Check that if a second note is pressed, whilst the first is still pressed, that the frequency does not change. If it does check if Q6 is turned on in the two note condition. If it is, increase R24 to 12k. If Q6 turns on with a single note pressed decrease R24 to 8.2k.

10. Release all keys, short C9 to ground, set modulation control to zero

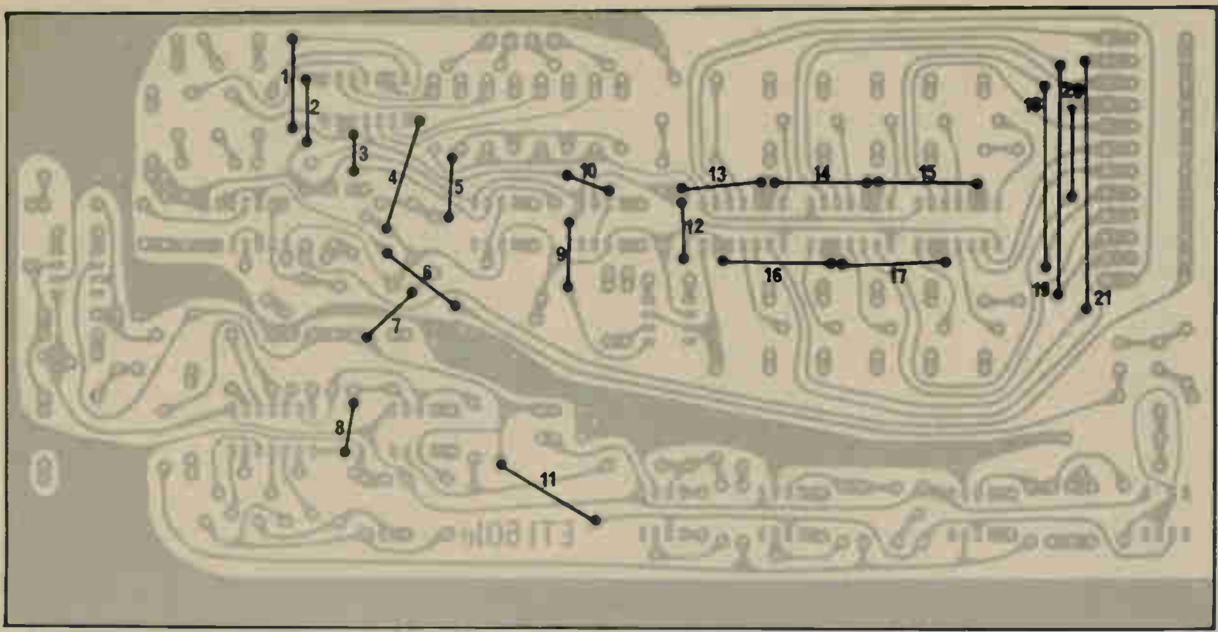

Fig. 7. Linking for keyboard controller. This should be installed before fitting components.

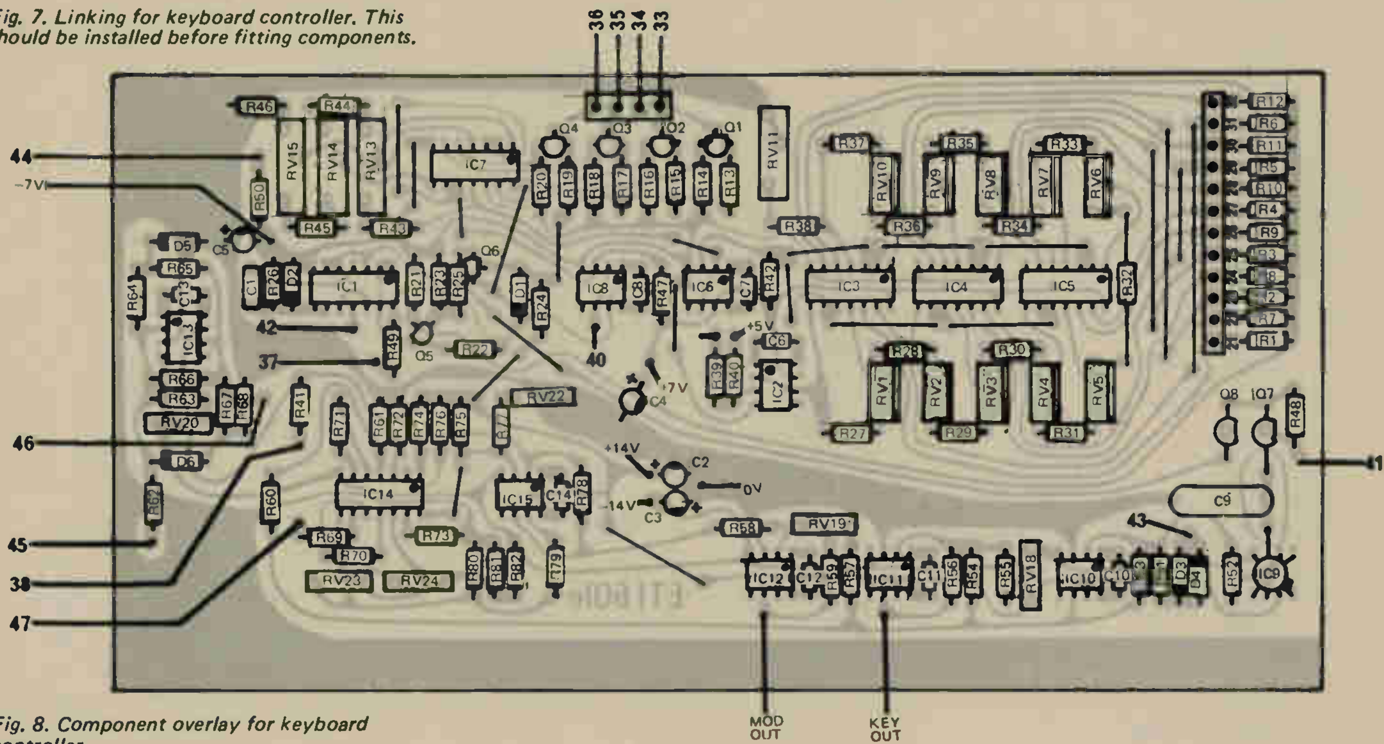

Fig. 8. Component overlay for keyboard controller.

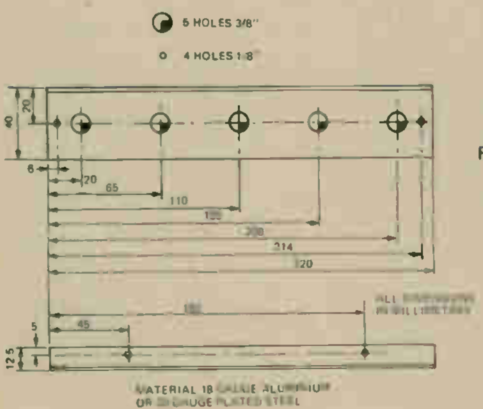

Fig. 9. Mounting bracket - oscillator.

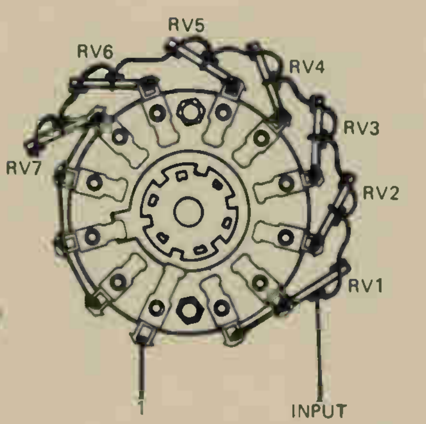

Fig.10. Method of wiring up oscillator switch SW1 bottom wafer.

and free run control of the oscillator to obtain approximately 1 kHz.

11. Connect the output of the oscillator via or series 0.1 microfarad capacitor and piece of wire to pin 4 of IC14.

12. Observe the output at IC15 pin 6 and adjust RV24 to eliminate the 1 kHz from the output. Now inject the signal into pin 9 of IC14 and adjust RV23 to remove the 1 kHz.

13. Remove the signal input and adjust RV22 to provide zero volts output.

PARTS LIST
KEYBOARD CONTROLLER

R1–R12 R14,16,18,20,22 59,77	Resistor	33k ¼ watt 5%
R13,15,17,19,23	"	1.2k " "
R21,69,74,75,76	"	3.3k " "
R24,49,50,51,58 60,61	"	10k " "
R25,38,44,80,81	"	2.2k " "
R26	"	1M " "
R27	"	220 " "
R28	"	180 " "
R29	"	150 " "
R30,31,32	"	120 " "
R33,34,37	"	100 " "
R35,36	"	68 " "
R39,62	"	47k " "
R40,43	"	4.7k " "
R41	"	18k " "
R42,47,55	"	10M " "
R45	"	820 " "
R46	"	1k " "
R48	"	4.7M " "
R57,71	"	27k " "
R63	"	220k " "
R64,65,78	"	39k " "
R66	"	120k " "
R67	"	22k " "
R68	"	56k " "
R70	"	8.2k " "
R72,79,82	"	15k " "
R73	"	12k " "
R52,53,54,56	Resistor	33k ¼ watt 2%
RV1 RV10	Potentiometer	100ohms
RV11	"	1k ten turn cermet Morganite type 84 or similar
RV12	"	50k linear rotary
RV13,14,15	"	500ohm tenturn cermet Morganite type 84 or similar
RV16, 21	"	10k linear rotary
RV17	"	5M log rotary
RV18,23,24	"	50k trimpot type
RV19,22	"	10k trimpot type
RV20	"	100k trimpot type
C1	Capacitor	0.068μF polyester
C2,3,4,5	"	10μF 25 volt PC mount electrolytic
C6,7,8,10,11 12,13,14	"	33pF ceramic
C9	"	0.47μF polyester
Q1,2,3,4,6	Transistor	PN3638A or similar
Q5	"	PN3643 or similar
Q7,8	"	2N5459 or similar
IC1	Integrated Circuit	SCL4011AE CMOS*
IC2,6,8,10,11 12,13,15	" "	LM301A minidip
IC3,4,5,7	" "	SCL4016AE CMOS*
IC9	" "	LH0042C TO5 cans
IC14	" "	1495 or μA795

*prefix and suffix varies with manufacturer

D1 to D6	Diode	IN914 or similar
SW1	Switch	Single pole toggle switch
SW2	"	Single pole double throw toggle switch

PC board ETI601e, metal bracket, 5 off 14 pin sockets for CMOS. 4 knobs, 2 extra pot nuts, 2 off 1/8" x 3/8" long screws and nuts.

14. Remove the shorting link on C9.

15. Take a wire from the key out to pin 45 and press the second top E (connect pin 21 to pin 34). This will provide 2.5 volts into the exponential converter. Adjust RV20 to obtain zero volts at the output of IC13 pin 6.

16. Turn the free run control of the oscillator to zero and measure the frequency when the 'key out' is used as the voltage source. Now use the 'modulation out' as the signal and adjust RV19 for the same frequency.

TABLE 2
CALIBRATION ORDER

NOTE	OCTAVE	RANGE	FREQ (Hz)	ADJUST	NOTES
E	TOP	4'	2637	osc/tune	
F	TOP	4'	1396.9	RV11	
D#	TOP	4'	2489.7	RV1	RV1 – RV1- may
D	TOP	4'	2349.3	RV2	be adjusted in
C#	TOP	4'	2217.5	RV3	any order as
C	TOP	4'	2093	RV4	there is no
B	TOP	4'	1975.5	RV5	interaction.
A#	TOP	4'	1865.7	RV6	
A	TOP	4'	1760	RV7	
G#	TOP	4'	1661.2	RV8	
G	TOP	4'	1568	RV9	
F#	TOP	4'	1480	RV10	
E	2nd TOP	4'	1318.5	RV13	RV13 – RV15 do
E	2nd Lowest	4'	659.3	RV14	not interact and
E	Lowest	4'	329.6	RV15	can be adjusted in any order.

KEYBOARD CONTROLLER – HOW IT WORKS

A voltage representing the selected note on the keyboard is derived from a resistive divider chain. The keyboard is divided into 4 octaves each of 12 notes. The divider chain R27-R38 provides a voltage dependant only on the note itself regardless of the octave, that is, the same voltage represents all As etc. Integrated circuits IC3, 4 and 5 are CMOS switches which are 'ON' if the control input is greater than +5 volts and 'OFF' if the control input is at -7 volts. These switches are used to select the required voltage which is buffered by IC6 to prevent loading the divider.

To select the required octave a second divider chain, R43-R46, is used the output being selected by IC7 and buffered by IC8. Therefore, by selecting one switch of IC3, 4 or 5 and one switch of IC7, a total of 48 discrete voltages may be generated.

The four-octave keyboard is provided with single-make contacts. On one side of the contacts every twelth one is joined, that is all the As, all the A# etc. so that twelve wires come out (see Fig. 5). On the other side of the contacts all 12 contacts of an octave are joined so that 4 wires come out. Thus we have a 12 by 4 matrix.

If a single note is selected, for example A on the second top octave, a connection will be made between pins 28 and 34. The current produced in R10 turns on Q2 causing point (B) to go high. Similarly point 8 will go high turning on IC5/4 and IC7/2. This selects a discrete voltage which represents note A on the second highest octave. The process is similar for any other note on the keyboard.

When a single note is pressed the current in R1-R12 turns on Q5 causing its collector to go low. If two or more notes are pressed simultaneously the additional current through R24 forward basis Q6, turning it on. This lifts the emitter of Q5 turning it off. Thus Q5 collector is low only when one single note is pressed.

Contact bounce on the trigger output is prevented by IC1. Trigger output is held on for 50 msecs after the key is pressed. If contact bounce occurs within this period the timing recommences. The gate IC1/1 inverts the output of Q5 and controls Q7 and Q8.

In order to remember a particular note after the key has been released a FET INPUT OPERATIONAL AMPLIFIER, IC9, is used with capacitor C9 to *hold* the voltage applied to its input. Transistors Q7 and Q8 act as a switch to disconnect the output of IC8 from C9. If the control input is high, the switch is on, and vice versa. Potentiometer RV17 acts as a glide control by placing resistance in series with C9.

To provide sweep control (that is a voltage which can vary the frequency up and down smoothly over a large range), a voltage is derived from RV16 and mixed with the output of IC9 in IC10. Two diodes are fitted back to back, and in series with R51, to provide a dead band which facilitates setting of the zero position. Since IC10 inverts the output of IC9. IC11 is used to reinvert to the required polarity, and RV18 is used to cancel all offset voltages due to the characteristics of the linear ICs.

A second output is provided (mod output) which is normally the same as the key output but which may be modulated up or down. The keyboard output voltage is not linear per note but exponential. Hence the voltage change required to shift up 1 octave will depend on where the start point is. Therefore we must multiply the voltage by a factor to obtain the correct shift. This is done in IC14 and IC15, which form a linear multiplier, where the output is the product of the inputs (pin 4 and pin 9 of IC14). Pin 9 comes from the modulation potentiometer and pin 4 is the keyboard voltage. The output of the multiplier is then added to the keyboard voltage in IC12. With zero volts into pin 9 the output of the multiplier will also be zero and hence the modulation output will be the same as the keyboard voltage. If there is a voltage at pin 9 the keyboard output will be shifted so many semitones irrespective of the keyboard voltage.

Integrated circuit IC13 and its associated components form a linear to exponential converter which is used to control the input of the multiplier. The use of an exponential converter provides a subjectively linear frequency change for a linear input voltage change. The accuracy required is not great but the stability required is. This is the reason for synthesizing an exponential instead of the more commonly used voltage current relationship of a transistor or diode method. With this system an input of 2.5 volts will give zero volts out due to the balancing current of R63-RV20.

The gain of IC13 is determined by R64, R65 and R66 when the input voltage is around 2.5 volts. At about 1.3 volts diode D6 becomes forward biased and the gain is reduced. At the other extreme, around 3.7 volts, D5 becomes forward biased increasing the gain. This results in a reasonable approximation of an exponential function.

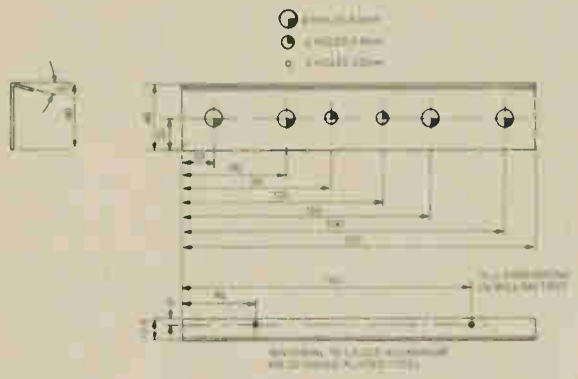

Fig.11. Mounting bracket – keyboard controller.

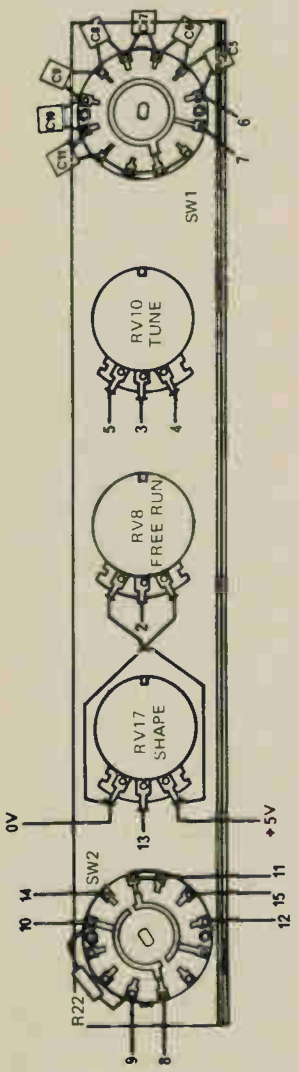

Fig.12. Wiring to switches and potentiometers of oscillator – top wafer of SW1 only shown refer to Fig. 14.

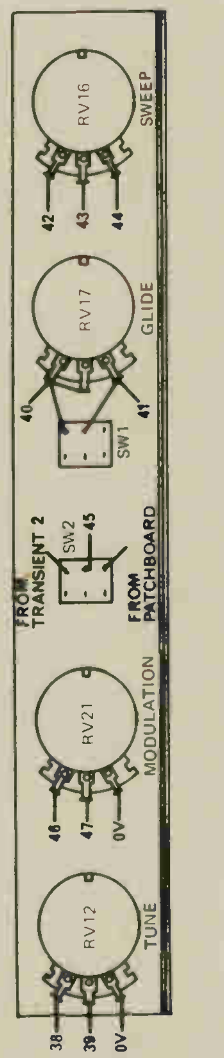

Fig.13. Wiring to switches and potentiometers of keyboard controller.

This completes the adjustment of the keyboard controller. Next month details of the power supply and mixers 1 to 3 will be provided. ●

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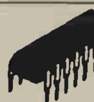

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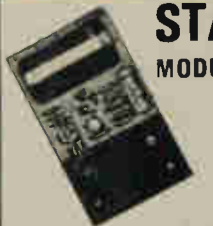


AP80 is especially designed to power 2 of the AL50 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer MT80, the unit will provide outputs of up to 1·5 amps at 35 volts. Size: 63 mm × 105 mm × 20 mm. These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including: Disco Systems, Public Address, Intercom Units, etc. Handbook available, 10p.

TRANSFORMER BMT80 £2·15 p. & p. 25p

INTEGRATED CIRCUIT PAKS

Manufacturers "Fall Outs" which include Functional and Part-Functional Units. These are classed as 'out-of-spec' from the maker's very rigid specifications, but are ideal for learning about I.C's and experimental work.

