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OCTOBER 1972 20p

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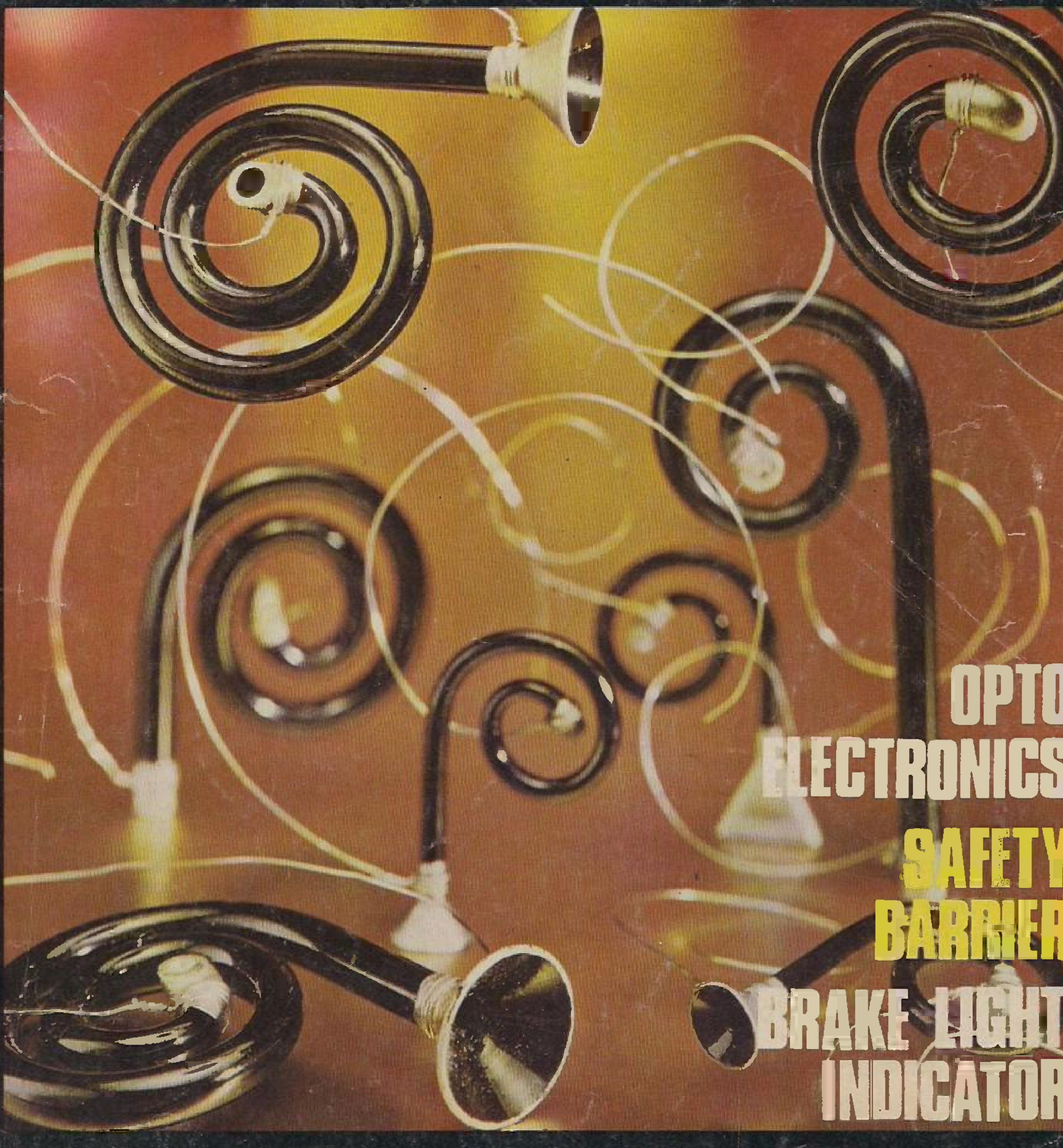

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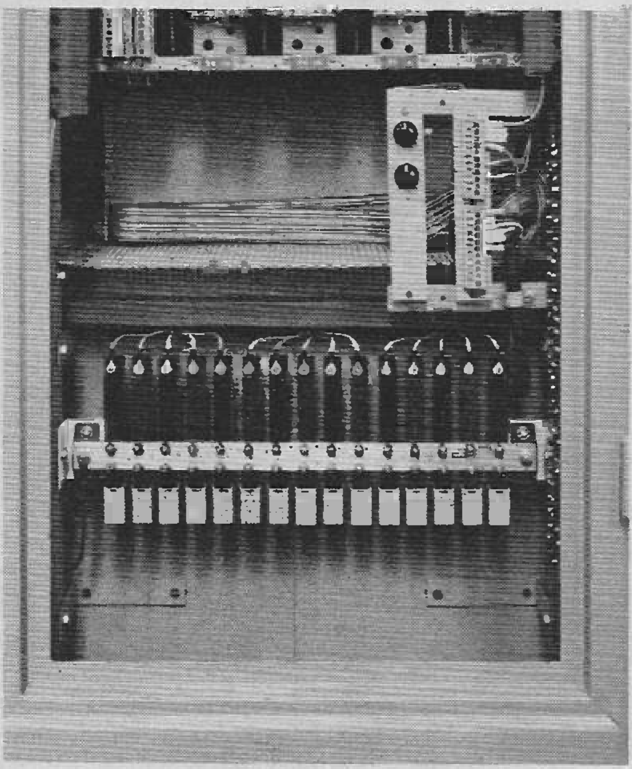
COVER: A selection of Philips Channel Electron Multipliers

NOVEMBER ISSUE ON SALE 20 OCTOBER 1972

PART 2 of 'Interactive Display' will appear in the November 1972 issue

mini - features



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F.M. Stereo Tuner **(£25)** & A.F.U. Filter Unit **(£5.98)** may be added as required.

(83)

electro optical warfare

Nuclear bomb outdated?

BY-AND-LARGE the general public are completely unaware of recent advances in Laser weaponry and the implications thereof.

According to "Aviation Week", the U.S. Air Force is intensively investigating the feasibility of equipping its new F-15 "air superiority" fighter with a Laser radiation weapon capable of shooting down enemy aircraft and missiles. Reports say that the laser ray gun looks very promising and will harness the power of rocket motors to produce a continuous output of 200 kilowatts.

Such weapons as these have virtually outmoded conventional atomic weapons – for example, a laser radar may track an ICBM from a space-based defence system and detonate it over the country from which it was launched.

The laser does not have any time lag problems that would make "aim-ahead" necessary; incorporated into a radar system, it will inexorably track the target aircraft or missile until it is destroyed.

As far as infantry warfare is concerned, a single laser sweep across the battlefield will fry everything in the beam path.

Could it be that the availability of such weapons as these was a prime reason for the recent atomic agreement between the US and the USSR? It would certainly seem so.

Another factor which arises is the question of scientific ethics. Should scientists develop such weapons without any thought to their possible use? Some scientists don't seem to show concern. For example, Professor Schalow, one of the principal developers of laser theoretical principles, stated – "I don't know what the military applications are; I don't want to know."

It would help if all involved in development of the latest mass-slaughter device – from the scientist to the man who pushes the button – would realize that if it comes to the crunch, they too will end-up in the ultimate frying-pan, along with the rest of us.

ERRATUM: DM2 price on page 40 to read £70

news digest

MARS MEMORY

Much of the knowledge about Mars that scientists hope to gain from NASA's two planned Viking landings on the red planet in 1976 will be stored on a small plated-wire data storage memory (DSM) for later radio transmission to Earth. The Viking missions are the first operational assignment for Honeywell's (Aerospace Division) MINI-Wire memories in a space environment. Their selection was dictated not only by their low power, small size, low weight, non-destructive readout, but also by their high life-time expectation in heat qualification and sterilisation tests. International agreements require that all Viking lander components be heat-sterilised to avoid contaminating Mars.

The DSM will serve as a temporary storage point for data from all studies conducted by the twin landers — biological, gas chromatography, mass spectrometer, seismometer, and meteorlogical tests. The results should enable scientists to determine whether life does or could exist on Mars, as well as porvide them with more complete knowledge about the planet's surface and atmosphere.

The DSM will remain inert throughout most of the year-long 460 million mile trip from Earth to Mars and will be activated just before the lander separates from the Viking orbiter and begins its descent to the surface. As the lander enters the Martian atmosphere, which is about 1/200th as dense as Earth's, the DSM will store entry data during the anticipated radio 'blackout' period and transmit the data after a 60-second delay. Once the lander is on the surface, data from the various experiments will be loaded into the DSM several times during each Martian day for temporary storage and will be read out for immediate transmission to Earth or stored on a tape recorder for later transmission. (54)

ZIP CODES

By March 1973, say the Post Office, postal codes will have been allotted to all the 20 million or so addresses in the UK. But no firm day has been announced for the completion of the complicated mechnical sorting systems which are intended to complement the postal coding of addresses. Although postal codes have been allocated to nearly 75% of the UK addresses, only 10 out of a planned 100 sorting offices are fitted with automatic sorting equipment capable of recognizing the written letters and numbers of postal codes — and unconfirmed reports suggest that, even in these few centres, debugging the character recognition equipment is proving costlier and slower than was originally anticipated.

Mechanising the letter post is expected to cost around £50 million in the next 10 years. The Post Office's plan is to confine sorting eventually to a few centres, each covering a large region of the country.

Whether all this mechanisation of sorting will result in quicker and/or more predictable mail delivery at addressees' premises is another question. Like the proberbial computer which is often blamed by basically inefficient accounting businesses, mechanised sorting should at least provide the PO with a ready-made scapegoat for misdirected, delayed and predictably irregular mail deliveries.

C & E POWER TO VETO

The commencement of VAT next April will be a testing time for the efficiency of the computer service industry according to Bryan Mills of Computer Management Group Ltd.

Notice No. 700 from the Customs and Excise Department stipulates: 'A taxable person who decides, after he has become registered, to install a computer or to use the services of a computer bureau for VAT accounting must notify his Customs and Excise VAT office and obtain approval of the proposed computer system.'

The paragraph also contains a reference to the fact that C & E will have the power to refuse or withdraw approval for the use of computer services in any case where their requirements cannot be met.

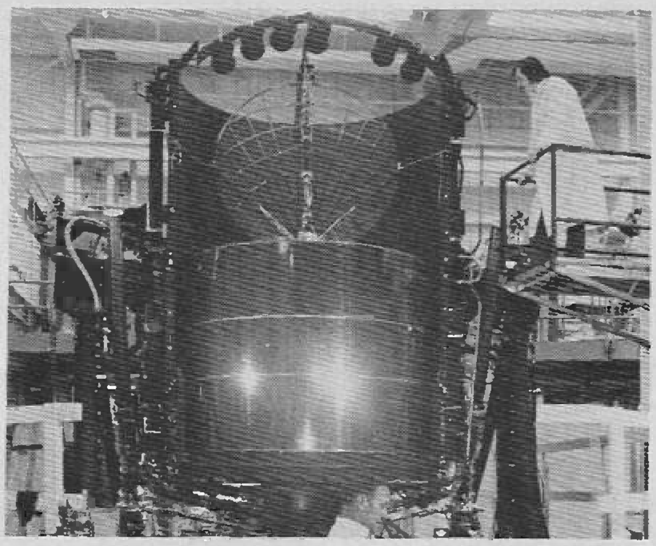
'The amount of information that has to be recorded, balanced and reconciled for VAT purposes makes it an ideal subject for computerisation,' says Bryan Mills. 'For example, every businessman must record every input of goods or services on which he is charged VAT by his supplier, every importation or removal from warehouse on which he must account for VAT to Customs and Excise, and all the taxable outputs of his business, including zero-rated outputs, gifts and loans, taxable self-suppliers and any goods which he acquires or produces in the course of his business but applies to personal use. He must also record such things as an error in his accounts, an amended tax invoice, or a credit for goods returned by him to a supplier or returned to him by a customer.' (56)

news digest

DOMESTIC SATELLITE

A $20,706,000 contract for the manufacture of spacecraft for the United States' first domestic communications satellite system has been awarded to the Hughes Aircraft Company of California by the Western Union Telegraph Company. Hughes will build three satellites plus launch support services. The contract includes options for additional spacecraft and launch services. The first satellite is due to be delivered in 18 months and the others at three-month intervals, enabling Western Union to have a satellite in operation before mid-1974.

A domestic satellite for Canada, Anik 1, is already being built by Hughes who, as the leader of an international consortium including eight companies in Europe, are responsible for the current Intelsat IV series of communication satellites, two of which are now in orbit over the Atlantic, another above the Pacific and a fourth over the Indian Ocean — all of which helped to provide world-wide TV coverage of the Munich Olympic Games.



Anik 1 being prepared for thermal testing

ELECTRONIC GOGGLES

Instantaneously-actuated variable density goggle lenses devised by researchers at Sandia Laboratories, furnish the wearer with an 'electronic blink' which cuts off the peak brilliance of light flashes. The system can be switched from transparent to near opaque (0.01% transmission) within 50 microseconds and returns automatically to the transparent state when light levels drop to a non-hazardous value.

Primary applications for the goggle include flashblindness protection from nuclear flashes as well as from damaging light levels in industrial jobs such as arc welding and metal working. The same basic device also may be used to protect sensitive light detectors (such as image intensifiers and vidicon tubes), as an electronic shutter in photographic applications, as an optical switch or light gate, and as a variable density transmission window providing a gray scale over four orders of magnitude. A fast reacting window has been developed using this latter property, to provide a constant level of light transmission when coupled with a photodiode detector behind the lens. The device may also be operated at high voltage levels as a colour filter.

The goggle system incorporates an all-solid-state electro-optic PLZT ceramic element sandwiched between crossed polarizers. A self-contained power supply (consisting of a 5.4V battery, DC-DC converter and electronics) weighs 10 ounces but has not been fully miniaturized. The battery will power the goggles for about 200 hours. The newly-developed filter can be stored indefinitely and is resistant to fatigue.

(53)

STAR GAZING

Only in the last 10 years has it been discovered that there are, in the universe, objects other than the Sun which emit X-rays. Over 200 such sources have been located, some 10,000 times as hot as the Sun.

In this the 500th anniversary of the

(Continued on page 9)

news digest

(Continued from page 7)

Polish 'Father of Astronomy', USA launched its 'Copernicus' spacecraft on 21 August to study the stars and interstellar clouds. When it is revolving in space 460 miles from earth, the craft looks like a telescope with wings. The wings are solar panels to provide power for the controls and the experiments. The 10' long, 32" diameter telescope provided by Princeton University is said to be the largest orbitting telescope and will conduct studies in ultraviolet rays which normally do not reach optical telescopes on earth due to obscuration by Earth's atmosphere.

The British experiment consists of three telescopes and associated instruments to measure cosmic X-rays from stars and interstellar bodies to learn more about their composition. See feature on page 78.

COMPUTER GRAPHICS

ITT Data Services will shortly be offering computer graphics on remote terminal service. The system is being implemented with the help of a team at the Cambridge University Engineering Department who wrote the original graphics handling software. The routines allow the generation and manipulation of 'pictures'. Computer files can be created containing descriptions of objects which can then be displayed at the user terminal in a variety of projections and in stereo so that the object can be rotated and viewed from different positions.

The programs are written so as to allow them to be linked to any particular user-created program. Access to the routines will be from a graphic display terminal which can be purchased for between £2,000 and £2,500 or can be rented for about £65 per month.

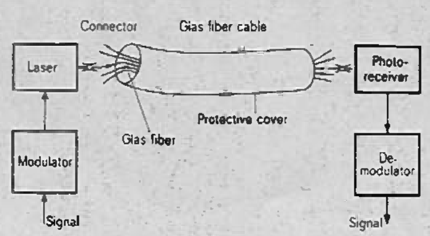
With low-cost computer graphics, interactive techniques in design could become more widely developed. This appears to be the first economical system available on a commercial time-sharing system. **(81)**

VIDEOTELEPHONY BY GLASS FIBRE

In a Siemens research laboratory, two experimental routes have been built with transmission channels made of glass fibre for videotelephone and speech signals. For the light source, a laser diode is used which — like a directional radio transmitter — radiates modulated waves into a glass fibre. After passing through the fibre, these light signals are converted back to electrical signals by means of a photodiode.

While such a closed transmission medium achieves a high degree of reliability, even the best fibres available today have high losses; after a line length of 1 km, only 1% of the original radiation energy is available. Therefore tiny laser diodes and photodiodes are used to amplify after every few kilometers.

The video and sound signals for transmission are converted to amplitude-modulated pulses (with a repetition frequency of 2 MHz) which are applied to GaAs laser diode to generate light pulses for optical transmission. At the other end of the transmission section, a photodiode converts the light pulses back to current pulses and the original communication signals are recovered by amplification and demodulation. **(57)**



OLYMPIC DRUG CHECKS

In a gas chromatograph, the sample to be analysed is passed through a long column at one end of which are sources of inert gas under pressure and a place to inject the sample. At the other end is an electrical detector that responds to each component in the sample. The constituents of the unknown substance move through the column at different speeds, so they are separated in the column and come out at different times.

A small urine sample may contain as many as 300 chemicals, so that the gas chromatograph's response to the different components of a sample is shown on a strip chart recording to enable chemists to identify the components. Information from several gas chromatographs operating simultaneously can be speedily analysed by a computer system.

Gas chromatography was used by the Drug Control Commission of the International Olympic Committee to monitor the use of drugs by competitors at Munich. In addition, more than 2,500 randomly selected competitors were screened for evidence of drugs in their urine. This mass screening task was performed by a Hewlett-Packard automated system with eight gas chromatographs, each capable of analyzing 36 samples automatically, connected to an HP computer for fast and accurate analysis of each urine sample. Suspicious samples were further analysed by a mass spectrometer for final confirmation. **(51)**

ENVIRONMENTAL RESEARCH

Gas chromatography combined with mass spectrometry is a highly powerful technique for the accurate analysis of chemical mixtures (see item above). However, such a combination produces vast quantities of data which are both tedious and time-consuming to interpret. A solution provided by Instem Ltd is Datamass LR, a computer system specifically designed to process data from low resolution mass spectrometers and especially gas chromatograph and mass spectrometry coupled systems. The system provides analysts with a rapid method for drug identification and greatly assists research in environmental, biomedical, pharmaceutical and related fields.

More than 100 spectra containing 200 peaks can be automatically acquired and stored, even from spectrometers cycling at three second intervals. The system incorporates a Carrick mass spectrometer data acquisition unit initially developed at the National Physical Laboratory, Teddington, and currently being marketed by Instem under licence from the National Research Development Corporation. The unit is linked to a PDP-11 computer with a 64K disc backing store (1.25M option), enabling pre-recorded fingerprint spectra of individual chemicals to be stored and compared with new spectra, and hence virtually instant positive identification of a compound. **(65)**

THE VERY END?

The Staff Association of the Ministry of Labour have de-registered under the Industrial Relations Act. Its members are the very people who administer the Act!

CAPTOR — a new approach to data capture

By P. CHASTNEY

P. Chastney is the Chief Engineer of Plessey's Environmental Sensors Division.

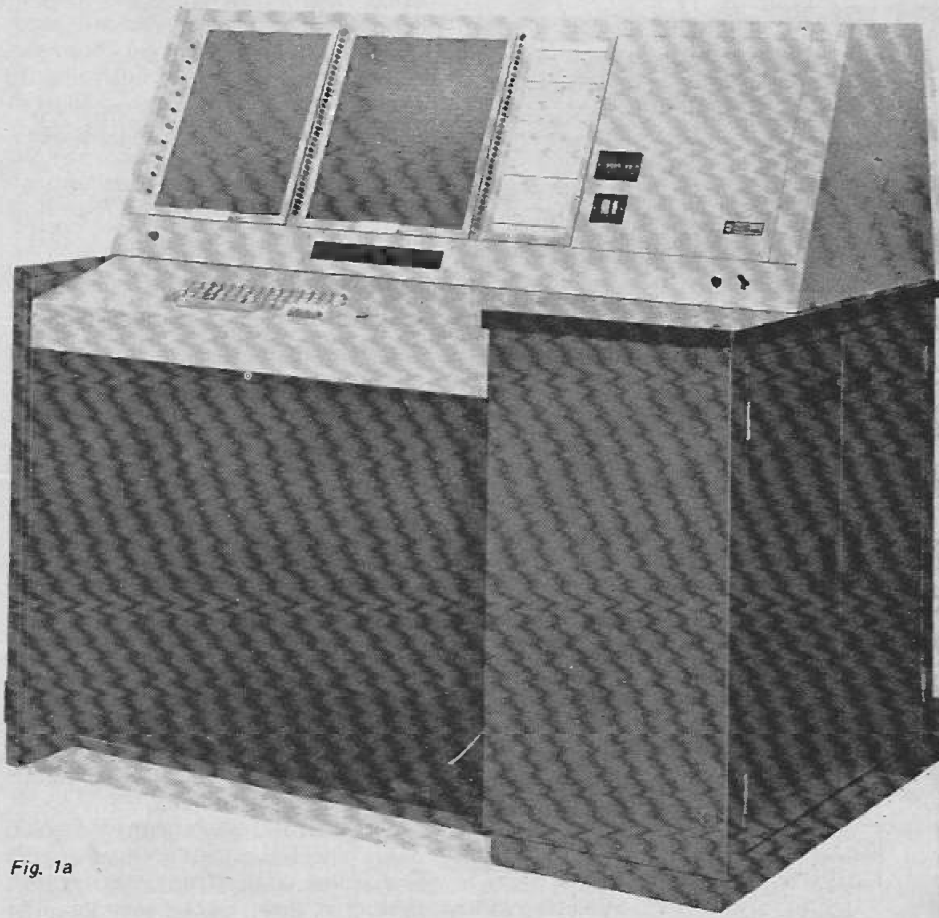


Fig. 1a

This article describes a low cost information retrieval system that uses a unique film storage technique.

THE TASKS undertaken by computers are continually expanding and this implies expansion of transmission networks and various interface mediums to keep pace with the demand. The methods of recording data are also undergoing radical change and there exists a need to record data and events when they happen. These recordings, coming under the general heading of data capture, must in essence comprise a human-to-computer interface and involve the absolute minimum of operator interpretation and intervention.

Data in this context is a term that contains all intelligence about an event which has taken place; an event is the basic subject matter which can be modified by variable features and qualified by an amount such as the quantity of a product or a price for a transaction. Data can be recorded by pushing buttons, inserting keys or cards, with magnetically marked articles or a host of other input systems. The method used for storage and display presents an equally wide choice; the criteria that determines the methods to be used in a system are convenience, accuracy, requirements and cost.

The system described, designed to meet a specific cost market, stores all fixed data on film which can be displayed when requested. The film is photographed directly from a computer print-out by a step-and-repeat camera (or may be created as a 16mm film directly from magnetic tape). The system shows cost advantages during the up-dating and processing operations when compared with other storage and access systems.

Figure 1a shows a model which, although designed by Plessey to meet a general requirement, lent itself readily to an adaption for a pharmaceutical market survey. Here data, in the form of product invoices, are collected from retail outlets and sent to a central establishment where coding, sorting and punch tape preparation takes place before statistical analysis by computer.

The system diagram, figure 1b, is the module sub-division showing that each line of information is arranged into formats by a programme unit. After selection, a format line allows data to be entered in random order. Further keyboard data insertions are inhibited when the programmed data for any line is completed.

In addition to access for the film display and verification of individual lines selected on the display, quantity is confirmed by digitrons and provision is made for items not listed, by selecting alpha, which gives free use of the keyboard.

ELECTRONIC KEYBOARD

The keyboard used on this machine has been designed with mass production techniques in mind. Each key contains a Hall effect generator and amplifier as an integrated chip. Moving parts are enclosed in plastic guides and each key is individually replaceable. Consequently, the keyboard can be arranged according to user requirements. Each key is bounce-free and generates the eight-element ASCII code with a parity bit. The output code levels are fully compatible with 5V DTL or TTL integrated circuit logic functions.

For the purpose of this system the digits 0-9 are used to indicate months in addition to quantity, with the characters + and - for November and December. In addition to the standard alphabet in upper and lower case, punctuation characters are used in the system to denote "country of origin", which can be either inserted from the keyboard or selected from the pre-set switch provided under a lift-up desk top. Function keys, which are provided on the right-hand side of the keyboard, are used to select format lines such as retailer, wholesaler, manufacturer, alpha, while a separate group of buttons allow control functions such as message end, cancel and correction. When pressure on any key is released, a further character may be inserted.

The integrated circuits are dual-in-line plastic packages mounted on flow-soldered printed circuit boards. These boards are arranged in layers, interconnected along one edge by Mylar encapsulated strip wires. This allows full servicing of the keyboard, during operation if necessary. In addition to keyboard function reliability, there is a requirement for minimum wear. This keyboard has, from the present evaluation, fully justified its use.

COUNTING SYSTEM LOGIC

Each frame from an endless loop of 16mm film, contains a block which is recognized by phototransistor sensors while passing the gate area. This is shown in Fig. 2. Each block is identical and is produced by a cut-out in the camera frame format. At the spliced ends of the film loop is a larger block, arranged to cover two sensors. This causes a reset pulse to be generated. The film travel is unidirectional and for every complete rotation, counters are reset; the film in its gate is shown in Fig. 3.

Since the keys generate the ASCII code, use is made of the first five elements which contain the binary coded weighting. It is evident that a choice of two letters from the alphabet can produce a selection from A to Z square, i.e. $26^2 = 676$.

The first input character from the keyboard goes to shift register A (see Fig. 4). When the second character is inserted, the contents of A are shifted to register B.

For general applications, 506 frames are required, these being arithmetically grouped as follows:

The first character keyed (letters A—W) represents one of

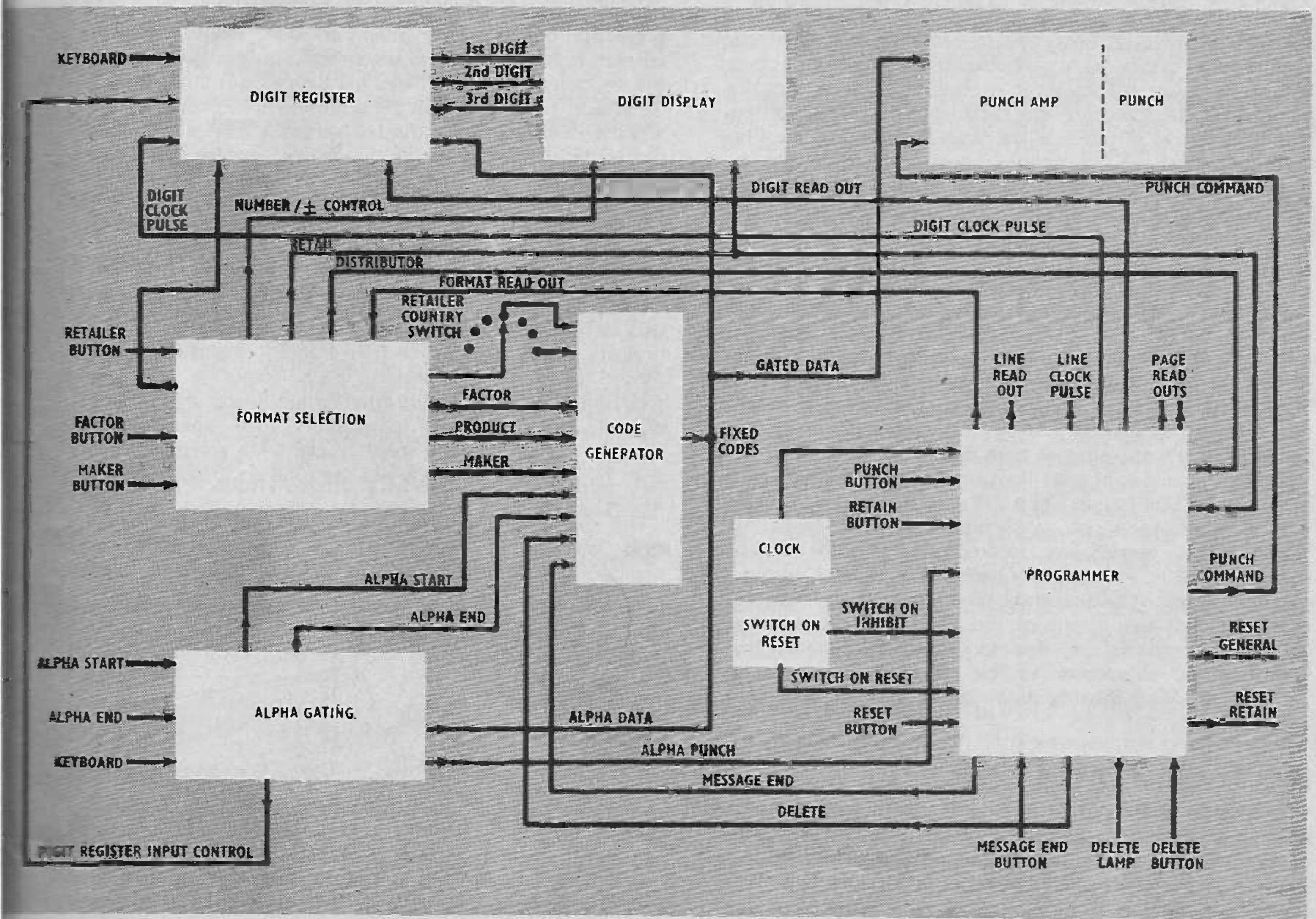


Figure 1b. Block diagram of the Captor system.

