BRITAIN'S DYNAMIC MONTHLY

DECEMBER 1972 20p

# electronics TODAY INTERNATIONAL

## SPECIAL OFFER ON FERRANTI RADIO IC

## SIMPLE FET VOLTMETER

## PORTABLE SOUND SYSTEMS

# electronics TODAY INTERNATIONAL

DECEMBER Vol 1 No 9

## main features



## product tests



## projects



## reviews

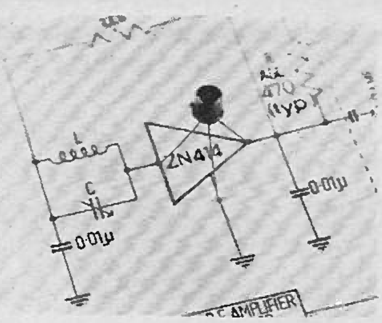


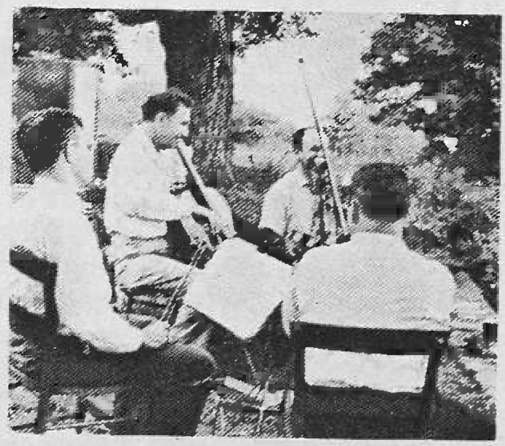
## news & information

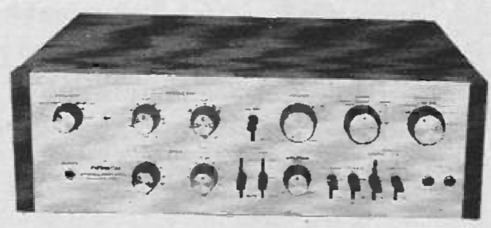


*COVER: Macrophoto of a typical TO5 operational amplifier*

JANUARY ISSUE ON SALE 15 DECEMBER 1972



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G. F. MILWARD

# ELECTRONIC COMPONENTS

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| 32µf 275 volt | 8p |
| Miniature type. Both wires same end. | |
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| 30µf 10 volt | 3p each |
| 50µf 10 volt | 3p each |
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| | |
|---|---|
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| 1,000µf 25 volt | 16p |
| 2,000µf 25 volt | 25p |
| 2,500µf 50 volt | 30p |
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| 125µf 4 volt | 3p each |
| 400µf 6.4 volt | 3p each |
| 320µf 10 volt | 3p each |
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| 320µf 2.5 volt | 3p each |
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| | | | | |
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| 0·056µf 50 volt | 0·47µf 50 volt | 4·7µf 35 volt | 15µf 20 volt | 82µf 20 volt |
| 0·068µf 35 volt | 0·68µf 35 volt | 5·6µf 6 volt | 22µf 15 volt | 150µf 6 volt |
| 0·068µf 50 volt | 0·68µf 50 volt | 5·6µf 35 volt | 22µf 75 volt | |
| 0·07µf 20 volt | 1·5µf 20 volt | 5·6µf 50 volt | 18µf 35 volt | 270µf 6 volt |
| 0·12µf 35 volt | 2·7µf 15 volt | 6·8µf 20 volt | 27µf 20 volt | |
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An aerosol spray providing a convenient means of producing any number of copies of a printed circuit both simply and quickly.
Method: Spray copper laminate board with light sensitive spray. Cover with transparent film upon which circuit has been drawn. Expose to light. (No need to use ultra-violet.) Spray with developer, rinse and etch in normal manner.

| | |
|---|---|
| Light sensitive aerosol spray | £1.00 plus |
| Developer and Etchant | 50p postage |

### NEWER THAN NEW ! ! !

Fibre Glass Board pre-treated with light-sensitive lacquer enabling you to produce prototype printed circuits within five minutes.

| | |
|---|---|
| 75mm × 100mm | 33p |
| 150mm × 100mm | 66p |
| 150mm × 200mm | £1·32 |
| **Epoxy-Resin** | |
| 75mm × 100mm | 22p |
| 100mm × 150mm | 44p |
| 150mm × 200mm | 88p |
| **Plain Fibre Glass Board, Copper-Clad, one side** | |
| 200mm × 175mm | 45p |
| **Bakelite Laminate Board, 1·57mm thick** | |
| 1 sq. foot | 50p |

### ERIE MONOLITHIC CERAMIC CAPACITORS

3p each; 24p dozen; £1·75 per 100

| | | | |
|---|---|---|---|
| | 330pf | 4,700pf | 33,000pf |
| 15pf | 470pf | 6,800pf | 47,000pf |
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| 33pf | 620pf | 8,500pf | |
| 39pf | 680pf | 10,000pf | |
| 47pf | 1,000pf | 15,000pf | |
| 68pf | 1,500pf | 19,000pf | |
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| | 2,700pf | | |
| 220pf | 3,300pf | | |

### MULLARD POLYESTER CAPACITORS

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| | | | |
|---|---|---|---|
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| ·0012µf | ·0022µf | ·01µf | ·033µf |
| ·0015µf | ·0027µf | ·012µf | ·082µf |

20p dozen; 75p-100; £5-1,000; £40-10,000

| | | | |
|---|---|---|---|
| ·15µf | ·22µf | ·39µf | ·82µf |
| ·18µf | | ·68µf | |

20p dozen; £1-100; £6·50-1,000; £50-10,000

### VEROBOARD

| | | |
|---|---|---|
| 2½in × 1in × 0·15in 6p | 5in × 3¾in × 0·15in 28p | 3¾in × 3¾in × 0·1in 24p |
| 3¾in × 2½in × 0·15in 16p | 17in × 2½in × 0·15in 55p | 5in × 2½in × 0·1in 23p |
| 3¾in × 3¾in × 0·15in 20p | 17in × 3¾in × 0·15in 74p | 5in × 3¾in × 0·1in 28p |
| 5in × 2½in × 0·15in 20p | 3¾in × 2½in × 0·1in 21p | |

Spot Face Cutter 38p. Pin Insert Tool 48p. Terminal Pins (0·1 or 0·15) 36 for 18p. Special Offer Pack consisting of 5 2½in × 1in boards and a Spot Face Cutter—50p. "ODDS & ENDS"—½p sq. in.

### RECORD PLAYER CARTRIDGES. Well below normal prices!

GOLDRING G850 Magnetic Stereo Cartridges, Diamond Needle, £4.75. ACOS 101 75p. (Compatible, Crystal) ACOS GP 91/3 (Compatible, Crystal) £1. ACOS GP 93/1 (Stereo, Crystal, Sapphire) £1.25. ACOS GP 93/1D (Stereo, Crystal, Diamond) £1.63. ACOS GP 94/1 (Stereo, Ceramic, Sapphire) £1.50. ACOS GP 94/1D (Stereo, Ceramic, Diamond) £1.88. ACOS GP 95/1 (Stereo, Crystal with two L.P./Stereo needles) £1.25.

### TRANSISTORS AND INTEGRATED CIRCUITS

| | | |
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| Output Transistors | BD 112 | 25p |
| | OC 36 | 50p |
| | BD 145 | 25p |
| Small Signal N.P.N. | BC 108 | 10p |
| | BC 109 | 10p |
| | BF 194 | 10p |
| Transmitting Types | BFR 64 | £1 |
| | BLY 89A | £5 |
| | BLY 93A | £9 |
| Microwave Varactor Diodes | BXY 27/28/32/35/36/37/38 39/40/41 | £1 |
| Microwave Detector | CAY 10 | £5 |
| Microwave Mixer | CL 7331 | £20 |
| Microwave Gun Effect Oscillator | CL 8370 | £10 |
| | CL 8380 | £10 |
| | CL 8390 | £10 |
| | CL 8470 | £40 |
| Microwave Tunnel Diodes | AEY 13 | £5 |
| | AEY 16 | £10 |
| R. F. Transistors | BF 180 | 20p |
| | BF 194 | 10p |
| | AF 124 | 20p |
| Field Effect Transistors | BFW 12/13/14 | 25p |
| Micro-miniature N.P.N. | BFS 18R | 10p |
| | LDA 400/403/450/452 | 10p |
| Infra-red Transmitters | CQY 11A | £4 |
| | CQY 12A | £10 |
| Light-sensitive Trans. | OCP 70 | 20p |
| Complementary Drivers 2 watt | DW 6518/9 (per matched pair) | 30p |

| | | |
|---|---|---|
| TBA 500 | Luminance I. C. | £1 |
| TBA 510 | Chrominance I.C. | £1 |
| FEQ 101 | 64 bit Memory | £1 |
| 7400 | | 12p |
| 7401 | | 12p |
| 7410 | | 12p |
| 7420 | | 12p |
| 7440 | | 12p |
| 7453 | | 12p |
| 7470 | | 24p |
| 7472 | | 24p |
| 7473 | | 32p |
| 7474 | | 32p |
| 7482 | | 88p |
| 7483 | | 95p |
| 7490 | | 58p |
| 7491 | | 78p |
| 7492 | | 58p |
| 7493 | | 58p |
| 7495 | | 68p |
| 5400 | | 10p |
| 5404 | | 10p |

| | |
|---|---|
| **£1** 100 ½-¼ WATT RESISTORS, 100 CERAMIC CAPACITORS, 100 DIODES | PACK No. 1 |
| **£1** 100 RESISTORS, 100 CERAMIC CAPACITORS, 100 POLYSTYRENE CAPACITORS | PACK No. 2 |
| **£1** 1 VERO-BOARD CUTTER, 5 2½ in. × 1 in. × ·15 BOARDS, 50 SQ. INS. "ODD PIECES" VERO | PACK No. 3 |
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**Shaun Kannan**
*Editor, British Edition*



# BIGGER and BIGGER and BIGGER and....

ELECTRONIC technology continues to expand at an astronomical rate with traditional mechanical and electromechanical tasks rapidly giving way to more reliable and accurate electronic methods. Truly, electronics may now be said to be the nervous system of our entire society.

It is extremely difficult for individuals to keep up with the mushroom expansion of electronic technology, for, it is physically impossible to read more than a very small percentage of the vast worldwide electronic literature output. This is where we come in.

Electronics Today International is dedicated to bringing you the broadest and most up-to-date coverage of progress in the electronics industry, and this written in everyday language without loss of detail or accuracy.

As part of our continued expansion we announce our new edition ELECTRONIQUE POUR VOUS INTERNATIONAL, a joint venture by ourselves and SOCIETE DES EDITIONS RADIO, the largest publisher of electronic journals in France.

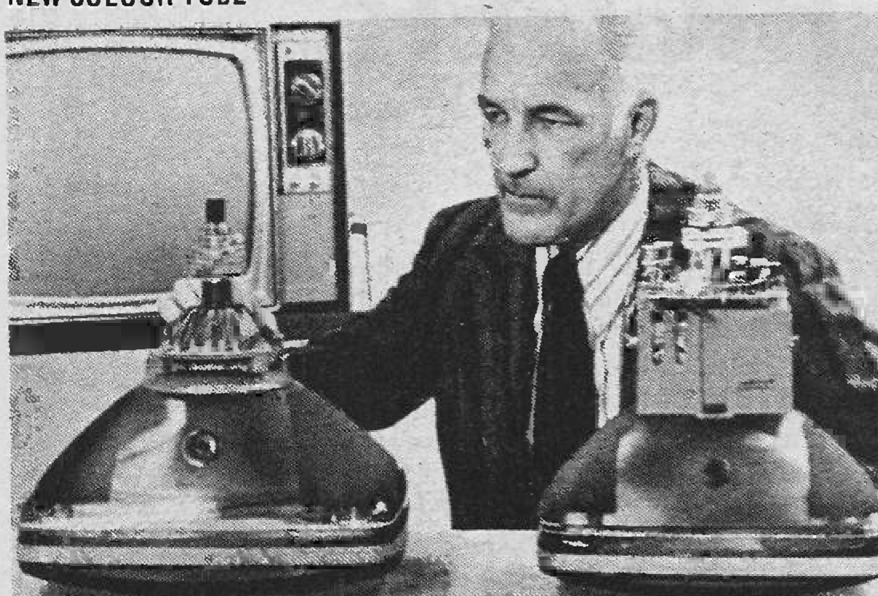
Details of the launching of the new publication together with photographs of our senior international editorial staff are provided on pages 18 and 19.

In keeping with the International character of the ETI organization, our senior editorial staff regularly travel the world, exchanging positions, thus maintaining the fresh approach that delights our readers.

Now we are the third largest in the world – and still growing.

# news digest

## NEW COLOUR TUBE



*Left: new RCA tube has all deflection and convergence elements bonded to neck — according to the manufacturers it is smaller, lighter, and easier to set up than conventional tube (shown on right).*

A new colour CRT, introduced by RCA, in America uses an in-line, triple-beam gun structure, and a line-focus-type of static toroidal deflection yoke that eliminates the need for dynamic convergence. The shadow mask has vertically oriented slit-shaped apertures with the phosphor array forming vertical green, red, and blue lines. Dynamic convergence magnets are not required.

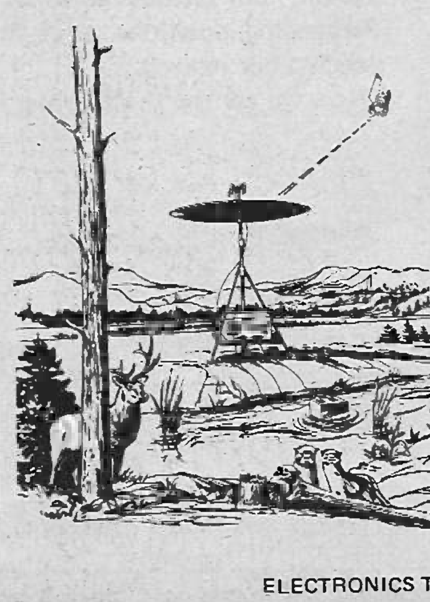
The three-gun assembly is arranged horizontally and is about half the size of the conventional delta layout.

A single static convergence and purity device is included in the yoke assembly which is bonded to the neck of the CRT.

The new approach produces a 1.8" shorter tube, 2½ lb lighter than present 90° systems. The new tubes will be available in 15", 17", and 19" sizes. RCA is also working on a 13" version.

## ERTSA SATELLITE

This artist's impression of the Earth Resources Technology Satellite-A (ERTS-1 in orbit) shows how remote data collection platforms will collect environmental data and then radio the information to ERTS-A as it passes overhead. Some 150 of these electronic rugged platforms will be scattered around the North American continent to monitor such local conditions as stream flow, snow depth, soil moisture, volcanic activity and almost any other environmental condition. These platforms are built for NASA's Goddard Space Flight Center by the General Electric Company.



## FOUR-CHANNEL PATENTS

Columbia Records and Electro-Voice have reached an agreement for an exchange of patent rights and technology related to their respective 4-channel quadraphonic disc systems. Such rights and technology will also be made available to others. Columbia introduced its SQ quadraphonic disc system in June of last year; Electro-Voice has marketed its own quadraphonic system under the brand name Stereo-4 since February 1971. Under the new agreement, E-V will be able to produce a new, modified integrated circuit designed to decode records for the SQ system. In turn, Columbia's equipment licensees will be able to obtain access to E-V's patent privileges and technical knowledge. Included in this exchange are rights to the recently issued U.S. patent to Peter Scheiber for matrixing techniques.

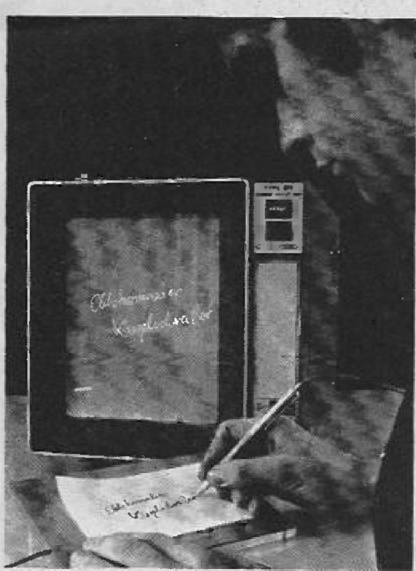
## NOISE SIMULATOR AIDS ARCHITECTS

A 'black box' that electronically mimics the sound insulation performance of any type of window system, has been developed by Pilkingtons in the UK (St. Helens, Lancashire) to aid architects. Known as a 'Spectrum Shaper', the equipment is fed tape recordings of 'raw' noise — such as the low frequency rumble of traffic and the high frequency screech of aircraft — which has not been 'softened' by any form of insulation. The volume and frequency of the sound on tape being fed into the equipment is modified by a bank of 16 electronic filters that are set to correspond with measured decibel figures for any window system. The resulting sound is what one would hear immediately behind the window area.

## ELECTRONIC PEN FOR COMPUTER

A new input device for direct transmission of hand-written matter to a computer has been evolved in the Siemens' research laboratories at Munich.

By use of a special electronic "ball-point pen" and a thin piezo-ceramic plate as a writing base, drawings, sketches and handwriting can be passed directly to a computer as they are being written. The data can be transmitted over regular telephone



lines for storage in the computer or to a display terminal.

The basic idea of the transmission method is to convert the position of the stylus continuously into electric signals and communicate them to the computer. An accurate image of the writing is obtained from evaluating the signal position by means of an electronic circuit linked to the plate and the pen. The pressure of the stylus on the writing pad does not, in itself, determine its position, but ultrasonic pulses with a pulse repetition frequency of 500 Hz are generated alternately at two edges of the writing pad, these edges being at right angles to each other. The acoustic pulses travel across the writing pad at a constant velocity, parallel to the edges from which they are emitted. Since the pulses apply slight pressure to the piezo-ceramic plate they create a voltage front which travels across the writing pad and is picked off capacitively by the stylus with a converted, common ball-point pen acting as a probe.

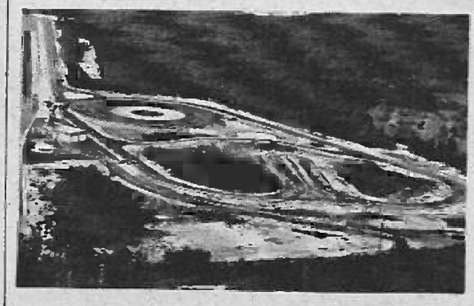
An electronic evaluator, connected to the piezo-ceramic sheet and to the stylus, forms signals from the propagation times of the acoustic pulses from the edge of the writing sheet to the stylus. These signals, which represent the instantaneous position co-ordinates of the pen, can then be passed to a transmission line.

The system being developed by Siemens is simple and economical in comparison with other methods. The degree of accuracy in transmission of writing to the computer is very high. In the present experimental set-up the deviations remain under one per cent. Even minute distances of only 0.2 millimetres between two points or lines, and notes jotted down very quickly, are registered accurately. After scanning, the graphic information can be transmitted to the computer via telephone lines.

For researchers, however, this is but one step in the direction of more advanced techniques. Later on they hope that the computer will "learn" to process handwritten matter independently — for example, to read it and send it out in printed form.

## TYRE TORTURE

An aerial-view of Pirelli's computerised open-air tyre test laboratory which is claimed to be the most advanced in the world.



The complex at Vizzola, 40 miles from Milan, uses electronic systems as sophisticated as those of the latest space and missile techniques.

Information from cars under test on the seven circular and straight multi-surface tracks is transmitted to the control room by multi-channel radiotelemetry units. This information is then analysed by computer, so that Pirelli's 1,300-strong research and development staff can compress into a few days, work which would otherwise take several months.

The second picture shows the telemetry equipment carried in each car.

## ELECTRONIC TORNADO DETECTOR

More than 15 sites in 10 tornado-prone areas will be monitored during the 1972 storm season with new portable electronic detectors developed by scientists of the United States Department of Commerce's National Oceanic and Atmospheric Administration (NOAA).

The new monitoring equipment will enable tornadic research to be spread out over a wide geographic area. This will greatly increase not only the probability of successful tornado observations but also the statistical accuracy of the results.

The tornado detector is a receiver tuned to 3 MHz and a recorder to note atmospheric electrical events. The locations for the test were selected for their proximity to radar observations of a National Weather Service WSR-57 weather radar station — ideally, 48 km between radar and the tornado electronic recorder should provide good radar views, free of ground clutter, of any storms triggering the receiving device. Scientists at NOAA's Environmental Research Laboratories have been studying the possibility of an identifiable electrical signal from severe storms that might be useful for tornado warnings.

The last two years of observational research indicate that many tornadoes occur simultaneously with what seems to be a distinctive electrical signature that becomes easier to identify as the storm increases in severity. Research is still in an early stage and further observations are necessary to establish the feasibility and reliability of using such an electrical precursor as a tornado forecasting technique.

## APOLLO 17

Apollo 17 commander Eugene A. Cernan prepares to remove a traverse gravimeter training mockup from Lunar Rover for deployment during

extravehicular activity (EVA) training at the Kennedy Space Center. Apollo 17, with Cernan, command module pilot Ronald A. Evans and lunar module pilot Harrison H. "Jack" Schmitt, is scheduled for launch on the sixth U.S. manned lunar landing mission no earlier than December 6, 1972.

## MOBILE DOG-SLED RADIO

Topping the 'whatever next' league at the moment must be this story from Racal Electronics in South Africa.

Having supplied quantities of radio equipment to the South African Antarctic Expedition, Racal is naturally in fairly close touch with events and was interested to hear of the claim by one of the Expedition's members to have effected the world's first radio contact (QSO in radio ham terms) by an amateur from a dog-sled mobile installation. The QSO was achieved on 7MHz between the sled in Antarctica and a station in South Africa. Racal has supplied the Expedition with a number of TR.28 HF transceivers which it uses for mobile applications.

The Expedition's base station (call sign ZSIANT) which is equipped with Racal transmitter and receiver, is in the charge of Frank Schneider who left Racal to join the Expedition as base radio technician. Frank is also an enthusiastic radio ham who operates most evenings between 1600 and 1900 GMT on SSB at about 14.30MHz (call sign ZS6GE). As Antarctica is classed as a separate continent for many amateur radio certificate awards, a contact with Frank is considered a rare achievement and so his QSL cards confirming radio contact are in great demand among the world's radio amateurs.

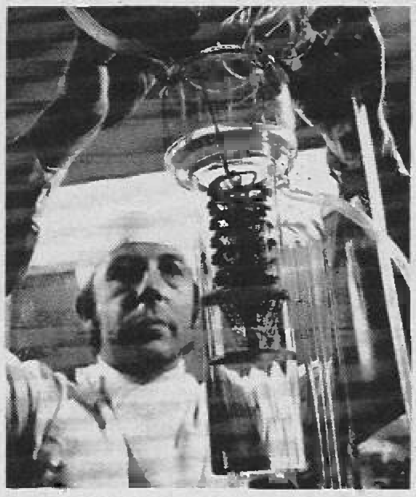
If any UK hams manage to contact ZSIANT, the address for QSL cards is 5, Prinshof Street, Pretoria, South Africa or via the SAARL QSL Bureau. (170)

## CANTAT 2 UNDERSEA CABLE

One of the cleanest places on earth is in a North London suburb. In a room about twice the size of the average garage the air has been filtered and conditioned to such a degree that it compares favourably with that in the most modern hospital operating theatre. The room exists so that telephone calls can be made more easily and with better results. It is part of the Post Office research establishment at Dollis Hill where tiny transistors, no bigger than pinheads, the vital heart of modern submarine cable systems, are manufactured and tested. Technicians dress like surgeons — even wearing nylon caps and special footwear — for the tiniest speck of dust will contaminate the transistor.

One of the more important tasks now being undertaken in the laboratory is the development and supply of some of the long-life transistors needed to help boost speech signals along the new £30,500,000 undersea cable to be laid between Britain and Canada in 1973/74. The cable, code-named CANTAT 2, will carry more telephone calls than any other trans-Atlantic undersea cable — almost 2,000 calls at any one time.

Of every 10,000 transistors made, only 1,000 find their way into a cable system. A few of the remainder are



rejected for minor faults at an early stage. The rest are used in exhaustive tests to demonstrate the complete reliability of those chosen for system use.

The picture shows a technician lifting a batch of transistor 'headers' — small gold-plated beds on which the transistors will eventually rest — from an alcohol bath. The 'headers' are then baked in a vacuum. (166)

## MINICOMPUTER OF THE FUTURE?

Recently Motorola's European Computer Marketing Group has been taking a long hard look at the computer market with the emphasis on the small machine. They came to the conclusion that the marriage of two separate semiconductor technologies could lead to some very exciting developments in the small computer field.

For some time now the performance of minicomputers has remained fairly constant while the price has continued to fall steadily, helped by the fall in cost of semiconductors. If Motorola'a predictions are correct the performance of small machines will rise dramatically while the cost will continue to fall and, for the first time, cost/performance trends will become divergent.

The way in which this exciting development might be achieved is to use a very high speed e.c.l. central processor coupled to nmos semiconductor stores. Such a computer could be extremely powerful and might have a minimum storage capacity of 32k words (against 4k) rising to a maximum of 256k words. The very high speed of the central processor and the large storage capacity could result in machines whose performance is limited only by software development and which are no larger than the minicomputers of today.

Reloadable control store structure and ambitious architecture will enable the small machine to enter areas previously dominated by other machines. As soon as clock rates up in the 100 MHz region are mentioned, engineers tend to take a deep breath and visualise sophisticated and expensive interconnection techniques. To see how easy, or how difficult, it would be to implement such a computer Motorola's application laboratories in Geneva designed and built a demonstration model.

It is stressed that Motorola have no intention of manufacturing computers. The exercise being discussed was carried out to assess the feasibility of an idea and to demonstrate to interested parties how a high-speed processor could be constructed with MECL 10,000.

The central processor built at Geneva consists of some 170 MECL 10,000 i.cs which have been connected together on normal double sided printed circuit boards without much regard for the rules of circuit layout at such high frequencies. The demonstration minicomputer stretches most of the basic engineering rules concerning MECL 10,000 layout and termination to their limits and yet still manages to function most successfully.

The demonstration minicomputer employs a 16 bit word length with a microcontrol word length of up to 56 bits. There is no random access memory fitted and control for demonstration purposes is provided by a read only memory or by switches. Arithmetic is carried out in two's complement form, the execution time being typically 100 ns; logical operations are carried out in typically 66 ns. Altogether 68 microinstructions are accommodated.

The combination of e.c.l. and nmos technologies is the most likely trend in the development of the minicomputer. (168)

# ONE CHIP

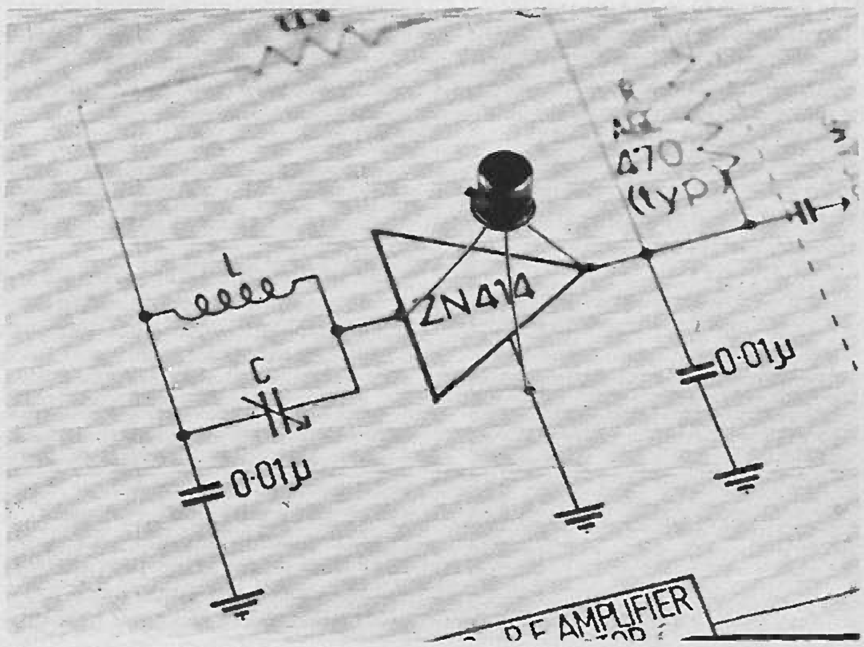



*Fig. 1. The Ferranti radio IC superimposed on a simple tuner circuit.*

**At last! A radio on a single IC chip. This low-cost device requires a minimum of external components to make a complete radio receiver.**

Over the past few years many integrated circuit radio receiver designs have been developed and marketed. Almost universally these designs have been expensive and have required a considerable number of external components to complete the circuit. Typically they have been priced in the £2 to £5 bracket and this has virtually doomed them to failure as a commercial proposition. For at such prices, a manufacturer is better off staying with his cheaper, tried and true, discrete component design.

Ferranti, using their new CD1 bipolar process of chip fabrication, have produced a 10 transistor, TRF radio circuit which is housed in a 3 pin TO18 package as used for conventional transistors.

The IC, known as the ZN414, provides a complete AM radio receiver circuit which is powered by a single one and a half volt battery (supply range 1.1 to 1.8 volt). The only external components required to start listening, are a ferrite antenna coil, tuning capacitor, two decoupling capacitors and headphones. By the addition of another power amplifier IC we have a full, standard wireless set.

## THE CDI PROCESS

How is it that Ferranti have been able to market the device at such low cost? The secret is in the CDI (Collector Diffusion Isolation) process originally developed by Bell Laboratories in the USA.

The process has been the subject of further intensive development work by Ferranti. This has now made possible for the first time, the practical manufacture of LSI (Large Scale Integration) circuits which combine the high complexity and density of conventional MOS with the performance advantages of current bipolars. Among these advantages are high switching speed, Dïgilin (digital and linear functions on the same chip), and high current capability. More significantly, a supply voltage range of 1 volt up to 5 volts not only gives a single 5 volt supply rail which is truly compatible with TTL, but also allows battery operation.

As a bipolar technology based on the bulk properties of semi-conductors, Ferranti CDI possesses the high stability and ruggedness of conventional bipolars. This allows simple, low cost plastic packaging, which is an advantage over conventional technologies like MOS, that are based on the surface properties of semi-conductors and are most susceptible to ionic contamination.

This new bipolar LSI technology, has such versatility of design and application, that it will be widely used in areas as diverse as desk calculators, automotive electronic systems, high speed random access memories for computer, random logic arrays and telecommunications

### CHARACTERISTICS OF ZN414

| | |
|---|---|
| Supply Volts | 1.1 V to 1.8 V |
| Storage Temperature Range | —65°C to +125°C |
| Operating Temperature Range | 0 to +70°C |
| Supply Current | 1 mA typical |
| Frequency Range | 200 kHz to 1.5 MHz |
| R.F. Output Impedance | 1.5 MΩ typical |
| Threshold Sensitivity | 100μ V rms (modulated R.F. signal across aerial coil) |
| Power Gain | 70 dB typical |

# RADIO

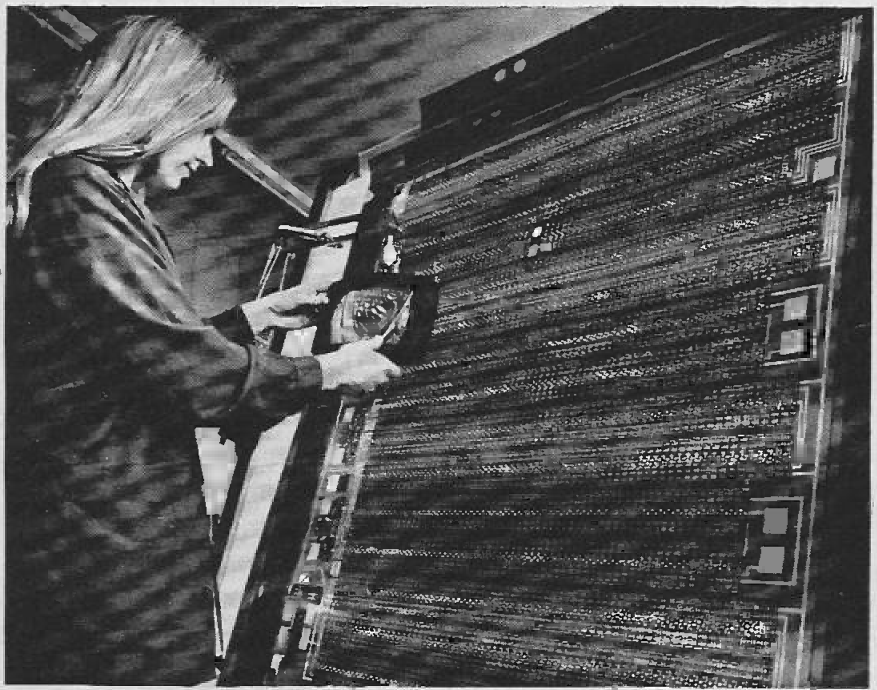


*Fig. 2. Physical inspection of the "rubylith" of a 1024 bit CDI shift register.*

through to consumer products. It could well provide the first high performance "computer on a slice", or maybe on a single chip !

### THE CDI RADIO

The ZN414 operates on the TRF (Tuned Radio Frequency) principle which was used in the earliest radios. The circuit is simple and reliable but was later superseded by the still used superheterodyne principle which has the advantage of greater selectivity.

With suitable layout the ZN414 may be used to build a stable radio circuit which requires no setting up of oscillator or IF coils (because it does not have any). Built-in AGC capability is provided, which is externally programmable if required. The chip has a built-in detector and provides sufficient output (typically 30 mV RMS) to drive headphones, or by the addition of a power amplifier stage, a standard loudspeaker.

To obtain good selectivity, the circuit must have an efficient high "Q" coil and capacitor tuning network. With such selected components selectivity is comparable to superheterodyne designs, with the exception that a very strong station may swamp the front end. For this reason it is best to use a ferrite rod antenna so that the set may be rotated for a null on a very strong station.

The radio output is taken from the AGC defining resistor through a capacitor and volume control to headphones or to a separate audio amplifier. In order to take full advantage of the wide bandwidth and low distortion offered by the tuner, a high quality audio amplifier is well justified.

Although a high quality amplifier and speaker are worthwhile, the tuner will still give improved performance and sound over superhet designs when used with small amplifiers and speakers. This is due to the wide bandwidth and low intermodulation distortion obtainable with these devices.

With a coil having a "Q" of from 75 to 100 a bandwidth of 12.5 kHz is obtained. Higher "Qs" will give better fidelity but selectivity will suffer.

(Continued overleaf)

**FEATURES OF ZN414**

- CDI bipolar process
- 1.1 to 1.8 volts supply range
- Medium and long waveband
- 3-pin package
- No setting up of IF coils
- Good stability on assembly
- Effective and variable AGC action
- Low current consumption
- Sufficient output to drive earphones or a simple audio amplifier
- Excellent audio quality
- Power Gain 70dB typical

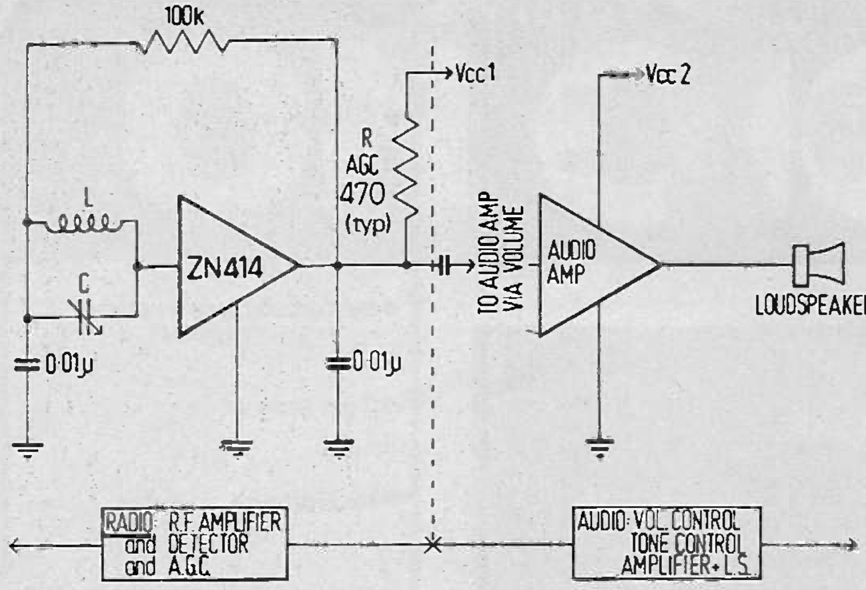



*Fig. 3. Circuit diagram of a typical radio receiver.*

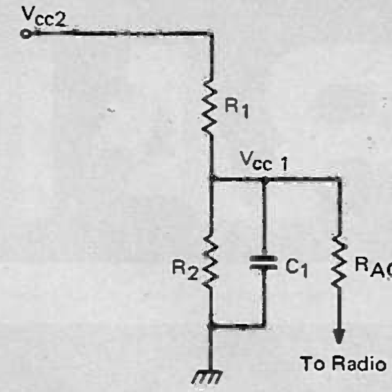



*Fig. 4. If the radio supply is derived from a high potential source, eg 6/9 volt battery, a potential divider must be used to obtain correct AGC action.*

Provided the detector is not overdriven by a very strong signal, the audio output is extremely linear. Manufacturer's measurements of distortion with a 1 MHz carrier wave modulated (30%) by a 400 Hz tone gave a total harmonic distortion of 21%. Most of this distortion is second harmonic which is not excessively objectionable to the ear.

By adjusting the AGC to suit individual requirements it is possible to receive local broadcasts on much smaller aerials than usual. The circuit is fully stable on a 1.5 volt supply, and will function, albeit with some reduction of gain, down to 1.0 volt. Temperature stability is also good, the circuit working well from 40°C to +70°C.

As well as radio receiver applications, we can see many others, such as for remote control. The device is a very interesting one and should find many uses.

## LAYOUT REQUIREMENTS

If the ZN414 radio is operated with the recommended component values and supply voltages, stable operation is assured provided the following layout criteria (in order of importance) are followed:

1. The output decoupling capacitor should be soldered as near as possible to the output and earth leads of the ZN414, and its value with the AGC resistor should cause roll off at ~4 KHz.
2. All leads especially from the ZN414 should be kept as short as possible.
3. The tuning assembly should be adjusted so as not to affect the stability. This normally involves keeping the ferrite aerial more than 1 inch away from the ZN414.
4. If stability problems are still encountered then supply voltages should be maintained below 1.5 volts.

In general, provided condition 1 is met, then no stability problem should be encountered. If a printed circuit board is found to be satisfactory, then any ZN414 will then work *in situ* on that board.

Next month ETI will present the first of two radio projects using the ZN414 integrated circuit. ●

## NEXT MONTH

**Special radio project using the Ferranti radio IC**

- **Operates on medium and long wave bands**
- **Full constructional details given**
- **Printed circuit board foil pattern**

**Don't miss this interesting and educational project.**

**TABLE 1**
**A comparison of CDI with present day Bipolar and MOS technology**

| | | Present day Bipolar | Present day MOS | CDI |
|---|---|---|---|---|
| Complexity | | Medium | High | High |
| Process | | Complex | Simple | Simple |
| Speed | | High | Low | High |
| Speed Power Product | | Medium | Medium | Low |
| Linear | | High Performance | Limited Performance | High Performance |
| Digilin | | Practical | Not Practical | Practical |
| Chip Size | | Up to 120 mils square | Up to 180 mils square | Up to 180 mils square |
| Supply Voltage | Digital | 1V to 15V | 12V to 30V | 1V to 5V |
| | Linear | 1V to 40V | | |

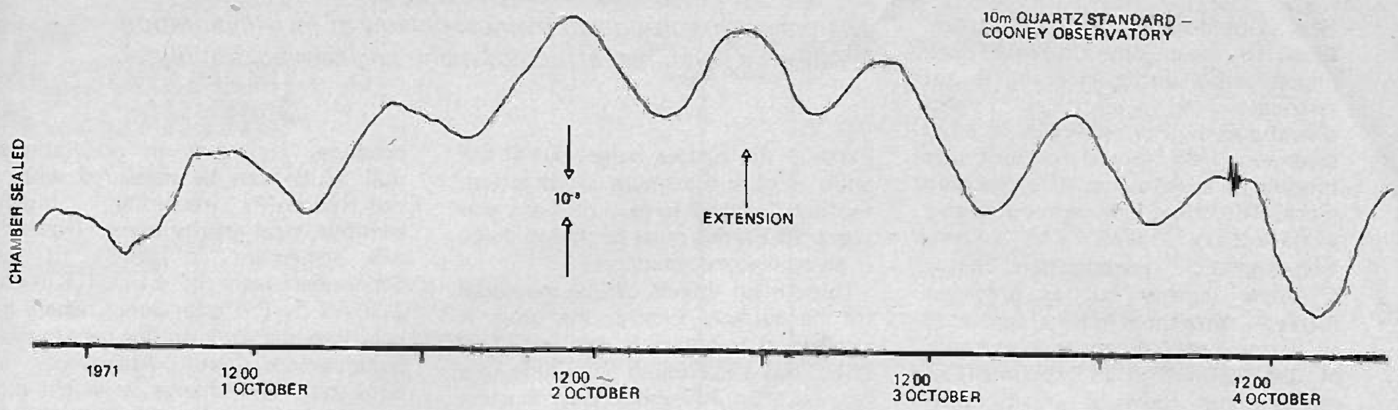



*Fig. 1. Tidal strain curve as produced by quartz-tube extensometer located in the Cooney Observatory in the New England area of NSW.*

*Fig. 2. Looking across the Hillgrove Gorge toward the Observatory entrance which is arrowed near the bottom on the right.*

*by*
*Associate Professor Ronald Green and Dr. Peter Sydenham, Department of Geophysics, University of New England, Armidale, N.S.W.*

# FINE MEASUREMENT IN GEOPHYSICS

NOT only the atmosphere and the oceans but the entire globe itself is continually changing shape due to the varying gravitational pull exerted by the Moon and Sun on the Earth.

Earthquakes and large explosions also set the Earth in vibrational motion as the released energy is slowly dissipated over a period of several days. The amplitude of the movements is usually too small to see visually but with extremely sensitive instruments the changes in the shape of the Earth are clearly demonstrated. It is geophysicists who are concerned with this phenomena.

## THE ROLE OF INSTRUMENTATION

Common to all aspects of geophysics (and indeed to all human activity) is the need to measure in order to provide quantitative facts for theories, for forming new theories to explain observed facts and for monitoring or improving a known process.

In particular, the task of gaining fundamental knowledge of the Earth continually requires the highest possible levels of detection and the greatest stability from instruments.

But instrumentation is more than the intercoupling of standard electronic black-boxes — it is a scientifically based creative art in which, in the main, electronic, mechanical optical and chemical processes are intermixed to change the original form of the one or more variables of interest into a converted (transduced is the technical term) equivalent form that is more appropriate for recording or control purposes. The best solution comes from careful selection of all available techniques — not merely from the tools of one discipline.

In geophysics, especially, consideration must be given to the noise present in a measurement (the term is used here in its most general sense to mean any unwanted and unpredictable disturbance and is not restricted to electrical signal disturbances). For example, a stray magnetic field would perturb the motion of a pendulum of a precision clock. The effect may be reduced to a satisfactory level by using non-magnetic construction. That is a simple remedy but as precision increases, unwanted effects appear at an alarming rate. A very good example of this occurred in an experiment to measure the force of gravity with extreme precision.

In this experiment a precisely calibrated ruler with distance marks at each end was released to fall past a photo-electric sensor, the whole operating in vacuum. The time taken for the two marks to pass enables the gravitational constant to be determined in relation to the time and length standards. It was found that precision was limited by length oscillations of the scale as it fell. The ruler altered length once it was released for it no longer had to support its own weight. The effect was minute but so was the precision required — parts in 100/ million.

It is the relative magnitude of signal resolution and noise disturbance levels that matters, not the absolute level.

## CRUSTAL MOVEMENTS

No material known to man is perfectly rigid; the Earth is certainly no exception. As it rotates around the Sun, and the Moon around it, the gravitational attraction between the three bodies varies due to changing orbital separations. This continually changing attraction produces sea tides which are familiar to all. It also produces the less obvious, minute changes in the shape of the elastic

*The optimum solution to many problems of instrumentation involve the combined efforts of many engineering disciplines.*

Earth — the surface bulges out at the point of maximum attraction. Earthquakes and large explosions also cause the Earth's crust to change shape in an oscillatory manner.

Three main effects can be measured in the surface. Firstly, the crust is strained as it bulges in and out. This effect has a maximum amplitude of a few parts in 100 million. In tangible terms, a 10 metre length of rock slowly increases in length by up to 300 nanometres (300 $10^{-9}$m) (12 millionths of an inch in a 33 foot distance) and then returns to zero. This cycle has a period of approximately 12 hours as seen from a recent record shown in Fig. 1. The maximum velocity of this movement is such that it would take a million days (2740 years) to cover a metre if the maximum rate of movement continued in one direction.

A second effect is that as the Earth's shape changes, the relative movements of mass causes changes in both the direction and magnitude of the local gravity field. A freely hanging plumb-bob on the surface will, therefore, change its inclination by a small amount. This tilt variation also follows the strain curves in its general form. It is a very small effect. A deflection of six inches over the distance from Sydney to Melbourne is the angle involved.

The point of measurement on the surface is raised and lowered with respect to the position of the centre of mass of the Earth. This effect added to changing gravitational pull exerted directly by the Moon and Sun produces variations in gravitational pull which can be measured with a continuously recording, highly sensitive, tidal gravity meter. (Readers will remember an article in the September issue of ELECTRONICS TODAY by Professor Jones, where he described the work on fine geophysical measurement at Aberdeen in Scotland). The change in weight due to tidal causes is like adding a one-cent piece to a 21 ton block (a steel block would be five feet cube).