Pak No. Contents	Price	Pak No. Contents	Price	Pak No. Contents	Price
UIC00 = 12 ± 7400	0·55	UIC46 = 5 × 7446	0·55	UIC90 = 5 × 7490	0·55
UIC01 = 12 × 7401	0·55	UIC48 = 5 × 7448	0·55	UIC91 = 5 × 7491	0·55
UIC02 = 12 × 7402	0·55	UIC50 = 12 × 7450	0·55	UIC92 = 5 × 7492	0·55
UIC03 = 12 × 7403	0·55	U1351 = 12 × 7451	0·55	UIC93 = 5 × 7493	0·55
UIC04 = 12 × 7404	0·55	UIC53 = 12 × 7453	0·55	UIC94 = 5 × 7494	0·55
UIC05 = 12 × 7405	0·55	UIC54 = 12 × 7454	0·55	UIC95 = 5 × 7495	0·55
UIC06 = 8 × 7406	0·55	UIC60 = 12 × 7460	0·55	UIC96 = 5 × 7496	0·55
UIC07 = 8 × 7407	0·55	UIC70 = 8 × 7470	0·55	UIC100 = 5 × 74100	0·55
UIC10 = 12 × 7410	0·55	UIC72 = 8 × 7472	0·55	UIC121 = 5 × 74121	0·55
UIC20 = 12 × 7420	0·55	UIC73 = 8 × 7473	0·55	UIC141 = 5 × 74141	0·55
UIC30 = 12 × 7430	0·55	UIC74 = 8 × 7474	0·55	UIC151 = 5 × 74151	0·55
UIC40 = 12 × 7440	0·55	UIC76 = 8 × 7476	0·55	UIC154 = 5 × 74154	0·55
UIC41 = 5 × 7441	0·55	UIC80 = 5 × 7480	0·55	UIC193 = 5 × 74193	0·55
UIC42 = 5 × 7442	0·55	UIC81 = 5 × 7481	0·55	UIC199 = 5 × 74199	0·55
UIC43 = 5 × 7443	0·55	UIC82 = 5 × 7482	0·55		
UIC44 = 5 × 7444	0·55	UIC83 = 5 × 7483	0·55	UIOXI = 25 Assorted 74's	1·55
UIC45 = 5 × 7445	0·55	UIC86 = 5 × 7486	0·55		

Packs cannot be split, but 25 assorted pieces (our mix) is available as PAK UIO X1.

STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL50 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.
Three switched stereo inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO MONO switch, volume, balance and continuously variable bass and treble controls.

SPECIFICATION:

Frequency response	20Hz—20kHz ± 1dB	Bass control	± 15dB at 20Hz
Harmonic distortion	better than 0·1%	Treble control	± 15dB at 20kHz
Inputs: 1. Tape head	1·25mV into 50KΩ	Filters: Rumble (high pass)	100 Hz
2. Radio, Tuner	35mV into 50KΩ	Scratch (low pass)	8kHz
3. Magnetic P.U.	1·5mV into 50KΩ	Signal/noise ratio	better than +65dB
		Input overload	+26dB
		Supply	+35 volts at 20mA
		Dimensions	292 × 82 × 35 mm

All input voltages are for an output of 250mV. Tape and P.U. inputs equalised to RIAA curve within ± 1dB from 20Hz to 20kHz.

SPECIAL COMPLETE KIT MK50 COMPRISING 2 AL50's, 1 SPM80, 18MT80 & 1 PA100 ONLY £25·30 FREE p.&p

only £13·15

LINEAR I.C's—FULL SPEC.

Type No	Case		1	25	100+
72702	DIL	14	0·50	0·48	0·45
72709	DIL	14	0·35	0·33	0·30
72710	DIL	14	0·45	0·43	0·40
72741	DIL	14	0·40	0·38	0·35
72741C	TO-5	8	0·45	0·43	0·40
72741P	DIL	8	0·38	0·36	0·34
72748P	DIL	8	0·38	0·36	0·34
SL201C	TO-5	8	0·50	0·45	0·40
SL701C	TO-5	8	0·50	0·45	0·40
SL702C	TO-5	8	0·50	0·45	0·40
TAA263	TO-72	4	0·80	0·70	0·60
TAA293	TO-74	10	£1·00	0·95	0·90
TAA350A	TO-5	10	£1·85	£1·80	£1·70
μA703C	TO-5	6	0·28	0·26	0·24
μA709C	TO-5	8	0·35	0·33	0·30
μA711	TO-5	10	0·45	0·43	0·40
ZN414	TO 18	4	1.20		

DTL 930 SERIES LOGIC I.C's

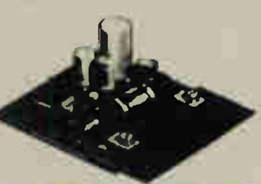
Type	1	25	100+
BP930	0.15	0.14	0.13
BP932	0.16	0.15	0.14
BP933	0.16	0.15	0.14
BP935	0.16	0.15	0.14
BP936	0.16	0.15	0.14
BP944	0.16	0.15	0.14
BP945	0.30	0.28	0.25
BP946	0.15	0.14	0.13
BP948	0.30	0.28	0.25
BP951	0.70	0.65	0.60
BP962	0.15	0.14	0.13
BP9093	0.45	0.43	0.40
BP9094	0.45	0.43	0.40
BP9097	0.45	0.43	0.40
BP9099	0.45	0.43	0.40

DUAL IN LINE SOCKETS.

14 & 16 Lead Sockets for use with DUAL IN LINE I.C's TWO Range PROFESSIONAL & NEW LOW COST.

PROF TYPE No	1-24	25-99	100up
TSO 14 pin type	33p	30p	27p
TSO 16	38p	35p	32p
TO 24	75p	70p	68p
LOW COST No			
BPS 8 pin type	13p	13p	11p
BPS 14	16p	14p	12p
BPS 16	17p	15p	13p

AL10/AL20/AL30 AUDIO AMPLIFIER MODULES



The AL10, AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power devices has resulted in a range of output powers from 3 to 10 watts R.M.S.
The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the car and at home.

Parameter	Conditions	Performance
HARMONIC DISTORTION	Po = 3 WATTS f = 1KHz	0·25%
LOAD IMPEDANCE	—	8 - 16 Ω
INPUT IMPEDANCE	f = 1KHz	100 kΩ
FREQUENCY RESPONSE ± 3dB	Po = 2 WATTS	50 Hz - 25KHz
SENSITIVITY for RATED O/P	Vs = 25V. Rl = 8 Ω f = 1KHz	75mV. RMS
DIMENSIONS	—	3" × 2½" × 1"

The above table relates to the AL10, AL20 and AL30 modules. The following table outlines the differences in their working conditions.

Parameter	AL10	AL20	AL30
Maximum Supply Voltage	25	30	30
Power output for 2% T.H.D. (RL = 8Ω f = 1 KHz)	3 watts RMS Min.	5 watts RMS Min.	10 watts RMS Min.
PRICE	£2·20	£2·59	£3·3

NUMERICAL INDICATOR TUBES

Type	Description	
3015F	Minitron 7 Segment Indicator	£1 50
MAN 3M	L.E.D. 7 Segment Display 0·127" High Character	£1 90
CD66	Side Viewing Nixie Type Tube 16mm	£1 87
GR116	Side Viewing Nixie Type Tube 13mm	£1 70

3 TERMINAL POSITIVE VOLTAGE REGULATORS

To-3 Plastic Encapsulation O/P 1·5 Amps
μA7805 5V (Equiv. to MVR5V) £1 76
μA7812 12V (Equiv. to MVR12V) £1 76

BI-PAK
CATALOGUE AND LISTS
Send S.A.E. and 18p.

TEAK VENEERED CABINETS for:

STEREO 20
TC 20. £3·95 p&p 30p.

MK 50 KIT
TC 100. £6·50 p&p 40p.

E.M.I. LEK 350 Loudspeaker System Enclosure kit in Teak Veneer, including speakers.
Rec Retail Price £45·50 per pr.
OUR SPECIAL PRICE £35·50 per pair p&p £1. *ONLY WHILE STOCKS LAST!*

The STEREO 20

The 'Stereo 20' amplifier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm × 14 cm × 5·5 cm. This compact unit comes complete with on/off switch volume control, balance, bass and treble controls, Transformer, Power supply and Power amps. Attractively printed front panel and matching control knobs. The 'Stereo 20' has been designed to fit into most turntable plinths without interfering with the mechanism or, alternatively, into a separate cabinet. Output power 20w peak. Input 1 (Cer.) 300mV into 1M. Freq. res. 25Hz-25kHz. Input 2 (Aux.) 4mV into 30K. Harmonic distortion. Bass control ± 12dB at 60Hz typically 0·25% at 1 watt. Treble con. ± 14dB at 14kHz.

£14·45

FRONT PANEL, 4 knobs, Headphone Socket, on/off switch and neon for PA 100/MK 50. FPK 100 £2·95.

TRANSFORMERS

T461 (Use with AL10) £1·38 P & P 15p
T538 (Use with AL20) £1·93 P & P 15p
BMT80 (Use with AL30 & AL50) £2·15 P & P 25p

POWER SUPPLIES

PS 12. (Use with AL10 & AL20) 88p
SPM 80. (Use with also AL30 & AL50) £3·25

PA 12. PRE-AMPLIFIER SPECIFICATION

The PA 12 pre-amplifier has been designed to match into most budget stereo systems. It is compatible with the AL 10, AL 20 and AL 30 audio power amplifiers and it can be supplied from their associated power supplies. There are two stereo inputs, one has been designed for use with *Ceramic cartridges while the auxiliary input will suit most †Magnetic cartridges. Full details are given in the specification table. The four controls are, from left to right: Volume and on/off switch, balance, bass and treble. Size 152mm × 84mm × 35mm. PRICE £4·35

Frequency response— 20Hz - 50KHz (−3dB)
Bass control— ± 12dB at 60Hz
Treble control— ± 14dB at 14KHz
*Input 1. Impedance 1 Meg. ohm Sensitivity 300mV
†Input 2. Impedance 30 K ohms Sensitivity 4mV

FRONT PANEL FP12 with knobs £1·20.

Giro No 388 7006
Please send all orders direct to warehouse and despatch department

BI-PAK
P.O. BOX 6, WARE · HERTS
Postage and packing add 11p Overseas add extra for airmail
Minimum order 55p Cash with order please
Guaranteed Satisfaction or Money Back

WHEN THE LIGHTS

WHEN THE LIGHTS GO OUT, whether the power cut is caused by a shortage of electricity supplies or by a breakdown of the generating or distributing equipment, you are left with a problem of how to find your way about your home or office. Oil lamps and candles provide a romantic solution, bottled gas another, but for convenience it is difficult to beat electricity. Having no primary source of electricity due to failure of the mains supply, we are thrown back onto secondary power sources such as storage batteries.

TABLE 1

Living Area	36 watt filament or 18 watt fluorescent
Stair Well	6–12 watts (depending on the size and whether the decorations are light or dark in colour.)
Toilet/Bathroom	6–12 watts
Kitchen	12–24 watts
Total Load	60–84 watts

which means a current drain of between 5 and 7 Amps from a 12V battery

PLANNING

The installation of an emergency lighting circuit is not difficult technically but must be carefully planned with the object of keeping the power consumption as low as possible, so increasing the time for which the system can function before the battery is exhausted. In order to achieve this, thought must be given to *where* standby lights should be placed and the minimum wattage that is capable of giving sufficient light for each chosen location. Suggested lighting levels are made in Table 1 but will need to be modified for individual requirements.

The sort of load indicated in the table could be carried by a standard 36 Amphour or larger car battery for the 4 hours that we now take for granted in a scheduled power cut during a load shedding period.

This takes care of basic requirements. Further lights fitted with their own on/off switch might be added where they are needed for short periods (bedrooms for example), without upsetting the basic system. If possible all lights should be fitted with on/off switches; those of the main light ought to be left in the *on* condition so that the main lights come on immediately the mains supply fails. The lights of secondary importance can be switched on and off as required in the same way as the normal house lights.

WIRING

The wiring from the storage battery to the lights must be of a heavy gauge to prevent any overheating of the cables and to keep the voltage drop between the battery and each light to as small a level as possible. This is particularly important in this sort of installation where low voltage bulbs are used. A drop of only 1V along the mains wiring is a mere 0.4 per cent at normal 240V mains supply but is 8 per cent for a 12V domestic stand-by supply. The problem of voltage drop in the supply line is compounded by the very rapid fall in luminous efficiency of electric bulbs with any reduction in the voltage.

The only practical way to reduce voltage drops along the wiring of a stand-by main is to use heavy cable and something in the order of 7 x 0.29 or the metric equivalent is about the minimum. Plan the route the wiring takes so as to keep the cable runs as short as possible.

For temporary installations the rather bulky appearance of 7 x 0.129 would be acceptable - just! But for a more permanent installation the wiring would need to be concealed in much the same way as normal power cables. For such a concealed *permanent* system installed in a two storey house, a 12V ring main could be installed in the floor of the first floor giving access to both storeys, and be provided with junction points in the cable close to where the stand-by lights are to be situated. Wiring from the junction points to the light fitting being made in a foot or eighteen inches of lighter and decoratively more acceptable flexible cable. Any cable used must be clipped firmly to the joists to prevent any danger of chaffing and subsequent short circuits.

To obtain the necessary 12V lighting fittings can present something of a problem, especially if decoratively acceptable types are required. However a visit to a caravan centre or good boat chandlers should pay dividends: both these outlets normally stock low voltage lighting fittings and, though the prices tend to be fairly high, many of the fittings are attractive and well suited to our purpose.

The type shown in the photgraph has the added advantage - it contains a primitive but effective on/off switch. This particular unit was purchased from Thomas Foulkes of Lansdown Road, Leytonstone who are a boat chandlers with a wide selection of similar light fittings available and intended for use on 12 or 24V systems.

LIGHT DIFFUSERS

One point to note is that any powerful (24W upwards) low voltage bulb being used in say a sitting room should be fitted with some form of diffusing screen as the small filament size causes the light to be very harsh (they are virtually point sources) and very tiring on the eyes over any long period. A diffuser can be fabricated from opal perspex and a ventilated wooden frame without a great deal of difficulty but small inexpensive lampshades made from white translucent glass are widely available from chain stores such as Woolworth's or British Home Stores.

Another point to bear in mind is that due to the small envelope size of

GO OUT . . .

Power CRISIS Special

low voltage bulbs, the glass gets very hot and can damage any plastic etc. with which it might come into contact.

BATTERY CAPACITY

Providing the power source for a stand-by lighting circuit requires careful thought. The minimum size of the battery needed is dependent upon the average load current drawn from it during stand-by operation. With 4 hour cuts, a battery with an Amphour capacity of six times the current consumption would be the minimum. With the 7A consumption of our first example this would mean at least 42 Amphour battery.

When choosing a battery - and we are at the moment only considering lead-acid batteries - consider one the same as in the family car: the car battery and the stand-by battery can then be interchanged should either fail, and during the summer time (when the stand-by system is not likely to be used) the stand-by battery can be kept in good condition by being used in the car from time to time. (The author forgot this point and found it exasperating to have a perfectly good battery in his garage that he could not use when his car gave trouble.)

For permanent installations in shops and offices and where capital cost is less important than at home but where reliability is required to be much higher, NiCd cells would prove much more reliable than lead acid cells as they can be left unattended for long periods with little deterioration and do not need periodic attention. An occasional charge/discharge/charge cycling is all that is required in order to keep them in tip-top condition. Though NiCd batteries cost rather more than lead acid cells in the first place, in situations where maintaining the batteries would itself cost money, the extra cost could be saved in only 2 or 3 years even assuming lead acid cells did not need replacing within that period. NiCd cells do tend to last for much longer periods than lead acid cells and so will reduce battery replacement costs for permanent installations.

AUTOMATIC SYSTEM

The final two components of a stand-by system which can be considered together are the battery and automatic switch-on system.

The battery charger should have a capacity capable of restoring the battery from fully discharged to maximum charge around 16 hours, assuming that the pattern of cuts of 1971/72 winter are repeated with two 4 hour cuts made in every 24 hours, one normally being during day-light hours when the stand by system would not be required and could be switched off. Thus for a 42 Amphour cell this would require an average charge current of 4A (constant current charging C/10). The larger Boots/Woolworths/Halfords chargers can provide this at very reasonable price though the more sophisticated type of charger like that described in the November ETI would be better though considerably more expensive. We have not suggested a battery charger circuit as complete commercial models cost as much as you would expect to pay for the transformer alone.

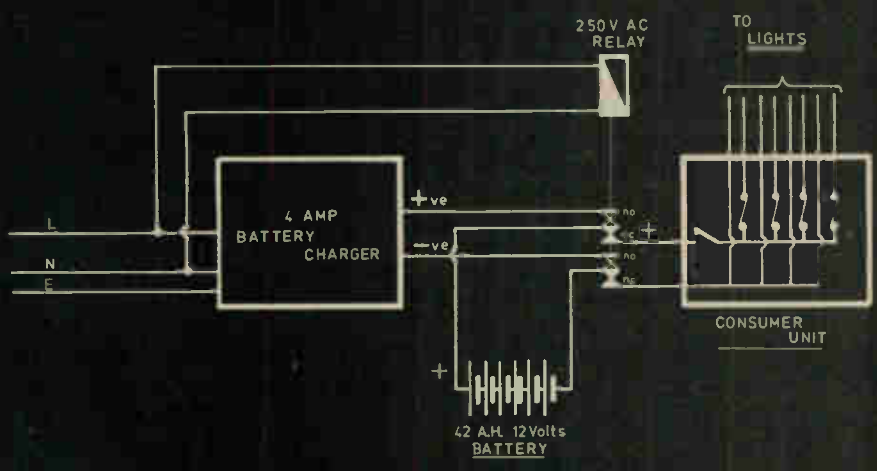


Fig. 1. Block diagram of an automatic emergency lighting system.

CHARGER RATE

A charger with two charge rates would be of considerable use in enabling a relatively high charge rate to be used to recharge the battery after it has been used for a lengthy period and a low trickle charge rate to be used to maintain the battery in fully charged condition and at instant readiness during long periods without any power cuts.

RELAY

The automatic switch on of standby lights can be performed by a 240V a.c. relay held on by the mains supply: when this fails the relay releases and the *normally closed* contacts of the relay connect the battery supply to the standby lighting circuit and at the same time disconnects the battery charger from the battery. A circuit of one such arrangement is given in Fig. 1.

The battery charger/change-over circuit should be separated from the wiring circuit by a suitable fuse (10A is a good starting value). The fuse could well be that in a standard "consumer unit" of the type used for the normal mains wiring of a house.

Finally any standby lighting system must be tailored to the situation in which it is to be used and in planning it the fewer the preconceived ideas you have the better will be the results. Always take great care that no additional hazards are introduced into the home by the standby system, particularly hazards caused by overheating cables and subsequent fires - and let your insurance company know what you have done since they may have something to say on the matter. ●

THE EVER SILVER SCREEN

Power CRISIS Special

DURING A PERIOD of power cuts such as we are now facing, the problem is often how best to pass the time while mains power supplies are not available. Normally a great many people enjoy T V viewing and for those who possess one of the many battery operated portables now available there is no reason for their pleasure to be interrupted.

About a third of all black and white T V sets sold last year were portables capable of operating from 12V batteries, and with nearly three dozen models to chose from, this may be the next area for keeping up with the Joneses when the colour T V "bush fire" has burnt itself out.

A great many portable T Vs are sold to caravanners and weekend sailors who can enjoy their favourite T V programme no matter where they may be during the summer, and, brought out of their winter mothballs, portables can provide the almost perfect solution to the problem of how to while away the dark hours of a power cut.

Battery portable T Vs divide roughly into two types, the larger group being those primarily designed to work from the mains supplies but when fitted with an adaptor and lead are able to accept 12V supplies. The other group (in a minority) have internal rechargeable cells and are completely self-contained for battery operation, though capable of working from the mains: of these only one is made in Britain, the Murphy 1230.

Some of the first group have facilities for recharging an external battery from the mains, but the charge rates available are generally quite low and useful if a rather small external battery is used, and they would charge say a car battery very slowly. Special external rechargeable battery packs are available as extras for many of the T V receivers in the group without internal batteries but having external batteries does greatly reduce their convenience of operation.

Almost without exception, battery portables T V sets are U.H.F. 625 line only types and most of them have either as a standard feature or as an extra item a small aerial, mostly of the loop type. These aerials are only suitable if the set is going to be used in an area where the signal is strong. However connection to the aerial of the normal domestic T V will enable pictures to be obtained every bit as good as those normally obtained on the bigger set and because of the high sensitivity of most of the battery portables there is a fair chance that the portable will even out perform its bigger brother.