CAPTOR-

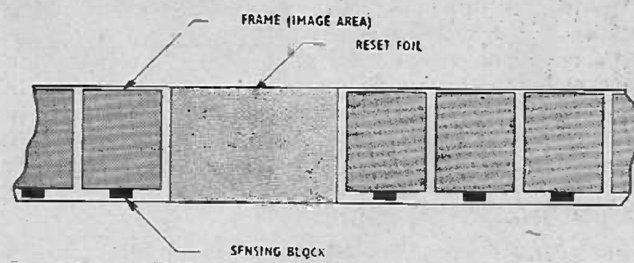


Fig. 2. Section of film

23 groups of 22 frames. The second character keyed (letters A—V) represents one of 22 single frames.

For example, if characters NL are keyed:
N represents the 14th group of 22 frames
L is the 12th frame within that group
NL, therefore, asks for the (14 x 22 + 12) frame = 320th frame.

Identical grouping systems are used for the counters A and B. Output from the comparators operates the film motor control until equality is reached. Another call-up system uses the first three sequential letters of a name or product description to identify precisely the film frame. Six coding bit positions are available on each frame; these relate to an alpha letter and an index level or an operational code. The searching and stopping electronics are controlled by comparators instead of counters.

To obtain rapid selection and ensure accuracy of correct frame selection, a fast and slow mechanism is used. Any group of twenty-two means fast, while single frames are slow. It is, however, necessary to cater for even or nearly even groups: this is readily achieved by adding one pulse to the group counter whenever groups are present in the comparator. If, therefore, the difference between counters and registers, as selected, is less than twenty-two, the film will move slowly; if the number is greater than twenty-two, the comparators will find equality at the fast speed and run slowly for twenty-two frames. A pulse width system is used for the drive motor which is varied according to the speed requirement.

Each displayed frame contains seventy lines of data arranged into two columns of thirty-five items and against each line on the side of the display screen is a lamp. To select one line of data from the seventy displayed, two further button actions are required from the keyboard. In later models, buttons are located adjacent to each lamp; operation of an identity button automatically inserts the code, thereby reducing both time and error probability.

The total number of data lines in the film store is 35/420 derived from 506 frames (23 x 22) each containing 70 lines. Without expansion of a further character from the keyboard, the system will accommodate 47,320 lines of data (26^2 x 70), access to any item being available within a maximum time of two seconds. When the correct frame has been selected and displayed, counters and registers are equal. The registers are, therefore, cleared, allowing line identification characters to be inserted. These cause illumination of an identity bulb and line verification before punching.

DISPLAY MODULE DESIGN

The design of the data display unit incorporates features which were deemed necessary but which were not available in any commercial product. The most important features are low wear rate of the film, rapid access together with correctly definable stopping point, a coding system for location which does not necessitate different markings on each frame, simple interchange of components subjected to wear and simple mechanical construction.

The frame from the film is rear-projected on to a diffused screen some 12in x 10in in a vertical format. This represents a x 24 magnification of the 16mm frame, the illumination source being a 100W tungsten-halogen lamp. The optical path to achieve this magnification is shown in Fig. 5. This uses two front-silvered mirrors, one of which is adjustable for vertical screen positioning. Since the film is held rigidly between two tapered guides during its passage through the gate, its vertical position on the displayed screen is accurately defined and repeatable.

To obtain horizontal location within a few thousandths of an inch at the frame gate, the stopping mechanism is arranged to sense one half-frame early. The motor control is controlled by two sensors and amplifiers located at the top of the projection screen. Here the block is magnified and, as illustrated in Fig. 6, the horizontal positioning can be controlled within very small fractions of the magnified frame; the final position is within ±¼in.

The photograph (Fig. 7) of the film canister shows how the film forms itself in loops, thereby ensuring very low mass for stop and start movements. The tapered guides which lead the film into and out of the gate are surface anodised, whilst the container profile is concave so that there is minimum friction. Drive is transmitted to the film through a roller and pinch idler, and components which can be subjected to wear are designed for rapid interchange. Film guides, which are split, allow simple access for film replacement and location is assisted by tapered studs.

The optical system has a double condenser lens and a heat filter. Heat is removed from the film surface by an extractor. The gate glasses are opened when the film is moving but a shutter obscures the optically projected picture; the shutter, however, has an aperture which allows projection of the marker blocks on to the screen. When the correct frame has been reached and the film is stationary, the shutter is withdrawn and the gate glasses close. In Fig. 1a it will be noted that the equipment incorporates two screens. The left-hand display screen is for a microfilm projector, whereby invoice copies etc., which have been photographed, can be sequentially placed before the operator without causing undue piles of paperwork on the console surface.

INTEGRATED CIRCUIT SYSTEM

With very few exceptions, all functions are TTL dual-in-line plastic packages. The exceptions are a few discrete diodes and power drive transistors and some DTL power gates for expansion. Each complete electronic function is allocated to a printed circuit board; these boards are mounted via edge connectors into one compact container. Fig. 8 and 9 show respectively a typical board with its integrated circuits and the total electronic circuitry in the container.

The container is mounted on slides within the console so that servicing is simplified by exposing both the motherboard interconnections and the individual cards.

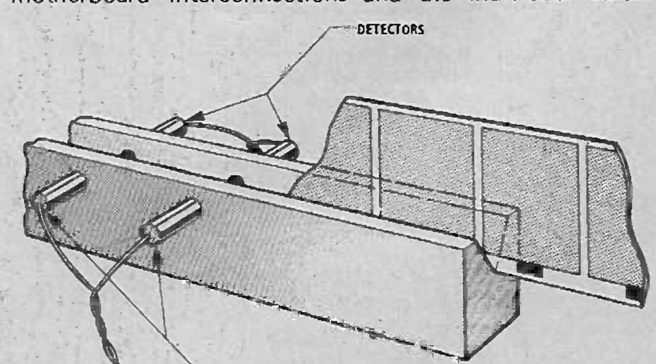


Fig. 3. Section showing film in film guide.

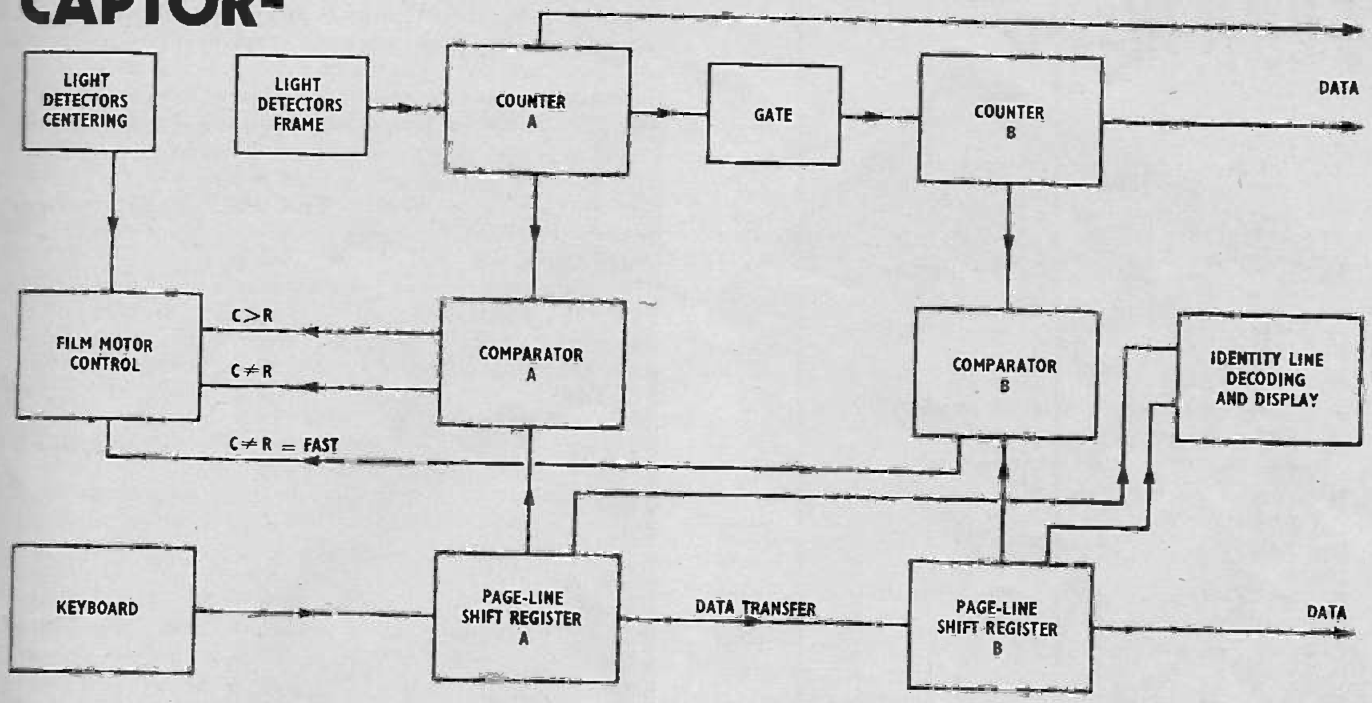


Fig. 4. Counting system diagram.

Wide tolerances in logic levels are allowable and this, together with a design well within maximum ratings, permits a high degree of confidence in full performance reliability.

PUNCH TAPE AND VERIFICATION SYSTEM

During the design stages, particular emphasis was placed on the likely environment for this type of machine. If this is an office, it will be advantageous to reduce noise to a minimum. The film unit, driving low mass is nearly noiseless, so too is the keyboard. The tape punch, a noisy part, is mounted inside the console and provision made for loading etc., through a panel door. Tape run-out or breakage is indicated by panel lamps. The punch tape unit is driven at ten characters per second, which is well within its capability and quite adequate for a temporary storage system.

Alphabet codes which define page selection and line identity are stored until a data line is completed; the line is then released by a "Punch" button which also clear the registers. If, however, a page should be retained because it contains the next data line item, a "Retain" button is selected. This allows punching to take place but does not clear the page register; only the line identity need be inserted for the next item.

If the tape is used to operate a reader and this resultant output is interfaced at the keyboard output, the system may then be driven in reverse, needing only a line completion signal for a fully automatic servo-loop checking system. Each page, line, quantity etc. will be sequentially displayed at a rate controlled by the film mechanism. A complete verification can, therefore, be made at much greater speed, against a check copy if necessary.

USER REQUIREMENTS

Recent market surveys have shown that there is a need for a low cost, reliable data system, which displays thousands of items, any one of which can be selected within one or two seconds and which, without elaborate coding or interpretation methods, will allow such a record to be made clearly identifying to a central or muncipal computer the precise item without ambiguity.

A tape output has been chosen for this model, but it could equally be punched cards, magnetic tape, or a direct telegraph line interface. Modems are expensive and are used when greater transfer speed between computer and user is required. The customers for whom this low cost data system is intended may have access to a remote computer or hire time. They may even be prepared to store a quantity of data before processing. Others may wish to feed the encoded data through a simple translator for the preparation of invoices, delivery notes, etc. Stock up-dating for wholesalers, distributors and manufacturers is clearly viable where high-speed processing is unjustified.

Up-dating costs for re-arrangement of the store content must be at a minimum, and, if it is assumed that the magnetic tape-to-film system for reproduction is not readily available, handling during preparation must also be minimized. It is felt that the system chosen meets these cost, time, processing and handling requirements.

The use of punctuation characters to define programmable format lines allows continuous and repeatable use of the whole alphabet for coding, each character denoting a new event, function or feature. Code methods in general use for semiautomated systems, tend to use multiple digits and a complex arrangement for determination of a check digit. Multiple digit systems, in conjunction with a printed look-up for the product customer name or distribution detail, lead directly to this data capture unit, where an amortized cost return can be calculated in real terms.

MAINTENANCE AIDS (MODULAR CONCEPT)

Each complete function of the system has been designed as a module to simplify maintenance. The cost of mechanically integrating each module with its own electronic circuits, or keeping all of the electronics in one site for routing, was thoroughly investigated. The outcome of this investigation showed beyond doubt that unless each module is to be sold as an individually boxed package, separate electronics are less expensive. A module for all electronic circuit cards, which can be varied according to

CAPTOR-

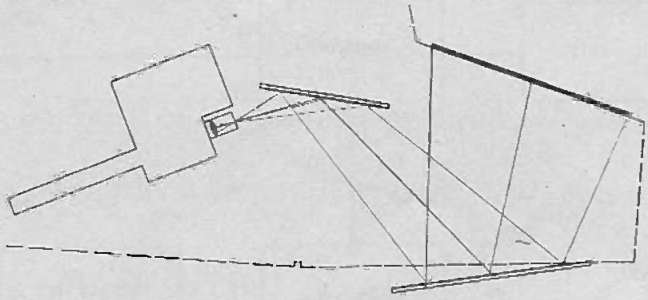


Fig. 5. DAP projection path.

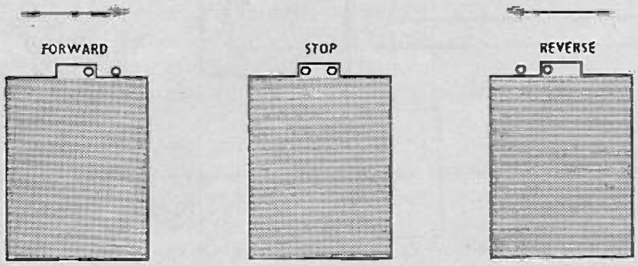


Fig. 6. Three views of the projected image.

the size and requirement of the system, has been incorporated.

Mechanical components, the lifetime of which is predictably short, or which may be liable to catastrophic failure, are designed for simple replacement. Films, subject to wear or frequent up-dating, can be inserted within seconds and need no special alignment instructions.

From time to time, tolerances will build up adversely on items affecting the displayed film image. This will result in a lateral displacement; to correct for this displacement the screen slides vertically out of its guides, giving access to a slide bar containing the photocell sensors, movement of which will re-centre the frame.

Plugs and sockets throughout the system are interchangeable and allow simple removal. Arrangements have also been made to service the keyboard and microfilm projector, both of which are mounted on hinged panels. The projector can be tilted through 90° for lamp, gate and blower adjustments.

PROTOTYPE INSTALLATION

Figure 1a shows the unit installed for system evaluation trials in the offices of Mercados y Analisis S.A. in Madrid, where direct comparisons have been made between trained operators using the existing system and the Plessey "Captor" unit. Some of the lessons learned from this installation are noted in the section on future developments.

Invoices, stock lists and survey results are viewed sequentially on the left-hand screen to obtain a distributor, manufacturer or retailer name, the initial letters of which, via the index, enable a data frame to be displayed. Data frames for each product in turn are then displayed, the complete coding of any item needing four letters from the keyboard in addition to quantity, date or other specific variant.

The existing system uses punched cards on which details are typed in clear; these cards are alphabetically arranged, each operator having only one or two letter groups; this, of course, involves prior sorting. Invoices etc. coming to the operator are also sorted by marking each product item with the operator's identity code. Several Zerox copies of the paperwork are circulated through the office, each operator completing his own work by finding the appropriate punched card, inking in the new item which is added to the existing quantity and adding one to the total of orders received for that product. Additional checks are made by other operators; daily or weekly totals from the cards are inked, using the 80 column system. Cards are then passed to punch and verification operators before despatch by air to a computer in Milan. With the system as described, it is essential for the operator to record a minimum of four items per minute throughout a working shift. Some operators with a high degree of dexterity, can achieve six per minute.

To compete, the Plessey system has to reach at least six lines per minute, at which speed, cost recoveries will allow a minimum amortization period and more important, will enable further survey work to be contracted, which currently cannot be undertaken. The only limitations to rates in excess of ten lines per minute are the programmed material layout on film and the index whereby a specific frame is determined without ambiguity.

The example chosen is typical of commercial requirements whereby any specific identity from some tens of thousands, may be entered and coded within one or two seconds. This, followed or preceded by a quantity and perhaps a qualifying feature, can be programmed as a basic equation, commonly known as a format line. Without further illustration it is evident that the system can accommodate a high percentage of business transactions.

SYSTEM RELIABILITY

Extended tests have been conducted on many aspects, particularly mechanical, of the overall system design, since it is readily recognized that failure of any component part may result in time loss not recoverable without recourse to manual methods or duplicating of systems.

The design of the film drive and guide mechanism was based on the 1000-hour concept between major service intervals. The film, which should be replaced each month for up-dating, causes more wear than it suffers, by the abrasive action of its edges in the guide: this has been overcome by hard anodising. Surface abrasion in the

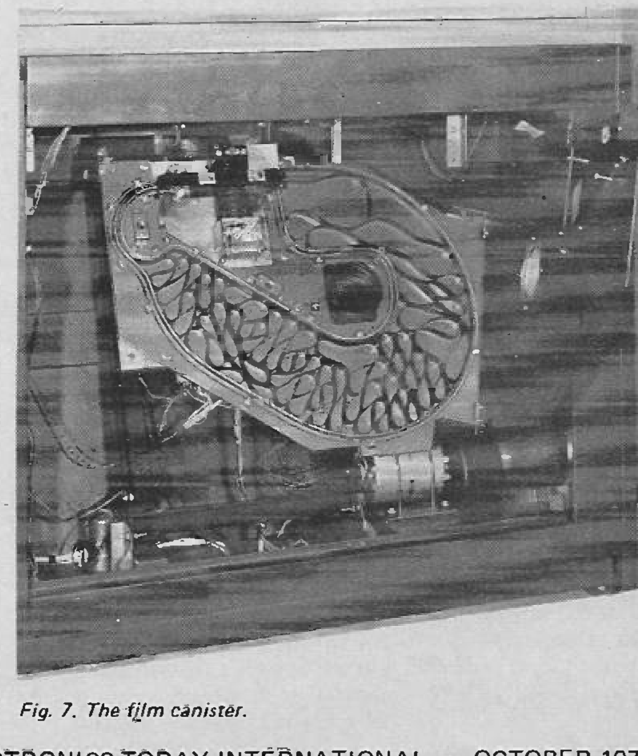


Fig. 7. The film canister.

CAPTOR-

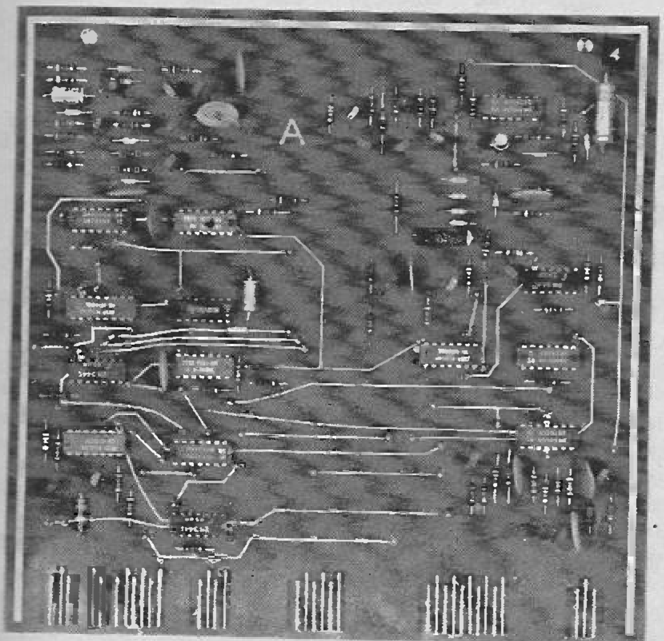


Fig. 8. The digit register board.

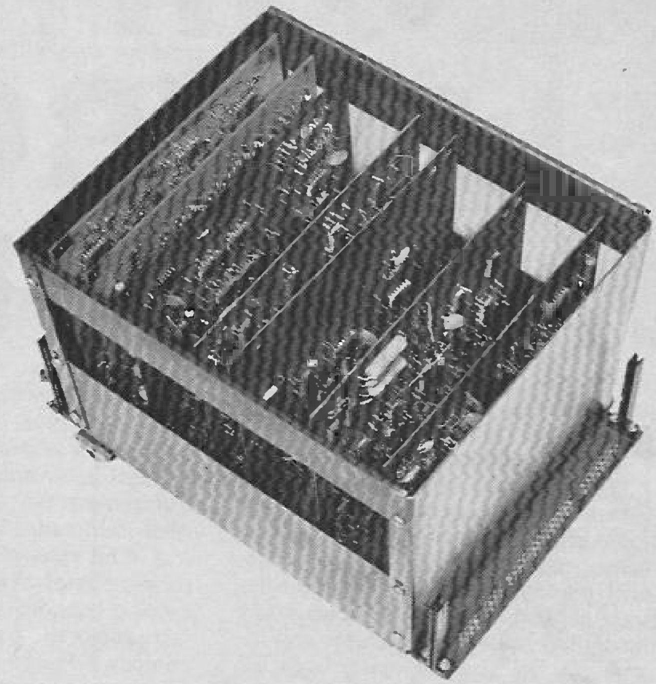


Fig. 9. The boards' container.

container was minimized by concave surfaces, whilst idlers are torque loaded to maintain constant friction with roller wear. These features, in addition to the shaped container, give long life expectancies.

The motor, a Plessey "Series 600" run under pulse conditions, has yet to be fully evaluated, although the life expectancy has been exceeded on mock-up models without failure.

The quartz-halogen lamps used in this data capture system were specially designed for a previous teaching machine project. They differ from the commercial quartz-halogen lamps by having a more robust envelope of a special quartz which also prevents the "poisoning" of the halogen gas.

Integrated circuit functions have been tested to their extremes of logic levels, temperature and fan-out without failure, and since these will not be subjected to rated specifications, checks will only be necessary at the service intervals. The punch unit and keyboard, which are guaranteed for several million operations, have been rigorously tested under extremes of environment and as these represent the input and output of data, the overall confidence level is high.

FUTURE DEVELOPMENTS

The quartz-halogen lamp with an ellipsoidal reflector of dichroic material was encountered late in the development programme and has not, therefore, been subjected to field or serious laboratory trials. The basic principle is that energy in the visible spectrum should be transmitted forwards to the lens focal point whilst infra-red energy is both directed and reflected to the rear through the reflector. This not only reduces the heat at the film plane but allows a condenserless system with thermal escape by ducted convection. The spectrum diagram emphasizes the energy content radiated as heat compared with visible light. The total energy radiated W_{total} is proportional to the fourth power of the absolute temperature T. For a black body radiator, W_{total} = Stefans constant xT^4. Advantages obtained by the use of a quartz envelope are based on a higher envelope temperature which, according to Wein's displacement law λ_{peak} x 2900T and since the peak λ is lower, more energy will fall within the visible spectrum.

When an operator wishes to confirm an identity, the two letters shown on the screen are selected from the keyboard: confirmation is shown by a lamp adjacent to the displayed data line. If buttons are added adjacent to each bulb, the action of pushing a button can cause illumination and insert the two data characters. This leads naturally to re-siting the screen from vertical to almost horizontal, which will eliminate fatigue. Where two screens are used, these must be very close to each other. Re-siting certain function buttons leads to a better ergonomic presentation in which colour also assists. Many lists of data contain lengthy groups, each item of which has the same initial letters. A single frame step-on button enables a rapid search through a group to be made. Block check characters, in addition to parity, are required for some installations, especially where transmission lines are involved. Characters for transmission may be held in temporary store until "Ack" is received, as on larger systems. Printed records can also be advantageous. The customer will choose these options or have them as additions to an existing terminal. Each system plan is finally determined by economic considerations.

It is, of course, known that this type of visual display will, within a few years, be superseded by a cathode ray tube with a large internal store as memory. The present cost of such an installation when on-line to a computer is, however, in excess of this data system and if on-line facilities are not available, costs are completely prohibitive.

ACKNOWLEDGEMENTS

Acknowledgement is given to Shell Mex & BP Limited who own the rights of the basic capture method and without whose specification for another data system – ACORN – this derivative would not have been considered. All engineering and design work has been carried out at the Development Laboratory at Ilford and subsequently at Upminster.

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REPORT ON THE ELECTRONICS INDUSTRY

Part 2 : What the industry faces when UK enters the European Economic Community.

The electronics industry in the European Economic Community has for several years been operative in a single European market dominated in many product areas by large international companies. As in the UK, the American influence is most apparent in the semi-conductor, computer and instrument fields where many large US firms have manufacturing facilities in Western Europe. However, not all the large electrical and electronics groups are US-owned; Philips, Siemens and AEG-Telefunken are examples of non-American organisations with sales over £1000 million. Also, small indigenous specialists with localised manufacturing centres have large shares of the market in many fields.

ELECTRONICS IN THE EEC

As in the UK, nearly all major European electronics manufacturers have extensive interests outside the industry; Siemens, AEG-Telefunken and Cie Generale d'Electricite in Europe are involved in all aspects of the electrical engineering field from power generation to micro-circuits — as are GEC in UK; similarly Thorn in UK and Philips in Europe produce, as well as electronic equipment, a wide range of domestic appliances, lighting and general electrical equipment.

Again, as in UK, production in such product areas as passive components, instruments and control equipment is most fragmented whilst production in computers, active components and (in the national markets) TV receivers and telecommunications, is concentrated in the hands of relatively few firms.

In 1970, UK-manufactured deliveries accounted for 24% of the combined EEC-UK electronics production. In a world industry dominated by the USA (accounting for 65% of world production), West Germany leads as the largest national producer in Europe and is followed by UK and France. (Estimated Japanese electronic production in 1970 totalled around £3500 million, certainly exceeding the total output of the six EEC members).

It should be noted that although American-controlled companies in UK and EEC manufacture a substantial proportion of the products they sell, a varying proportion of such goods are manufactured by either the parent company on the USA mainland or increasingly in low-cost off-shore areas such as Puerto Rico, Taiwan or South America.

Lack of directly comparable figures for trade or production for all the EEC countries considerably hampers any attempt to produce size and growth relationships on a European basis. Even in such well-developed products as TV receivers, for example, the Dutch international trade figures are at variance with the rest of the EEC. And for areas such as semi-conductors, control equipment, instrumentation and computors, the different systems of product group classification render official statistics of little use.

TARIFF CHANGES

When Britain enters the EEC, tariffs charged on most items of electronic equipment and components coming from outside the EEC will be significantly lower. The main exceptions are control instrumentation and telecommunications equipment, record players and tape recorders; even in these, little change in tariffs is expected.

Changes in tariff rates are likely to be of secondary importance to factors such as the existing international structure of the industry and restrictions on foreign equipment purchase in defence, avionics and telecom markets. However, in several markets where UK is already importing significantly from non-EEC areas, tariff reduction on imports after the transition period is quite substantial. Large tariff changes will occur in product groups such as semiconductors, resistors, capacitors and radio/TV receivers — and this is likely to accelerate the existing trend for UK and EEC to import from USA, Japan and the low-cost areas of Taiwan, Korea, Puerto Rico etc.

LEGISLATIVE CHANGES

The replacing of current Purchase and SET taxes by a Value Added Tax has several implications for the UK electronics industry.

1. Most consumer products in the durable goods category suffered a 3-3½% price fall at the retail level as a result of the purchase tax change in the March 72 budget (which was intended to minimise any distortion in demand caused by the advance warning of retail price falls after April 73). A further 3½% fall in retail price is likely on VAT introduction.

2. Producers in the component, capital goods and telecom sectors will have a 10% VAT imposed on them but this will not affect these areas since the VAT paid can be passed on to the buyer of the finished goods. However, the companies will have to finance the VAT payments (which are in effect interest-free loans to the Government) and a temporary adverse effect on cash-flow is foreseen; most seriously affected will be long order-cycle producers.

3. Although the software side of the computer sector could benefit from the accounting and invoicing operations inherent in VAT introduction, many problems are foreseen for the suppliers of software, mainly due to the short time allowed between announcement of details of VAT adoption in UK and its introduction in 1973. Also, many major customers of the computer industry (eg the financial companies) will be classed as traders exempt under the VAT and will thus be unable to offset VAT payments on their computor equipment purchases against their revenue. All this could lead to significant re-appraisals by VAT-exempt users of their computer usage and any plans to upgrade existing systems in 1973.