## THE COONEY UNDERGROUND TIDAL OBSERVATORY

Solid-tidal strain and tilt effects cannot be satisfactorily measured on top of the ground as the surface undergoes dimensional changes caused by exposure to the weather elements. For example, a submerged wall in the basement of our Geology building changes length by several parts per million as a court-yard above is cyclically exposed to the sun. This swamps tidal strain. Best measurements are made at depths of 100 metres or more where ground cover acts as an insulator to average-out surface effects to virtually zero. (Tidal gravity can be measured on the surface but underground operation eases the instrument construction considerably.) For large-scale observatory operations in this field of measurements it is essential to move underground. It is, however, not an easy matter to locate a suitable underground tunnel complex. It must be deep in the

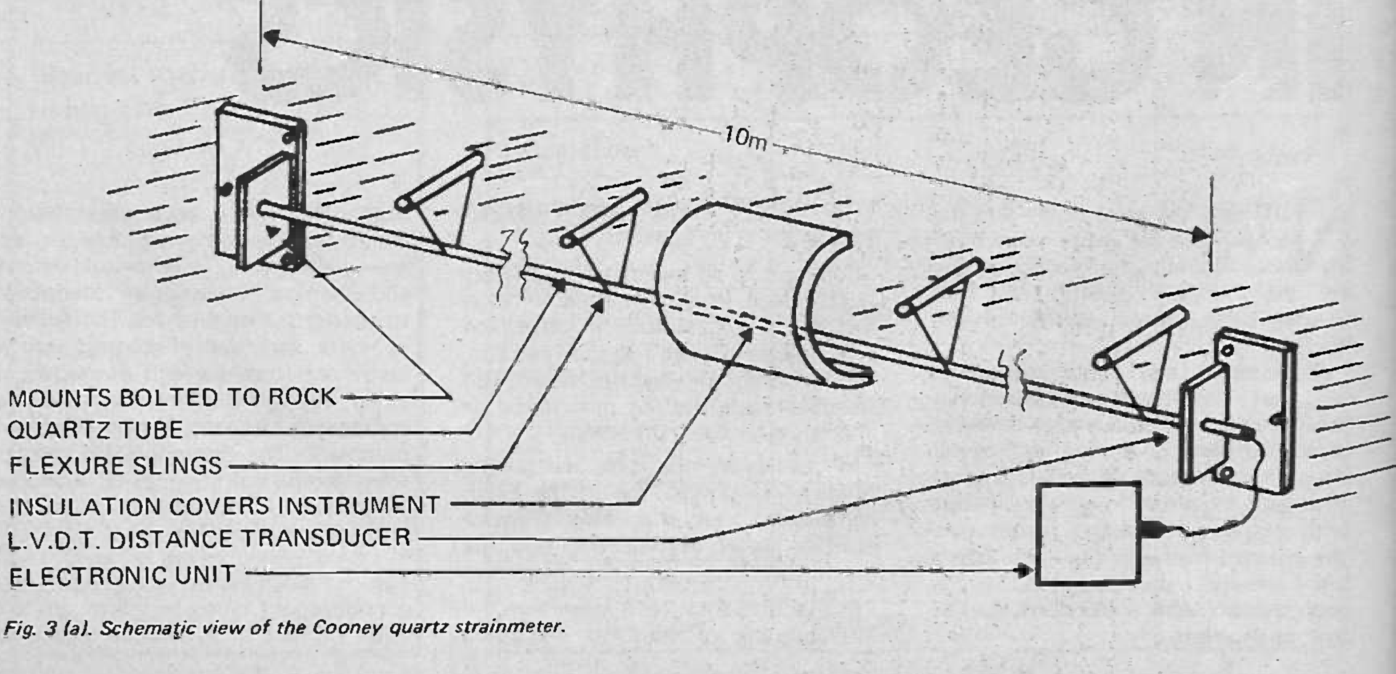



*Fig. 3 (a). Schematic view of the Cooney quartz strainmeter.*

# FINE MEASUREMENT IN GEOPHYSICS

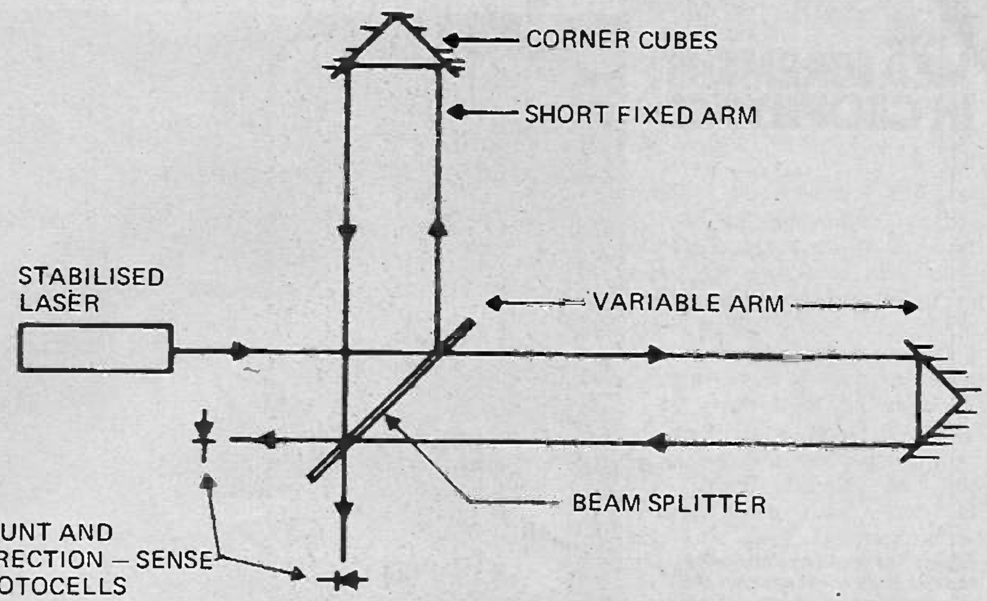



*Figure 3 (b). Layout of a laser interferometer extensometer.*

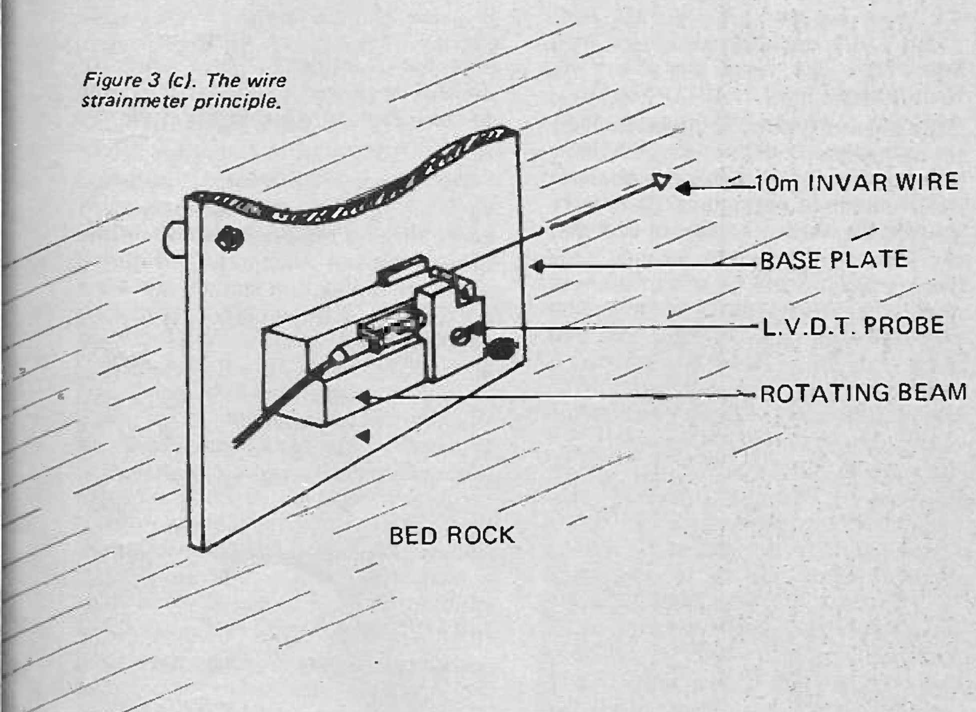



*Figure 3 (c). The wire strainmeter principle.*

ground, yet easy to get to; it should have mains electricity with good voltage stability; it must not be close to the sea as sea-loading effects modify the strains and tilts; it should not be close to a city as cultural noise can be a problem yet it should be near to the institution operating it. Dryness, or at least, absence of freely running water, is also highly desirable. In order to measure the three components of strain, two perpendicular tunnels in the horizontal plane are needed with one in the vertical direction. Finally, a newly made tunnel will not be as dimensionally stable as one made naturally.

Hillgrove is a small community some 25 miles from Armidale in the New England area some 350 miles northwest of Sydney. In the late 19th century, Hillgrove was booming: it was larger than (the then) Armidale, had several hotels and 3000 inhabitants who were there to seek gold and antimony. After a feverish 17 years it declined as rapidly as it had grown. Our heritage from this period is numerous shafts, drives and chambers that were driven into the sides of the Bakers Creek Gorge.

In 1969 two tunnels, known as the Upper and Lower Cooney drives were selected by this Department for conversion into the first Southern Hemisphere earth-tide observatory. The upper tunnel (see Figure 2) is 180 metres long and has passages and niches leading off it. The first 30 m of tunnel has been fitted out as an observers' chamber. Chart recorders, recording instrument-outputs can be placed here as the environment is less humid than deeper in. Benches are provided for on-site repair and servicing of equipment. This area also houses the terminal used to send signals from instruments to the gorge top for transmission by VHF radio back to the Department.

The tunnels are divided into chambers with brick walls to provide areas isolated from each other. Chambers are set-up to measure strain in one, tilt in another and one is devoted to the development of means to check the long-term stability of strainmeters. Walls are painted white and lit by fluorescent lights to provide attractive working conditions. Signal and power cables run through all chambers. The signal cable is used to take outputs to the observers' chamber.

We have called it the Cooney Observatory in memory of the mining syndicate who drove the tunnels in the 1890s. Although they did have explosives and crude air drills in those days, there was no electricity – they worked by lamplight using hand tools and hand-pushed trolleys. The rock in the Cooney is so hard it burns tungsten-tipped drills away. We are thankful for their efforts for today such a tunnel would cost $20,000 to drive and there would be no guarantee that it would be suitable until finished. Using their methods of mining, today's cost would be $1,000,000.

Down the side of the gorge runs large overhead power lines and a multi-pair signal cable which takes signals to the transmitter. It also provides a circuit for a P.M.G. telephone. Once an instrument is deemed satisfactory its output can be fed back via the data-link.

# FINE MEASUREMENT IN GEOPHYSICS

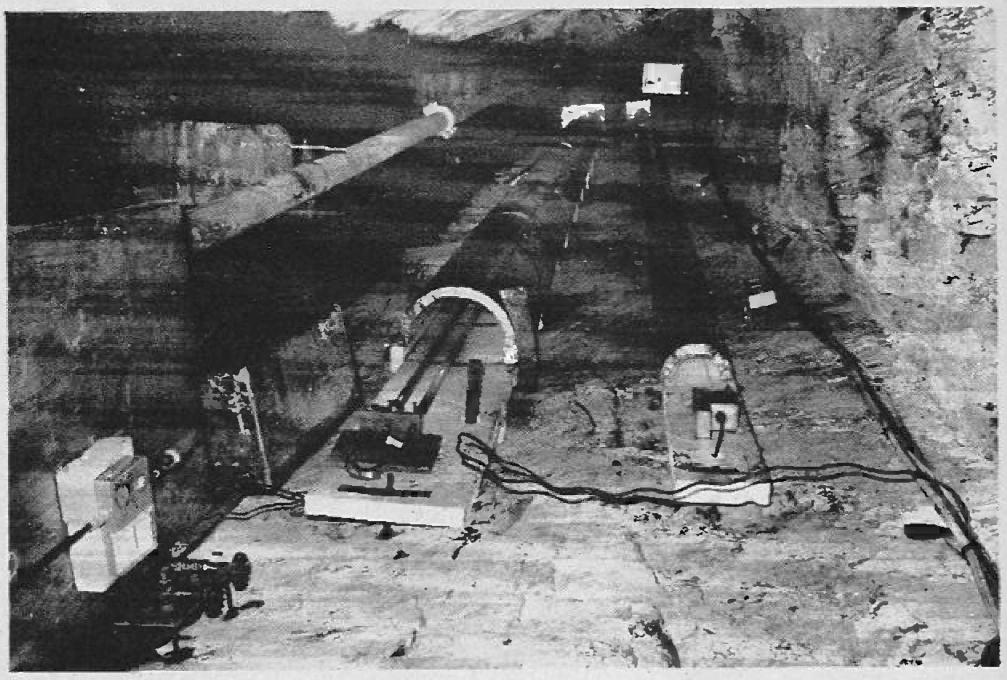


*Fig. 4. The strain chamber. The top insulated cover encloses the wire strainmeter, the lower cover the quartz tube strainmeter and the pipe near the floor encloses the laser beam of the interferometer.*

## THE INSTRUMENTS IN THE COONEY OBSERVATORY

To date we have built several strainmeters and have installed two tilt-meters in co-operation with the Bureau of Mineral Resources. Gravity instruments will be added soon.

There are three types of tidal strainmeters. The first, and oldest, style uses a long fused-quartz tube as an invariant length standard. A ten-metre length is hung along the wall on flexible pivots. One end is fixed to the wall, the other hangs free. At the free end is a transducer that monitors the gap between the end and a wall bracket. Strain appears as gap variations. The set up is shown schematically in Figure 3(a) and is the middle instrument seen in Figure 4.

At present we use inductive measurement techniques in which an iron-core moves inside a centre-tapped solenoid. When the core is central, each half of the coil has equal inductance and the ac bridge to which it is connected is balanced giving no output. As the core moves away from the centre, an output appears which is linearly related to displacement. These are called linear variable differential transformers, LVDTs for short. Although the commercial units we use are not as sensitive as the capacitance micrometers of Professor Jones' group, they can reliably detect $10^{-10}$m (1 angstrom) which is adequate for our purposes. They do, however, have some advantages over the capacitance method for they are little affected by moisture in the air, are easier to adjust, have greater dynamic range and are commercially available at low cost. There are a number of quartz rod instruments operating over the globe but few are in the Southern Hemisphere.

The second type of strain instrument to be adopted widely was the laser interferometer. A stable wavelength laser radiates a beam through a beam splitter, (as shown in Figure 3b) that provides two coherent beams. One beam travels to the far end of the wall and is returned by a corner-cube reflector. The other beam is returned as a reference-phase signal and it interferes with the other to form fringes. Changes in length between the beam splitter and the corner cube show up as movements in the fringes. Electronic methods monitor this movement by counting fringes or by keeping the fringe stationary with a servo in which case the servo position is a measure of movement. As the wavelength of the light is varied by air pressure, humidity and temperature, the interferometer is operated in a vacuum using pipes to enclose the beams (see Figure 4). There are about six units operating in the Northern Hemisphere but as yet, none in our half. They range in length from 40 to 1000 metres and are the most expensive strainmeter to build.

A few years ago one of us devised a very simple method which uses an invar wire as a length standard. The wire is tensioned by a robust, yet sensitive, beam balance which is bolted to the rock with expanding bolts. Figure 3(c) shows this method. The gap between the wire end and the mount is measured with the LVDT transducer. Following limited success with an initial crude design, Cambridge University have now developed an improved version and several units are being placed at intervals over Britain and the Continent. Three units of another improved design are operating in New Zealand. Our unit is at the top in Figure 4.

The Cooney Observatory is but a year old and to date we have been concentrating on development of one of each type of strainmeter, measuring in the same direction and on the same rock face. This greatly assists the eradication of defects as each should give the same results. Once a satisfactory design has been settled on (it is not possible to buy tidal-strainmeters ready made) we will place more instruments over the local region and then across Australia using two-wheel trailers to operate them in remote areas. The first trailer-station, an advanced student project, nears completion in readiness for field work in 1972.

Although overseas groups have been working on strainmeters for over thirty years, no special effort has been expended on research to investigate the stability of each standard in use. Mechanical rods and wires may change length even though the temperature is controlled. Laser wavelength also is a function of the laser cavity length stability. In one chamber is a 10m long, massive, steel frame which hangs from the wall on flexure strips. This base, shown in Figure 5, is temperature controlled to a few millidegrees by a sensitive mercury contact thermometer. In this thermometer, the mercury rising up the small indicator tube contacts a fine tungsten wire. This closes a circuit switching off the heating. This degree of control holds the length stable to within a part in 100 million per day. On to this framework we can mount the various types of strainmeter for intercomparison of their drift and calibration. If the wall were used as a measuring base we would not be certain if it were instrument or earth drift that was observed. The base is under continual development and the next stage should realise ten times better stability. A project to start in 1972 will use coaxial tubes and water jackets in an attempt to reach microdegree instead of millidegree control.

The tilt-meters came ready made, for the Bureau of Mineral Resources chose the Cooney as a suitable place to instal two horizontal-pendulum tilt meters which were purchased from Professor Melchior of the Royal Belgium Observatory. These are the same as tens of other pendulums working elsewhere and now we are able to supply Australian data to the International Centre for Earth Tides which is situated in Brussels.

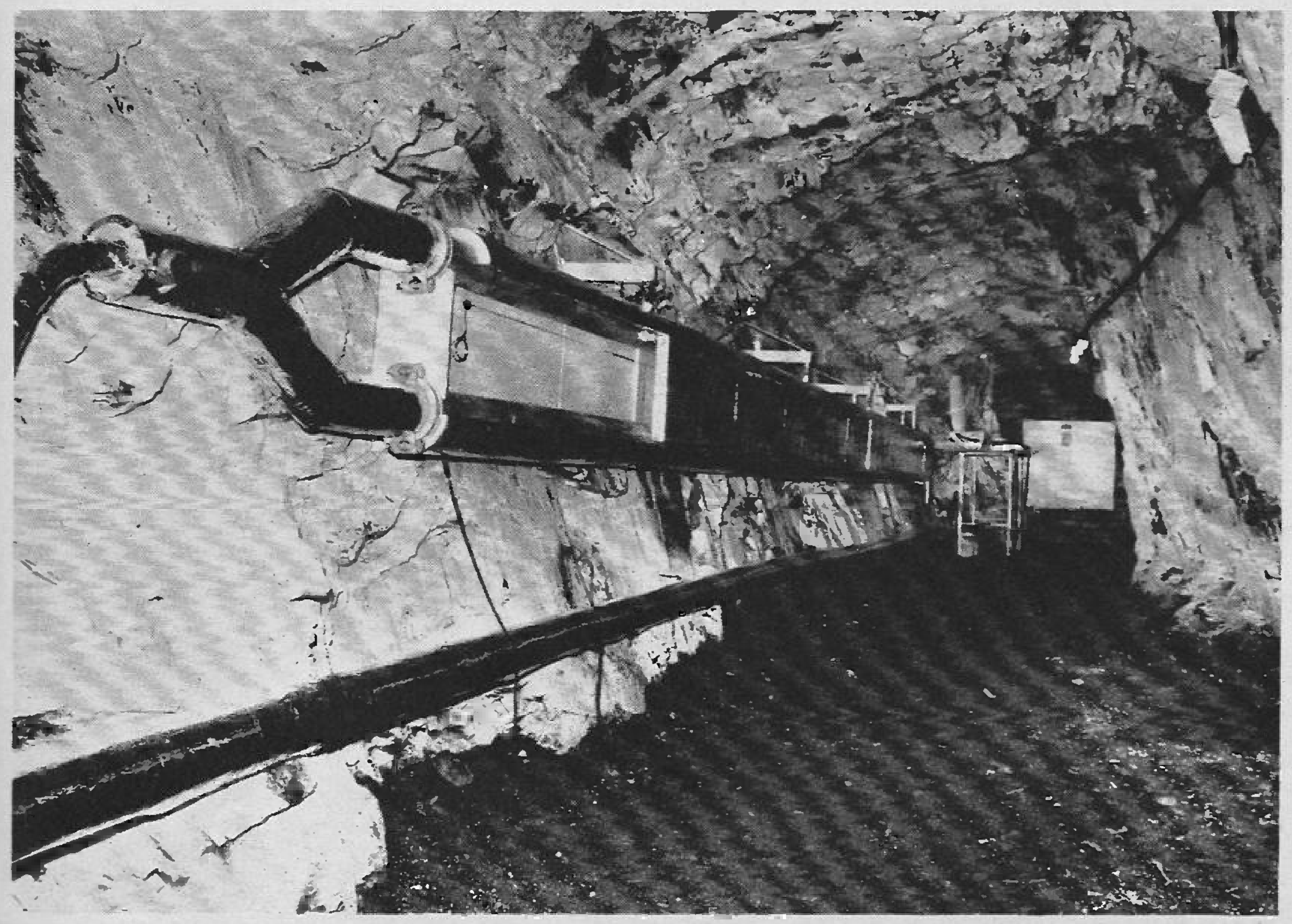
These tilt-meters are based on a different principle to those Professor Jones described. Imagine a gate. Even with minimal friction, if the hinge-line of the gate is vertical the gate will remain at rest in what ever direction it is swung round to. If now the hinge line is tilted slightly out of vertical, the gate will swing and come to rest fronting in the direction of the tilt. Melchior's pendulums consist basically of a quartz tube pyramid frame, suspended horizontally is a quartz arm with a quartz bob (the weight) on the end. This is the pendulum. Quartz fibres, 6 μm in diameter support the pendulum in what is known as a Zollner suspension arrangement. They are fused directly to the pendulum and to the frame. Hanging from the pendulum arm is a small mirror which supplies the readout using the optical lever principle. Five metres away is a light source that projects a fine slit of light onto the mirror and back to the recorder. This equipment uses photographic recording and no sophisticated electrics are needed. Tide inclination changes show up as 150 mm amplitude signals having a similar form as tidal-strain. Two pendulums are needed to measure the two components of deflection of the vertical. To ensure stability the units are placed on the floor of a niche drilled into the end of the tunnel (shown in Fig. 6).

With all types of tide record, it is necessary to have a common time system to synchronise the data. At present Observatory timing is derived as hour pulses provided by a Bulova Accutron clock. Soon an IBM observatory clock will also be installed. This clock is synchronised with the international radio timing system.

Other instruments are used to monitor the environment for few instruments are entirely free from the effects of pressure, humidity and temperature. For instance, in the

*(Continued on page 74)*

*Fig. 5. The stabilised base. Water is pumped around the steel pipework, the temperature being controlled by a sensitive mercury thermometer.*



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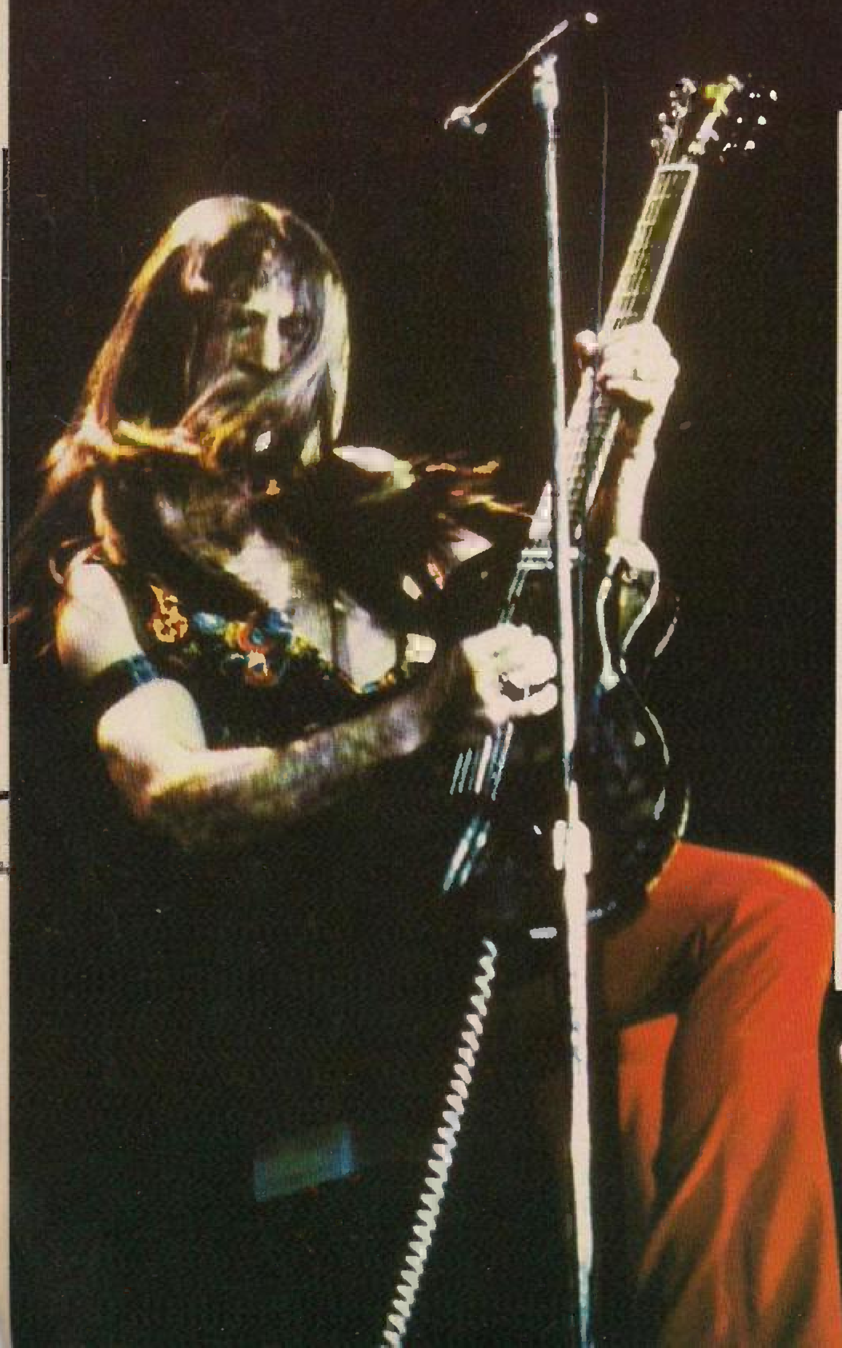
# PORTABLE SOUND SYSTEMS



ABOVE: Didgeridoo, vocalist and electric guitar! (Johnny Ashcroft and his group).

LEFT: Mark Farner of Grand Funk Railroad – photos courtesy E.M.I.

# HOW TO ACHIEVE OPTIMUM RESULTS

by Donald L. Potter,
Senior Development Engineer,
Shure Brothers Inc.

**Ironically perhaps, the quality of sound obtainable from home hi-fi systems is often far better than that achieved at most live performances, for modern recordings are produced under practically ideal conditions — free from such problems as acoustic feedback, background noise, and halls with poor acoustics. By comparison a live performance provides a real challenge to both performers and soundman. Since an audience judges a performance by the quality of sound, it is obvious that a good sound system is absolutely essential to a good performance. But even with the best available equipment, its improper use can give results that are catastrophic.**

THE basic sound system consists of one or more microphones, microphone cables, a mixer/amplifier, speakers, and speaker cables.

A low-impedance directional microphone of rugged construction is recommended. Low-impedance microphones (50-250 ohms) are required to permit the use of long cables to the mixer/amplifier.

High-impedance microphones (10,000-50,000 ohms) are limited to only about 20 feet of cable because they are subject to a high-frequency roll-off, or loss of high-frequency signals in the cable. For example, consider a 30,000-ohm microphone connected to a 20-foot cable whose capacitance is 26 pF per foot. With this combination, the microphone output is attenuated by 3 dB at at 10 kHz. With the same cable capacitance, but using a 150-ohm microphone, 4000 feet of cable would be required to produce the same high-frequency loss.

High-impedance microphones may be used if the mixer/amplifier is to be located on stage. This may be the case with a small group where one of the performers doubles as the soundman. Since the microphones are located close to the mixer/amplifier, 20-foot cables may be long enough.

High-impedance microphone cables are susceptible to hum pickup from stage lights and other ac-line-operated devices, and care should be taken in locating them. The use of low-impedance microphones and cables generally eliminates this problem.

The use of low-impedance microphones and long microphone cables permits the mixer/amplifier and the soundman to be located off-stage and, preferably, in the audience area. This is the only way he can hear the performance exactly as the audience does.

Microphones are available with a number of different popular characteristics. The polar characteristic is a chart or graph of how well the microphone picks up sound from the front *versus* the sides or the back.

There are two types of microphones in general use today. One is the *omnidirectional* microphone, which picks up sound equally well from all around. The other is the *unidirectional*, sometimes referred to as the *cardoid* microphone, which picks up sounds with maximum sensitivity from the front, has slightly reduced sensitivity from the sides, and rejects sounds from the rear. Of these two types, the unidirectional model is preferred for two reasons. Firstly, the microphone is less prone to feedback because the back of the microphone can be pointed towards speakers or reflecting surfaces. Secondly, the microphone is sensitive to the performer and less sensitive to the audience background noises or other instrumental sounds that are coming from the sides or back of the microphone.

When selecting a unidirectional microphone, it is desirable to consider whether or not a microphone with *proximity effect* is wanted. Proximity effect is the increase in low-frequency response as the microphone is moved closer to the performer's lips.

Microphones with proximity effect increase bass output as the microphone is brought closer to the performer's mouth. This allows the performer a great degree of control over the sound and the response by moving the microphone closer or farther away. This change in low-frequency response is desirable in many cases so that a performer can move close to the microphone and produce a deep, resonant sound when doing very soft, intimate work, and move away when this effect is not wanted. The proximity effect also aids the younger performer — giving a more resonant, mature sound to the voice. However, a few performers, prefer a microphone without proximity effect. The choice is up to the individual.

It is important to choose a microphone that has the same frequency response from the front and sides. This feature allows the performer to turn the microphone off-axis without changing the sound quality. The only effect that should be

*Close-mike technique. This reduces acoustic feedback and increases bass output with microphones having proximity effect.*

# PORTABLE SOUND SYSTEMS

noted is slightly reduced sensitivity.

One more consideration in choosing a microphone is the windscreen or "pop"-filter over the end of the microphone. Microphones that are used for close work by performing vocalists should have an extremely good "pop"-filter. The "pop"-filter is designed to cut down the wind or "pop" blast that comes when a "P" or other explosive-type sound is made. If you hold your hand a few inches from your mouth and make a "P" sound, a blast of air can be felt on your hand. The microphone also feels this blast of air and this creates a "popping" sound. Microphones equipped with a blast or "pop"-filter reduce or attenuate this effect. This blast sound, if not attenuated, may cause preamplifiers to overload or distort and produce an objectionable sound in the speaker system.

## MICROPHONE PHASING AND CABLES

The importance of the cable that is connected to the microphone should not be overlooked. Good cables and periodic cable maintenance ensure reliability.

It is recommended that microphone cables be wired with three-pin male and female *Cannon*-type connectors. This type of connector has proven to be rugged and reliable and requires little maintenance. The end of the cable that connects to the microphone should be wired with a female connector and the amplifier end with a male connector. By so doing, every cable can be used as a microphone cable or as an extension microphone cable.

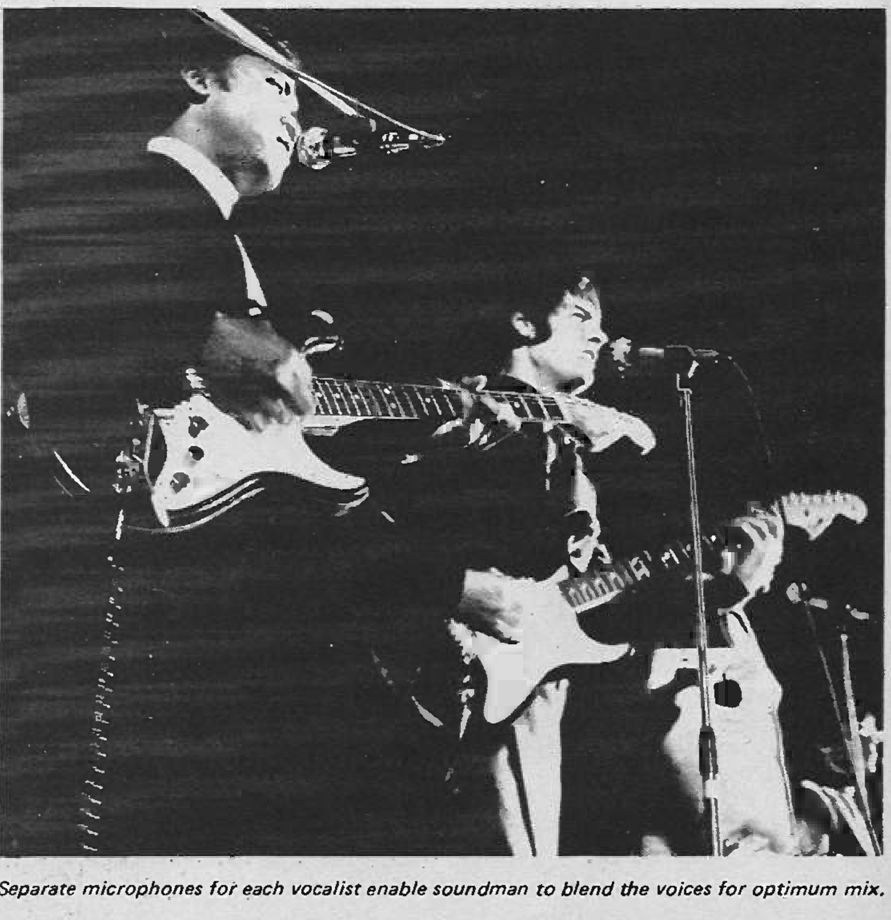
The three-pin *Cannon*-type connector is designed so that pin No. 1 connects first as two mating connectors are joined together. Pin No. 1 is used as the shield or ground and therefore the shield is connected first. Because of this design feature, microphones or microphone cables may be connected to live amplifier inputs during a setup or performance without the annoying buzzes, clicks, or pops that are normally associated with open grounds. Pins 2 and 3 of the connector are wired to the two balanced conductors of the microphone cable. Consistency is important when wiring connectors to mike cables to ensure compatibility and proper phase.

To test two microphones and/or their cables for proper phasing connect them to an amplifier and then talk or sing into the two microphones while holding them three or four inches apart. The sound from the speakers should be the same when talking into either microphone or directly between them if they are in-phase with each other. If the sound drops drastically, or a dead spot is found when talking between the two microphones, one of them (or its cable) is out-of-phase.

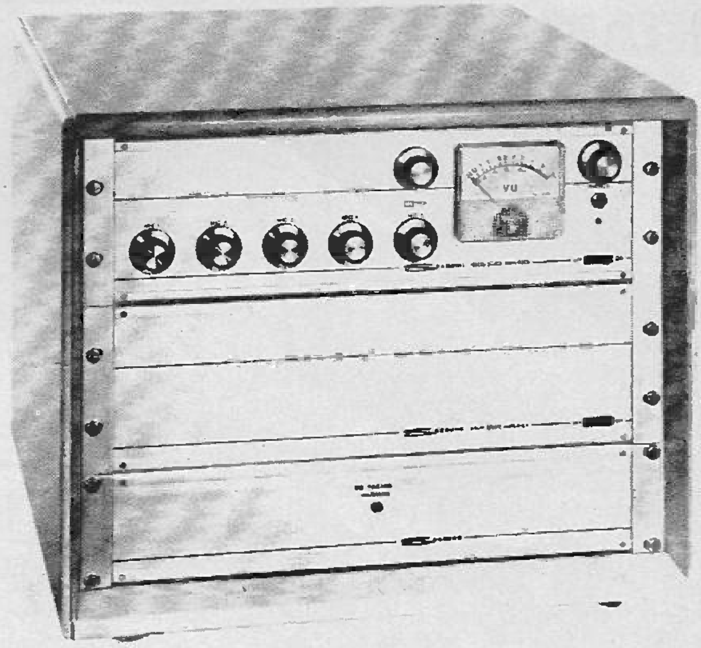
To change the phase of the one microphone or cable, interchange the wires that are connected to pins 2 and 3 of the connector. All cables and microphones should be tested in this manner to ensure that they are in-phase with each other. If a microphone is of different phase than other microphones, refer to the manufacturer's instructions on how to change the phase of that microphone. Some microphones are designed so that phasing changes are made by removing the male plug element in the microphone. In others, this element is cemented in place, forming a seal for the microphone to provide proper low-frequency response; removing the plug element in this type of microphone may alter or seriously affect the microphone's performance.

It should be noted that when performers are hand-holding microphones and singing and dancing with them, the cable is subjected to severe twisting, bending, or stretching. This will eventually cause the shielding inside the cable to break into small pieces, reducing its effectiveness. Continuity of the shield may be tested with an ohmmeter. A good shield should measure no more than a few ohms. A poor shield or one that has been broken inside the cable will measure in hundreds or even thousands of ohms, and twisting or bending the cable will cause the ohmmeter reading to change. Cables in this condition should be replaced. Only high-quality, low-capacitance, two-conductor shielded cable should be used for microphone cables.

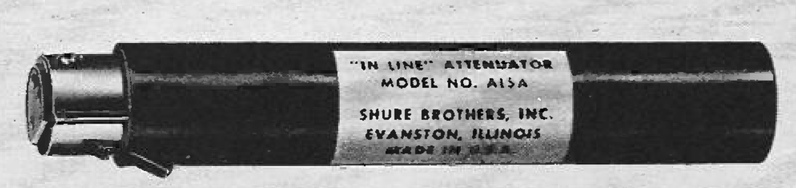
A very convenient method of running a number of microphone lines between the mixer/amplifier and the stage or performance area is to use a multiple-pair cable or a number of single cables bundled together. There are quite a few multiple-pair cables available which may be used for this purpose. It is suggested that each end of this cable be terminated in a junction box. Such an arrangement will reduce setup time significantly and is generally much neater than running many separate cables from the stage to the mixer. Each microphone cable should be connected to a separate mixer/amplifier input channel.



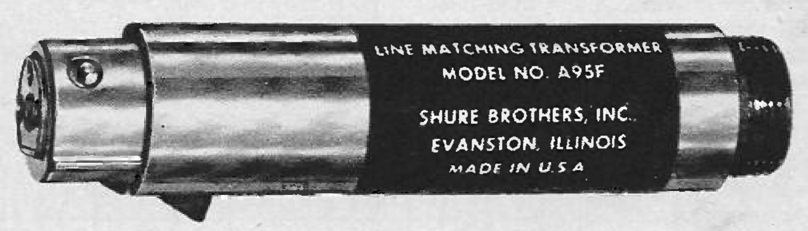
*Separate microphones for each vocalist enable soundman to blend the voices for optimum mix.*



*Solid state amplifier from Seeburg has individual level adjustments (plus master control) on each of five separate input channels.*




*This balanced and symmetrical in-line microphone attenuator has a 15dB loss.*




*Low impedance microphone matching transformer.*

## MICROPHONE TECHNIQUE

Microphone technique is extremely important in obtaining a good live performance. For example a performer who holds a microphone at arm's length while singing in front of a band cannot expect to be heard over the instruments. The soundman will try to compensate for this poor technique by turning up the volume control until acoustic feedback is produced. Generally one of two things happens under these conditons. Either the sound of the orchestra entering the vocalist's microphone will drown out the vocalist, or the sound system's acoustic gain will be limited by feedback. To avoid these problems, the vocalist should work the microphone at a distance of one to three inches from his mouth.

By varying the distance between the microphone and his lips, it is possible to use the microphone as a very effective volume control. For soft, intimate work the microphone should be used very close. For extremely loud passages the microphone should be backed off to a distance of several inches. By backing off the microphone in this way the performer helps to avoid overloading the microphone preamplifier on extremely loud passages.

Some performers create "popping" sounds when working close to the microphone. This effect may be reduced by holding the microphone slightly below chin level.

Normally, it is not necessary to "mike" the instruments. However, it may be desirable to "mike" a piano or wood wind, such as the flute. In "miking" a piano it is sometimes necessary to put the microphone inside the piano over the strings and partially close the top to avoid acoustic feedback. As an alternative, the microphone may be placed behind (on an upright) or underneath (on a grand) the sounding board. The flute or similar acoustic instruments may be picked up very effectively by playing it very close to an unused vocal microphone.

Acoustic feedback often dictates general microphone placement. But also to be considered is the rejection of unwanted loud instruments, such as drums. In the case of "miking" a flute, it may be necessary to point the back of the unidirectional microphone towards the drums in order to maintain a high signal (flute) to noise (drum) ratio.

## SELECTING MIXER/AMPLIFIERS

When choosing a mixer/amplifier (which may be a single integrated unit or two separate units), a number of specifications and features should be considered. These include input impedance, input clipping level, number of input channels, individual tone controls, built-in reverberation, feedback filters, and power vs speaker load impedance.

The mixer/amplifier microphone inputs should be wired or connected for low-impedance microphones. If the mixer/amplifier does not have provision for low-impedance microphones, but is only wired for high-impedance types, an accessory impedance-matching transformer may be added to the input jacks to convert them to low impedance.

It is important to be aware of the microphone preamplifier input clipping level. If clipping or distortion occurs in the microphone preamplifier, this distortion will be heard in the speakers, regardless of the settings of the tone or volume controls on the mixer/amplifier. It is interesting to note that performers, when working very close to the microphone, such as with hard-rock or acid-rock program material, may produce signals in excess of the clipping level of the preamplifier. In this instance, an input attenuator will generally eliminate the distortion that would otherwise occur. Some amplifiers have an input attenuator switch built in. For those amplifiers without this feature, an

# PORTABLE SOUND SYSTEMS

in-line attenuator may be connected in the microphone cable. Some vocalists are capable of producing sound-pressure levels of approximately 130 dB SPL, at the microphone diaphragm, 10 dB above the threshold of pain! This would correspond to approximately 1/10th of a volt output from a low-impedance microphone. This is a case where an input attenuator would certainly be invaluable.

If there is more than one vocalist, it is desirable to have a separate microphone for each performer and a mixer/amplifier with enough inputs and controls to allow individual adjustment of each mike for proper balance.

Adjustment of the individual-channel-volume controls, tone controls and master volume control — commonly referred to as "mixing" — is done by ear. Two possible situations exist which could cause problems First, if individual volume controls are adjusted too low and the master control is set too high, output from the speakers may contain an excessive amount of hiss and noise. On the other hand, if the individual volume controls are too high and the master volume control is too low, the mixing stages ahead of the master

*This microphone has ball type 'pop' filter and is characterized by proximity effect.*

volume control may distort and produce premature clipping thus limiting the overall output power of the amplifier with the result that full power is not obtainable. It is best to follow the amplifier manufacturer's instructions as to how to set up the volume controls. In the absence of such instructions, an audio-signal generator connected to an input channel and an oscilloscope monitoring the speaker output may be used to determine minimum volume control settings at which the power amplifier is still capable of producing full output without mixer or preamplifier clipping distortion.

It is desirable to have separate tone controls on each input channel. This permits individual tone shaping of each voice to "brighten" a flat-sounding voice or "mellow" a nasal-sounding one.

Built-in reverberation is another feature to be considered. Since much of the modern music today uses artificial reverberation, both the entertainer and the audience expect this effect in a live concert. Two types of reverberation systems lend themselves to portable sound-system use. They are the tape-loop and the coil-spring reverberation devices. The coil-spring devices are popular due to their more natural sound when reproducing the voice, and freedom from the mechanical problems and frequent maintenance associated with tape-loop devices.

A number of the newer mixer/amplifiers incorporate feedback or frequency-equalizing filters that are useful in maximizing acoustic gain and minimizing acoustic feedback. While these filters are useful when the system is operated at or near the threshold of feedback, they are often misused. Feedback filters generally employ selective-frequency filtering that produces a notch or dip in frequency response over a limited frequency band with a filter depth of between 3 and 10 dB at the centre frequency. These filters, when properly used, can compensate for peaks in the acoustic response of a sound system in a particular room without seriously affecting the sound. But indiscriminate use of the filters, such as turning on all the filters, can produce a frequency response with more peaks in the response than with all the filters out and may seriously affect the sound.

Proper use of filters will provide maximum acoustic gain with no apparent change in over-all sound quality. The filters are adjusted by increasing the gain until feedback is noted and the one filter that will eliminate that feedback mode is activated. Generally the first feedback pitch noted is a low-frequency one and activating the low-frequency filter may remove too much of the bass response of the overall sound. To compensate for this lack of bass, increasing the amplifier bass controls will restore normal sound quality. Alternating back and forth between the feedback-filter adjustments and the tone controls, and increasing the volume control until feedback is again noted, a point will be reached at which two or more feedback frequencies are present at the same time. This is generally the optimum adjustment position for the tone controls and feedback filters. It should be noted that changes in location or orientation of the microphones or loudspeakers can produce drastic changes in feedback thresholds for different frequencies. It may be possible to gain additional feedback margin by repositioning the speakers and/or the microphones. After this is done, the feedback filters and tone controls

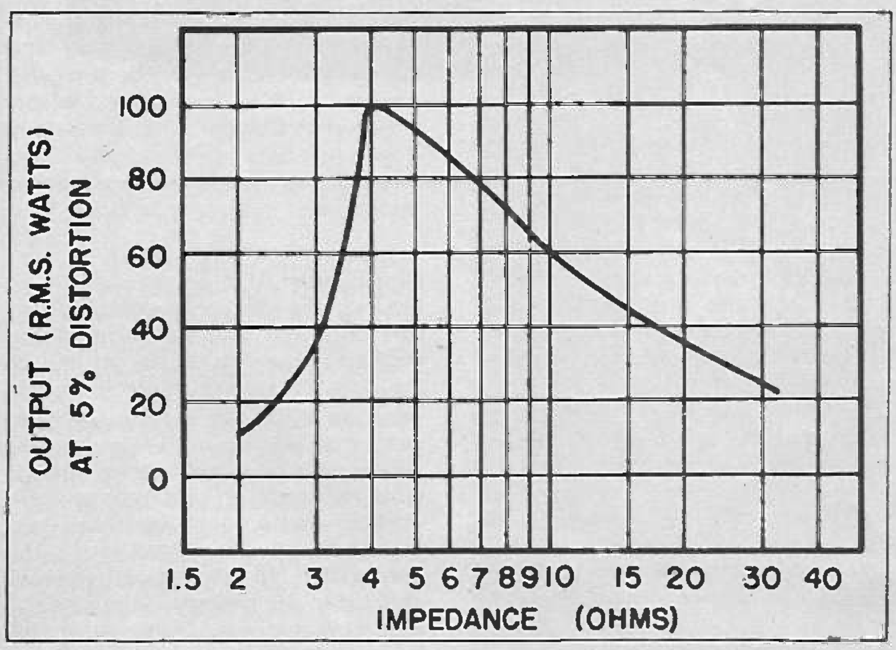



*Fig. 1. Available output power of typical amplifier for various loudspeaker loads. This particular unit has been optimized for a 4-ohm speaker load. Other impedance values reduce available output power. Where mismatch is unavoidable, always pick higher rather than a lower impedance.*

should be readiusted for an optimum setting.

It is very important to check the impedance of the speaker load that is to be used with the power amplifier. If this point is disregarded, it is very likely that maximum output power from the amplifier will not be obtained and damage to either the speakers or amplifier, or both, may possibly occur.

For example, take the case of an all-transistor 100-watt amplifier without an output transformer, designed to operate into a 4-ohm speaker load. This amplifier, when loaded with 4 ohms, will produce 100 watts When an amplifier is operated with its rated speaker load, it is generally operating at its maximum voltage and current output; this results in maximum power output. If this same amplifier is operated at a higher impedance load, for example 8 ohms, the available output voltage is the same, but less output current is required and the amplifier might typically produce only 60 or possibly 70 watts. If it were connected to a 2-ohm speaker load, the amplifier would operate at its maximum current capabilities trying to drive the 2 ohm load but would not be able to reach maximum voltage conditions. Again, output power would be limited. In this case it may produce only 10 or 20 watts (Fig. 1.)

Some amplifiers are not protected against low-impedance or short-circuited speaker loads. Such components may be damaged if operated at speaker loads less than those specified by the manufacturer. Generally, when an amplifier is operated at a lower impedance load than that recommended by the manufacturer. it will tend to overheat and may damage some of the transistors. Some amplifiers incorporate thermal switches to avoid such damage due to overheating. When the speaker load cannot be exactly matched to the recommended amplifier loading, it is generally better to use a speaker load impedance that is somewhat higher than recommended rather than one that is lower. Operating an amplifier in this way sacrifices less power (see Fig. 1) and increases reliability.

Some solid-state amplifiers employ voltage and current-protection circuitry. This type of amplifier, while capable of producing tremendous amounts of output power to a resistive load, may not deliver the same amount of power to a highly inductive speaker load such as may be encountered with 15-inch heavy-duty cone-type speakers. Under these conditions the amplifier may "current-limit", producing a triangular-shaped output rather than flat-top clipping which is normally associated with output distortion. If this happens, the speaker load impedance should be increased by reconnecting the individual speakers in a different impedance configuration.

## SPEAKER PHASING AND CABLES

Speaker and speaker-cable phasing is usuallv more important than microphone phasing. Proper phasing of speakers and speaker cables will insure that all speakers will work together rather than canceling out each other's efforts. Each individual speaker in a speaker cabinet or enclosure should be checked for proper phasing with every other speaker in that cabinet. A simple method for checking the phasing of loudspeakers is to connect a 1½-volt flashlight battery between the speaker cabinet terminals and noting the direction in which the speaker cones move. All cones should move in the same direction, either towards or away from the grille cloth. All speaker systems or assemblies and speaker cables should also be checked for proper phasing.

If more than one type of power amplifier is being used to drive the different speakers, it is important to check the phasing of the overall power-amplifier/speaker system. Depending on the number of transistors in the amplifier, phasing from the input terminals to the speaker terminals may be different for different power amplifiers. The simplest way of checking the entire speaker/power-amplifier system is to play program material, preferably with low-frequency content, or have someone talk into a microphone while another person walks through the listening or audience area, checking for dead spots between the various speaker cabinets. Should a dead zone be found, simply reverse the speaker wires at the power amplifier to change

# PORTABLE SOUND SYSTEMS

the phasing until all the speakers are in-phase.

## SELECTION OF SPEAKERS

Sound-reinforcement speaker systems may be divided into two basic types; these are called the "distributed speaker system" and the "source-oriented speaker system."

The distributed speaker system utilizes a large number of loudspeakers mounted at equidistant intervals over a large area — usually in the ceiling. Generally speaking, these speakers may be of low-power-handling capability since each individual loudspeaker is required to cover a relatively small area. The major advantage of this type of system is that it provides very uniform sound intensity over virtually any area and is ideally suited for paging and background music in such locations as airports, restaurants, hotel lobbies, and industrial plants. All of these applications require uniform coverage over large areas at relatively low levels of sound intensity. Of greatest significance, however, is the fact that these installations do not require that the listener be able to see the sound source for it to function as a good sound-reinforcement system.

A speaker system for any of the performing arts must be source-oriented to give the listener the illusion that all sound is coming directly from the actual source. Two basic speaker systems are in general use for providing source-oriented sound: one system employs both high-and low-frequency horns, the other employs speaker columns or line radiators.

The horn-speaker approach usually employs two drivers, one for low frequencies and another for higher frequencies. The single-horn low-frequency speaker exhibits a directional characteristic that becomes less defined at low frequencies. Quite often, this nondirectional pattern will lead to low-frequency acoustic feedback. Also, as the pattern becomes less directional, the total radiated energy on the listening axis of the speaker is decreased.

High-frequency horn-driver combinations can be made to have very uniform directional characteristics with respect to frequency. When used in conjunction with the low-frequency horns, a full-range system is obtained. Due to the non-directional character at low frequencies, such a system will have an imbalance of low- to high-frequency directional characteristics. For example, when the low-frequency device is reproducing a low-frequency tone as an omnidirectional source, the on-axis intensity is low. At the same time the high-frequency device may be operating and its on-axis intensity is high. The result will be a very "metallic" sound, exhibiting a lack of low-frequency content. Increasing the amplifier bass controls to balance the sound may cause low-frequency feedback.

The high efficiency of this type of speaker system is its major advantage over most column speaker systems, although this difference is rapidly disappearing as better column speakers are developed.

The column speaker or line-radiator offers a number of significant advantages over the other types of speaker systems where source-oriented sound is required. The column speaker can offer high-quality reproduction at modest cost; columns are generally small, compact, and light in weight, which minimizes mounting problems and provides considerable flexibility in their placement. Narrow vertical distribution and wide horizontal distribution are characteristics of a column, which make it such an

*The 'small' centre speaker enables the entertainer to hear herself. It also provides sound fill for the first four rows of the audience. The column speakers located at the sides of the stage provide source-oriented sound covering entire auditorium.*

# PORTABLE SOUND SYSTEMS

outstanding sound-reinforcement tool.

The wide horizontal front distribution pattern of a column speaker is generally the same as that of any single loudspeaker within the column; the design of the column has virtually no effect on horizontal distribution. It is the length of the column that determines the *vertical angle* of dispersion — the longer the column the smaller the angle.

*Microphone shown above has integral 'pop' filter. Proximity effect is minimized as a result of holes in handle above mounting bracket.*

Some column speakers use rear ports to produce a bidirectional low-frequency horizontal polar pattern. This design reduces the omnidirectional low-frequency characteristic, which might lead to acoustic feedback, the bidirectional characteristic provides a relatively "dead" area at the sides of the column, with the result that microphones may be placed there with minimal low-frequency-feedback problems.

## SPEAKER PLACEMENT

It must be remembered that every room or space is acoustically unique and there are no set rules for speaker placement. However, a number of generalizations may be made which will at least provide a good starting point.