Another feature of many portables is the provision in them of a headphone Jack socket which enables viewing to take place without disturbing those around you.

If the intended uses for which a battery portable T V set is purchased involved carrying it around, then it is as well to consider carefully the weight including batteries, any set that weighs more than 20lb. should be considered very carefully to see whether it has any special features that a lighter set could not provide. Sets with internal batteries will obviously weigh much more than those without them, but even if the batteries are external they need to be carried around so add their weight to that of the T V set.

The final aspect of performance that is peculiar to battery portables is their current consumption. In general this is in the region of from 750mA up to 1.5A or about the same consumption as one side lamp on an automobile, from which it can be seen that they can be operated off a relatively small rechargeable battery for several hours, alternatively the power could be provided from a 12V stand-by lighting circuit like that described elsewhere in this issue of E.T.I.

The choice of sets is wide and the features available manifold; some sets incorporate push button tuning while others have a rotary tuning. Two sets have internal batteries while others use an external 12V supply. What is included in the basic retail price of any set varies widely and, as primarily 12V operation is envisaged here, it is wise to check that when an external 12V battery is required that a 12V connection lead and battery is provided or can be obtained easily. The prices quoted in the survey are the manufacturers' suggested retail prices at the beginning of November 1973 but many of the sets are available at much lower prices, only a little over half that quoted, so shop around. As far as possible, the table is complete and accurate but is based on information supplied by the manufacturers and errors may have occurred in interpretation. Anybody contemplating the purchase of a battery portable T V should see the set he wants in action to decide whether it suits his application; if it does not, remember there are about 45 other choices!

DIRECTORY OF BATTERY -OPERATED TV SETS

The first figure refers to the size of the screen, measured diagonally in inches. The second and third figures are the consumption (from a 12V source) and the weight of the set.

ALBA (RADIO & T V) LTD.					
T14	14			The set features push button tuning and comes complete with loop aerial, and leads for connection to a 12V battery. Personal earphone.	£62.14
BROWN BROTHERS LTD					
Rigonda VL100	6	500mA	8lb	Russian made Rotary tuner. Includes aerial preamp. Supplied complete with battery connection leads and earphone. Power supply can be detached from the back when using batteries.	£40.15
Startlet	9		14.5lb	Operation Rotary tuner. Earphone socket and loop aerial.	£67.44
CROWN RADIO LTD					
12T V 5	12	1A approx	17lb	Tape earphone jack. Loop aerial. 12V connector cord provided as an extra.	£67.44
DECCA RADIO & T V					
MS 1212	12	1.8A	under 20lb	Push button tuning. Loop aerial. Supplied with battery lead.	£65.04
MSM 1211	12	1.8A	under 20lb	Delux version of MS 1212. smartly finished in teak. Otherwise identical.	£71.07
MS 1511	15			Loop aerial. Push button tuning. Slider controls.	
DENHAM & MORLEY OVERSEAS LTD. (NOW JVC (UK) LTD)					
JVC 3240	9	1A	11.5lb	Spherical in shape with day light viewing screen and loop aerial battery lead supplied as an extra.	£74.80
JVC 3020	5		5.3lb	Very light and works off internal dry battery, 12V car battery or AC mains.	£63.80
JVC 3410	12	just under 1A	15lb	Features a high sensitivity preamp to help reception in fringe areas. Battery lead supplied.	£72.05
EUROPHON					
Europhon Portable	11¼			Rotary tuner, loop aerial, mains lead and battery lead provided.	£57.00
G.E.C. (RADIO & T V LTD)					
2114	14			White cabinet	
2114/1	14			As above with matt black screen surround.	
GRUNDIG (GB) LTD					
Elite 1230GB	12	1.25A	16.5lb	Built in changing circuit for external battery. Push button tuning. Personal earphone socket and slider controls.	£76.90
HITACHI SALES (UK) LTD					
189U	9	1A	11.5lb	Comes complete with loop aerial 12V battery lead, detachable daylight viewing screen.	£65.00
TU 75A	14	1A	19.5lb	"	£79.00
P32	12	1.3A	17lb	"	£69.00
F54 9	14	1.3A	21lb	"	£78.00
TU190	9	1A	17.5lb	"	£97.00
INDESIT					
12L	12		14.5lb	This set has what the manufacturers call a special shock proof case and a non glare tinted screen. Loop aerial.	£62.73
I T T CONSUMER PRODUCTS					
Featherlight Super 12	12		16¼lb	An attractive looking wood grain cabinet sets this T V off in the grand manner. It has push button tuning, a loop aerial and comes complete with battery lead.	£64.69

Pye 172

ITT Featherlight Super 12

Europhon Portable

Hitachi F54

The first figure refers to the size of the screen, measured diagonally in inches. The second and third figures are the consumption (from a 12V source) and the weight of the set.

LEE PRODUCTS					
Elizabethan T12	12			Rotary tuner - earphone socket, loop aerial and coax input socket.	£68.38
T9	9			Rotary tuner, earphone socket, loop aerial and coax input socket. A special feature of this set is a rotary turntable base.	£67.72
PHILIPS					
TVette 12	12		17.5lb	Telescopic aerial socket for external aerial. Daylight viewing screen. "Speed tune" rotary tuner. Headphone socket.	£70.60
TVette 9	9		11lb	Loop aerial. Detachable filter screen. Battery plug provided. Headphone socket	
PYE LTD					
Ekco T545	9			Slider controls. Daylight viewing screen, loop aerial amd earphone socket.	£62.10
Pye 172				Daylight viewing screen, loop aerial. Battery lead supplied.	
Pye 99	12			Rotary tuner, telescopic aerial and external aerial socket. Built in daylight viewing screen.	£70.60
RANK RADIO INTERNATIONAL LTD					
Murphy V1400	14				
Murphy V1230 (New model available in February 74	12			This is the latest from R B M and has provision for internal batteries or car battery operation. Push button electronic tuning. All usual extras. Made in UK.	
Bush TV 350	12			Daylight viewing screen. Battery lead supplied with set.	
SANYO MARUBENI (UK) LTD					
10 T150	10			Internal battery (extra) operation is possible with this smart little set and the whole set is mounted on a swivel base.	£67.95
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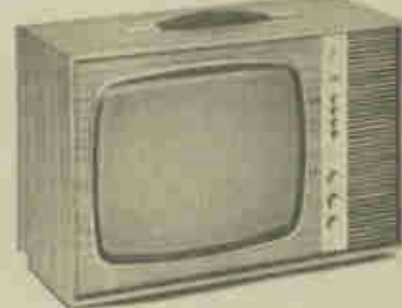
Grundig. Elite 1230GB

Alba T14

Lee Products. Elizabethan T12

Decca. MS1211



Sanyo. 10 T150

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Alba (Radio & T V) Ltd.
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453, Caledonian Road, London N79BA.

Europhon (UK) Ltd.
Europhon House, 70, Caledonian Road, London N1 9DN.

GEC (Radio & T V) Ltd.
Longley Park, Slough, Bucks.

Grundig (GB) Ltd.
42, Newlonds Park, Sydenham, London SE26 5NQ.

Hitachi Sales (UK) Ltd.
New Century House, Coronation Road, Park Royal, London NW10 7QN.

Indesit.
292 Streatham High Road, London SW16.

ITT Consumer Products (UK) Ltd.
Maidstone Road, Sidcup, Kent, DA14 5HT.

Lee Products (GB) Ltd.
Dallas House, 10-18, Clifton Street, London EC2P 1JR.

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Rank Radio International Ltd.
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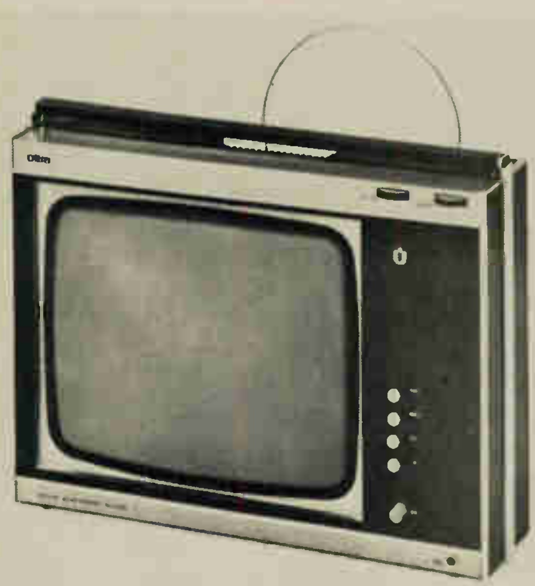
Sanyo Marubeni (UK) Ltd.
Sanyo House, Bushey Mill Lane, Watford, Herts.

Sharp Electronics (UK) Ltd.
48, Derby Street, Manchester.

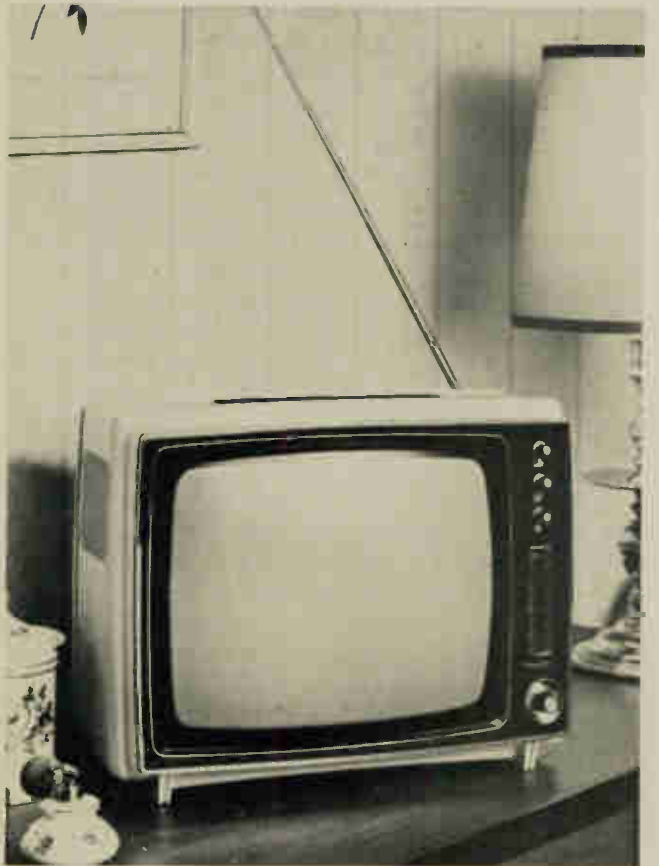
Sony (UK) Ltd.
Pyrene House, Sunbury Cross, Sunbury-on-Thames,Middlesex.

Teleton Electro (UK) Ltd.
Teleton House, Waterhouse Lane, Chelmsford, Essex.

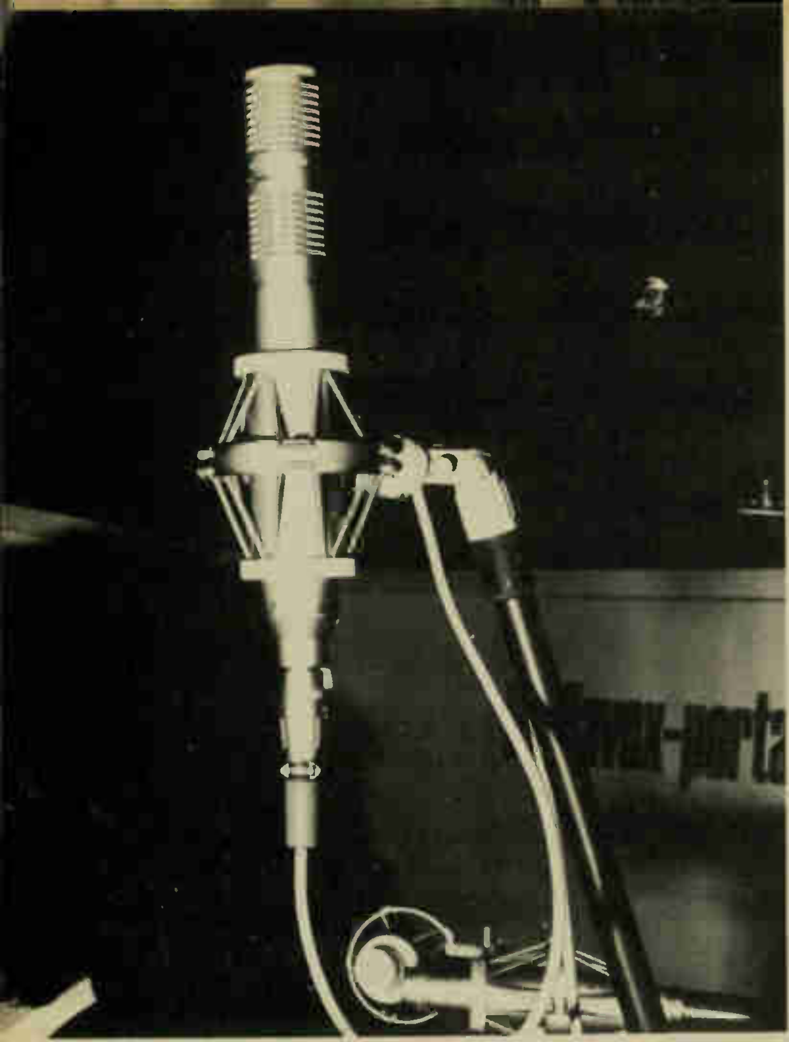
Thorn Consumer Electonics Ltd.
384, South Road, Enfield, Middlesex EN1 1TJ.



Thorn Consumer Electronics Ltd.
Ultra 6818/55



Philips. TVette 12



PART THREE

CREATIVE AUDIO

This series continues with a discussion on microphone types and how to use them to advantage.

IN THE two articles that we have published so far in this series we have concentrated mainly on processing material that has already been committed to tape.

The introduction of a microphone considerably widens the creative scope of the existing complement. It is about microphones and their usage in the recording of music that this article is concerned. (The use of microphones for speech and sound effects will be covered in future articles.)

Successful recording of musical instruments is governed by a number of interrelated factors. These are, in no particular order of importance:—

The means by which a musical instrument produces its tone.

The ambient nature of the recording room.

Various characteristics of the microphone (or microphones used).

Placement of the microphone(s) and instrument relative to one another and to the acoustics of the recording room.

PRODUCTION OF MUSICAL TONES

Every instrument has its own means of exciting a reasonance and then passing these vibrations to the surrounding air. The excitation may be caused by blowing across an aperture in a cylindrical pipe (flute) or by blowing across a reed (clarinet). It may result from scraping a tensioned string, thus causing a repetitive sequence whereby it distends and springs back at high audio frequencies (violin), or from striking the spring percussively (piano). Or the vibrations may excite the air directly (drums), or semi-directly via some acoustical matching device — i.e. the sounding board of a piano or the bell of a trumpet.

Additionally to the 'tone' of an instrument there are also produced — in varying quantities — the actual 'operating sounds' of the instrument. Some of these sounds are vital to the instrument, for example the opening transients: should they be removed (by editing), the characteristic sound disappears. Opinion is divided about other operating sounds, such as finger noises when guitar chords are changed.

Finally there are irrelevant and redundant sounds that are often difficult to avoid — a squeaking bass drum pedal, the valve-operating noises of a trumpet, even perhaps the breathing of an asthmatic violinist!

These distracting sounds must be minimized in recording, either by tactful advice, alteration to the musical instrument (a squeaking bass drum pedal could be muffled by a blanket), or by well implemented microphone technique.

There is the further consideration when tackling redundant instrumental sounds that the tone of an instrument will differ over a markedly wide range, dependant on the position and proximity at which it is heard. Some guidance can be given although there is no single 'correct' position for placing a microphone — the recordist's personal aesthetic judgement is a major determining factor.

THE ENVIRONMENTAL AMBIENCE

The room acoustics can be regarded as the 'absolute acoustics' of the recording situation because the microphone is just as prone to give a subjective impression of the instrument/acoustics (related to its disposition within the room) as is the human ear. But, unlike the ear, it can make no allowances for poor positioning.

The two most likely situations to confront the recordist are those engendered by a domestic room or a large hall, concert or otherwise. It is feasible to carry out more drastic acoustic modifications in domestic rooms, so what follows primarily concerns these.

The policy adopted by the majority of small music recording studios is to provide a constant value of sound absorbtion or dissipation throughout the audio spectrum, adding artificial reverberation to the recording as required. The reverberation time in a domestic room is usually short, but will inevitably be coloured by increased resonance at points in the audio spectrum where standing waves are occurring. The frequencies at which these standing waves are centred will be governed by the shape, 'geometricity' and size of the room. The simplest way to prevent or reduce standing waves is to arrange the furniture so as to break up the regular shape of the room.

The effects of large smooth reflecting expanses can be negated by draping with blankets, though this tends to dissipate the high frequencies to a rather greater extent that the low ones, leading to 'boominess'. One of the most successful and ubiquitous sound absorbers is the human body, and a well placed audience may prove the most adequate weapon for dealing with the large hall situation. Ultimately though, it will be the placement of the microphone between the artist and his reverberation that will determine the acceptibility of a recording.

MICROPHONE CHARACTERISTICS

This section can be subdivided into the microphone's mode of operation, which determines its directional properties, and its impedance, which affects the length of cable that can be interposed between the microphone and its amplifying stage.

Microphones may be termed 'pressure operated', or 'pressure gradient operated'.

The pressure operated device consists of an air chamber with a thin diaphragm stretched across its front. The movements of the diaphragm result from the instantaneous differences in pressure between that of the air trapped in the chamber and that adjacent to the 'open' side of the diaphragm. The magnitude of the diaphragm's travel is virtually independent of the frequency, or direction from which the pressure arises. Thus pressure operated microphones give a constant amplitude output for equidistant sound sources from any direction; they are said to have an omnidirectional pick-up pattern.

When both sides of the diaphragm are open to the atmosphere, sound

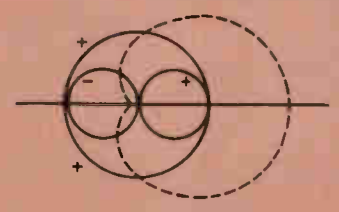


Fig. 2. Derivation of cardioid response (shown dotted) from phase differences between a pressure-operated and a pressure-gradient operated capsule when they are combined in one unit.

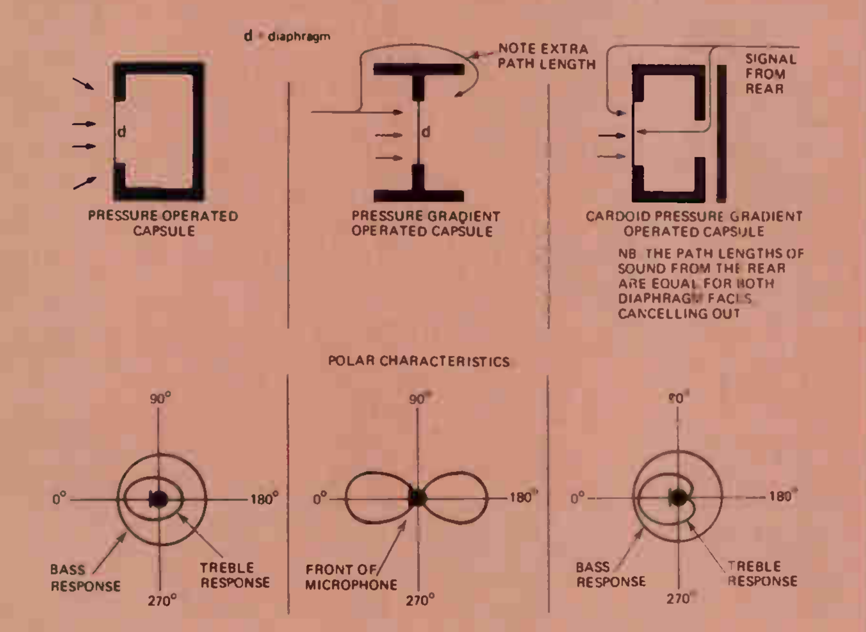
reaching the rear face has a slightly longer distance to travel than that reaching the front, hence a phase difference will exist between the two faces of the diaphragm. This is known as pressure gradient operation, as at each instant, the diaphragm is moving towards the region of lower pressure. The gradient, which controls the amplitude of diaphragm movement, is proprotional to the extra path length (a constant) and also to frequency; the extra length assuming greater significance with high frequencies as pressure will be maximal when there is a half-wavelength difference in path length, and zero where the path length difference is equal to the whole wavelength. The extra path length will be determined by the size, shape and thickness of the diaphragm, and size and disposition of the magnetic pole-pieces and microphone casing.