Future performance of the industry could also be affected by legislation sought by members of the EEC, in several areas, to ensure common standards, fair competition and cooperation between member states. The Commission has, for example, sought to remove restriction on supply of products to central governments, local authorities and other public bodies, excluding defence, telephone authorities, electricity, gas and rail transport undertakings. Though any extension of this legislation could eventually affect the electronics industry profoundly, a genuine common market in this area is still a long way off. The main effects are likely to be realised in aerospace and avionics fields where multi-national airframe projects are already becoming commonplace.

Although attempts by the Six to harmonise R & D projects to reach long-term efforts comparable to those in USA have so far failed, greater research cooperation is probable in the long-term.

On the question of production standards, UK industries are generally well advanced in metrication and slightly ahead of the Six in following the internationally agreed SI system of units.

EFFECTS OF EEC ENTRY

The foreseeable effects of EEC membership on the UK electronics industry sector by sector, are outlined below.

• COMPONENTS

Even the removal of the 12½%(UK) and 7-8%(EEC) tariffs for valves and tubes is unlikely to give noticeable increase in the trade flow between UK and the Six, except possibly in terms of inter-firm trading between the Philips companies, particularly in colour TV tubes where (and when) consumer demand increases rapidly, leading to component shortages. The export to total output ratio in this field is traditionally low, partly due to the tight control by indigenous local producers (90% sales by 2 or 3 firms) and partly due to the nature of the products.

British companies could usefully increase their sales to Europe (inspite of tough competition from Thomson-CSF, Siemens and Philips) in the industrial tube market where export to output ratio is already higher than for domestic valves and tubes.

In the semi-conductor (notably ICs) market, any tariff concessions following UK entry are less likely to affect trade flow than factors such as future changes in trade structure, siting of production units by US firms, pricing trends and the possible entry of Japanese producers into the EEC market by 1974-75. The key to future trade flows lies with the American and, perhaps later, Japanese firms. With acceleration of manufacturing in low-cost areas by US producers, imports to EEC from non-EEC sources are likely to increase. Hopes for the retention in European hands of a viable and substantial semi-conductor production would seem to rest with outcome of moves towards a pan-European organisation — eg the Plessey-AEG-Sescosem talks.

In the passive components sector, the trend of increasing UK imports (started by the progressive lowering of the tariffs under the Kennedy Round agreements) is likely to continue as UK tariff rates on EEC exports are eliminated. However, in certain specialised areas, several UK companies seem well-placed to reap longterm benefits from abolition of EEC tariff; BSR, AB Electronic, Colvern and Ever Ready have already proved their superiority over EEC competitors on technical or price terms.

• CAPITAL GOODS

In the computer sector, rationalisation on a multi-national basis has commenced in Europe; the Siemens-CII-Philips link-up concluded recently was largely due to political pressure from the respective governments who already provide more direct support to their computer industries than ICL has received from Whitehall. Such political involvement is likely to increase along with government protection of local industry and discrimination against non-European producers in government and EEC contracts. In the private sector, this xenophobic attitude should give a rising two-way trade level. American companies, who continue to dominate the industry and the European scene on a multi-national basis and have at least 2 or 3 major plants in Europe, seem to have adopted policies of localised production so as to allay nationalist reaction; IBM for example has extensive plants in every major West European country and has recently commenced the 370 Series mainframe production

Solid-state microwave amplifier (Impectron Ltd).

in the UK for marketing in the EEC. Lowering of UK/EEC trade barriers is sure to add to this trend.

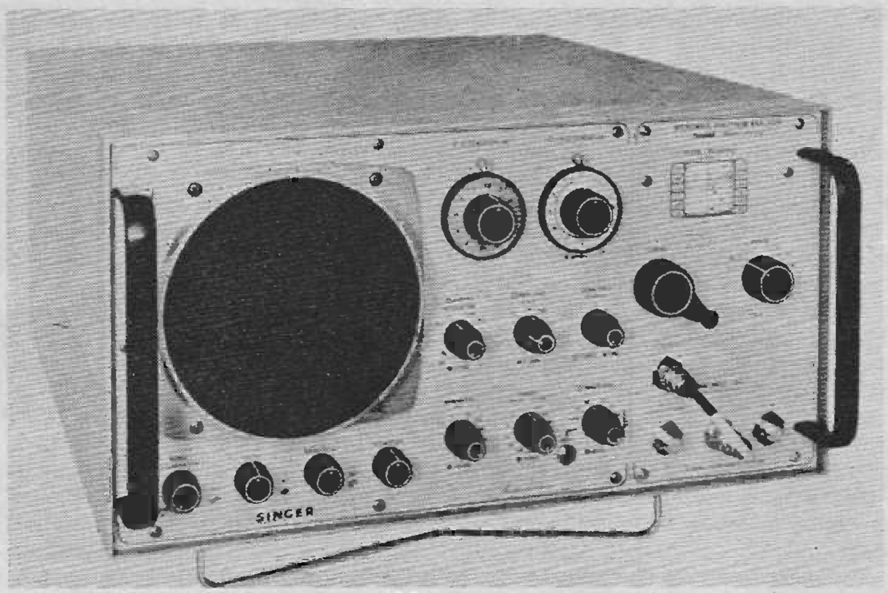
In the instrumentation sector, especially in technically advanced electronics and electro-optics, American firms continue to dominate the European market. The largest threat to UK instrument firms in the home market would appear to be from US firms, like Hewlett-Packard, General Radio or Beckmen Instruments who have factories in the EEC and would benefit from abolishment of tariffs.

In the control equipment sector, UK and West Germany are significant net exporters while France, Belgium and Italy are net importers. Netherlands' trade has been balanced but, with growing internal demand, deficit will almost certainly develop in the next five years. While UK entry into the EEC could well benefit several British producers, American and West German competition will continue to be tough. Tariff changes as such are unlikely to affect UK exports since factors such as technical specifications or speed of delivery are more important in these markets than price alone. However, in time, UK entry may help to remove many of the non-tariff barriers erected by European defence, civil aviation, postal and broadcasting authorities as protection for their home industries against non-EEC

PR 320 manpack set developed by Plessey under a MoD contract for the British Army.

REPORT ON THE ELECTRONICS INDUSTRY

products. Those UK sections dependent on the aviation market could benefit also from more (or further) multinational aerospace projects like MRCA, the Anglo-French Jaguar and Concorde and the four-nation A300B 'airbus'. Against all this, British products could fare worse in the loss of preferential tariffs in the Commonwealth markets where, in such areas as mobile radio or broadcasting equipment, they will be competing against Japan. UK imports are likely to remain largely from the USA in communication equipment though, in commercial markets, Dutch and French imports could rise marginally.



Singer SPA-100 Spectrum Analyser (REL)

• TELECOMMUNICATIONS

Since the 1920s, European postal, telephone and telegraph authorities have preferentially allocated their requirements among principal and long-standing domestic companies to protect and sustain continuous supply — as was the practice in UK till the recent rescindment of Bulk Supply Agreements. This has resulted in many American and European companies (eg L M Ericsson, Siemens, ITT, Philips etc) having major producing subsidiaries in several European countries. Scope for UK expansion in the EEC appears to be limited by non-tariff trade barriers imposed by government-controlled carrier organisation and the technical differences (especially true of exchange equipment) between British and European specifications. The most promising country for UK producers, inspite of competition from local production subsidiaries of Siemens, Philips, ITT and Ericsson, is Italy with its relatively loose government control, its lack of a dominant national producer and its low level of telephone penetration.

Imported equipment holds only 6% of the UK market and foreign suppliers are significant only in the non-PO market. The key to long-term penetration by foreign firms is with the Post Office who currently purchase over 80% of all UK deliveries. Despite PO threats, in the face of chronic late delivery of telephone exchange equipment, to place contracts overseas, competitive tendering by Siemens or Philips is unlikely in the near future due to the high transport costs and the special PO specifications. However, imports from the EEC in non-PO goods such as subscribers' apparatus and (following the relaxation of supplier approvals by the PO) PABX equipment are most likely to rise when the existing 9% import tariff is abolished.

In the Middle East markets, the preponderance of installed equipment to British PO specification, especially exchanges, inhibits European and American competition, and UK entry into EEC will not effect these areas. UK will lose the preferential export-rates to the Commonwealth but the main UK producers all have production plants in the large Commonwealth markets and South Africa to which production may be switched.

One other result of UK entry into the EEC may be the participation of UK telecom manufacturers in some of the many cross-licensing agreements and patent pools between American and European producers.

• CONSUMER GOODS

The British industry, now virtually totally reliant on the home market due to their inability to compete on price, will face large EEC producers such as Philips and Grundig as well as intensified non-EEC (notably Japanese) competition when import tariffs from third-party producers is reduced from 16% to 7% on radio and TV sets. The major continental radio and TV producers will intensify their export marketing, with UK as the prime target, due to factors such as colour TV price-cutting in Germany in 1971, expected lower growth rate in consumer electronics demand in Germany and Holland in the next 3 or 4 years, and the threat of low-cost imports into their own home markets. Chances of such import penetration in UK seem greatest in tape recorders, audio equipment and possibly small-screen monochrome TV sets.

The best opportunites for UK exports to the EEC in the next five years seem to be in colour TV. With the adoption of the Telefunken-patented PAL system in West Europe (including UK and excepting Italy which is still experimenting with SECAM), technical differences between receivers for West German, Dutch and British markets are minimal. This will benefit Philips most, although Thorn and Grundig can also expect to benefit from the trade increase resulting from removal of tariffs and technical trade barriers.

The largest threat to the European industry in general (including UK) is still Japan whose producers (led by Hitachi now manufacturing PAL sets under license and Sony who have circumvented the Telefunken PAL patent) have started PAL set production for West German and UK markets, as seen in well-advanced Japanese plans for assembly plants in Eire. Outside France where the SECAM system is some barrier to Japanese entry, Thorn is best defensively placed among all major European producers — mainly because of its large rental interests.

The greatest potential for the UK industry lies in the expansion of TV rental links and production facilities on the Continent; Telefunken already have recently purchased Carpentier (a small Belgian manufacturer) and have embryonic rental chains in France, Sweden and Denmark. The development of a British-controlled TV rental industry in EEC (where virtually no rental firms now exist) would seem to be one way for UK to get a foothold in the European TV markets but this entails a race against the Japanese with their low-priced small-screen sets.

AUDIO NEWS

PUBLIC ADDRESS ENGINEERS

The Association of Public Address Engineers was formed in England in 1948 and is still the only organization in the world devoted specifically to this branch of audio engineering. Its objectives are: to represent the interests of its members at local, national and international level, to act as spokesman of the PA industry, to set standards and promote confidence in the use of PA equipment, and to educate trainees and to disseminate information.

The membership covers manufacturers, trader and professional engineers, and apprentice/trainee grades. The strength of APAE is that it brings together individuals and companies, designers, traders and the working engineers in the growing PA sound industry allied to many other audio-visual and entertainment media, including CCTV and discotheques. With the know-how available today, there is no excuse for poor sound reproduction in public places, if only those concerned in such presentations will consult the experts for installation advice and suitable equipment, and not merely 'make-do' with lash-up systems on hand.

Next year the APAE will celebrate its Silver Jubilee, and an international exhibition will be staged at London's Bloomsbury Centre Hotel (March 13 to 15th). A series of technical talks and demonstrations will form part of this Sound '73 event. **(66)**

RADIO MICROPHONE LICENCES

A reader has enquired whether any licence is required before buying or using a radio microphone in the United Kingdom? Yes, indeed, a licence (costing £3 for a 5-year period) is necessary and can be obtained from the Ministry of Posts and Telecommunications, Waterloo Bridge House, Waterloo Road, London SE1. The licence issued is subject to certain limitations. For example, the mobile stations shall be used only with emissions at frequencies within the band 174.1-175.0 MHz, and shall have classes, power aerial and other characteristics as stated in the Schedules of Specification W6489 (narrow deviation) and W6490 (wide deviation). A clause stipulates that the station shall not be established or employed in such a way as to enable the licensee or any other person, by means thereof, to overhear or record any spoken words without the consent of the speaker. That rules out bugging applications!

ISODYNAMIC HI-FI HEADSET

The manufacturers of the new design British stereo headphones (page 19, September) are Rank Wharfedale. Final production models will be shown at this month's International Audio Fair and Festival at Olympia. We understand that the semi-pressure acoustic loading at low frequencies maintains the response right down to 35Hz without the need for high side pressure to seal the head or ears, and the bass characteristic is not modified significantly by the normal leakage that occurs around the ear pinnae. This, combined with the 360g weight, excluding cable, makes the headset comfortable to wear, even for quite long periods. Price is about £20 and listeners have found the performance comparable with expensive electrostatic headphones. **(68)**

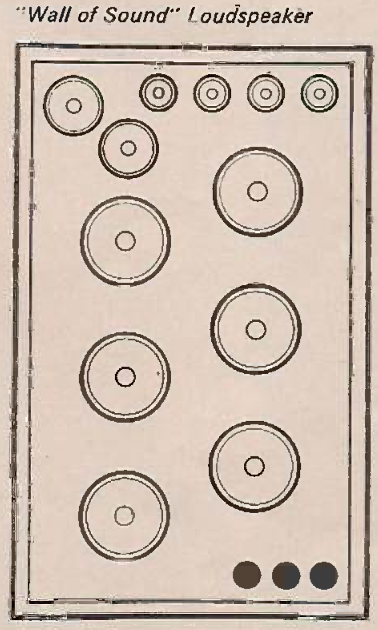
Wharfedale Isodynamic Hi-Fi Headphones.

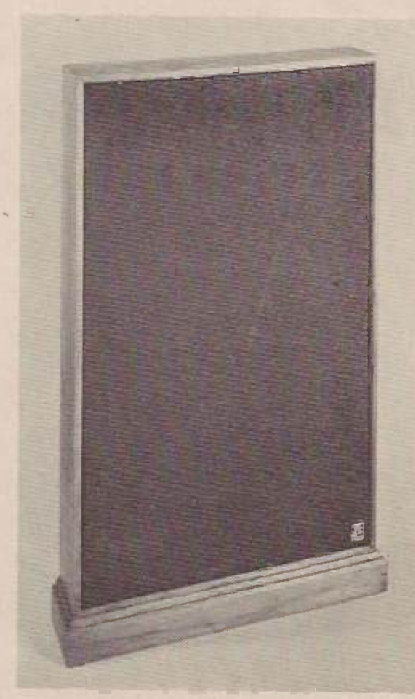
'WALL OF SOUND' SPEAKER

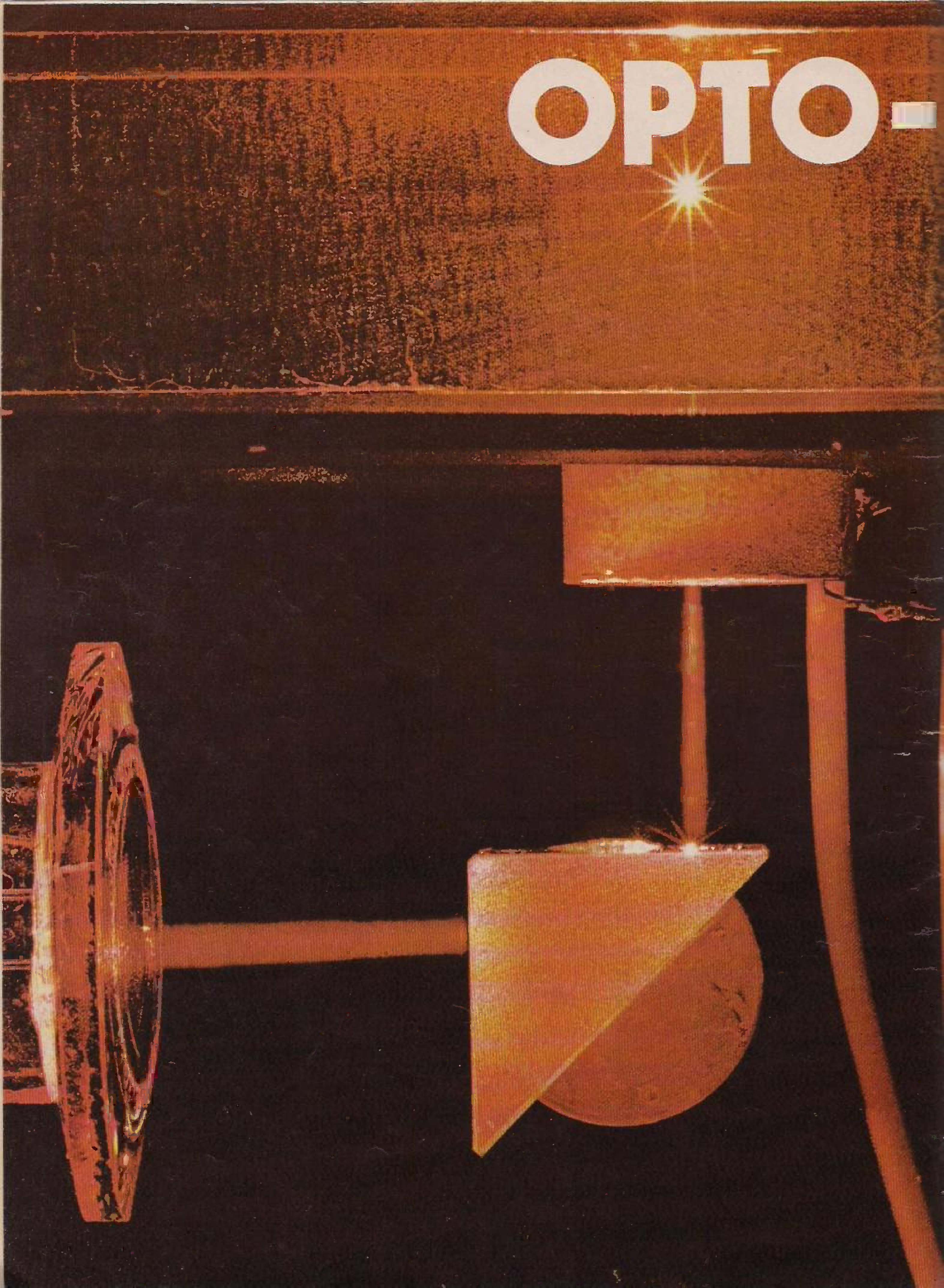
Fairfax have introduced a range of 'Supersound' speakers with features which they describe as true pitch and zero frequency overlap, advanced sound enclosure design and differential circuitry gate design.

Of the seven units in the series, the Wall of Sound model has an 'integrated cyclone' labyrinth system with eight separate sound chambers, resulting in — so the manufacturers claim — negligible harmonic and intermodule distortions and complete freedom from crossover fuzz and feedback problems. This model has six heavy-duty 8" bass drivers, two 5" mid-range, two 3½" mid-high and two ultra high-frequency dome tweeters, 100W capacity, 6.5 ohms impedance, and 20W minimum power requirement. Frequency response is 20 to 22,000 HZ. Dimensions are 52" h x 30" w x 6½" d. Weight is 125 lb and price in USA is about $400. **(67)**

"Wall of Sound" Loudspeaker






OPTO-

ELECTRONICS

- BASIC SYSTEMS

There is an exciting revolution taking place in the electronics industry — that of Optoelectronics. More and more devices based on the transmission and reception of light, or near light radiation, are finding their way into electronic equipment principally because optoelectronic devices offer characteristics unmatched by conventional methods. Factors such as sensitivity, isolation, bandwidth and low power consumption are better attainable by optoelectronic rather than conventional devices in specific applications.

The proliferation of devices and applications is increasing at a greater than exponential rate. We have just begun to learn.

Typical applications include — optical communication links which offer bandwidths of several gigahertz as well as privacy, liquid crystal displays having extremely low power consumption, and a host of applications utilising the coherent light generated by LASERS. Even LASER weapons are with us — it has been reported recently that a ballistic missile was shot down by a powerful LASER.

The developments in optoelectronics are indeed revolutionary and will have a far reaching effect on our technology and our way of life.

Articles in this series will include:—

* Basic systems
* Photosensitive materials and devices
* PIN photo diodes
* Silicon phototransistors
* Light emitting diodes (and displays)
* Lasers
* Holography
* Optical memory systems
* Liquid crystal displays
* Opto-electronic applications

IN the design of opto-electronic systems a knowledge of the factors governing transmission and reception of radiant energy is essential. Consider the classical problem of an optical link as shown in Fig. 1.

To properly utilise such a system we must know many factors including the following:—

1) The spectral distribution and radiation pattern of the emitted energy from the source.

2) The characteristics of the optical lens system.

3) The source intensity.

4) The spectral response and sensitivity of the detector.

TABLE 1 — Radiometric and Photometric Terminology

Description	Radiometric	Photometric
Total Flux	Radiant Flux, P. in Watts	Luminous Flux, F. in lumens
Emitted Flux Density at a Source Surface	Radiant Emittance, W. in Watts/cm^2	Luminous Emittance, L in lumens/ft^2 (foot Lamberts), or lumens/cm^2 (Lamberts)
Source Intensity (Point Source)	Radiant Intensity I_r. in Watts/ steradian	Luminous Intensity, f_L, in lumens/steradian (candela)
Source Intensity (Area Source)	Radiance, Br, in (Watts/steradian)/cm^2	Luminance, B_L, in lumens/steradian)/ft^2
Flux Density incident on a Receiver Surface	Irradiance, H, in Watts/cm^2	(Illuminance, E, in lumens/ft^2 (footcandle)

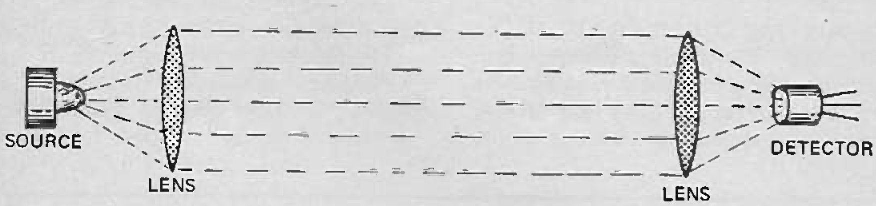


Fig. 1. A basic opto-electronic system.

The majority of these factors are given in manufacturer's data sheets but in addition we must understand how to manipulate the geometric and unit system factors involved. It is the purpose of this article to present a survey of the methods of solving problems such as that above.

The first problem that one meets with, is defining the quality, quantity and directivity of the emitted energy from the source. There are two systems of defining radiated energy in use, these are the Radiometric System and the Photometric System. Although the two systems to some extent describe the same phenomenon

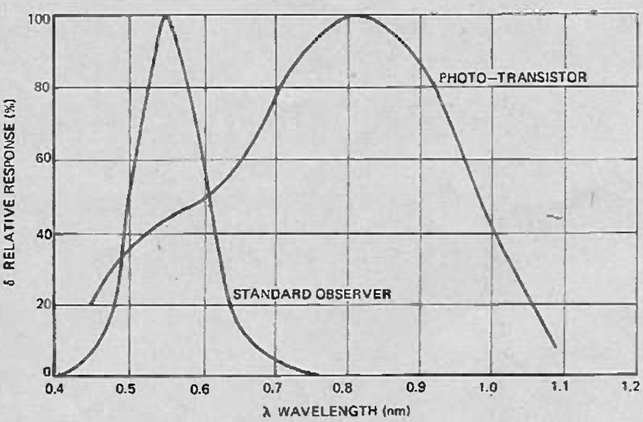


Fig. 2. Spectral response for Standard Observer and a typical phototransistor.

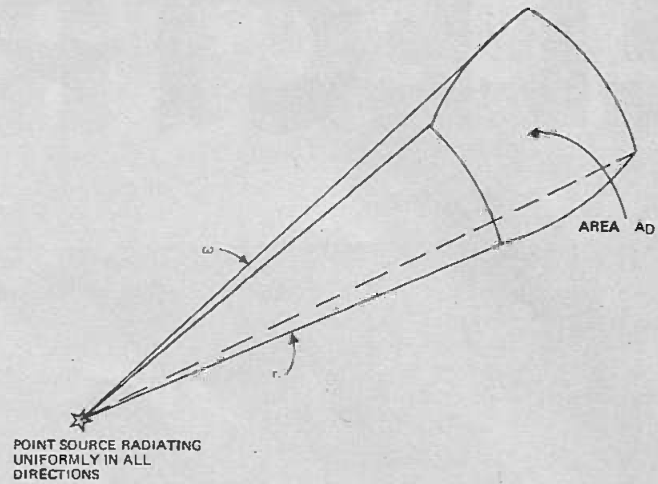


Fig. 3. Point source geometry.

TABLE 2 – Point Source Relationships

Description	Radiometric	Photometric
Point Source Intensity	1_r, Watts/steradian	1_L lumens/Steradin
Incident Flux Density	H (Irradiance) $= \frac{1_r}{r^2}$ Watts distance^2	E (Illuminance) $= \frac{1_L}{r^2}$ lumens/distance^2
Total Flux Output of Point Source	$P = \pi 1_r$ Watts	$F = 4\pi 1_L$ lumens

they are entirely different, but both are essential and useful.

The photometric system defines energy relative to its visual effect. As an example, light from a standard 60-watt bulb is certainly visible, and as such, has finite photometric quantity, whereas radiant energy from a 60-watt resistor is not visible and has zero photometric quantity. Both items have finite radiometric quantity.

The defining factor for the photometric system is the spectral response curve of a standard observer. This is shown in Figure 2 and is compared with the spectral response of a typical phototransistor. The defining spectral response of the radiometric system can be imagined as unit response for all wavelengths.

A comparison of the terminology for the two systems is given in Table 1.

There exists a relationship between the radiometric and photometric quantities such that at a wavelength of 550nm, the wavelength of peak response for a standard observer, one watt of radiant flux is equal to 680 lumens of luminiqus flux. For a broadband of radiant flux, the visually effective, or photometric flux is given by integrating with respect to wavelength, the spectral response curve of the device multiplied by that for the standard eye.

A similar integral can be used to convert incident radiant flux density, or irradiance, to illuminance:

Fortunately, it is usually not necessary to perform the above integrations. The photometric effect of a radiant source can often be measured directly with a photometer.

Unfortunately, most phototransistors are specified for use with the radiometric system. Therefore, it is often necessary to convert photometric source data, such as the lumen rating of an incandescent lamp to radiometric data. This will be discussed shortly.

GEOMETRIC CONSIDERATIONS

In the design of electro-optic systems, the geometrical relationships are of prime concern. A source will effectively appear as either a point source, or an area source, depending upon the relationship between the size of the source and the distance between the source and the detector.

Point Sources

A point source is defined as one for which the source diameter is less than ten percent of the distance between the source and the detector.

Figure 3 depicts a point source radiating uniformly in every direction. The detector area, A_D can be approximated as a section of the area of a sphere of radius r whose center is the point source.

The solid angle, ω, in steradians subtended by the detector area is

$$\omega = \frac{A_D}{r^2}$$

Since a sphere has a surface area of $4\pi r^2$, the total solid angle of a sphere is

$$\omega S = \frac{4\pi r^2}{r^2} = 4\pi \text{ steradians}$$

Table 2 lists the design relationships for a point source in terms of both radiometric and photometric quantities.

The above discussion assumes that the photodetector is aligned such that its surface area is tangent to the sphere with the point source at its centre. It is entirely possible that the plane of the detector can be inclined from the

TABLE 3 – Design Relationships for an Area Source

Description	Radiometric	Photometric
Source Intensity	B_r, Watts/cm^2/steradian	B_L, lumens/cm^2 steradian
Emitted Flux Density	$W = \pi B_r$, Watts/cm^2	$L = -B_L$, lumens/cm^2
Incident Flux Density	$H = \frac{B_r A_s}{r^2 + \frac{d^2}{2}}$ Watts/cm^2	$E = \frac{B_L A_S}{r^2 + \frac{d^2}{2}}$ lumens/cm^2

TABLE 4 Conversion Factors

I

Illuminance Units

	lux (lx.)	phots (ph.)	foot-candles (ft.-c)
Lux (metre-candles) lm/m² - -	1	0.001	0.0929
Phots (1m/cm2) - - -	10,000	1	929
Foot-candles (lm/ft2) - -	10.764	0.001076	1

II

Luminance Units

	nits cd/m²	stilbs (sb.)	cd/in.²	cd/ft.²	millilamberts (mL.)	foot-lamberts (ft.-L.)	apostilbs (asb.)
Candelas per sq.m.(nits)	1	0.0001	0.000645	0.0929	0.3142	0.2919	3.1416
Stilbs (cd/cm2)	10,000	1	6.452	929	3141.6	2919	31,416
Candelas per sq. in.	1550	0.155	1	144	486.9	452.4	4869
Candelas per sq. ft.	10.764	0.001076	0.00694	1	3.382	3.1416	33.82
Millilamberts	3.183	0.0003183	0.002054	0.2957	1	0.929	10
Foot-lamberts	3.426	0.0003426	0.002211	0.3183	1.0764	1	10.764
Apostilbs	0.3183	0.00003183	0.0002054	0.02957	0.1	0.0929	1

(Value in unit in left-hand column) x (conversion factor) = (value in unit shown at top of column).