Always consider speaker placement in relation to microphone placement. It is desirable for the loudspeaker and microphone to be in close proximity in order to provide the illusion of source-oriented sound. It is also desirable to keep loudspeaker and microphone separated in order to achieve a high threshold of acoustic feedback. While these two statements are contradictory, a good solution can generally be found. When the column speakers are used on stage, the speakers should be placed at each side of the stage and as far forward as possible. With this setup; the entire stage area will be relatively free from acoustic feedback; also the illusion of sound coming from the centre of the stage will be quite good except for those occupying the first few forward rows of seats.

Generally the stage is higher than the main audience area, therefore placing the speakers on the stage helps to project sound over the heads of the audience. If the stage is low, or a dance floor is directly in front of the stage, it may be necessary to raise the speakers by placing them on platforms or solid boxes.

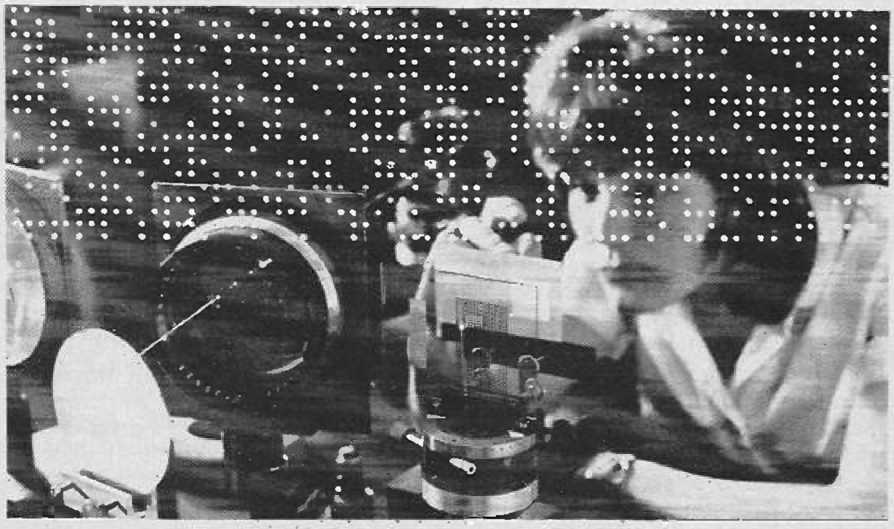
Keeping in mind that the speaker columns have a narrow coverage angle in the vertical plane and a broad coverage angle in the horizontal plane, we can generalize on speaker requirements for various room shapes. A deep, narrow auditorium would generally require only two speakers if the seating is all on one level. If balconies are added to this same room, additional speaker columns would be required to aim sound up into them. A shallow, broad room might require four speakers in order to cover the entire horizontal expanse. Again if balconies are added, four more speakers might be required to expand the vertical coverage. A "theatre-in-the-round" configuration will almost always require the use of at least four columns. More speakers might be required to provide adequate horizontal coverage if the theatre is very deep.

Adequately to cover all phases of speaker placement in all types of rooms would consume a great deal of space and still would not answer all possible criticism and arguments. *Every* room is different from *any* other and thus correct speaker placement will vary from room to room.

Good speaker placement will provide an audience with even distribution of sound intensity, sound which is free from excessive reverberation and echoes, and the illusion of sound emanating from the real source.

Providing good sound reinforcement is an art-science requiring considerable technical knowledge and a good deal of practice to become a master. However, by using the techniques we have discussed, the performer and soundman should be able to improve their performances. Good equipment is necessary, but proper use of the equipment is of greater importance. Using these guidelines as a tool, the performer must experiment with his equipment to find the particular sound he desires. In this respect microphone placement, mixer/amplifier control settings, and speaker placement are like tuning a fine instrument. Of these, the correct placement of speakers is the hardest problem to solve. Only after a great deal of practice will you be able to make good first choices. Let the people in the audience be your judge and listen to their comments. ●

# THE LASER HOLOGRAPHIC MEMORY



*Laser data storage model from Siemens holds 100,000,000 bits on photo-plate 9x12cm.*

**Storage density of this laser holographic memory is 100,000 bits/ mm²**

MORE than two decades ago, scientists began to experiment with basic types of holograms. Trial holograms were produced by electron beams and other means, but no practical applications were developed. Since the actual meaning of "hologram" is "complete writing," the word has continued to be widely used for a number of subsequent and related processes.

## HOLOGRAPHY POTENTIAL RECOGNISED

Hitachi became interested in holography, the technology involving the production of holograms, in 1967 when the company's Central Research Laboratory commenced preliminary research into practical uses for this potentially comprehensive type of "memory" utilizing laser beams as the light source. As many as 50 engineers were organized to work on the project.

Two years ago, a team of four men began intense work on an improved type of laser holographic memory which would have a larger capacity, greater stability and far more significant applications than any hologram developed to date.

## DEFINING THE TEAM'S TASK

Since laser beams are inherently stable sources of monochromatic optical frequency waves and are able to form sharply directed beams parallel to within a small fraction of a degree, it was determined some years ago that the laser should serve as the light source for the ambitious holography program. Still, the problem of how to properly disperse the laser beam onto the information plate remained to be solved.

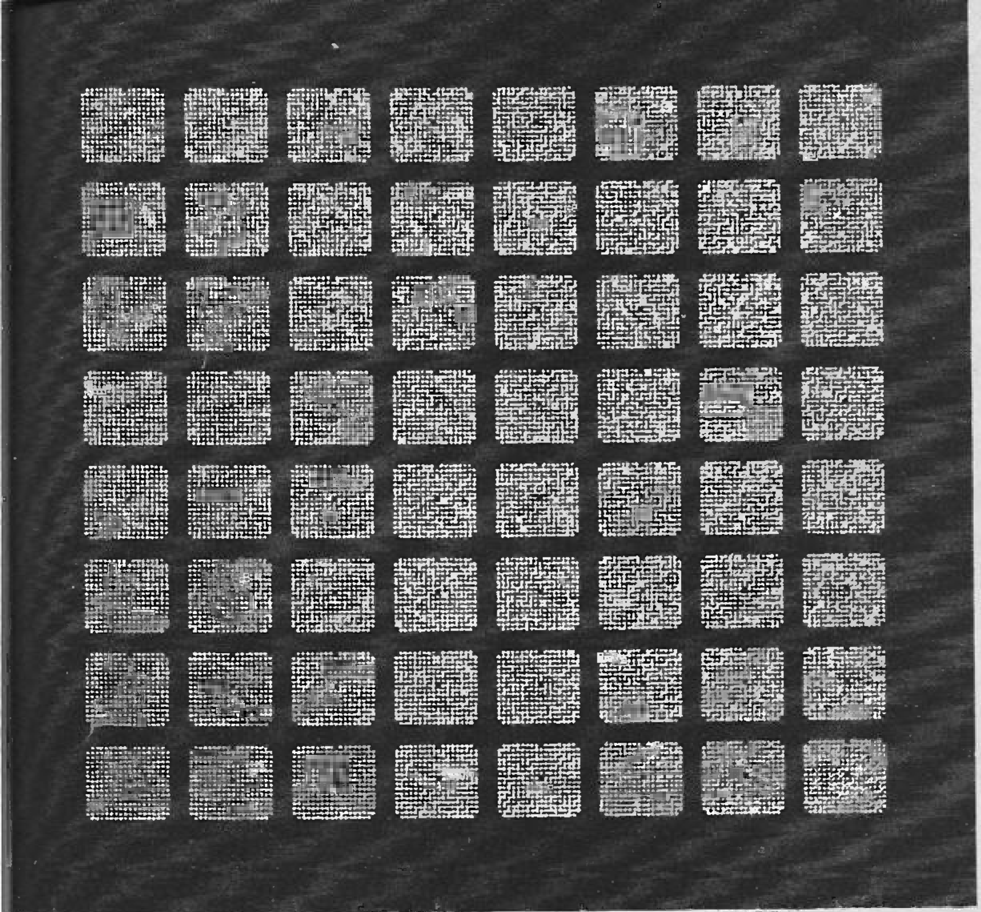
The Hitachi team's task was therefore well defined: a device was needed which would evenly diffuse the beams onto the plate, increase the density, or capacity of information, and permit all types of information to be accepted.

## DISCOVERING THE PERFECT FORMULA

By early 1971, after innumerable computer calculations and laboratory experiments with various types of diffusion coatings, the Hitachi team succeeded in developing an optical plate which they called a Random Phase Shifter (RPS). The new device not only met their expectations, but proved to have ten times the density of the most advanced existing model. In appearance, the RPS looks like an ordinary glass plate, but when viewed at an angle which permits prismatic reflection to occur, a multi-hued random pattern can be seen. It is made of numerous thin layers of cerium oxide which are evaporated by vacuum deposition onto the glass substratum through several kinds of random-patterned screens. The correct patterns were arrived at through repeated experiments with a random number table.

## INCORPORATING THE RPS

The pure laser beams pass through a lens onto the RPS where they are "routed" to the information plate. After the diffused beams go through the plate, they are called "information-bearing beams" and are then directed to the specially-treated transparent gelatin film for recording of the information. An astounding 20,000 bits of digital information, or 2,500 characters, may be stored in a circular space only one-half millimeter in diameter using this system. Capacity has been limited in previous laser holographic memories to around 10,000 bits per square millimeter because noises usually appeared as the



information-bearing laser beams were concentrated in a specific area.

As depicted graphically below, another way of expressing the worth of the laser holographic system is to say that the RPS eliminates unwanted "fringes" among the information beams and creates clearer interference, or information patterns. The RPS therefore permits both the density and quality of the memory recording to be vastly increased.

The type of laser employed in this project is the powerful, blue-green Argon Ion Gas Laser (Ar ION).

## STABLE, FAST AND LESS EXPENSIVE

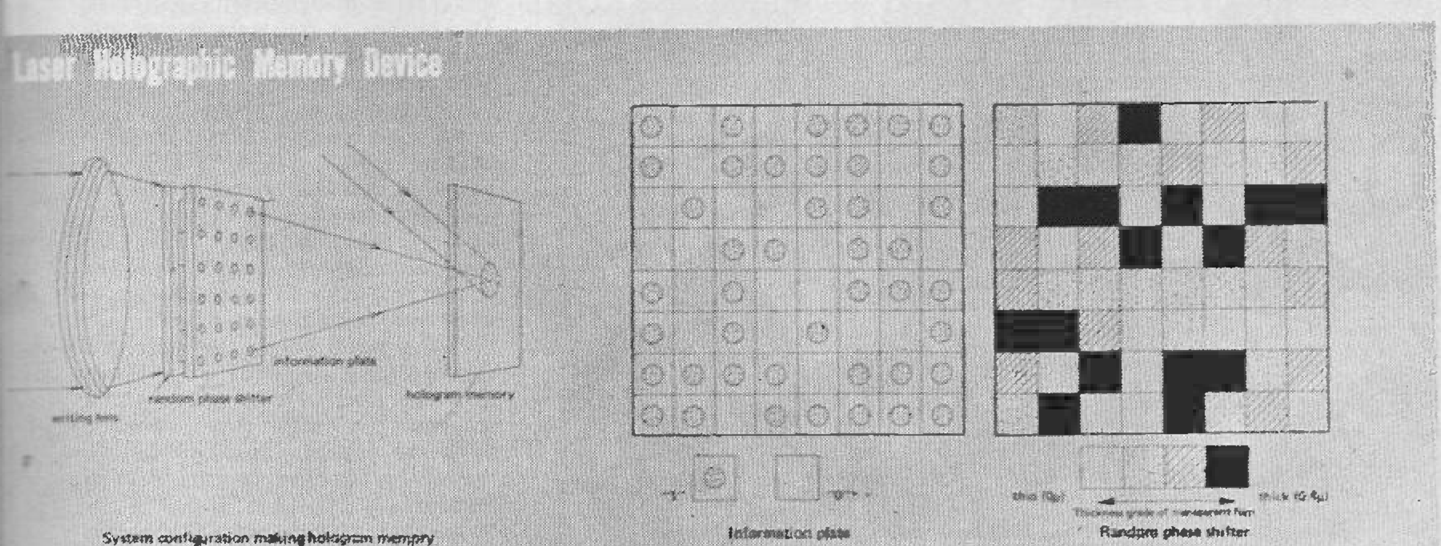
Another feature of the laser holographic memory is its "redundancy" or high stability. Although the film is incredibly small, the information is not lost if the film is accidentally scratched, unlike many other types of memory systems. Also, the readout speed of the memory is 10,000 to 100,000 times that of disc memories. By throwing a laser beam on the memory, 20,000 bits can be read in only one microsecond.

If applied to a computer system the laser holographic memory could greatly lower production and usage costs, as well as speed up functions, as it is much less expensive than either LSI or core memories.

## APPLYING THE TECHNOLOGY

Although the memory may not be ready for practical applications for perhaps three to five years due to other technicalities which must be resolved, the scope of the laser holographic memory is broad. Four basic types of usage are foreseen at this time: High speed computers, as mentioned above, could utilize the minute memory system. A total of 10,000 holographic memories, laid on a 5 $cm^2$ plate, would have a total storage capacity of 200 million bits and a read-out speed of only a few microseconds. Information retrieval systems — actually any system which stores information and gives answers to questions fed into the system — could benefit from it, also. In addition, such seemingly unrelated and diverse fields as audio-visual equipment — three-dimensional movies and VTR cassettes — and recognition systems (such as for recording and identifying fingerprints) could utilize the laser holographic memory system.

The laser holographic memory may well usher in a new era of super-miniaturized memory systems which will certainly be needed to keep pace with the flood of information produced by the present and future generations. ●




System configuration making hologram memory

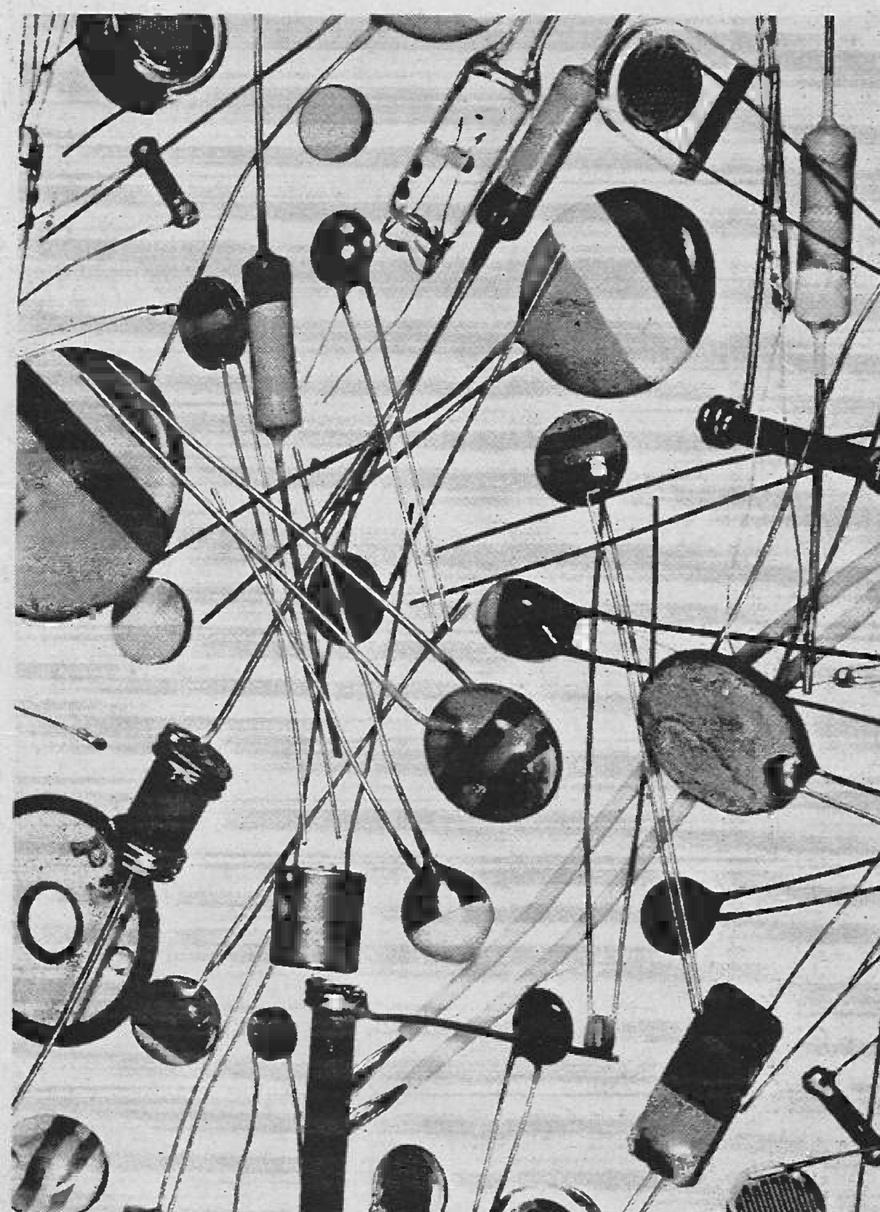
Information plate

Random phase shifter

PART II

# PRACTICAL GUIDE TO TEMPERATURE CONTROL

**In this article, Collyn Rivers shows how thermistors are used for temperature control.**



Thermostats and contact thermometers – described in the first article in this series are essentially 'on/off' devices. They cycle continuously above and below the required temperature.

Their major limitation is that (with few exceptions) they can only control energy on an 'all or none' basis. It is because of this that the majority of heating systems controlled in this way are characterized by a large overshoot when initially coming up to the set temperature.

This problem is overcome by using sensing elements in which changing temperature causes linear changes in one or another electrical parameter. Of these, the most commonly used are thermistors, resistance thermometers, and thermocouples.

## THERMISTORS

Thermistors are temperature-dependent resistors generally having a negative temperature coefficient. Thus, the resistance of a thermistor decreases as the temperature increases. This change in resistance is typically between 3% and 6% per degree Celsius at room temperatures.

In construction, thermistors are small, solid, semiconductors made of various metal oxides. They are produced in several shapes and sizes as rods, discs, beads, washers, and flakes.

For temperature control applications, the thermistor is located within the space to be controlled. A small current is caused to flow through the thermistor and the resultant voltage drop – which is proportional to temperature – is compared with a reference voltage. Any resulting difference voltage is used to control the energy applied to the heating elements.

Figure 1 shows the relationship

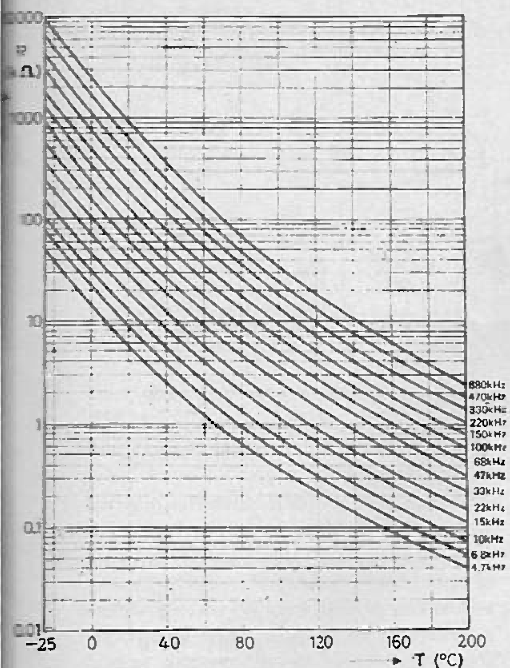



*Fig. 1. Relationship between temperature and resistance for 14 different thermistors.*

between resistance and temperature for 14 different thermistors. Taking the lowest curve as an example, it can be seen at −25°C the resistance is 50k. This is reduced to approx 5k at 0°C and finally to around 40 ohms at 200°C. The resistance (4.7k) shown on the right side of the graph is the resistance at 25°C, and it is at this temperature that the 'resistance' of any specific thermistor is generally given. The graph shows thermistors in which the 25°C resistance may vary from as little as 4.7k to as high as 680k. Thermistors are available with 25°C values as low as 2 ohms.

The 25°C resistance value of a thermistor becomes stable after a thousand or so hours of use, but before this time has passed, quite considerable changes may take place.

Figure 2 shows a plot of percentage change in resistance value against elapsed time for two commonly used thermistors. It is clear that for good stability, thermistors must always be aged (at high temperature) before use in critical applications. Always so if they are to be used for temperature measurement.

Although as described earlier, thermistors enable control circuitry to be used in a manner other than straight 'on/off' control, many thermistor controlled circuits still have the basic 'on/off' characteristic. However as the response time of a thermistor may be much quicker than that of a thermostat or contact thermometer, 'on/off' thermistor controlled circuits generally have far less initial overshoot.

## SIMPLE THERMISTOR CONTROL

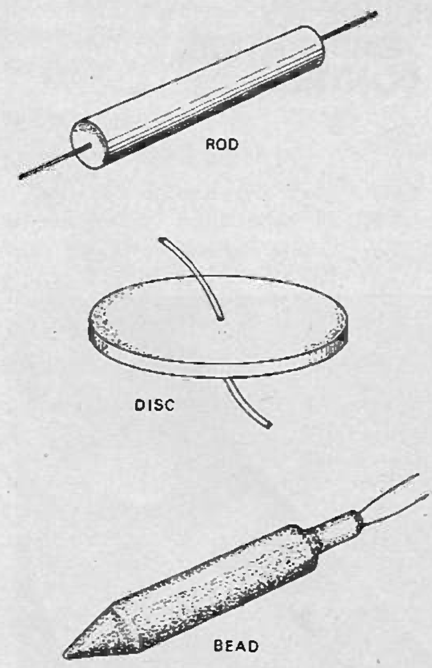
A relatively low cost on/off type thermistor controller is shown in Fig. 3.

This is a simple circuit ideal for controlling ovens, hot plates, soldering irons, water baths etc. The circuit will control the temperature to within one degree or less over a temperature range from 0°C to 100°C.

Transformer TI may be an old filament transformer having two secondary windings, each of 12.6 volts, 0.5 amps or so. Winding WI supplies energy to the relay RL1 through SCR1, the second winding (W2) supplies 12.6 volts ac to the bridge circuit of thermistor R1, resistors R2 and R3, and temperature setting potentiometer RV1.

Power is supplied to the heating element via the 'normally open' contacts of relay RL1. In other words power is applied to the load when the relay coil is energized.

When the heating load is colder than required, the resistance of the thermistor will be higher than that of potentiometer RV1 and this unbalances the bridge in such a way




*Construction of various types of thermistors*

that a positive voltage is applied to the gate of SCR1 when its anode is positive. This causes it to trigger and hence power is supplied to RL1. The contacts of RL1 close and power is applied to the heating elements of the load.

As temperature increases, the resistance of the thermistor decreases until eventually it becomes less than that of RV1. This unbalances the bridge in the opposite direction and now a negative signal is applied to the gate of SCR1 while the anode is positive.

The SCR now turns off, thus de-energizing RL1, and hence removing power from the load.

The type C106 SCR chosen for this circuit can handle relay coil operating currents up to a couple of amps. This

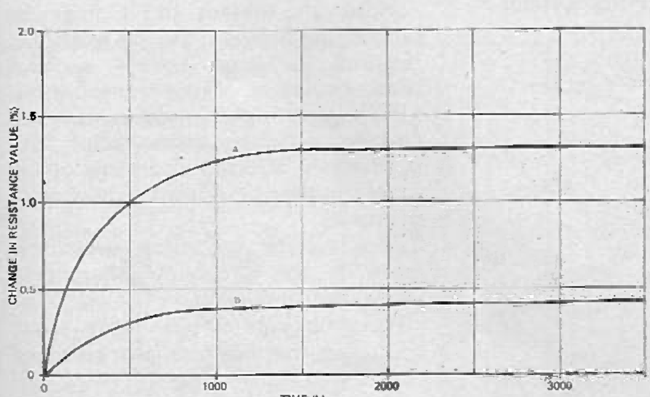



*Fig. 2. How thermistors change characteristics during initial period of use. (a) Disc type thermistor with 1 watt load (b) Miniature bead type thermistor with 20mW load.*

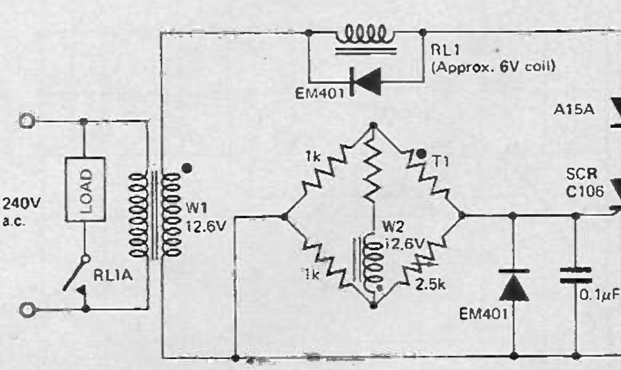



*Fig. 3. Versatile low-cost controller.*

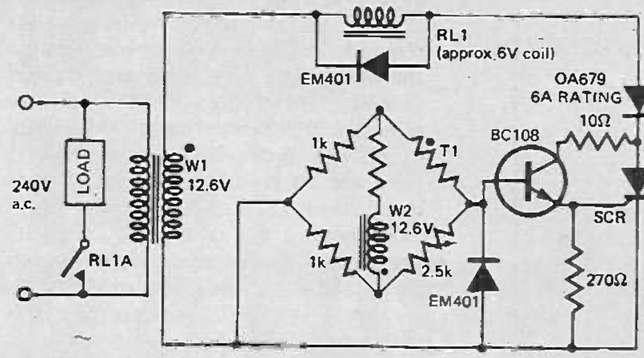
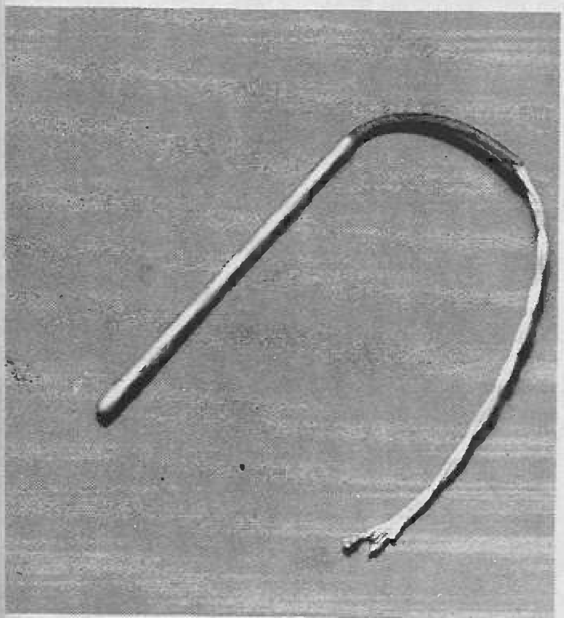



*Fig. 4. Basically similar to Fig. 3, this circuit can handle relay operating coil currents of up to six amps.*



*Thermistor protected by metal sheath operates to 300°C.*

is adequate for a fair sized relay capable of switching at least ten to fifteen amps. Heavier loads (including three-phase loads) can be handled either by using RL1 to energize a larger contactor or by modifying the circuit to obtain a larger triggering signal capable of controlling a heavy current SCR.

A circuit capable of switching six amp coil currents is shown in Fig. 4. Operation of the circuit is similar to that described for Fig. 3. except that transistor Q1 is used to amplify the bridge output signal.

Either of the circuits shown in Figs. 3 and 4 may also be used to control cooling loads — such as fans, refrigerators, air conditioners etc. The required 'opposite' operation can be achieved simply by connecting the load to a pair of normally closed contacts on RL1 — or by reversing the leads on the transformer secondary winding W2.

The thermistor chosen for the applications described above should have a resistance of approximately 1000 ohms at a temperature halfway up the control range required.

The circuits shown in Figs. 3 and 4 have very considerable operational flexibility, for within the triggering and current handling limits of the SCR, a relay may be chosen to suit the characteristics and size of the load. Thus either single or three-phase loads of practically any voltage and current may be catered for.

## TOTALLY SOLID-STATE CONTROL

Although the circuits shown in Figs. 3 and 4 are extremely reliable there are many applications in which a totally solid-state system is to be preferred, for if correctly designed, a totally solid-state system is inherently more reliable and practically maintenance free.

Another major advantage of solid-state electronic control systems is that proportional control may readily be obtained.

Unlike the 'on/off' system in which full power is applied to the load until the required temperature is reached, proportional control continuously varies the power applied to the heating element in an amount depending upon the deviation between the actual temperature and the required temperature (Fig. 5).

Solid-state controllers — apart from having either 'on/off' or proportional control — may be categorized as using either phase control or zero voltage switching techniques.

Phase control is a technique used to control the effective power input to a load by a process of rapid on/off switching. In this the ac supply is connected to the load for a controlled (but variable) fraction of each half cycle. A full description of this technique was included in the Practical Guide to Triacs series — which commenced in the Electronics Today International April 1972 issue.

This type of circuit, although inherently suitable for proportional control applications, generates large amount of radio interference, primarily at low and medium frequencies. It seriously affects reception of long and medium wave radio transmissions and may also interfere with audio equipment.

Whilst the extent of rfi may be reduced by filtering, the size of chokes required for large loads — such as heating systems — becomes excessive.

Phase control also introduces another problem — namely power factor. This is adversely affected and some power supply authorities object to this quite strongly.

Zero voltage switching overcomes most of the problems inherent in phase control systems.

The technique differs from phase control in that line voltage is switched

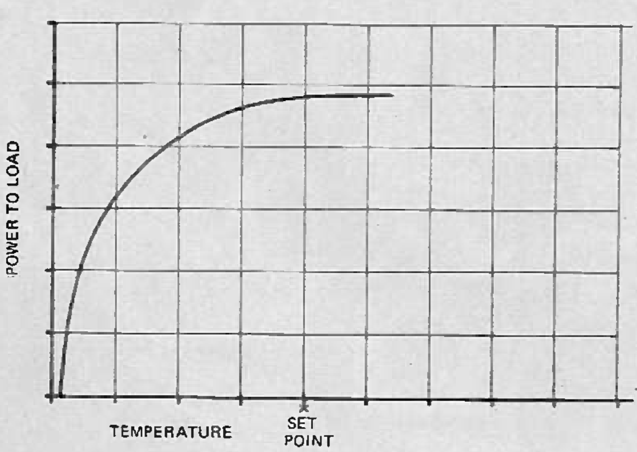



*Fig. 5.*

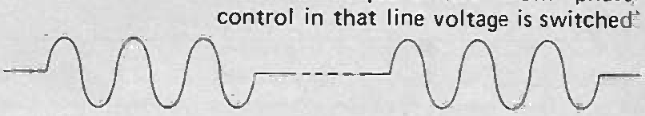


*Fig. 6. Zero-voltage switching waveform*

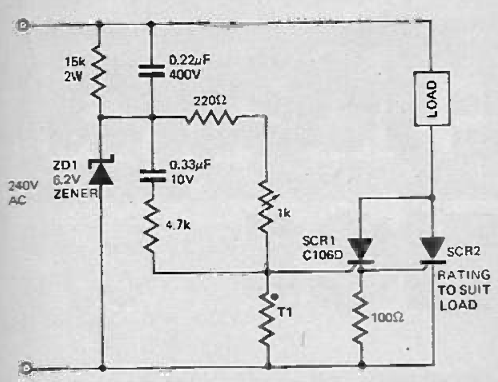



*Fig. 7. Basic half-wave zero-voltage switching circuit.*

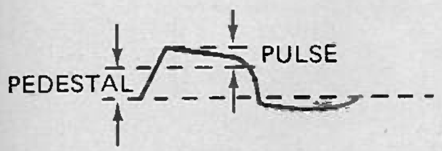



*Fig. 8. Pulse and pedestal wave-form of circuit shown in Fig. 7.*

'on' as well as 'off' only at the zero crossing points on the ac waveform. The power applied to the load is controlled by varying the ratio of time that power is applied, to the time that power is switched off.

At first sight this technique appears similar to the basic 'on/off' thermostat systems – and so to a point it is. The main difference is that power is switched only at zero crossing points of the ac waveform – apart from this the 'on/off' cycle may be very much quicker. For example, if only a small amount of power is required to maintain the set temperature, the circuit may pass only a few complete half-cycles and then remain switched off for a further twenty or thirty complete half-cycles before repeating the sequence (Fig. 6). A simple zero voltage switching circuit is shown in Fig. 7. In this circuit there is also a 'half power' mode within the temperature differential in which every second sine-wave is applied to the load.

The sensing differential of this circuit is approximately ±1/4°C about the set point and neither changes in ambient temperature not line input voltage degrade the accuracy.

The action of the circuit is as follows: Zener diode ZD1 forms a voltage pedestal of 6.2 volts (nominal) amplitude by clipping the incoming 240 volt ac supply. This pedestal is differentiated by capacitor C2 and resistor R2 to form a pedestal of reduced amplitude with a pulse superimposed on top of the pedestal (Fig. 8). This waveform is then applied to the gate of SCR1.

Zero voltage switching action is provided by the pulse (which is superimposed on the 'pedestal' at the beginning of the positive going line voltage) appearing at the anodes of SCR1 and SCR2. This pulse is shifted to the correct phase by C1 and R1.

As the controlled temperature approaches the set point, the decreasing resistance of the thermistor continuously decreases the height of the pedestal until the amplitude of the pulse plus pedestal is insufficient to trigger SCR1.

The lock-in configuration of SCR1 plus SCR2 virtually eliminates errors due to ambient temperature variations affecting SCR2 trigger voltage.

As the heating load of this circuit is in series with an SCR the power applied to the load will be half-wave. This may not necessarily be a severe limitation as many heating elements have more than sufficient heating capacity, and the inevitable loss when only halfwave power is applied may well be acceptable. If an element is being constructed specifically for the application then of course the element may be designed for half-wave power.

The zero voltage switching action of this circuit eliminates the need for rfi filtering. Hence the cost is very much lower than a comparable phase control circuit in which rfi components would be necessary.

## SIMPLE PHASE CONTROL

The zero voltage switching circuit shown in Fig. 7 should be compared with the phase control circuit shown in Fig. 9. This latter circuit has a very similar performance and – with the exception of rfi components – similar cost. It is commonly used to control the temperature of photo-developer baths. Again like the circuit shown in Fig. 7 it has half-wave output.

The 10 megohm potentiometer connected from the positive rail to the emitter of the unijunction controls the 'gain' of the circuit. In effect it controls the temperature range over which proportional action is obtained. It is not an essential feature of the design and may be omitted (or replaced by a suitable value fixed resistor if required).

Shown in Fig. 10. is a full-wave version of the circuit described above. The basic operating principle is similar, the main difference being that a Triac is used in place of the SCR. The pulse transformer shown in this circuit consists of two windings, each of approximately 100 turns of 24G enamelled copper wire, on a ½" diameter ferrite rod. Each winding must be well insulated from the other, and from the ferrite rod. Construction of this pulse transformer is not at all critical and minor variations from the specification should not affect operation of the circuit.

It should be noted that both these phase control circuits result in ac potential being applied across the thermistor. This may be overcome in the latter circuit by supplying the firing circuit via an isolating transformer rather than via a dropping resistor. ● *(to be continued)*

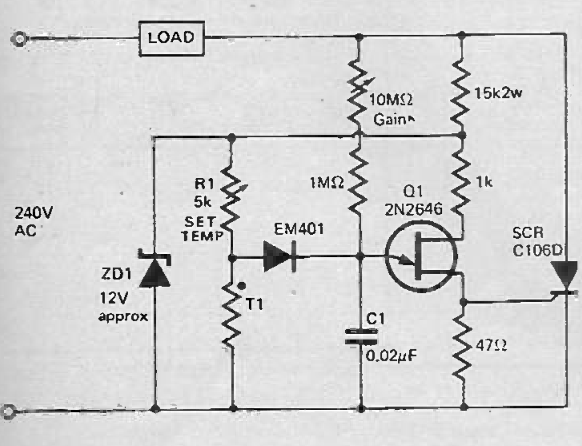



*Fig. 9. Half-wave phase control system.*

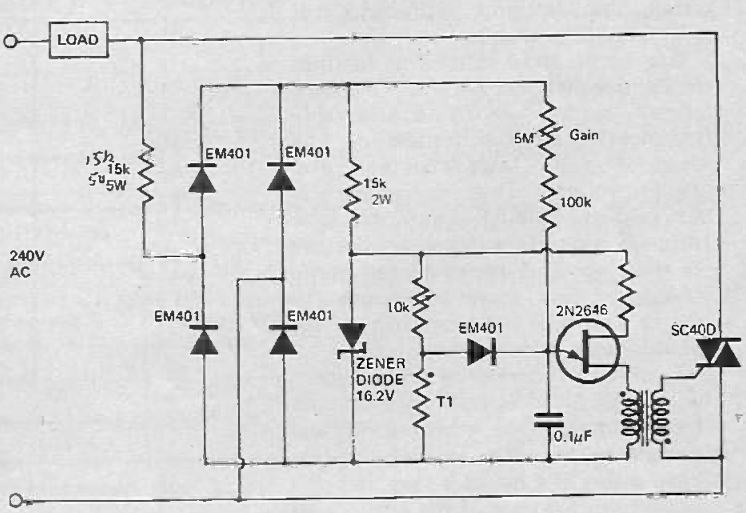



*Fig. 10. Full-wave version of phase-shift controller shown in Fig. 9.*

# Advances in Read Only Memories

*A new device from National Semiconductor offers considerable advantages over previously available Read Only memories.*

READ only memories (ROMs) are finding every increasing useage in modern instrumentation and computational equipment. The devices are particularly suited for applications where a small fixed memory is required. Typical applications would be for code conversion, random logic synthesis, look-up tables, character generators and for micro-programming.

Development has been towards putting as many memory bits as possible into standard IC packages, and towards improving the ease of customer programming.

One of the latest devices in this field is the new electrically programmable 2048-bit read only memory. (PROM) from National Semiconductor.

The new device known as the MM4203/MM5203 uses silicon gate technology to achieve bipolar compatability. The device is a non-volatile memory organized as 256 eight-bit words, or 512 four-bit words.

Programming of the memory contents is accomplished by storing a charge in a cell location by programming that location with a 45 volt pulse.

Operation is completely static, no clocks are required and the output is organised for common-data busing using the National Semiconductor TRI-STATE principle.

One of the most interesting features of the device is the optional "memory erase" feature which considerably enhances the attractiveness of the device for laboratories and experimenters. This erasability is achieved by shining ultra-violet light through a quartz window on the top of the chip. This allows the cell stored charge to leak away and hence the device can be re-programmed for another application.

This field programmability coupled with high speed operation (maximum access time of One microsecond) and compatability with existing bipolar logic makes the device a very versatile addition to the state of the art. ●

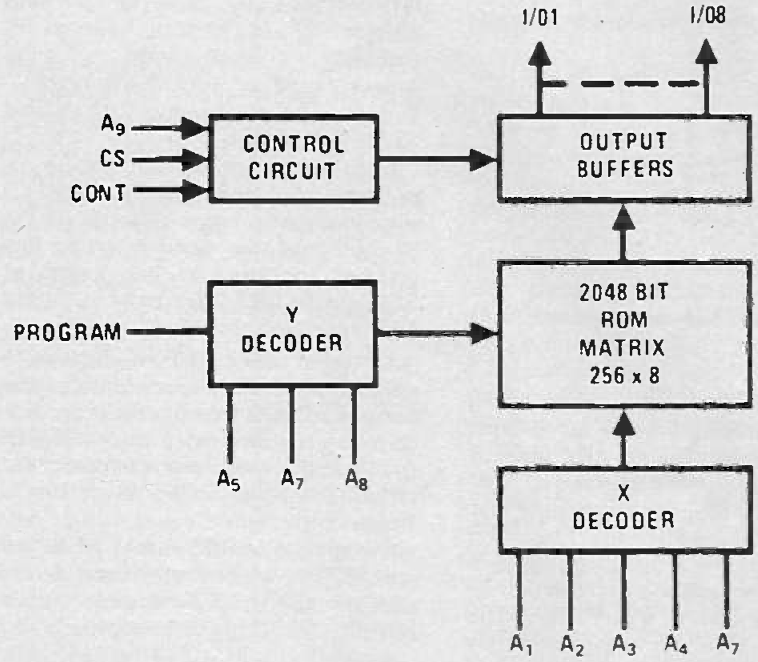



*Fig. 1. Block diagram of National MM4203/MM5203 ROM*

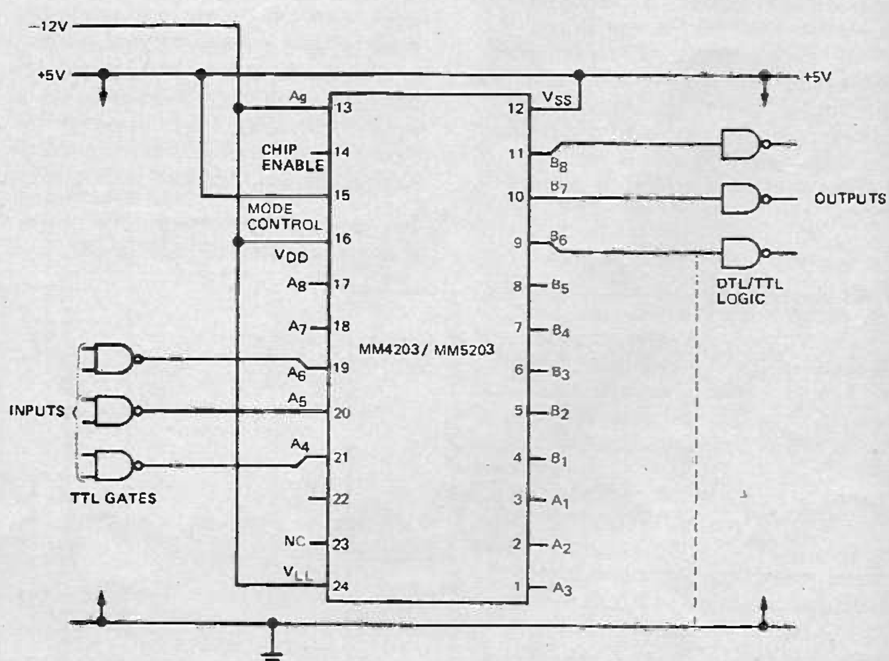



*Fig. 2. ROM connections and typical application as 256×8 PROM with TTL interface.*

# FET DC VOLTMETER

**ETI PROJECT 110**

**This cheap and easily constructed dc voltmeter has 10 Megohm input resistance.**

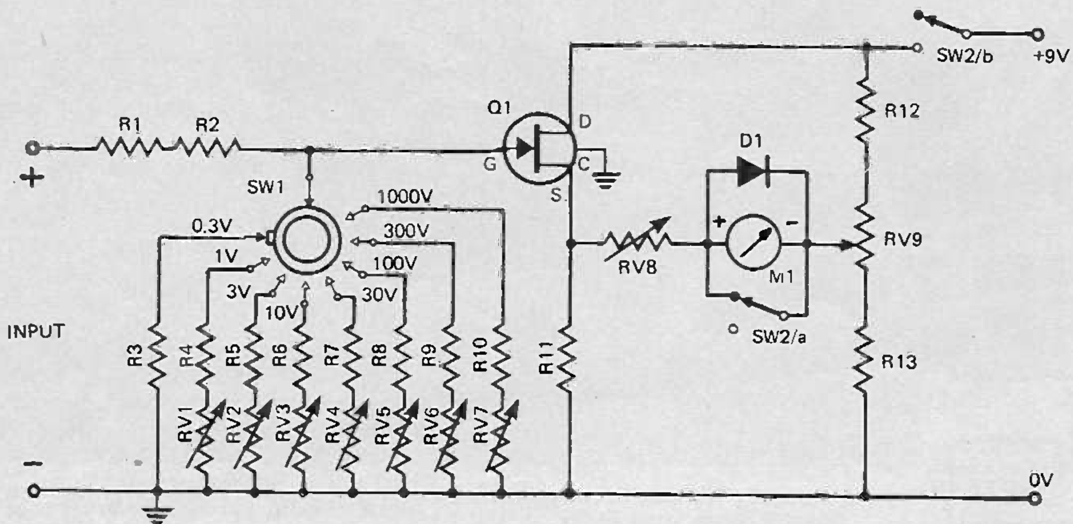



*Fig. 1. Circuit of complete instrument.*

**PARTS LIST – ETI 110**

| | | |
|---|---|---|
| R1, R2 | – | 5 Meg 5% ½W |
| R3 | – | 18M |
| R4 | – | 2.2M |
| R5 | – | 560k |
| R6 | – | 180k |
| R7 | – | 56k |
| R8 | – | 18k |
| R9 | – | 5.6k |
| R10 | – | 1.8k |
| R11 | – | 4.7k |
| R12 | – | 680 ohm |
| R13 | – | 120 ohm |
| RV1 | – | 470k trim pot |
| RV2 | – | 220k " |
| RV3 | – | 47k " |
| RV4 | – | 22k " |
| RV5 | – | 4.7k " |
| RV6 | – | 2.2k " |
| RV7 | – | 470 ohm " |
| RV8 | – | 4.7 ohm " |
| RV9 | – | 250 ohm ww pot |
| Q1 | – | BFW 61 BFW 10 BFW 11 |
| D1 | – | OA91 |
| SW1 | – | Single pole eight position rotary switch |
| SW2 | – | DPDT Toggle Switch |
| M1 | – | 50 uA meter 0-10 and 0-3.16 scales. |

For accurate voltage measurements in high impedance circuits it is essential that the measuring instrument has an input impedance that is very much higher than the circuit being measured. If the meter drains current away from the point being measured then an inaccurate reading will be obtained.

The valve voltmeter (VTVM), with its inherently high input impedance has for many years been used for such measurements.

But until the advent of the field effect transistor (FET), solid state technology was not commonly used in these instruments, for the bi-polar transistor has the disadvantage of having an inherently low input impedance.

The field effect transistor, on the other hand, has a *high* input impedance and because of this, forms an excellent basis for a high input impedance voltmeter.

Here then are constructional details of a simple yet accurate FET dc voltmeter having an input impedance greater than 10 megohms on all ranges.

The attainable accuracy is very much determined by the quality of the 50 uA meter (M1). We have not specified any particular make or type, for this will be determined by the accuracy required. Generally however the meter chosen should be at least four inches in diameter and should have a guaranteed 1% to 2% accuracy at full scale deflection.

Three types of FET may be used in this circuit – BFW10, BFW11, and BFW61. Of these the BFW61 is the cheapest and this is the one that we have used in this project.

High stability resistors must be used throughout. These should be of 5% tolerance (or better). Metal film resistors – such as those produced by Philips are ideal. Corning Electrosils are also an excellent choice.

## CONSTRUCTION

The physical design of the instrument is determined primarily by the size and shape of the 50 uA meter. Within reason the larger this is the better.

A good quality switch must be used for SW1 – preferably of ceramic construction. A single-pole twelve-way switch was used in the prototype (four of the available positions were not used for switching).

The electronic components may be located on tag strips or on matrix

# FET DC VOLTMETER

board. A matrix board layout is shown in Fig. 2.

As FET's are a bit touchy about input voltage it is wise to keep their terminal leads shorted together by a thin strand of wire whilst soldering them into the circuit.

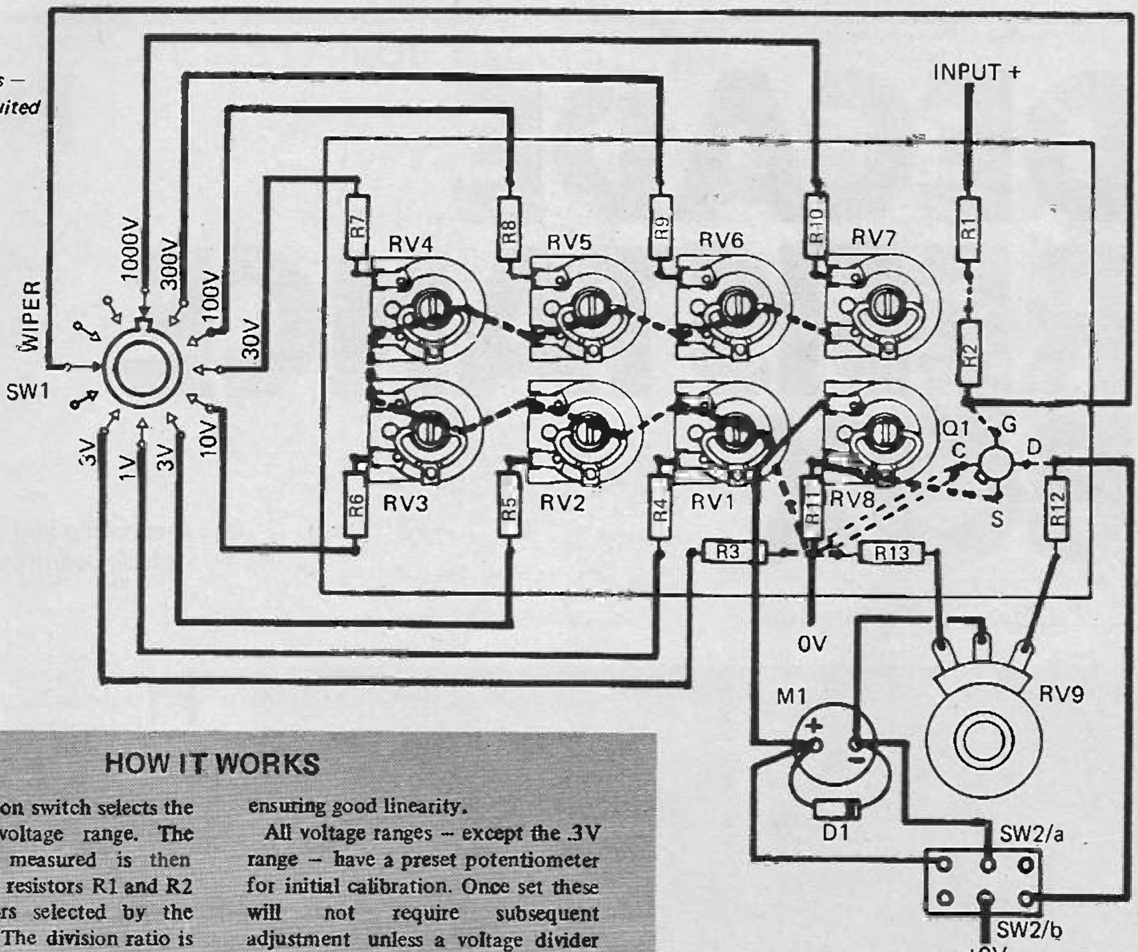
The battery 'on/off' switch should be double-pole double throw. When it is in the 'off' position the second set of switch contacts place a short circuit across the meter movement thus protecting it against mechanical damage whilst the instrument is not in use.