Sound waves emanating 'edge-on' to the diaphragm (i.e. at 90° to the microphone axis) strike both faces simultaneously, resulting in a null output from the microphone to sounds striking the microphone from this position. A graphical plot relating output from a pressure gradient device to the direction of the sound source forms a "figure-of-eight", the lobes of the '8' being perpendicular to the faces of the diaphragm.

The third major pick-up pattern is the heart-shaped cardioid. One of the easiest methods of generating this characteristic is to induce the sound, that would otherwise reach the back of the diaphragm directly, to follow a devious route so that it reaches the diaphragm in synchronisation with the same wave fronts reaching the front. As no pressure difference results, the microphone will be insensitive to sounds from its rear. Alternatively, an omnidirectional and figure-of-eight capsule may be carried in the same housing — the rear lobe of the figure eight being cancelled by the omnidirectional capsule which fills in the null areas at 90° to the figure eight axis.

It may be useful at this stage to briefly survey the actual electro-mechanical methods employed by the transducers as in most cases this affects the microphone technique employed.

Fig. 1. Microphone capsules (schematic) with related polar characteristics



MOVING COIL MICROPHONES

This can be likened to a loudspeaker with a small flat cone — a light coil is attached to the fine diaphragm and moves freely within the field of the permanent magnet surrounding it. The magnet/cone arrangement may be sealed to give pressure operation, or may have vents that, utilising phase-shift paths, produce a cardioid characteristic. Main benefits are small size, resistance to mechanical shock and relative immunity to condensation.

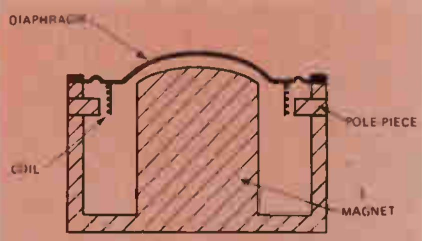


Fig. 3. Diagrammatic cross-section of moving coil microphone insert

CREATIVE AUDIO

RIBBON MICROPHONES

In this method, the ribbon acts as the microphone diaphragm. Corrugations increase its rigidity and provide a tension to control its low frequency resonance so that the resonance that does result can be damped out by the primary inductance of its matching transformer. The ribbon is suspended between polepieces of a powerful magnet with both its surfaces open to the atmosphere. The mode of operation is thus pressure gradient. Cardioid response can be generated by enclosing part of the rear of the ribbon but this does not always permit a wide flat response.

All ribbon microphones have integral matching tranformers to transform the miniscule ribbon impedance to an impedance suitable for matching into an amplifier. Ribbon microphones, especially in 'close-miking' applications, have a progressive bass boost as the frequency drops. This accounts for the former "deep brown" radio announcer's voices during the period when ribbons were exclusively used for speech.

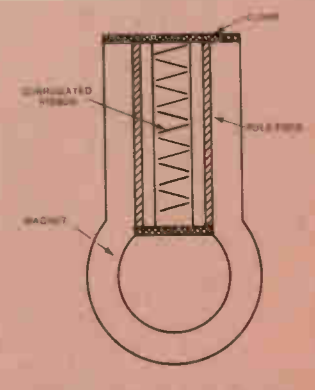


FIG. 4. RIBBON MICROPHONE INSERT (DIAGRAMMATIC)

CAPACITOR MICROPHONES

The studio standard for many years, these give a wide flat frequency response with a choice of polar patterns (using combinations of basic capsules or capsules with twin diaphragms). The capacitor capsule consists of a thin metal, or metal-flashed plastic diaphragm, spaced from a back-plate covered with damping holes. A constant voltage charge is applied between the diaphragm and the back-plate via a high resistance. The diaphragm, responding to air pressure variations in its vicinity, will move, varying the size of the air space, hence capacitive effects cause corresponding voltage variations to be present on the diaphragm. A preamplifier, contained within the microphone casing, and a separate polarizing power unit or self-contained battery complete the basic system.

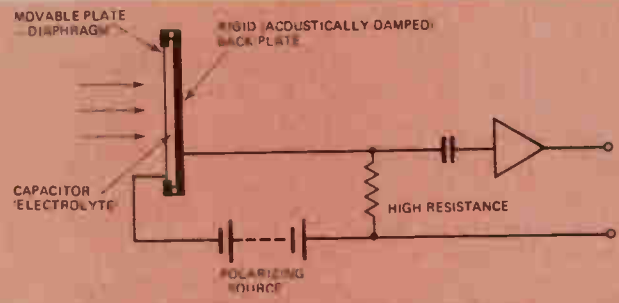


FIG. 5. CAPACITOR MICROPHONE SCHEMATIC

AKG have recently developed two microphones (C12 and C24) with a central plate sandwiched between two independently polarized diaphragms. Varying one voltage, whilst keeping the other constant, enables the whole gamut of polar responses to be synthesized. This offers the useful facility of permitting the polar response to be remotely controlled.

ELECTRET

This comparatively new type of microphone is rapidly achieving importance especially in the amateur field, as its claimed performances approaches capacitor fidelity. The design is very similar to that of capacitor microphones, but no polarizing voltage is needed as a 'permanent' charge is impressed on the diaphragm. The electret microphone has considerable advantages of low price, size and convenience, but at present there is some uncertainty regarding lifespan. Some users claim this to be less than five years, many say much less than that, quoting a recent pop festival where electret microphones lasted only 1½ days!

MICROPHONE POSITIONING

The two distinct philosophies of single-miking and close, or multi-miking, are very often integrated in recording sessions. On location, single-miking may be the only practicable solution, as when recording a brass band on the move. Single-miking offers the advantages of low financial outlay and easy manoevrability. If the desired musical balance cannot be achieved with musicians playing louder or softer, regrouping the ensemble may do the trick. The further the microphone is placed from the ensemble, the greater will be the "acoustic presence" on the recording.

MULTIMIKING

A multimike set-up only utilises the acoustics incidentally, reducing its effects as far as possible and synthesizing the ambience required on the recording. This approach provides great flexibility in the recording, which is very useful when considering stereo or even quadraphonic work. A mixer is a pre-requisite, and so too are a number of good quality microphones so initial outlay may well be high.

The criterion of microphone placement need not be that which gives the 'most realistic' sound. When multimiking one may feed the sound from a single instrument into a number of mixer channels, via multiple microphone positions, with each channel set to treat the sound such that the composite output enhances the listener's interest.

A review of basic microphone positions with respect to various musical instruments is given below, although it is stressed that these are far from absolute, experiment being essential for best results. Once a microphone has roughly been placed, it is handy to monitor 'live' over headphones, adjusting the microphone whilst the musician plays.

Grand piano

The lid is raised and a cardioid microphone, close to the lid is pointed down towards the strings, in line with 'middle C', poked in from the back, i.e. the middle of the curved side of the piano.

Guitar (Spanish)

Most natural string effect is achieved with a cardioid pointed towards the sound hole from about one metre away. Miking too close gives a dull, throbby effect.

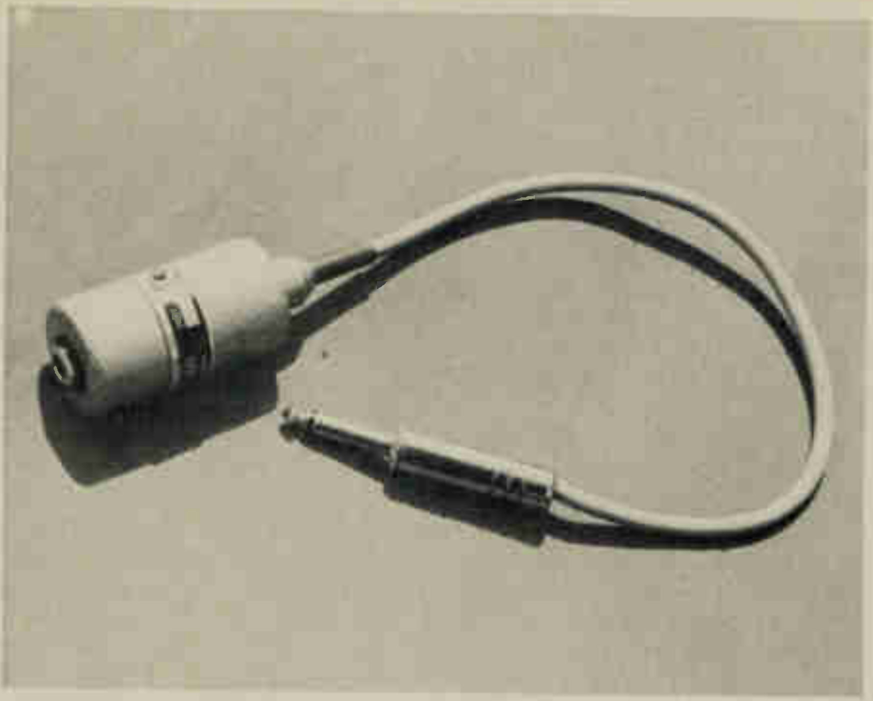
Guitar (Steel-string)

These give a more incisive sound than the Spanish variety, and can take a closer microphone although if the microphone is closer than 30cm it should be directed towards the sound hole at an oblique angle, to minimize bass boominess. When more microphones are available, directing an extra microphone a few centimetres from the front of the sound box, near the sound hole, will accentuate the fingering noises.

Viola and Violin

Vertical distance is required here —

one and a half metres or more above the sound box, and just in front keeps the clarity, at the same time losing the unwanted 'scratch and scrape' sounds. A small violin section may similarly be covered; a large section can be subdivided into a number of smaller groups, balancing each group as described, and using the mixer to 'recombine' the section. Violas are less prone to objectional operating effects than their higher pitched relatives, and hence can be miked slightly closer.



Mumetal-shielded microphone matching transformer, made by Grampian.

Cellos and Basses

In this case it is the scrape that provides the definition to the tone. A hard reflecting surface is preferable to a carpet for bringing out the 'body' of the sound. Laying a hardboard sheet under the instrument is very effective. Microphone position is a bit less than a metre in front and just below the bridge, bringing it to within half this distance if the instrument is to be plucked rather than bowed.

Clarinet, Flute, Oboe and Piccolo

A difficult group to record as they produce wide variations in dynamics, not necessarily obvious to the ear. The operating noises, the huff-and-puff of the flautist and the clicking of keys, add to the difficulties. A minimum distance of a metre should be used when miking soloists, to lose the operating noise, but in the ensemble situation, 30cm or less may be used, directing the microphone to the centre of the instrument body. Wooden instruments tend to give less trouble generally, but when heavy peaking does occur, it is normally the upper musical registers that are affected.

French Horn and Cor Anglais

Ribbon microphones seem well suited to capture the rasp of all the brass section. Horns give out deceptively high pressure signals that can easily overload so miking should be a good two feet in front of, and directed at, the bell of the instrument. Polished wooden reflectors should be placed round the 'back' lobe of the figure eight to capture the chunky richness of the sound.

Flugel Horn, Sax, Trumpet and Tuba

The sax is miked close to get the breathiness, pointing the microphone down the bell. All the rest are also miked in line with the bell, the further away, the more stark will be the resulting sound. Reflectors, as in the previous section, may be used to strengthen the tone, but once again experimentation is the key.

Percussion

Timpani only give of their best in a lively acoustic; a cardioid should be placed a metre or so above them, directed slightly towards picking up the more elusive deep-toned timpani.

Hand percussion, bongoes and congas, must be closely miked, otherwise, in an ensemble situation, the delicate nuances of timbre will be lost.

The conventional drum-kit may be satisfactorily miked using anywhere between two and seven microphones. Unwanted drum rattling may be more noticeable with close-miking and it may require a combination of cushions, blankets and carpet tape to subdue the unwanted noises. The bass drum microphone must be capable of withstanding high pressure signals without sound break-up occurring; for this application a sturdy moving-coil unit is best, located on a cushion just below the centre of the skin, maybe even inside the drum with the front skin removed. Tom-toms can be miked near their rim, close to where the sticks strike. Cymbals do not need special miking as they happily spill over onto any of the other drum microphones.

Snare drums can be miked similarly to tom-toms, but when few microphones are to be used a single top-kit microphone can be positioned level with the drummers head which, combined with a bass drum microphone, gives quite acceptable results.

Voice

A solo vocal microphone should be at least 15 cm away, in front of the performer and in line or just below the mouth. The soloist should be advised to lean slightly back on the fortissimo sections. A distance of up to a metre gives good results when a suitable room acoustic is available; it also prevents the stage-oriented performer trying to 'swallow' the microphone.

Choirs can be treated as a number of smaller sections, splitting them up into the various vocal ranges and grouping each in a semi-circle around a cardioid. Practically, a small number of groups is preferable, as there are less faders to balance.

An empirical rule which seems to work well with most instruments is to regulate the miking distance to between ½ and 1½ times the length of the instrument being miked.

STEREO

As in mono there are the same three possibilities: close multimiking, single (pair) miking, and a combination situation.

Classical music recording demands that the sound image corresponds closely with the concert hall positioning. One school of thought favours a 'crossed pair' of cardioids spaced well back and pointed towards the ensemble, the theory being that this would give the same subjective impression as would be received by a human listener located in the same position.

CREATIVE AUDIO

A multimike set-up would follow the foregoing guide, but after the signal has to an extent been processed in the equalization section of the mixer, it is then routed to the two output channels. The subjective position of each instrument in the sound panorama will be dependent on the relative loudness — there will be an orientation bias towards the speaker carrying any signal at greater volume.

The alternative to these two discrete techniques is to utilise an overall cross-pair and then pick out soloists or complete sections with spot microphones which are injected into the sound panorama in the correct position.

MONITORING

A critical part of the recording chain is the monitoring section, for non-linear operation here will be misleading to the recordist and will in all probability spoil any recordings made. Flat response should be combined with powerful amplification and good speakers that can handle power without distortion. The monitoring must be conducted out of earshot of the microphones for obvious reasons. It should also be conducted at the greatest volume compatible with the equipment and environment. Monitoring at low levels will not show-up induced mains hum and similar small sounds.

MICROPHONE IMPEDANCE

The stated microphone impedance should match the impedance of the equipment it is feeding. The elementary rules to follow when long microphone cables are required, is that the lengthy section is at low impedance, 600 ohms or less. Hence if a high impedance microphone is to feed a low impedance input, a step down transformer will be required adjacent to the microphone. If a long run is required between a high impedance microphone and a high impedance input then a step down transformer will be needed as before, with a step up transformer next to the input. ●

The next article in this series, to be published next month, will describe the techniques used in multi-truck recording.

Crossed pair of Neumann KM 76 capacitor microphones — variable patterns set to cardioid — for location stereo recording.

WHAT TO LOOK FOR IN

March eti

ON SALE MID-FEBRUARY—20p

THE FORTHCOMING ARTICLES MENTIONED ON THIS PAGE ARE, AT THE TIME OF THIS ISSUE GOING TO PRESS, IN AN ADVANCED STATE OF PREPARATION. HOWEVER, ETI TAKES A PRIDE IN BEING REALLY UP-TO-DATE AND TOPICAL ARTICLES MAY REPLACE THOSE SCHEDULED.

DIY LASER

Reasonably priced helium-neon laser tubes are now available, opening up completely new fields for the experimenter. Those who have not come across these before will be surprised at the simplicity of the circuit - basically a very high voltage power supply and a single transistor modulator.

SPECIAL OFFER

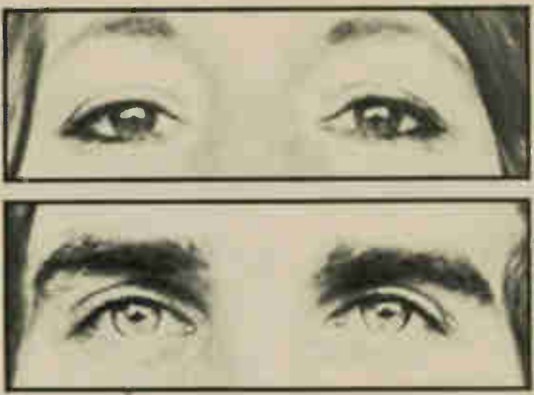
ETI have made arrangements for the supply of a development pack of resistors: 10 of each value in the E12 series (1.0, 1.2, 1.5, 1.8, 2.2, 2.7, 3.3, 3.9, 4.7, 5.6, 6.8, 8.2 and their decades) from 10Ω to 1MΩ. These are ¼W, 5% carbon film components and cost only about 0.4p each! (price includes VAT and postage).

610 RESISTORS: £2·65

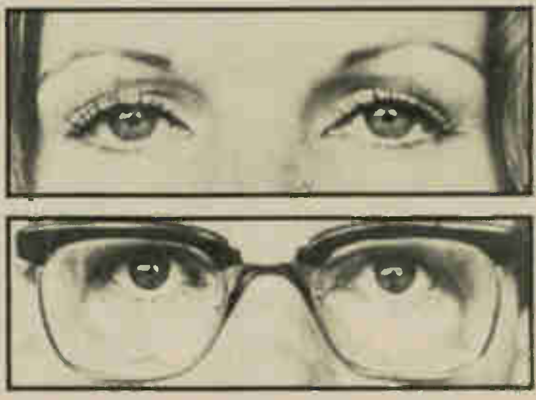
ALL AT SEA

Not long ago a sextant and a chronometer were good enough for fixing one's position at sea: there was little chance of collision and what lay under the sea was only of academic interest.

Today, accurate positioning at sea is vital. A super tanker fitted with the latest equipment can reduce its time at sea by nearly one percent and save literally tens of thousands of pounds in a year. Oil rigs and diamond dredgers require pin-point accuracy, not forgetting defence requirements. Next month's issue contains a major article on positioning at sea, prepared for ETI by Dr. Peter Sydenham.



ELECTRONICS AND YOUR EYES



Sophisticated electronic techniques in Optometry. This up-to-the-minute report, commissioned exclusively for Electronics Today International, by Terence Mendoza BS.c. (Hons).

AN OPHTHALMIC optician (optometrist) is legally responsible for a range of functions in the interest of public health. Testing eyesight is only one aspect of this.

He must determine the integrity of the eyes and visual system by detecting the presence of any ocular ill-health in any individual who consults him. He is trained to recognise the ocular signs of *general systemic* disease; in the early stages this may *only* be evident in the eye, visible by skilled inspection within the vitreous-filled cavity behind the pupil using an ophthalmoscope (See Fig. 1). General diseases that may be manifest in the eye include diabetes, hypertension, anaemia and secondary growths from a primary cancerous site existing elsewhere in the body.

The more widely appreciated aspect of the work of the ophthalmic optician is his determination of appropriate optical corrections after which he decides the most beneficial manner in which the subsequent prescriptions should be dispensed. The possibilities include spectacles, contact lenses or telescopic aids.

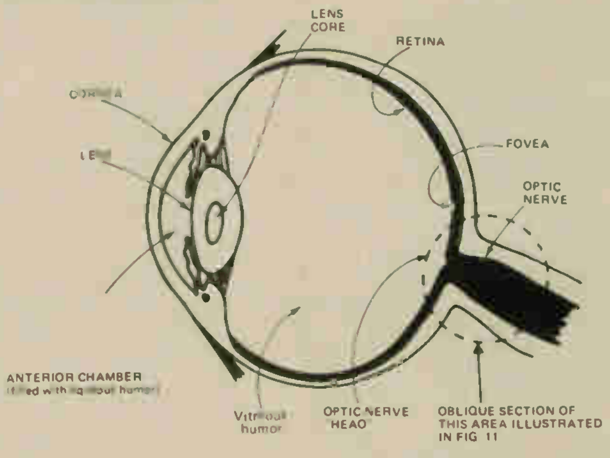
Both pathological and refractive aspects of ophthalmic work increasingly use electronic methods, enabling the ophthalmic optician to undertake his tasks more effectively.