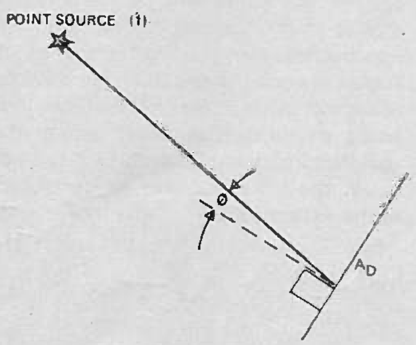


Fig. 4. Detector not normal to source direction.

tangent plane. Under this condition, as depicted in Figure 4, the incident flux density is proportional to the cosine of the inclination angle, Φ. Therefore,

$$H = \frac{I_r}{r^2} \cos \Phi, \text{ and}$$

$$E = \frac{I_L}{r^2} \cos \Phi.$$

AREA SOURCES

When the source has a diameter greater than 10 percent of the separation distance, it is considered to be an area source. This situation is shown in Figure 5. Table 3 lists the design relationships for an area source.

LENS SYSTEMS

A lens can be used with a photodetector effectively to increase the irradiance on the detector. As shown in Figure 6a, the irradiance on a target surface for a point source of intensity, I, is

$$H = I/d^2$$

where d is the separation distance.

In Figure 6b a lens has been placed between the source and the detector. It is assumed that the distance d' from the source to the lens is approximately equal to d, and the solid angle subtended at the source is sufficiently small to consider the rays striking the lens to be parallel.

If the photodector is circular in area, and the distance from the lens to the detector is such that the image of the source exactly fills the detector surface area, the radiant flux on the detector (assuming no lens loss) is

$$P_D = P_L = H' \pi r_L^2,$$

where

P_D is the radiant flux incident on the detector.

P_L is the radiant flux incident on the lens.

H' is the flux density on the lens, and rL is the lens radius.

Using equation (12),

$$H' = I/d^2 = H.$$

The ratio of irradiance on the detector with a lens to the irradiance without a lens is given by:—

$$\frac{H_D}{H} = \frac{r_L}{r_d}^2$$

That is, if the lens radius is greater than the detector radius, the lens provides an increase in incident irradiance on the detector. To account for losses in the lens, the ratio is reduced by about ten percent.

$$R = 0.9 \frac{r_L}{r_d}^2$$

where R is the gain of the lens system.

It should be pointed out that arbitrary placement of a lens may be more harmful than helpful. That is, a lens system must be carefully planned to be effective.

For example, the phototransistor usually contains a lens which is effective when the input is in the form of parallel rays (as approximated by a uniformly radiating point source). Now, if a lens is introduced in front of the phototransistor as shown in Figure 7, it will provide a non-parallel ray input to the transistor lens. Thus the net optical circuit will be misaligned. The net irradiance on the phototransistor chip may in fact be less than without the external lens.

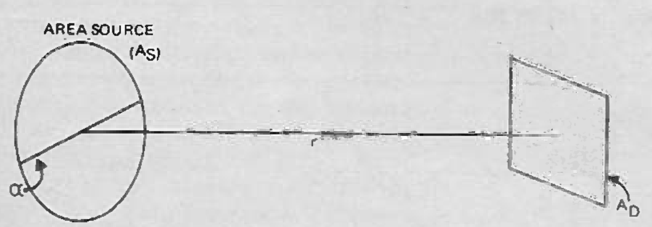


Fig. 5. Area source geometry.

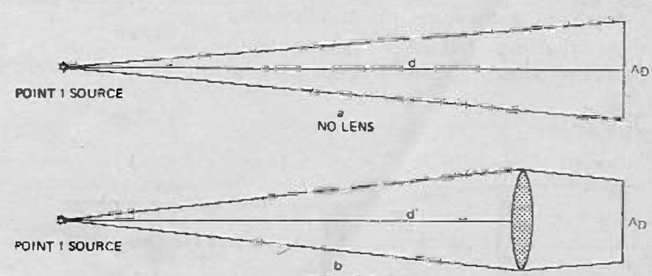
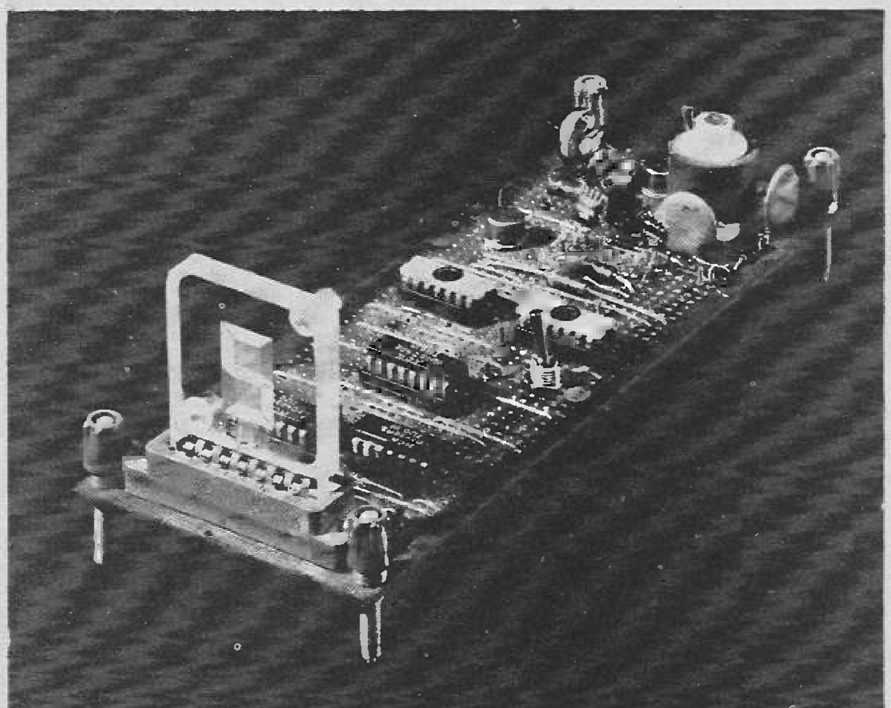


Fig. 6. Use of lens to increase the irradiance on the detector.



Demonstration liquid crystal display

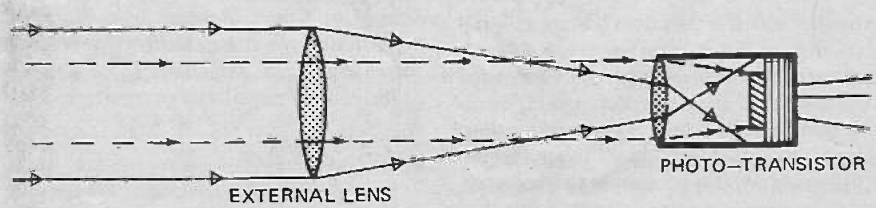


Fig. 7. Possible misalignment due to the arbitrary use of an external lens. Dotted lines indicate performance without lens.

The circuit of Figure 8 does show an effective system. Lens 1 converges the energy incident on its surface to lens 2 which reconverts this energy into parallel rays. The energy entering the phototransistor lens as parallel rays is the same (neglecting losses) as that entering lens 1. Another way of looking at this is to imagine that the phototransistor surface has been increased to a value equal to the surface area of lens 1.

FIBRE OPTICS

Another technique for maximizing the coupling between source and detector is to use a fibre optic bundle to link the phototransistor to the light source. The operation of fibre optics is based on the principle of total internal reflection.

Figure 9 shows an interface between two materials of different indices of refraction. Assume that the index of refraction, n, of the lower material is greater than that, n', of the upper material. Point P represents a point source light radiating uniformly in all directions. Some rays from P will be directed at the material interface.

At the interface, Snell's law requires:

$$n \sin \theta = n' \sin \theta',$$

where

θ is the angle between a ray in the lower material and the normal to the interface,

and

θ is the angle between a refracted ray and the normal. By rearranging we obtain

$$\sin \theta' = \frac{n}{n'} \sin \theta.$$

By assumption, n/n' is greater than one, so that

$$\sin \theta' > \sin \theta$$

However, since the maximum value of $\sin \theta'$ is one and occurs when θ' is 90°, θ' will reach 90° before θ does. That is, for some value of θ, defined as the critical angle, θC, rays from P do not cross the interface. When $\theta > \theta C$, the rays are reflected entirely back into the lower material, or total internal reflection occurs.

Figure 10 shows the application of this principle to fibre optics. A glass fibre of refractive index n is clad with a layer of glass of lower refractive index, n'. A ray of light entering the end of the cable will be refracted as shown. If, after refraction, it approaches the glass interface at an angle greater than θC, it will be reflected within the fibre. Since the angle of reflection must equal the angle of incidence, the ray will bounce down the fibre and emerge, refracted, at the exit end.

The numerical aperture, NA, of a fibre is defined as the sine of the half angle of acceptance. Application of Snell's law at the interface for θ_C, and again at the fibre end will give.

$$NA = \sin \Phi = \sqrt{n^2 - n'^2}.$$

For total internal reflection to occur, a light ray must enter the fibre within the half angle θ.

Once a light ray is within the fibre, it will suffer some attenuation. For glass fibre, an absorption rate of from five to ten per cent per foot is typical. There is also an entrance and exit loss at the ends of the fibre which typically result in about a thirty per cent loss.

As an example, an illuminance at the source end of a three-foot fibre bundle would appear at the detector with a loss of 50%. This assumes an absorption loss of ten percent per foot.

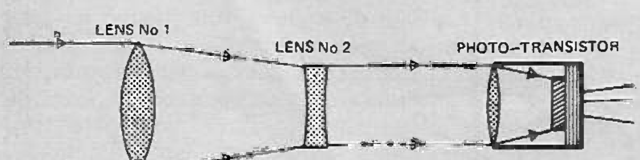


Fig. 8. An effective lens system for phototransistors.

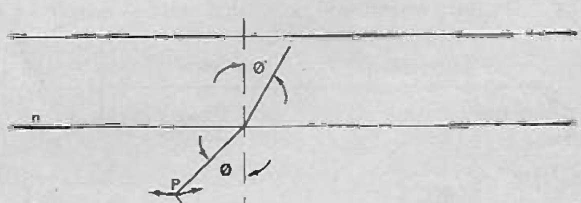


Fig. 9. Ray refraction at an interface.

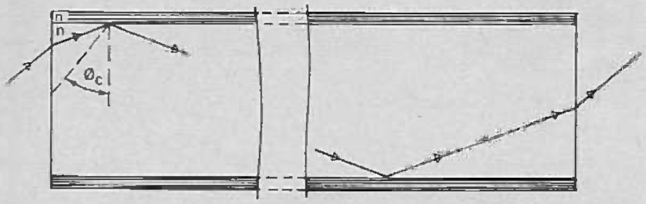


Fig. 10. Refraction in an optical fibre.

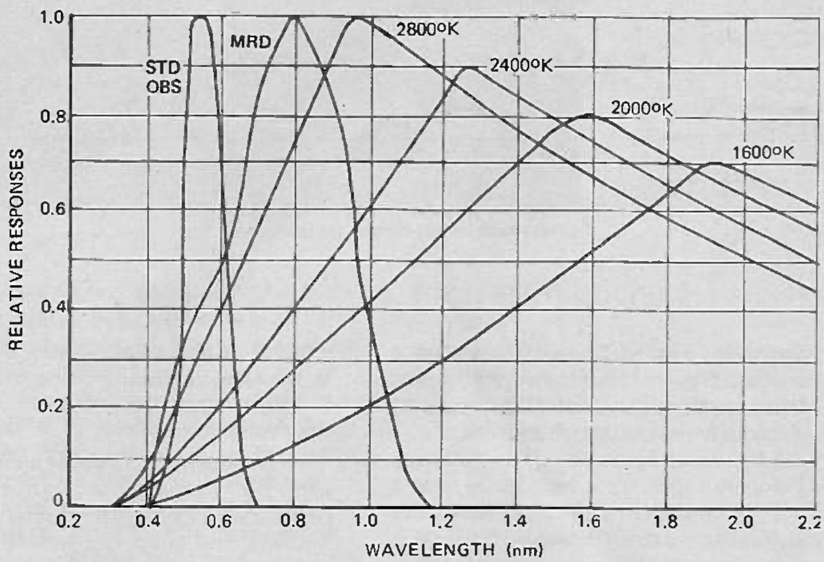


Fig. 11. Radiant spectral distribution of a tungsten lamp.

TUNGSTEN LAMPS

Tungsten lamps are often used as radiation sources for photodetectors. The radiant energy of these lamps is distributed over a broad band of wavelengths. Since the eye and the phototransistor exhibit different wavelength-dependent response characteristics, the effect of a tungsten lamp will be different for both. The spectral output of a tungsten lamp is very much a function of colour temperature.

Colour temperature of a lamp is the temperature required by an ideal blackbody radiator to produce the same visual effect as the lamp. At low colour temperatures, a tungsten lamp emits very little visible radiation. However, as colour temperature is increased, the response shifts towards the visible spectrum. Figure 11 shows the spectral distribution of tungsten lamps as a function of colour temperature. The lamps are operated at constant wattage and the response is normalized to the response for both the standard observer and a typical phototransistor series are also plotted. Graphical integration of the product of the standard observer response and the pertinent source distribution from Figure 11 will provide a solution to the flux and irradiance problems referred to earlier.

Effective irradiance

Although the sensitivity of a photodetector to an illuminant source is frequently provided, the sensitivity to an irradiant source is more common. Thus, it is advisable to carry out design work in terms of irradiance. However, since the spectral response of a source and a detector are, in general, not the same, a response integration must still be performed. The integral is similar to that for photometric evaluation, and again, such an integration is best evaluated graphically.

Graphical integrations have been performed for the Motorola MRD series of phototransistors for several values of lamp colour temperature. The results are given in Figures 12 and 13 in terms of ratios. Figure 12 provides the irradiance ratio, H_E/H versus colour temperature. As the curve shows, a tungsten lamp operating at 2600°K is about 23.6% effective on the MRD series devices. That is, if the broadband irradiance of such a lamp is measured at the detector and found to be 20 mW/cm², the transistor will effectively see

$$H_E = 0.236\,(20) = 4.72 \text{ mW/cm}^2$$

The specifications for the MRD phototransistor series include the correction for effective irradiance. For example, the MRD450 is rated for a typical sensitivity of 0.8 mA/mW/cm². This specification is made with a tungsten source operating at 2870°K and providing an irradiance at the transistor of 5.0mW/cm². Note that this will result in a current flow of 4.0mA.

However, from Figure 12, the effective irradiance is

$$H_E = (5.0)(.255) = 1.28\text{mW/cm}^2$$

By using this value of H_E and the typical sensitivity rating it can be shown that the device sensitivity to a monochromatic irradiance at the MRD450 peak response of 800nm is

$$S = \frac{I_C}{H_E} = \frac{4.0\text{mA}}{1.28\text{mW/cm}^2} = 3.13\text{mA/mW/cm}^2$$

Now, as shown previously, an irradiance of 20 mW/cm² at a colour temperature of 2600°K looks like

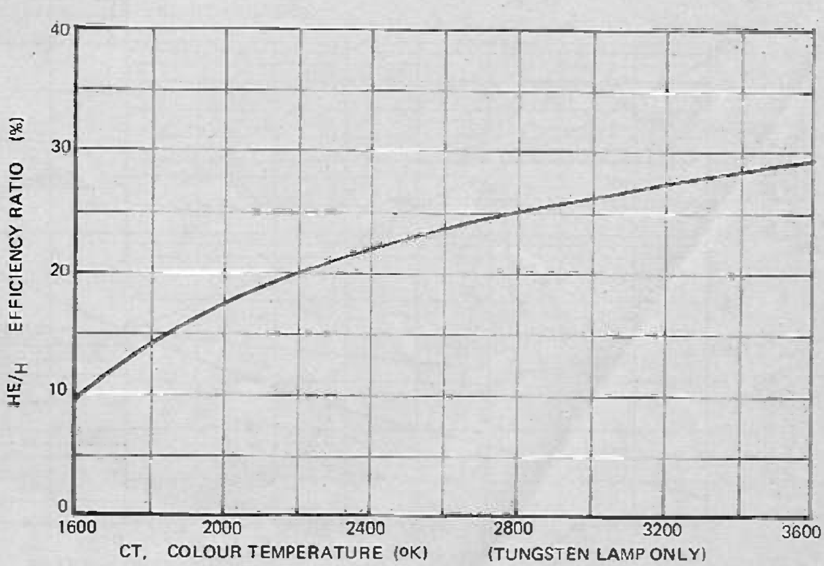


Fig. 12. Phototransistor irradiance ratio versus colour temperature.

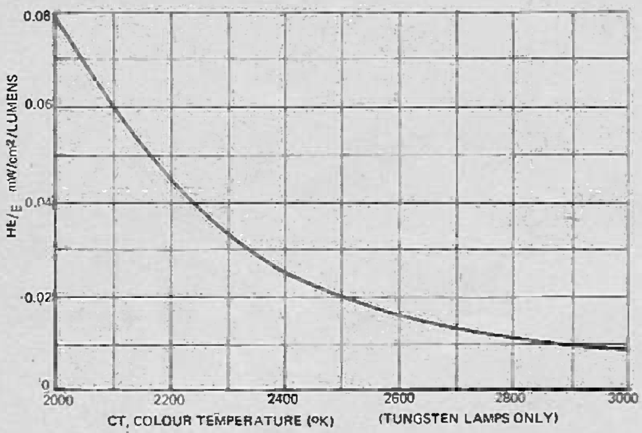


Fig. 13. Phototransistor irradiance/illuminance ratio versus colour temperature.

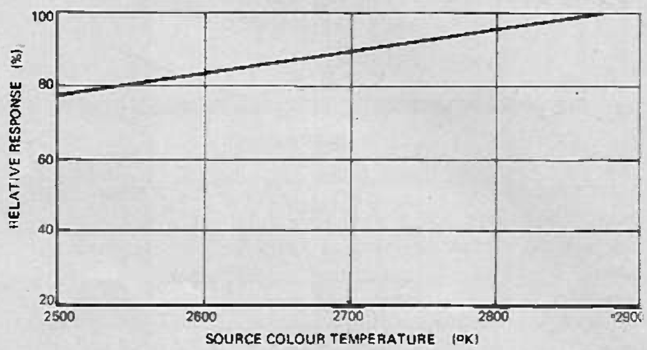


Fig. 14. Relative phototransistor response versus colour temperature.

monochromatic irradiance at 800nm of 4.72 mW/cm². Therefore, the resultant current flow is

$$I = SH_E\,(3.13)(4.72) = 14.4\text{ mA}$$

An alternate approach is provided by Figure 14. In this figure, the relative response as a function of colour temperature has been plotted. As the curve shows, the response is down to 83% at a colour temperature of 2600°K. The specified typical response for the MRD450 at 20mW/cm² for a 2870°K tungsten source is 0.9mA/mW/cm². The current flow at 2600°K and 20 mW/cm² is therefore

$$I = (0.83)(0.9)(20) = 14.9\text{mA}$$

This value agrees reasonably well with the result obtained earlier.

Similarly, Figure 13 will show that a current flow of 6.67 mA will result from an illuminance of 125 lumens at a colour temperature of 2600°K.

Determination of Colour Temperature — It is very likely that a circuit designer will not have the capacity to measure colour temperature. However, with a voltage measuring capability, a reasonable approximation of colour temperature may be obtained. Figure 15 shows the classical variation of lamp current, candlepower and lifetime for a tungsten lamp as a function of applied voltage. Figure 16 shows the variation of colour temperature as a function of the ratio.

$$\rho = \frac{MSLP}{WATT}$$

where

MSLP is the mean spherical lumens at the lamp operating point and WATT is the lamp IV product at the operating point.

As an example, suppose an indicator lamp is used as a source for a phototransistor. To extend the lifetime, the lamp is operated at 80% of rated voltage.

Rated Volts	Rated Current	MSL
6.3V	150mA	0.52 approx.

Geometric Considerations

The lumen ratings on most lamps are obtained from measuring the total lamp output in an integrating sphere and dividing by the unit solid angle. Thus the rating is an average, or mean-spherical-lumens. However, a tungsten lamp cannot radiate uniformly in all directions, therefore,

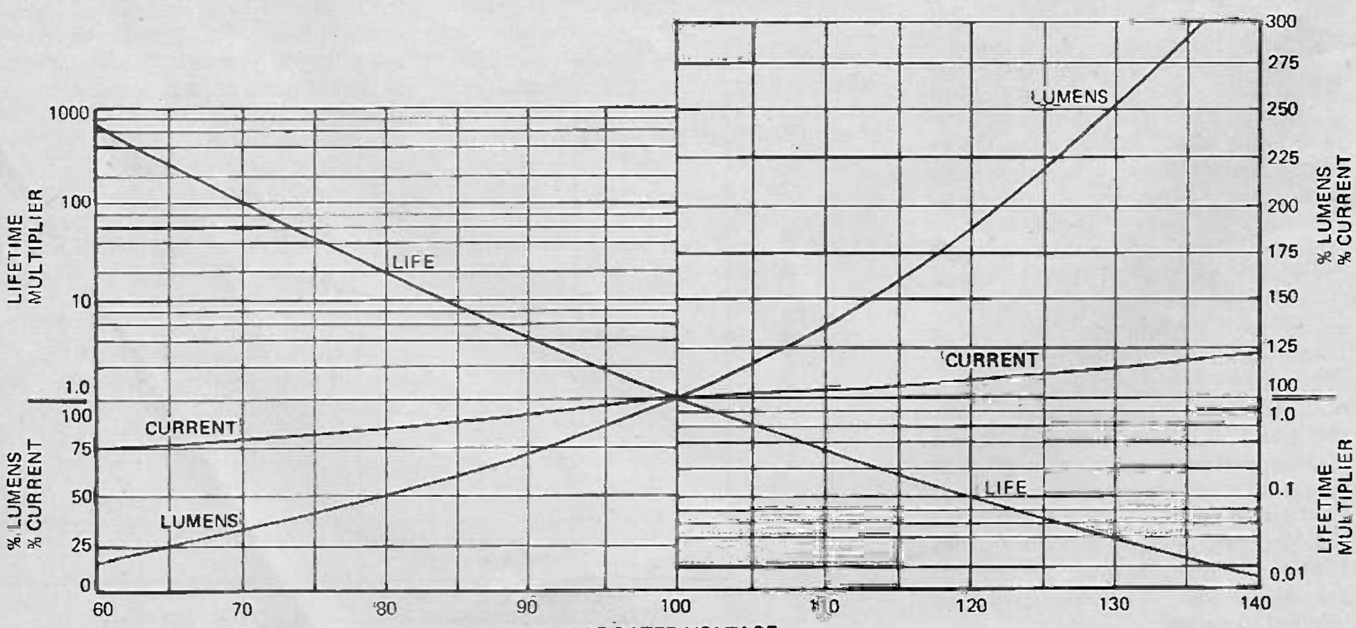
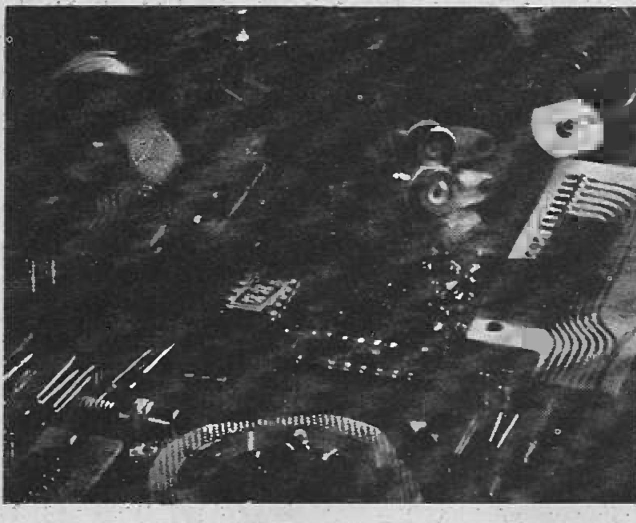


Fig. 15. Tungsten lamp parameter variations versus rated voltage variations.



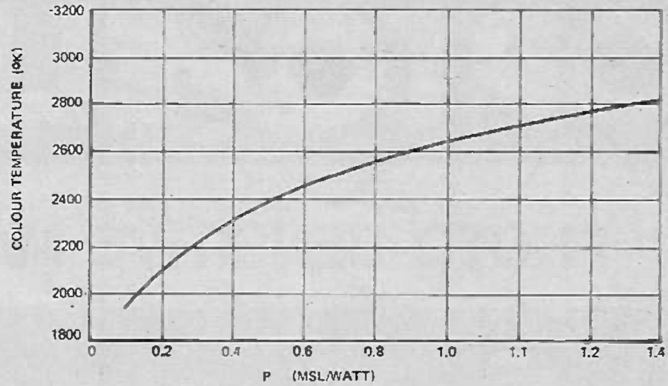


Fig. 16. Colour temperature versus candle power/power ratio.

Various opto-electronic devices in the Texas Instruments range.

the lumen rating varies with the lamp orientation. Figure 17 shows the radiation pattern for a typical frosted tungsten lamp.

The circular curve simulates the output of a uniform radiator, and contains the same area as the lamp polar plot. It indicates that the lamp horizontal output is about 1.33 times the rated MSL, while the vertical output, opposite the base, is 0.48 times the rated MSL.

The actual polar variation for a lamp will depend on a variety of physical features such as filament shape, size and orientation and the solid angle intercepted by the base with respect to the centre of the filament.

If the lamp output is given in horizontal lumens (HLR), a fairly accurate calculation can be made with regard to illuminance on a receiver.

A third-form of rating is beam lumens, which is provided for lamps with reflectors.

In all three cases the rating is given in lumens/steradian or candlepower.

SOLID STATE SOURCES

In contrast with the broadband source of radiation of the tungsten lamp, solid state sources provide relatively narrow band energy. The gallium arsenide (GaAs) light-emitting-diode (LED) has spectral characteristics which make it a favourable mate for use with silicon photodetectors. LED's are available for several wavelengths, as shown in Figure 18, but as the figure shows, the GaAs diode and the phototransistor are particularly compatible.

The GaAs response and the MRD series response indicates that the efficiency ratio, H_E/H, is approximately 0.9 or 90%. That is, an irradiance of 4.0 mW/cm² from an LED will appear to the phototransistor as 3.6 mW/cm². This means that a typical GaAs LED is about 3.5 times as effective as a tungsten lamp at 2870°K. Therefore, the typical sensitivity for the MRD450 when used with a GaAs LED is approximately

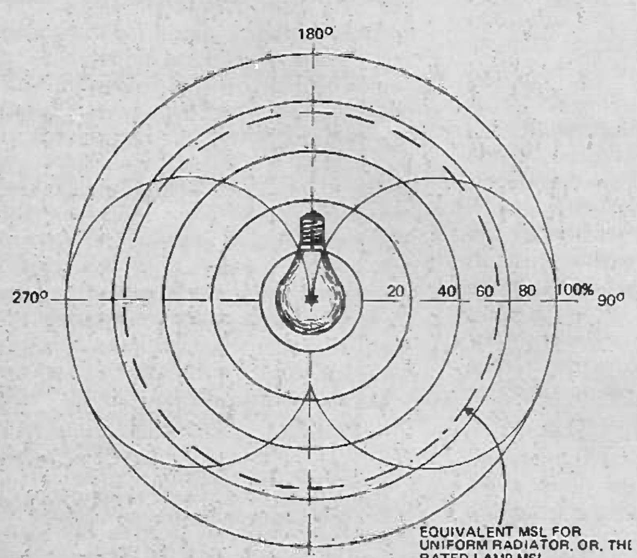
$$S = (0.8)(3.5) = 2.8\text{mA/mW/cm}^2$$

An additional factor to be considered in using LED's is the polar response. The presence of a lens in the diode package will confine the solid angle of radiation. If the solid angle is θ, the resultant irradiance on a target located at a distance d is

$$H = \frac{4P}{\pi\theta^2 d^2} \quad \text{watts/cm}^2,$$

where

P is the total output power of the LED in watts
θ is the solid angle in steradians, and
d is the distance between the LED and the detector in cm. ●



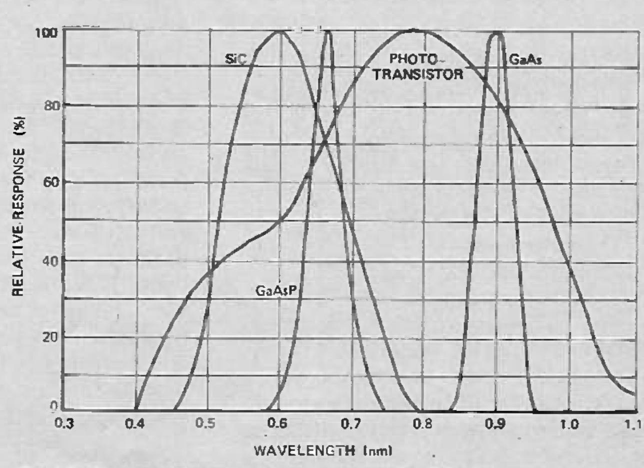


Fig. 18. Spectral characteristics for several LEDs compared with response of a typical phototransistor.