This switch together with range switch SW1 and 'zero-adjust' potentiometer RV9 must be mounted on the front panel of the instrument case.

## CALIBRATION

1. Connect the meter to a nine volt battery. Make sure that the polarity is correct. Switch the instrument to 'on'.
2. Switch SW1 to the .3V range. Short circuit the input terminals and adjust the 'zero-set' potentiometer (RV9) for zero meter deflection. Then remove the short circuit.
3. Apply an accurately known 300mV to the meter input terminals and adjust RV8 to obtain full scale deflection on the meter.
4. Repeat steps 2 and 3 until the meter reads correctly both at zero and full scale deflection. Once this has been achieved do not readjust RV8. during any subsequent operation.
5. Switch the meter to the 1V range, apply an accurately known 1V and adjust RV1 to obtain full scale deflection.
6. Now switch to the other ranges in turn and, in a similar fashion to operation 5, apply the appropriate input voltage and adjust the appropriate potentiometers for each range (RV2, RV3, RV4, RV5, RV6, and RV7) to obtain full scale deflection on each range. This completes calibration. ●

*Fig 2 Interconnections — layout shown here is suited to matrix board construction*




DOTTED LINES REPRESENT INTERCONNECTIONS ON THE UNDERSIDE OF THE BOARD

### HOW IT WORKS

An eight position switch selects the desired input voltage range. The voltage to be measured is then divided by input resistors R1 and R2 and the resistors selected by the setting of SW1. The division ratio is such that approximately 200mV is applied to the gate of the FET with 100% input.

The naturally high input resistance of the FET together with negative feedback from R11 ensures that, even on the lowest range, there is never less than 18 Megohms in parallel with the lower end of the input voltage divider. This will have a negligable effect on meter accuracy.

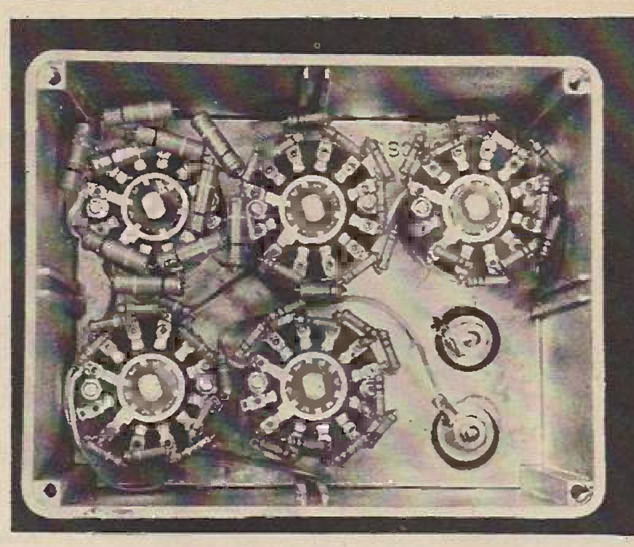
Another advantage of using negative feedback is that this limits the working range of the FET thus ensuring good linearity.

All voltage ranges – except the .3V range – have a preset potentiometer for initial calibration. Once set these will not require subsequent adjustment unless a voltage divider resistor or the FET is replaced.

Potentiometer RV8 establishes full scale deflection on the 0-3V range. It is also used to correct for any spread in the transfer conductance (gain) of the FET.

The 250 ohm wire wound potentiometer RV9 is mounted on the front panel of the instrument and is used as a 'zero adjustment'. In effect it cancels out the voltage appearing at the source terminal or the FET when there is zero voltage at the input.


*The decade resistance box.*



*Interior of the completed unit.*

# DECADE RESISTANCE BOX

ETI PROJECT 108

**A versatile and accurate variable resistance unit for experimenters**

HERE is a simple, but very valuable, addition to your electronic workshop equipment. Every experimenter constantly finds that the breadboard mock-up doesn't quite match the theory calculations, and that he needs to fiddle resistor valves.

There is nothing more time consuming than the "unsolder and try another" method. This time waste may be virtually eliminated by using a good decade resistance box.

Another use for a decade box is as a precision variable-resistor in experimental measurements and to meet this requirement we have provided ten-ohm resolution and have specified 2% accuracy resistors. These resistors are available at reasonable cost; the expense of higher accuracy components being not justified for most applications.

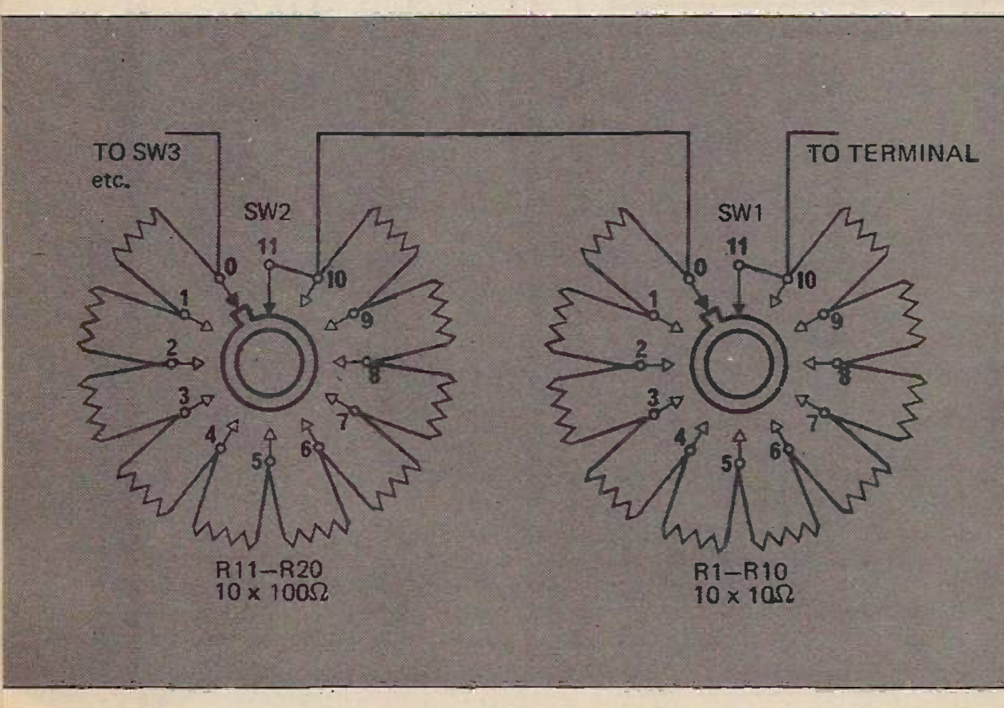



*Fig. 1. The method of interconnecting the switches.*

**PARTS LIST**

R1 – R10 Resistor 10Ω 2% ½ watt Philips type MR30 or equivalent.
R11 – R20 Resisfor 100Ω 2% ½ watt Philips type MR30 or equivalent
R21 – R30 Resistor 1000Ω 2% ½ watt Philips type MR30 or equivalent
R31 – R40 Resistor 10kohm 2% ½ watt Philips type MR30 or equivalent
R41 – R50 Resistor 100kohn 2% ½ watt Philips type MR30 or equivalent
SW1 – SW5 Wafer switch, single pole, 11 position OAK type F or similar.
diecast box 4¾" x 3¾" x 2", ITT type 043B00 or similar.
2 binding post terminals and 5 knobs.

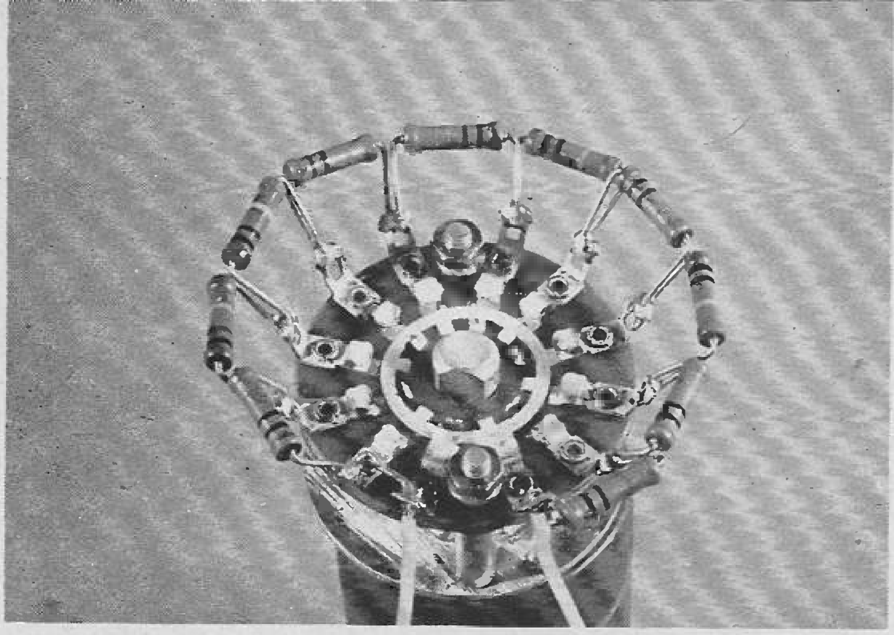


*Fig. 2. The resistors are mounted to the switches as shown.*

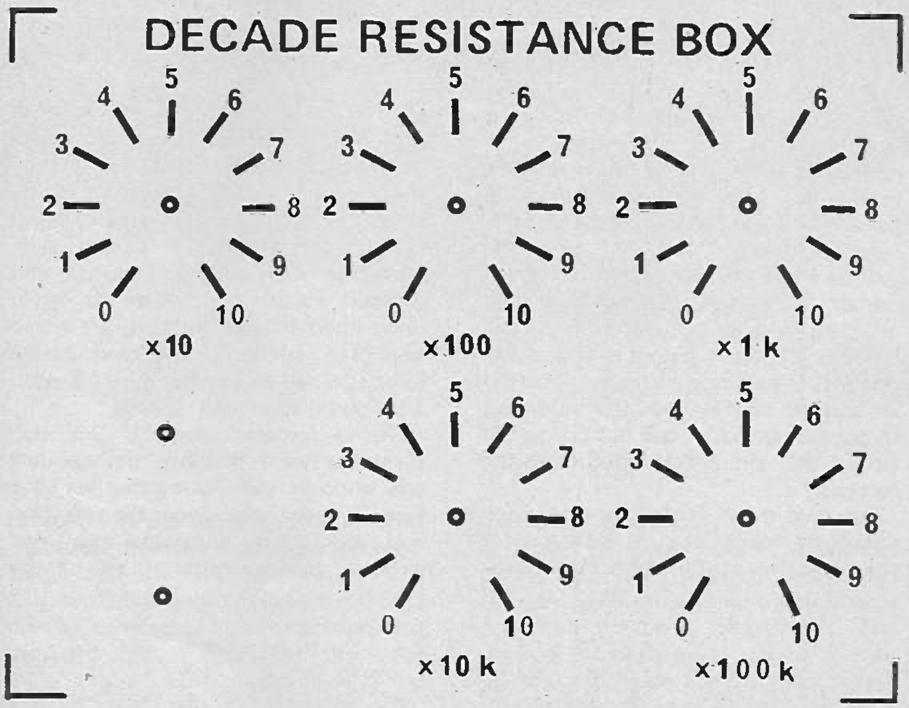



*Fig. 3. Front panel overlay (full size).*

## CONSTRUCTION

Assemble the resistors to the switches as shown in the photograph, R1-R10 to SW1, R11-20 to SW2 and so on to SW5.

Fit the switches to the metal box and ensure that the resistors are clear of the metal box sides. If there is insufficient clearance a piece of manila-folder cardboard will provide the necessary insulation.

Connect all the switches in series, as shown in Fig.1, and then connect the wiper of SW1 to one of the input terminals with one single strand from a piece of flexible hook-up wire. This will act as a fuse and protect the switch contacts from damage due to shorts. Finally connect pin "O" of SW5 to the other terminal.

In our prototype we disassembled the switches and filed away the stops thus allowing continuous rotation in either direction. Be very careful, if you decide to do this, not to damage the switch. Remove the wafer assembly taking care not to apply pressure to the rotating wiper section. Remove the circlip retaining the shaft and withdraw the shaft/clicker plate assembly. The stop may then be removed with a file and the switch reassembled. ●

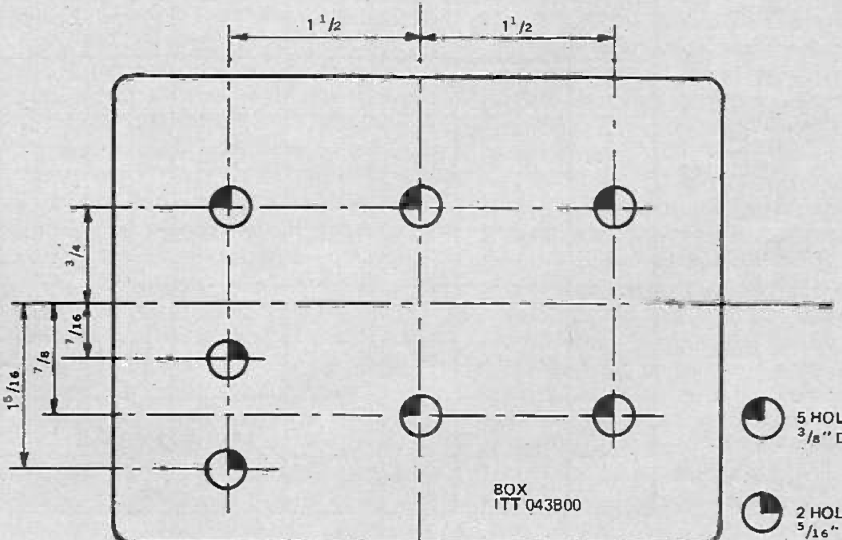



*Fig. 4. Drilling details for the diecast box.*

electronics TODAY INTERNATIONAL
product test

# SONAB MODEL 85S TURNTABLE

**This Swedish designed turntable is excellent value**

AS with the Sonab speakers — reviewed in our June issue — the Sonab turntable is unusual both in appearance and design philosophy.

Our review model was built under licence by Yamaha in Japan, but in UK Swedish built units are sold.

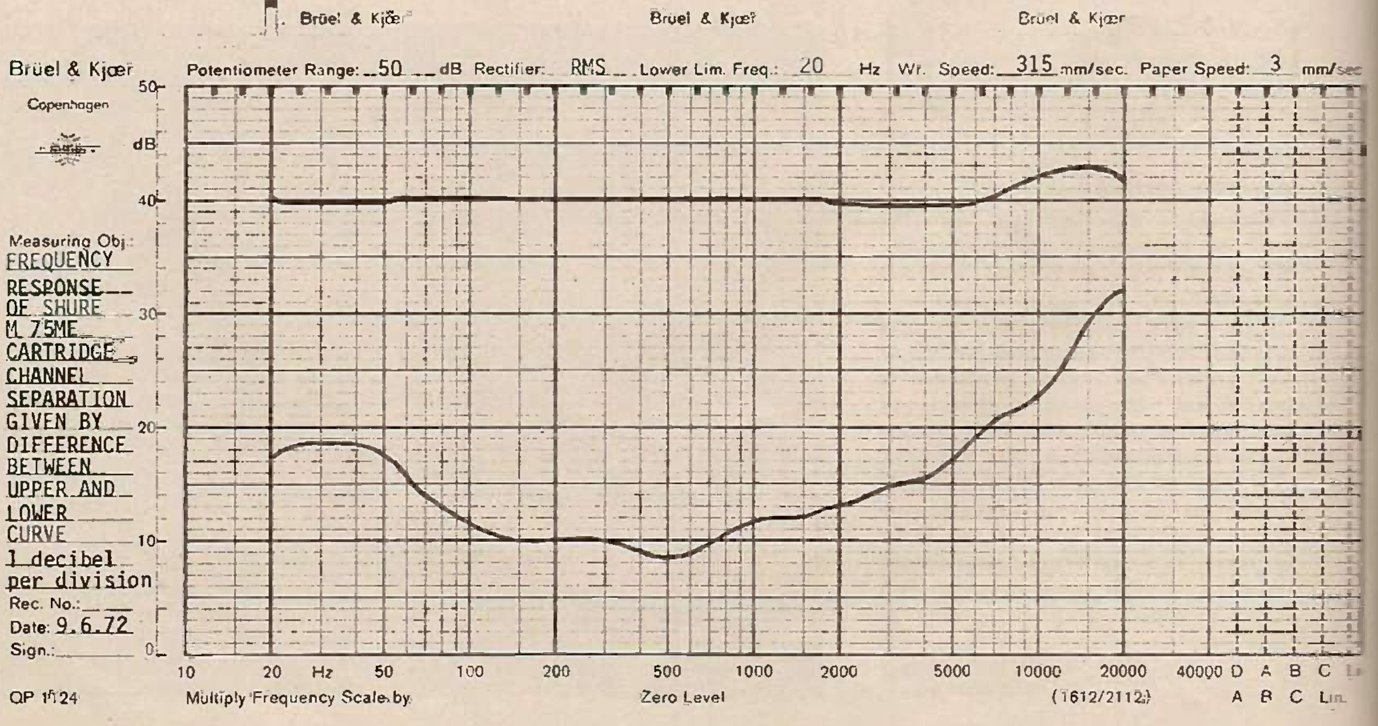
Once unpacked from its moulded polystyrene foam packaging, one immediately notices the lack of trimmings and fancy controls so evident on many turntables now on the market. Apart from the chromed tone arm, the metal disc in the centre of the black rubber turntable mat, and the visible edge of the cast aluminium alloy turntable, the complete plinth is finished in black.

The top of the base consists of a single diecast panel. This supports the spring-isolated motor, spring-isolated tone arm, and turntable mounting panel with its associated automatic cueing controls.

A clear perspex cover with a small Sonab label glued in the centre is attached to the base with friction type hinges. These hinges effectively dampen the closing of the lid. There is an audible knock when the lid comes in contact with the base but not to the extent that the arm is lifted from the records.

The two main controls are recessed rocker switches, one on each side of the top panel at the front. The one on the left hand side is for 45 r.p.m. or 33-1/3 r.p.m. speed selection whilst the one on the right is used for starting the player or rejecting a record in the middle of play. The only other control is an unusual shaped cueing lever which is confusingly labelled and difficult to use because of its direct unclamped linkage. In fact, after two weeks of operation the bent cueing lever still had us confused, resulting in a couple of scratched records.

The automatic controls on this turntable were possibly the quietest and smoothest operating that we have seen. A quick look under the precision cast aluminium turntable explained why it was so quiet; most of the




components are moulded from nylon. Operation of the automatic controls is simple and effective. To play a record it is necessary only to place the record on the turntable, move the tone arm over the record edge, and press the play switch. Once the switch is pressed, the turntable starts rotating, and the arm is lowered automatically on to the record. At the end of the record the arm is automatically lifted and returned to the rest, after which the motor stops. The automatic return and shut off can be initiated at any time during the playing of a record by pressing the play switch.

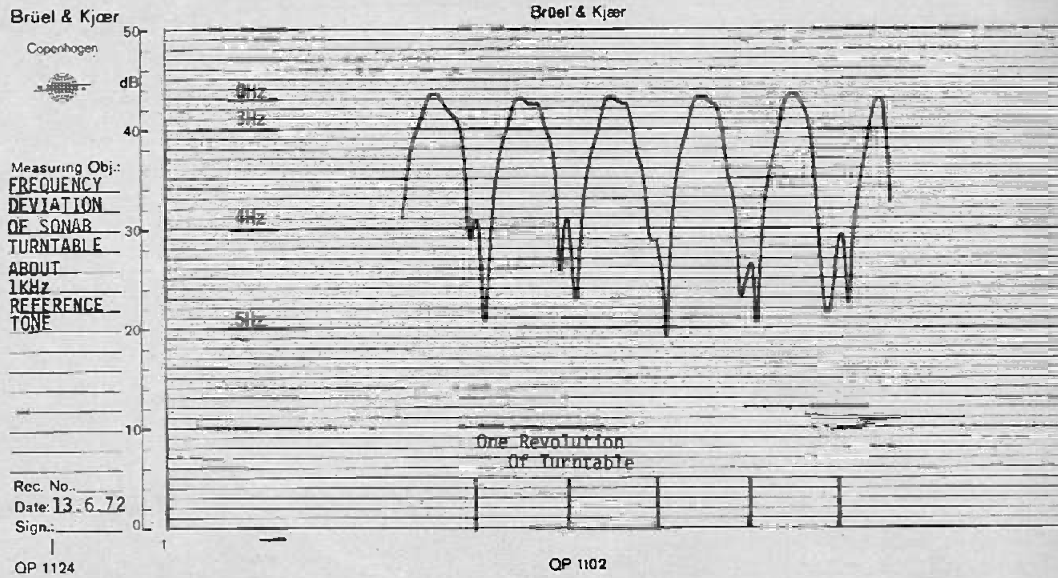
## TONE ARM PIVOT

The tone arm pivot arrangement is another unusual feature of this turntable. Whereas most conventional tone arms have the axis of the horizontal bearings in the same plane as the tone arm axis, and externally visible, the Sonab has completely the opposite. The bearings are located inside the tone arm pedestal and approximately ¾ of an inch below the tone arm axis. This results in a clean and uncluttered external appearance but produces complex out of balance moments. This problem is adequately corrected by a cantilevered mass fixed to the tone arm pedestal underneath the turntable, minimising the moments produced in the vertical plane. The only resultant error is that produced by the imbalance necessary to obtain the desired tracking weight. However, this makes it impractical and very unwise to change the cartridge type or brand, unless it has the same weight as the one installed, as any change in cartridge weight would necessitate adjustment of the cantilevered mass, so that the resultant reaction is through the horizontal bearings. However as the Shure M 75 ME cartridge supplied with the turntable has above average performance, few people are likely to make any change.

The frequency response of the cartridge was one of the flatest we have seen, being within ½dB from 20Hz to 7kHz and rising 3dB at 15kHz. This small rise at the top end was undetectable. Channel separation was exceptional, being as much as 31.5dB at 500Hz and only dropping below 20dB above 10kHz (and this possibly being due to excessive antiskating force). The tone arm is balanced and the tracking weight set by screwing a chrome counter weight in or out to obtain balance, and then moving it a calibrated distance to produce the desired tracking weight. The antiskate mechanism is factory preset and presumably not adjustable — apart from a screw located under the turntable, which if removed, considerably reduces the antiskate force. On the turntable reviewed, the antiskate force was slightly excessive, producing a difference of approximately 1.8dB between the left and right channels when checked with a 1kHz tone.

The measured performance of the turntable was quite good with the linear unweighted signal to noise ratio of the complete system being 43dB. This level was predominantly hum pick-up from the four-pole synchronous motor. The A scale weighted signal to noise ratio of the complete system was 57dB. The wow and flutter was higher than Sonab's specification, being 0.4% RMS. This appeared to be due to an irregularity in the belt and possibly a high spot on the drive rim. For interest we produced a spectrogram of the output

# SONAB MODEL 85S TURNTABLE




frequency from the turntable (using a 1kHz test tone) to see how speed varied during each revolution. The spectrogram clearly shows the flexing of the belt during each revolution. The results are typical for any belt drive turntable and highlight why a belt drive turntable generally has higher wow and flutter than a rim drive type turntable.

## INSTALLATION AND OPERATING KIT

The Sonab 85S is the only record player we have reviewed to date which is supplied with a comprehensive installation and operating kit. This kit includes

(i) a record cleaner with cleaning brush
(ii) a plastic container of oil for the motor bearings
(iii) an additional counterweight if a heavy cartridge is to be used
(iv a 45 R.P.M. record centre
(v) a styling brush
(vi) a small screwdriver
(vii) a plastic bag containing an untreated blue cloth and a small squeeze tube of some perfumed liquid, presumably for cleaning extremely dirty records, (if we could read Japanese we would know!)

Apart from all this, there is also a pair of tweezers for removing and fitting the leads to the cartridge pins — a very useful and worthwhile inclusion.

The instruction manual, as with all Sonab manuals, is written in four languages and is arranged in a logical sequence, starting with unpackaging instructions and followed by installation and operating instructions. Under the heading of "The Records" is some very noteworthy advice:-

"this has been said many times before, but is nevertheless worth repeating:
Take good care of your records.
Never touch the playing surface with your fingers.
Grip the record at the edge only.
Do not allow dirt to accumulate in the grooves. The stylus is made to reproduce music, not plough through dust and dirt."

There are a couple of minor errors in the manual. In the illustration showing how to align a cartridge correctly Sonab incorrectly show the stylus in front of the white mark, and not directly below it as detailed in the written instructions. The other error in the instructions is in the "technical specification" and shows the output signal as "16.8mV RMS." instead of 6.8mV.

The Sonab 85S record player adequately combines automatic control with a belt drive turntable and is complemented by a very good quality Shure cartridge. A few minor changes to the cueing control and the antiskate adjustment would make it a very good unit. At a recommended selling price of £89.50 the Sonab 85S record player compares favourably, particularly in appearance, with many other automatic record players. ●

### MEASURED PERFORMANCE OF SONAB MODEL 85S

### TURNTABLE SERIAL No. 04023

| | |
|---|---|
| **Frequency Response** 20 to 20kHz | $^{+3}_{-0.5}$ dB |
| **Channel Separation** At 1kHz | 28dB |
| **Channel Difference** | 1.8dB |
| **Sensitivity at 1kHz** (re 5 cm/sec) | 6.3mV |
| **Signal to Noise Ratio** (complete system re 1kHz at 5cm/sec) | 43dB |
| **Wow and Flutter** | 0.4% RMS refer spectrogram |
| **Hum And Rumble Equalized But Unweighted** (re 1kHz at 5cm/sec) | 43dB |
| **Cartridge Weight** | 6.04 grams |
| **Turntable Weight** | 3lbs. |
| **Dimensions** Width 17-3/8" x Depth 14-1/2" x Height 6-3/8" | |
| **Recommended Selling Price** | £89.50 |

# INPUT GATE

LETTERS FROM OUR READERS

## INTEGRATION INDEX

I wonder if, with so much useful information being published in your excellent magazine, you have considered publishing an index? This is a facility which would be well worth paying for.

Have you heard the rumour concerning the company mentioned on page 8 of the July issue under the heading 'Large Scale Integration'. This is to the effect that, to overcome objections by the Race Relations board against importation of their products, Powell Enterprises Ltd have been granted a concession to manufacture the Colour Bar Generator under licence. Messrs Powell's Ltd are, of course, famous for their whitewash. (I can not be held responsible for the accuracy of this rumour though it is probably as authentic as your news item!).

Seriously I would like to express continued admiration and appreciation for your incomparable publication — it continues to be 'just what the Doctor ordered'.

—D V, Durham

*An index will be published at the end of each volume. We can confirm that the rumour you quote is definitely as authentic as the news item. —Ed*

## LASER DEFENCE

It was interesting to read the editorial in the October issue. Like most scientists, my main interest is in the science of things and not the politics, diplomacy or financial speculation that surround such discoveries.

The laser beam (which travels at the speed of light, the highest known speed) unlike the bullet or the rocket, is of low mass and can be dispersed, refracted, or reflected. By the use of a simple passive corner reflector, the beam can be reflected back to it's source almost independent of the angle of incidence. Such corner reflectors suitably mounted on an ICBM or carried by infantry in the battlefield can reflect the damage back to it's source.

The laser beam system can be made more sophisticated by incorporating a means for checking the reflective properties of the target before switching on the death ray. Again the corner reflector can foil the laser beam by including a thin black sheath that disintegrates under high power and renders the corner reflector effective. And so goes on the argument ad infinitum. For every weapon there is a counter weapon, and only those that can afford them will survive.

The danger is not in the scientific strides that we attain, but in the lack of progress in our social standards. Like the knife edge as first discovered by the stone age scientist, we could have forecast an end to the human species within decades of it's first discovery, but it took up to the twentieth century to learn to live in peace with the knife edge.

Thank you for an interesting magazine.

—K K L, Cornwall

*Can you imagine an infantry man with 6000 cube-corner reflectors pasted all over him? The knife was never a danger to the survival of the race as a whole. Can we say the same for modern weapons? — Ed*

## SPUDNIK

After reading your article on Murphy's Laws (October issue) I got the feeling that the author actually believes in them. He doesn't......does he?

—N W T, Doncaster

*Definitely not......I think. — Ed*

## ADAPTION

I was very interested in the emergency light unit which you had published in the October issue of your very excellent magazine Electronics Today International.

I would be most grateful if you could help me to adapt part of the light unit to use for an ammeter that I am building for my car.

The type of meter that I am using is a 1mA meter with the pointer resting on the left hand side of the scale. For positive and negative readings, charge and discharge, I want to use this so that when a positive current is flowing the meter would read from left to right as it normally would but when it is passing a negative reading, I want it to read the same way, that is from left to right as it previously did but through a diode circuit as in the Emergency Light Unit only this time switching on a lamp indicating a negative reading, ie the discharge.

—V W, Lanarkshire, Scotland

*Regretfully we are unable to give advice on circuitry for extensive modifications to project circuitry. We just don't have the time and are unable to spend more than 10 minutes or so on any readers letter. So please......keep it simple.*

I wish to make an Infra-Red Night Scope for my own use. Do you have and would you supply, a suitable circuit diagram for it? If not, can you inform me of someone who will be able to help me? Thank you.

—K F, Cornwall

*Try ITT or EMI who are both active in image intensifier and night scope equipment. Ed*

## ZERO —100 REVIEW

How do you explain the fact that every electronics and hi-fi magazine in the world have given the Zero — 100 turntable a rave review whilst yours was somewhat less than enthusiastic.

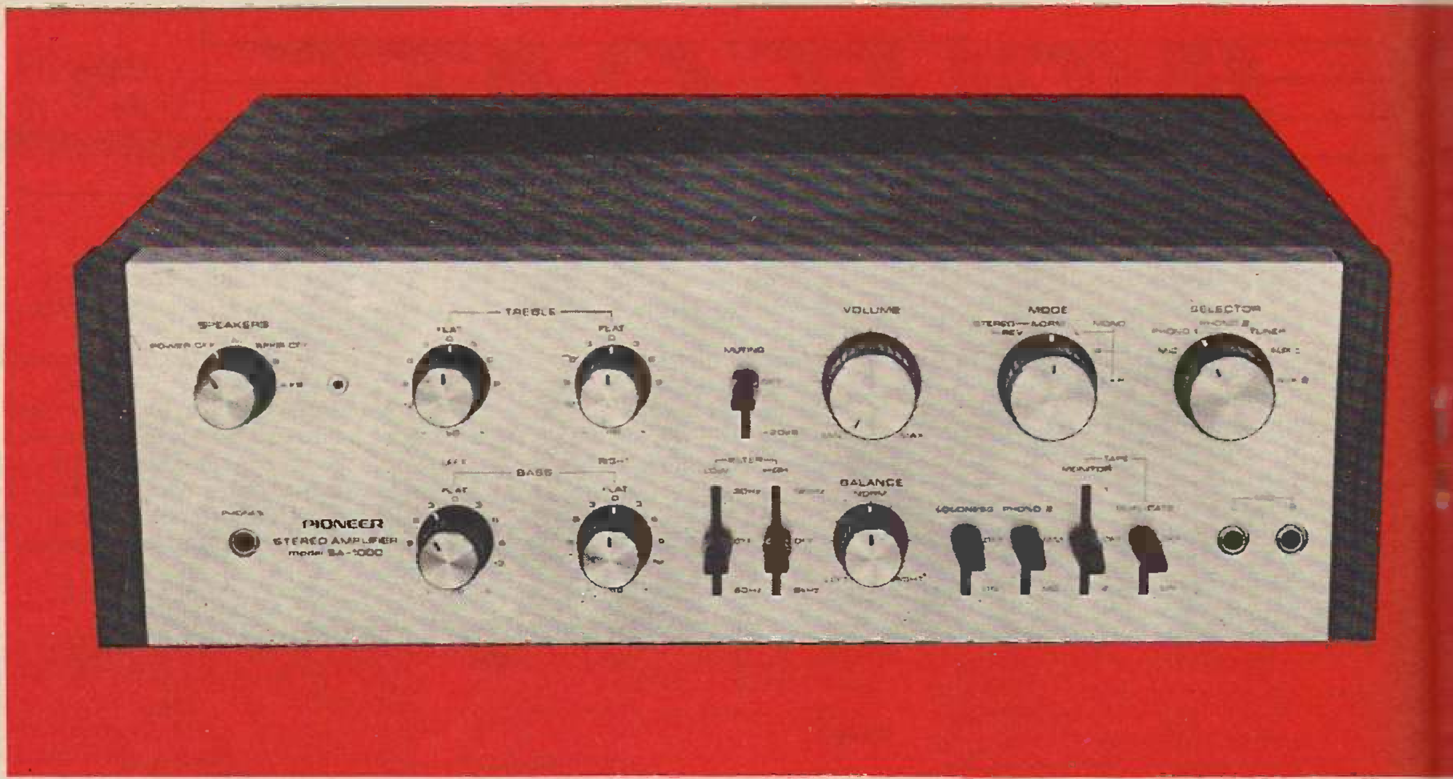
—T S, Newport NSW

*Let's take your points one at a time, Firstly it is not true that all magazines except ours gave rave reviews. For example writing in Hi-Fi Sound (August '71) John Wright says 'We feel to go to all this trouble simply to avoid a few degrees tracking error towards the outside of the disc is merely a rage over a lost penny'. Many other equally authoritative reviewers have made similar comments.*

*Secondly, price must be taken into account when reviewing any item of equipment. In England this unit costs £55. It is in competition with many other excellent units at similar and lower prices. In fairness to other manufacturers and our readers we must bear this in mind in our final assessment.*

*Thirdly, as we were aware of the unit's overseas reputation we took the precaution of testing two Zero —100 units. Both had substantially similar performance. We stand by our review.*

*Ed*




# PIONEER SA 1000 AMPLIFIER

**Versatile high-power amplifier is good value for money.**

electronics TODAY INTERNATIONAL
**product test**

JAPAN'S Pioneer Corporation started as a rather small speaker manufacturing concern, known as the Fukuin Electric Works, in 1938. It now has four large divisions, manufacturing audio equipment, speakers, car stereos and recording instruments.

The Pioneer SA 1000 is one of the most recent additions to the company's amplifier range and incorporates some of the most recent "state of the art" circuitry. It has many design improvements over the SA 900 which was previously Pioneer's top amplifier.

The unit arrived adequately packed in moulded expanded polystyrene enclosed in a cardboard box. Once unpacked we were confronted with a complex array of switches and control knobs on the front panel and what appeared to be, at first sight, an infinite array of input and output sockets on the rear panel; without doubt the SA 1000 stereo preamplifier/main amplifier has one of the most comprehensive sets of controls and switching facilities that we have seen to date. The front panel


is smoked, brushed, aluminium with polished timber end trim and contains two horizontal rows of controls. The top row of controls have the following functions – from left to right:–

a) Speaker-select knob with five positions; power off, speakers 'A' speakers off, speakers 'B' and speakers 'A' and 'B'.

b) Treble control left channel with three 3dB per step boost positions and four 3dB step cut positions.

c) Treble control right channel with three 3dB per step boost positions and four 3dB per step cut positions.

d) Muting switch with off and 20dB cut positions.

e) Volume control.

f) Mode select switch with five positions; stereo reverse, stereo normal, mono left, mono right and mono left plus right.

g) Programme source selector switch with six positions; microphone, phono 1, phono 2, tuner, auxiliary 1, auxiliary 2.

On the bottom row we have, from left to right:–

i) Headphone jack socket.

ii) Bass control left channel with four 3dB per step boost positions and three 3dB per step cut positions.

iii) Low filter select switch with three positions up – 30Hz filter; centre – off; down – 60Hz filter.

iv) High filter select switch with three positions up – 12kHz filter; centre – off; down – 6kHz filter.

v) Balance control.

vi) Loudness switch, with on and off position.

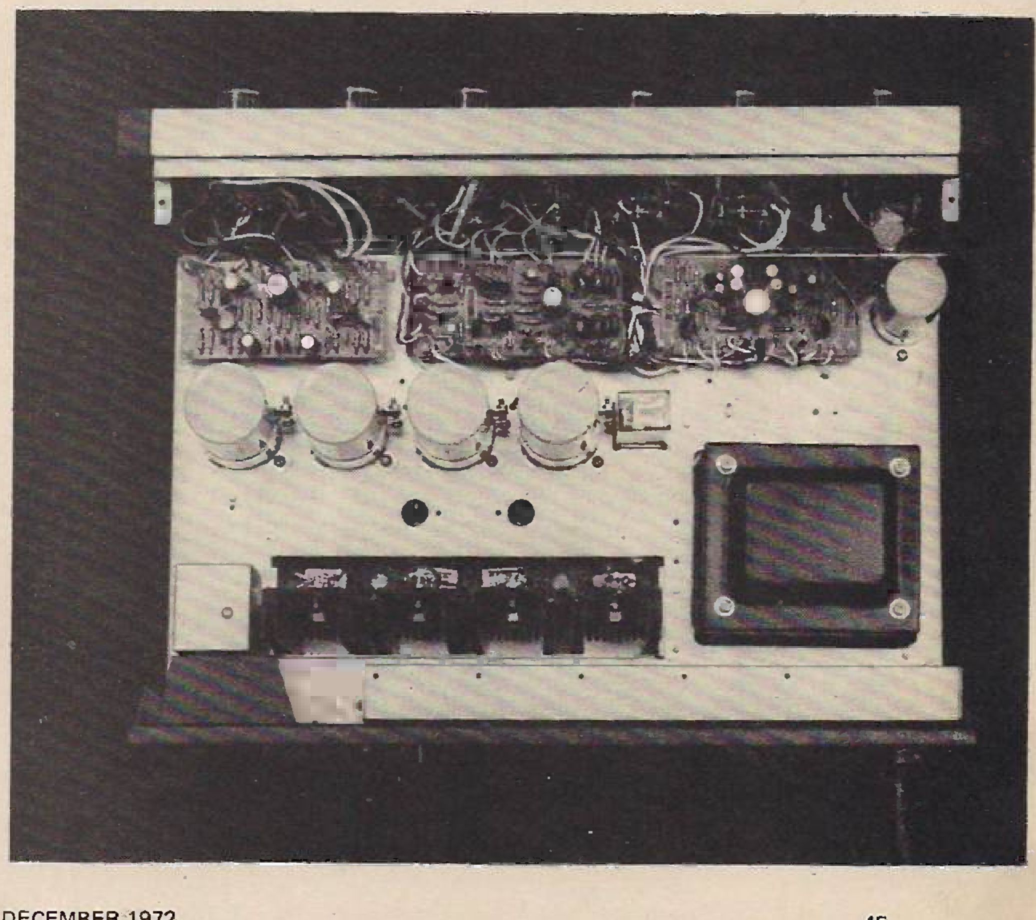
vii) Phono 2 cartridge type select switch with two positions; moving coil and moving magnet.

viii) Tape monitor switch with three positions; up, tape 1 monitor, centre, 'off', and down tape 2 monitor.

ix) Tape duplicate switch with 'on' and 'off' position.

x) Two microphone input jacks.

All input and output sockets are



# PIONEER SA 1000 AMPLIFIER

located on the rear panel with the exception of the microphone inputs and headphone output as detailed above. Pairs of R.C.A. sockets are used for:— Phone 1 magnetic input, Phone 1 ceramic input, Phono 2 input, tuner input, auxiliary 1 input, auxiliary 2 input, preamplifier out, main amplifier in, tape 1 record, tape 1 monitor, tape 2 record and tape 2 monitor.

Centre channel output is via a single R.C.A. socket at the right hand end. To facilitate connection of a tape recorder with a combination DIN record playback lead, a DIN socket is included in addition to the R.C.A. sockets for Tape 1. Outputs for speakers 'A' and speakers 'B' are via polarized two pin sockets grouped in pairs. Three 2 pin American type power outlets are also provided on the rear panel, one switched, the other two unswitched. Other features of the rear panel include:—

a) A multipin valve-base socket into which a phono transformer plugs for moving coil cartridges.

b) A phono 2 input impedance select knob with 20kΩ 50kΩ and 100kΩ positions.

c) A pre-amplifier, main amplifier isolation switch.

d) A multipin fuse holder which doubles as a mains voltage selector with 'off', 110V, 120V, 130V, 220V, and 240V positions.

**MEASURED PERFORMANCE OF PIONEER SA 1000 AMPLIFIER SERIAL NO**

| | | |
|---|---|---|
| **Power Output Into 8Ω Load At Rated Input** (both channels driven) | | 65W |
| **Frequency Response At Rated Output** 20 to 20kHz | | ± ½dB |
| **Channel Separation At Rated Output** | | |
| Phono Input | | 45dB |
| Auxiliary Input | | 50dB |
| **Hum And Noise Unweighted With Respect To Rated Power Volume Control At Minimum Gain** | | |
| Phono Input | | 84dB |
| Auxiliary Input | | 94dB |
| **Total Harmonic Distortion At Rated Output** | | |
| 100Hz | | 0.25% |
| 1kHz | | 0.2% |
| 6.3kHz | | 0.2% |
| **Tone Controls** | | |
| Bass | — boost at 50Hz | 14dB |
| | cut at 50Hz | 12dB |
| Treble | — boost at 10kHz | 7dB |
| | cut at 10kHz | 11dB |
| **Filters** | | |
| 30Hz | (at 30Hz ) | −3dB |
| 60Hz | (at 60Hz ) | −2.5dB |
| 6kHz | (at 6kHz) | −3dB |
| 12kHz | (at 12kHz) | −3dB |
| **Loudness** | | |
| | boost at 50Hz | 11dB |
| | boost at 10kHz | 4dB |
| **Mute Control** | at 1kHz | 19.5dB |
| **Dimensions** | 16-15/16" wide x 5-11/16" high x 13-1/4" deep. | |
| **Weight** | | 28lbs |
| **Price** | recommended | £152.82 |

The top and side panels are oiled walnut and may be removed for flush mounting of the amplifier and for this purpose a full size template, showing shelf and front panel cutouts and fixing screw centres, is also supplied.

One function which warrants particular attention is the tape duplicate switch. When the switch is in the "on" position it is possible to transfer from tape 1 to tape 2 or tape 2 to tape 1 without affecting the normal operation of the amplifier via the modes available on the selector switch. For instance, it is possible to listen to a record in the normal fashion whilst the dubbing is in process and to interrupt the record to check the dubbing process by operating the tape monitor switch without affecting the recording being made. The monitor switch will either monitor the signal off the master tape or the signal off the just recorded tape, assuming the recorders have separate record and playback heads.

## THE ELECTRONIC CIRCUITRY

The circuitry consists of five sections, each on their own individual printed circuit boards plus a power supply printed circuit board.

The first board in the system is a preamplifier for phono 1, phono 2 and microphone inputs.

This board is followed by the main preamplifier which includes treble and bass tone control circuits, This circuit incorporates a FET in the input stage to eliminate switching transients from the stepped tone controls. The SA 900 amplifier, which was previously the most powerful amplifier of the Pioneer range, was well known for the clicks which its stepped tone controls produced. The SA 1000, by contrast, shows no sign of this, even at maximum power levels.

The third board contains the filters and the loudness control circuitry. The second last board is the power amplifier stage. This is directly coupled and drives the speakers via protection circuits.

The circuitry used in the main amplifier and protection circuit is rather ingenious. The input to the main amplifier drives one leg of a long tail pair, the other leg of which is in a feed-back-loop from the output. This arrangement very effectively reduces the inherent distortion produced by the quasi-complementary output stage. To balance the collectors of the long tail pair, a transistor load is placed into the collector of the feedback transistor. The protector circuit (which uses seven transistors) senses three main conditions; abnormally high temperatures on the heat sinks, the dc level at the speaker outputs, and excessive voltage at the output of the power transistors. The output power is also limited to 100 watts maximum when driving an 8 ohm load due to clipping in the output stage.

If a fault occurs it is possible to hear the relay switching in and out – checking the condition every couple of seconds until the fault is removed – whereupon it restores normal operation. This does not produce any thump at the speakers. When the amplifier is switched on, this circuit takes about three seconds to operate. Thus no switching transients are heard.

The dc sensing circuit protects the speaker coils against possible overheating and resultant damage. The unit tested was subjected to short circuited outputs and 12V overloads on the auxiliary's inputs over a period of three hours without any resultant damage.

The SA 1000 is particularly well constructed, with the mains transformer, all the front panel controls, the rear panel sockets and the printed circuit boards enclosed with sheet metal panals to minimize external interference. The four power transistors are mounted on a large common heat sink, vertically mounted between the perforated sheet-metal bottom panel and the expanded mesh grille in the timber top cover. This arrangement restricts the location of other equipment above the amplifier, as the grille in the top panel must always be clear to allow free air circulation. The amplifier was supplied with an operating-instructions manual and a comprehensive wiring diagram. The wiring diagram included individual circuit board layouts, as well as a large wiring schematic. From our past experience with Pioneer equipment we expected to find more information on the electronic circuitry and performance curves than are provided in this handbook. However, this data is supplied on a separate three-page sales leaflet, which gives a complete set of tone and filter response curves and good descriptive information on the main parts of the circuitry.

## MEASURED PERFORMANCE

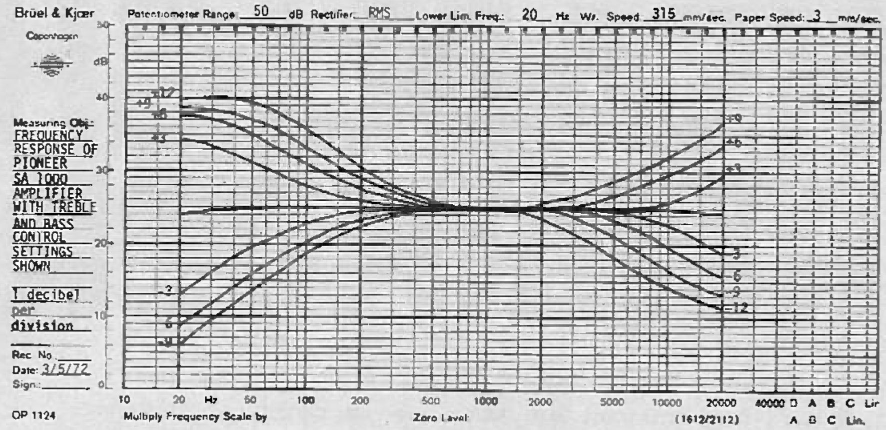
The measured performance of the SA 1000 was very good and equalled, or bettered, the manufacturer's specifications.

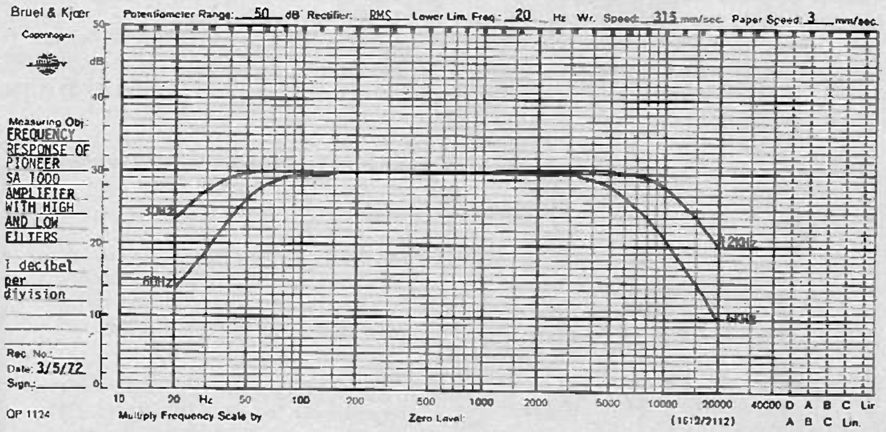
The harmonic distortion was less than 0.25% at all level settings. This is a realistic distortion level resulting in negligible increase in distortion from programme source or speakers. All the other parameters were correctly related to the overall performance of the amplifier and were more than adequate for true high fidelity amplification.

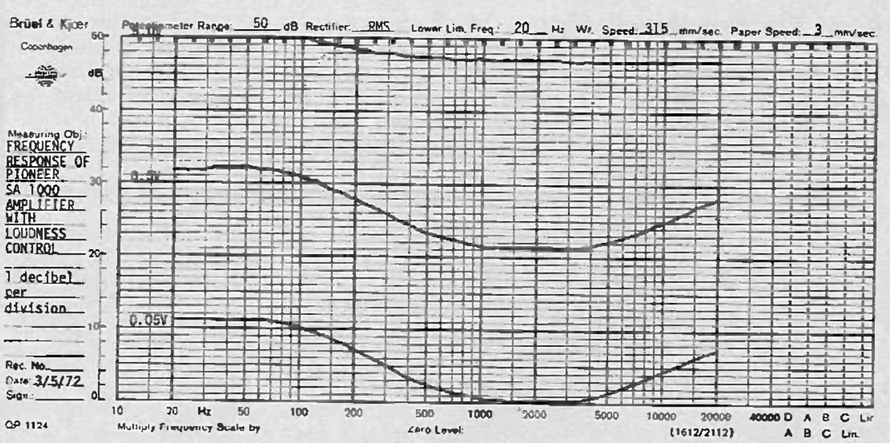
The subjective assessment of amplifiers is rather difficult because basically either they work or they don't. If they don't, then the measured performance will clearly show where the faults are.