REFRACTION OF THE EYE

When considering the visual 'correction', the ophthalmic optician is concerned with the efficient formation of the (inverted) image on the retina. The eye's optical system consists of four transparent media which refract, (bend) the light incident on the front surface of the eye — called the 'cornea'.

These four transparent media are the cornea itself, the aqueous and the vitreous humors and the focussing element of the eye, the crystalline lens which is interposed between the aqueous and vitreous, humors.

Fig. 1. Horizontal Section through Eyeball.



The lens has two separate refracting areas, the outer shell and the core. The gradients between the media dictate that the bulk of the eye's power is in the cornea. The lens, in its relaxed state, contributes only about one third of the 'refracting power' to the eye.

MYOPIA

Should the refracting power be too *strong* for the length of eye, a parallel beam of light from an object situated at 'infinity' will be focussed in front of the retina; by the time the rays reach the retina they will have crossed and diverged-subjectively, a blurred image

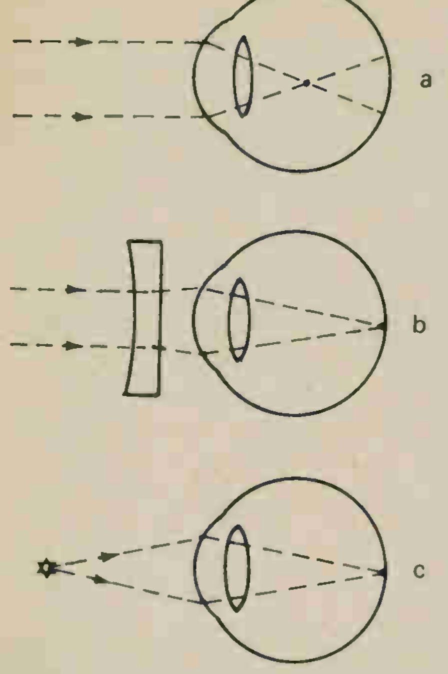


Fig. 2. (a) Parallel rays cross before reaching the retina. (b) Interposing a concave lens diverges the parallel rays before they enter the eye so they can be focussed on the retina. (c) Moving the 'object of regard' much closer, to the far part of distinct vision will also enable the rays to be focussed on the retina.

results. (See Fig 2.) In this case the angle at which the refracted rays converge has to be slightly reduced to eliminate the blur – this situation is fulfilled when either the object is brought very much nearer to the eye or when an external supplementary concave "spectacle" lens is interposed to diverge the parallel beam, neutralizing the state of the eye.

HYPERMETROPIA

The opposition condition, loosely termed long-sighted, requires a convex lens to focus the parallel beam onto the retina.

ASTIGMATISM

Astigmatism (from the Greek meaning 'without a point') is the condition whereby the rays from a parallel beam cannot be focussed onto the retina by a spherical convex or concave lens.

The usual reason for this very common condition is that the cornea, instead of possessing a near-spherical character, has a toroidal surface (like a portion of the surface of a tyre– with two distinct radii of curvature at right angles to one another – each curvature producing its own line focus. The two line foci may be refocussed onto the retina with the combination of a 'spherical' refracting element and a 'cylindrical' element (a spherical element will move both line foci an

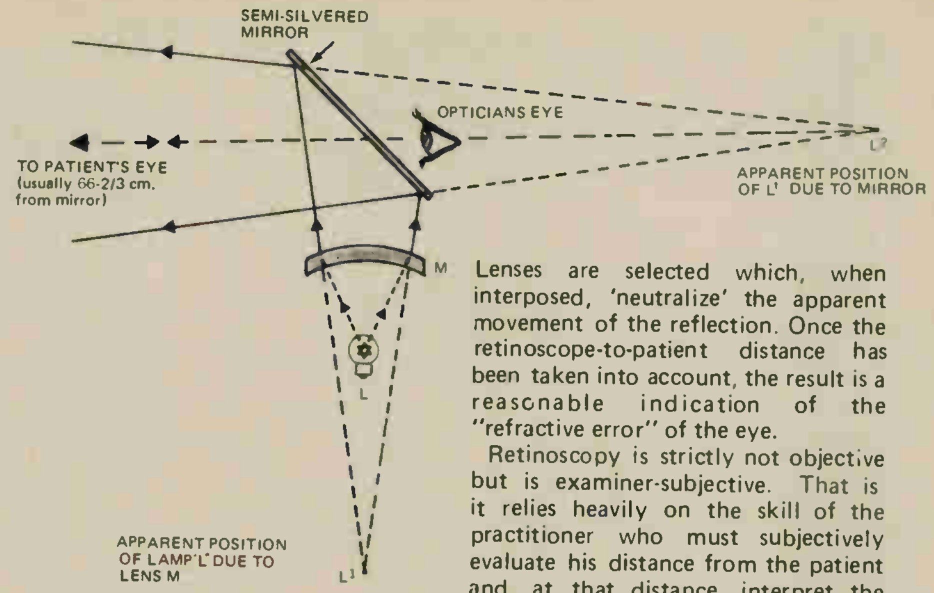


Fig. 3. Simple self-luminous Retinoscope using semi-silvered mirror.

equal distance – when one line is focussed on the retina the cylindrical element can selectively move the other line focus to the retina to once more achieve 'point focus' conditions).

HOW REFRACTION MEASUREMENTS ARE MADE

The 'refraction' that the optometrist carries out to determine the required spectacle lens correction uses a number of integrated methods, some requiring patient's judgment and response – ('subjective' testing), and others, (the 'objective' tests), relying on the practitioner's own judgment.

Supplementary tests are conducted to examine the ability of the two eyes to work together, to maintain a unified perceptual image when the eyes track a moving object; also how the eyes come to (physiological) rest when using apparatus which prevents active fusional movement.

The 'classical' objective test for determining the correcting lens required is *retinoscopy* – a light beam from a retinoscope is moved across the pupil of the patient. The beam, reflecting from the retina is viewed along the path of the incident beam (a mirror, either semi-silvered or with a central aperture is used in the retinoscope to permit the illuminating/viewing axes to be coincident). (Fig. 3). The distance of the retinoscope from the patient is kept constant, enabling the optometrist to relate the speed of the incident beam scanning the eye, with that of the reflection from the back of the eye. This reflected beam emerges after going through the refracting influences of the various ocular media.

Lenses are selected which, when interposed, 'neutralize' the apparent movement of the reflection. Once the retinoscope-to-patient distance has been taken into account, the result is a reasonable indication of the "refractive error" of the eye.

Retinoscopy is strictly not objective but is examiner-subjective. That is it relies heavily on the skill of the practitioner who must subjectively evaluate his distance from the patient and, at that distance, interpret the direction, speed and brightness of the moving reflection.

THE OPHTHALMETRON

An exciting new instrument, designed by Dr Aran Safir (Mount Sinai School of Medicine, New York) in 1970 has proved itself capable of carrying out a truly objective refraction. The Ophthalmetron, utilising photo-electric, optical, electronic and graphical elements is marketed by the American company of BAUSCH and LOMB. (See Fig. 4). Safir takes pains to stress that the instrument does not completely determine the lenses required. "The practitioner's experience and judgment remain, as always, crucial factors in determining whether or not the

Fig. 4. Lining up the measuring system of the Ophthalmetron prior to carrying out a recording of the refractive error of the subject's right eye.

ELECTRONICS AND YOUR EYES

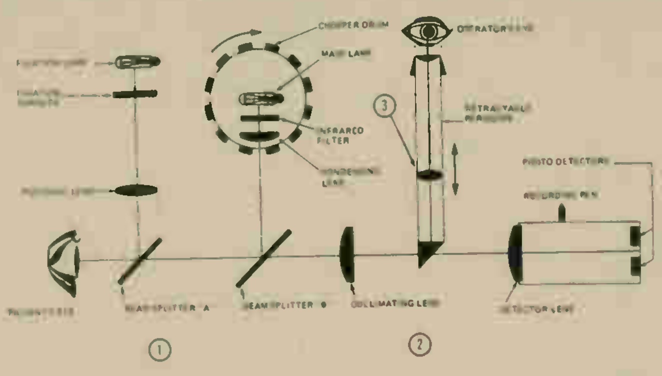


Fig. 5. Schematic illustrations of the three sub-systems of the Bausch and Lomb automatic refractionometer – the "Ophthalmetron".

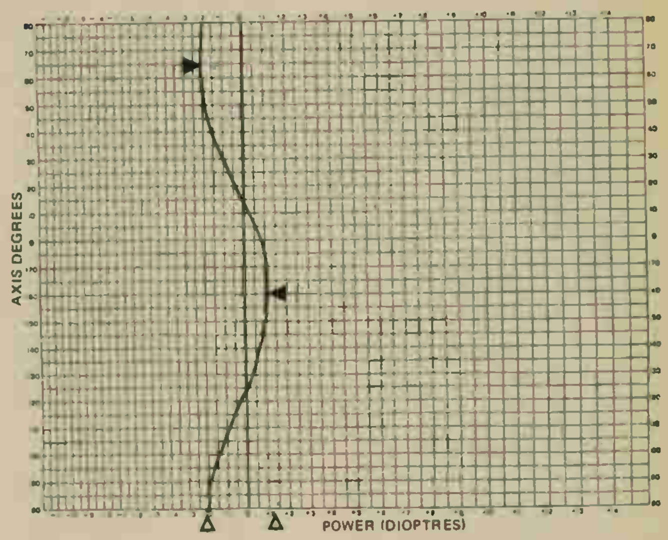


Fig. 7. Black arrowheads indicate most negative and most positive excursions occurring at 180° and 75°. Clear arrow heads point to dioptric value where the peaks are registered – -2.00 D and + 1.12 D.

patient is made visually functional and comfortable."

The Ophthalmetron has three overlapping systems (see Fig. 5); first there is the fixation system – the patient is directed to observe a target presented to his eye. When he 'fixates' it steadily, his eye will line up with the optic axis of the measuring instrument.

The fixation system consists of a light source, fixation target (a transparency of a rocket at blast-off – very impressive!), a focussing lens and a semi-silvered mirror (beam-splitter) which permits the reflected target-image to reach the eye simultaneously with the directly transmitted "measuring beam."

The second system is the measuring-recording system. An ingenious light-source assembly gives a scanning light beam. It consists of a lamp, a near-infra red transmitting filter, a condensing lens and a chopper drum. The chopper drum is divided by many equally-spaced slots and in operation rotates around the light source to provide 720 slit/scans per second. The near infra-red light reflected from the retina is brought to a focus within the body of the instrument by a collimating lens. The position of this focal point represents the patient's far point i.e. the furthest 'distance' at which the patient can focus before objects appear blurred – it necessitates the crystalline lens to be relaxed. A myope's far point is closer to his eye and a hypermetrope's is behind his head when the eye is completely relaxed.

If the photo-detector assembly is forward of the far point (See Fig. 6) the beam reflected from the retina, and the incident scanning beam travel in the same direction – in classical retinoscopy this is termed a 'with' movement. An integral servo-mechanism moves the detector apparatus back towards the far point. Should the detectors be situated *behind* the far point they sense the reflection travelling in the opposite direction to the illuminating beam – an 'against' movement; the assembly in this case is moved forward to the far point. At the far point, simultaneous illumination of the photo-detectors occurs and the recording pen begins to mark on a chart.

The measurement system (to the right of beam-splitter A in Fig. 5) is rotated through a 180° scan of the eye, recording the power in every meridian on a static chart wrapped around the pen cylindrical detector assembly.

The alignment of the recording system with the eye's visual axis is critical, hence the attention that has been paid to this facet of the design. During the setting-up procedure the measuring light source is modified (the infra-red filter is removed and a pinhole aperture is introduced) and the operator views the reflection of this 'object' in the front of the patient's eye. The reflection is correctly centred, using a retractable periscope lowered into the axis of the measuring system and by moving the instrument by its XY joystick. The height is adjustable via the bezel ring at the base of the joystick.

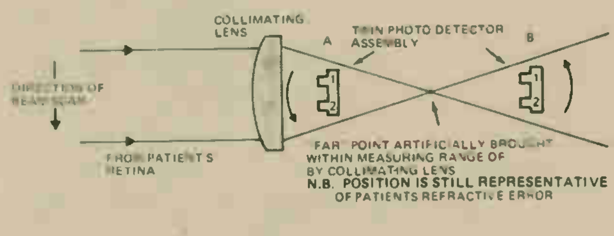
Once aligned, the measuring/recording takes three seconds to produce the final read-out (See Fig. 7).

In use the Ophthalmetron produces results of an accuracy equivalent to that obtained by the skilled optometrist using streak retinoscopy, which is recognised as one of the most sophisticated 'objective' consulting-room techniques.

ELECTROPHYSIOLOGY

Various research programmes have been undertaken in recent years to try to develop an electrophysiological method for measuring refractive error objectively. Basically they consist of graphing the *visually evoked cortical potentials* (VECP) emanating from the visual cortex – the part of the brain at the back of the head which is concerned with seeing. The signals, picked up by electrodes painlessly placed on the scalp evidently bear a direct relationship to the clarity of perception of a target viewed by the "fovea" (the part of the retina where

Fig. 6. Schematic illustration of Scan/photo-detector principle in the Ophtholmetron.



At position A, detector 1 is illuminated before 2 by collimated scan reflection from retina – detector assembly is moved back. At position B, detector 2 is illuminated before 1 – detector assembly is moved forward. At 'far' point both detectors are simultaneously illuminated – tracing commences by pen attached to detector assembly.

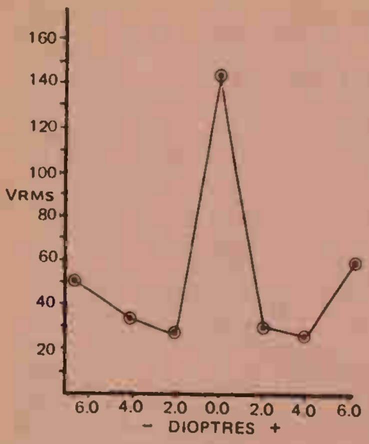


Fig. 8. Variation of Vrms (see text) with refractive error. The peak response coincides with the absence of any refractive error (after Arden, Barrada and Kelsey)

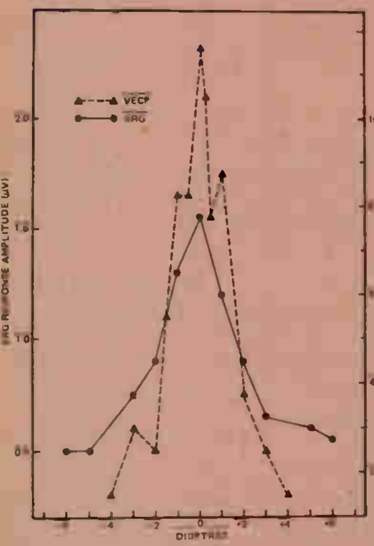


Fig. 8(a) Variation of the VECP and ERG with refractive error. Maximum response is obtained with the spherical power addition of zero dioptres (ie no refractive error) and falls off rapidly on either side (after Arden, Barrada and Kelsey).

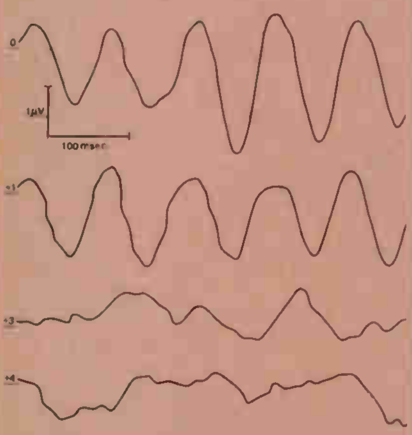


Fig. 8(b) Recordings of the VECP obtained upon light stimulation of the eye. Note how the amplitude of the response decreases as the retinal image is progressively blurred by the addition of 1, 3 and 4 dioptre lenses (after Arden, Barrada and Kelsey).

critical vision is carried out). (See Fig. 8).

When an eye fixates a dark/light border of a stimulus pattern a surface positive 'late wave' (180 – 375 msec) results in the VECP, the amplitude of which depends on the contrast, between the black and white areas of the pattern i.e. the less distinct are the borders, the smaller will be the amplitude of response. Blurred border margins, (defocussed either by the eye's crystalline lens or by an artificial

Fig. 9. Preparing to record an Electroretinogram; the subject wears a scleral contact lens containing one electrode, others being placed on forehead and ear. To the left of the picture an oscilloscope with a Polaroid camera attached provides a more detailed analysis of the ERG. The small unit in the centre is a high gain differential amplifier.

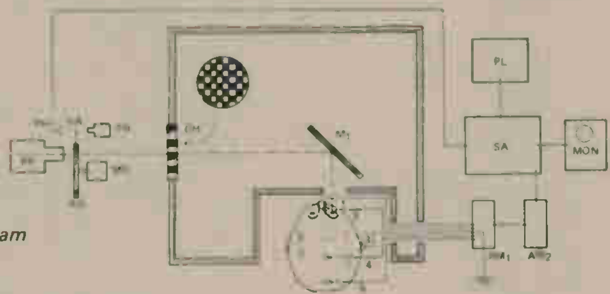


Fig. 9(a). Layout of apparatus for recording the electroretinogram and the visually evoked cortical potential. (Illustration after Millodot).

KEY: CH – circular crossed polaroid checkerboard stimulus target AM_1, AM_2 – series connected differential amplifiers giving amplification 10^5 to 10^6.
1. 'live' sclerol contact lens electrode on eye
2. reference electrode on cheek — *ERG Electrodes*
3. grounding electrode on ear
4.)
5.) Scalp midline VECP electrodes
SA – response-averaging computer. PH – photocell triggering sweep of SA via hole in vane (VA) attached to rotating polaroid (PO); light emitted from projector TR. MON – oscilloscope monitor. PL – X-Y chart recorder. PR – target illumination. MO – motor. M_1 – mirror.

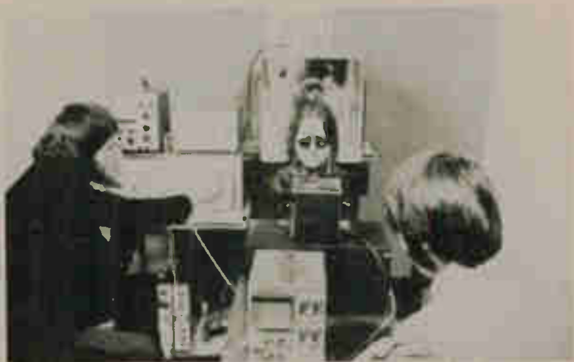


Fig. 9(b). Recording the change in VECP when viewing a flashing stimulus through various additional lenses. Subject is using her left eye (the right is covered). Metal shield prevents stray pick up. Xenon Strobe Stimulus is directly in front of subject. Bottom left is X-Y chart recorder and above it is the response averaging computer (being adjusted).

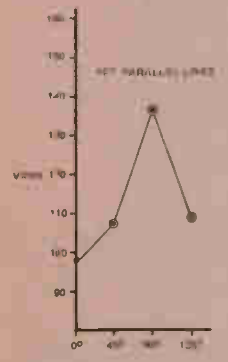


Fig. 9(c). Vrms and astigmatism. Peak response is obtained when astigmatism is minimal.

lens outside the eye) will give the same effect. If the process is considered in reverse and the VECP response is maximised using additional lenses, the visual performance of the eye will be found to have been improved; an objective lens correction will have been found. (See Fig. 8a and 8b).

The measurement is actually related to the visual sensation and is registered by the patient's visual cortex. Hence there is virtually no discrepancy between the objective indication of the 'right' lens and the patient's subjective sensation of 'best vision'.