Fig. 17. Typical radiation pattern for a frosted incandescent lamp.

PHOTO SENSITIVE MATERIALS AND DEVICES

Part of the range of Philips' Photomultipliers.

In this article we discuss the various methods and equipment used in the detection and measurement of light and near light radiation.

THERE are many materials and devices which are in use now, or have been in the past, for converting light or near-light radiation directly into electrical energy. These photosensor devices may be grouped into three broad categories:—

1) Photo emissive
2) Photo voltaic
3) Photo conductive

PHOTO EMISSIVE DEVICES

The basic form of photoemissive device is similar to an ordinary vacuum tube diode in that it is a two electrode device and is built into a glass envelope which may be either highly evacuated, or filled with an inert gas.

The vacuum devices are used in instruments specifically designed for the precise measurement of illumination levels, whereas the gas filled devices are generally used in switching-mode designs where a large photo-current change is required with small changes of incident illumination. Typical applications of gas filled photodiodes are in flame-failure detectors and burglar alarms.

The structure of a typical photo-diode is as shown in Fig. 1. A single rod or loop of wire forms the anode. The cathode, a curved metal plate located behind the anode, is coated with an emissive material which will liberate free electrons in proportion to the amount of incident light. These electrons are attracted to the anode, which is at a positive potential with respect to the cathode, and hence a current flows through the external circuit, again proportional to the incident light level.

Two types of alkali-earth materials are used for the cathode coating, depending on the spectral response required. These are:—

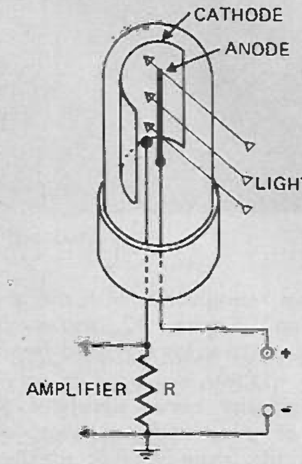


Fig. 1a. Photo-emissive vacuum-tube diode.

1) Caesium-antimony (blue sensitive)
2) Caesium-oxidised silver (red sensitive).

Dark Current

Some current flows due to thermionic emission and leakage without any illumination incident on the cell. This current, known as the *dark current*, varies with ambient temperature and applied voltage and is the factor which limits the ultimate sensitivity of the cell.

The Photomultiplier Tube

Photo emissive diodes have largely been replaced by their solid-state counterparts, but there are some

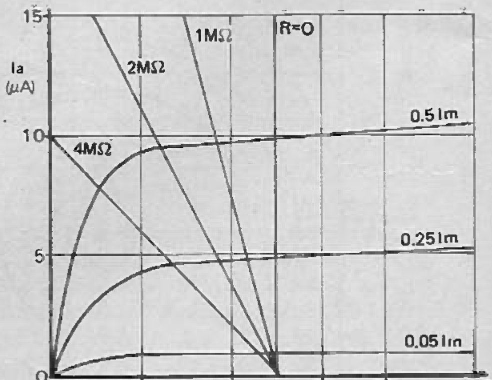
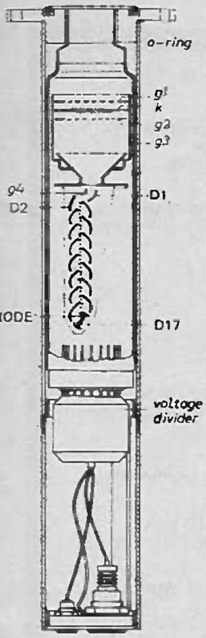


Fig. 1b. Characteristics of vacuum-tube photo-emissive diode with various load resistors.



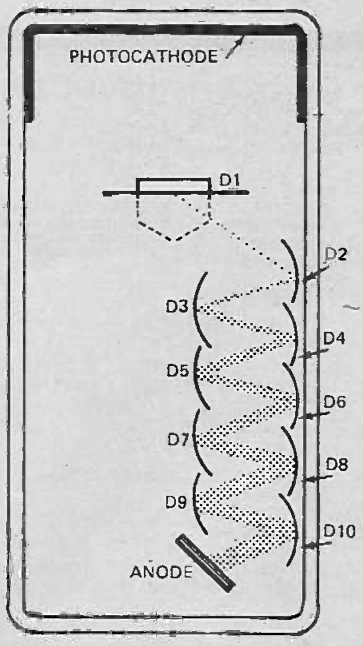


Fig. 2b. Illustration of electron multiplication process of photomultiplier.

Fig. 2a. Construction of typical photomultiplier tube (Philips).

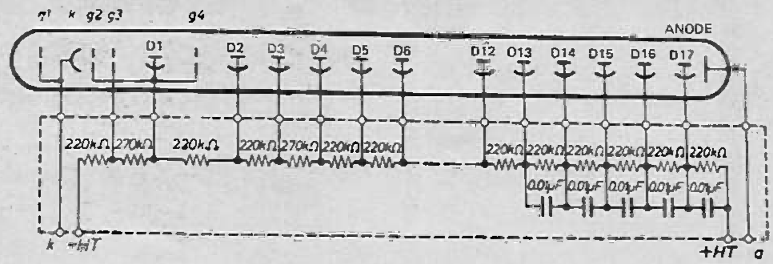


Fig. 3. Power supply divider chain for photomultiplier.

devices, developments of the basic photo-emissive diode which are still widely used in observatories etc for the measurement of extremely low light levels. This is the photomultiplier tube — these devices have gains of the order of 10^8 and offer signal to noise ratios virtually unmatched by photo-semiconductor/amplifier combinations. The construction of a typical photomultiplier is sh own in Fig. 2.

The cathode of the photomultiplier has a coating of translucent alkali-earth material (caesium antimonide) on the inner surface of the faceplate. Incident light, passing through the face plate, releases electrons that are attracted to electrode D1 which is at a positive potential with respect to the cathode. These electrons impinging on D1 release secondary emission electrons that are attracted to D2 which is held at a higher potential than D1. The process continues with electron multiplication occuring at each stage. The intermediate elements commonly called dynodes, are coated with emissive material, the number of dynodes depends on the application and is usually between 9 and 14. Using this principle photomultipliers can achieve sensitivities better than 125 microamps per lumen. This high sensitivity means that the tube cannot be connected to the power supply under normal light conditions without damage. A luminous flux of less than 10^{-5} lumen is sufficient to cause the maximum permissible anode current to be exceeded.

The photomultiplier is obviously a valuable tool for the detection and measurement of very low light and radiation levels. The device is much used by astronomers and is capable of detecting and measuring single photons and particles.

Photomultipliers do have some disadvantages however, some of these are:—

1) with tubes having 9-14 dynodes a supply of 1500 to 2100 volts is required (150V per dynode).

2) the supply must be extremely well regulated. If a gain stability of 1% is required, a supply with a regulation of 0.1% must be provided. That is power supply regulation must be 10 times better than the accuracy required.

3) an external divider must be provided to give the necessary electrode voltage steps. Fig. 3.

4) the device must be switched on for at least half an hour before use to allow the dark current to stabilise.

Channel Electron Multiplier.

The channel electron multiplier, a relatively new device, is particularly suitable for the detection of low level radiation in the ultra-violet and soft X-ray regions (1500 to 2Å). The operating principle is similar in many ways to that of the photomultiplier tube but it is physically much simpler and smaller (an inch or so in diameter) and does not require a resistive divider.

The device is essentially a small curved glass tube, the inside of which is coated with a high resistivity material. When a potential is applied between the ends of the tube, the resistive surface becomes a continuous dynode, electrically analogous to the separate dynodes of the photomultiplier together with the resistive divider chain used to establish the separate dynode potentials.

The channel electron multiplier operates happily in a vacuum. For space research the environmental vacuum is sufficient, and there is then no window separating the multiplier from the radiation source with consequent loss of sensitivity. The devices were in fact used as the principal charged particle detector in the Apollo mission lunar environment experiments and have also found use in rocket-probe investigations of plasma in auroral zones.

Operation of the device is as follows — an electron (or other charged particle) entering the low potential end of the channel multiplier, generates secondary emission electrons on collision with the wall of the tube (Fig. 4). These are accelerated along the tube until they strike the wall again, where further secondary emission electrons are generated. This process is hence similar to that in the photomultiplier, but — the number of collisions and therefore stages of multiplication is indeterminate due to the number of different electron paths possible. Hence the principle application of this device *is to produce an output pulse for each incident charged particle.* It is therefore primarily a particle counter without the photomultiplier's ability to measure energy levels accurately. It can be compared in some measure to the geiger counter.

The devices are typically operated in

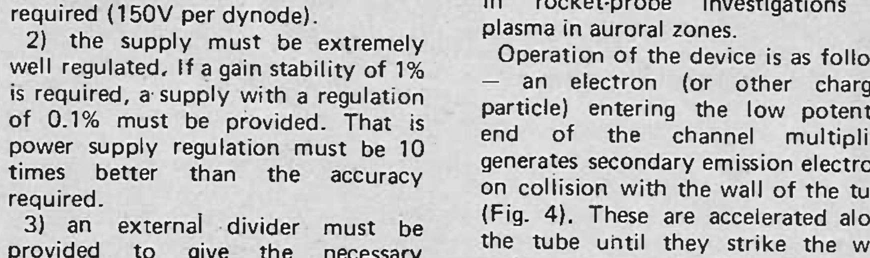


Fig. 4. Operating principle of basic electron multiplier

OPERATING CHARACTERISTICS OF LIGHT–SENSITIVE DEVICES

Parameter	Phototransistor Si (PNP or NPN)	Photodiode Si	Photo SCR	Photovoltaic & Si	Photoconductive Selenium	Photoconductive Only Cd S, Cd Se	Photoemissive (Phototubes Etc.)
Fatigue or Hysteresis	None	None	None	None	Fatigue: Worst Case: (R_{Load} — $R_{Int.}$)	Hysteresis: Conductance function of the cell's exposure to light & duration.	Anode current decreases with time.
Bilateral Electrical Characteristic	No	No	No	No	No	Yes	No
Maximum Operating Temperature.	125°C	125°C	100°C	150°C	Continuous 85°C Intermittent 100°C	75°C	75°C to 100°C
Maximum Voltage	50 VDC	100 VDC	200 V_{BO} See Note 1	V_R=1.5V See Note 3	V_R=1.2V See Note 3	Up to 1000V	2800V (Anode)
Current Capability	1-50 mA	50-200µA at 200 mW/cm²	1.4 A	1 A See Note 2	150 mA	10 mA-1.0A	Up to 10 mA
Power Dissipation	50-400 mW	Up To 50 mW	2 Watts	Up To 400 mW See Note 3	75 mW	50 mW-25 Watts	10 mW-1 Watt
Frequency Capability	200 KHZ	200 KHZ (Pin Device up to 10 MHZ)	1 KHZ	50 KHZ	5 KHZ	1kHz	10MHz
Rise Time and Fall Time	2-100 µ Sec.	Up To 2 µSec.	2 µSec.	0.5-100 µSec.	1 m Sec.	0.2 to 100 m Sec.	0.1 µSec.
Spectral Response	Visible To Near IR	Visible To Near IR	Visible To Near IR	Visible To Near IR	UV To Near IR	Visible To Near IR	UV To IR
Color Sensitivity	More Red Than Blue	More Red Than Blue	More Red Than Blue	More Red Than Blue With Filter & Heat Absorbing Glass Approx. Std. Obs. Curve	More Blue Than Red with Kodak Wraten Filter #G1 Approx. Std. Obs. Curve.	More Red Than Blue	At Higher Voltages Are slightly more Red Sensitive.
Useful Operating Light Levels	0.001-20 mW/cm²	0.001-200 mW/cm²	2-200 mW/cm²	.001 mW/cm² 1.0 Watt/cm² See Note 2	0.1-70 mW/cm²	0.001-70mW/cm² or 10^{-3} to 10^{+3} Pt. C.	10^{-9} — 500 mW/cm²
Long Term Stability	Good	Excellent	Good	Excellent	Poor To Good	Poor To Good	Good
Size	Small	Smallest	Small	Medium	Medium	Medium	Large

NOTES: (1) V_{BO} — Breakover Voltage
(2) Subject to an energy density limitation of 1.0 watt/cm²
(3) Normal operating range

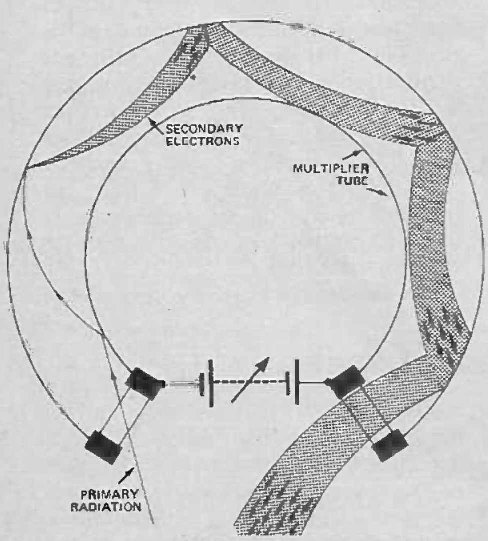


Fig. 5a. Curved tube improves electron multiplier operation.

the saturation mode (gain independant of particle energy) with an applied potential of 2.5kV. In this mode the gain is typically of the order of 3 x 10^8. Below saturation, that is when the gain is 10^7 or less, there is some proportionality between output and input, but as stated above, there is a spread of pulse amplitudes because of the many possible electron paths and accurate energy level measurements are not possible.

It has been found that the gain of a device using a straight glass tube is limited because of an effect known as "ion feedback". In the collision process some positive ions are liberated which drift back towards the front of the tube where they collide with the wall generating spurious output pulses. If the tube is curved rather than straight, the ions strike the wall before they have acquired sufficient energy to liberate secondary emission electrons. Electron gain however, is unaffected as electrons need acquire an energy of only 50eV in order to liberate secondary emission electrons from the tube wall.

The multiplier will respond to ions, particles, X-rays or any other sufficiently energetic radiation. The detection efficiency of a channel multiplier is different for the various forms and energies of excitation, but any particle or quantum capable of exciting an electron from the dynode surface has a finite probability probability of detection.

The Image Converter and The Image Intensifier.

Image converters are devices which convert an applied image, which may

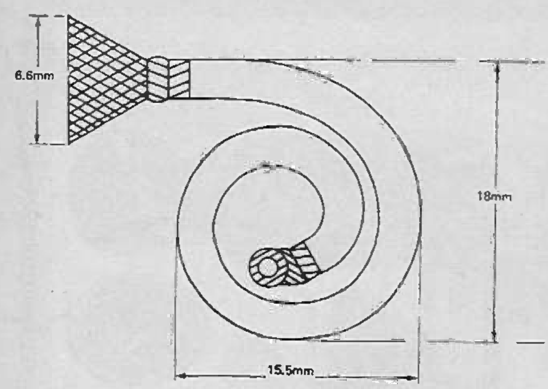


Fig. 5b. Dimensions of typical Philips electron multiplier (see also front cover picture).

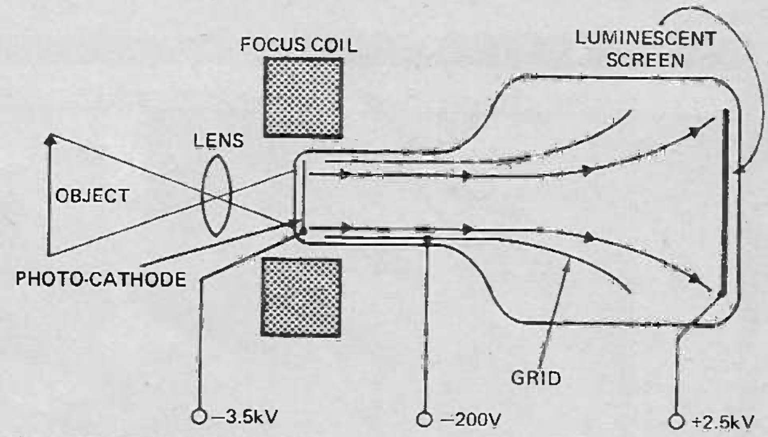


Fig. 6. The image converter tube.

be either visible or invisible into a visible image on a fluorescent screen. The principle of operation may be understood by reference to Fig. 6. An infrared image, for example, may be focused onto the photoemissive cathode which emits electrons from each tiny segment of the surface in proportion to the incident radiation. These electrons are accelerated along the tube by an electric field and impinge on a screen at the far end of the tube which is coated with phosphors, and hence produces a visible image. Apart from the use as a converter, the tubes are also sometimes used as a shutter for high speed photography by applying very short pulses to the control grid thus gating the tube on for a very short period.

The image intensifier is similar to the image converter but is specially designed to produce a very bright final image and hence finds considerable use in electron microscopy and in low light level television systems.

PHOTOCONDUCTIVE DEVICES

A photoconductive device is essentially a resistor in which the resistance value changes in inverse proportion to the amount of incident light energy.

Photoconductors are typically made of amorphous semiconductor materials such as cadmium sulphide (CdS), and cadmium selenide (CdSe).

The cadmium sulphide cell (sometimes known as a light dependent resistor LDR) is a compact and inexpensive detector of infra-red radiation. Basically the device consists of a ceramic substrate which supports a layer of photo-conducting cadmium sulphide. Metallic electrodes make contact with the device the whole being mounted in a protective enclosure. When exposed to visible radiation it exhibits the greatest change of resistance of any photoconductor, varying 4 to 6 orders of magnitude between the dark and illumined conditions. Its dark resistance is of the order of 5×10^{11} ohms. The energy band gap is 2.4 electron volts, providing a cut-off wavelength of 500nm. (Fig. 7). The response of the cell closely matches that of the human eye and it is quite often used for photographic exposure meters and inexpensive illumination meters.

One disadvantage of cadmium sulphide cells is their slow recovery rate. Starting with an illumination level of 100 lux, the recovery rate during the first 20 seconds, after removal of the illuminant, is 200kohm per second. This limits their use to relatively steady state applications.

Cadmium selenide photoconductors are very similar to cadmium sulphide devices but have an energy gap of 1.8 electron volts. Hence the spectral response extends further into the near-infrared region with a peak at 700nm. Cadmium selenide also has a very high ratio of dark to light resistance.

If a silicon PN junction sensor is reverse biased by an external voltage, it will act in a photoconductive mode. The amount of reverse current will be proportional to the intensity of the incident radiation. When used in this reversed biased mode, the silicon junction is known as a photo diode.

Photoconductive devices are passive and must be supplied with power in order to work. Hence modern photographic exposure meters using cadmium sulphide cells are also fitted with a mercury battery.

PHOTOVOLTAIC DEVICES

Photovoltaic devices convert incident radiation directly into electrical power, producing voltage and current without the need for a separate bias

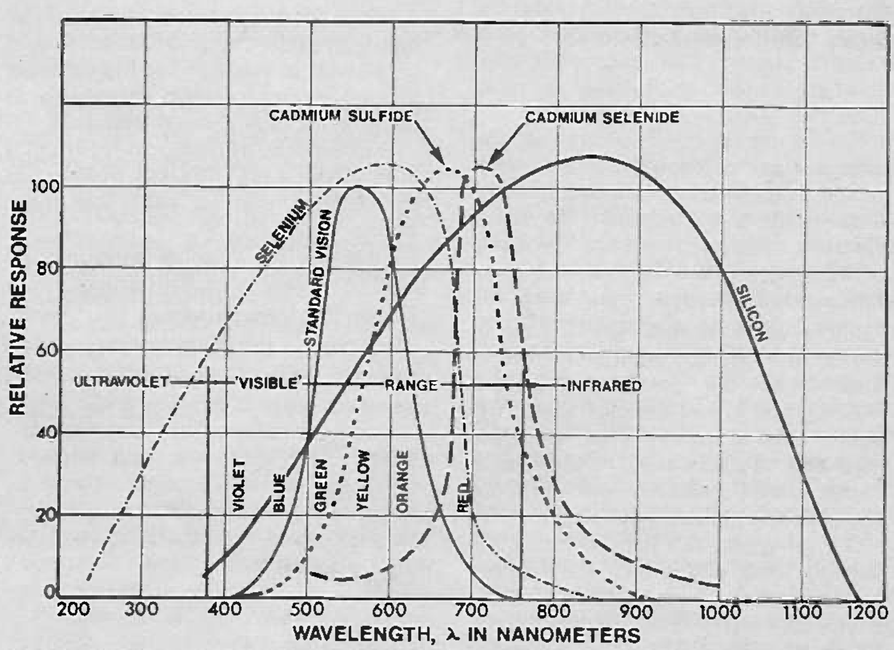


Fig. 7. Typical photodetectors — comparison of spectral responses.

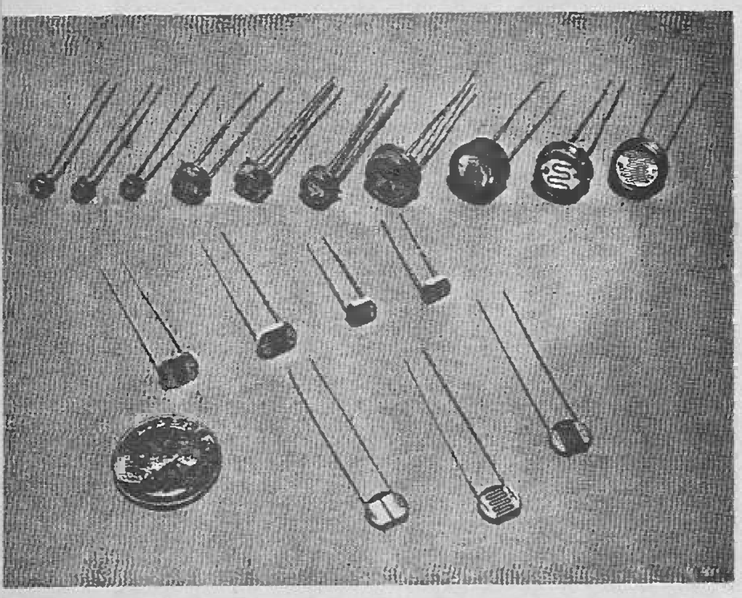


Fig. 8a. Photoconductive cells (Vactec Inc).

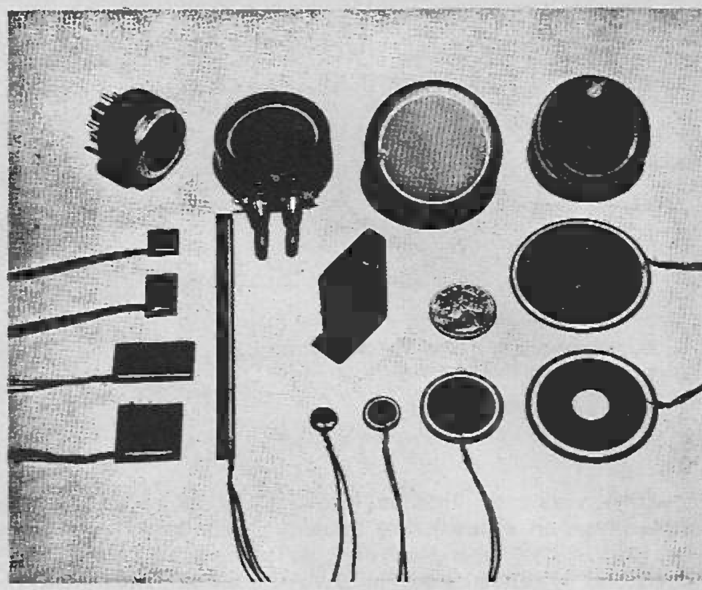


Fig. 8b. Photovoltaic devices (Vactec Inc).

supply. The photons of light impinging on a semiconductor junction form hole/electron pairs. These are acted upon by the internal field at the junction, resulting in a potential difference and hence a current when an external circuit is completed.

Typical examples of early photovoltaic cells are the copper oxide and selenium types. Typical modern devices are silicon solar cells, photo diodes and photo transistors.

The Selenium Cell

The selenium cell, also sometimes known as the barrier layer cell, has been in use for many years in photometric equipment and more recently in automatic cameras and exposure meters. The reasons for its use are its high efficiency in the visual range and its high output for a given radiant power. The output is high enough in fact to operate a relay directly.

The short circuit output of the selenium cell is directly proportional to the irradiation, and to the detector area irradiated, whereas the open circuit voltage is logarithmically proportional to irradiation.

Silicon Photo Diodes

Silicon photo diodes may be used in either the photoconductive (reverse biased) or the photovoltaic (zero biased) modes, but because size of the active area is usually small they are used almost exclusively in the reverse biased photoconductive mode in order to obtain significant signal levels.

The physical size of the effective (active) area will affect the leakage current, junction capacitance and the device sensitivity to incident radiation. These characteristics in turn greatly influence the frequency response and switching time parameters.

The reverse biased photodiode's signal current is linear over a wide range of irradiance, provided the load plus series resistance is not current limiting. On the other hand, at extremely low irradiance levels, signal linearity is limited by the shot noise current for the operating noise bandwidth. Shot noise current results from reverse leakage current and is minimized by reducing surface leakage to the minimum through planar, diffused, oxide passivated fabrication.

In many applications, the photodiode is used with an amplifier circuit. Basic considerations for the amplifier include proper photodiode reverse bias voltage (to reduce the diode shunt capacitance) and amplifier input impedance. Impedance should be as high as possible for high gain or low noise requirements, or as low as possible for high speed of response.

Another class of photodiodes are PIN diodes which are ultra-fast devices (up to 10MHz) with a very low noise figure.

These devices in some areas may be used to replace photomultipliers.

Silicon Phototransistors

Silicon phototransistors have inherent gain which provides a much higher output than photodiodes for a given irradiance level. However, the phototransistor may not provide usable output signal levels at low irradiance levels. Due to gain fall off at low currents, a phototransistor at low irradiance level may not produce more signal output than a photodiode. Therefore, a designer should first determine the type of light source to be used and its radiation level before device selection. Performance characteristics can be obtained from a manufacturer's data bulletins.

In most cases, the phototransistor is operated open base (floating) see Fig. 9 The photo-induced current is the transistor base current; the collector-base junction is reverse biased and the diode current is the reverse leakage current. Thus if the incident radiation is applied to the base, a significant increase is base current is observed. If the emitter injection efficiency is large enough, collector current will increase significantly and will observe the relationship.

$$I_C = (h_{FE} + 1) I_\lambda$$

where I_C is the collector current, hFE is the forward current gain, and I_λ is the photo-induced base current.

PIN diodes and phototransistors are discussed more fully in a later article.●

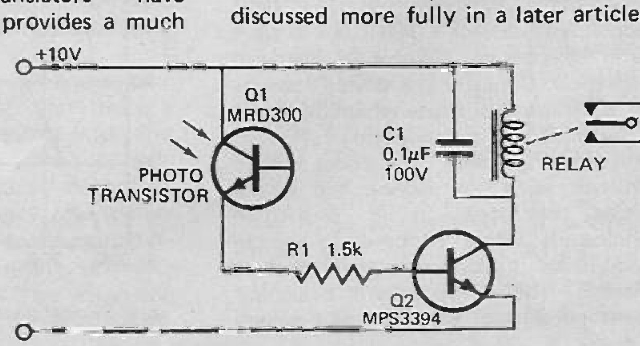
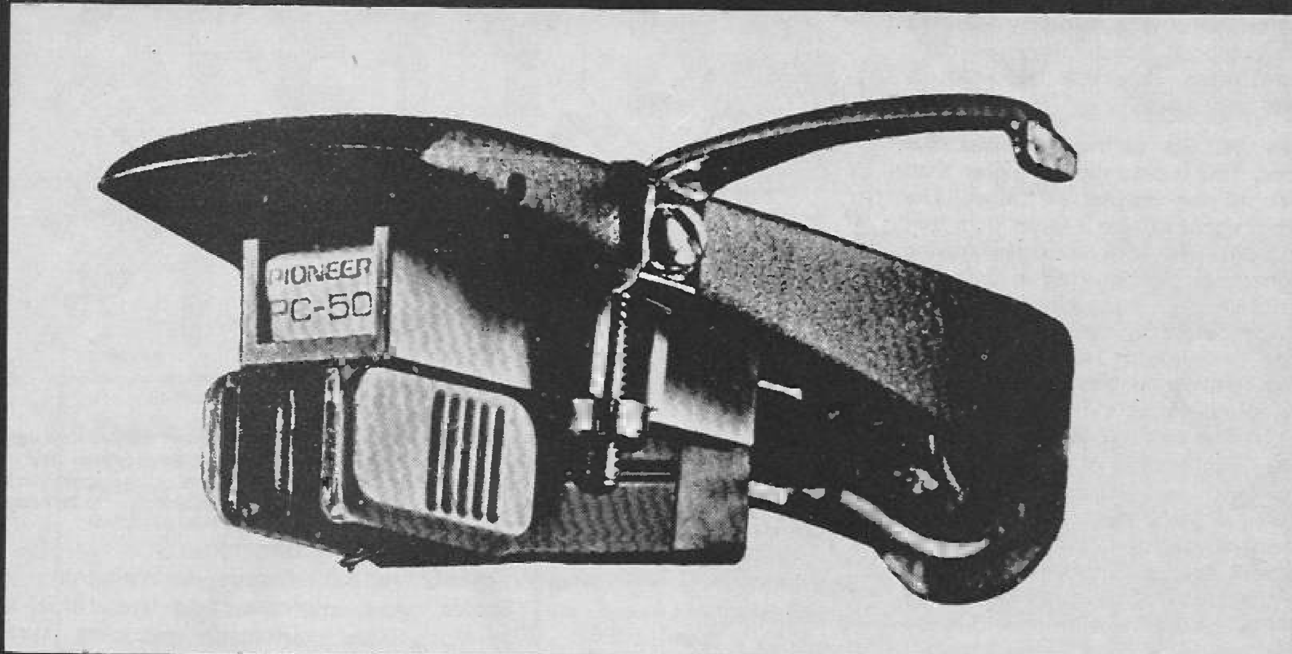


Fig. 9. Circuit of light operated relay illustrates open base operation of a phototransistor.