Possibly more to the point is the assessment of the ergonomic design of the front panel controls. In this respect the Pioneer SA 1000 is good, with the controls most often used being placed across the top, and the secondary controls being placed along the bottom. A good example is the location of the two most used controls:– the combination power on and speaker select switch, and the source select switches which are located one at each end of the front panel.

The Pioneer SA 1000 is undoubtedly the most versatile amplifier ever produced by the Pioneer Electronic Corporation. It should satisfy the most fastidious purist in terms of switching facilities and performance and, at a price of £152.82, is very good value for money. ●



# HEADLIGHT REMINDER

**This electronic 'reminder' safeguards against flat batteries.**

A car's headlights cost less than one penny an hour whilst in use. Until you forget to turn them off.

Then you are up for recharging the battery, tow starting, apologizing to the managing director who has just flown 5,500 miles to discuss your future with the company, placating uptight parents whose daughter you returned just after they realized it was now daylight, or whatever combination of circumstances are least favourable to your immediate situation.

To avoid such predicaments is relatively simple and a number of circuits have been published that provide an audible warning if the ignition is switched off whilst the headlights or sidelights are still burning.

These circuits are simple and effective but invariably fail to cater for those occassions when one requires lights to be on whilst the ignition is switched off.

## HOW IT WORKS

Normally capacitor C1 is discharged via R1 and the closed switch contacts of an accessory wired via the ignition switch. If the ignition is now switched off, C1 will charge rapidly via R2 thus producing a negative going pulse at the base of transistor Q1.

If the vehicle's headlights (or side and tail lights) were switched on at this time, this pulse will turn on Q1, and close RLA.

The relay contacts RLA(1) and RLA(2) now close and contacts RLA(1) connect the base of Q1 to ground via R2 and R3 thus causing the relay to 'latch on'.

If either front door of the vehicle is opened with the relay in the latched condition an earth will be extended to the audible alarm device via the now closed contacts of RLA(2) and the closed door light switch.

The audible warning will cease immediately the door is reclosed. Q1 will of course be cut off and the relay reset when the lights are turned off (thus removing the positive voltage from the emitter of Q1).

If at any time it is required to disable the alarm circuit all that is necessary is – having first switched off the ignition – to switch the lights off and then on again. The circuit will revert to the status quo next time the ignition is switched on.

## PARTS LIST

**PARTS LIST – ETI-307**

| | | | | |
|---|---|---|---|---|
| R1 | – | 3.3k | 5% | ½W |
| R2 | – | 330 ohms | 5% | 1W |
| R3 | – | 3.3k | 5% | ½W |
| D1 | – | EM401 – 1N 4005 | | |
| D2 | – | " | " | |
| D3 | – | " | " | |
| Q1 | – | BC178 | | |
| C1 | – | 25 uf 25V electrolytic cap. | | |
| RL1 | – | miniature relay type VP2 185-280 ohm coil two change-over contacts. | | |
| 12V | – | alarm, Sonalert, bell, etc. tagstrip etc. | | |

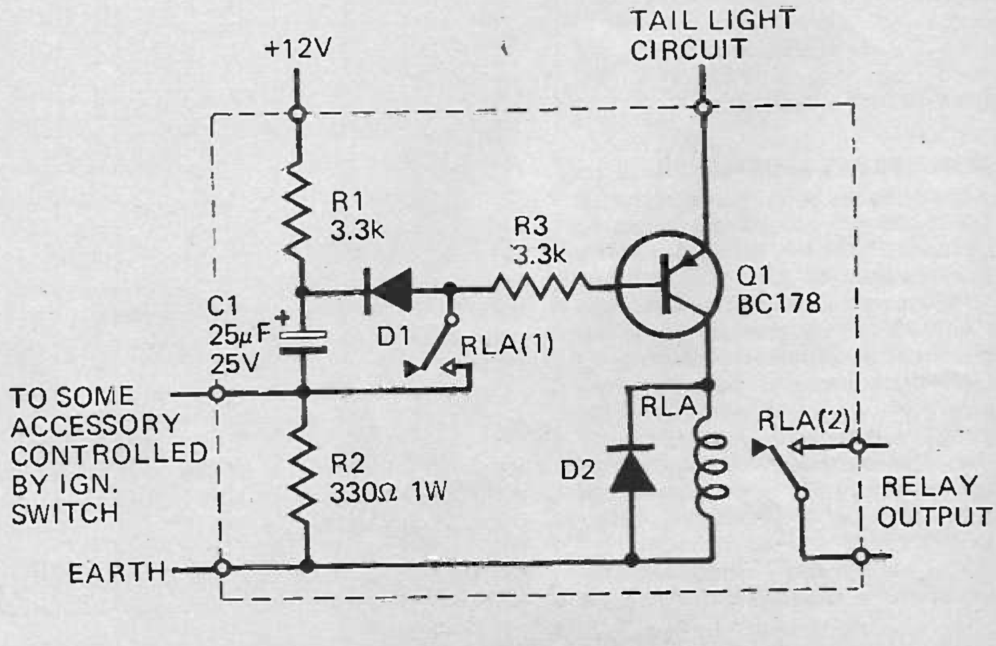



Fig. 1. The basic circuit.

ETI PROJECT 307

# HEADLIGHT REMINDER

Here then is a slightly more complex circuit that provides a 'headlight on — ignition-off' warning as the driver opens a door to leave the vehicle. The alarm ceases as soon as the driver closes the door.

The basic circuit is shown in Fig.1. The components may readily be mounted on matrix board or tag strips, and wired as shown in Fig.2.

As shown in Fig.1, the circuit is suitable for vehicles with a negative earth electrical system. To convert the circuit for use with positive earth vehicles replace the BC 178 by a BC108 (the connections are the same) and reverse the diodes and the 25 uF capacitor.

Figure 3 shows how the basic circuit is wired into the car's electrical system. The alarm unit may be a Sonalert, a buzzer, bell or even a flashing light. The existing door-operated interior light is used to extend an earth to the relay thus obviating the necessity to install any additional switches.

The lead marked 'tail light circuit' should be connected to the live side of the tail light wiring. (If a headlight only warning is required, this lead should be connected to the live side of one of the headlights). Further leads connect the unit to earth, the 12V vehicle supply and to the live side of any accessory that is wired through the ignition switch. ●

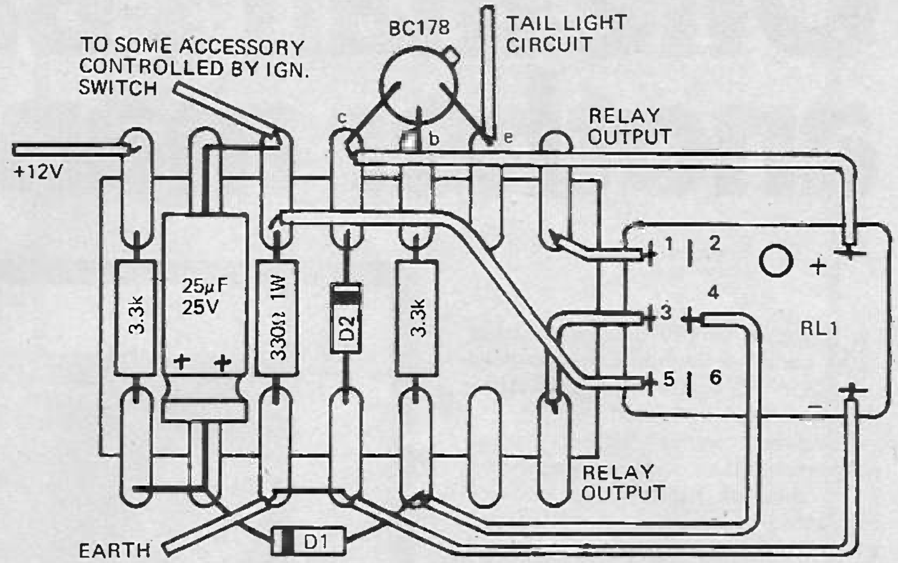



*Fig. 2.*

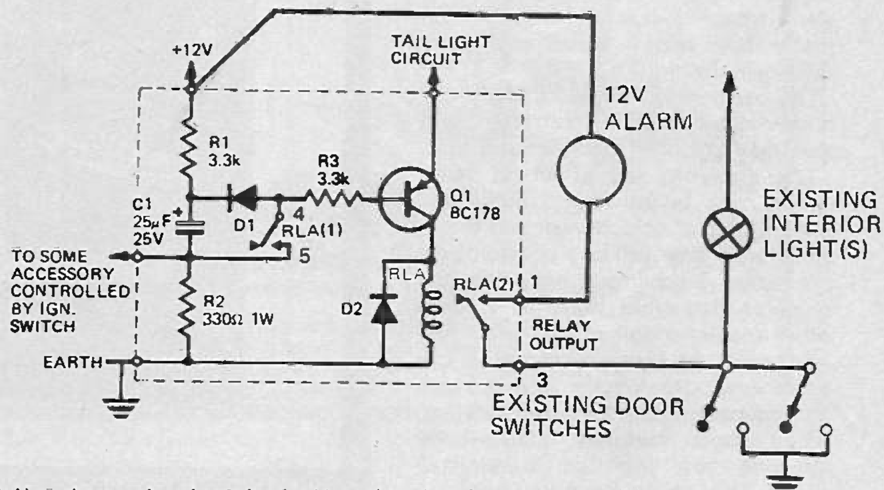



*Fig. 3. How the warning circuit is wired into the vehicle's electrical system.*

# One man's Bach is another man's blight

Noise is simply unwanted sound and few sounds are less wanted than 50 watts of hi-fi blasting through an adjoining wall.

Unwanted sound bothers some people more than others, as was shown by studies of subjective annoyance conducted in noisy areas of London and New York.

A quarter of those questioned were not bothered by noise at all — they could live happily in a discotheque. At the other end of the scale, one-tenth were troubled by any noise — no matter how faint — which was not of their own making.

The remainder were increasingly bothered by noise, or conversely said that they gradually became used to it.

The discomforting effect of noise should not be minimised. Like the discomforts of cold, hunger and thirst, annoyance may well be a physiological protective mechanism impelling the organism to avoid noise as it does other uncomfortable phenomena.

So, what of those 50 watts — can you have both Wagner *and* a social conscience?

You most certainly can — by reducing the level of transmitted sound. This article shows you how.

It is important to discern between materials that stop sound *transmission* and those which prevent sound *reflection*. A room lined with acoustic tiles, for example, seems less noisy because sounds originating in it are not reflected back to a listener in the room.

External noises, however, will penetrate the tiles. And noise from within the tiled room will penetrate to adjoining rooms. To prevent penetration, a sound barrier is required.

A good sound barrier must either be so massive that air pressure variations cannot cause any movement at all; or the barrier should have some mass but also be limp. In the latter case, any local movement will not affect the whole but will be dissipated within the material.

Lead is an obvious choice of a heavy limp material. Having a density two or three times that of common building bricks or concrete (and 10 to 15 times that of wood), it is a 'limp' material in the acoustical as well as the mechanical sense.

This combination of properties leads to the surprising conclusion that if two equally effective sound barriers are built, one of lead and one of any other common construction, the lead barrier will almost invariably be thinner and lighter — and in many instances cheaper as well! This is why lead is so often used for sound reduction in modern aircraft.

## How much sound reduction?

The generally accepted level is that which will reduce offending noise to the level of the background noise in the adjacent area. For example, an 80dB noise impinging on a wall which has 30dB attenuation will generate a 50dB noise on the other side.

If the normal and accepted level of background noise in the quiet area is 50dB, no annoyance will be experienced.

If, however, the normal background noise level is 40dB, it will now increase to 50, indicating that the barrier is inadequate. In this case a wall attenuation of 40dB is called for.

In practice, recorded music is rarely played at levels exceeding 85dB (although music peaks may occasionally attain 90). Assuming that an acceptable noise level in an adjacent area is 40-45dB, then the noise reduction required is also 40-45dB.

Decibel ratings quoted for sound reduction are generally averaged over nine specified frequencies, from 125 to 4000Hz.

Averaging methods are used because high frequency sounds are more disturbing than low frequency sounds (the ear does not have a flat response) and the averaged measurements take these differing sensitivities into account.

As a corollary of the above, the noise barrier must be more efficient in the medium and high frequencies than in

**Most people hate a noisy neighbour — and few of us want to be hated. This article tells how to sound-proof your music room, so you can enjoy hi-fi without annoying others.**

The Decibel (db)

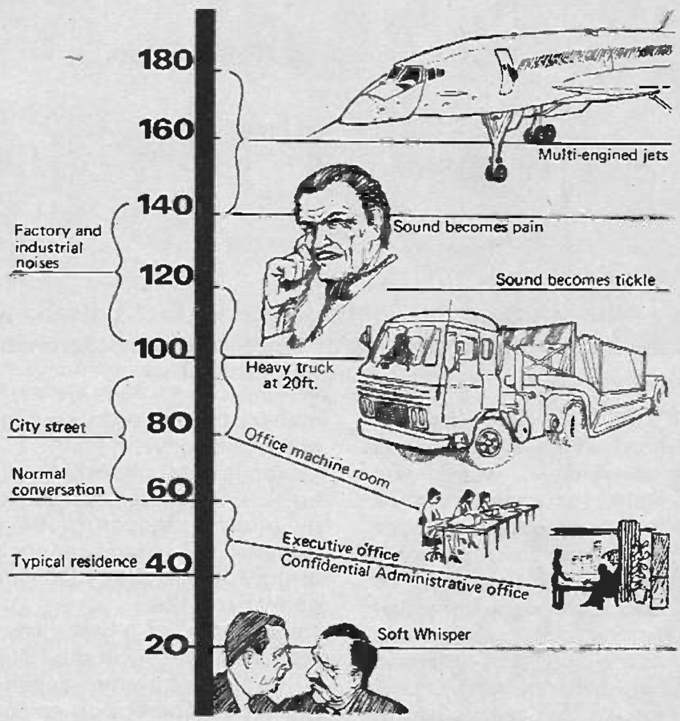
*The ear can hear a sound power as low as $10^{-13}$ watt — this is a pressure of ·0002 dynes per $cm^2$. The ear drum moves an amount approx. equal to the diameter of a molecule of nitrogen. When sound is uncomfortably loud, the hearer "feels" a tickle, then pain in the ear; a power level of 1 watt. approx.*

*Engineers take the logarithm of the power ratio and call it the DECIBEL (db).*

*The db level is given by —* $db = 10 \log 10 \frac{Watts}{10^{-13}}$

*The sound pressure level is =* $20 \log 10 \frac{P(dynes)}{\cdot 0002}$

Typical Decibel levels encountered




- *For a sound to be perceptibly louder or softer, it must be changed by 3 decibels.*
- *A noise twice as loud or ½ as loud is a change of 10 decibels.*
- *A reduction in noise of a few decibels in the low noise region (administrative office) is not significant. The same change at high sound levels (office machine room) is significant.*

the low frequency region. The most critical region is around 3kHz.

Although the sound insulation of a barrier depends largely upon its mass, single-leaf barriers of different materials of the same weight will not have the same noise isolating value. This is due to a 'coincidence' effect.

'Coincidence' occurs when the projected wavelength of the unwanted sound matches the wavelength of the natural resonance of the barrier. When this happens, a 'reinforcement' occurs and the barrier will transmit sound more readily. This is illustrated in Fig. 1, where the attenuation of different materials is plotted over a range of frequencies. The two building boards exhibit considerable 'coincidence' effects — note the dips at 1200/2400Hz and at 2400/4800Hz.

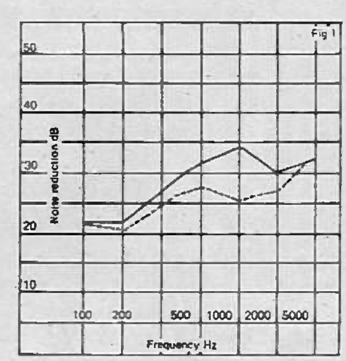
Because of its inherent limpness lead does not have any 'coincidence' — and by combining lead sheet and a suitable backing material a 'coincidence-free' acoustical barrier is obtained. It is, however, essential that the weight of lead in a laminate should equal or exceed the weight of the backing material.

Materials suitable for backing include hardboard, plasterboard and plywood. Comparative sound reduction figures (in decibels) are given below:

| | |
|---|---|
| ¼" hardboard | 28 |
| 3/8" plasterboard | 28 |
| ½" plasterboard | 30 |
| 5/8" plasterboard | 31 |
| ¼" plywood | 22 |
| 3/8" plywood | 24 |
| ½" plywood | 26 |

The sound reduction required will probably be between 40 and 45dB — possibly 50dB in quiet areas, or if you run your hi-fi flat out.

Existing walls may have attenuations as low as 15dB or as high as 40. Measurements taken in a number of home units show that the average attenuation is 25-30dB.




To reduce sound transmission to acceptable levels we must (on average) provide a further 25dB attenuation.

At first sight it would seem that this can be achieved merely by adding half-an-inch of plasterboard. In practice 'coincidence' effects and increased wall stiffness will negate all but a few dB.

# PART 6

# TRANSDUCERS IN MEASUREMENT AND CONTROL

**In this, the sixth article in this continuing series, Dr. Sydenham discusses the history and technique of temperature measurement.**

PREVIOUSLY we have discussed dimension, which is termed an extensive variable, where two physical lengths (or angles) can be placed together to produce the sum of the two. By contrast there are some physical parameters that cannot be added this way, as addition of equal quantities merely produces the same value. These are known as intensive variables of which temperature is one.

It is now known that heat is a form of energy but it has only been regarded this way since the late 18th century when Benjamin Thompson proposed the energy theory using, as an example, the boring of cannon. Prior to this, a substance known as caloric was thought to permeate all matter: the more caloric present, the hotter the body.

Experimental evidence shows that heat energy is stored as rapid molecular motion. Boyle had suggested this concept in the late 17th century, but it was Joule who finally demonstrated the numerical equivalence of heat energy and mechanical energy in the 1840's.

Temperature is the measure of the degree of hotness or coldness of a substance and a thermometer is a sensitive device used to indicate temperature in a convenient manner. Human senses are very limited when attempting to resolve temperature differences.

When two substances at different temperatures are placed in physical contact, heat flows from the hotter to the colder until thermal equilibrium is reached, that is, they reach the same temperature. This axiomatic law of thermodynamics enables auxiliary devices to be used to sense temperature. In many cases the presence of the thermometer may alter the measurement, so care is needed when using temperature sensors.

## SCALES AND UNITS OF TEMPERATURE

As temperature is directly related to molecular kinetic energy, it is theoretically feasible to define temperature in terms of the mass and

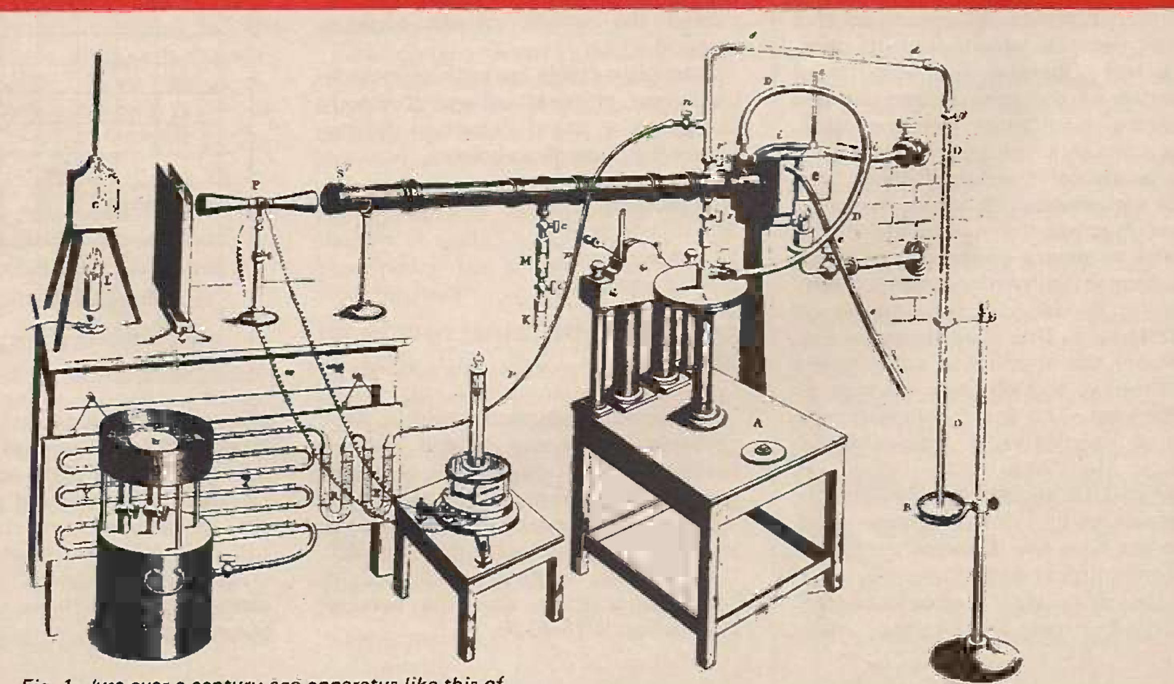


*Fig. 1. Just over a century ago apparatus like this of Professor Tyndall was in use for investigating heat phenomena.*

velocity of the molecules but this is not possible practically as yet. The high precision of mass, length and time standards (errors less than parts in $10^9$ in each case) cannot be realised when measuring masses as small as molecules. Other methods of standardizing temperature have therefore been devised.

Practical thermometers existed well before the energy concept was accepted and ancient references credit Galileo with inventing the first around 1590. These early thermometers used the fluid (liquid or gas) expansion effect and it was not until the 1820's, when the basic laws of electricity were discovered, that electrical methods began to appear for measuring temperature. Figure 1 shows how a laboratory was equipped in 1860 to investigate heat and radiation.

Early thermometers used liquids expanding inside slender glass tubes and had scales which were simply equal length divisions ruled along the tube. It is easy to see that there was not necessarily a relationship to others made elsewhere.

In the late 17th century, it was realised by several people that the transition points where ice melted to water and water boiled to steam could be used as invariant standard points for a temperature scale. Newton is said to have used human armpit temperature as an invariant point on his scale and the familiar, but now deprecated, Fahrenheit unit (devised by Daniel Fahrenheit in 1710) had 100 degrees chosen to range from the coldest laboratory temperature known at the time to body temperature. In 1742 Celsius, of Uppsala, proposed the scale which designated 0 deg. as the icepoint of water and 100 deg. as the boiling point. (The Centigrade scale was independently suggested a year later but is now correctly called only Celsius). The remaining problem was how to accurately subdivide between the two fixed points — there were as many values at the end of the 18th century as there were interpolation thermometers. Liquid-in-glass thermometers are still most useful in everyday measurements, and as sub-standards, for nothing has been devised which is as reliable and inexpensive. For standards use, however, they have been overshadowed by superior methods.

Boyle's law states that the product of the volume and pressure of a given mass of gas is constant at constant temperature. The law holds well for the gases that are hard to liquify such as helium, oxygen and nitrogen. Boyle's contribution led to the Charles-Lussac-Gay law (they each had a hand in its discovery in 1787). This shows that the thermal coefficient of expansion of all gases is the same, provided they are held at constant pressure. This provided a more promising standard thermometer principle, for the actual gas used was of little consequence. Furthermore, the expansion coefficient of gases exceeds that of liquids and solids. In the early 19th century, air-filled thermometers were the accepted standard, as scientists could construct their own and obtain the same results.

In an effort towards further improvement, scientists of the time again turned to thermodynamics and it was Lord Kelvin who realised that Carnot's heat-engine cycle held the key to an absolute thermometric scale. The Carnot cycle is the most perfect thermal cycle that can exist in a heat engine. The Otto cycle is a less perfect one used in some internal-combustion engines and the Stirling cycle is another. Each of these are practical realisations of ways to convert full energy into mechanical energy via a thermal process. In essence, Carnot's theory states that the maximum efficiency of energy conversion occurs when the temperature of the energy input medium (be it steam, petrol combustion, etc.) at each stroke is made to vary from the hottest available at the commencement of the cycle extracting the heat, to the coldest possible, that is, absolute zero. This is logical, for no heat can be transferred from an object at absolute zero, as nothing can be made colder. Absolute temperature can, therefore, be defined theoretically and Kelvin defined his absolute, or thermodynamic, scale with zero at the absolute zero. He also chose the value of 273 degree K (K is the symbol for absolute temperature) for the ice point. The thermodynamic scale is easily related to Celsius values, for only the value 273 has to be added to Celsius values. He chose fixed points along the scale to coincide with various transitions of state. Kelvin's scale is identical with the gas thermometer scale.

In 1927 it was internationally agreed that six reproducible equilibrium

| tp — triple point<br>bp — boiling point<br>fp — freezing point | 1927<br>ITS-27<br>C | 1948<br>ITS-48<br>C | 1948<br>IPTS-48<br>C | 1968<br>IPTS-68<br>C | K |
|---|---|---|---|---|---|
| tp hydrogen | | | | −259.34 | 13.61 |
| bp hydrogen, 25/76 atm. | | | | −256.108 | 17.042 |
| bp hydrogen | | | | −252.87 | 20.28 |
| bp neon | | | | −246.048 | 27.102 |
| tp oxygen | | | | −218.789 | 54.361 |
| bp oxygen | −182.97 | −182.970 | −182.97 | −182.962 | 50.188 |
| fp water | 0.000 | 0 | | | |
| tp water | | | +0.01 | ±0.01 | 273.16 |
| bp water | 100.00 | 100 | 100 | 100 | 373.15 |
| fp zinc | | | | 419.58 | 692.73 |
| bp sulfur | 444.60 | 444.600 | 444.6 | | |
| fp silver | 960.5 | 960.8 | 960.8 | 961.93 | 1235.08 |
| fp gold | 1063 | 1063.0 | 1063 | 1064.43 | 1337.58 |
| fp tin | | 231.9 | 231.91 | 231.9681 | 505.1181 |
| fp lead | | 327.3 | 327.3 | 327.502 | 606.652 |
| fp zinc | | 419.5 | 419.505 | | |
| bp sulfur | | | | 444.674 | 717.824 |
| fp antimony | | 630.5 | 630.5 | 630.74 | 903.89 |
| fp aluminium | | 660.1 | 660.1 | 660.37 | 933.52 |

*Fig. 2. The temperature scale is defined by several fixed points. This summarized table shows the minor changes made as measurement improved.*

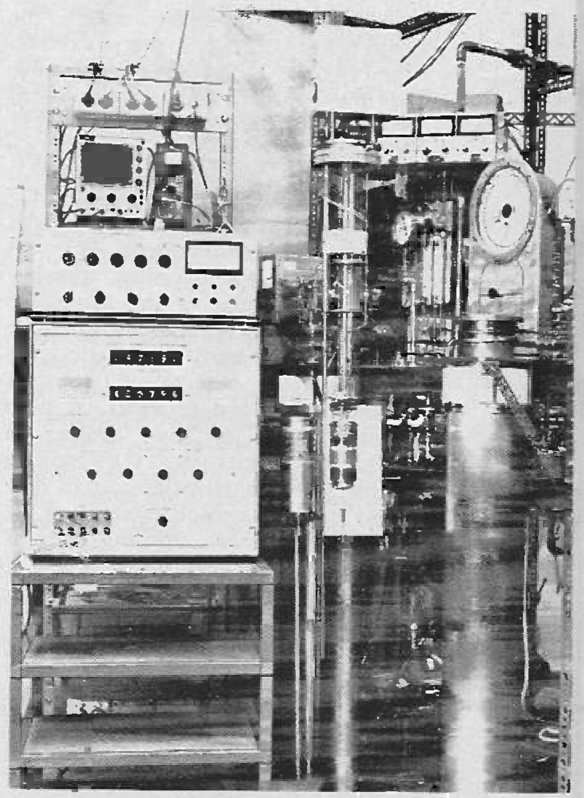


*Fig. 3. Establishing the oxygen point (−218°C) on the IPTS-68 scale at the National Standards Laboratory in Sydney.*

states be used to define the absolute scale and Celsius values were assigned to each. This is known as the International Practical Temperature Scale, IPTS for short. In 1948, and again in 1968, small changes were made in the values of the definitions as can be seen in the table of Figure 2 where the main features are shown. In general, the normal user of thermometers does not become involved in lengthy standardisations — (one equipment is shown in Figure 3). Instead we have secondary standards (calibrated thermometers of various kinds) that are used only to calibrate everyday instruments. Interpolation between the IPTS fixed points is made with defined electronic thermometers which are able to provide the continuous scale division required. Several methods are used — the resistance thermometer covers the range up to 630 deg.C, thermocouples from there to 1064 deg.C and above that the indirect radiation method of pyrometris takes over.

## TRANSFER OF HEAT

A proper understanding of temperature measurements (do not forget measurement must precede control, and control is only as good as sensor accuracy) requires a knowledge of how heat is transferred. This gives clues to obtaining accurate measurements and provides us with principles that can be invoked to transduce temperature. It is by looking at the fundamental principles in new ways and in new combinations as technology changes, that our state of the measurement art is improved.

Heat transfers by conduction, convection or radiation processes. Conduction is explained by the kinetic energy principle, in which adjacent particles impart energy to those having lower energy. The energy exchange process continues until thermal equilibrium is established. The rate at which conduction takes place is decided by the thermal conductivity of the material and this parameter is most important in temperature measurement and control.

If a slab of material is heated at one end, the rate of heat flow is dictated by its thermal conductivity and the temperature difference between the ends. Thermal conductivity can be regarded as analogous to electrical conductivity, as can heat flow to current, and temperature difference to voltage. Consequently, the solution of thermal conductivity problems can be treated in much the same way as simple series electrical circuits. A fact often overlooked, however, is that the interfaces between layers may have considerably greater thermal resistance than the layers themselves. By way of an example, when air is flowing in a steel pipe at room temperature and atmospheric pressure, the tube has 100 arbitary units of thermal conductivity, the air-steel interface 20 and the air to internal probe 0.02 units. Consequently, when a thermometer is used it must be ensured that the active part of the device is truly at a closc enough temperature to the body or fluid being measured. Silicon grease is a good heat conductor and is used to bed transistors onto heat sinks and thus obtain good thermal contact: a similar practice is recommended when bedding temperature sensors. Sometimes the sensor dissipates heat. In this case the indicated temperature will be high, as the sensor will be at a higher temperature than the body being measured, due to encapsulation conductivity. Another source of error could be that the thermometer mounting is conducting external heat to, or away from, the sensor. Simple basic rules for such cases are shown in Figure 4a.

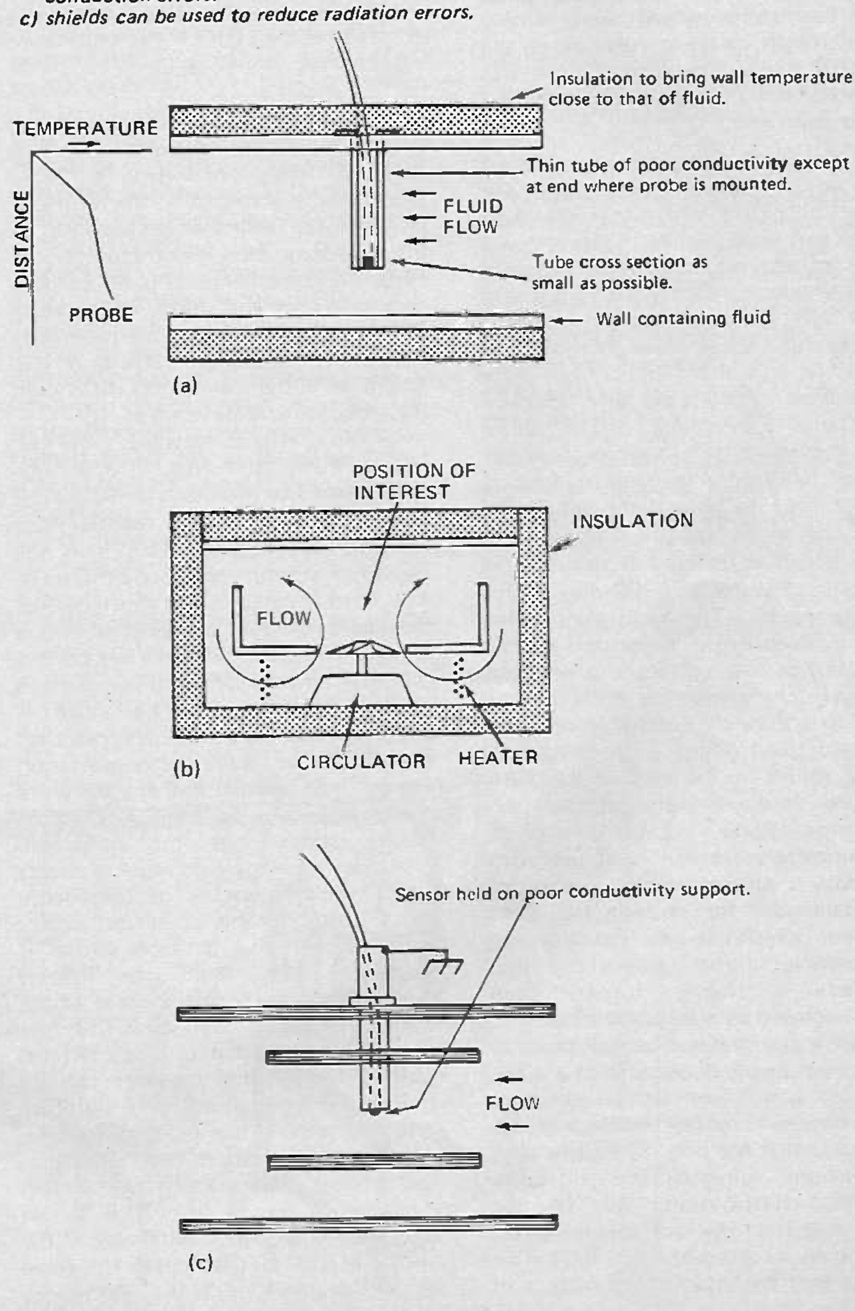
Convection occurs in substances that can flow: heating reduces density and colder sections of fluid therefore settle displacing the hotter. If there is no

*Fig. 4. Mounts for thermometer sensors need good thermal design to reduce errors due to thermal transfer mechanisms.*

*a) points to be observed when installing a thermometer well.*

*b) a good temperature-controlled bath circulates the fluid to reduce convection and conduction errors.*

*c) shields can be used to reduce radiation errors.*



physical medium, convection cannot exist. If, however, the temperature gradient in a medium is sufficiently small, convection will cease producing what is called inversion. Again sensor location must be chosen accordingly. In a car engine the temperature gauge sensor is placed high in the block to ensure a conservative reading. Fluids with poor thermal conductivity should be stirred, Figure 4b, to obtain reliable temperature measurements.

The third form of transfer, radiation, transmits heat by virtue of electro-magnetic (EM) radiation. More will be said of this in the following part where non-contacting methods are discussed. Radiation is most effective in vacuum for the EM waves are not attenuated by any interposed medium. The degree of transfer depends much upon the surface characteristics and is greatest when irregularities are of the same size as the radiation wavelengths. Shields are sometimes used around a sensor, as in Figure 4c, to ensure that the thermometer is measuring the medium and is not influenced by external radiation.

The measurement of temperature is as old as dimensional measurements; there are, therefore, many methods in use today. They can be grouped into expansive, direct electrical, radiation and acoustic techniques, in the main, with a large group of miscellany which sometimes provide answers for unusual problems. In this part we will consider expansion and direct electrical methods. For details of practical circuits used in temperature controls, refer to the series on temperature control which commenced in the August issue.

## EXPANSIVE DEVICES FOR MEASURING TEMPERATURE

Of the many means by which temperature changes effect physical things, the most obvious is movement due to expansion and contraction. It is, therefore, not so surprising that the earliest thermometers operated on this principle with water, alcohol and, later, mercury in glass tubes.

In expansion thermometers, operation depends on the relative coefficients of two materials, which may be solids, liquids or gases in various combinations. The indicated temperature is not absolute, so standardisation is needed. We shall see that some methods *are* absolute producing an output that is directly related to temperature.

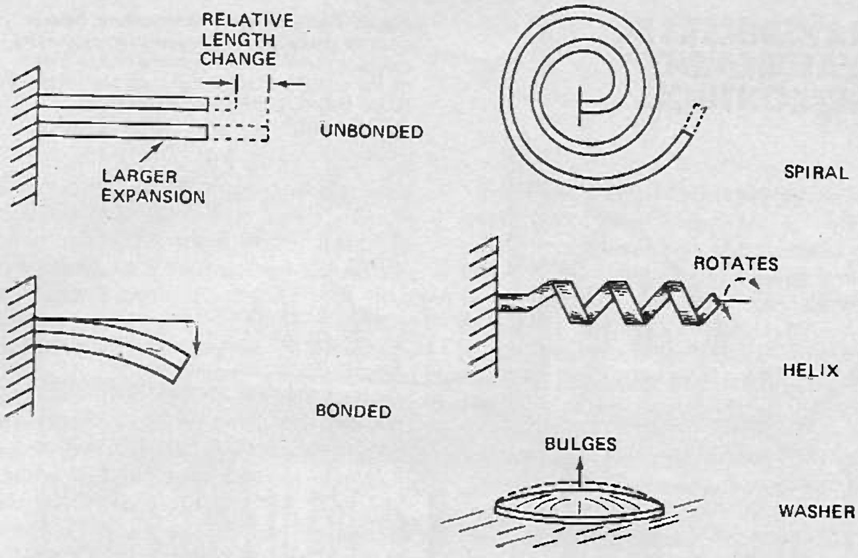



*Fig. 5. Two metals having different expansion coefficients are often used to provide a dimensional movement from a temperature change.*

## BIMETALLIC SENSORS

If an attempt is made to measure the change in length of a rod due to temperature effects, it will be found that the standard which is used for comparison may be altering in length also. Ideally, the standard should be made of a zero thermal coefficient material or be temperature controlled during the measurement. To avoid these requirements, the relative length change between two bars of different coefficient material is monitored rather than the complete length of each. In the bonded bimetallic thermostat, two strips of different metals are bonded together. If each has a different thermal coefficient, the strip must bend as the temperature changes. Ideally, the two should have the greatest possible difference in expansion rate, implying the use of the largest positive and the largest negative coefficient materials. Few satisfactory negative materials exist, so conventional designs use a combination of the smallest and largest positive materials — invar and steel or brass alloys usually. A variety of shapes are used as illustrated in Figure 5 — flat-strips, coiled helixes, disk washers and flat spirals. In each case temperature change produces a linear or rotary movement which is used to actuate contacts or drive a microdisplacement transducer (if a continuous output signal is needed). Although these methods are generally regarded as useful to a precision of only 0.1 deg.C (due to marketed versions being made to perform only to such limits), they are capable of extreme sensitivity if coupled to secondary transducers. Their simplicity, low cost and range capability, from —50 to 500 deg.C, makes them an obvious first choice for temperature control. The same principle is often used to produce a mechanical movement to compensate for temperature errors in an instrument.

## LIQUID-IN-GLASS THERMOMETERS

Early thermometers used water in a fine glass tube that was open at the end. It was soon realised that the varying air pressure seriously influenced readings and now the top space is filled with an inert gas at sufficient pressure to keep the liquid thread continuous. It is the relative volume change between the glass (steel sometimes) container and the liquid that causes the liquid to move in the graduated tube. Thermometers must, therefore, be used in the same conditions of immersion (bulb only, thread and bulb or complete unit) in which they were standardized.

Mercury is not the most sensitive liquid, toluene expands in volume at a rate five times that of mercury, and methyl alcohol at seven times. It is, however, particularly useful in contact thermometers where the mercury thread completes a circuit with an internal contact and hence, for example, cuts off the heater in a control system — see Electronics Today International, November 1972 issue. The difficulty with liquid expansion thermometers is that range must be reduced with increasing sensitivity. Special designs are used, such as the Beckmann thermometer, in which the set point can be varied by manipulating the quantity of mercury in the reservoir, placing that unwanted in an upper storage reservoir. These can be read to 0.001 deg.C within a

# TRANSDUCERS IN MEASUREMENT AND CONTROL

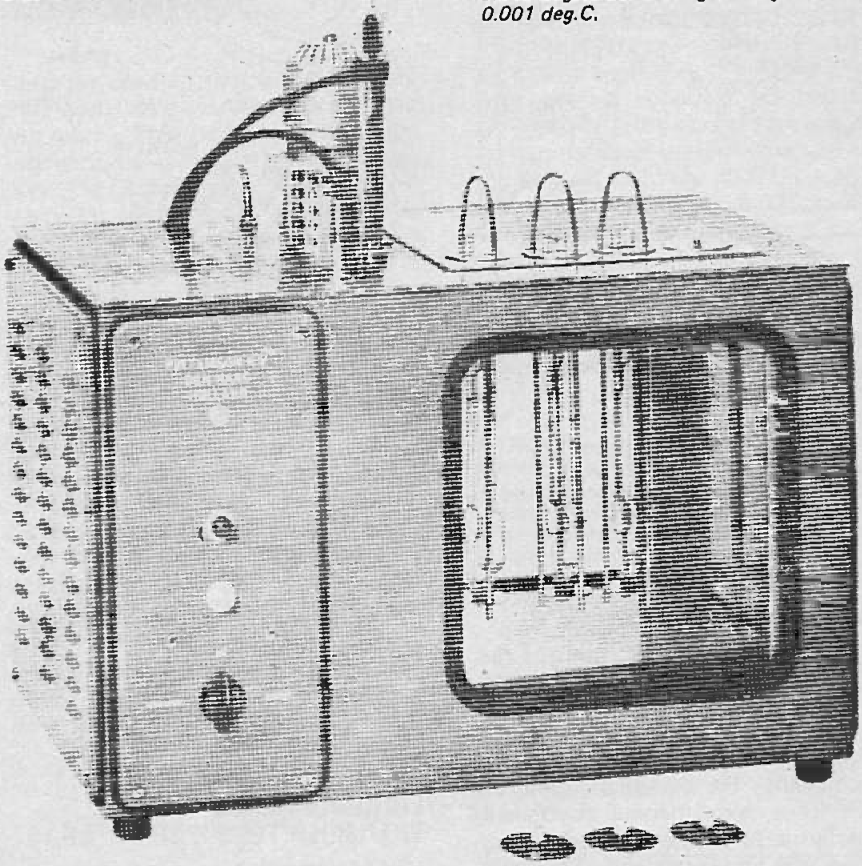


*Fig. 6. This precision temperature bath is used to make viscosity measurements. The contact thermometer (centre top in front of the stirring motor) controls the water to 0.005 deg.C. Calibrating baths go to 0.001 deg.C.*

range of 5 deg.C and contact thermometers sensing to 1 millideg.C have been used. A precision, controlled temperature bath is shown in Figure 6.

A disadvantage of the liquid-in-glass thermometer is its zero depression characteristic. When subjected to a temperature change, the glass volume changes as does the liquid. The glass, however, takes a finite time to regain its original volume so a movement back toward zero from a higher temperature causes a depression of the zero which can last several hours or even days, depending upon the sensitivity of the thermometer. The effect is not large – modern glasses give rise to 0.01 deg.C error per 100 deg.C change.

Although mercury-filled manometers (devices for measuring pressure by the height of a column of mercury) have been automated to provide a readout of thread position as an electrical signal, it is surprising to find that no commercially available, proportional-output mercury-thermometer is marketed.

Also operating on the expansive principle are pressure thermometers in which mercury or xylene completely fill the system under an initial pressure. Heat at the bulb causes the internal pressure to rise operating a pressure sensitive element such as a bourdon tube or diaphragm which is electrically instrumented. Some car temperature gauges and most radiator thermostat units operate this way, the latter illustrating a neat solution where electronics could not provide as simple an answer.

## QUARTZ CRYSTAL THERMOMETERS

The resonant frequency of a quartz crystal depends upon temperature. Temperature changes crystal dimensions and the velocity of acoustic waves within it.

In operation (the Hewlett Packard version is shown in Figure 7) the frequency is measured by a timer counter and displayed directly in degrees by a digital readout. The advantages of the method are its high degree of linearity (±0.05%) (as good as the best platinum resistance thermometer) and resolution. In the short term, it is possible to discern 100μdeg.C changes; over longer periods 0.01 deg.C.

## DIRECT ELECTRICAL METHODS

All methods discussed so far make use of heating effects to provide a mechanical displacement, to which a secondary electrical output device could be attached. Several direct, that is, temperature to electrical signal, methods exist. These can be grouped as resistance, thermoelectric, thermistor and semiconductor junction thermometers. Thermistors are a form of resistor but their differences are distinct enough to place them in a category of their own. The first two methods date back to the early 19th century, the others to just a decade or two ago, for they are products of the semiconductor age.

## RESISTANCE THERMOMETRY

Although Sir Humphry Davy had realised in 1821 that the resistance of metals generally increased with

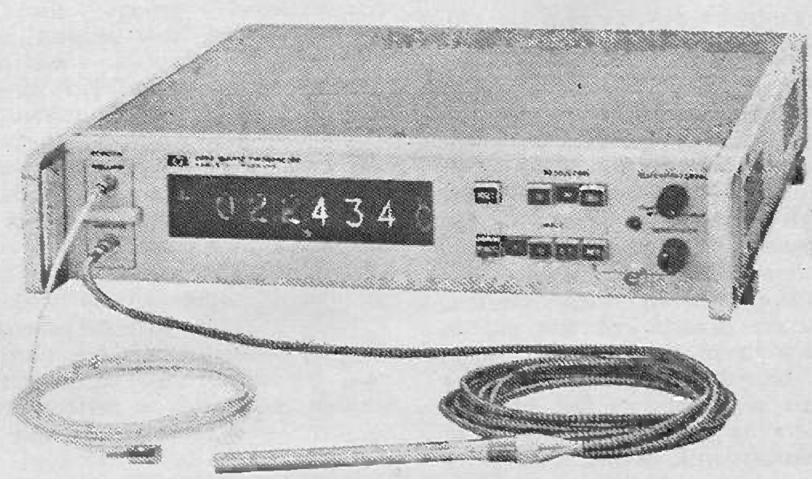


*Fig. 7. The Hewlett-Packard quartz crystal thermometer with digital readout can monitor temperature to 100udeg.C.*

increasing temperature, it was not until 1871 that this observation was put to use for temperature measurement. At that time Sir William Siemens constructed a special Wheatstone bridge for measuring changes in temperature of the resistance sensing element in his radiation detecting instrument. The modern form of resistance thermometer is due to Callendar and Griffiths who published a work in 1887 upon which today's procedures have been largely based. Resistance thermometry is still the most reliable method available, (along with thermocouples) being simple to use, having a good degree of linearity over a wide range and, not the least, assured long-term stability. It is not as sensitive as modern methods however.

In practice, the temperature sensing resistance is placed in the environment to be measured and its value read using a modified Wheatstone bridge. The resistance values are necessarily low (100Ω is typical) so connecting lead resistances are comparable in value. For this reason in accurate work, special bridges, see Figure 8, are used in which extra extension leads are connected to the sensor element to balance out the effect of leads. The three lead bridge (Callendar-Griffiths) suffices for general industrial plant control (potentiometric resistance recorders have three lead connections built in) but for standards work, a Mueller bridge (devised in 1939) is used. To give an idea of current sophistication, bridges can now be used to measure the hundred ohm value to 1$\mu\Omega$. Special precautions, such as the use of ac excitation with reactance instead of resistance elements, and temperature control of components and switch contacts to 0.01 deg.C are employed.

Platinum is the metal used for sensors in IPTS work. This was chosen because of its immunity to chemical corrosion, stability of resistance, high melting point and reasonably high specific electrical resistivity (ten times that of copper but far less than many resistance wires). Extreme care is exercised when winding the typically 100um diameter wire onto stable formers as mechanical stress in the element could produce a strain gauge rather than a temperature sensor. The spiral is then housed in a tube filled with dry air to prevent contamination. Sensors are available in all shapes and forms and the cost is reasonable.

The temperature scale indicated by the resistance change of a platinum thermometer does not agree entirely with the IPTS fixed point scale. To overcome this, correction values are calculated using equations that have been developed to convert measured values into the desired IPTS values. This is the world standard for laboratory temperature measurement from −270deg.C to 660 deg.C and has also found extensive day to day use in less sophisticated forms where ultra-precision is not required. To speed up the calibration of service instruments, a sub-standard transfer thermometer is intercompared with one requiring calibration using a controlled temperature bath (like that in Figure 6) which is filled with water, oil or salt as the temperature demands.

Platinum sensors are reliable to at least 0.01 deg.C as far as IPTS reproduceability goes, but in cases of control where the absolute value is not critical, they can do far better. Probably, the best example to date, was in a calorimetry bath built by the National Bureau of Standards (NBS) in 1968. A most sophisticated control system using a commercial platinum sensing element, held water at the centre of the container to within 20 udeg.C per day.