A checkerboard 'stimulus target' is used, constructed from crossed Poloroid strips; when lighted via a ▶

ELECTRONICS AND YOUR EYES

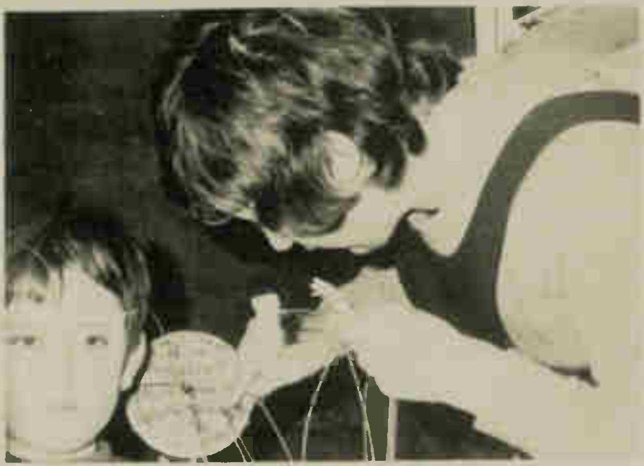


Fig. 10. Connecting electrodes prior to recording the electro-oculogram. (see text) Photo courtesy Dr. Binny, St Bartholomew's Hospital, London.

Fig. 11. Microscopic section of the optic nerve 'head' where undue intra-ocular pressure has most deleterious effect. The light area to the left is the vitreous and the large central circular area is the optic nerve which has been obliquely sectioned — the striped appearance is due to bundles of nerve fibres. In glaucoma the slight dip at the nerve head may be pushed right back to a goblet-shape, termed cupping.

piece of rotating Polaroid, alternate squares sinusoidally lighten then darken — thus constant overall brightness is maintained in a continuously changing stimulus presentation.

The signals obtained from the electrodes on the midline of the skull, with a grounding electrode on the ear, are fed to a response-averaging computer and, after averaging, are printed out as a single trace on an XY recorder; this trace represents the VECP.

The prime advantage of this method is that it detects abnormalities anywhere within the visual system; these could be in the eye or in the nerve fibres to the brain. Blindness due to injury to the nerve pathway will affect the VECP trace but would not be indicated by instruments such as the retinoscope and the Ophthalmetron. Measurements of electrical potentials generated between the front and rear of the eyeball, termed the *electroretinogram* (ERG) also demonstrate a relationship between the size of the potential difference and visual clarity. In this case, one electrode is carried by a scleral contact lens worn on the eye and another is fixed on the cheek or ear (See Figs 9a, 9b, and 9c).

Most prescriptions have the astigmatic component which was mentioned earlier, therefore to determine the axis of the cylindrical element electrophysiologically, a grating stimulus can be used in the form of a series of parallel alternate light and dark bands. The orientation of the lines is rotated until maximal trace amplitude is achieved, indicating the axis where minimal astigmatism exists (See Fig. 9c).

THE ELECTRO-OCULOGRAM

Finally, this group of techniques includes the clinical possibilities of the electro-oculogram.

A resting or standing potential of the eye, maximal between the cornea and back of the eye, exists. Measuring some 6mV, its cause is part retinal, and part due to the semi-permeable membranes within the eye, such as that which contains the lens. Its magnitude is greatest in the direction of the visual axis i.e. cornea to fovea. Electrodes placed either side of the eye will detect an increase in potential as the cornea approaches one electrode. If eye movements (of constant size and orientation) are repeated under different illumination conditions, changes in the relative resting potential can be noted. These can provide a useful diagnosis of the retinal function. Figure 10 illustrates a current piece of research being conducted at St. Bartholomew's Hospital, London. The form of the EOG is being correlated with reading difficulty in school-children. In the picture, the electrodes are being connected to the rest of the apparatus via the circular plug-board behind the subject.

CURVATURE OF THE CORNEA

Contact lens fitting has also benefitted from electronic automation — albeit on a limited scale.

The cornea never follows a completely spherical curve. Central corneal curvatures can be indicated by a *keratometer* — an instrument that measures the angular size of an image reflected from the cornea of an object of known angular size. A direct reading of the corneal radius of curvature allows the choice to be made of 'trial' lens (of appropriate curvature) from a comprehensive set of contact lenses. The 'fit' of the lens curve to the corneal curve is determined by viewing the quantity and distribution of tears between the lens and the cornea — the tears rendered visible by a harmless dye (fluorescein 2%) which fluoresces when viewed under blue light.

Lenses of differing back surface curves are tried until the best 'fit' has been determined; this is often a compromise.

RECORDING KERATOSCOPES

The skilled procedures described above have held their own, even with the advent of devices such as recording keratoscopes.

The principle of the recording keratoscope is basically similar to that of a keratometer in that the device produces a series of concentric ring reflections from the anterior corneal surface — this resulting pattern is photographed.

The rings of the 'object' bear a constant relationship to each other hence the reflected and photographed rings will also bear a (different) mathematical relationship to each other. From the photographed data it is possible to compute the curvature at an infinite number of points and plot the entire corneal topography. The photograph may be placed in a reader, the various measurements registered and recorded onto a teletype hooked up to a time-sharing computer. A readout of a number of lens specifications can be obtained in 30 seconds using this system but more accurate analyses naturally take longer. However, to date most optometrists feel that there has been little apparent advantage over classical keratometry.

DISEASE AND THE EYE

The recognition of pathology involving the eye is a constant responsibility of the ophthalmic optician, because in most countries he is the "general practitioner" of eye-care.

A major concern to the ophthalmological and ophthalmic professions is the development of suitable instruments to detect glaucoma, that most insidious of visually-crippling maladies. This disease can be quite advanced before the affected individual has any awareness of his condition.

Fortunately present-day medicine can however prevent blindness from glaucoma if recognised and treated early; once detected the process can be halted but not reversed.

Although the causes of glaucoma are many and varied, one prime factor nearly always present is an increase in pressure exerted on the wall of the eye. This may be due to an adverse differential between the volume of fluid (mainly blood) entering to nourish the eye, and the volume of fluid leaving the eye. The pressure, although equally distributed, will have its greatest and most deleterious effect at the weakest portion of the globe — where the optic nerve fibres enter the eye at the nerve "head" (See Fig. 11). This is gradually and often imperceptibly pushed backwards affecting the entering nerve fibres and slowly destroying the sight. As the nerve fibre functions are affected, so also is their distribution, within the retina.

Characteristic patterns of visual loss, unnoticed, appear in the field of vision (until late in the disease when the peripheral losses start to encroach on the fovea).

There are three principal means of glaucoma detection — recognition of optic nerve head "cupping", disclosure of a pathological level of raised 'ocular tension' and detection of characteristic scotomata (visionless areas) in the visual field of the patient.

Visual field screening has been a slow, painstaking process, but in the last few years a rapid and efficient piece of equipment, known as the Friedman-Bedwell Screener, has lightened the task for both practitioner and patient (See Fig 12).

Multiple stimuli of accurately calibrated brightness and size are exposed to the patient for set short periods. The patient is required to state how many stimuli he sees. The stimuli are positioned in the areas most likely to demonstrate pathological visual field defects. Previous devices of this type relied on flashes of blue light or the time-consuming use of a single stimulus. Great success has been achieved in screening the public by this new method.

TONOMETRY

The measurement of ocular tension is known as tonometry. It is closely allied to a technique known as *tonography,* in which there is a measure of the outflow of fluid from the eye in response to controlled pressure applied to the eye. In pathological states there is reduced outflow.

Two related, though distinct, principles are utilised in the measurement of tension — *indentation* and *applanation.* The corneal surface, suitably anaesthetised, is normally the site for the measurement as it affords a thin regular surface.

Indentation instruments utilise a flattened annular foot-plate. A plunger of known weight slides freely down the centre of the footplate, linked to a pointer indication via a gravity system. The more compressible the eye (i.e. the lower the tension), the further the plunger indents, when the footplate is rested on the cornea (See Fig. 13).

Applanation techniques rely on various methods of flattening the cornea — some, using a pre-calibrated scale, provide a direct reading of the force required to flatten a set area of cornea. Others employ a standard weight and relate the measured area of corneal flattening to the ocular tension.

The Imbert-Fick law states that the intra-ocular tension is equal to the weight applied, divided by the area of cornea flattened. This theoretical relationship applies to a perfectly dry, flexible membrane but of course the cornea is wet and has a degree of rigidity.

In a typical situation an area of about three square millimetres of cornea is flattened and then the meniscus of tears which surrounds the flat area provide a certain amount of surface tension. This surface tension is enough to counteract the effects of the corneal rigidity so the Imber-Fick law will still hold good.

THE NON-CONTACT TONOMETER

All the methods discussed so far for the measurement of ocular tension have three drawbacks; they require a high degree of skill and care, the prior application of a local anaesthetic, and mechanical contact with the eye.

A recent instrument with electronic sub-systems developed by Dr. Bernard Grolman (1972) of the American Optical Company obviates the above considerations. Nevertheless it enables a complete measuring cycle to be carried out in three milliseconds with minimal discomfort to the patient.

The applanating medium is an air-pulse and the *time* taken for the air impinging on the cornea to result in applanation is recorded; testing on both human and animal subjects has demonstrated that there is a direct linear relationship between ocular tension and the "time interval to applanation." The readout is generated in binary coded decimal form and is digitally displayed in "mm Hg" on a readout panel in front of the operator.

Precise instrument-to-cornea ▶

◀ *Fig. 12. Friedman-Bedwell Visual Field Screener in use. Patient fixates central target through circular fluorescent tube which keeps lighting conditions consistent. Patterns, selected by a lever behind the white fascia, are flashed onto the black screen (in fact they are apertures illuminated by a xenon flash-tube).*

Fig. 13. Locating a Shiotz indentation tonometer on the eye to measure the ocular tension. The pointer is to one end of the scale as the plunger has not yet made contact with the cornea. Note the supine position of the 'patient' necessary with gravity systems of this type. ▶

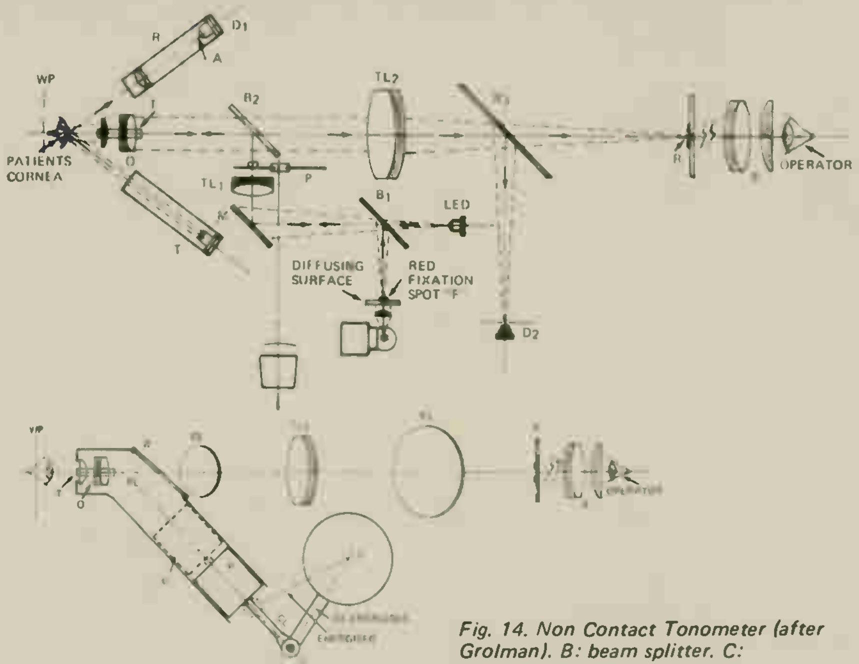


Fig. 14. Non Contact Tonometer (after Grolman). B: beam splitter. C: compression cylinder. P: piston. S: solenoid. O: objective broached by duct (T).

alignment is required, therefore a system similar to that of the Ophthalmetron is used.

A small target is reflected from the cornea and is monitored by the operator. A secondary automatic "fail-safe" alignment system is superimposed upon this primary visual one. A LED light source is reflected onto the cornea by a semi-silvered mirror, the image then being reflected by a second mirror onto a photo-detector, after negotiating a small aperture (See Fig.14). When the visually – judged alignment satisfies the spatial tolerances bounded by the measuring system, the machine can be operated. Misalignment results in the reflected light not illuminating the detector behind the aperture and the machine becomes inoperable.

The long-focus microscope (See Fig. 14) used for visual alignment has a novel modification which forms the basis for the whole system – this is that its objective lens is broached by an axial duct; this ducted-lens forms one end of a cylinder with a compression piston, situated at an angle to the axis of the microscope – a window in the cylinder wall allows unobstructed light-path through the microscope.

When energised, an adjacent solenoid propels the piston down the cylinder and the positive pressure is ported through the lens duct. The resulting highly-repeatable force-time envelope (it takes 12msec to peak) impinges against a properly oriented cornea and sequentially causes first a gradual reduction of curvature, then applanation, next a slight concavity and finally, (with the decay of the force-time envelope) progressive restoration of the cornea.

The status of the cornea is continuously monitored by a separate system consisting of a transmitter, to direct a collimated (parallel) beam to the centre of the cornea, and a telecentric receiver – this accepts only parallel rays symmetrically disposed relative to the transmitter (See Fig. 16). Only a small amount of light is received by the detector from an undisturbed cornea. Increasing numbers of rays are accepted and sensed with progressive corneal flattening, with a maximum occurring at the instant of applanation.

This peak, when sensed, shuts off the current supply to the solenoid, ensuring that minimal applanating force is directed at the cornea.

In the commercially-available instrument the time data output (i.e. time to first applanation 'spike' from the telecentric receiver) is instantaneously converted to give the tension in mm Hg, a form which is more clinically useful.

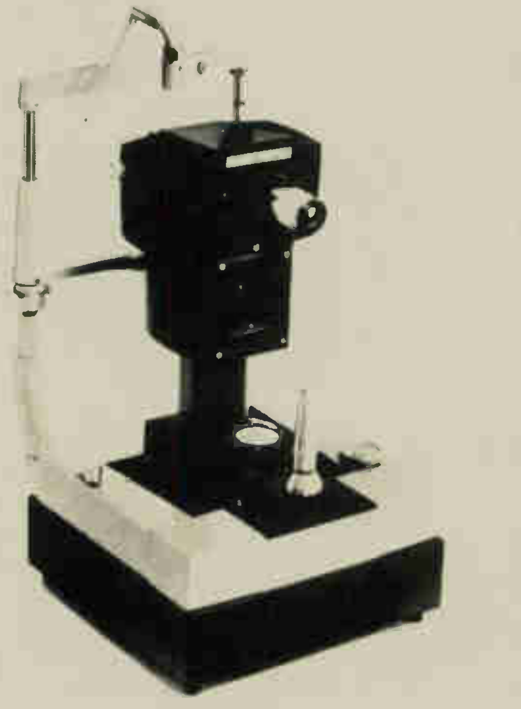


Fig. 15. The non-contact tonometer viewed from the side of the operator. The Nixie panel is visible beneath the alignment telescope. In the foreground the joystick alignment handle can be discerned.

DETECTION OF FLICKER

The ability of the eye to detect flicker is depressed in Glaucoma, and in various other conditions including disseminated sclerosis, and diabetes.

The frequency at which a flickering source appears to become constant or at which the flicker is just perceptible is termed the critical fusion frequency of flicker (CFF). It varies with different parts of the retina and is highly dependent on such factors as the wavelength and waveform of stimulus used, and external considerations such as the ambient illumination.

Drasdo and Woodall of the University of Aston in Birmingham (England) have devised a technique (See Figs 17a and 17b) for charting

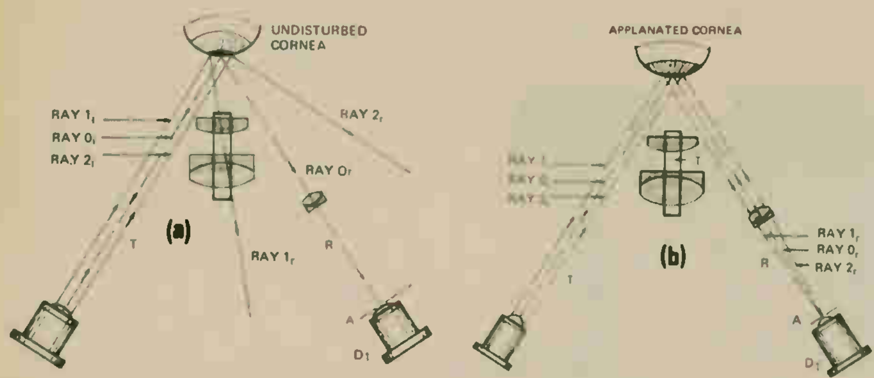


Fig. 16. Non-Contact Tonometer — Telecentric Corneal Status Monitoring (a) normal undisturbed cornea — few collimated rays from transmitter (T) are reflected by the cornea to be focussed on the detector D, behind the aperture A. (b) Applanated cornea resulting from air-pulse from tube (T); maximal signal is detected by the receiver due to the collimated transmitted beam.

the CFF for the 'visual field' by superimposing a modulated stimulus on a grey homogenous field.

A light emitting diode modulated with a 50% bright interval, is applied to the rear of a grey translucent screen fixated by the patient. Fine control of screen brightness is possible, and the ideal nature of the LED permits great scope by virtue of its small size and rapid response. The patient views one-second pulses of modulated light presented in various positions in his visual field — he is asked to indicate whether or not the pulses appear to be modulated. Once the CFF field has been plotted, it can be compared with the 'norm' to confirm or negate any suspicion of pathology.

CONCLUSION

The sophisticated electronically-based techniques now being included in day-to-day practice, safeguard public eyesight and health, and will do so to an ever-increasing degree as the rapidly expanding electronic technology reveals yet further applications in this important field. ●

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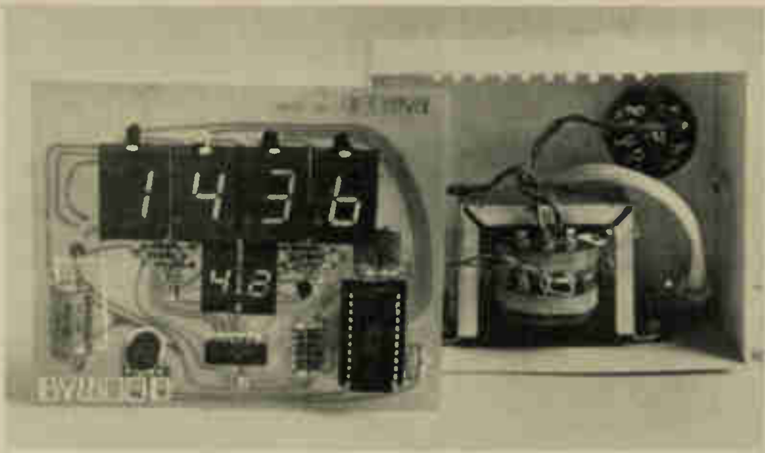
The writer would like to thank the Department of Ophthalmic Optics and Visual Science of The City University, London and in particular to Professor R.J. Fletcher, Dr. J.E. Saunders and Mr. C. Bishop for helpful suggestions received in the preparation of this feature. The co-operation of the various ophthalmic equipment manufacturers and distributors is also gratefully acknowledged.

Fig. 17(a). Plotting critical fusion frequency of flicker using a flat screen perpendicular to patient's line of sight; patient fixates central red light.

Fig. 17(b). Plotting CFF using a LED externally applied to evenly illuminated hemispherical 'bowl'. Photos 18 and 18(b) courtesy N. Drasdo, University of Aston, Birmingham.



LATEST KIT!

5314–JUMBO EVALUATION KIT

BYWOOD are pleased to announce another in our range of digital clock evaluation kits, the 5314–JUMBO kit. The National Semiconductors MM5314 is a 24-pin LSI chip containing all the logic required for a 4 or 6 digit, 50 or 60Hz, 12 or 24 hour digital clock, interfacing to LED displays is easily accomplished by use of switching transistors. JUMBO is the pet name given to the new Litronix 0·6" LED seven segment display.