PIONEER PC-50 PHONO CARTRIDGE

electronics TODAY INTERNATIONAL product test

This new induced magnet cartridge from Pioneer is very good value for money.

THE most critical elements in a record playing system are the cartridge and the speakers, for it is these devices that convert the velocity of the stylus in the record's grooves into an electrical signal, and then to audible sound at the far end of the system.

The types of cartridges available today are many and varied and, of these, crystal cartridges dominate the low-cost market whilst moving magnet and induced magnet units are more commonly used in the high fidelity field.

The performance of most good cartridges has increased steadily over the past decade, to the point where dramatic improvements are unlikely to be made — whether judged by subjective appraisal or comparison.

Whilst the measured performance of a cartridge is of great value, most users will regard subjective impressions as being more important. And so do we. Nevertheless, whether the purpose of an evaluation is to compare two cartridges, or simply to determine a standard of quality, measurement still has a significant role.

The new PC-50 cartridge constitutes a radical change for the Pioneer group, for, after many years intensively developing moving magnet cartridges, the company has produced an induced magnet type. Very few manufacturers produce induced magnet cartridges; for it is generally claimed that moving magnet cartridges are easier to make, lighter in weight and provide better performance.

Perhaps as a generalization this is correct, but this new cartridge has shown that, on two counts at least, there are exceptions to the supposed rule.

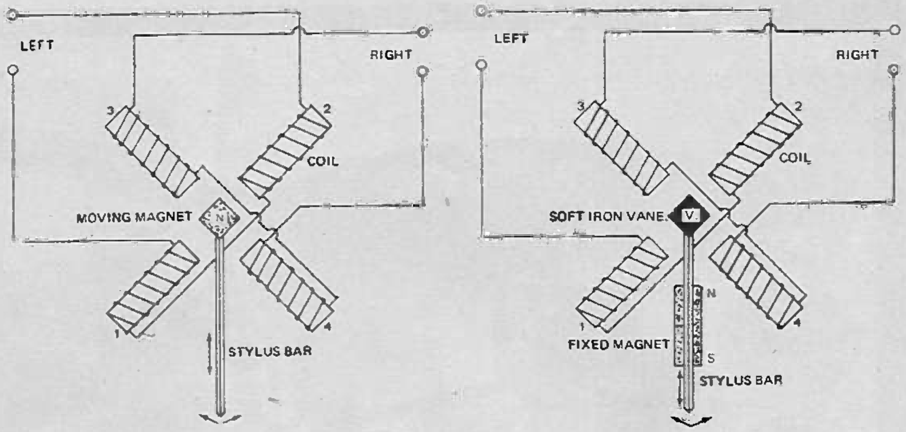
The PC-50 cartridge is different in appearance from the other magnetic cartridges produced by Pioneer. Whilst its dimensions are similar, the first, and immediately apparent difference, is the light blue 'H' yoke of the stylus assembly — which comes complete with finger grip and stylus protector. The choice of an 'H' yoke is rational, and the ease with which the stylus can be removed is slightly better than we have found in some other conventional moving magnet assemblies.

The positive location of the induced magnet assembly of the stylus is assured by two slots in the assembly as well as by two strong moulded stops. The front of the 'H' yoke acts as a holder for the stylus protector and this may be useful with manually operated arms, or on a record player which is moved often. Otherwise we doubt its practical value.

The PC 50 cartridge weighs 6.8 grams. This is only slightly higher than most moving magnet cartridges. The output signal voltage is lower than that produced by the *average* moving magnet cartridge, but higher than that produced by cartridges commonly regarded as being the best obtainable.

The performance of this cartridge, using commercial trackability records, was found to be extremely good. In fact, it was so good that we reran the test to confirm the results. Had it not been for an ultrasonic resonance beyond 20kHz this cartridge would provide a trackability comparable to the very best cartridges available. The high frequency trackability is affected by this resonance and consequently there is a slight mistracking apparent at velocities in excess of 15cm/sec at frequencies over 10kHz.

The subjective impressions from this cartridge were formed using a number of new records. These included the new Cherry Pie "Just the Beginning" (NCPS1009), which is a fine demonstration record to show off a high fidelity system. Another, new record that we used was Boulez Conducts Ravel, (SBR 235446), featuring the Cleveland Orchestra. This exhibits the extremes in levels and tempo characteristic of Ravel's work and provided an excellent trackability test for the Pioneer PC 50.



These drawings show the basic difference between the moving magnet and the induced magnet principle. The moving magnet system is shown on the left – here the magnet is mounted directly on the end of the stylus – the induced magnet pick-up is shown on the right – in this case magnetic flux is induced into the stylus from a magnet that is located close to but not in contact with the stylus.

Instrumental testing confirmed our outstanding subjective impressions of this cartridge.

The frequency response was measured using our latest Bruel and Kjaer automatic recording system which records the true frequency performance and also the channel separation. This confirmed that the frequency response from both channels is within plus or minus 2 dB

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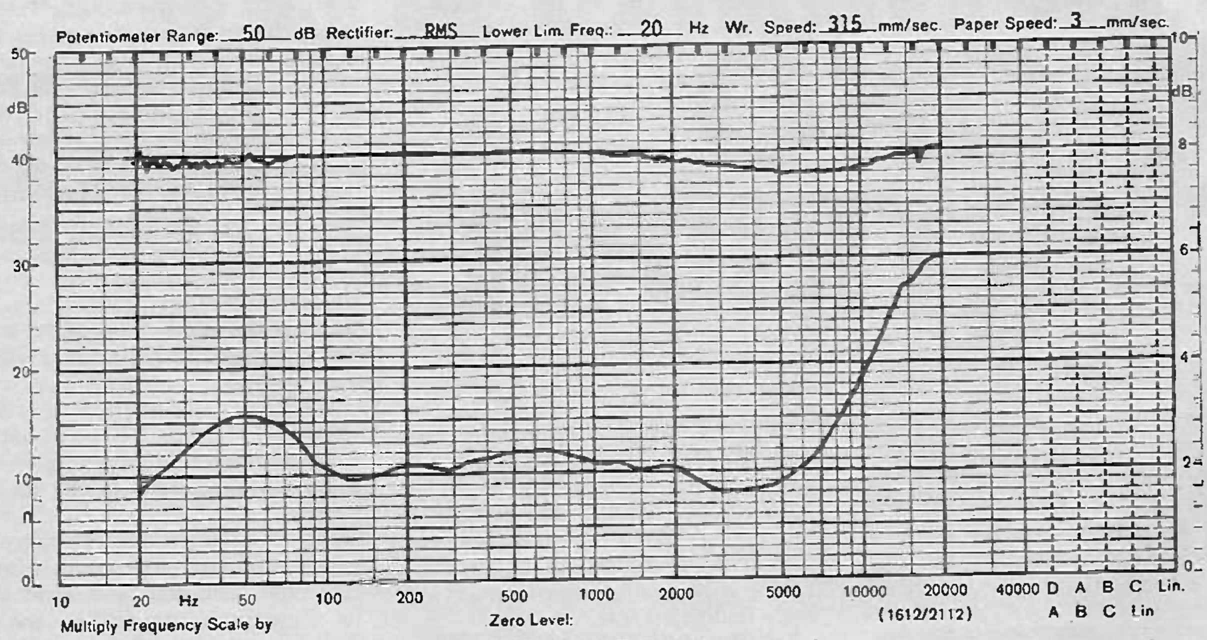
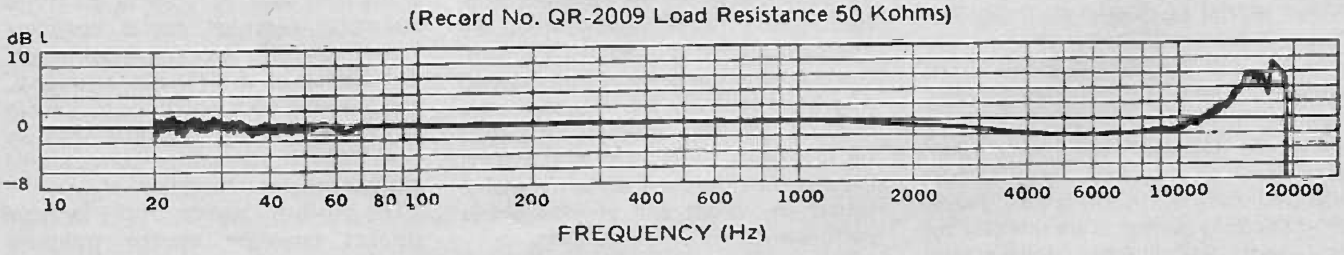


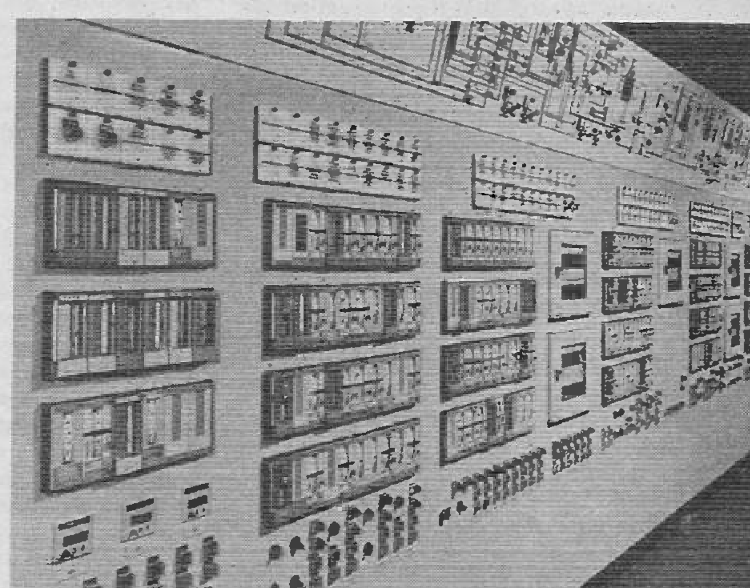
Frequency Response

(Record No. QR-2009 Load Resistance 50 Kohms)



The measured frequency response of the Pioneer PC-50 cartridge is better than the maker's specifications. Compare these graphs. The top curves are ours – measured in a NATA registered laboratory – whilst Pioneer's graph is show below.

SAFETY BARRIERS



A typical control panel protected by Zener Barriers.

The combination of electrical equipment and flammable atmospheres can be quite explosive. This article, abstracted from a paper by D R Gaunt* and A T Mead* and information provided by George Kent Ltd, explains how Zener barriers contribute to industrial safety.

A FUNDAMENTAL requirement of any *electronic control scheme* operating in or around flammable process materials is an inherent safeguard against interaction between process material and equipment. More specifically, any circuit, or part of a circuit, should be incapable of causing ignition of the gas or vapour in which it is operating. This applies not only to the normal working conditions of fault, such as damage to leads, wiring or failure of electronic components. Generally speaking, a system which fulfils these requirements is said to be intrinsically safe for use within specified conditions.

Note here the use of the word 'system'. It is not always appreciated that an instrument can only be regarded as safe when all other equipment associated with it also meets the required safety standards. This applies not only to equipment located within the danger areas but to all relevant equipment (right back to the control room if necessary). Thus, it is more correct to speak of 'intrinsically safe systems' rather than intrinsically safe instruments.

Also, of course, the degree of hazard involved is related to the nature of the flammable material and to the proximity of the measurement, transmission or control systems. Hence, requirements for a particular scheme operating in one location may differ considerably for the same scheme operating elsewhere.

Formerly with Kent Instruments.

Types of hazard encountered are closely defined in the UK by British standards and the methods of classification are detailed below.

UK CLASSIFICATIONS

Intrinsically Safe Circuit

Applied to a circuit to denote that any sparking that may occur therein in normal working is incapable of causing an explosion of the prescribed flammable gas or vapour.

Intrinsically Safe Apparatus

Applied to apparatus to denote that it is so constructed that when connected and used under the prescribed conditions any sparking that may occur therein is incapable of causing an explosion of the prescribed flammable gas or vapour.

Safe Area

An area or enclosed space within which a flammable or explosive substance, whether gas or vapour or volatile liquid is never present in concentration within the upper and lower limit of flammability. A 'local' safe area may be created by techniques such as flameproofing, purging or pressurisation.

Hazardous Area

An area within which a hazard is present, occurs or is liable to occur. Areas of hazard are generally classified into three catagories.

Division 0 — An area or enclosed space within which any flammable or explosive substance, whether gas, vapour or volatile liquid, is continuously present in concentration within the upper and lower limits of flammability.

Division 1 — An area within which any flammable or explosive substance, whether gas, vapour or volatile liquid, is processed handled or stored and where, during normal operations an

	CONTINUOUS HAZARD	INTERMITTENT HAZARD	HAZARD UNDER ABNORMAL CONDITIONS
UK	DIVISION 0	DIVISION 1	DIVISION 2
ITALY		DIVISION 1	DIVISION 2
GERMANY	ZONE 0	ZONE 1	ZONE 2
FRANCE		ZONE E	ZONE F
NETHERLANDS	INCREASED HAZARD		LIMITED HAZARD
USA		DIVISION 1	DIVISION 2
CANADA		DIVISION 1	DIVISION 2

Fig. 1: How different countries classify hazardous areas.

explosive or ignitable mixture *is likely* to occur in sufficient quantities to produce a hazard.

Division 2 – An area within which any flammable or explosive substance, whether gas, vapour or volatile liquid, although processed or stored so well under control that the production (or release) of an explosive or ignitable concentration in sufficient quantity to produce a hazard is only *likely under abnormal conditions.*

These are the conditions laid down CP 1003 and apply generally within the UK.

INTERNATIONAL CLASSIFICATION

The principle of area classification is common to many other countries, although the various systems and terminologies differ slightly. An approximate comparison can be made between these as illustrated in Fig 1.

In the USA the National Electrical Code defines two hazard areas, Division 1 and Division 2. The latter corresponds to the UK Division 2 but the former, covers both divisions 1 and 0. In Germany the practice has been revised to form three zones – **0**, 1 and 2, which corresponds approximately to the UK convention.

In France three area classifications, Zone E, F and G, have been considered for refinery applications, Zone E corresponds to the combined UK Division 0 and 1 where risk of a flammable atmosphere exists in normal operation, while Zone F is equivalent to a Division 2 area in which abnormal operating conditions have to exist before flammable atmosphere can be produced. Zone G is effectively a safe area. The American Practice is also followed in Italy and Sweden.

In the Netherlands' Code of Practice NEN 1010 two main divisions are also recognized: those of 'increased' hazard and those of 'limited' hazard. These roughly split the UK classification, ie the lower part of the increased hazard division taken together would correspond approximately to a Division 1 area.

HISTORY

The concept of intrinsic safety was first recognised in the United Kingdom following a mining disaster over fifty years ago. The first intrinsic safety certificate issued for a non-mining application by the Factory Inspectorate was in 1936.

Until recently the preferred method of protection in chemical processing plants was flameproofing. This allows the electrical equipment in the hazardous area to cause sparks and explosions, but contain them in a heavy cast enclosure which withstands these explosions. All the electrical cabling is contained in flameproof conduit. The equipment is rendered safe by switching off the power or purging the area before any covers are removed and ensuring that they are correctly replaced.

Intrinsically safe equipment does not require a heavy enclosure and can be tested while in operation.

One of the problems in the certification of intrinsically safe equipment was that all associated equipment right back to the control room had to be included in the certification. This was a small problem on simple standard instrumentation loops, but in large control schemes the time and money spent in investigation was prohibitive. It was also found that often during commissioning small modifications were required and re-testing had to be done before approval could be obtained. Thus the feeling arose that only the equipment in the hazardous area should be certified. But it took until the early 1960s to find a solution – a network of resistors, Zener diodes and a fuse.

This network, designated a Zener barrier, is placed between the safe and hazardous area equipment and means that only equipment in the hazardous area need be certified.

SAFETY BARRIERS

Up until now it has been assumed all equipment within a particular loop must be certified as intrinsically safe if any part of the loop operates inside a hazard area. This is necessarily true since the whole concept of intrinsic safety rests upon the ability to restrict the transfer of energy from a safe to a hazardous area.

However, as the units in the safe area generally outweigh those in the hazardous area, both in number and complexity, considerable simplification of certification could be achieved if only

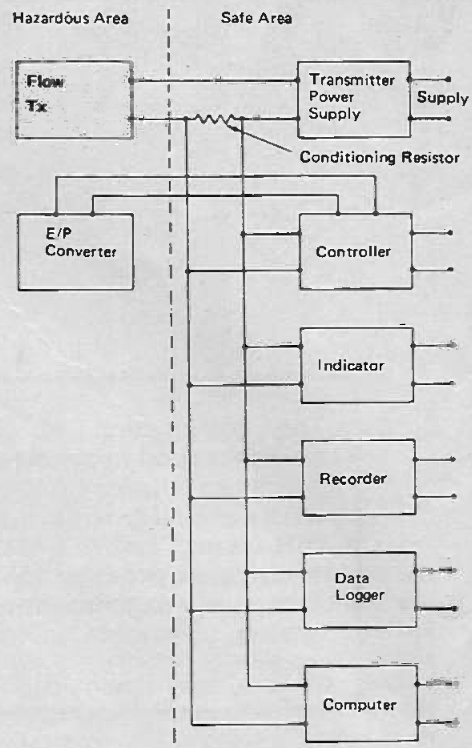


Fig. 2: Typical control and instrumentation loop.

hazardous area equipment was considered and the safe area ignored. This is now possible by the use of a safety barrier placed in any line passing through the hazard boundary, to inhibit the transfer of more than a restricted amount of energy from one side of it to the other.

The advantages to be gained from the use of a barrier are clearly illustrated in Fig 2 and 3. Figure 2 shows a typical control loop with instrumentation of average complexity. For certification, not only the whole loop but each individual unit must be examined. Any future change or addition will therefore require that the whole loop be re-examined before updated certification is possible. Figure 3 shows the same system with barriers. In this case only the components actually within the hazard area need be considered.

ZENER BARRIERS

The basic circuit diagram of a Zener barrier is figure 4. The prime function of the barrier is to limit the amount of

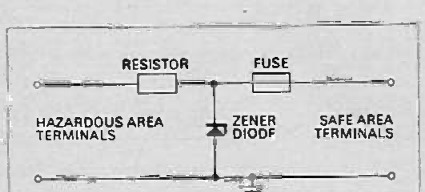


Fig. 4: Basic Zener Barrier.

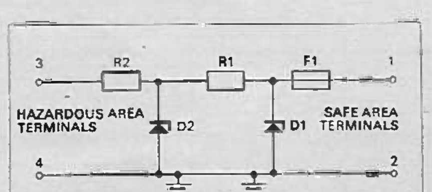


Fig. 5: Zener barrier circuits used in practice.

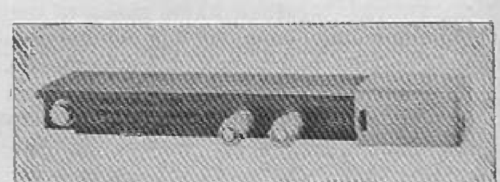


Fig. 6: 10v 47 ohms Barrier.

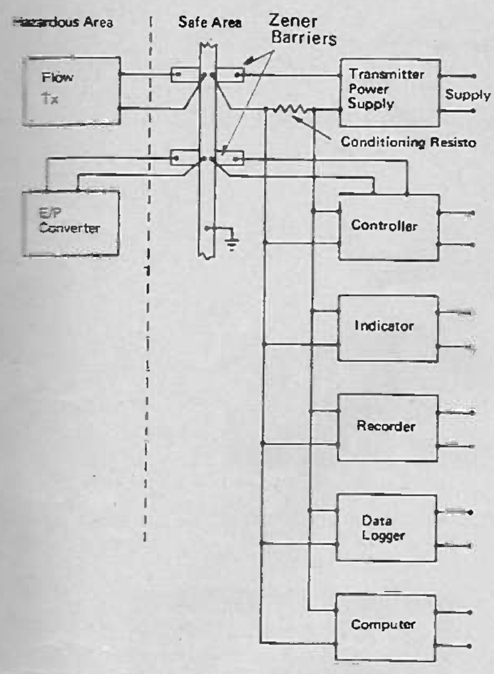


Fig. 3: Typical loop using Barriers.

energy that can be transferred from the safe area to the hazardous area under normal and fault conditions.

It is assumed that the worst fault condition is the application to the safe area terminals of the full mains voltage (250V rms or 360V peak). The surge of current so produced is diverted to earth through the Zener diodes. The fuse is incorporated to protect the Zener diode from being operated in excess of its long-term rating. The thermal characteristics of the fuse and diode are such that, regardless of the magnitude of the fault condition below 250V rms the fuse ruptures before the diode is damaged.

Under the surge condition (and normal operation) the maximum voltage and current available in the hazardous area is therefore limited by the Zener barrier. It follows that the circuit in the hazardous area must be safe as well, therefore the equipment and cables connected to the output of the barrier must also be intrinsically safe.

Figure 5 is the design of a Zener barrier used in practice. Two diodes are used for additional protection since open-circuit diode failure is not a safe condition and not self-revealing, unlike short-circuit failure which is both self-revealing and safe. R_1 enables D_2 to limit the hazardous area terminal voltage during any transient pulse condition which may occur while the fuse is blowing. In this period, the Zener voltage of D_1 may be increased. A typical instrumentation loop using barriers was shown in Fig 3.

It is important that the installation requirements, particularly that of earthing, are strictly adhered to. It is in this area that there may be differences between countries, but the basic design and philosophy remain the same.

The action of the Zener barrier in a 2-wire transmitter circuit is shown in Fig 7. As long as the applied voltage 'V' on terminals 1 and 2 is below the zener breakdown voltage of diode D1, the diode will not conduct (ie is effectively an open circuit) and the barrier will pass the signal normally. Should 'V' rise above this voltage the D1 will conduct and maintain the output voltage on terminals 3 and 4 at its breakdown voltage. The breakdown voltage is the voltage at which a significant leakage of current through the diode commences, and for the 18V barrier is above 26V.

Should a barrier of opposite polarity be inserted or the polarity of the input voltage be reversed then D1 will act as an ordinary diode and commence conducting when its forward threshold is reached. This voltage is approximately 0.5V and when reached the barrier will effectively act as a short circuit to the applied voltage until the fuse ruptures.

The principal requirement of a barrier of this type is coordination of the thermal characteristics of fuse and diodes such that the diodes are adequately protected under any faulty condition. Assuming that this is so, terminals 3 and 4 can be regarded as a non-inductive source of power with a voltage not exceeding the zener breakdown and an internal impedance equal to R2. Thus it is possible to certify the barrier as an approved source so that the danger area components can be certified for connection to barrier terminals 3 and 4 and no reference need be made to the safe side of the barrier.

Three types of barrier are commercially available: 28V 240 ohm, 10V 47 ohm, 4V 10 ohm. There are two versions of each type, positive polarity and negative polarity, to permit earthing to either the positive or the negative transmission line.

The barriers are fully encapsulated in epoxy resin, colour coded to indicate polarity and type, and designed for mounting on an earthed busbar, (as shown in Fig 9). The fixing studs are offset to minimise the possibility of replacement barriers being inserted in the wrong direction.

SELECTING A BARRIER

In two wire transmission circuits where one line is capable of being earthed, a single barrier is used, its polarity being dependent on the polarity of the line it is connected within (Fig 7).

If the transmission circuit is floating then two barriers are required. If the conductors operate at opposite polarity with respect to earth then one positive and one negative barrier is required. Extreme care should be taken when applying this method in ensuring that the barriers have been designed for

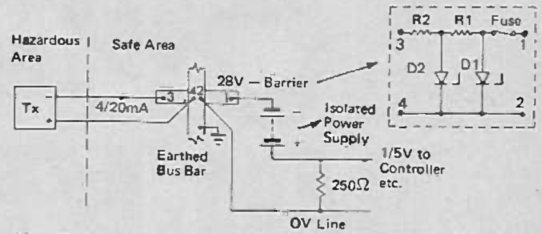


Fig. 7: 2-wire transmitter circuit.

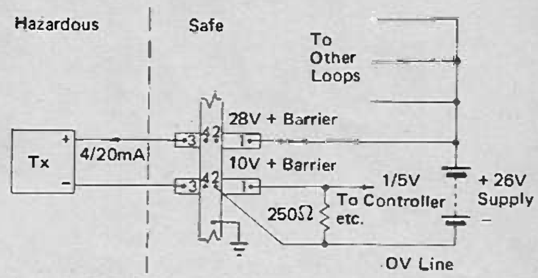


Fig. 8: 2-wire transmitter using common power supply.

this configuration (refer to the I/S certification schedule) as this method doubles the short circuit energy available in the hazardous area.

If both conductors operate at the same polarity potentials above earth then two barriers of the same polarity are required (Fig 8). The voltage to be considered is the maximum elevated potential of each transmission line. The use of multiple barrier systems increases the possible fault energy, and consequently care must be taken to consider this increased energy in relation to the particular hazard involved.

It is extremely important to establish that the characteristics of the hazardous area equipment and associated cabling are within the terms of the limiting conditions for use of the particular Barrier. These conditions can be determined by reference to the I/S certification schedule for the barrier and/or the equipment certified for use with the barrier, which will detail equipment which has been approved for use with the barrier and the maximum inductance and capacitance values that can be tolerated in the equipment and associated cabling. (73)●

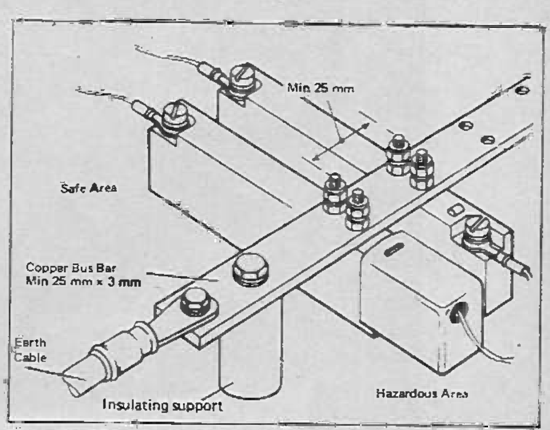
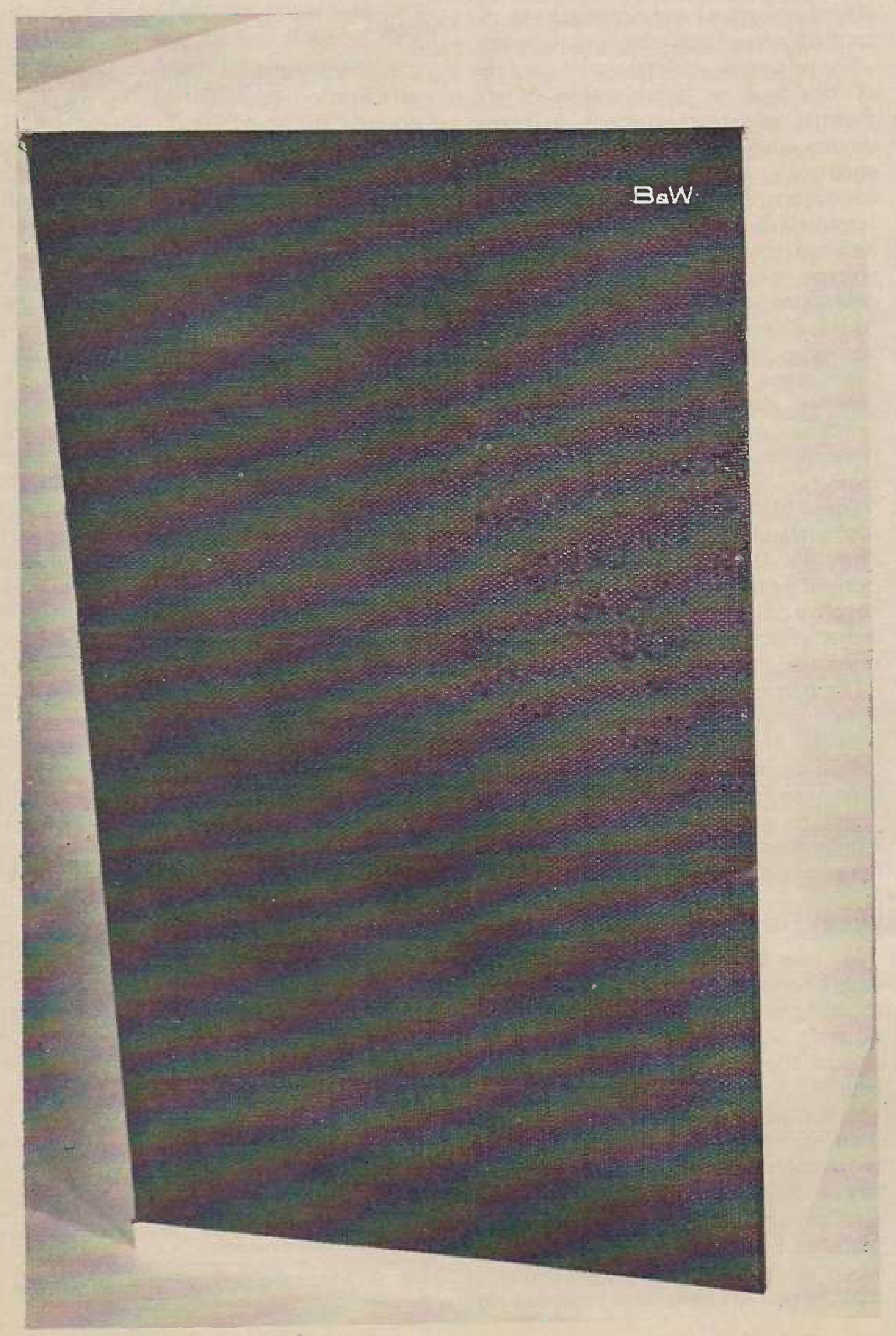


Fig. 9: Mounting arrangement for Zener barriers.