Not all resistance thermometers use a wire wound element, for that form of construction is often too large and has insufficient thermal response. For example, in the United States, several people have built sensors made from 1 mm of 630 nm diameter platinum wire

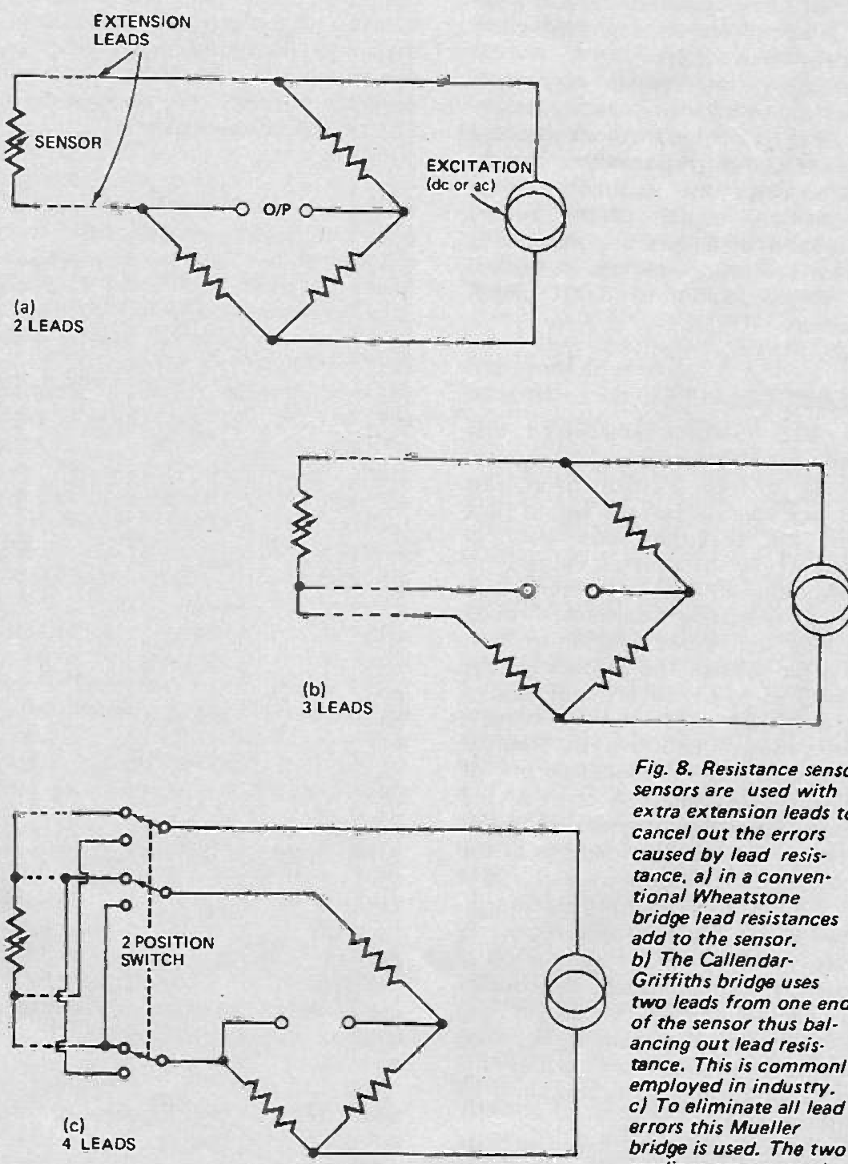



*Fig. 8. Resistance sensors sensors are used with extra extension leads to cancel out the errors caused by lead resistance. a) in a conventional Wheatstone bridge lead resistances add to the sensor. b) The Callendar-Griffiths bridge uses two leads from one end of the sensor thus balancing out lead resistance. This is commonly employed in industry. c) To eliminate all lead errors this Mueller bridge is used. The two readings are averaged.*

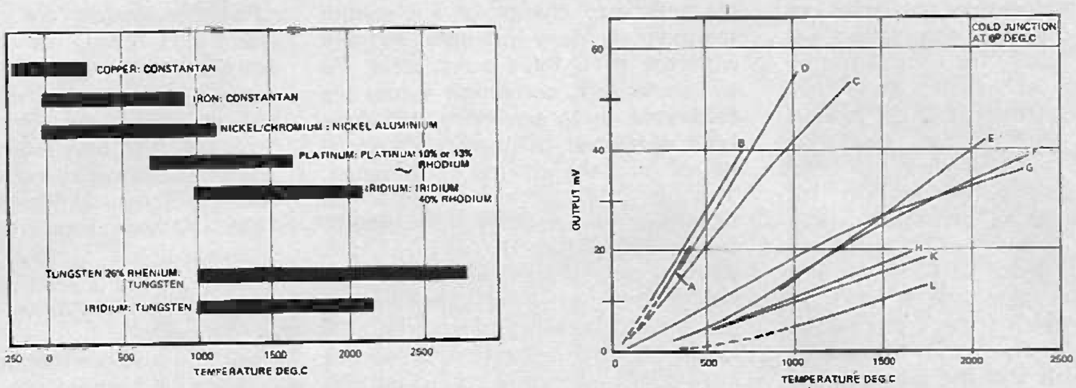



*Fig. 9. Ranges and output-temperature relationships for commonly used thermocouples.*

to measure millisecond temperature variations in the atmosphere. Here the mounting is critical, to minimize external heat conduction to and from the sensor. Vacuum deposited films have also been employed.

Increasing interest in cryogenic temperatures (these near absolute zero) has resulted in methods specially suited to that region. One simple solution uses the common carbon composition resistor as the sensor. Calibration equations are needed to correct the actual readings in the 0.6 –5 deg.K region to 0.001 deg.K precision.

## THERMOCOUPLES

In 1821 Seebeck discovered that when dissimilar metals were joined together to form a circuit of at least two junctions, a current would flow when the two junctions were at different temperatures. Peltier, in 1834, observed that the reverse also applied – passing a current through the loop caused one junction to cool, the other to heat. The Seebeck voltage is small being of the order of tens of microvolts per degree so the method is comparatively insensitive. By contrast thermistors can produce signals of millivolts per degree. A chart of the voltage output for common couples is given in Figure 9. Provided one of the junctions (the reference couple) is held at a constant temperature, temperatures measured with respect to it are absolute for no calibration is needed if the materials of the couples are known. Tables of values are available for the commonly used combinations which will enable the thermovoltage to be converted in IPTS values.

Thermocouples are formed by joining two wires together (twisted together often suffices, otherwise they are welded or clamped). Outputs vary from the couples and are not linear over the entire range (they closely follow a parabolic curve of which only the initial linear region is used). For this reason the senstitivity of a couple depends upon the temperature. Copper to constantan, for instance, gives 18$\mu$V/deg C at –183 deg.C and 62$\mu$V/deg.C at 400 deg.C. A couple made from two similar materials of different batch, copper from two different coils of wire for example, can generate as much as 10% of the voltage of a recommended thermocouple so care is needed in wiring. Special leads sold for connecting thermocouples as all connections are potential temperature sensors. For high temperature work, such as in furnaces, room temperature is adequate for controlling the temperature of the reference couple (temperature sensitive copper resistors are usually included in temperature recorders to allow for ambient changes). For ambient temperature operation, however, the reference couple must be better controlled with either a simple ice bath (miniature controlled Peltier units are available) or a special temperature tracking power supply that simulates a couple at the ice-point.

The advantages of thermocouples are their low cost, extremely wide temperature range (with different materials they cover from absolute zero to several hundred degrees Celsius) but the main feature is often the small size possible which enables millisecond response times to be realised.

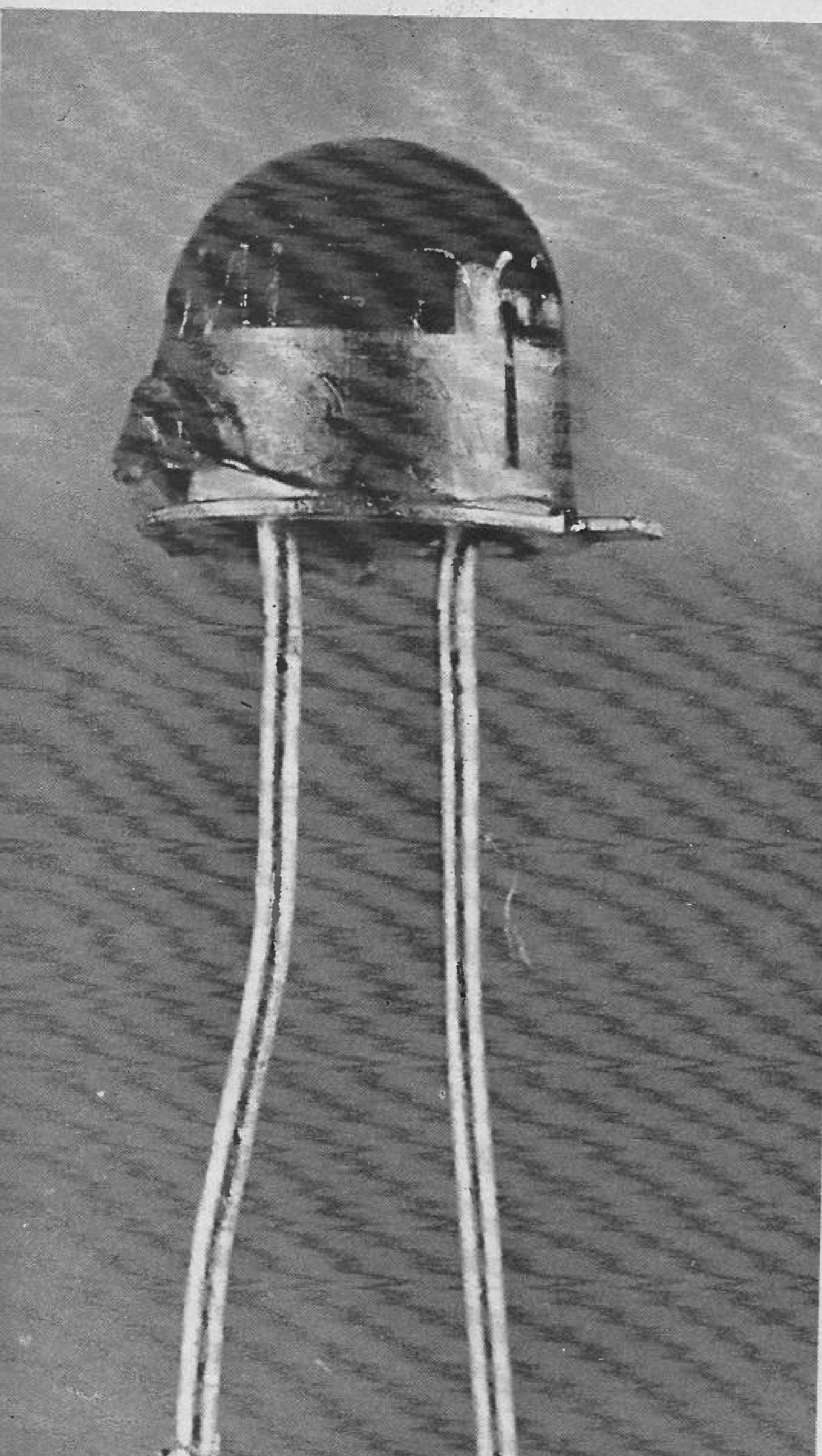
The simplest way to measure temperature by thermocouple is with a milli-voltmeter and a set of tables. Although the circuit draws current to drive the meter, the resultant Peltier effect is negligible. For more precise work, potentiometers are used to determine the unloaded voltage. It is possible to resolve to 10nV with a good potentiometer so thermocouples are useful to 0.001 deg.C but great care is needed at such sensitivity to eliminate stray thermoelectric effects. As with resistance sensors, the universal demand has caused manufacturers to provide a wide range of hardware for applying thermocouples. Self balancing recorders are available that display temperature directly provided the correct couple is used. In these the pointer/pen is driven by a powerful, but crude motor which also drives a coupled potentiometer. If the potentiometer output does not balance the thermocouple signal, the error between the two is amplified electronically and used to drive the motor accordingly. The system rapidly balances and by this expedient the recorder is made extremely robust whilst retaining full scale sensitivity of a few millivolts.

To increase the sensitivity, several couples (a thermopile) can be joined in series so that more than one couple is measuring temperature. There will, therefore, be more reference junctions also. For example, to test the NBS water bath mentioned earlier, a thermopile was placed in the fluid and the reference pile in the centre of a fluid filled, large size, dewar flask that provided a time constant of many hours to the reference temperature. By this means they were able to verify the short-term stability, the thermopile senstivity being limited by electronic resistance noise to an equivalent temperature of less than 1$\mu$deg.C. ●

To be continued . . .

# OPTO-ELECTRONICS

## THE LIGHT EMITTING DIODE



*Typical LED from Motorola is shown over ten times full size.*

**The light emitting diode is a fully solid-state light-source which is having a far reaching effect on equipment technology.**

LIGHT emitting diodes (LED) are semiconductor diodes which have the property of converting electric power into electro-magnetic radiation at specific narrow wavelengths within the infrared or visual regions. These devices are having a considerable impact on modern technology and equipment techniques due to several factors:—

1. Their speed of response is many times greater than that of incandescent lamps, they work very well at frequencies from dc to well into the megahertz region. Some diodes have been produced which operate at speeds up to 100 megahertz.
2. They are rugged devices much less prone to mechanical damage than their glass bulb counterparts. They are not subject to microphony nor affected by vibration in any respect.
3. LED's have no warm up time and the light output is monochromatic (narrow bandwidth). Although LED'S do not normally produce coherent light, diode lasers are available.
4. The LED is a low voltage, low current device and can readily be interfaced with transistor or IC circuitry. Some equipment manufacturers are now using LED's as monitors to provide a visible indication of circuit malfunction. This application will become more widespread as LED prices fall, and will vastly reduce equipment servicing time.
5. The life of an LED is of the order of 20 to 30 years in contrast to 5-10,000 hours for incandescent or neon lamps.

Up until fairly recently the price of these devices has prevented their widespread use — £9 each in 1969. Nowadays, in quantity, they can be obtained for around 35p each and will no doubt be priced even lower in the near future. Apart from discrete device applications LED's are also being

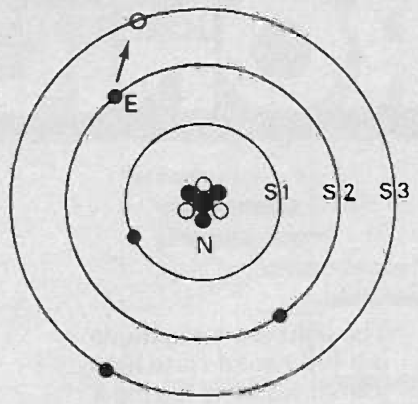



*Fig. 2. The structure of a typical atom showing the energy level transition of an electron.*

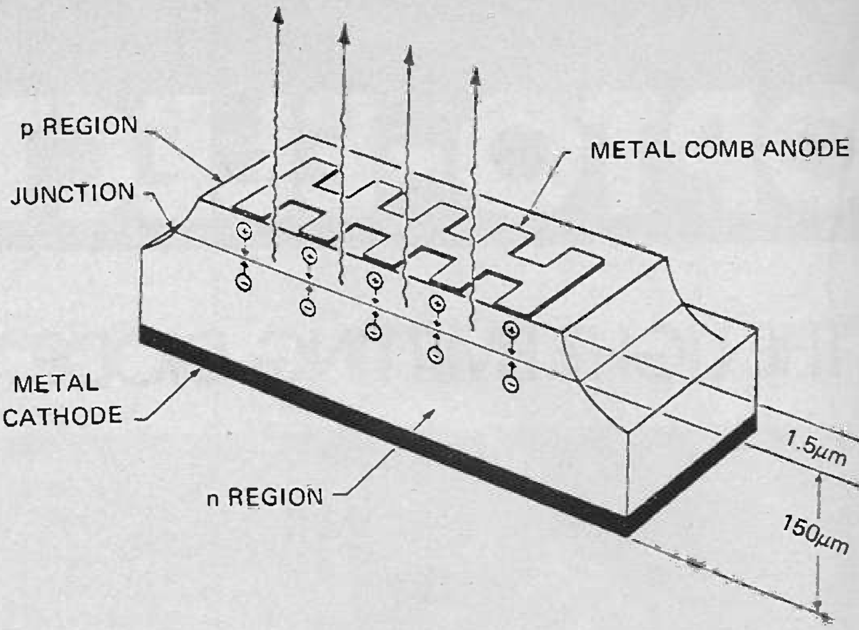



*Fig. 1. Each light emitting diode chip is a simple mesa-structure*

integrated into alpha-numeric displays which in some cases include the count/store/decode electronics in the same package.

The devices are manufactured from three basic materials. These are — gallium arsenide, which produces infrared radiation (wavelength 900nm approximately) when the device is forward biased, or — gallium arsenide phosphide, which produces visible red light of about 660nm, and lastly, gallium phosphide which produces green light of about 560nm or, red light of 700nm depending on the dopant used. Gallium phosphide devices are not generally available as yet but this material will probably be that most favoured in the future for visible emitters.

Some earlier experimental devices were manufactured from silicon or germanium, but although they did produce infrared, they were very inefficient, and only reached the commercial market in limited quantities.

## STRUCTURE OF GASP LED'S

Each light emitting diode chip is a simple mesa structure as shown in Fig. 1. An epitaxial layer of n-type gallium arsenide phosphide is grown on a gallium arsenide substrate. Impurities are then diffused into the epitaxial layer to form a very shallow p-region. The cathode contact is plated onto the n-region, and the anode contact is evaporated into the p-region.

## THEORY OF OPERATION

The physics of semiconductor light emission is entirely different to that for incandescent lamps. The light emission of an incandescent lamp is due to the heating effect of the current, in contrast to this, the energy emitted by an LED is produced by a phenomemum known as electro-luminescence. This phenomenon is not necessarily associated with heating and hence is quite commonly known as cold light. There are many examples of cold light production in nature — for example fireflies, some deep sea fish, marsh gas etc. to mention just a few.

Luminescence is produced by electron energy level transitions. Reference should now be made to Fig. 2. which shows the familiar structure of an atom with nucleus N and electrons E rotating in orbital shells S around the nucleus. If the atom receives energy in form of radiation heat or collision etc. an electron in the outer shell may be stripped off altogether, or alternatively, it may be raised to a higher energy level, that is, for example, from shell 2 to shell 3. When the source of energy is removed, the electron will fall back to its original orbit and in doing so, will release the acquired energy in the form of a photon of radiation. The wavelength of the emission is directly proportional to the difference between the two energy levels in electron-volts and depends on the material.

In the case of a photo diode in the forward biased condition, the current flow causes electrons to be raised to a higher energy level in the N material, and in this state it crosses the PN junction. It then falls from this energy level and recombines with one of the

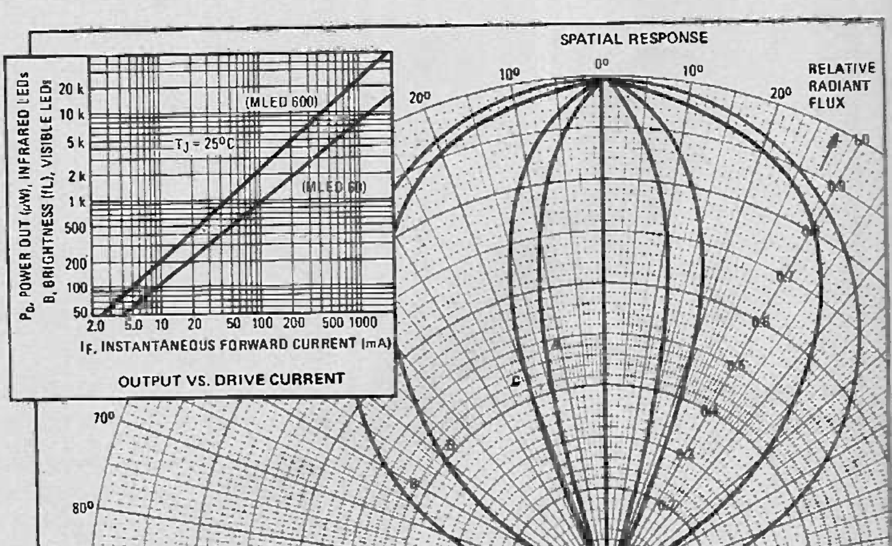
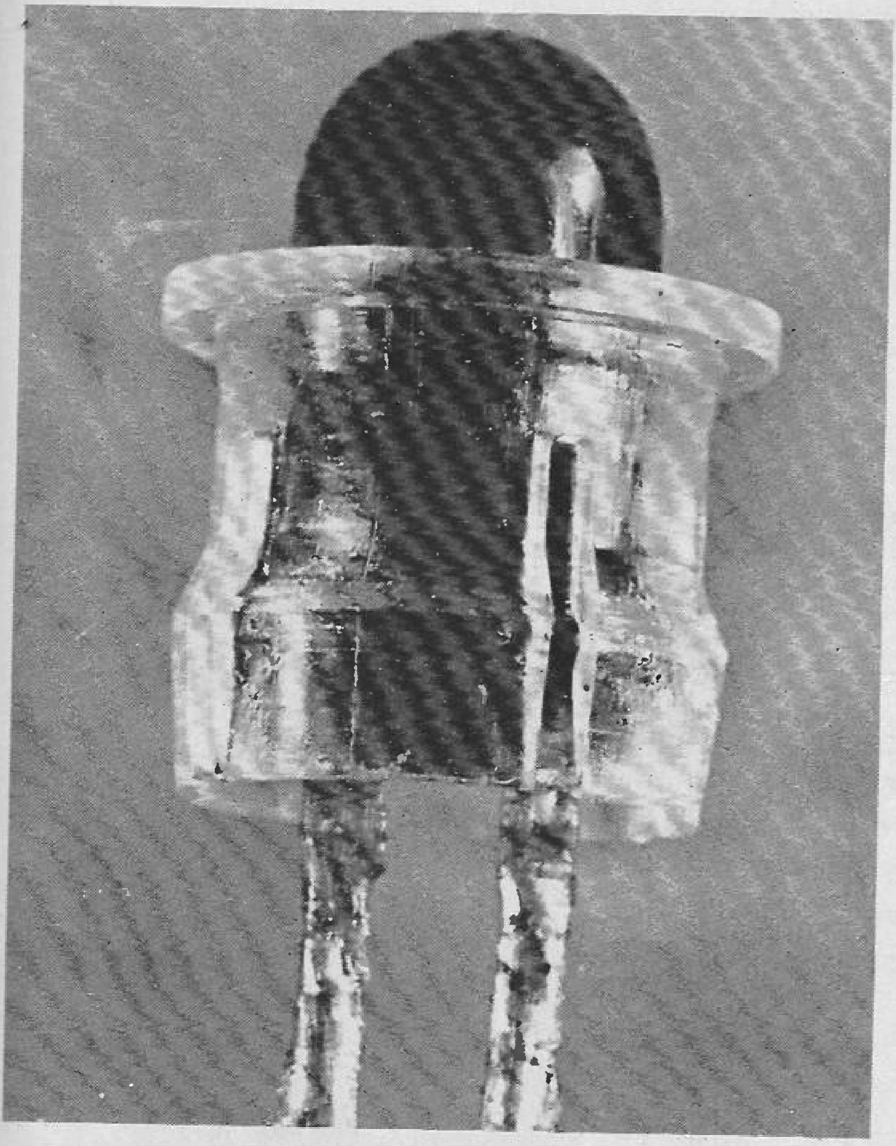



*Fig. 4. Typical characteristics of commonly available LED's, Graph, upper left, shows typical light output as a function of drive current. Spatial response curves are functions of package and lens designs.*



holes in the P material with a consequent emission of a photon of light.

Factors effecting the overall efficiency of a light emitting diode chip are:

1. Quantum efficiency, or percentage of recombinations which produce photons. This is the ratio of the number of photons produced to the number of electrons passing through the diode. Quantum efficiency can be as high as 50% in LED's

2. Absorption of photons within the p-region.

3. Internal surface reflection due to the difference between the refractive indices of the LED material and air. For example for GAsP, n = 3.5 (in air n=1.0) All photons making an angle of greater than about 17° with the normal to the surface of the chip are internally reflected and absorbed.

4. Contact resistance and bulk resistance.

5. Optical losses due to the package and lens.

Factors contributing to loss of efficiency are illustrated diagrammatically in Fig. 3.

The overall efficiency of a diode producing visible light is called luminous efficacy. It is the ratio of the optical energy out to the electrical power in, and is expressed in footlamberts per unit current density. The term efficacy is used rather than efficiency because the light output is measured in terms of the response of the eye to the emitted radiation. (see Fig. 4.) A typical value for luminous efficacy is 50 fL/A.cm² in presently available materials. This corresponds to an overall power to light conversion efficiency of about 3% with efficiencies as high as 7% being reported from laboratories. In the microamp current range, electroluminous efficacy is very low, but increases with increasing current and hence diode luminance increases at a greater rate than diode current. Luminous efficacy increases nearly linearly with increasing current.

In GAsP devices, the relative amounts of arsenide and phosphide may be varied. This permits manufacturing control over the recombination energy (bandgap) and thus the wave-length of emitted light. The alloy composition also effects the electro-luminous efficacy as shown in Figs 5a/5b.

Peak eye sensitivity occurs at 555nm, and as Figure 5a shows, it is the product of eye sensitivity and diode radiant efficiency which determines optimum wavelength for maximum luminous efficacy.

Potential light emitting materials are classified as having either direct or indirect bandgaps.

In direct materials, the electron jumps directly from one energy level to another lower one, releasing a certain amount of energy. To be a candidate for electroluminescence this energy jump must produce radiation with a wavelength falling in the visible spectrum.

In indirect materials, electrons may take one of many different paths in seeking the lowest energy state. Some paths will be of the correct energy to produce light; others will produce infrared (heat). In addition to natural intermediate energy levels, other levels may occur due to lattice imperfections

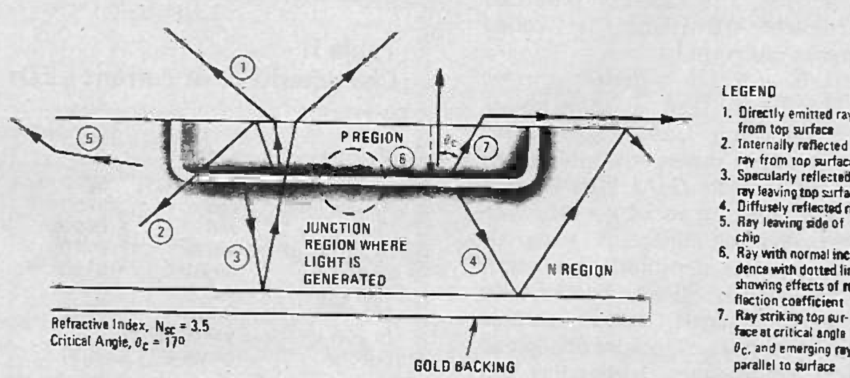
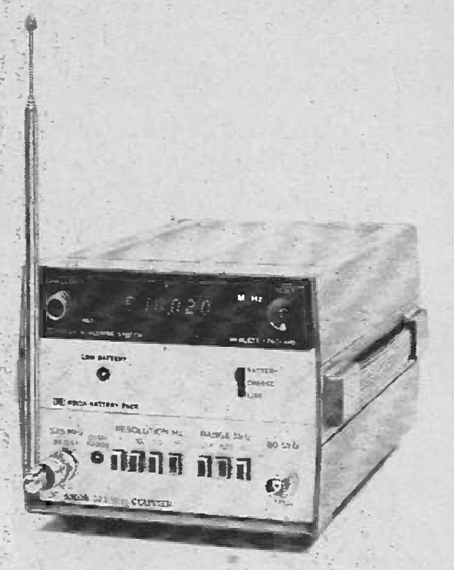



*Fig. 3. This illustration depicts factors contributing to internal losses in LED diodes.*

### Table I
### Common Electroluminescent Materials

| Material | Energy Gap, eV | Band Structure | State of Development |
|---|---|---|---|
| GaN | 3.5 | direct | A |
| SiC | 2.8–3.2 | indirect | B |
| $Al_xGa_{1-x}P$ | 2.26–2.45 | indirect | A |
| GaP | 2.26 | indirect | C |
| AlAs | 2.16 | indirect | A |
| $In_{1-x}Ga_xP$ | 1.34–2.26 | direct-indirect | B |
| $In_{1-x}Al_xP$ | 1.34–2.45 | direct-indirect | A |
| $GaAs_{1-x}P_x$ | 1.44–2.26 | direct-indirect | C |
| $Al_xGa_{1-x}As$ | 1.44–2.16 | direct-indirect | C |

*A still in experimental stage; B some commercial production; C wide commercial usage.



*Low current LED digital readout has been chosen by Hewlett Packard engineers for this model 5303B 525 MHz frequency counter.*

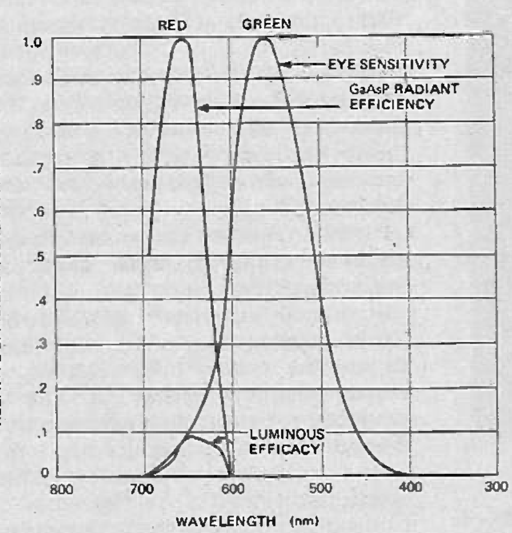



*Fig. 5a. Relative Efficiency/Response versus wavelength for GaAsP LED's.*

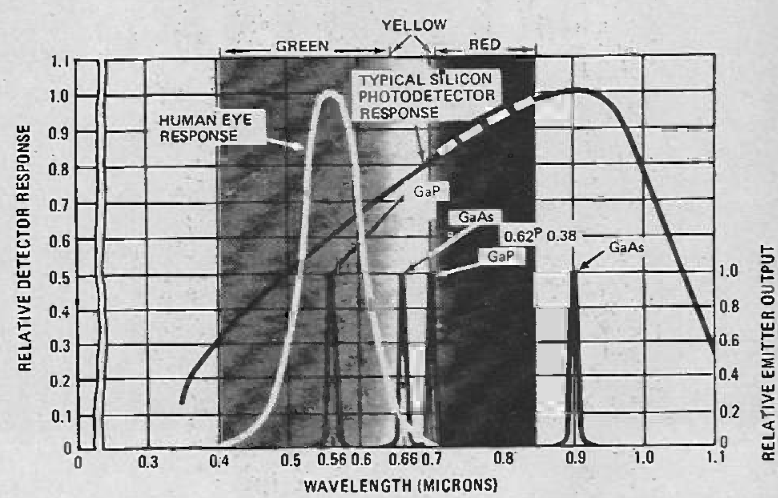



*Fig. 5b. Spectral output of various LED materials compared with the response of the human eye and a typical silicon photodetector.*

or impurities. That radiation produced by direct transitions is called resonance radiation.

GaAs is a direct material, whereas GaP is indirect. Thus, at some points the composition GaAsP is a direct material and at others it is indirect. In the alloy formula GaAs (1-s) Px, the crossover occurs at about x = .45.

Other electroluminescent materials include gallium phosphide (indirect), gallium arsenide (direct) coated with lanthanum fluoride, silicon carbide (direct) and gallium indium phosphide (direct or indirect, depending on composition). A comparison of various LED materials is shown in Table 1. Table 2 provides details of current LED characteristics.

### Table II
### Characteristics of current LEDs

| Material | Color | Peak Wavelength, A | Lum. Eff., Lumens/watt | Conv. Eff., percent | $fL/A\text{-}cm^{-2}$ |
|---|---|---|---|---|---|
| GaP:Zn,O | red | 6900 | 20 | 3–7 | 350 |
| $Al_{.3}Ga_{.7}As$ | red | 6750 | 16 | 1.3 | 140 |
| $GaAs_{.6}P_{.4}$ | red | 6600 | 42 | 0.5 | 145 |
| $In_{.42}Ga_{.58}P$ | amber | 6170 | 284 | 0.1 | 310 |
| $GaAs_{.5}P_{.5}$ | amber | 6100 | 342 | 0.013 | 35 |
| $GaAs_{.25}P_{.75}$:N | amber | 6100 | 342 | 0.04 | 40–100 |
| SiC | yellow | 5900 | 515 | 0.003 | 10 |
| $In_{.4}Ga_{.6}P$ | yellow-green | 5700 | 648 | 0.02 | 115 |
| GaP:N | green | 5500 | 677 | 0.05–0.6 | 470 |

## OPTO-ELECTRONICS

### APPLICATION OF DISCRETE LED'S

Light emitting diodes which generate visible light are finding their main applications as panel lights, circuit-condition indicators, light modulators, displays and the like. Infrared emitters on the other hand are used in card readers, shaft encoders and other applications where visibility is not only not required, but may be an embarrassment (e.g. burglar alarms). At infrared wavelengths maximum transfer efficiency is achieved when LED's are used with silicon photo detectors.

### OPTICAL COUPLERS

An excellent example of the use of LED's in systems application is the optical coupler. The optical coupler consists of an LED and a phototransister in a single package. This device is an almost ideal replacement for such components as interstage transformers and relays as well as coupling and feedback networks.

Important characteristics of these devices are:—

1. Signal transfer is in one direction only. Radiation from the LED is detected by the phototransister, but the reverse cannot happen. Thus an amplifier fed from an oscillator by means of such a coupler, cannot possibly have any detuning or pulling effect on the oscillator. This is because no possible load effects on the output side of the coupler can affect the input side. Isolation is typically 10" ohms in parallel with 1 pF at 1.5 kV.
2. The LED is a low impedance device when operated in the forward biased mode (normal operation) and several devices may be operated in parallel by a low power driver. This feature allows fan-out of the signal in a very simple manner.

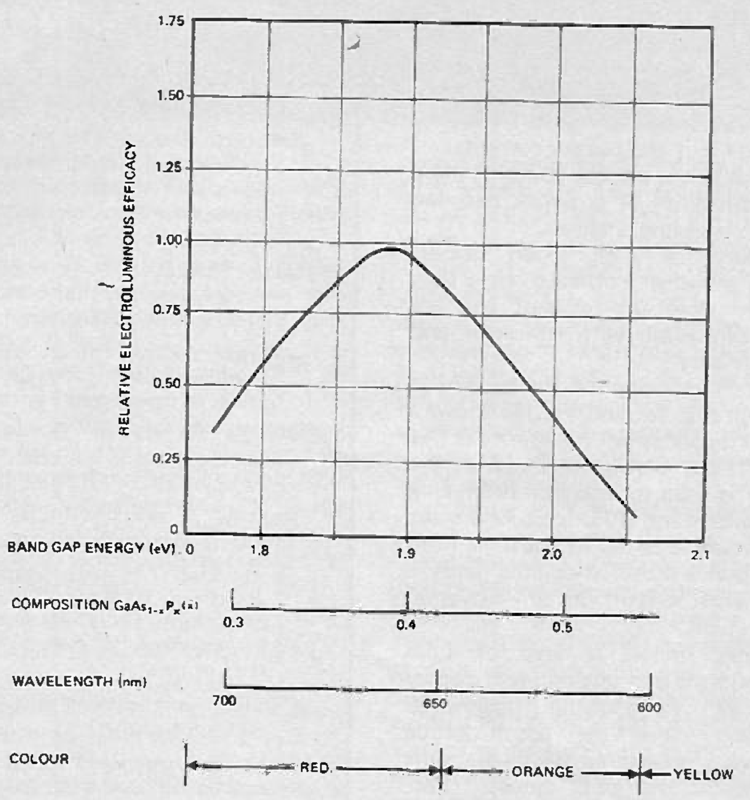



*Fig. 6. Relative electroluminous efficacy versus composition and wavelength.*

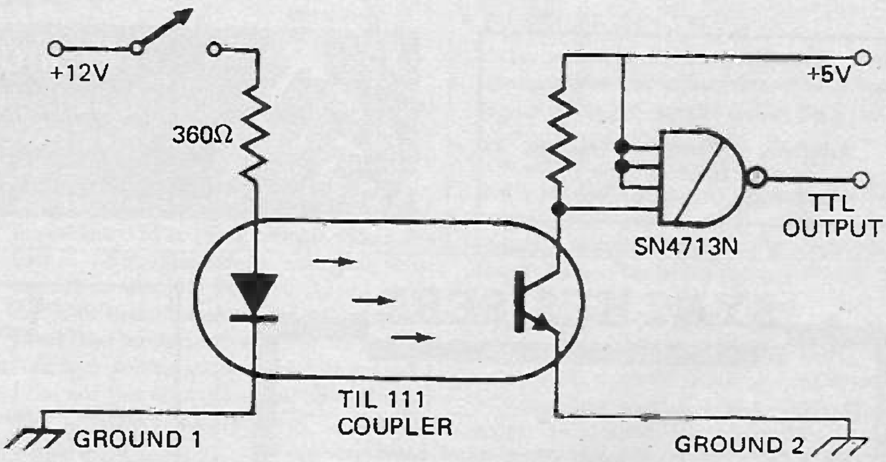



*Fig. 7b. Here, an optical coupler interfaced between a microswitch and TTL logic is used to reject background noise.*

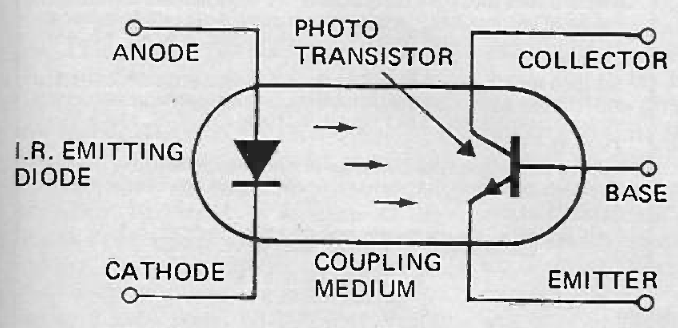



*Fig. 7a. Basic construction of an optical coupler.*

3. The LED coupler can be used to transfer signals between circuits having widely different supply voltage rails, whilst maintaining good linearity between input and output currents.

4. Due to the photon coupling there is no possibility of crosstalk between adjacent coupling channels.

5. They are high speed devices (several megahertz at least), have long life, are vibration resistant and are fully compatible with transistor and logic circuitry.

The configuration of the coupler is shown in Fig. 7a, and Fig. 7b shows a typical application of the TIL111 from Texas Instruments. Here the coupler is used to interface between a microswitch and TTL logic where the requirement is to isolate the logic from the ground noise associated with a microswitch circuit in an industrial environment.

Another important area of LED application is in alpha-numeric display panels as used in digital instruments. In many cases the count/decode electronics is integrated into the same 1C chip as the LED diodes. These displays will be discussed more fully in a later article. ●

## GLOSSARY OF TERMS

**Diffusion** The process of adding impurities to a semiconductor material in order to affect its characteristics.

**Epitaxial Growth** The process of producing an additional crystal layer of semiconductor material on a semiconductor substrate. The crystalline structure of the substrate is continued into the epitaxial layer, however, the impurity concentration can be made to differ greatly.

**Mesa Structure** A diode whose structure is mound-like. During processing, material is etched away from the original chip in order to produce the final shape.

**N-Type** Refers to an excess of negative electrical charges in a semiconductor material. Natural silicon, which is an insulator, is made to be n-type, by the addition of a donor impurity.

**P-Type** Refers to an excess of positive electrical charges in a semiconductor material. Natural silicon is made to be p-type by the addition of an acceptor impurity.

**Reactor** A semiconductor processing device where epitaxial growth processes are carried out.

**Lambertian** An area source as opposed to a point source in light emission. Whereas radiation from a point source is equal in all directions, radiation from a Lambertian source is strongest in the direction of the normal to the surface and decreasing at angles from that normal.

**Parallax** An apparent displacement of an object when viewed from two different points.

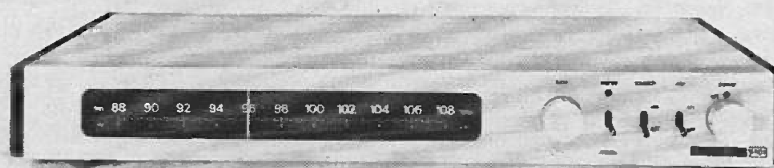
**Photons** A quantum of light energy with energy hf, where h is Planck's constant, f is the light frequency.

# AUDIO NEWS

## NEW CAMBRIDGE AUDIO TUNER

Cambridge Audio Ltd, of St Ives, Huntingdon, have established themselves well and truly in the genuine hi-fi market with their P Series of amplifiers (now known as the P50 and P100 models) and the R50 and R40 loudspeakers. The former design is classified as a monitor loudspeaker using transmission line loading, and the R40 is a three-way speaker system featuring damped labyrinth loading of the bass driver. Now this organisation has produced the F501, the first in a range of radio tuners of high quality.

Technical features include RF and mixer stages utilising MOS transistors with voltage controlled varactor tuning, which allows a remote tuning facility to be incorporated. The IF stages use two high quality ceramic filters, plus discrete and integrated circuit amplification. The discriminator is of the quadrature detector type with a double-tuned coil, resulting in exceptionally low distortion figures. Stereo decoding is by means of a phase-locked loop IC, which also achieves a low level of harmonic distortion, allied to a high degree of spurious response rejection. This feature is further aided by the addition of extra filters to remove the residual 19kHz pilot tone and its harmonics.




Frequency coverage is 88 to 108MHz. Signal/noise ratio is 70dB (in mono mode), stereo channel separation is 34dB at 1kHz, and the audio output is adjustable up to 1V (5kohm source). De-emphasis of 50us or 75us is available. Recommended retail price is: £97.99 including PT. Illustrated literature available. (188)

## BKS & TS LECTURES

On Wednesday November 15 at 7.30pm in the Colour Film Services Theatre, 22-25 Portman Close, off Baker Street, London, Mr Charlie Watkins, of WEM (Watkins Electric Music), the widely known company producing sound equipment for PA and sound reinforcement, will talk on the topic 'Sound for Giant Audiences' to members of the British Kinematigraph, Sound and Television Society. He will tackle in his inimitable fashion the problems of providing 10 kilowatts of audio power for audiences of half a million people. Guest invitations are available from the Secretary, 110/112 Victoria House, Vernon Place, London WC1B 4DJ.

The BKS & TS organization, through its Journal and lectures, in this age of constantly changing technology provides for a regular exchange of information on all of the techniques used to record and reproduce 'moving' pictures both sound and silent. In planning their Third International Technology Conference and exhibition, called FILM '73, it is planned to review the converging techniques of film and video tape, their current usage and development. Sound systems and applications get due attention in the work of the BKS & TS. Details of the FILM '73 conference and Exhibition, at the Royal Lancaster Hotel, London, from June 25–29 1973, available later. (191)

## EUROSOUND TO MARKET DUAL

Admirers of the *'hi-fi plattenspielers'* produced by the important German company Dual will know that when the UK distributor Dual Electronics went into liquidation earlier this year, what might be called an interim company, International Audio, was formed to handle servicing and other matters until alternative arrangements for marketing the range were made here.

The new company, expected to be called Eurosound Ltd is being formed within the Farnall Electronics Group, operating from Farnall House, 81 Kirkstall Road, Leeds LS3 1HR, under Sales Manager Bill Jamieson. Other Dual products than the excellent turntable/arm combinations – of which model 1229 is a fine example – will be handled in the UK by the new distributer. (189)

## BASF 'SPECIAL MECHANICS' CASSETTES

Introduced originally on its range of chromium dioxide cassettes, BASF (United Kingdom) Ltd of PO Box 473, Knightsbridge House, London SW7 1SA, incorporated the patented 'Special Mechanics' feature in its range of LH (low noise, high output) ferric oxide compact cassettes, released at the recent International Audio Festival and Fair.

The SM fittings are a combination of plastic 'elephant' tusks and rollers which, in combination, guide the tape smoothly on and off the hubs. It is claimed that this innovation ensures constant free running of the tapes and eliminates jerking caused by static, particularly improving the sextuple play tape C120 performance. BASF LH cassettes with SM are available in C60, C90 and C120 format. See accompanying illustration.

Among other BASF tapes shown at the Audio Fair were the full group of SP52 standard types, various long play and double play, and the TP18 LH triple play, as well as its new LPR35 LH tape, available in three lengths. It has a special matt backing, giving excellent winding characteristics, and is especially suitable for hi-fi recorders without tape pressure pads.

In October 1972, BASF launched 18 disc record albums, its first entry into the UK record business. The material – much of it from the Harmonia Mundi catalogue – covers classical, through jazz and progressive to light music. A series of Gilbert and Sullivan recordings are due for issue now. BASF has also marketed a new portable cassette recorder, CC9200, and model CC9300, a radio-cassette model, which incorporates a four waveband radio. We understand these units are manufactured in Japan specially for BASF.

A complete BASF product brochure, illustrated with retail prices, is available free from the organization in Knightsbridge. (190)

## TV SOUND QUALITY

The restricted audio quality from most television receivers – due primarily to skimping on the sound circuits and fitting a small elliptical loudspeaker, often on the side of the cabinet – has been well discussed in many journals, but it would seem that the manufacturers are becoming aware of the growing consumer interest in high-grade sound TV sets for which they are willing to pay.

Earlier this year, Dynatron introduced a connection for tape recorders on their 26in colour TV receiver, made practicable and safe by the use of a fully isolated power supply. In addition, on some models, a socket is provided for video recorder input and output, plus a headphone/amplifier socket.

Decca and Bang & Olufsen, too, manufacture TV sets capable of radiating good sound quality, but it must be remembered that some TV chassis can be 'live' and extra high voltages are present. However, safe add-on units (for headsets or for feeding hi-fi amplifiers) are available from several sources. Separate TV Sound Monitors are produced by Motion Electronics, East Peckham, Kent, and an ingenious sound tuner, called the Tele-Fi, which picks up the spurious radiation from a TV receiver (by induction when placed on top of the cabinet) without any physical connection. Marketed by Rola Celestion Ltd of Ipswich Suffolk. (192)

# NEW TECHNOLOGY

THE Seventh International Aerospace Instrumentation Symposium and Exhibition was held at Cranfield Institute of Technology (CIT) in England recently. Sponsored jointly by CIT, the Royal Aeronautical Society, the Instrument Society of America and the Institute of Measurement and Control, the biennial events provide a forum primarily for discussion of developments in equipment and techniques of airborne measurement.

This year the scope was broadened to include instrumentation devised for specific functional tasks beyond mere basic vehicle behaviour measurement. The response was enthusiastic; over 160 delegates, representing research establishments, universities and the aerospace industry in 10 countries attended and 17 companies were represented in the exhibition.

Twenty-six Papers were submitted, under the broad group headings of instrument systems, earth sciences, data systems, test philosophy and instrumentation training.

Of these papers, four described techniques of outstanding general interest. Space limitations preclude our reproducing these papers in full, however we present here a brief synopsis together with details of where the complete papers may be obtained

## MEASURING AIR TEMPERATURES 10km AWAY!

The disadvantage of present outside air temperature measuring devices, particularly as applied to helicopters, where flight into icing conditions could have serious consequences, are outlined by Mr Sassoon. Conventional outside air temperature transducers read incorrectly if ice-covered; in any case they provide historical information rather than advance warning.

Working on the principle of variation of noise power received by an antenna pointed at an absorbent medium due to variation in temperature, a radiometric device will, he claims, overcome these problems.

Equipment based on this principle and incorporating thermal feedback has been constructed and a limited series of tests performed with it in an Argosy aircraft. Despite problems of interference from aircraft radio transmissions, results are encouraging and it is considered that this form of radiometer could become a practical aircraft instrument when the difficulties of working at such high frequencies have been overcome. The equipment would work in cloud and, ultimately, forward ranges of up to 10km should be possible.

*"A 60 GHz Radiometer for Outside Air Temperature" — G. Sassoon, JZK Electronics.*

## HIGH PERFORMANCE PRESSURE TRANSDUCER

In this paper the author described a low-range pressure transducer employing electrostatic pressure balance, and gave results obtained from an experimental model of range plus or minus 40 N/m$^2$. The work stemmed from a belief that no satisfactory instrument existed for low pressure measurement in demanding environments where significant temperature change and vibration occurred. The performance of present transducers employing diaphragms, membranes, bellows or capsules hinged on the stability of such elements, and materials hysteresis and creep could degrade accuracy.

In the method devised, pressure is measured by a sensitive pressure cell employing electrostatic pressure balance consisting of two pressure chambers separated by a lightly tensioned thin conductive membrane. Polarised electrodes, surrounded by guard rings, are positioned at a fixed distance on each side of the membrane and movement of the latter causes a differential capacitance change to be sensed by an alternating-current bridge having transformer ratio arms (Fig. 1).

It was shown that the electrostatic transducer could measure low pressures with such precision that its use as a low pressure standard was feasible. It would be particularly suitable as the heart of a rate-of-climb indicator with a time lag of about 0.1 second and the adoption of such a fast-responding instrument might make certain aircraft maneouvres, such

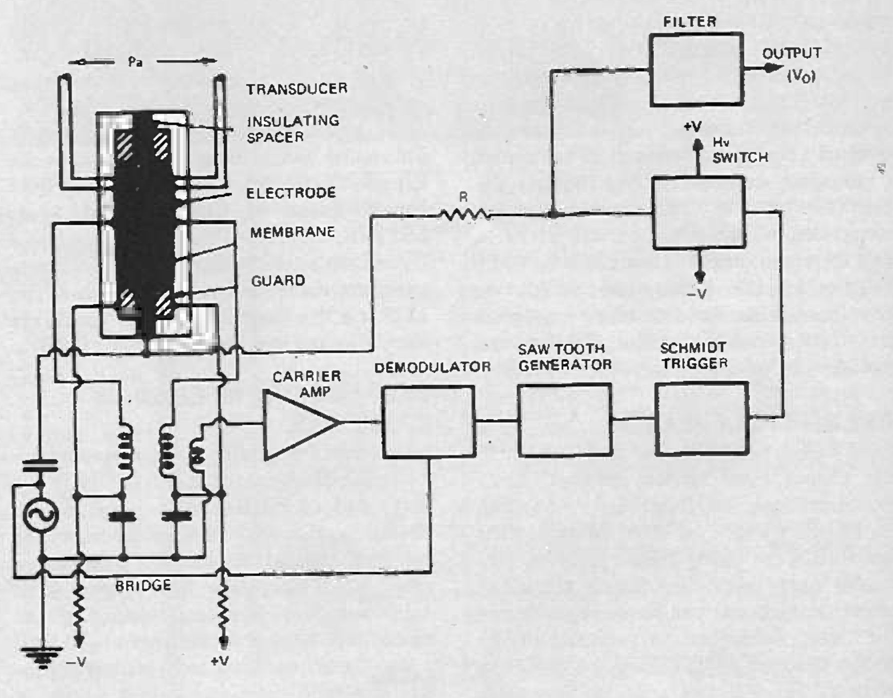



*Fig. 1. Electrostatic feedback transducer for measuring very low differential pressures developed by the Royal Aircraft Establishment, Farnborough, England. It has a high order of accuracy and can be used in many areas; an example is a rate-of-climb indicator with a time lag of about 0.1 second.*

as landing in bad weather, less hazardous. The method also had application to the measurement of angular acceleration, where the transducer formed a pressure cell which measured pressure generated within a fluid-filled column.