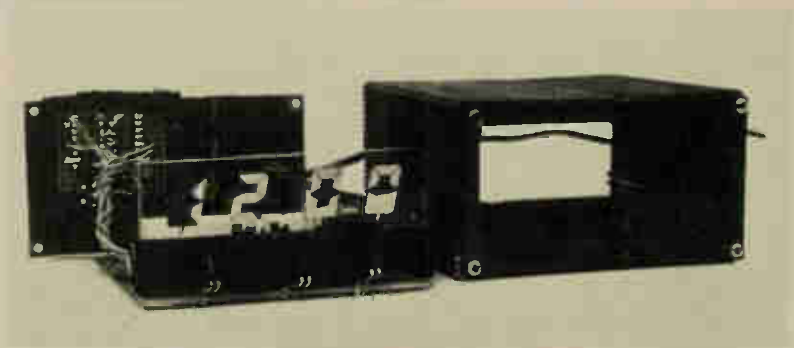
We supply MM5314, socket, 4 DL747s, 2 DL707s, CA3081 display segment driver and a 5"x4" fibreglass PCB.

You supply 16 resistors, 3 capacitors, 2 diodes, 6 transistors, transformer and switch.

A real wood (not laminate) case is available in limited quantities at £4·50 plus 20p p&p.

Kit Price
£26·80

5316–LC EVALUATION KIT

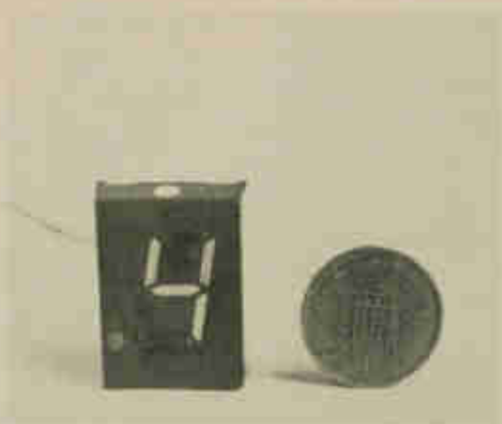


The MM5316 is a 40-pin chip containing a complete logic module for a digital alarm clock. The four digit outputs can display hours and minutes; minutes and seconds; alarm time; sleep time. The clock also has snooze facility and reset to zero capabilities. This is one of the easiest ways presently available to run a liquid-crystal display as this chip has the necessary interface to AC run the crystal. The TA8055 is a pack of four 0·6" liquid-crystal digits plus a colon presented in a glass envelope complete with edge connector.

We supply MM5316 and socket, TA8055 and connector, PCB.

You supply 13 resistors, 2 capacitors, 4 transistors, diode, switches and miniature transformer.

Kit Price
£32·00



DL747 LED

The new DL747 ("JUMBO") 0·6" LED seven segment display is made using the lightpipe and ELD techniques. This results in a very evenly bright digit with clean lines making it easily readable from distances of over 25 feet. It is ideal for digital clocks, DPMs, POS terminals and such and with this spec and price the DL747 is going to be the digit of 1974.

Price per Digit £2·62

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LM380 2½W Audio Amp	£1·50
555 Mono/Astable timer	£0·90
LM322 precision timer	£2·50
TIL209 type LED lamps	£0·20
DG12 Ph-diode 7 segs	£2·00
TA8055 Liq-crys 7 segs	£13·00
DL707 0·3" LED 7 segs	£2·00
MM5316 Alarm clock chip	£15·00
MM5314 Clock chip	£9·00
CT7001 Alarm/Date/clock chip	£18·00

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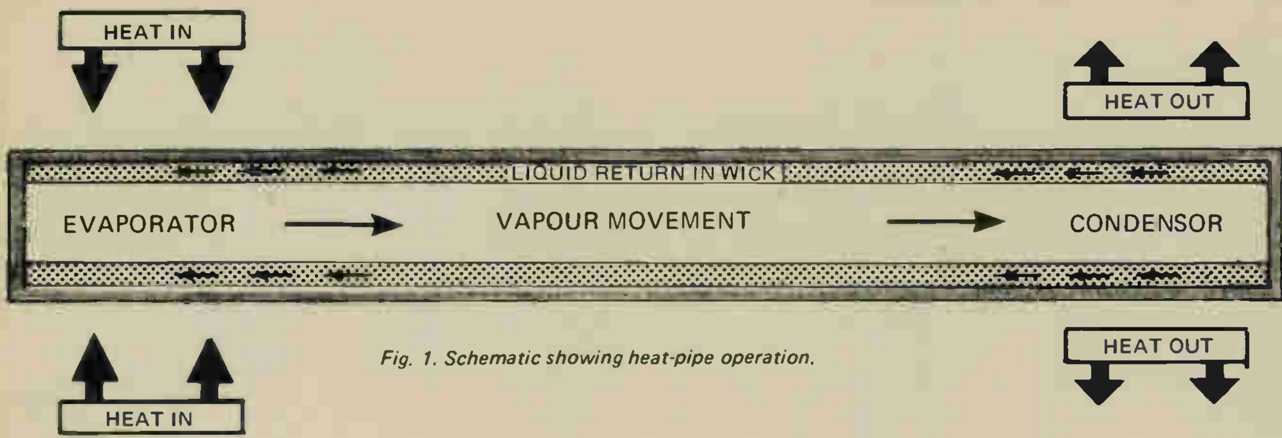


Fig. 1. Schematic showing heat-pipe operation.

HEAT PIPES

Heat pipes transfer heat up to 500 times more efficiently than any known solid conductor.

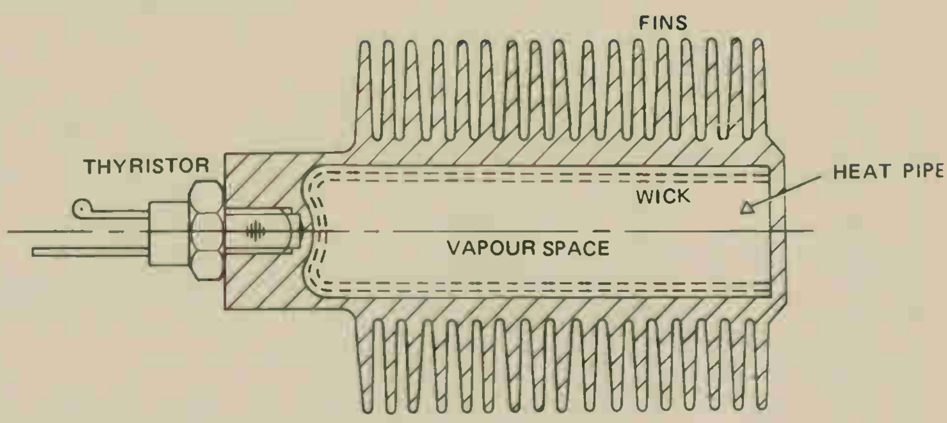


Fig. 2. This Heatsink/Heatpipe combination was designed by Marconi as cooling for a thyristor used in space research. The unit is 65 x 75 mm.

HEAT pipes, first patented in 1942, are unique in that they use surface tension, generating capillary pressure, to return the condensed liquid to the evaporator. This process was first patented by R.S. Gaugler in relation to the cooling of an ice box. The term "heat pipe", however, was first used in a paper by G.M. Grover, et al, reporting work carried out under the auspices of the U.S. Atomic Energy Commission. This work, entitled "Structures of Very High Thermal Conductance", was directed towards the use of sodium filled heat pipes for thermionic generators and thus was the first electronic application of heat pipes.

Although the efficiency of electronic components has steadily improved since their inception, the higher packing density and more stringent environmental requirements have resulted in thermal problems of increasing difficulty. Consequently, early consideration is now given to the thermal design of many advanced electronic equipment projects.

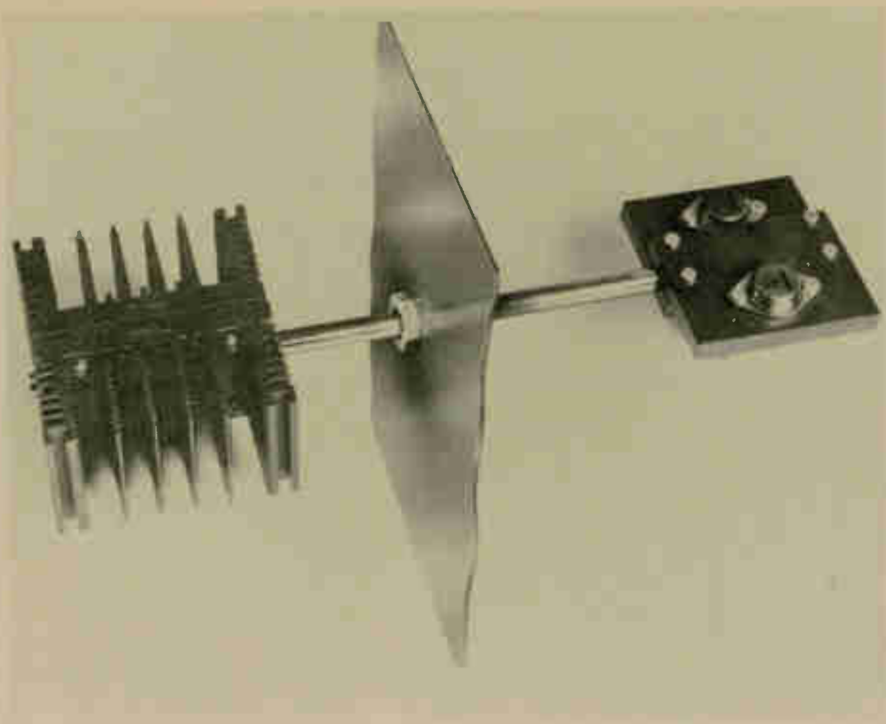
In many cases the more conventional techniques such as heat sinking, are found to be inadequate and designs embodying heat pipes are gaining popularity. In the main, applications are potential rather than current, a situation which is changing rapidly as engineers become better acquainted with design parameters, and as an increasing demand leads to lower prices.

WHAT IS A HEAT PIPE?

A heat pipe is a sealed tube containing fluid and a "wick". Figure 1 shows a cross-section of a simple tubular version of a heat pipe. One area of the tube is heated, causing the fluid to evaporate; another area is cooled, causing the vapour to condense. The fluid carries the heat, as latent heat, from the heated area to the cooled area and is then recirculated from the condenser to the evaporator by the capillary action of the "wick". Gravity aids this capillary action when the evaporator end is downward and opposes capillary action when the evaporator end is upward. In simple versions of the heat pipe, the "wick" is uniform throughout the length of the tube, and the roles of the evaporator and condenser can be interchanged.

The range of fluids which may be used for cryogenic heat pipes is limited, (liquid hydrogen being one of the most favoured) those that can be used suffer from the low performance inherent in the physics of low temperatures. Although high temperature heat pipes enjoy outstanding performance, the working fluids (such as molten sodium, potassium or lithium) must be of the utmost purity and the methods of construction are not easily adapted to the production line. Both cryogenic and liquid metal heat pipes are expensive and at present in fairly low demand. Prices range from £500 to £3,000.

The demand for cheaper heat pipes



This stock 3/8" O.D. x 300mm long heat pipe with standard source and sink attachments shown, facilitates remote cooling of the two TO-3 devices, whilst at the same time minimising the temperature difference between them. Attachments for semiconductor sources, water coolers and cartridge heaters are available.

Fig. 3.

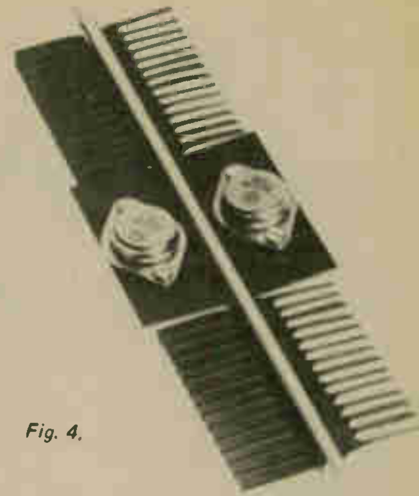


Fig. 4.

The ability of heat pipes to transfer heat from the heat source to the remote parts of the sink, results in an efficient, small, lightweight unit. The unit shown is 200mm x 60mm, weighs 60gm, accepts TO-3 devices and has a forced convection performance of 0.3° C/W. This patented Redline series includes dual in line packages and P.C. board accessories.

in the more moderate temperature range is increasing, and in some measure this market requirement can, and is, being met by tubular forms with simple woven wire mesh wick structures.

PERFORMANCE PARAMETERS

Table 1 shows typical values of some heat pipe performance parameters for a number of working fluids. In this temperature range (-40 °C to +350 °C), where water can be used, it has the best physical properties, but can give chemical corrosion problems with some wick and container materials. Chemical passivation of these items has been proved to be effective and lifetimes in excess of five years are forecast as a result of trials at elevated temperature.

Water filled heat pipes, with simple woven wire mesh wick structures will operate satisfactoriy at temperatures between 15 °C and 250 °C, and will function against gravity with up to 150mm vertical displacement between source and sink.

It is unusual for axial heat transfer to limit the performance of a heat pipe. This is well illustrated by water filled heat pipes which have a typical axial capability of 500 W/cm^3. The heat pipe relies upon capillary action to provide the pressure difference along the wick, so returning the working fluid to the evaporator, and this capillary action can be destroyed if nucleation (boiling) takes place within the wick. Using water, nucleation occurs typically at 3W/cm^2 when operating against gravity, this can be increased to 10W/cm^2 for horizontal operation, and up to 30W/cm^2 when the heat pipe is being used as a thermal syphon with full gravity return. The pipe diameter is therefore chosen in such a manner that these radial fluxes are not exceeded.

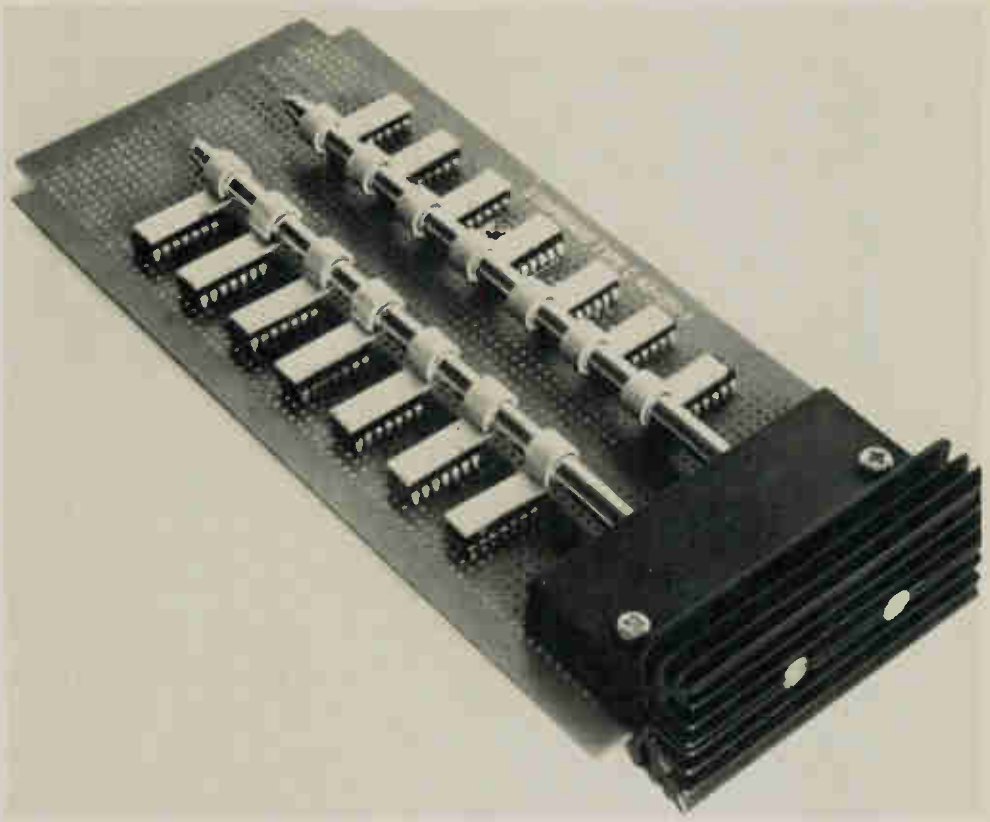
The major part of the temperature drop in a heat pipe occurs across the wick at the source due to the radial input flux. This is about 5 °C to 8 °C at the fluxes quoted above for heat pipe operation. At the highest fluxes possible with gravity return, this

TABLE 1

	Boiling Point °C	Axial Flux W/cm^2	Limiting Superheat °C	Radial Flux W/cm^2	Capillary Rise cm
Ammonia	–33	109	1.8	0.3	7.2
R11	24	12	1.7	0.4	2.2
R113	48	8	1.5	0.3	1.8
Acetone	56	34	1.8	0.8	3.9
Methanol	65	49	2.1	1.1	3.9
Ethanol	78	24	3.9	1.7	4.2
Water	100	450	5.0	10.0	10.0
Toluene	111	22	2.3	0.8	4.4
Thermex	257	25	3.4	1.1	5.0

NOTE: This data refers to boiling point temperature and atmospheric pressure. It is only approximate

HEAT PIPES



Thermal problems often limit further size and weight reduction in many advanced electronic equipment units. Designs embodying heat pipes are rapidly gaining popularity. One such design by Redpoint Associates Ltd., is shown in the accompanying photograph.
The board handle doubles as a heat sink, cooling fourteen D.I.Ps via the two ¼" O.D. heat pipes. With the D.I.Ps running at 1 watt each, the temperature drop from D.I.Ps to handle is less than 5°C. All the components of the thermal system including adhesive, D.I.P. "flags", heat pipes, handles and heat transfer compound are available from Redpoint Associates Ltd., who can also supply thermal systems to customers' specification.

increases to a maximum of 30 °C. In most designs the temperature losses along the length of the pipe and at the condenser amount to less than 10% of these values.

PROPERTIES

Within the design performance parameters above, heat pipes may be used to transport heat, bidirectionally, with temperature differences some hundreds of times smaller than any known solid conductor. This ability to transfer heat efficiently makes the heat pipe a useful tool in the design of equipment for remote heating or cooling, temperature balancing and for heat flux transformation.

APPLICATIONS

When heat is generated at a point where it is impossible or ill – advised to dissipate it, a heat pipe may be used to transfer the heat, with negligible loss to a more convenient point. Such a design is shown in Fig. 3. The heat is transferred from the TO-3 transistors to a flat mounting platform which is in intimate contact with the pipe. As explained above, it is this area of contact between the mounting platform and pipe which determines the maximum power capability of the assembly. The thermal rating of the condenser assembly is the major factor in determining the overall performance.

Conventional high performance heat sinks are large and heavy. In contrast heat pipes may be used to transfer heat to the remote parts of a heatsink, resulting in a lightweight efficient unit. Such a heatsink is shown in Fig. 4. It is approximately one third of the weight of a conventional heatsink having the same performance. The lightweight heatsinking which heat pipes allow, may be combined with the facility of separation, to design a lightweight assembly with a high packing density, for example a stack of power diodes.

Thermal balancing heatsinks have a variety of applications, not the least of which is batch testing a number of solid state devices all at the same temperature. Conventionally, large masses of metal are used to provide the thermally conductive path, but heat pipes give far superior performance. In this field, in order to maintain a near isothermal (one temperature) surface, design values of the radial flux are kept as low as possible consistent with the geometry of the device mounting. A flux of 0.1 to 1W/cm^2 is typical, with temperature variations of 0.1 to 1 °C respectively.

An example which embodies remote cooling, lightweight heatsinking and near isothermal operation is the application to card frame units. In one such application, the heat from all the D.I.L. packages on the PC board is transferred to the handle, which doubles as a heatsink.

In the field of microwave components there are many instances where large amounts of heat can be generated in a confined space. Examples include circulators, isolators, dummy loads and rotating joints as well as such active devices as klystrons, magnetrons, crossed field amplifiers and travelling wave tubes. The current use of heat pipes in this field is minimal, but the potential is considerable.

Although the heat pipe has mainly found application as a means of removing heat. It may also be used as a means of introducing heat. An outstanding example of this is the cooking pin. This device, now on sale in Britain, is inserted by the housewife into her roast and conducts heat into the centre of the meat which therefore cooks more quickly and uniformly.