BOWERS AND WILKINS DM2 SPEAKERS



electronics TODAY INTERNATIONAL

product test

Latest B & W speakers have exceptionally smooth response

THE Bowers and Wilkins model DM2 is the result of the company's requirement to produce a unit which filled the gap between their very small monitor speaker, the DM1, and their large monitor speaker, the DM3.

The external appearance of the DM2 is different from previous units in the Bowers and Wilkins range. This is particularly true of the one we reviewed, which was painted gloss white and fitted with a black grille with aluminium edge trims. The DM2s are also available in either a teak or walnut veneer. By contrast both the DM1 and DM3 have timber enclosures fitted with chamfered timber front trims and recessed grilles.

The main design aims of the DM2 are as follows:—

a) to improve the mid-range frequency linearity

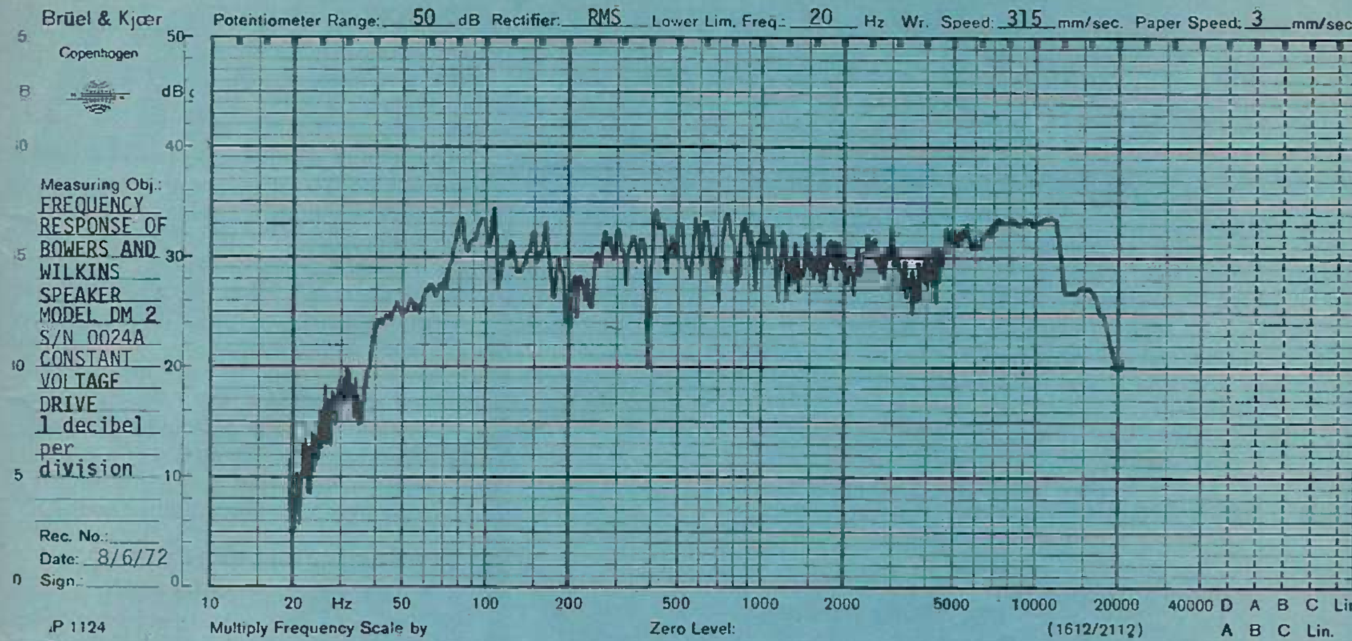
b) to evaluate and use the acoustical load line technique in the 30 to 60Hz region to enhance bass output for a given cone excursion.

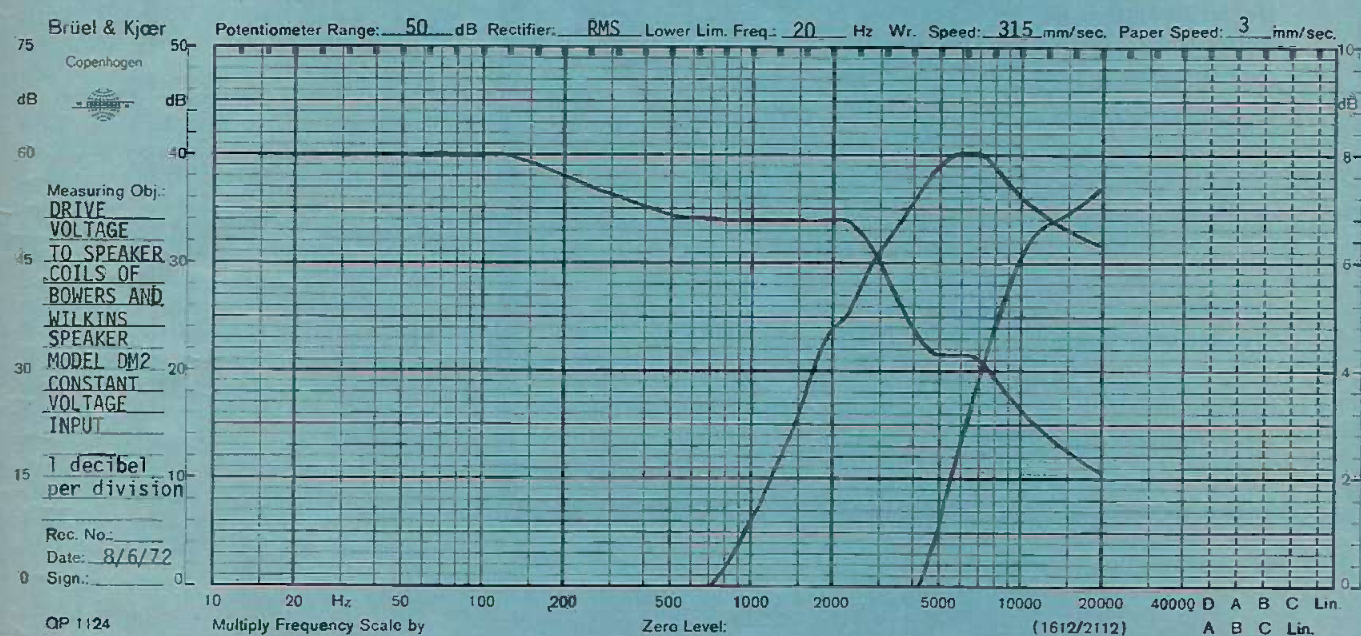
c) to be economical to manufacture, so that it falls between the price of the DM1 and DM3

d) to have a similar sensitivity to the DM1

Some of these aims have been obtained with exceptional results.

The design and construction of the enclosure is very interesting because of the 1/8 wave acoustic line loading on





the oval bass/mid-range speaker. The sketch shows the folded tapered pipe which is constructed from ½" thick particle board panels rigidly fixed between the ¾" thick particle board sides of the enclosure. To correctly load the speaker, batts of coarse plasticized hair felt have been stuffed into the pipe. The aperture at the bottom of the enclosure has approximately the same area as the cone of the bass speaker located at the top of the front panel. Another interesting feature of the bass unit is the very large magnet which measures 5" diameter by ¾" thick.

Just below the 6" bass-speaker, and mounted side by side, is the 2" high-range speaker and the 1" tweeter.

COMPLEX CROSSOVER NETWORK

The cross-over networks are extremely complex, consisting of four air cored inductors, two ferrite cored inductors, 10 polyester dielectric capacitors and five high wattage resistors. These components are fitted on two printed circuit boards which have the component sizes etched on them. One board is mounted on the back of the front panel, the other board on the left hand side panel. The cross-over networks for the high range speaker and tweeter are third order Butterworth.

SUBJECTIVE IMPRESSIONS

The subjective assessment was at first deceiving because of the extremely smooth mid-range response devoid of any leaks or drop outs. This fact was particularly evident when 'A-B' tests were performed with our studio monitors — which do have a slight presence and brilliance. The 'A-B' tests also showed up the early roll-off of the low frequency response of the DM2 at approximately 65Hz. However, even with this low frequency roll-off the reproduction of the C.B.S. record "The Romantic Philadelphic Strings" was a delight to listen to, particularly the violins, which came out sharp and clear. On the heavy bass passages in the J.B.L. Contemporary Record PRO 496 the bass speaker could be slightly overdriven against the magnet

BOWERS AND WILKINS DM2 SPEAKERS

MEASURED PERFORMANCE OF B & W SPEAKER MODEL DM 2 SERIAL NO 0024A

Frequency Response	40Hz to 18kHz ± 6dB		
Total Harmonic Distortion			
	100Hz	1kHz	6.3kHz
1 Watt input	7%	0.8%	1%
5 Watts input	10%	1%	1.2%
Electro-Acoustic Efficiency	0.6%		
Cross Over Frequencies	2800Hz and 12kHz		
Woofer Resonance			
In free air	80Hz		
In enclosure	65Hz		
Measured Impedance	100Hz	1kHz	
	6.5Ω	11.5Ω	
Enclosure Volume	1.8 cubic feet		
Dimensions	25¼" high x 13¾" wide x 13" deep		
Recommended Selling Price	$274.00 each.		

assembly on very loud passages. Some audible distortion was also apparent at the low frequency end and was mainly produced by the ferrite cored inductors. The Bextrene cone of the bass driver was extremely well constructed and did not exhibit any break up. The smooth mid-range and top end response of the speakers complemented the sound track recording of Harold Fielding's London Production of 'Show Boat', (Columbia No. SCXO 6480) giving the singers a very natural and uncoloured sound.

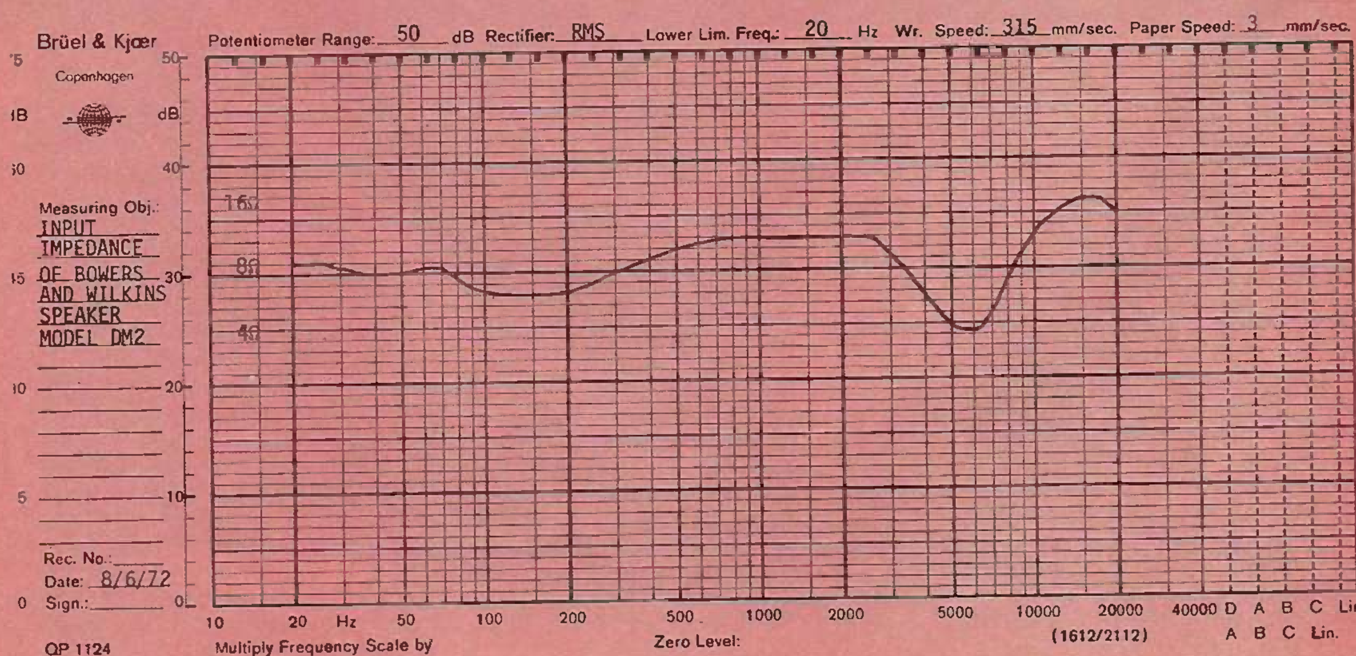
MEASURED PERFORMANCE

The measured performance showed one of the smoothest mid-range frequency responses that we have ever seen, being typically within ±4dB between 60Hz and 15kHz with few exceptions.

Off-axis measurements showed a slight roll off of 2dB between 1kHz and 5kHz and a very sharp roll off of 11dB between 5kHz and 10kHz plus a further 8dB loss at 15kHz. This drop off around 10kHz could be attributed to the spider fitted over the cone of the high range speaker. The domed tweeter however, behaved as expected having only a 8dB loss off-axis.

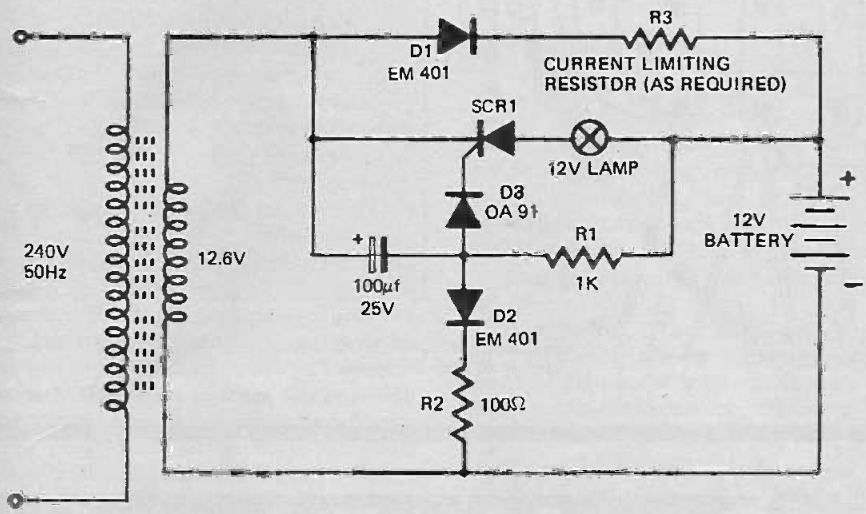
The total harmonic distortion at 100Hz was high, being 7% with 1 watt input. However, because of the high efficiency of the speaker at this frequency, this level of distortion is of less concern that it would otherwise be. Above 500Hz the total harmonic distortion was good, being around 1%

(Continued on page 57)



EMERGENCY LIGHTING UNIT

This simple versatile circuit has many uses



The 12 volt lamp shown in this circuit should be rated at 12 watts or less — this may be increased to 24 watts if the SCR is mounted on an adequate heat sink.

HERE's a project with any number of different uses.

Basically it's a 240 volt mains operated device that provides low voltage dc power, and switches instantaneously and automatically to battery operation in the event of power failure. When power is restored the unit automatically reverts to mains operation and recharges the battery.

The unit may be used to provide emergency lighting in hospitals, or dark corridors, as an automatic battery change-over supply for intruder alarm systems, or as a power failure alarm for heaters or deep freeze systems.

The circuit may be used in many different forms with circuit component values and battery ampere/hour capacity chosen to suit individual applications.

Figure 1 shows a circuit designed to supply 12.0 volts at 1.0 Amp, this may be increased to at least 2.0 Amps if the SCR is mounted on a heat-sink.

Transformer T1 is a standard filament transformer with a secondary winding capable of supplying 12.6 Volts rms. Any SCR capable of handling a couple of Amps may be used for SCR1. We suggest a C106 series, primarily because they are generally available from most parts suppliers.

In theory, capacitor C1 should be non-polarised because, during emergency operation, it is reverse-charged to the SCR gate triggering voltage.

This rarely exceeds half a volt and in practise standard electrolytics may be used without fear of breakdown.

Resistor R3 must be chosen to limit the charging current of the battery to a safe level. This level varies from one type of battery to another — most nickel cadmium batteries, may be trickle charged continuously at 1/100th of their Ampere/hour rating — i.e., a one A/h battery may be continuously charged at 1/100th of an Amp = 10 mA.

The value of R3 may be calculated as:—

$$R3 = \frac{V_S - V_B}{I_C} \times 1000$$

Where V_S = Supply voltage from transformer
V_B = Battery voltage
I_C = Charging current in milliamps

If in doubt, the maximum safe continuous charging current can be ascertained from the supplier or manufacturer of the battery that you have chosen.

To modify the circuit for other applications it is necessary to choose a transformer having an output about 5 or 10% higher than the standby battery, and rated to provide the load current required. The SCR must also be chosen with voltage and current ratings suited to the application.

(Continued overleaf)

HOW IT WORKS

When ac power is on, the battery is trickle charged through diode D1. At the same time the 100 uF capacitor charges through D2 and discharges through R1 and the battery, and, because the discharge time constant is longer than the charge time constant, the SCR gate is reverse-biased.

If ac power fails, the capacitor discharges completely, and the battery will then charge the capacitor in the opposite direction until the voltage is sufficient to trigger the SCR (typically 0.6 Volt). At this point the SCR triggers and supplies power to the emergency light.

The circuit is reset automatically when power is restored.

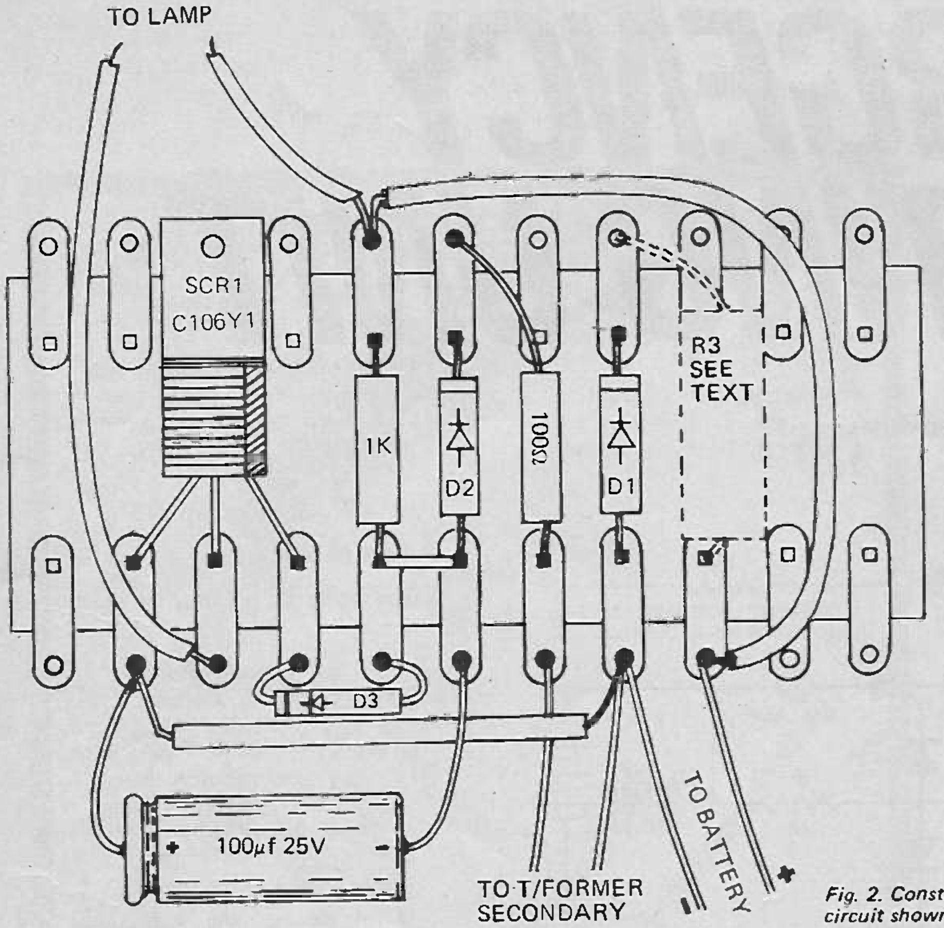
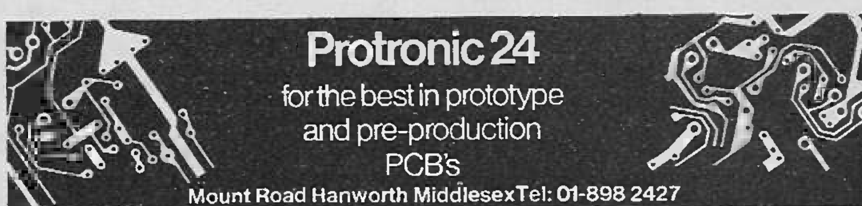


Fig. 2. Constructional details of the circuit shown in Fig. 1.

PARTS LIST

R1 —	resistor, 1k, ½ Watt, 5%.
R2 —	resistor, 100 ohm, ½ Watt, 5%.
R3 —	resistor, see text.
C1 —	capacitor, electrolytic, 100uF, 25 Volt.
D1 —	silicon diode, EM 401 or equivalent.
D2 —	silicon diode, EM 401 or equivalent.
D3 —	germanium diode OA91 or equivalent.
SCR1 —	silicon controlled rectifier C106 Y1 or equivalent.
Txf —	filament transformer — 240 volt to 12.6 volt at 1½ Amps.
Battery —	12 Volt nickel cadmium or lead acid battery — size to suit application.



INPUT GATE

LETTERS FROM OUR READERS

A TIP, AN IDEA, AND A COMMENT

First, may I say how impressed I have been with your magazine which is very much above the 'electronics comics'. Being interested not only in electronics (especially medical applications) but also photography, I found the May issue particularly helpful. It may interest your other readers to know that the sound-operated flash can be conveniently housed in a 36-exposure slide box.

May I suggest a flash meter for a project? These instruments are extremely useful but their price virtually precludes use by any but the most affluent photographic amateur.

Re the pain-killer feature (also May issue), it may interest other readers to know that this method of pain relief has been known, in principle, for centuries. The fast conducting fibres are in fact those subserving the conscious sensations of touch, position, temperature etc. Since it is these fibres which can 'gate' the pain conducting fibres, any stimulation of the 'fast' fibres (if strong enough) will relieve pain — hence 'hot packs', counter-irritation techniques and even manual massage of the part. Moreover, 'referred pain' eg, pain in the shoulder tips due to irritation of the diaphragm) can be relieved by heat to the shoulder but not to the chest wall.

All the best for the future!

—Dr B W Ellis, Ashstead, Surrey

Ni-Cd CELLS

Can you give me any information about Ni-Cd batteries?

—G F Barnett, Birmingham

The characteristics of battery systems are authoritatively examined in a feature scheduled for the November issue. —*Editor*

LOGICAL ILLOGIC

Every time I see logical 1 and logical 0 in an article or manufacturers' data sheets, I go up the wall. The circuits are *logic* circuits, the elements are *logic* elements, we have *logic* tables and your feature on page 32 of the September issue itself is titled 'Logic Probe'. So why logical 1 and 0? Is there a special English for digital electronic engineers which makes ungrammatical adjectives logi*cal*? There is nothing logi*cal* about the signals 1 and 0; they are merely *logic* states. Otherwise we may as well equate logical 1 with illogical 0 and vice-versa. Please stick to *logic* and be logical. —P Boughton, London SE1

Climb down off the wall, Mr B; your logic has us beaten. —*Editor*

MAY WE REPRINT?

As Editor of the British Ferrograph Owners' Club magazine, may I congratulate you on the excellent coverage of articles in your magazine? You may be interested to learn that I have taken steps to ensure getting my copies of ETI every month and my purchase of other publications has really dropped off.

Our members, I am sure, will find your article on the Ferrograph Series Seven of particular interest. So may I have your permission to reprint this article in our magazine?

Keep up the good work!

—R W Panting, BFOC, Reading, Berks

Permission gladly given — and thanks for the appreciation! —*Editor*

PUZZLES

Please make your puzzles simpler and the prizes larger!

—P Marchese, Maidstone, Kent

Come off it, Mr M! What is the fun in that? —*Ed*

700 WATTS

Thank you for your informative article on the 700 watt amplifier. I am looking forward to a review of the new 'Dephon' electrostatic headphone amplifier with quasi-complementary Van de Graff generators in its output.

—S W Bromfield, Sawbridgeworth, Herts

ERRATA

In the Super-stero testing instructions (Sept issue), RV2 (not RV1) should be adjusted for minimum output in speaker 1 with input 2 and output 1 only connected — see page 40.

FROM YOUR EDITOR

We have been literally swamped with solutions to the Cube problem in the August issue and regretfully have to hold back publication of the answer and an analysis of the offered solutions for the November issue.

We have also had many letters from readers complaining about lack of ethical or administrative behaviour by some component dealers. Since none of such dealers are advertisers in ETI, we can do no more than advise all readers to deal with advertisers in ETI preferably, in which case we can undertake to deal with any difficulties which may arise.

Only two readers have indicated that they would like approximate Project cost to be stated — see page 84 of the August issue. So we have decided not to include this information in our Projects for the present. We will however indicate the cost to readers who specially write to us for this information.

Lastly, the response to our Questionnaire in the last issue has been excellent. May we remind readers that additional forms are available for the asking? —*Editor*

READERS' LETTERS

It is our policy to reply to all readers' letters — but not necessarily in these columns. Please give your name and full address in your letters. While we cannot, for obvious reasons, enter into correspondence on products not mentioned in ETI, we welcome informed and/or experienced opinions on all subjects of general, engineering and electronic interest.

We try to reply to letters as quickly as we can. However, if sometimes there is some delay, please bear with us and do not think that your letter has been ignored. — Ed.

BRAKE LIGHT WARNING

ETI PROJECT 303

Faulty brake warning lights are dangerous — to others as well as to yourself. This simple fail-safe unit tells whether they are working, at all times.

A vehicle with inoperative brake lights is a menace on today's roads.

But what is far worse is a vehicle with only one brake light working, for this may be mistaken for a turning indicator.

ETI's brake alarm unit is designed to detect both conditions. It indicates, via a dashboard mounted lamp, that both brake lights are working each time the brake pedal is depressed. If either or both brake lights fail, then the indicator lamp fails to light.

As the great majority of cars use 12 volt electrical systems, the unit has been designed specifically for this system. It will not work satisfactorily with six volt systems.

The unit shown in this article is for vehicles with negative earth systems. The unit can be constructed for positive earth systems merely by substituting transistors shown under 'positive earth' in the parts list. Make sure that you specify the correct type for your vehicle when ordering the components (or kit set) from your parts supplier.