*"An Electrostatic Feedback Transducer for Measuring Very Low Differential Pressures" — W.R. Macdonald, Royal Aircraft Establishment.*

***(This paper has already been published as RAE Technical Report TR 71022 and is available from Ministry of Defence (Procurement Executive), Defence Research Information Centre, St Mary Cray, Orpington, Kent BR5 3RE, England.**

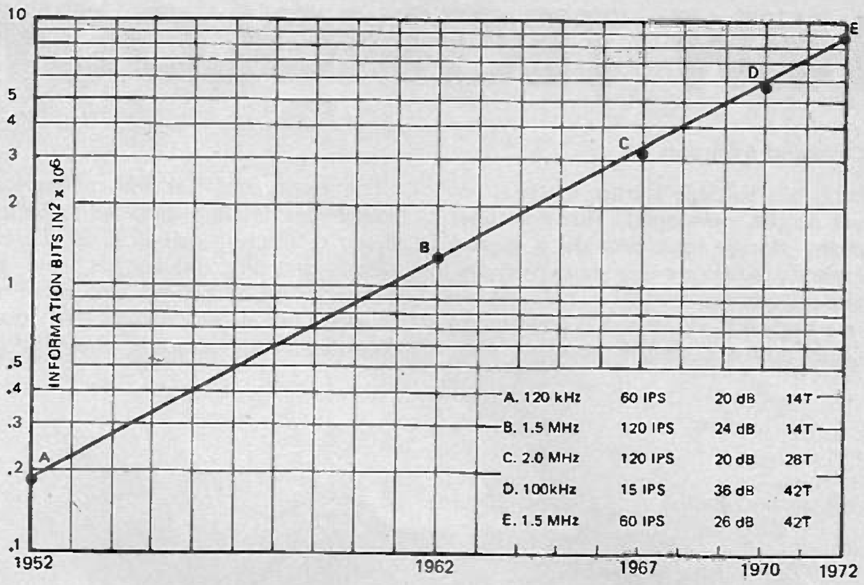



*Fig. 2. This graph shows the increase in information density achieved by representative recording systems in general use, their basic specifications and approximate introduction dates; "E" illustrates a system that is operational but not yet in general use.*

## MAGNETIC RECORDING HEADS

Dr Lemke's Paper traces recording head developments which, he says have stemmed from demands made by users of instrumentation-class recorders and have always been preceded by recording-tape developments. Tapes have improved in a number of ways, including particle size and dispersion, surface finish, chemical composition and coercivity.

With each improvement, resolution is increased but tape speeds do not reduce, so that heads have to have better resolving power and operate at higher frequencies than before. Figure 2 illustrates the increase in information density achieved by representative recording systems in general use, their specifications and approximate introduction dates, point E representing a system not yet in general use but nevertheless operational.

The two most important mechanical properties of head materials are resistance to slip planing and wear resistance. Head wear is a complex situation dependent on head and tape mechanical and chemical properties and environmental conditions such as humidity. In general the harder the head material the longer the head life; however this situation could be dramatically altered if frictional polymers could be generated on the head surface, thus inhibiting wear.

As for the future, tapes will undoubtedly continue to improve and draw forth new generations of head designs. It is possible to design heads to record tapes of coercivity greater than 1 000 but it is difficult to bulk-degauss such tapes. Surface finish improvements will come from increased track densities. Pitches of 42 tracks/inch (16/cm) are in regular production and batch process heads with hundreds of tracks/inch are under development and will exert great influence on recording methods.

*"Recent Advances in Magnetic Recording Heads" — J.U. Lemke, Spin Physics Inc, USA.*

## LASERS FOR DATA RECORDING?

Looking farther into the future, Mr King foresaw that magnetic recording improvements could not continue indefinitely. Increasing demands for extended performance would therefore necessitate a fundamentally different recording method, preferably one with no moving parts, since these tend to cause much unreliability in present recorders.

Two methods showed promise: the magnetic bubble store and the holographic recorder. The magnetic bubble technique has the potential capacity to store $10^8$ bits in an 80mm

*Continued on page 68*

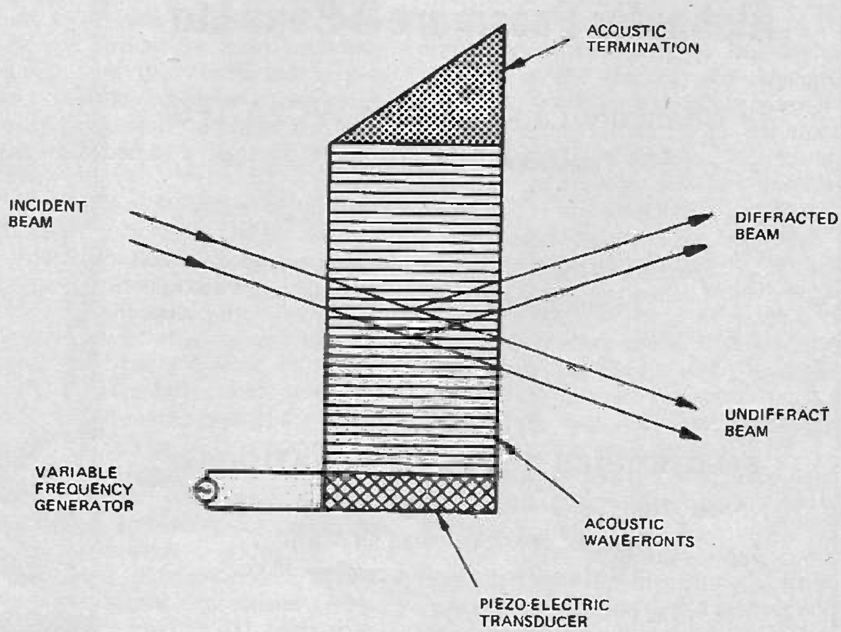



*Fig. 3. Acousto-optic light beam deflector — the Bragg diffraction cell. This is said to offer the most practical answer in situations where a laser beam deflector cannot be employed.*

# NEW TECHNOLOGY

*Continued from page 67*

cube but suitable storage material has yet to be developed. However laser beam storage can provide a gigabit capacity single on-line mass memory, accessible electronically in microseconds without present-day cores, drums, discs and tapes.

The most practical non-mechanical laser beam deflector appears to be the Bragg diffraction cell (Fig. 3). Direct mode recording difficulties may be overcome by first composing data into blocks, or pages, which are then recorded as holographic images (Fig. 4). A bismuth titanite ferroelectric crystal may provide the most suitable recording medium where selective erasure is required; where no erasure is necessary a photographic emulsion will probably give best results. The high angular sensitivity of the laser beam permits three-dimensional storage which, it is estimated, can be as much as $10^{10}$ bits/mm$^3$.

The ideal laser light source for airborne holographic recording does not yet exist, but with a precise specification of required characteristics, prospects for its development are good. However it will be some years before the development of all the individual components makes a practicable airborne holographic data recording system feasible.

*"New Digital Recording Methods for Flight Data Acquisition" – J.W. King, Royal Aircraft Establishment, England.*

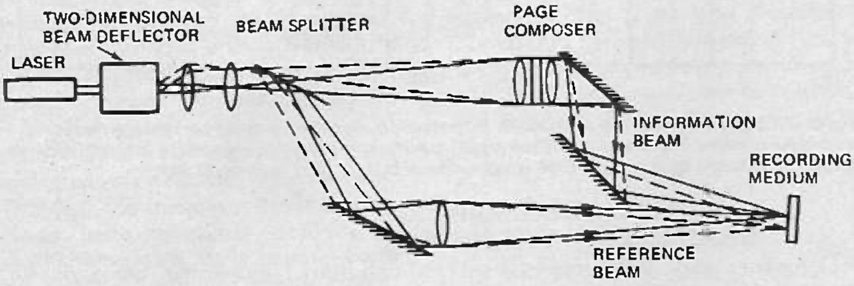



*Fig. 4. Direct mode recording difficulties can be overcome by first composing data into blocks and then recording the blocks as holographic images on a set-up such as the one illustrated.*

# AUDIO FAIR HIGHLIGHTS

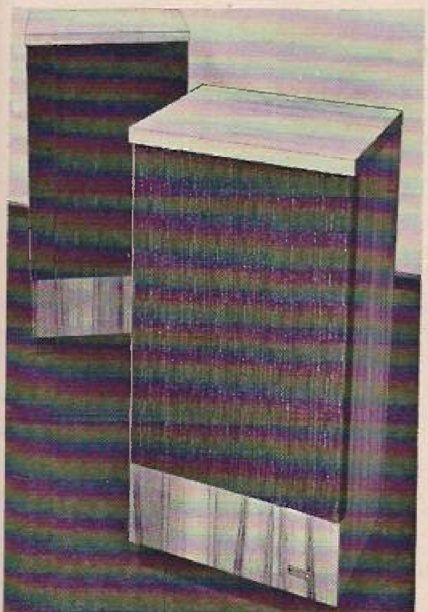
**Olympia's audio fair biggest and most successful ever**

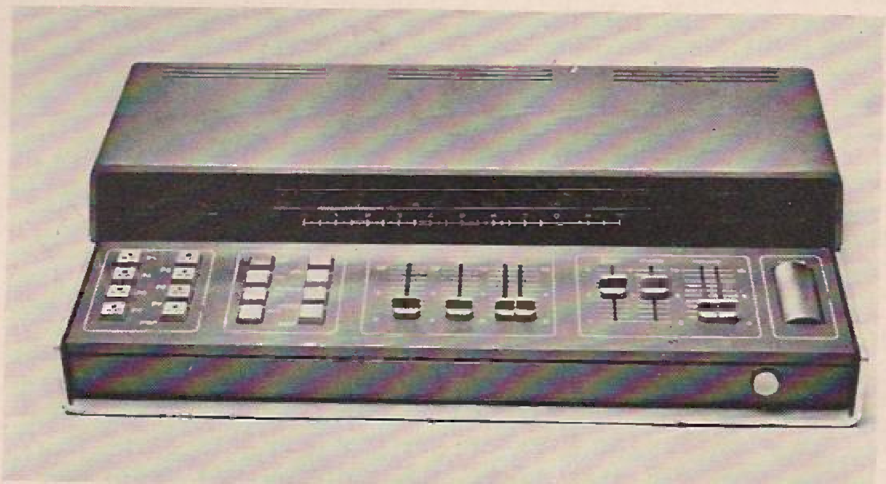
ALTHOUGH the British Sound Recording Association was responsible for the first audio equipment show in London some years before 1956, that year saw the first full-scale Audio Fair held at the Washington Hotel, Mayfair.

Organised by Cyril Rex-Hassan, this gathering of the Audio clans paved the way to its extension and transfer, first to the Waldorf Hotel, thence to the Hotel Russell in 1959. In 1962, it was given a new title, International Audio Festival and Fair, and, in 1969, yet another move to Olympia.

So much for the history of the audio shows. The 1972 exhibition, which closed its doors on Saturday evening, October 28th, proved to be the biggest and most popular of all the series, reflecting the massive interest by audiophiles as well as the public who are merely concerned with a 'good sound', from their record players and radio receivers. Queues formed outside Olympia all day long on closing day, even though admission was not free, as in the early shows, but cost 40p.

The 'Goodwood' domestic monitor loudspeaker from Goodmans.





Scan-dyna's new tuner-amplifier, the 2400 provides 2 x 40 watts RMS for channel.

Looking at some of the highlights, unquestionably Bang & Olufsen's Beogram 4000 straightline-tracking turntable unit attracted a great deal of attention. In a recent Audio News page, we have already commented on this remarkable 'electronic data-controlled turntable system' and, even at a price around £160, the audiophile wanting the newest devices for social performance will seek this model out at the dealers. Combined with the latest B&O SP.15 pickup cartridge, the unit can be described as a 'state of the art' system.

ADC's latest LM series of pickup cartridges — handled in UK by Hisonic Ltd (part of KEF Electronics Ltd, Maidstone) — incorporates tiny moving parts, hence the description Xtra and Very Low, Mass, which allows the use of smaller lightweight arms. Not confirmed as we write but, almost certainly accurate is the taking over of the ADC company in USA by BSR Ltd here.

Reverting to electronically controlled turntables, several other firms demonstrated designs with servo-controlled dc motor direct-drive systems, for example, Sony, Pioneer and National. More conventional turntables were shown by BSR (model 701, a cheaper version of their successful 801) and Garrard, with its new AP96 unit. Thorens displayed the new TD160, based on their TD150 model. This is a two-speed transcription unit, incorporating the TP16 arm, with a unique 4-position magnetic anti-skating bias adjuster, which eliminates the functions normally associated with mechanical bias adjustment.

An arm of world-wide renown, the SME Series 9, is now released in an improved version, with various useful changes at the rear of, and beneath, the pivot. A smaller and lighter counterweight is now fitted, with the rider detached. Below deck level, horizontal entry plugs are now standard and the headshell is not detachable, although a removable shell can still be ordered.

Loudspeakers continue to attract electroacoustic designers, and Olympia offered a wide selection of models. If a trend was discernible, it is towards smaller physical size and less efficiency, although the bigger enclosure models are coming back into fashion where deep bass radiation is desired.

One such system is the Goodmans 'Goodwood', a monitor type enclosure for less than £100.

Other total enclosure designs are produced by B & W Electronics, a small firm with a growing world market and reputation. Their improved DM70 has a big curved ELS unit for high frequencies, with matching transformer and level control. B&W introduces two

# AUDIO FAIR HIGHLIGHTS

The Philips 2510 Hi-Fi stereo cassette recorder is specially designed for chromium dioxide tape.

new models, the D5 two-way compact loudspeaker system, and the DM4, a three-unit monitor, using Bextrene coned bass/midrange unit produced in their own factory, a type HF1300 Mk II lower HF unit, and a plastic domed upper HF unit.

AR's range of 'acoustic suspension' systems, now marketed from Acoustic Research's British office in Houghton Regis, Bedfordshire, are now available at greatly reduced prices. Their top model is the LST, but the performance of the small AR7s (costing around £25) has to be heard to believed. An undoubted winner for this American company.

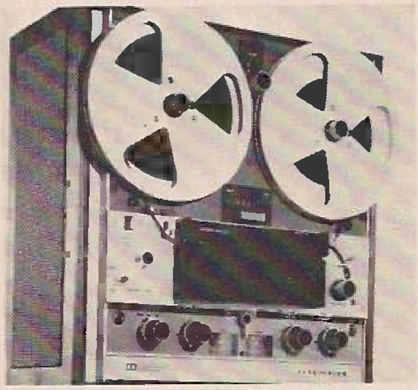
Lecson demonstrated a system employing a horn-loaded bass, mid- and HF units, of high efficiency, due to John Greenbank. Another uncommon design was the Sinclair Q30 loudspeakers, which are doubled designs, with inverted cone units, handling up to 25 watts. The slender shape is only 2½in deep by 23½ x 34½in and the Q30s cost only £25 each.

Heathkit's new AS9520, and AS9515 loudspeakers (using KEF units in the first two models) offered exceptional sound quality in the demonstrations, and are competitively priced. As well as social 'receivers' (tuner-amplifiers in UK terminology) Heathkit is later introducing a quadraphonic decoder unit. Goodmans Module 90 is another outstanding example in this category.

Scan-Dyna showed an attractive new tuner-amplifier, the 2400, with many advanced design features, including touch-sensor controls for function selection.

Many amplifiers today employ slider controls (for instance, the Philips RH521 right down to the inexpensive Amstrad Integra 4000, selling at a recommended price of £32.95 but likely to be discounted at less than £25). So called 'Sound Effect Controllers' — a sort of graphic equalizer, are fitted in JVC equipment, which permits the user to contour the frequency response. Philips also use 'presence' controls in their new models. Ferrograph introduced several new products, including the F608 Stereo amplifier, developing 60 watts RMS per channel into 4 or 8 ohm loudspeakers.

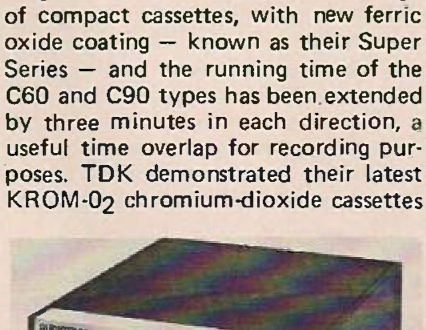
Although open reel tape recorders still dominate the professional users' market, and such designs as the latest Revox A77 (Mark 3) could be seen



The Ferrograph Series 7 recorder is now available with Dolby B as an optional extra.

and heard in use in practically every demonstration room, the domestic market would seem to be swinging towards cassette units, of varying degree of sophistication, many fitted with Dolby B noise reduction circuits. Philips DNL (dynamic noise limiter circuit) is incorporated in their latest N2510 Hi-Fi stereo cassette deck and in the Pye Model 9145 stereo cassette deck, intended for use with existing audio systems.

Agfa-Gevaert introduced a new range of compact cassettes, with new ferric oxide coating — known as their Super Series — and the running time of the C60 and C90 types has been extended by three minutes in each direction, a useful time overlap for recording purposes. TDK demonstrated their latest KROM-$O_2$ chromium-dioxide cassettes




Audiotronic 6-pole remote control SQ decoder for 4 channel discs and tapes.

and other endless loop and head cleaner cassettes.

Following the BBC's plans for extending FM — stereo broadcasts, much interest was being shown in Antiference's new range of FM stereo-aerial arrays, described as 'mush-killers'.

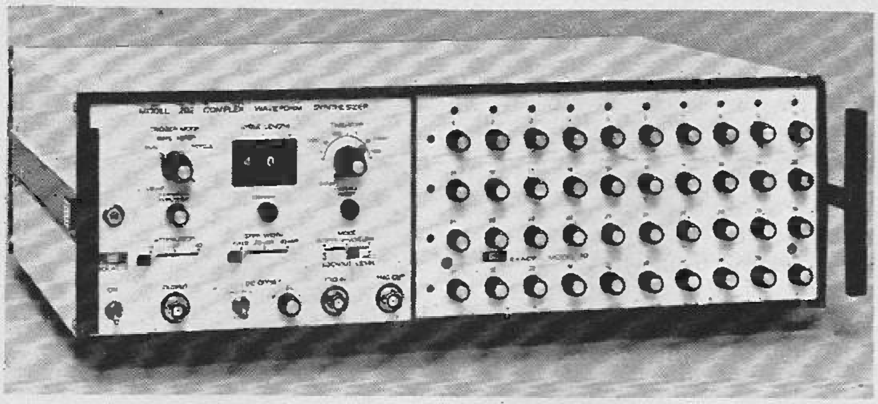
As might have been expected, with the current widespread promotion of 4-channel sound systems, a number of 'quadraphonic' demonstrations by different exhibitors supporting various techniques could be heard. None was wholly satisfying and no standard system appears to be emerging for the present. Repertoire is still small from such companies as EMI and CBS, and decoders are in short supply, although several manufacturers are working on this problem.

Ambient and 'surround sound' systems are becoming available such as, the B&O Beomaster 4000 with optional ambiophonic speaker channels, and Interconti Electronics launched the new £30 'Quadiosound' amplifier.

The conflicting systems of SQ, QS, JVC/CD4 etc, are still engaged in combat for the 4-channel market, and Professor Peter Fellget (University of Reading) gave a provocative lecture in the Hi-Fi theatre (one of 20 such talks during the Fair) on 'Commonsense and Quadraphonia', in which he offered his opinion, based on researches with John Wright, of IMF, that three channels — not four, can fully represent the sound field at a point, and can substantially reproduce this field in the region occupied by a listener's head and ears. He believes that the future of, what he calls, 'Pantophonic' sound, depends on escaping from the tyranny of 'quadraphonic 4-channel' thinking.

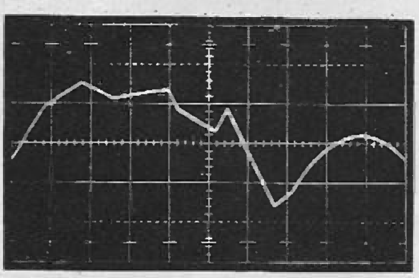
All in all, the 1972 Audio Show had great appeal to the masses, if not to the audio specialists. This is perhaps, not surprising, as one stand even had the Penthouse magazine girls displaying their wares! ●

# EQUIPMENT NEWS



## COMPLEX WAVEFORM SYNTHESIZERS

Models 201 and 202 from Exact Electronics are instruments to electrically generate complex waveforms in a bit-by-bit manner; the bits can be independently controlled in amplitude, width and slope, permitting the generation of an almost unlimited variety of usual and unusual waveforms. The instruments have either digital or analog waveform capability. Proven and potential applications are: Shock Table Drive – using the synthesizer to input vibration systems for shock testing so that the table can be forced to follow a desired function; simulated Medical information – nerve and muscle potentials or heart pulses in normal as well as abnormal conditions as an aid to research without the



need for patients to supply live' data; simulation of Telemetry Data for marginal checks on telemetry equipment; Waveform Analysis and Distortion studies, etc. The instruments also feature a plug-in programmer.

Further details from:
Environmental Equipment Ltd
Denton Road
Wokingham, Berks (139)

## FLOATING POINT OPTION FOR SCIENTIFIC COMPUTERS

Transworld Data Systems of Greenford, Middlesex, has just announced the availability of a hardware floating point facility for most popular mini-computers and medium-scale scientific computers.

The FP-01 Floating Point Hardware is a peripheral arithmetic unit attached to either the programmed I/O bus or DMA channel of a general-purpose computer. Operations within the FP-01 are carried out in 32-bit parallel fashion for the Add/Subtract. Multiply/Divide, Fix and Float functions with the results presented to the computer in normalized form.

The FP-01 utilizes an 8-bit, two's complement exponent with a 24-bit signed binary mantissa. The FP-02 utilizes a 32-bit mantissa giving increased precision. The FP-03 gives an even further increase in precision by utilizing a 40-bit signed mantissa. Options for the FP-01/02/03 are plug-ins which perform trigonometric, or other closed functions such as roots, logs, FFT, etc, via a combination of hardware/software, and a 'Formatting Interface' to account for changes in format.

Typically execution times show better than an order of magnitude improvement over floating point software execution on all floating point operations with most computers.

The FP-01, 02, or 03 consists of a single unit, complete with power supply and is available in either table-top or rack-mountable versions. In rack-mount form, it inserts in a standard E1A 19-inch relay rack, requires 7-inches height, and is 32-inches deep. As a table-top unit, it measures 6¾ x 17¼ x 22¼ inches, plus handles, which are 1¾ inches past the front panel.

Both programmed I/O and DMA Interfaces are available for a wide range of computers including PDP-11, PDP-8, PDP-9/15, NOVA, HP 2100, Varian, Honeywell, Raythen, Texas Instruments, General Automation, IBM 1130/1800, CDC 1700/1705 and many others.

Further details from:
Transworld Data Systems Limited
416 Derby Road
Greenford Industrial Estate
Greenford, Middlesex (176)

## RADIO TELEPHONE

A self-contained, solid-state, 12 channel VHF/FM radio-telephone introduced by EMI Marine combines high performance and straightforward operation in a package especially designed to withstand marine use. Costing £310, the 'Mariner' uses solid-state circuit techniques and corrosion resistant materials, to ensure reliability and interference-free communication. It incorporates design features which provide protection against accidental misuse, to enhance performance, and simplify maintenance and servicing. The circuits provide full performance over the ambient temperature range −30°C to +60°C and have a rated capacity of double their working load, providing a wide safety margin.

Low current drain (less than 0.15A) allows continuous receiver operation in the stanuby mode, with only a single 12V to 14V wet-cell battery as the power source. The transmitter provides 1W or 25W RF output, dc current consumption is 3.5 amps. The equipment conforms to the latest Post Office specification, incorporating 25kHz channel spacing. All circuits are contained in plug-in

modules, which may be removed or replaced for servicing without disturbing the equipment in its mounting. This radio-telephone may be installed readily by the boat owner: no technical knowledge is required, and comprehensive fitting and operating instructions are supplied, and a range of accessories is available.

Further details from:
EMI Electronics and
Industrial Operations
Blyth Road
Hayes, Middlesex (133)

## UNIVERSAL COUNTER

Model 9837 Universal Counter Timer is said to offer a far wider range of facilities than are available with similar priced counters. These include the facility to measure frequencies up to at least 80 MHz with a sensitivity better than 10mV at 1 megohm in parallel with 25pF, and the ability to measure contact closure time intervals for either normally open or normally closed contacts in addition to pulse operation of the counter. When pulse operated, trigger slope selection is provided for both start and stop edges. It also acts as a totalizer. Readout is by a six-digit display, including

# EQUIPMENT NEWS

automatic positioning of the decimal point, and with memory if required.

The internal frequency standard is a 5 MHz crystal oscillator with an ageing rate of better than 1 part in $10^6$ per month. Higher precision internal standards are available as options, and the 9837 may be operated from an external 1 MHz standard. The front panel is said to be ergonomically designed and the

internal construction to provide extremely easy access to all components, and freedom from mains borne interference.

Further details from:
Racal Group Services Ltd
26 Broad Street
Wokingham, Berks (135)

### LONG RANGE PAGER FROM PYE

Pye Telecommunications Ltd has launched a new miniature long range radio paging receiver which is to be known as 'Pyecall 4'. It is said to use highly advanced design techniques including plug-in thick film hybrid micro-circuits.

This unit, not much longer than a small packet of cigarettes, measures only 120 x 48 x 21 mm (4.7 x 1.9 x 0.8 in) and has been designed to work within existing Pye VHF mobile radio systems. It only requires the

addition of a relatively inexpensive Pyecall Encoder.

Personnel with a 'Pyecall 4' may then be paged anywhere within the area of existing R/T coverage. In county wide systems this can extend over ranges of 20-30 miles.

The 'Pyecall 4' (type PG1AM) can also serve as a conventional pager providing local coverage over a few miles for use in conurbations, and is a further element in the versatile Pyecall Selective Calling System, with a capacity for up to 960 receivers which can be called individually.

Pye Telecom Pagers are already widely used in the UK to alert crews of standby firemen as a replacement for the old-fashioned siren call-out. The wearer may adjust the volume of the pager which emits a 5 second tone.

The 'Pyecall 4' is powered by two mercury cells which are said to provide over 280 hours continuous use. Based on a hypothetical number of calls per day, say one per hour for a nine hour day over a five day week, the two mercury cells will last for approximately nine weeks.

The 'Pyecall 4' is an overlay pager which enables personnel with two-way radios in their vehicles to be paged to the effect that they should return to the vehicle to speak to base. Personnel need no longer be off-air or not available.

Further details from:
Pye Telecommunications Ltd
Newmarket Road
Cambridge
CB5 8PD (171)

### TEMPERATURE CONTROLLER

An electronic temperature controller said to be more versatile, stable and cheaper than similar devices on the market, is now available from Pilkington.

The controller uses a solid state electronic circuit to generate linearly increasing, decreasing or constant temperature conditions in electric or gas furnaces of up to 80 kVA capacity.

It will operate, it is claimed, at infinitely variable rates and these can be pre-set before a run or drastically altered during it. By incorporating timers, various combinations of the three temperature regimes can be obtained automatically.

In four years use, Pilkington has found its rate of increase of temperature stable to ± 4% over three years.

The group currently has 20 in use, mostly for R & D purposes but some are used industrially. They have been used on furnaces ranging from 0.2 kVA to 80 kVA. Working experience has been from ambient to 1500°C at rates from 0.1 to 200°C/minute.

Pilkington also found resetting required only once a year. Integrated safety features protect the controller against overheating and furnace thermocouple failure. The solid state components make it reliable and as there are no moving parts, there is no wear.

Measuring 200 x 125 x 125 mm (8 x 5 x 5 in) the controller has been used by Pilkington for differential, thermal and thermo-

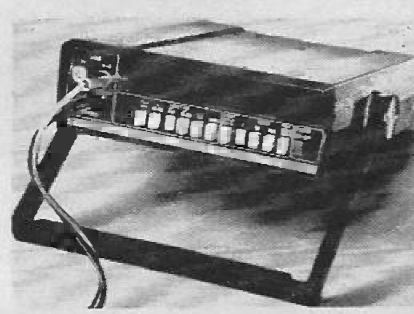
gravimetric analyses as well as for annealing and special heating cycles.

Further details from:
Pilkington Brothers Limited
St Helens
Lancashire
WA10 3TT (172)

### DIGITAL MULTIMETER

Fluke have announced the 8000A, a new, low-priced full digital multimeter.

The 8000A has a one-year guaranteed accuracy, 15° to 35°C, of ± (0.1% of reading + 1 digit) and will measure ac and dc volts to 12000V, ac and dc current to 2A and resistance to 20 megohms.



The following is a brief specification:
Accuracy: (1 year 15°C–35°C)
DCV ± (0.1% + 1 digit)
ACV ± (0.5% + 2 digits)
DCA ± (0.3% + 1 digit)
ACA ± (1.0% + 2 digits)
Ohms ± (0.2% + 1 digit)

Overload protection on voltage ranges is to 1200V rms, current ranges to 2A rms (fused), ohms to 230V. There is a wide range of options and accessories available. Price £99.

Further details from:
Fluke International Corporation
Garnett Close
Watford WD2 4TT (138)

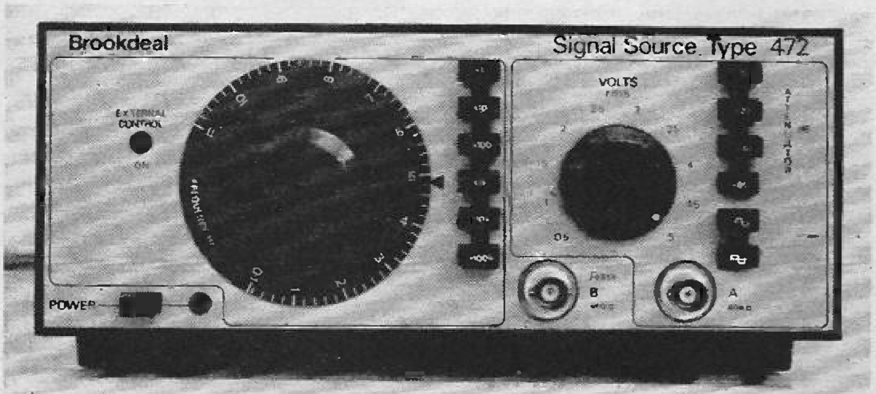
### LOW DISTORTION SIGNAL SOURCE

Brookdeal Electronics have added to their product range with the introduction of the Signal Source type 472, the second in a family of oscillators. This family is said to

# EQUIPMENT NEWS

be based on a new concept in oscillator design combining complete freedom from amplitude bounce with very low sinewave distortion (typically 0.1%).

The frequency output spans two decades on any range setting over the instruments range of 0.1Hz to 1.1MHz. The frequency control law is linear and may be set either manually or by an external voltage. It gives a sine or squarewave output from 5V rms to




less than 500uV rms, with a calibration accuracy of 1% up to 100 kHz, plus a fixed level squarewave of 3.5V p-p for triggering oscilloscopes or, as a reference for lock-in amplifiers, etc. An ideal laboratory signal source suitable for bench use, or with adaptors, in a 19 in rack. It weighs only 2.9 kg and measures 218 x 87 x 285 mm deep.

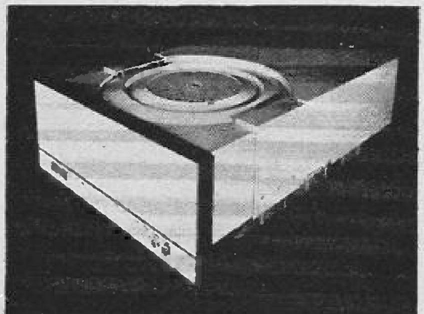
Further details from:

Brookdeal Electronics Limited
Market Street
Bracknell, Berks
RG12 1JU (173)

## DISC FILE FOR IBM 1130

Perex Ltd, the Reading based Computer Systems Engineering Group, announce a new range of Disc Files for use with the IBM 1130.

Their Perex 1130 Subsystems include an interface and controller and will either be



compatible with IBM 1130 operating software or provide both I/O driver software and diagnostics. All subsystems use well tried and proven disc files already in major current production. Both fixed head fast access disc files (up to 12.8 Mbits) and moving head disc files (IBM 2310 compatible or IBM 5444 type) are available.

A typical Perex Moving head Disc system would use the Data Recording Instruments Ltd Model 4043 disc drive (IBM 5444 type). This drive stores 100 megabits using a combination of the IBM type 5440 removable disc on the same spindle, with a common moving head actuator.

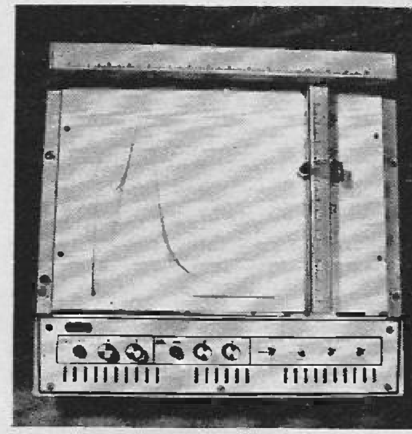
A particular feature of Perex 1130 subsystems is the fact that they can be attached directly to the SAC channel. NO MULTIPLEXER IS REQUIRED and up to TEN Controllers for different peripherals can be 'daisy chained' on to the SAC bus.

The Perex Disc subsystem is one of a series of peripherals soon to be announced for the IBM 1130 computer.

Further details from:

Sintrom Electronics Limited
2 Arkwright Road
Reading, Berks
RG2 0LS (174)

## NEW CALCULATOR PLOTTER



Wang Electronics Limited are announcing two new flat bed plotters known as types 712 and 612, which are designed to provide plots and alphanumeric labelling of problems computed by their 700 and 600 Series electronic calculators.

Plots can be drawn automatically by the calculator programme or manually from the calculator keyboard. Provision is made for 15 different sizes of alphanumeric labels to be selected by programme command. This labelling facility enables the user to draw finished plots that are labelled, titled and scaled in one simple operation.

Basically, the 712, 612 are flat-bed X-Y plotters using analog servomotors and having a paper capacity of 11 x 16.6 inches and provided with an electric paper hold-down system. Plot accuracy is said to be ±0.2% of full scale, with 0.1 inch from one plot to the next. Linearity is ±1% of full scale, as is resettability. Peak acceleration in both the X and Y axes is said to be 15in/sec$^2$.

Average plotting speeds between points is 6in/sec. However, the actual plotting time is dependent on the calculator programme being executed.

Operating temperature range of the plotters is claimed to be 15 to 45°C with a humidity of between 20 and 80%. Power requirements are 115 or 230V ac = 10%, 50 to 400Hz, 150VA.

These plotters, together with the many other peripheral devices available from Wang, will further extend the versatility of the 700 and 600 Series electronic calculating systems and will provide the solution to many previously ardous and time consuming plotting applications.

Further details from:

Wang Electronics Limited
40/44 High Street
Northwood (175)

## DIGITAL FREQUENCY METER

The TC16 digital frequency meter is a low cost five-digit unit which covers the range from 5Hz to 80MHz. It features high input impedance and stored display. Readout is by means of five, neon, numerical display tubes. Input impedance is said to be approximately 1 megohm/25pF, sensitivity is 75mV from 5Hz to 40MHz and 120mV from 40MHz to 80MHz.

The timebase utilises an internal 1MHz crystal. Provision is made for using an external standard. Gating times are 1ms or 1s. 'Gate open' indication is by means of an LED which illuminates when the gate is open. The decimal point is fixed for readings in either kHz or MHz depending upon the gate time selected. An LED lights to give a positive indication of over range when the display overspills.

Dimensions of the TC16 are 20 x 8 x 18.3 cm and weight is 1.64Kg. Power requirements are 115V or 230V rms ± 10% 48Hz to 65Hz and the unit is said to have an operational temperature range of 0°C to 50°C.

Further details from:

Advance Electronics Limited
Instruments Division
Raynham Road
Bishops Stortford, Herts (177)

# FINE MEASUREMENT IN GEOPHYSICS

*(Continued from page 17)*

mechanical strainmeters, atmospheric pressure will vary the length of the standard. The daily variation causes length changes equivalent to about 10% of the tidal strain amplitude. Temperature changes also vary the length of standard. Whilst quartz has the low coefficient of thermal expansion of roughly 1 part per million per degree, Kelvin, (the new name to be used for Centigrade in the S.I. unit system) a temperature change of 0.01°K gives tidal amplitude changes in signal. To combat this we are developing a novel instrument. Hanging under the quartz tube is a brass tube (as can be seen in Fig. 4). The two outputs of each gauge are mixed electronically to produce a temperature compensated signal, for the brass expands some thirty-times greater than the quartz, enabling length changes due to temperature to be differentiated from those due to true strains. This technique was used in 1890 by Colby to survey the British Isles but he had to use a mechanical link to couple brass and steel bars, electronics being unknown in his day.

At present these measurements are taken by manual means but soon the Observatory will record the variables continuously so that the conditions at any time can be recalled. One of the small niches has been built into a small room. At first sight it looks like any other room but, in fact, the construction has been performed without the use of magnetic materials. This is the laboratory area for testing magnetometers to their limit of resolution. There appears to be no strong relationship between the magnetic phenomena and earthtides but the Observatory offers excellent thermal conditions for testing instruments as the daily variation is only several thousands of a degree.

The development of alkali-vapour magnetometers is another Departmental project which involves optics, mechanics and electronics. In this a discharge lamp radiates visible light through a glass cell fitted with an alkali-metal vapour, to shine on a phtocell. Around the cell is a magnetic solenoid coil which is energised by control from the output of the photocell. As the magnetic field strength is adjusted the system breaks into oscillation at a high frequency, the frequency depending on the total magnetic field around the cell. This method is the most sensitive magnetometer device available.

Another project underway is a possible new form of gravity meter which uses no springs. Molecules in a gas flowing along a horizontal heated tube deflect downwards proportional to the gravitational attraction. A laser beam is radiated along the tube centre and its vertical displacement is measured with a position-sensitive photocell. Electronics control the heating of the tube.

Electronics and geophysics are inseparable. Electronics, however, must be combined with mechanical and optical techniques if measurement is to be employed to the fullest. ●

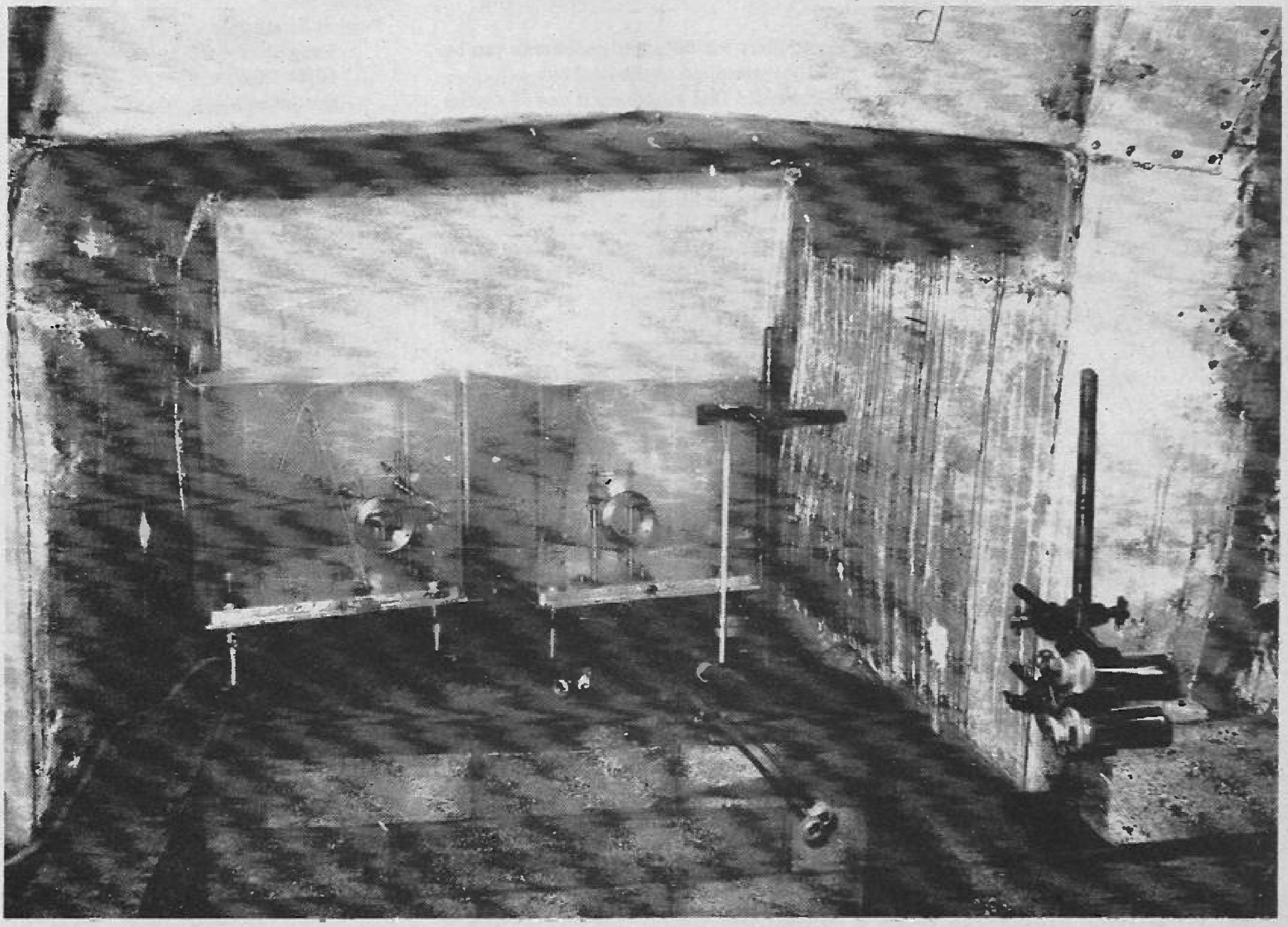


*Fig. 6. Horizontal-pendulums — the niche was made without explosives, by drilling and chiselling. It is lined to prevent water droplets falling on the instruments.*

# One man's Bach is another man's blight

*(Continued from page 51)*

The required reduction can most easily be obtained by adding a lead/plasterboard barrier spaced an inch or two from the existing wall. This partition should be constructed from 3/8" or ½" plasterboard plus 1 lb./sq.ft. or 2 lb./sq.ft. lead, bonded by contact adhesive.

## Preparing and bonding the lead

Sheet lead is a soft, limp material and is usually supplied in rolls. It is easily flattened by unrolling it on any smooth, clean surface. Kinks and wrinkles should be removed by a roller.

If cast sheet lead is used, the surface will be chemically clean – other types of lead may have an oily surface. This can be removed with trisodium-phosphate or any heavy-duty alkaline cleaner. Traces of the cleaner must be washed off with warm water.

A viscoelastic bonding material must be used to adhere the lead to the backing material. This type of adhesive assists the damping action of the lead. Suitable types are rubber-based contact adhesives such as Bostik 400W, Bostik 1450BB, Laminex 440TS, Behr Manning 600, etc. Rigidly setting glues must not be used.

## Installation is simple

Cut the plasterboard to exact wall size. Ensure that the board fits tightly at floor and ceiling. Bond lead sheet to plasterboard following adhesive manufacturers' instructions.

Nail 2" x 1" battens to existing wall, preferably picking up existing wall studs, top and bottom plates, noggins, etc.

Attach laminate to battens, ensuring that it fits tightly around the perimeter. The amount of sound that can leak through the tiniest gap or crack is unbelievable. The penalty imposed by these leaks becomes much greater as the wall's performance is improved. When in doubt, use a gasket, tape, or caulking compound.

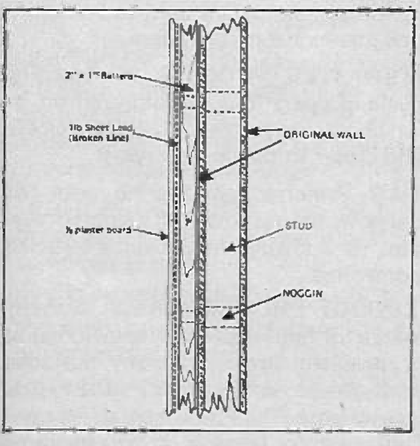
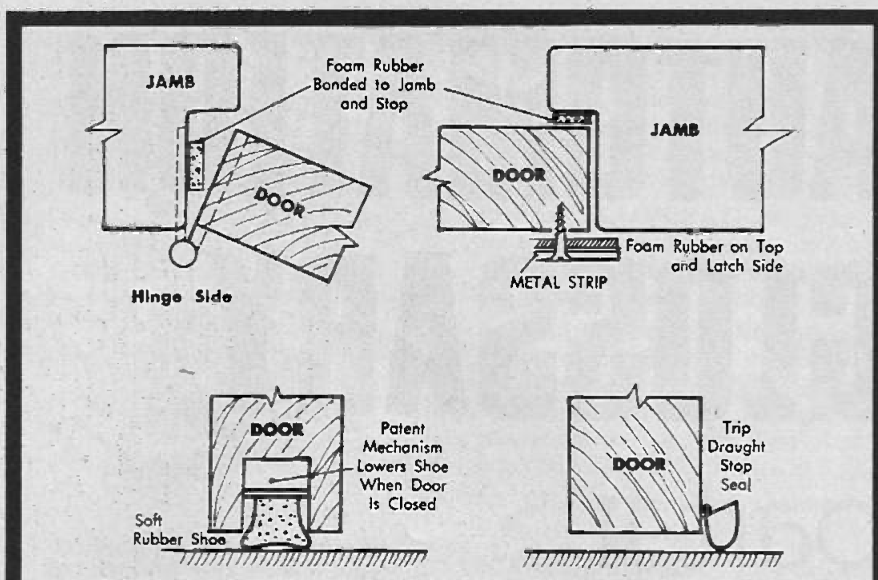



*Fig. 3. Laminate fastened to wall.*




Gaps around door edges.

*Remedy:* The simplest method of closing air gaps around the door is to fit strips of soft rubber against the door stop and rebate. Alternatively, fit a metal draught strip with a rubber seal on the top and latch sides of the door. For the bottom of the door fit a drop tongue or rubber cushion trip type draught excluder.

## Treatment for doors

Two main factors determine the sound insulation provided by single doors – the mass of the door, and the amount of air leakage around the edges.

Typical figures for doors are –

*Standard flush panel, ply or hardboard finish (1-2lb./sq.ft., 1 7/8" thick):*

| *Normal installation* | *With correct sealing* | *Maximum insulation* |
|---|---|---|
| *18 dB* | *21 dB* | *22 dB* |

*Ply/lead panels cavity type, absorbent infill (6-7 lb./sq.ft., 1 7/8" thick):*

| *Normal installation* | *With correct sealing* | *Maximum insulation* |
|---|---|---|
| *21 dB* | *30 dB* | *35 dB* |

The inner faces of cavity doors should be lined with at least 1 lb./sq.ft. lead and the space between faces filled with an absorbent material if possible.

Every effort must be made to reduce sound transmission through gaps around door edges. Suitable methods are shown above.

## Ceilings and floors

The sound insulation provided by concrete floors and ceilings is generally sufficient to attenuate all but the loudest noise. Wooden floors, however, may have an attenuation of less than 25dB. This is totally inadequate and treatment will be necessary.

Here again lead sheet is most effective. Thin lead sheet carefully overlaid on top of an acoustic tile ceiling will provide an adequate barrier to the passage of sound without materially affecting the performance of the acoustic tile in the job which it is intended to do – i.e., reduce the reverberation of sound within the room.

To summarise:

1. A heavy barrier is more effective than a light barrier.
2. A double wall or floor is more effective than a single one on a weight-for-weight basis.
3. Air spaces between skins should be filled with glass-fibre, mineral wool or other absorbent material.
4. The weight of lead in a lead/plaster plasterboard laminate should equal or exceed the weight of plasterboard.
5. Viscoelastic adhesives are better than rigid varieties for laminating leaded panels.
6. Sound transmission through small gaps is high. Wall and panel joints must be tight. Gaskets or caulking should be used where there is the slightest gap.
7. Cost of lead sheet will vary from area to area but is unlikely to exceed 10p per pound. ●

# AUTOMATION GLOSSARY

**A contemporary glossary of words and phrases in the language of automation, abstracted by permission from a compilation by Honeywell Automation**

# part II

**FREQUENCY RESPONSE ANALYSIS** The use of alternating or pulsating signals to excite a control system that is being studied. The system's response to different frequencies permits analysis of its operating characteristics.

**GAIN** The increase or amplification of a signal as it passes through a control system.

**GYROSCOPIC CONTROL** Control or stabilization system utilizing the gyroscopic phenomenon of resistance to change in the direction of the axis of spin. Such a system employs as a gyroscope an attitude sensing device. See 'inertial guidance'.

**HARDWARE** The equipment or machinery' used in a computer system. The computer itself and peripheral devices; as opposed to 'SOFTWARE' (qv), which denotes written information.

**HUNTING** A control system's continuous, cyclical search for a desired or ideal value. Very rapid hunting is usually termed 'oscillation'; slower cycles called 'bird-dogging'.