CONCLUSION

The design parameters of heat pipes may generally be expressed as performance limits such as those given in table 1. The overall thermal performance of a system is usually determined by the heatsink when the heat pipe is operating within those limits. Thus heat pipes for a design may be simply specified in terms of these performance limits, and when operating within these limits may be considered as near isothermal conductors of heat.

Although applications are presently potential rather than current, interest is at a high and increasing level. Increasing demand will inevitably lead to a further reduction of prices and widening of economic application. ●

electronics tomorrow

BY JOHN MILLER-KIRKPATRICK

MANY OF YOU reading last month's article on the digital stopwatch will have wondered whether any of the many digital clock circuits presently on the market will do the same job. The answer is unfortunately no, not at present. There are at present two chips in the final development stage which will be suitable for a digital stopwatch circuit but one of these is a custom design and will not be released for some time and the other is due for release in April-May 1974. No prices or full data have been released on this second chip but I can say now that it runs from a 300kHz crystal input and has hours, minutes and seconds as well as minutes, seconds and decimal alternative display modes. The chip also includes alarm and sleep features but for some reason these features only work for the first display mode and are not presetable down to the decimal seconds. I hope the manufacturers know how much of a potential market they are losing in photographic timers, etc.

The digital clock market is now begining to get into full swing with Cal-Tex introducing three additions to the CT7001 digital alarm/calendar clock. The new ones are the CT7002 with BCD outputs in place of the 7 seqment, the CT7003 with inverted output levels and the CT7004 with the European format of DDMM in place of the American MMDD. Price of samples of these chips is £18. Data and devices (1).

Cal-Tex have also announced the CT6002 digital watch chip running from a 1.5V battery and driving a 3½ digit liquid crystal display. The chip is available in five forms, a 40 pin DIL, a 34 lead flatpack, the die itself, a complete watch module and a completed watch with case and strap. Final prices have yet to be announced but initial samples are now available. Data and devices (1).

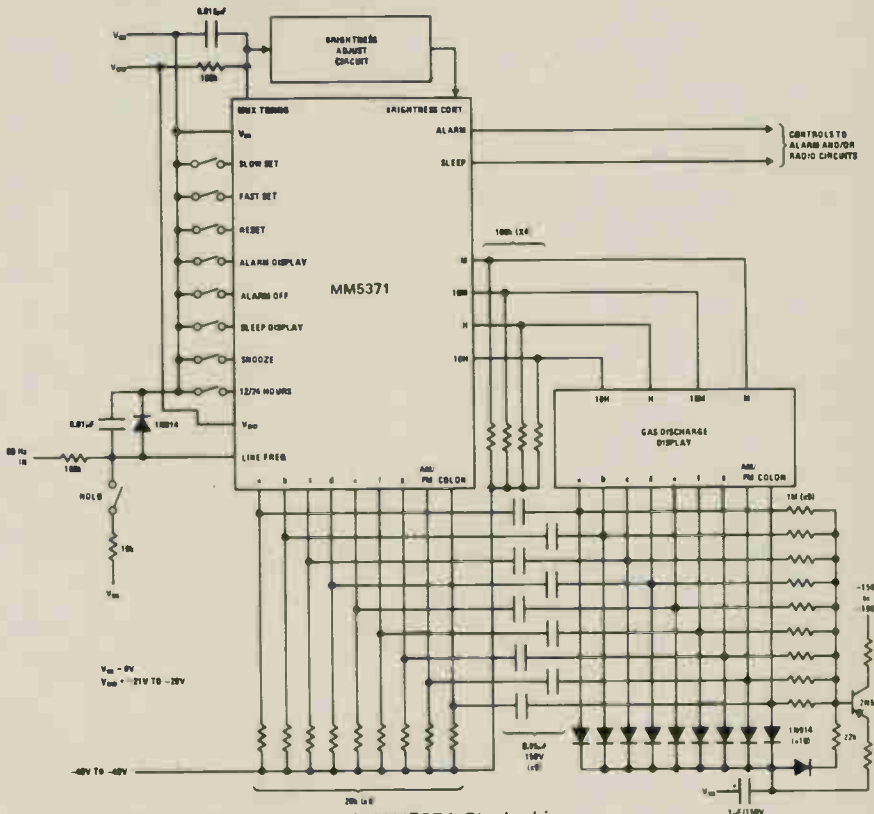
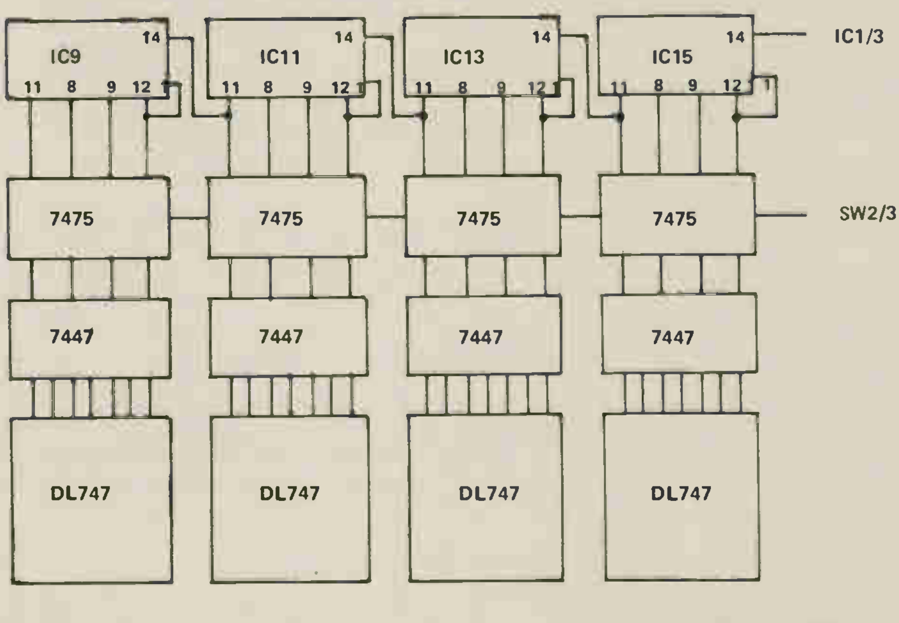


Fig. 1. National Semiconductor's MM5371 Clock chip.

National Semiconductors have announced a new chip for the European market - the MM5371 digital alarm clock chip. Three display modes are incorporated (time, alarm and sleep) with displays in 12 or 24 hour modes only at 50Hz input, the MM5370 is only for 60Hz input. The advantage of this chip is that it interfaces very simply with high-voltage 7 segment displays such as the Sperry SP151. To facilitate the interface to the SP151 the MM5371 includes AM/PM indication and a colon drive outputs. Power supply requirements are 8-29V unregulated d.c. at 5mA, additional supplies at 40-50V and 150-190V are required for the SP151. The simplicity of the circuitry involved is shown in fig. 1. Data on the MM5371 (2), devices (3). Data and devices on the SP151 (4).



MODIFICATION TO ETI STOPWATCH

If you are building the stopwatch in the last issue of ETI you may be interested in an alternative circuit for the display. It is mentioned here because it utilises the new Litronix DL747. The circuit is shown in functions of the HP5082-7302 and produced the three separate units as shown. The outputs from 7490 ICs are passed into the 7475 four bit latches which are latched by

switch SW2/3. The latched outputs are passed into the 7447 BCD to seven segment converters and then on to the DL747s. The use of the 7447s means that leading zero suppression and/or complete display blanking can be added to the circuit but, for details of this, see the 7447 data sheet in the Texas Instruments data book number 2 (available from Henry's Radio 60p). The advantage in using the 7447 is the size of the digit, at 0.6in it is twice the size of the DL707 and similar digits currently available. Data on the DL747 is available from (1) and the devices are available from the same address at the one-off price of £2.62 plus VAT. Our special offer this month is for four of these digits for the stopwatch project at a special price of £10 including VAT. For details see the application form which must accompany all special offer orders. The offer is limited to 250 kits (ie 1000 devices) so please enclose a sturdy stamped addressed envelope for the return of the DL747s or the return of your money.

DATA BOOKS

Finally this month we have news of a set of data books from National Semiconductors. A couple of months ago we mentioned the National range of consumer ICs such as audio amps and colour TV ICs and we said at the time that data was available in sheets. Now National have decided to sell their data books containing full data and applications on their full range of ICs. The books and prices are –

1. Linear Integrated Circuits, Pin layouts and data, some applications. £1.05.
2. Linear Applications, hundreds of circuits and applications, makes a good companion book to the Linear IC book. £2.15.
3. National CMOS Catalogue, Free.
4. National Digital ICs, data on the DM74 range and others. £1.30.
5. National Transistor Book, Full specs on all the transistors. 80p.

The National data books are available from (3) not from National direct.

REFERENCES

1 Bywood Electronics, 181 Ebberns Road, Hemel Hempstead, HP3 9RD.

2 National Semiconductors (UK) Limited, The Precinct, Broxbourne, Herts.

3 Atlantic Components Limited, 143 Loughborough Road, Leicester.

4 REL, Croft House, Bancroft, Hitchin, Herts.

Please remember to send a reasonably sized SAE with all enquiries, include VAT and P & P in any order and mention ETI as a common reference.

VAT AND P & P

Some of the suppliers mentioned in this column in the past months have commented on the number of orders received without allowance for VAT or postage and packing.

Cut

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To BYWOOD ELECTRONICS,
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Dear Sirs,

Please supply four DL747 seven-segment LED displays as mentioned Electronics Tomorrow in the February issue of Electronics Today International. I enclose P.O/Cheque for £10 to include VAT and also enclosed a sturdy SAE for return of devices or payment.

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Unless otherwise stated all the prices mentioned in Electronics Tomorrow exclude any such element of cost and orders without such an allowance are a great deal of trouble to execute. Some of the suppliers mentioned are large distributors and usually ship very large quantities of devices in one parcel, if your order is correct and easy for them to execute and despatch they will do so, if not, then the order might be delayed or even refused. ●

DX MONITOR

Compiled by Alan Thompson

THIS IS IN NO SENSE of the term either a political or an economic feature but "Batten down the hatches, me hearties, there's dirty weather ahead" seems to be a fair comment on the situation as I start writing this month's compilation. Gloom and despondency seems to be the general theme of today's political and economic commentaries. So far as DXing is concerned, we at least know that competition from "the box" will now cease to be with us after 10.30 p.m. each evening, although it may well be that the extra DXing time will be there to enjoy by the light of a guttering candle as the central heating ceases to pump its cheerful warmth against the icy blasts of Winter, and the electric fire gets steadily darker red before lapsing back into chill off-white. I may not be a weather forecaster but I'd guess it is odds-on that 1973-74 will rank as the coldest Winter for many years: shades of 1946-47 and the last real energy crisis.

One takes electricity so much for granted that it is only when it is not available that one realises just how great a part it has in the life of the 20th Century. Assuming that supplies are still available, the curtailment of TV hours will certainly add greater interest to DXing the lower frequency bands, including the medium-wave band. For many years now, we have become accustomed to the harsh sharsh that bedevils the lower frequencies at intervals of some 15kHz whilst TV is on the air: just for the record, the TVI occurs at intervals of 15.625kHz being the product of 615 lines and 25 frames per second. Those of us who can recall the days before 625 line TV can remember when it really was possible to DX the 90, 75 and 60 metre bands without finding that an harmonic of 15.625kHz always occurred just on the frequency of the weak station that one was trying to extricate from the conglomeration of noise and utility transmission signals of all kinds which are to be found in those bands.

Quite truthfully, it is so long since the low-frequency bands were last free of this interference (in the hours up to midnight or so) that it would be a pure guessing game to suggest what one may manage to uncover in the newly released hours from 10.30 p.m. to about midnight. Sticking my neck out a very long way, I would suggest that 90 minutes or so, might well become the serious DXers favourite time-slot if he is a low-frequency addict. There *ought* to be a chance to hear quite a number of the lower-powered African stations which haven't been noted for some time: there *ought*, too, to be an opportunity of logging numerous Asian stations as they start taking the air for their early morning transmission periods: there *ought*, also, to be some good opportunities to hear some of the Latin-American stations at tolerable strength before midnight, rather than in the wee small hours as is usually the case. Lists of stations wouldn't serve a great deal of purpose because so much will depend on the total amount of reduction in noise that will be brought about by the absence of TV-interference *and* the reduction in usage of other commercial apparatus all of which adds to the amount of ambient noise against which a DXer is forever battling. It does, though, seem within the bounds of possibility that there will be a gain in the all-important signal to noise ratio of something of the order of a factor of 3 so long as the present restrictions are with us and that will make an astonishing difference to the number of stations that should be loggable under average conditions. It will be very interesting to experience, again, conditions that have been missing since about 1950 for those of us who are located in average DX - i.e. urban - environments.

If the worst comes to the worst and the mains electricity supplies are cut for long periods then DXing will see more and more of us having to resort to the ubiquitous transistor radio. Even if your "trannie" is equipped with short-wave bands it is unlikely that it will be a suitable instrument for serious DXing on those bands unless it is one of the very expensive variety which can give results comparable to a real Communication receiver, although, sadly, very few of them achieve a very high standard of both sensitivity and selectivity. The "trannie" will, therefore, find its greatest use in chasing unfamiliar stations on the long and medium-wave bands and since most of them are fitted with ferrite-rod aerials they can make very useful receivers for this purpose. The essential fact to be grasped is that the ferrite-rod aerials displays very marked directional properties with maximum pick-up taking place when the ferrite-rod is at right-angles to the direction of the transmitter. Here again, long lists of stations that might be heard are somewhat pointless since so much will depend on one's location, the sensitivity of the "trannie", the time of day or night and, of course, the amount of enthusiasm that the listener brings to the quest. An interesting start might be to make a concerted assault on logging as many as possible of the BBC local radio stations which I listed in last month's feature.

More than likely you have a transistor radio, or FM tuner, capable of receiving VHF transmissions. Once again, it is pointless for me to list stations that you might manage to hear since this would mean setting out practically all the VHF stations of Europe (not to mention North Africa) as in unusual conditions VHF signals can travel over extremely long ranges. At the dead of Winter, long-distance reception is not very likely (although strange openings do occur from time to time) but careful tuning through the VHF band - with the AFC off, if it is fitted - can produce quite a number of stations that you will normally pass by in day-to-day tuning through Radio 2, 3 and 4. The average 4-element folded-dipole is not too critical on its acceptance angle for signals and will receive many that reach it at quite wide angles to its general line of direction. Here near the South Wales coast at only some 60ft or so above sea level, VHF signals are regularly heard from the transmitters of Radio-Telefis Eireann and from ORTF, with West German stations putting in an appearance now and again – this, all on an ordinary domestic "trannie" and a 4-element folded dipole mounted on a chimney about 35ft above ground level.

As you may have guessed, this feature is being written in something of a hurry so that it makes the February issue – Christmas always causes complications in the publishing world and the projected 3-day working week means that a rush-job was called for! I hope that I've managed to give you a few ideas for how DXing can carry on despite the threat of power cuts and that, maybe, it will wean a few readers away from "the box" and get them interested in the pleasures of good old "steam-radio'.

Don't forget the note in last month's issue regarding QSL photographs, will you? There'll be a £1 for each one that we print and you can always go and spend it on a few candles. Send your black-and-white photgraphs (lots of contrast and not bigger than postcard size) to me, together with any queries and comments about DXing, to arrive by the 15th of each month: sorry, but 'photos can *not* be returned. The address to write to is: Alan Thompson, 16 Ena Avenue, Neath, Glamorgan SA11 3AD, and if your query needs a personal reply then a self-addressed, stamped envelope should be enclosed. 73 and Gud DX to you all.

Continued from page 11

PORTABLE RADIO - CASSETTE RECORDERS

For those who like to take their music with them wherever they go, JVC have designed models 9310LS and 9403LS. These models combine a good FM/MW/LW radio receiver with a built-in Cassette Deck.

The cassette recorder sections of both models have auto-stop mechanisms, tape counters, and built-in Condenser microphones. Recording is greatly simplified by the Automatic Level Control (A.L.C.) facility, and a microphone mixing feature with variable sound monitoring adds that professional touch. Model 9310LS has a Pause Control fitted to the deck, and Model 9403LS has a Sleep Timer, and an Anti-Rolling device which keeps the tape speed constant when the unit is being carried around. Model 9403LS also has a slider Tone Control, and a VU meter which doubles as a battery level indicator.

Both models have a dual-cone speaker with cellular horn fitted to give true Hi-Fidelity reproduction, and they can be operated from both AC and DC power sources. Recommended retail prices are £62.50 and £69.95 plus VAT for models 9310LS and 9403LS respectively.

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output. The separate a.c. winding can be used for 24V indicator lamps, making this model especially useful in instrumentation applications.

Pinnacle Electronic Components, Electron House, Cray Avenue, St. Mary Cray, Orpington, Kent.

STEREO TEST RECORD

A new Ortofon 12in LP stereo test record is now available from Feldon Audio. The type QR 2010 disc incorporates 15 separate bands covering a frequency response from 5Hz - 45kHz with a reference level 10cm/sec RMS lateral (L+R) at 1kHz.

Basically intended for pick-up evaluation the test disc can also be used for system engineering evaluation from the cartridge through to amplifier output. In addition to professional recording and audio applications, the disc will prove of value for high quality domestic audio testing purposes and in a number of laboratory testing situations.

Recorder start signals are incorporated on bands one, two, 13, 14, and 15 to allow the disc to be used, in conjunction with B & K pen recorder equipment, to produce graphical illustrations of test results. The record is priced at £11.50.

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SONEX

Sonex, the High Fidelity exhibition will be held from March 29th to March 3lst 1974, at the Post House Hotel, London Airport, with Trade preview days on March 27th and 28th. Entrance will be free to the public and admission is by ticket freely available from local Hi-Fi dealers.

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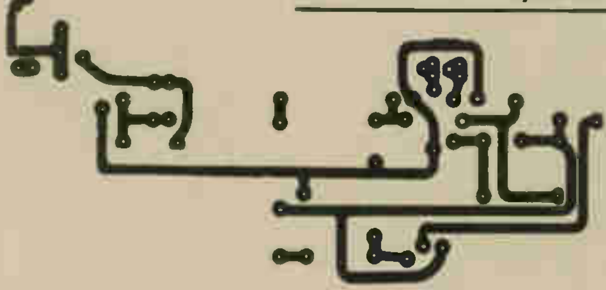

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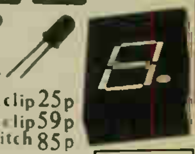

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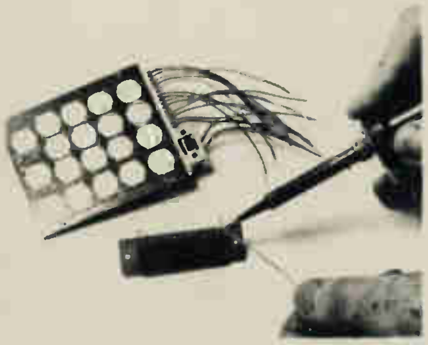

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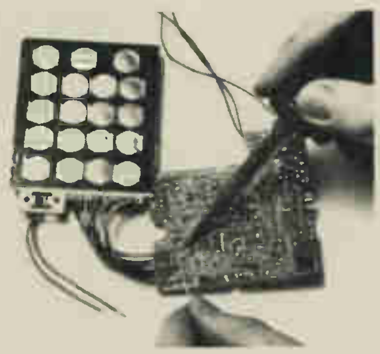

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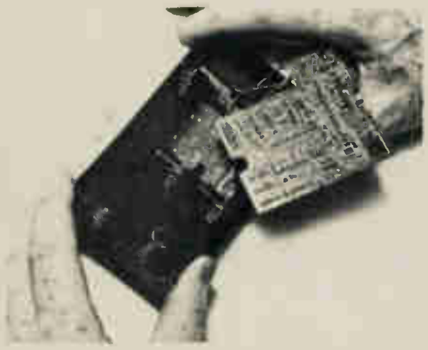

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