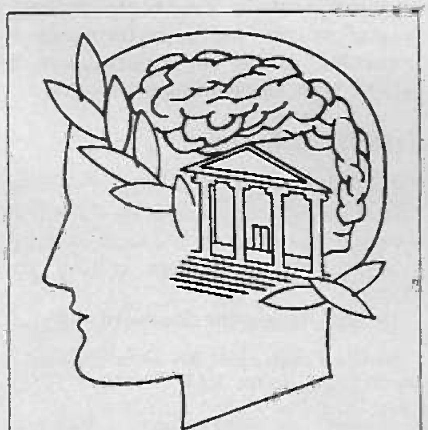
**HYBRID** (1) An electronic circuit having both vacuum tubes and transistors. (2) A mixture of thin-film and discrete integrated circuits. (3) A computer having both analog and digital capability.

**HYSTERESIS** The lag in an instrument's or process' response when a force acting on it is abruptly changed. Hysteresis may be caused by various mechanical, electrical, or physical conditions; and may or may not be desirable.

**INERTIAL GUIDANCE/NAVIGATION** A self-contained system for navigation where position can be computed by knowing a craft's starting point, and where it has been.

Changes in acceleration are detected by gyroscopes for direction and attitude and by accelerometers for velocity. These signals are integrated to determine resulting velocity and distance. The system needs no outside reference and cannot be jammed.

**INFORMATION RETRIEVAL** Attention to the techniques employed for recovering certain desired information from a computer's memory.



*Will the man-made computer someday out-smart man himself? Not soon, it seems. The human brain can hold some 10 million-million 'bits' of information — enough to fill the shelves of a good sized library — all stored away in a 100 cc case. That's about 1/20th of a cubic foot, and weighs about 3 pounds. A 1-to-4 million bit computer requires around 60-70 cubic feet, and holds around 200 pounds of memory units.*

**INPUT** In *electronics,* the current, voltage, power, or driving force applied to a circuit or device; or, the terminals or other places where current, voltage, power or driving force may be applied to a circuit or device. In *computer terminology,* the data being supplied to a computer for processing.

**INSTRUMENT** As used in industrial control, an instrument is a device incorporating any one or a combination of measuring, recording, and controlling abilities.

**INSTRUMENTATION** Used to describe the application of industrial instruments to a process or manufacturing operation. Also describes the instruments themselves.

**INTEGRATED CIRCUIT** A miniaturized 'chip' in which semiconductor components, thin or thick film and other such technology combine the functions of a number of conventional components (resistors, capacitors, diodes, etc).

**INTEGRATED TRANSDUCERS** Semiconductor transduction components that change the form of energy; ie piezoelectric devices, photogenerators, thermistors, etc; integrated into multifunction 'chips'.

**INTEGRATOR** A device which continuously adds up a quantity being measured over a period of time. Similar in use to a home electric meter.

**INTERFACE** In *computer terminology,* a common boundary between automatic data processing systems or parts of a single system. In *control terminology,* the means used to link components in a control system.

**ITERATIVE PROCESS** A repeating cycle of operations, in computation, in which the successive solutions are closer and closer to the desired result.

**LAG** Preferred engineering term for delay in the response of a control system to a change in the variable being controlled.

**LINEAR PROGRAMMING** A technique for finding the best solution(s) to a problem involving many variables that can be expressed as mathematical equivalents. The math equivalents must be linear to (that is, must change in direct relation to) any change in the variables, for the solutions to be valid.

**LINEARITY** The ability of a device or system to change its output in exact proportion to changes of input. For example, if an electrical meter were perfectly linear, one percent of current would deflect the indicating needle one percent of total travel at any point throughout the travel of the mechanism.

**LOAD** What the process calls for in fuel or energy input.

**LOGGER** An instrument that automatically scans certain values in a controlled process and logs or records the readings for future record.

**LOGIC** In computers and in information-processing networks, the systematic method by which information is processed, usually with each successive step influencing the next one.

**LOOP** In *electronics,* a complete electrical circuit. In *automatic control,* 'loop' is the path followed by command signals, which direct the work to be done, and feedback signals which flow back to the command point to indicate what is actually being done. See 'CLOSED LOOP' and the discussion of early automation.

**MATHEMATICAL MODEL** A mathematical representation that simulates the behaviour of a process, device or concept.

**MANIPULATED VARIABLE** The one variable (value, condition, quantity, etc) of a process that is being controlled. By manipulating this variable, the process can be controlled.

**MEASURING MEANS** Whatever is used to measure a condition. A thermometer is a measuring means for room temperature.

**MODIFIER** A component or subsystem that alters an instruction without changing the form of energy; ie changes electrical input energy to electrical output signals.

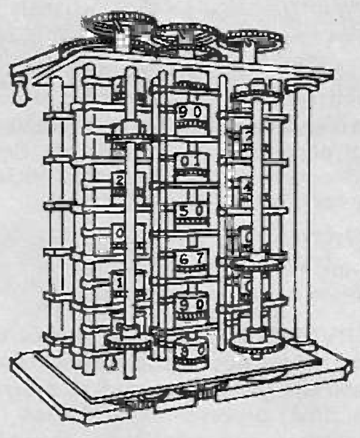
**MONTE CARLO METHOD** Any method for obtaining a statistical estimate of a desired quantity by random sampling.

**MULTIPLEX** (1) To execute several functions simultaneously in an independent but related manner. (2) To interleave or simultaneously transmit two or more messages on a single channel.

**MULTI-PROCESSING** Two or more processes running simultaneously in one computer system.

**MULTI-PROGRAMMING** Two or more programs operating simultaneously in one computer system.

**NEUTRAL ZONE** A range in the total control zone where the controllee does not respond to changes in the controlled process. A dead zone, usually at the midpoint of the control range.



*It should be no great surprise that the first computer was devised by a man determined to beat the horse races. And the result should be equally unastonishing. The gentleman lost his shirt . . . his lady friend hocked and lost her jewellery . . . finally the British government bet £17,000 on his computer, and lost that. The inventor was Charles Babbage, a mathematically-gifted Briton who first attempted to equate a fast buck with slow horses; then in 1822, set out to build a mechanical calculating machine. He got an advance of £17,000 from the British government for his 'difference engine'; but, in mid-construction, he redesigned it into a much more ambitious 'analytical engine' and finally bogged down entirely. The British government took possession of the unfinished model and placed it in London Museum. Babbage died broke and embittered, never realizing that he had tackled an impossible task: Nobody beats the horses.*

**NOISE** In electronic systems, the undesirable background signals that clutter up the control signal. Originally called noise because, in audio and early radio systems, the spurious signals created static that interfered with the amplified sound signal.

**NUMERICAL ANALYSIS** To provide convenient methods for obtaining useful solutions to mathematical problems and for extracting useful information from available solutions which are not expressed in tractable forms.

**OFFSET** The difference between the value or condition desired and that actually attained.

**OPEN LOOP** Pertaining to a control system in which there is no self-correcting action for error of the desired operational condition, as there is in a closed-loop system. See 'CLOSED LOOP'.

**OPERATIONS RESEARCH** Solution of large scale or complicated problems arising from any operation (production, distribution process, etc) where a major decision must be based on solving a large number of variables.

**OUTPUT** In *electronics,* the power, energy, or signal delivered by a device or system. In *computer terminology,* the processed information being delivered by a computer; or the device employed to accomplish this data delivery.

**PARALLEL OPERATION** Type of information transfer within a digital computer in which all digits of a word are handled simultaneously.

**PARALLEL PROCESSING** The operation of a computer so that programs for more than one run are stored simultaneously in its storate, and executed concurrently. Also, operation of computer 'HARDWARE' in parallel.

**PATCH** In *electronics,* a temporary electrical connection.

**POSITION SENSOR** Device which measures position and converts the information into a signal that can be used by a control system.

**PRECISION** The degree of agreement among repeated measurements of a given quantity, taken by the same method and under the same conditions.

**PROBABILITY THEORY** A measure of likelihood of occurrence of a chance event, used to predict behaviour of a group, not of a single item in the group.

**PROPORTIONAL CONTROL** Control system in which corrective action is always proportionate to any variation of the controlled process from its desired value. For example, instead of snapping directly open-closed in the manner of two-position control, the proportional valve will be always positioned at some point between open and closed, depending on the system's flow requirement at any given moment.

**PULSE MODULATION** Use of a series of pulses, modulated or characterized to convey information. Types of pulse modulation include amplitude (PAM), position (PPM) and duration (PDM) systems.

**QUANTUM** The smallest unit of measure employed in a system.

**QUEUING THEORY** Research technique concerned with the correct sequential orders of moving units. May include sequence assignments for bits of information, whole messages, assembly line products, or automobiles in traffic.

**RANDOM NUMBERS** Array of independent digits having no logical interrelationship, so that the occurrence of any particular one is totally unpredictable.

**RATE ACTION** Control action in which the rate of correction is proportional to the rate of deviation from a standard value. Also called derivative action.

# AUTOMATION GLOSSARY

## part II

**READ** In computer terminology, the procedure of obtaining data from a particular source.

**REDUNDANCY** In general instrumentation, redundancy is the duplication deliberately designed into a system to provide substitution in case of component failure. In transmission systems, it is the amount (or percent) of a transmitted message that could be lost without critically impairing the total message.

**REPLACEMENT THEORY** The mathematics of deterioration and failure, used to estimate replacement costs and determine optimum replacement policies.

**REPRODUCIBILITY** In instrument work, the exactness with which measurement of a given value can be duplicated.

**RESET ACTION** Type of control in which correction is proportional to both the time, and the amount, that a controlled process has deviated from its desired value; and provision is made to guarantee return of the process to its setpoint.

**RESET RATE** Number of corrections a control system makes per unit of time (usually per minute).

**ROUNDING OR ROUND-OFF ERROR** Error resulting from rounding off a quantity; eg rounding off 0.2751 to 0.275, dropping the last ten-thousandth.

**SCAN** To examine point by point in logical sequence.

**SCANNER** An instrument that automatically surveys a number of processes and provides selective readout and (if desired) corrective action for each. In communications, a scanner may check various sites on a line to determine whether a message is present. A 'visual scanner' scans various stations optically, providing analog or digital signals for visual readout or written representation.

**SEMICONDUCTOR** A solid with an electrical conductivity that lies between the high conductivity of metals and the low conductivity of insulators. Semiconductor circuit elements include crystal diodes and transistors.

**SENSITIVITY** The degree of response of an instrument or control unit to a change in the incoming signal.

**SERVOMECHANISM** A control system that provides the following; a *command* instrument to control or program the final process; *amplification* to strengthen and modify the command signal; *work* instrumentation to manipulate the controlled process; and *feedback* provision to initiate corrective action when needed. Since feedback signals go from the controlled process back to the original command station, a servo system is said to operate 'closed-loop'.

**SETPOINT** The required or ideal value of a controlled variable, usually preset into the computer or system controller.

**SIGNAL CONDITIONING** Modifying signals into the form required for its proper use by measuring, recording or controlling instruments, Such conditioning may include amplification, linearization, attenuation and isolation.

**SIMULATION** Practice of substituting instrumentation (often a computer) for actual operational conditions, so that a real process can be simulated for valid data.

**SIMULATOR** A computer or other model of an actual system that so closely imitates the system's operation that usable data can be extracted from it.

**SOFTWARE** Programs, routines, codes, and other written information used with digital computers, as distinguished from 'hardware', the equipment itself.

**SOLID STATE** Term given to electronic components made of static and solid materials, as opposed to vacuum tube or electro-mechanical relays. Transistors and magnetic computercores, for example, are solid-state components.

**SYSTEM** A collection of parts or devices making an organized whole, through some form of regular interaction or interdependance.

**TELEMETERING** Transmission of a measurement over long distances, usually by electrical or electromagnetic signals. A receiving instrument converts the transmitted electrical signals into readings of the variable being measured.

**THERMISTOR** A semiconductor whose existance is extremely temperature-sensitive. Like carbon, thermistors have negative temperarure co-efficients; that is, their resistance increases as temperature decreases. They are used to compensate for temperature variations in other parts of a circuit and are also used as transducers.

**TOOL FUNCTION** In automatic machine tool control, a command which identifies a specific tool and calls for its use.

**TRACER** In automatic machine control, the word 'tracer' refers to a sensing element made to track around a contoured template so as to produce the desired control signals.

**TRANSDUCER** Any instrument that converts one form of energy to another, as for example, a proportional thermostat that converts temperature into analog electrical signals.

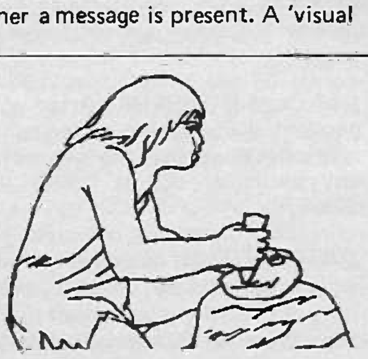
**TRANSFER FUNCTIONS** Mathematical model of a device that receives instructions from an infinite tape, Sometimes, the device itself.

**VALUE THEORY** Process of assigning numerical significance to the worth of alternative choices.

**VARIABLE** A factor or condition which can be measured or altered by a control system, such as temperature, pressure, flow, liquid level, humidity. weight, or chemical composition.

**ZENER DIODE** A semiconductor used as a constant voltage reference or control element in various electronic circuits — particularly power supplies.

**ZERO OFFSET** In automatic machine tool control, that characteristic which allows the zero reference point of an axis to be located within a specified range, with the control 'remembering' the location of a 'permanent' zero. ●



*Although only recently under study by control engineers, the principles of automation have been used by living things for millions of years. The cave man never heard of a servo loop; yet his brain sent the COMMAND SIGNAL, say, to chip an edge on a stone axe. His muscles TRANSDUCED, AMPLIFIED and ACTUATED the signal, his hands were the WORK TOOLS that did the chipping, and his eyes and other senses provided FEEDBACK. Eons have gone by, and still the human body is the most fantastic computer-controlled servomechanism ever devised.*

# COMPONENT NEWS

## EXCEPTIONALLY SAFE FUSEHOLDER

A miniature panel mounting fuseholder, type F396, has been designed to the safety requirements of IEC257, has a high degree of protection against electric shock and


accepts 5 x 20mm fuses at up to 6.3A250V rating.

The inbuilt safety features include: shatter resisting moulding; a flush fitting fuse carrier, with coin slot to aid removal; and fully recessed contacts which cannot be reached by a standard test finger. The fuse is automatically withdrawn when the carrier is removed, and the conventional 'live' contact is coded by the use of a redwasher.

All contacts and solder tags are silver plated and the whole unit is single hole rear nut fixing.

Further details from:

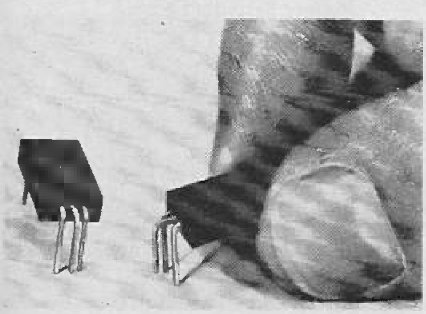
A F Bulgin & Co Ltd
Bye-Pass Road
Barking, Essex

## NEW OPTO-ISOLATOR

For the designer who must electrically isolate low voltage logic circuits from high voltage outputs, Pye TMC Components Ltd offers its 'Diodelite' 551-0001 opto-isolator.

This optically coupled isolator connects two systems by the transmission of light energy (photons), thereby eliminating the need for a common electrical ground. Another typical application for these devices is in the telephone line where transmitted data must be isolated from each other.

The optically coupled isolator incorporates an infrared emitting gallium-arsenide diode that drives a phototransistor. The isolator



provides a minimum current transfer ratio of 0.4 IF/IC, with 2500 volt isolation.

Further details from:

Pye TMC Components Ltd
Roper Road
Canterbury, Kent

## FIVE 2048-BIT READ ONLY MEMORIES

Microsystems International have added a family of five 2048-bit Read Only Memories to their continuously expanding portfolio of silicon-gats MOS products.

Erasable/Reprogrammable ROM's are designated MF 1701, 1702; electrically programmable ROM's, MF 1601, and 1602; mask programmed ROM, MF 1301. These devices are in volume production and are backed by a custom programming service.

All are in 24 pin dual-in-line ceramic packages and, with the exception of MF 1301 use the same 256-word-by-8-bit chip. MF 1701, 1702, 1601 and 1602 are guaranteed to have all 2048 bits programmable. This is said to be 100% tested in Microsystems' plant.

The program erasing feature of MF 1701 and 1702 is achieved by a quartz lid on the package through which data is completely erased with high intensity ultra violet light. Devices are then electrically reprogrammed. There is no elimination in number of frequency of this erasing and reprogramming procedure. These two devices are used primarily in system prototypes for which program experimentation is necessary. They are also widely used for small volume system production and in long run applications requiring reprogrammable nonvolatile memories.

Typical applications include secure communication systems and cryptographic equipment where codes need to be established or changed, program controllers in process control systems and microprogram stores for fixed CPU's.

MF 1601 and 1602 electrically field programmable ROM's are primarily used for relatively low volume applications. They are said to be usable as character generators enabling low cost custom formats. Both MF 1601 and 1701 are operable in either static or dynamic mode (refers to the decoding circuitry) as dictated by individual system requirements. Dynamic operation offers greater speed and lower power dissipation. MF 1602 and 1702 are for static only operation.

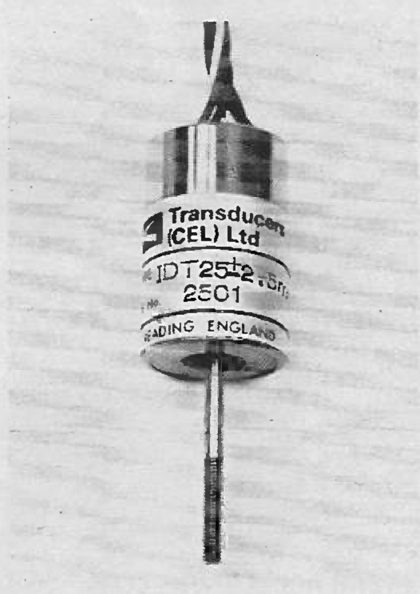
The programming of MF 1301 is achieved by the use of a metal mask during manufacture and is a lower cost replacement of the field programmed devices for long run system production. The MF 1301 is operable in both static and dynamic mode.

Further details from:

Microsystems International Ltd
1 Great Cumberland Place
GB-London W1H 7AL

## INTEGRATED DISPLACEMENT TRANSDUCER

Now introduced by Transducers (CEL) Ltd of Reading is a dc to dc integrated displacement transducer (type IDT 25) which will convert a linear movement of ±2.5mm from a variety of primary mechanical or hydraulic functions into an electrical output (between ±1.3 V) directly proportional to that function. The new device is therefore said to be suitable for a wide range of monitoring,




recording and control applications, and has the additional advantage that the integrated electronics contained within the transducer body obviates the need for any complex external ac carrier systems.

Complete isolation between input and output signals is achieved by the IDT 25, which is claimed to have a ±0.2% non linearity and an infinite resolution that is limited only by the discrimination of the readout electronics. The device can be energised by any stabilised dc voltage between 2 and 12 V (for example Transducers' own MIF power module) and is robustly constructed in a stainless steel body incorporating fully encapsulated electronics and a 3mm diameter armature extension rod.

The IDT25 is said to have the following specifications: 85mV/V/mm sensitivity;

# COMPONENT NEWS

-0.06% per oC temperature coefficient; -20 to +80oC operating temperature range; 200 Hz (-3db) frequency response, 23mA excitation current; and 1%rms ripple. It measures 48mm long by 22mm diameter.

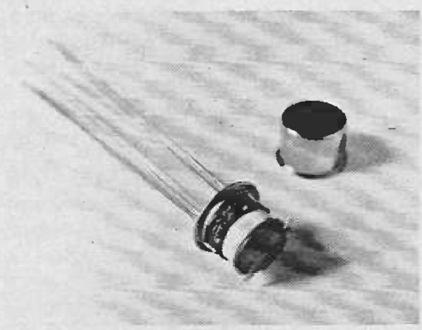
Further details from:

Transducers (CEL) Limited
Trafford Road
Reading RG1 8JH

## TO5 RELAY

A TO5 relay is now available from PBRA Ltd, Redhill. Designated BR40, the relay has a DPDT non-latching contact arrangement and is said to have a 1 Amp rating and a 2ms make/break time.

With operating voltages of 6, 9 or 12V DC, the relay is claimed to have minimum life expectancy of 100,000 operations; to operate within a temperature range of -65oC to +125oC; to have a shock rating of 80g and to be MIL-R-5757 approved.



A wide range of relays of other configurations is also said to be available.

Further details from:

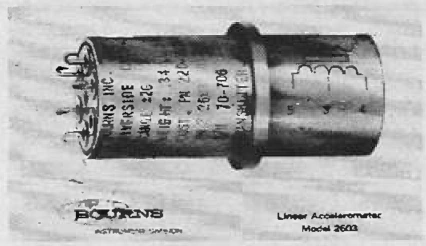
PBRA Ltd
33 Holmethorpe Avenue
Redhill, Surrey

## LINEAR ACCELEROMETERS

Bourns Instrument Division have introduced two Linear Accelerometers both of which use a Linear Variable Differential Transformer (LVDT) as the 'pick off'. This is said to allow a virtually friction free design and to offer a threshold sensitivity as low as 0.001g.

The basic units accept ac input and give ac output but integral conditioning packages can be provided to accept either ac or dc inputs. Bourns unique single degree of freedom, non-pendulous suspension is said to offer very low cross axis sensitivity - less than 0.01g/g.

Model 2603 is a cylindrical servo mounting unit 1.125in diameter x 2.5in long and is available from ±0.5g to ±2g. Model 2609 has dimensions of 1.99in x 1.09in x 2.2in high and is available from ±0.5g to ±50g.




Special features such as self test coils, offset 'g' ranges are available if needed, and as standard, both units incorporate fluid damping giving good stability of damping factor with temperature change.

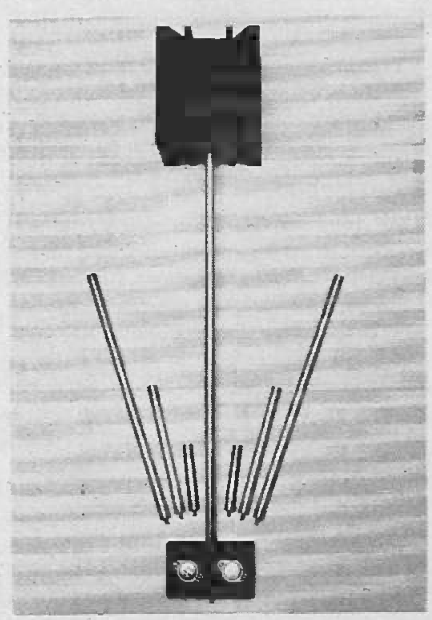
Further details from:

Bourns (Trimpot) Ltd
Hodford House
17/27 High Street
Hounslow, Middlesex

## JU SERIES HEAT PIPES

The latest products from Jermyn Manufacturing – the JU series of heat pipes – represent a revolutionary approach to cooling techniques for electronic components and equipment. They are particularly suitable for cooling devices in inaccessible places, or where the use of a heatsink is impracticable, since it is claimed they can transfer heat some 400 times more efficiently than a solid copper bar of equivalent dimensions.

In operation, the heat pipe (which basically comprises an evacuated drawn copper tube that contains a special wick material and a small amount of working fluid) is mounted between the device to be cooled and an external heat dissipator. Typically, it is claimed that it will transfer heat from a 100W source over a distance of 3 feet with a temperature drop of only 2.5OC per foot.



The JU series are plain pipes for conducting heat from a source connected to one end of the pipe to a heat dissipator at the other end. They are available in straight lengths from 3 to 36in long and 0.5in diameter, although special lengths, shapes and diameters can be custom made.

Also available from Jermyn Manufacturing is a range of mounting plates onto which the heat pipes can be clamped and which can accommodate various semiconductor configurations such as TO-3 and TO-66. Suitable heat dissipators which also clamp onto the heat pipes and have power ratings of up to 750W can also be supplied.

Further details from:

Jermyn Manufacturing
Vestry Estate
Sevenoaks, Kent

## IMPROVED ALKALINE BATTERY

A new structure for the Mallory Duracell Mn1604 multi-cell alkaline 9 volt battery has provided a marked increase in performance at continuous high rate discharge.


The battery, popular in a wide range of international applications, has been constructed using a new internal assembly incorporating cylindrical cells with increased active electrode materials. This brings it into line with the new range of Mallory Duracell alkaline batteries announced earlier this year, all of which are said to have improved performances.

The Mn1604, which conforms to international size (IEC) requirements, is said to maintain the long storage life – two years or more – of the Mallory alkaline system.

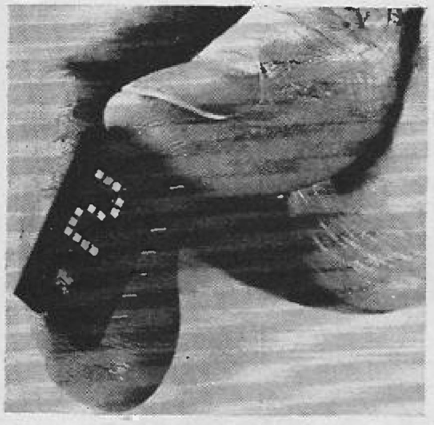
Further details from:

Mallory Batteries Limited
Gatwick Road
Crawley, Sussex

## LED HEXADECIMAL DISPLAY

A new 'Diodelite' solid state hexadecimal readout with integral TTL circuit that accepts, stores, and displays 4-bit binary data is announced by Pye TMC Components Ltd (Type 745-0007).

The display and TTL MSI chip are mount-



ed on a lead-frame assembly that is then cast within a red, electrically nonconductive, transparent plastics compound. In addition left and right decimals, single plane wide-angle visibility, and high brightness due to the gallium arsenide phosphide used for the light-emitting diodes.

These readouts can be used with separate LED and logic 5-and-6 volt power supplies; they contain internal TTL MSI chip with four-bit latch, decoder, and driver, and have a constant-current drive for hexadecimal characters.

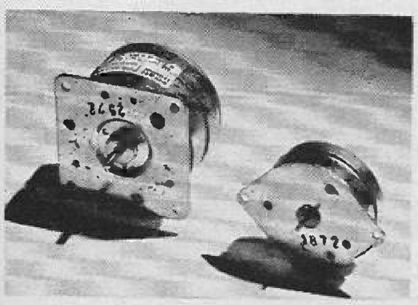
The LED driver outputs are designed to maintain a relatively constant on-level current of approximately 5 milliamperes through each of the LED's forming the hexadecimal character. This current is virtually independent of the LED supply voltage within the recommended operating conditions. Drive current varies with changes in logic supply voltage and results in a change in luminous intensity. The decimal-point anodes are connected to external pins.

Multiple displays may be mounted on 0.450-inch centres and the unit is said to easily interface with systems. The TTL MSI chip is designed with a wider supply voltage range than standard series 54/74 circuits so that it will operate from either a 5- or 6-volt power supply.

Further details from:
Pye TMC Components Ltd
Controls Division
Roper Road
Canterbury, Kent

## MAGNETIC DEVICES OFFER NEW BERGER MOTORS

Year by year the Berger range of permanent magnet synchronous motors, stepping motors and geared units is being extended. The latest additions, the RSM 47 and the



RSM 63, first introduced at this year's Hanover Exhibition are now available in this country through Magnetic Devices Limited of Newmarket.

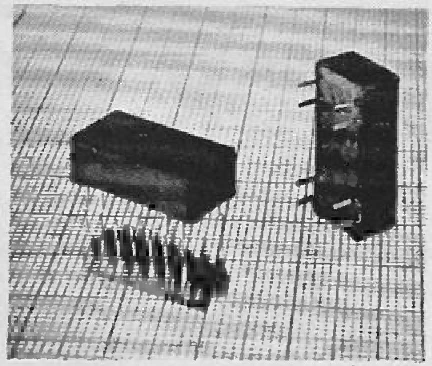
The RSM 47/8, the smaller of the two, fills the earlier gap between the small RSM 36 and the RSM 50. This new motor is said to give an output speed of 375 rpm direct drive at a torque of 160 grm cm in synchromism. The motor can be fitted with a reduction gearbox type 'L' offering ratios between 5:1 and 36,000:1. This wide range of gear ratios is said to make the unit eminently suitable for many applications in instrumentation, timing devices, office machines and countless other fields.

The new RSM 63/8 is also said to give a direct drive speed of 375 rpm with an output torque of 700 grm cm in synchronism and can also be fitted with various gearboxes to cover output speeds from 2.5 rph to 120 rpm.

Further details from:
Magnetic Devices Ltd
Exning Road
Newmarket, Suffolk

## 'DUAL IN LINE' DRY REED RELAY

A dry reed relay with an epoxy resin encapsulation and connection pins corresponding to a TO-116 dual-in-line package is now available from ITT Components Group Europe.



The HRE 1298 consists of a single reed contact form A (make) with an electromagnetic shield. With the epoxy resin housing, the units measure 20.2mm length x 9.8mm width x 7mm height.

Coils are available for nominal operating voltages of 5, 6, 12 and 24V, the 5V units being suitable for use in circuits employing 7400 Series TTL devices. The relays are said to be rated at 10W with a maximum switched current and voltage of 0.4A 11V ac/dc.

These relays can be mounted directly onto printed-circuit boards up to 2,5mm thick, and are suitable for general-purpose switching and control circuit applications.

Further details from:
ITT Components Group Europe
Electromechanical Product Division
West Road Harlow, Essex

# BOOK REVIEWS

*REVIEWER: Brian Chapman*


**BASIC ELECTRON DEVICES** by E. George Griffith. Published by Holt, Rinehart and Winston 1971. Soft covers, 212 pages 9" x 6". Review copy supplied by Holt, Rinehart and Winston. Price £1.95.

This is the basic volume of Rinehart Press Electronic Technology series and knowledge of the material contained is a prerequisite for all the later volumes.

The book is a "labour of love" of its author who completed this work knowing that he had only a short time to live and could not financially benefit from its publication. Primarily his aim was to provide assistance to young students, and this aim shines through the text.

The opening section inevitably deals with the physics of devices. It is unfortunate that this theory, which is so essential to thorough understanding of later topics, is almost always presented in a dry and uninteresting manner. But Mr Griffith has made quite a creditable effort in alleviating the tedium of this subject.

Solid state devices are introduced by means of sections on the PN junction, the Junction Transistor and Electron Emission and Acceleration, and then the last four sections examine vālve theory in considerable detail.

Again, as is the practice with all the volumes in the Electronics Technology Series, each chapter includes adequate diagrams and examples and is followed by selected problems and questions.

The text is clear and concise, with all the relevant formulae provided where applicable. Transistor and valve theory each consume about 50% of the book.

All books of this excellent series are recommended as companion texts for technical college courses in electronics. – B.C.


**TAPE QUESTIONS – TAPE ANSWERS** Compiled and answered by Heinz Ritter. Published by Josef-Keller-Vereag Starnberg, Germany. Soft covers, 126 pages 8¼ x 5¾. Review copy supplied by BASF price 40p.

Heinz Ritter was head of the BASF tape marketing section in Germany at the time this book was written, and is now head of sales in educational technology.

Tape recorder useage, whether it be reel-to-reel, cartridge or cassette, has increased dramatically in the last few years. Tape recording is no longer a pastime reserved for the dyed-in-the-wool audio expert. Instead recorders, particularly cassette, are beginning to rival hi-fi record players for the reproduction of canned music.

There has been an obvious need for a book setting out in an easily understood manner, the basic principles of domestic tape recording technique. The present volume adequately fills this need at a more than reasonable price. B.C.


**ELECTRONIC POWER SUPPLIES** by Joseph Grabinski. Published by Holt, Rinehart and Winston 1969. Soft covers, 223 pages 9" x 6". Review copy supplied by Holt, Rinehart and Winston. Price £2.

This book is a further volume of the publisher's Electronics Technology series designed for use in technical colleges and institutes.

The object of the book is to give a thorough understanding of power supply circuits and the waveforms found in these circuits. A knowledge of dc and ac network theorems and a basic understanding of transistor and valve circuitry are prerequisites.

Section one contains an introduction to basic rectifier circuitry, an examination of half-wave and full-wave circuitry under different load combinations of R,L and C plus a treatment of voltage doublers and triplers and practical rectifier systems.

Section two deals extensively with polyphase rectifiers and this is followed by a section on magnetic amplifiers.

The last three sections give details of components and circuitry used in conventional regulator circuits. Included are details of the use of thyratrons, SCR's, Zeners in series and shunt regulator circuits.

The text is clearly written, in a no-nonsense format, and has adequate diagrams and examples to give the student every assistance in assimulating the data.

Each chapter is followed by a selection of problems designed to confirm and extend knowledge of the chapter content. Answers to odd-numbered problems are given in the rear of the book. Additionally, a series of questions are included at the end of each chapter which may be used as a rapid self test of comprehension.

At the modest price, this book is excellent value indeed and is well recommended for students of electronics. – B.C.

# RECORDINGS... CLASSICAL

*REVIEWERS: Tanya Buchdahl John Araneta, C.M. Wagstaff.*

**SCHUBERT – Symphony No. 8 (Completed Gerald Abraham) Rosamunde overture – Charles Groves, Royal Liverpool Phil HMV OASD-2743.**

The idea of an "Unfinished" finished seems particularly monstrous to most people. But after all, there are useful musicological resasons for it, and it is good to see a recording company letting us hear an example of such reconstructions.

Let me say straight away this is a strong performance of the Eighth, and if one objects very much, nothing prevents the lifting of tonearms after the second movement. But to begin with, I think this recording can at least be useful to dispel the far too many romantic notions associated with this work.

When one is able to hear the powerful Scherzo after the Andante and not just "read" it, you cannot help realizing that if this symphony had in fact been completed, it could have been a far more interesting work than the "Great". Also, no matter how many times one hears this work, it is marvellous, and would perhaps not have owed its uniqueness to those two extant movements. But it may also be tragically instructive to think that precisely after those movements, Schubert may have felt unable to live up to their achievement.

You may object to my dealing in "might-have-beens" but we do not object to this in the Art of Fugue, so why here? As I said there are useful musicological reasons for this "recorded" experiment. No musicologist would undertake the completion of any Schubert unless most of the work has been presumed done by Schubert himself. In this case, the crucial problem, the Finale, is presumed to be the great entr'acte from Rosamunde. As Gerald Abraham puts it himself, he is not the first Schubertian to hit upon this solution. The entr'acte is in B minor, scored for the instruments of the symphony, and we know Schubert did not have time to write an overture for Rosamunde and yet is supposed to have written the entr'acte.

Well, we can hear whether the theory holds good or not. The point is that it is not quite as effective to just hear the entr'acte after the Andante. Is the entr'acte a true finale or not? One can judge properly if one is able to hear what the Scherzo was like, or could have been like. Yet Gerald Abraham arbitrarily fills in the middle section of the Trio with an orchestral version of Der Liedende included in Rosamunde and I am afraid Abraham's insertion seems more inspired than Schubert's own Trio, at least after that arresting Allegro. But perhaps that is also because the insertion is based on finished Schubert but one can perhaps see one reason why Schubert did not go on with this movement.


I have to admit that after repeated listenings the entr'acte does not strike me as a convincing finale after all. It seems to me rather episodic, even operatic in character particularly the lyric episodes which have a curious similarity to similar episodes in the Magic Harp overture or as we commonly refer to it these days, the Rosamunde, a performance of which follows the symphony on this record. Others will disagree, and they will have the company of Tovey, Einstein, and Grove, among others. Or perhaps as Tovey put it, I am demanding a typical Schubertian finale for the Unfinished. We can hear for ourselves. Recording seems at times to be rather over modulated but nothing the controls cannot remedy. – J.A.A.

**MOZART – 4 Horn Concertos – Alan Civil (horn), Marriner, Academy of St-Martin-in-the-Fields Philips SAL-6500 325. Barry Tuckwell (horn), Marriner, Academy of St. Martin-in-the-Fields HMV OASD-2780.**

At first sight these records seem useless duplication on the part of Tuckwell, Civil and Marriner. Both Civil and Tuckwell have recorded these concertos twice before and Marriner is here to help both with their third recordings. On second thought, I suppose if I were a horn player and had to play this music, I would prefer to play with the Academy. But not being a horn player, admit that after that superb Brendel/Academy recording of two Piano concertos, I will have to have one of those recordings. How about the Violin Concertos?

To get to the point, however, I rather expected these performances not to be so dissimilar, having as they do the common denominator of the Academy. Well, they are very different. Civil/Marriner is bright, sharply accented, a very gallant performance – pure champagne.

Tuckwell/Marriner is more romantic and also serious, the bounce of the music underplayed. Comparing these, not surprisingly, Civil and Tuckwell's views have really not changed all that much. One suspects both horn players felt the Academy might be the deciding factor for the better. That seems true enough and it is perhaps a tribute to Marriner and the Academy that they can accommodate such different interpretations. I feel Civil's gallant approach benefits more from the Academy's backing, at least, the playing seems also more characteristic of the orchestra's ideas.

Oddly enough, Tuckwell/Marriner includes a harpsichord continuo, an unnecessary feature it seems to me, in this music. At any rate the general romantic tenor of Tuckwell/Marriner gives the harpsichord a curious irrelevant character. Each artist plays his own respective completions of K.371 and cadenzas. Tuckwell manages to include the unfinished K.494A. Different sounding instruments are used. Decide on the basis of technique? Civil tends at times to sharpness, Tuckwell flatness. If you are a horn fancier or player, no doubt, you will have both. Otherwise it will depend on what you think these concertos should sound like. Even the recordings reflect the tendencies of the performances. I myself will opt for the Civil, but honi soit ... J.A.A.

**CORELLI – 12 Concertos, Op.6. Solisti dell Orchestra "Scarlatti" Napoli Ettore Gracis (cond.) 3-DGG ARC 2710011.**

We have needed an up to date recording of the complete Op.6 concerti and Archiv is to be commended for trying to fill in this gap in the catalogue.

It seems unfortunate then that the project has been entrusted to a group that plays well but also has little present day knowledge (or prefers not to use it) on the performance of baroque works. Which is to say this performance seems a bit romantic to suit Corelli: tempi are barely differentiated, rhythms not sharp enough, and the continuo hardly enterprising, to put it lightly. Ornamentation is also kept to a threadbare minimum.

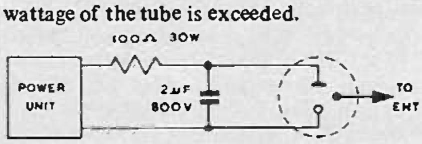
Twenty years ago this recording might have served will enough, but not today. One looks to a Marriner or a Harnoncourt to do these works justice but it has taken long enough for this set to come along and I suppose it will have to do in the meantime. Fine sound and surfaces. – J.A.A.

# Solve a problem

Do you have a problem — in locating a device with special characteristics, in achieving a design or usage function, in applying electronic and (associated) techniques or merely as a challenge to ingenuity? Write and tell us — and, through this column, your fellow-readers in all engineering disciplines — about it. Here are two more problems:

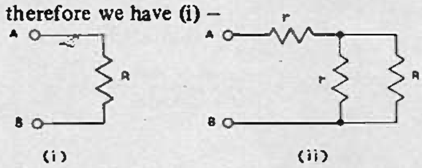
Solution to 006: Most Xenon flash tubes as used in stroboscopes are triggered by applying a high voltage pulse to a wire wound round the outside of the glass envelope. The ionisation path is thus shortened capacitively.

The pulse necessary is in the order of 9kV. This can be obtained directly from a car ignition circuit. Ensure that the charging capacitor is not so high a value that the wattage of the tube is exceeded.




A M Coppin

Solution to 009: Let the infinite resistor chain have res. R (each element res. r) therefore we have (i) –




Since the chain is infinite, adding an extra stage can make no difference, therefore we have (ii). But both must have the same resistance.

$$\therefore R = r + \frac{1}{\frac{1}{r}+\frac{1}{R}} = r + \frac{rR}{r+R}$$

$$\therefore R^2 + rR = r^2 + rR + rR$$

$$\therefore R^2 - rR - r^2 = 0$$

Using the quadratic formula to solve for R,

$$R = \frac{r \pm \sqrt{r^2 + 4r^2}}{2}$$

$$\therefore R = \frac{r(1+\sqrt{5})}{2}$$

$$= r.\ 1{\cdot}61803398\ldots.$$

–S R Wray

*This was the best solution submitted.*

PROBLEM 010: I wish to measure the rpm of an aero engine from the L T pulses of its magneto points. The pulses are of course alternately positive and negative. There is no other electrical system.

Circuit and meter should be cheap, simple, light, robust and reliable.

There must be no chance of earthing the magneto or compromising the spark.

Linear indications please, 0 – 4,000 rpm

–R F Selby

PROBLEM 011: I am seeking a means of indicating either contact with or extremely close proximity to an almost non-conducting liquid surface, the liquid in question being highly inflammable. The device must not exceed 1¾in overall diameter (though of any reasonable axial length), must operate reliably within a 2in diameter mild steel tube, must present no explosion hazards, and must stand immersion in petrol. It should be robust and suitable for work in the field, simple and not too expensive.

–John H Rapley

*To readers with solutions: please help our mail department by writing the problem number prominently on the bottom left of the envelope. Since almost every problem has more than one solution, do not give up seeking or sending your solution to a problem even if one solution to it has been published in these columns.* –*Ed*



## NEW LITERATURE

● A leaflet available from Coutant Electronics Ltd gives details of a range of high quality potted eht converters. The converters can have stabilised or unstabilised, and fixed or adjustable outputs depending on the model. Input supplies can be from 5 to 36 volts dc and units with outputs up to 50kV at 1mA are available.

The leaflet provides full mechanical and electrical details.

Coutant Electronics Ltd, 3 Trafford Road Reading, RG1 8JR.

● Carus AG and Company, the computer service firm, has published the first comprehensive guide to the selection of peripheral equipment for IBM computer installations in the United Kingdom.

According to Carus, the report is 'compulsory reading for all IBM System 360 and 370 users'. More than 1000 of these users in the UK could take advantage of different-make peripheral devices and realise total savings of up to £20 million on equipment costs. In the US, about 30 per cent of all computer installations already use peripheral units supplied by independant manufacturers, the report states.

Carus offers the Mixware Report as a continuous service, with regular up-dates. Copies of the initial report are available at £40 each, which price includes the first four quarterly up-dates. Subsequent up-dates will be available on a subscription basis at £20 per year.

Carus AG & Company, 36 The Broadway, Maidenhead, Berks.

● A wide range of standard instrument cases are illustrated and described, including technical drawings, in a new 8-page, A4 size, colour brochure published by F T Davis (Kings Langley) Ltd, Primrose Hill, Kings Langley, Herts.

● A leaflet, publication number RO5111 fully describes new 'Diodelite' solid state hexadecimal readout with integral TTL circuit that accepts, stores, and displays 4-bit binary data is announced by PYE TMC Components Ltd. (Type 745-0007).

The display and TTL MSI chip are mounted on a lead-frame assembly that is then cast within a red, electrically nonconducive, transparent plastics compound. In addition to the 0.270inch character, the display has left and right decimals, single-plane wide-angle visibility, and high brightness due to the gallium arsenide phosphide used for the light-emitting diodes.

The leaflet is available from PYE TMC Components Limited, Controls Division, Roper Road, Canterbury, Kent.

## READER ENQUIRY SERVICE

Both advertisement and editorial matter are allocated code numbers, in bold type in brackets, accompanying the item.

Enter the relevant numbers in the list provided on a card, cut it out and mail it to us. Your enquiries will be passed on to the manufacturers or companies concerned, and you can expect to hear from them directly.

If you did not see this copy first-hand or if you are way down on the circulation list, you may not be getting the best benefit from this enquiry service.

May we suggest that you have your own copy? Place an order with your newsagent at 20p per copy delivered to your door.

Subscription rates:
UK, £3.60 a year.
Overseas, £4.00 a year, postage by surface mail.

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### ELECTRONICS TODAY INTERNATIONAL

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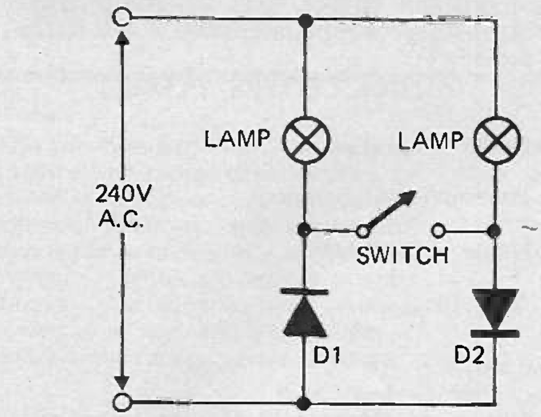
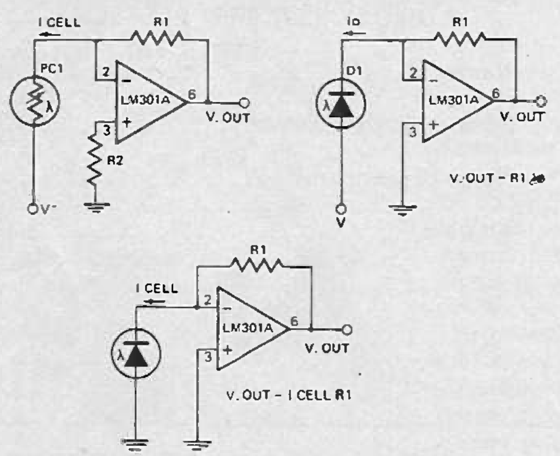
# TECH-TIPS

## FLOODLAMP POWER CONTROL




When setting up photographic floodlamps it is sometimes desirable to operate the lamps at lower power levels until actually ready to take the photograph. The circuit shown allows the lamps to operate on half cycle power when the switch is open, and full power, when the switch is closed. The diodes D1 and D2 should have a 400 volt PIV rating at 5 amps.

## USING OP-AMPS AS PHOTOCELL AMPLIFIERS



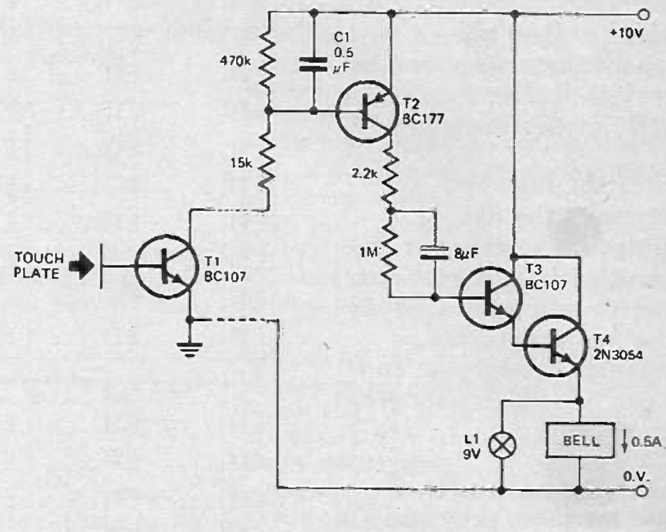

Amplifiers for photoconductive, photodiode and photovoltaic cells are shown in Figures 1, 2 and 3 respectively.

All photogenerators display some voltage dependence on both speed and linearity. It is obvious that the current through a photoconductive cell will not display strict proportionality to incident light if the cell terminal voltage is allowed to vary with cell conductance. Somewhat less obvious is the fact that photodiode leakage and photovoltaic cell internal losses are also functions of terminal voltage. The current-to-voltage converter neatly side-steps gross linearity problems by fixing a constant terminal voltage, zero in the case of photovoltaic cells and a fixed bias voltage in the case of photo-conductors or photodiodes.

Photodetector speed is optimized by operating into a fixed low load impedance. Currently available photovoltaic detectors show response times in the microsecond range at zero load impedance and photoconductors, even though slow, are materially faster at low load resistances.

The feedback resistance, R1, is dependent on cell sensitivity and should be chosen for either maximum dynamic range or for a desired scale factor and should be chosen to minimize bias current error over the operating range.

## TOUCH CONTROLLED DOORBELL

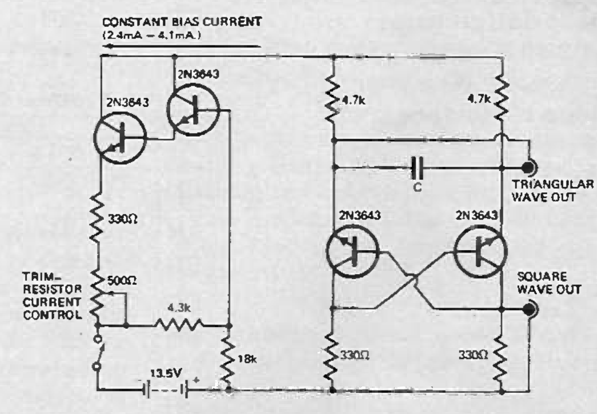



In the circuit shown, hum is induced into the touch plate when touched with a finger. This hum signal is rectified in envelope detector/amplifier T1 and the resultant dc current amplified by T2, T3 and T4.

Decoupling is provided by C1, and C2 limits the length of doorbell signal to three seconds. The recovery time between signals is five seconds. The lamp L1 may be used to verify the signal, to the caller, if required.

Submitted by: M.W. RICHTER Eindhoven Netherlands.

## WIDE RANGE MULTIVIBRATOR




In the circuit shown the multi-vibrator section is driven by a constant current generator. This causes the square wave across C to be flat and the triangular wave across resistor R to be linear. When the constant current is varied, the repetition rate of the multi is varied by 70% with the current control, and from 5Hz with C equal to 100 microfarad, to over 2.5mHz with C equal to 330pF.

Voltage to frequency conversion may be performed by injecting an analogue voltage into the base of the first current regulator transistor.

# Now available in quantity – the big hit of the Radio Show

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