The unit is shown here in two forms, in its simpler form (Fig. 1) the indicator light operates at the same intensity day or night. A simple modification to the basic unit, (Fig. 2) automatically reduces the intensity of the indicator light when the headlights are switched on.

Many vehicles are fitted with a handbrake warning light, and this can be adapted as a dual purpose indicator. Alternatively a separate indicator light may be used.

CONSTRUCTION

Our original prototype was constructed on a printed circuit board the foil pattern of which is reproduced (full size) in Fig. 3. Alternatively, the components may be assembled on veroboard, matrix board, or tag strips. The layout is not at all critical.

The component layout for printed circuit board construction is shown in Fig. 4. The same board and basic component layout is used for both versions of the unit. In the simpler version the extra components are omitted and resistor R8 replaced by a shorting link. At this stage do not install R3 (220 ohms).

The completed board should be mounted in a small case — we used an aluminium case 3" x 2" x 1½". Ensure that no internal wiring touches either R1 or R2, as these become hot when the brakes are used for a long period.

INSTALLATION

Locate the box in a convenient place under the dashboard or in the engine compartment.

Now refer to Fig. 5.

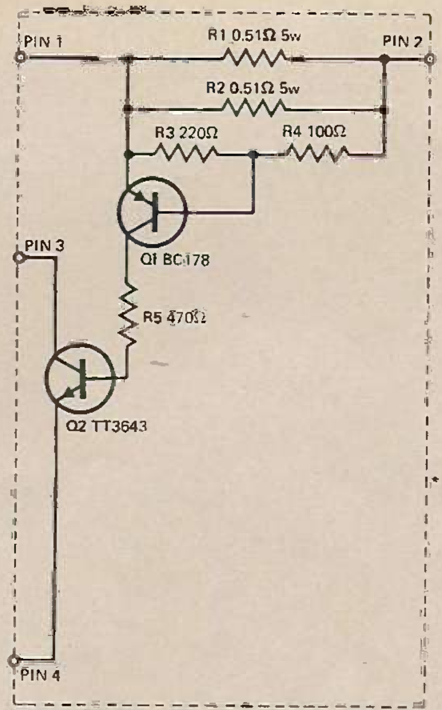


Fig. 1. Circuit diagram of the basic unit.

The existing wire from the brake lights is removed from the brake switch and wired to Pin 2 of the warning unit. A new wire is then taken from the brake switch to Pin 1 of the warning unit. Pin 4 is connected to any convenient earth. In the automatically dimmed version of the unit, Pin 5 is wired to the switched side of the side or tail-light circuit.

The brake warning indicator light should be rated at 12 volt,

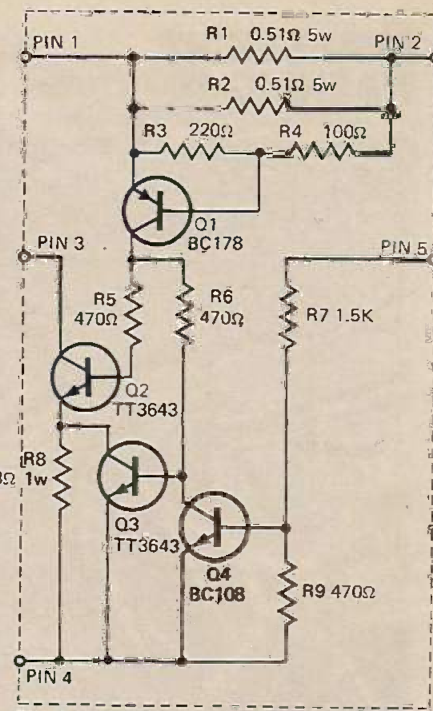


Fig. 2. In this form the intensity of the indicator light is automatically reduced when the headlights are switched on.

approximately 150 mA. One side of the light should be connected to the vehicle's 12 volt supply, preferably via the ignition switch, and the other side of the light is wired to Pin 3 of the warning unit.

If a handbrake warning light is fitted to the vehicle (and if the actuating switch is of the type that earths one side of the light when operated) then this handbrake light may also be used for the brake warning function. All

Fig. 3. Foil pattern for the printed circuit board (full size).

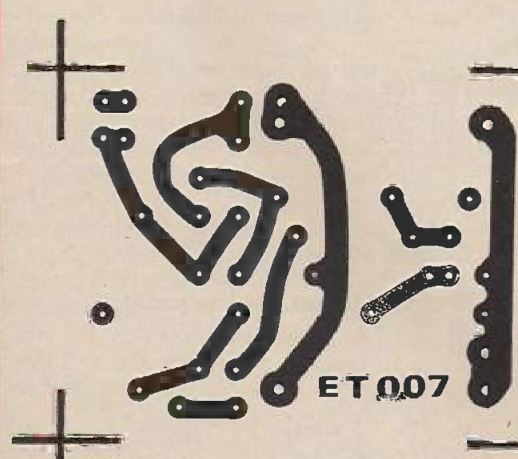
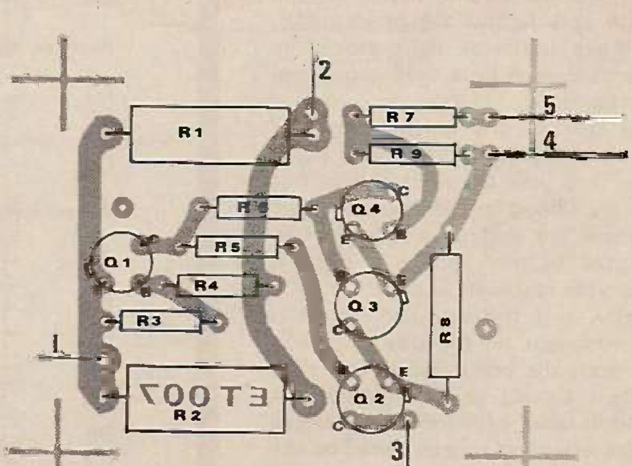
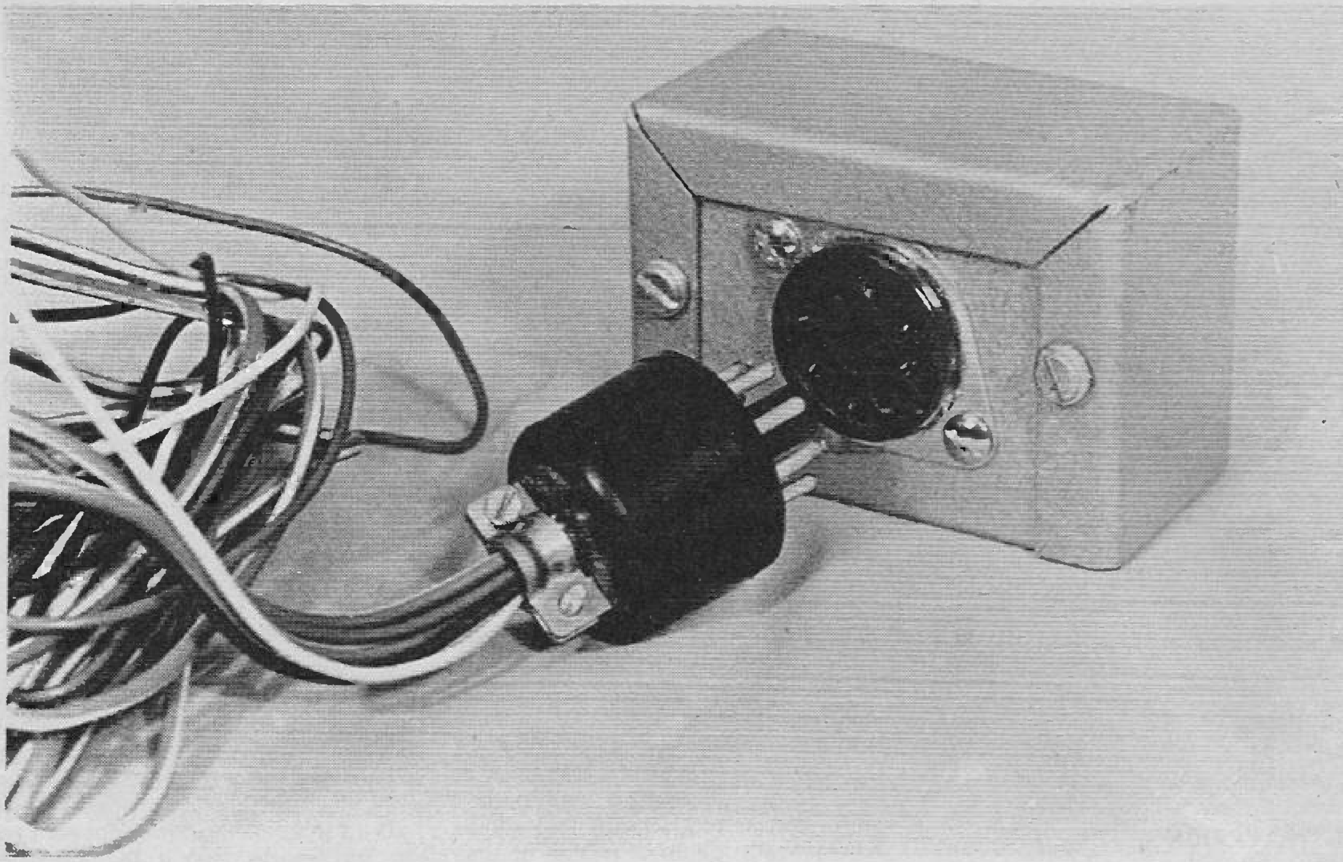


Fig. 4. How the components are assembled on the printed circuit board — in the basic version some components are omitted, and a shorting link wired across the position shown for R8.



BRAKE LIGHT WARNING



The completed unit — we used an octal plug and socket to connect the unit to our testing vehicle, but for general use it is better to connect the unit directly to the vehicle's wiring system.

that is required is to connect Pin 3 to the junction of the handbrake warning light and the actuating switch. (Fig. 5 refers).

TESTING

Having installed the brake warning unit, chock the wheels of the vehicle, release the handbrake, switch on the ignition and depress the brake pedal. The brake indicator light should be illuminated each time the brake pedal is depressed.

Now remove one of the rear light bulbs and depress the brake pedal again. This time the light should not come on. Check that it does not come on when the engine is running (i.e. when the battery voltage is higher). Replace the rear light bulb.

Finally — if the modified circuit is used — switch on the sidelights, and again press the brake pedal. This time the light should be illuminated, but with decreased brilliance. The degree of light reduction is determined by the value of R8 — this is normally 33 ohms but may be varied as required.

FAULT FINDING

Indicator does not come on at all.

If the indicator does not light up

PARTS LIST

Negative earth vehicles.

Q1	—	transistor	BC 178
Q2	—	"	TT 3643
Q3	—	"	" "
Q4	—	"	BC 108

Positive earth vehicles

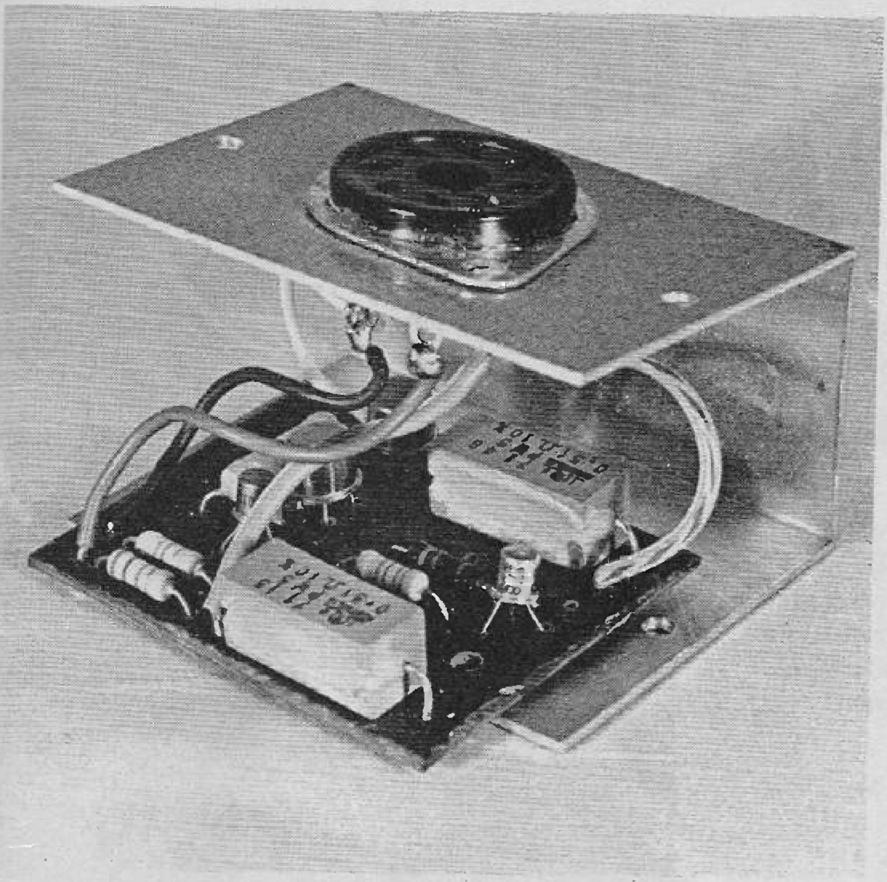
Q1	—	transistor	BC 108
Q2	—	"	TT 3638
Q3	—	"	TT 3638
Q4	—	"	BC 178

All vehicles

R1	—	resistor	0.51 ohms, 5 watt.
R2	—	"	" " " "
R3	—	"	220 ohms, ½ watt, 5% (see text)
R4	—	"	100 " " " "
R5	—	"	470 " " " "
R6	—	"	" " " " "
R7	—	"	1.5k " " " "
R8	—	"	33 " 1 Watt "
R9	—	"	470 " ½ " "

PC board — ET 007, 1 metal case, wire, screws, grommets etc.

These components are generally available from the parts suppliers who advertise in ETI.



Here the assembled printed circuit board is ready to be located within the case.

HOW IT WORKS

Resistors R1 and R2 are in series with the brake lights. The voltage drop across them is proportional to the current through them, and if this voltage is high enough Q1 will be turned on via R4. When both brake lights are working the current is approximately 3½ to 4 Amps thus producing about one volt drop across the resistors.

This exceeds the base emitter voltage of Q1 and so Q1 and Q2 conduct, extending an earth to the indicator lamp which is thus energized.

In the modified circuit shown in Fig. 2 the earth to the indicator lamp is extended via 33 ohm resistor R8, thus giving a lower intensity than otherwise. However transistor Q3 is in parallel with this resistor, and, unless the sidelights are switched on, Q3 is biased on by R6. Thus in effect, Q3 shorts out R8 ensuring normal lamp brightness.

But if the sidelights are switched on, Q4 will be biased on via R7, and will clamp the base of Q3 to zero potential. Q3 will be switched off. Hence the full 33 ohms will appear in series with the indicator light, thus atuomatically reducing its brightness whenever the sidelights are on.

when the brake pedal is depressed, make sure that the ignition switch is on and that both brake lights really are working. Then make a thorough check of wiring both inside and outside the brake warning unit.

Indicator not extinguished when one rear light removed.

Firstly disconnect the lead to the rear brake lights from Pin 2 of the warning unit. If the indicator still does not extinguish, then the fault is within the unit; check internal wiring and transistor Q1.

If, one the other hand, the indicator goes out with the brake lights disconnected, check the number of lights connected in the brake circuit. Normally there is only one each side, each rated at approximately 2 Amps. The unit is normally set up for this load.

If there are more than two brake light bulbs, then for each additional globe a further 0.51 ohm resistor must be paralleled across R1 or R2. In other words the total number of 0.51 ohm resistors, must equal the total number of brake light bulbs.

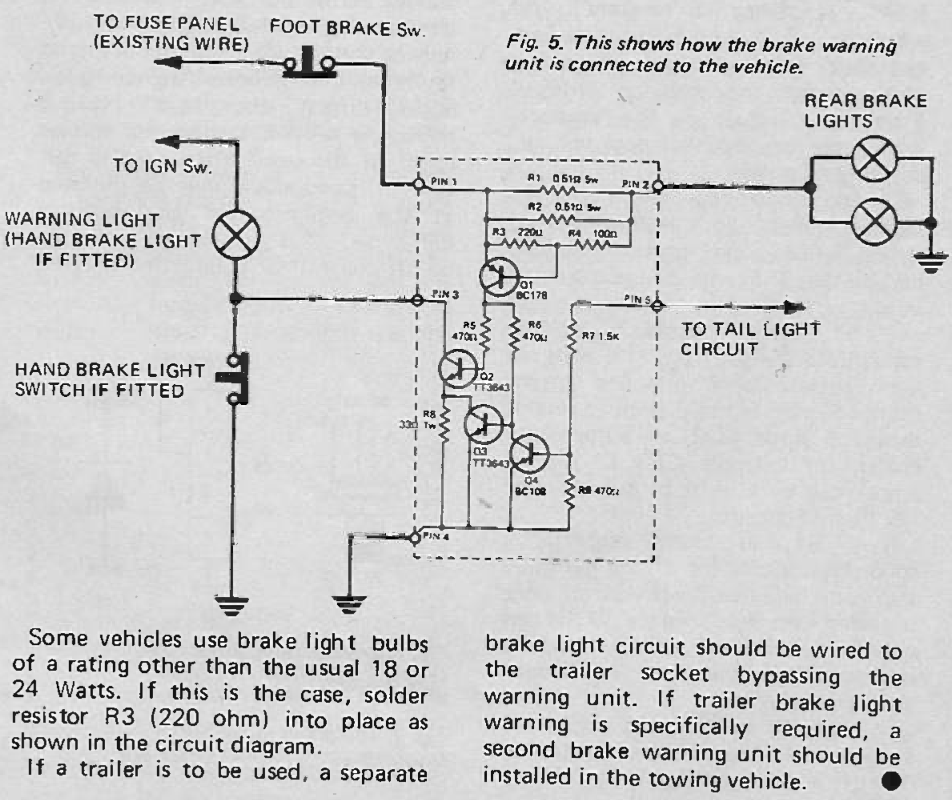


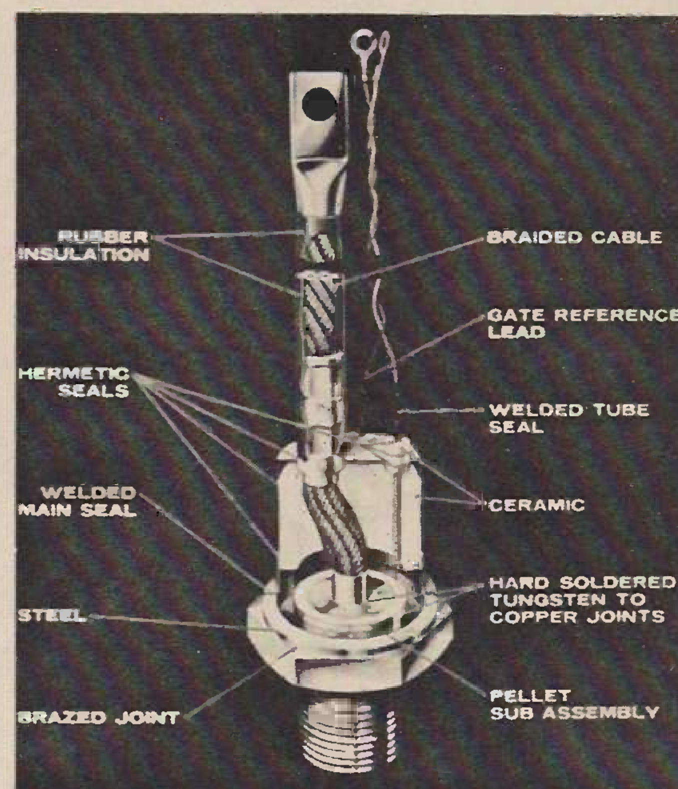
Fig. 5. This shows how the brake warning unit is connected to the vehicle.

Some vehicles use brake light bulbs of a rating other than the usual 18 or 24 Watts. If this is the case, solder resistor R3 (220 ohm) into place as shown in the circuit diagram.

If a trailer is to be used, a separate brake light circuit should be wired to the trailer socket bypassing the warning unit. If trailer brake light warning is specifically required, a second brake warning unit should be installed in the towing vehicle. ●

A PRACTICAL GUIDE TO SCR's

Used in applications as diverse as switching 240 volts in a photographic timer to forming a major element in a 50,000 hp motor speed control system — the SCR is a simple device with a myriad of uses. Here, Collyn Rivers explains, simply and clearly, how to use this versatile circuit component.



THE silicon controlled rectifier (or SCR as it is commonly called) is a rectifying device in as much that it can be *caused* to have a low resistance in the forward direction, but *always* has a high resistance in the reverse direction.

The device is called a silicon *controlled* rectifier since it can be switched from a very high forward resistance (its 'off-state') to a low forward resistance (its 'on-state'). And although silicon controlled rectifiers can cope with both high voltage and high current, they can be switched from the 'off-state' to the 'on-state' with very low levels of gate voltage, current and power.

Silicon controlled rectifiers are readily available in a wide variety of shapes, sizes and power handling capabilities. They may be encapsulated in plastic, encased in metal, and either air or water cooled. Voltage capabilities range from 12 volts to many thousands of volts, and current ratings from a few milliamps to several thousand amps. SCRs are surprisingly cheap, for example GE's C 106 (4 amps) can be bought in quantity for less than fifty cents.

They are, in many respects, a solid-state equivalent of the gas-filled thyratron, and like the thyratron, once triggered into the 'on-state', SCRs can only be switched off again by breaking (or reversing) the flow of current through them.

The circuit symbol and schematic diagram of the silicon controlled rectifier is shown in Fig. 1.

THE SCR IN AC CIRCUITS

In ac circuits, the polarity of the voltage across the SCR is reversed on alternate half-cycles, and the resultant reverse voltage will cause the device to revert to the 'off-state', switching on again during the next positive half-cycle only if a triggering voltage exists at the gate. When used in this fashion, conduction may be initiated at the beginning of any positive half-cycle, thus providing a simple on-off control. Or conduction may be initiated at some later time in the positive half-cycle, thus varying the voltage impressed upon the load. This process is known as 'phase-control'.

Silicon controlled rectifiers may be used to control ac power by connecting them in inverse parallel so that one SCR conducts load current in one direction, while a second conducts in the opposite direction. The gate firing signal may be used to switch on the flow of current, and by using phase control, the average power applied to the load may be varied.

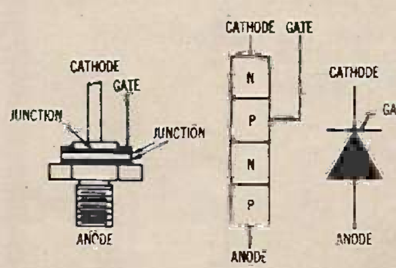


Fig. 1. Cross Section, Block Diagram, and Electrical Symbol of Silicon Controlled Rectifier.

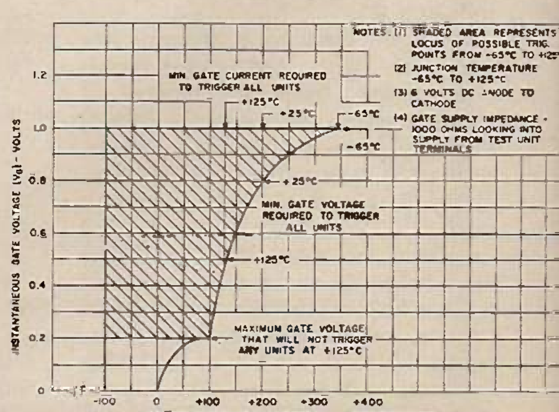


Fig. 2. This graph shows the triggering characteristics of the low-current type C106 SCR.

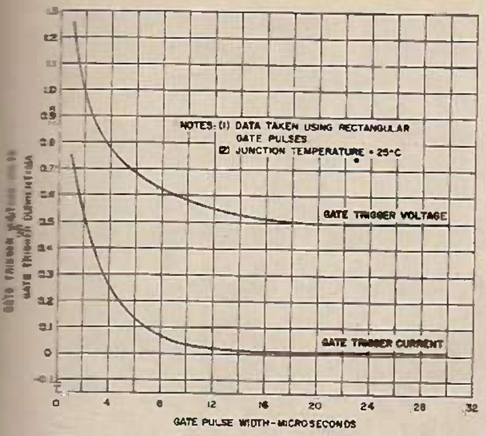


Fig. 3. Relationship between trigger pulse width and pulse magnitude (C106 SCR).

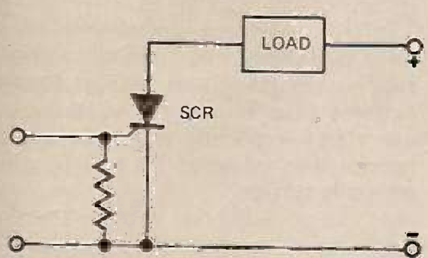


Fig. 4. A 1k bias resistor is connected between gate and cathode to provide operational stability.

THE SCR IN DC CIRCUITS

In dc circuits, where the voltage across the SCR does not reverse, the gate may be used to initiate current flow, but some specific means must be used to turn the SCR off again. This may take the form of a mechanical switch that interrupts the load current, or a more complex circuit in which firing a second SCR causes a break in load current or a momentary flow of reverse current through the first controlled rectifier, causing it to turn off. This latter process is called commutation and is the basis of operation of the SCR inverter.

TRIGGERING THE SCR

A silicon controlled rectifier is triggered into conduction by a positive pulse (or continuous dc voltage) applied to its gate terminal.

The level of voltage required varies from one type of SCR to another — and between individual SCRs of the same type. It is also affected by ambient temperature (voltage and current firing requirements decrease as temperature increases).

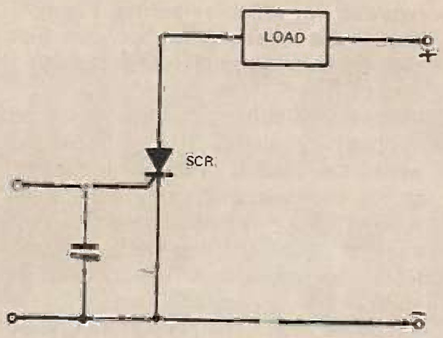


Fig. 5. Where dc triggering is used, a capacitor may be used in place of a bias resistor.

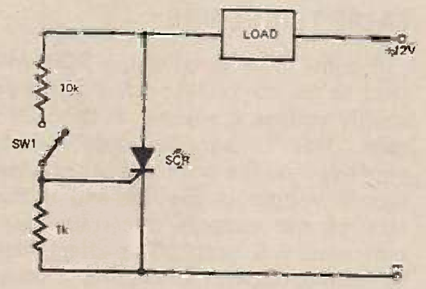


Fig. 6. Basic SCR switching circuit.

typical graph — showing firing requirements of the C106 series is shown in Fig. 2.

Manufacturers of SCRs publish specification sheets showing firing requirements in graphical form. A

The graph also shows the maximum gate voltage that will *not* trigger a C106. This knowledge is invaluable in applications where a small constant voltage may be impressed on the gate.

The graph shown in Fig. 2, and its counterparts for other SCRs, applies only when the SCR is being triggered from a dc gate source, or from a pulse source where the pulses are of relatively long duration. But if the width of the trigger pulse is reduced below about 20 micro-seconds, it is necessary to increase the magnitude of the triggering pulse above that shown for constant voltage triggering (in Fig. 2 etc.). The relationship between trigger pulse width and magnitude for the C106 is shown in Fig. 3.

BIASING

Many low-current SCRs are so sensitive that they require only a few micro-amps of gate current for reliable triggering. In fact, at high temperature, or with high voltage applied, the SCR's internal leakage may be sufficient to cause self-triggering. Similarly, in high frequency ac applications, or in dc circuits where anode voltage is suddenly applied, sufficient capacitive current may flow to trigger the SCR. In all applications where low-current SCRs are used, the possibility of spurious triggering must be eliminated by the provision of sufficient stabilizing gate bias.

In most applications the necessary gate bias can be readily obtained by connecting a resistor (of about 1k) between the gate and the cathode — as shown in Fig. 4. A bias resistor — *as such* is not always required, for in dc coupled gate circuits the output resistance of the trigger source (pulse transformer — or UJT base one resistor) will serve the same purpose. Again in many circuits where dc triggering is used, a capacitor may be used in place of the bias resistor (the optimum size will be somewhere between 0.1uf and 0.5uF.) Fig. 5 refers.

Generally it can be said that the stability of SCR circuits increases almost in proportion with decreasing bias resistance and that the maximum amount of bias (minimum resistance) should be used commensurate with the available triggering source. The lower limit of bias resistance is reached when the trigger source can only just supply sufficient current for the parallel combination of SCR gate and bias resistance.

(Continued overleaf)

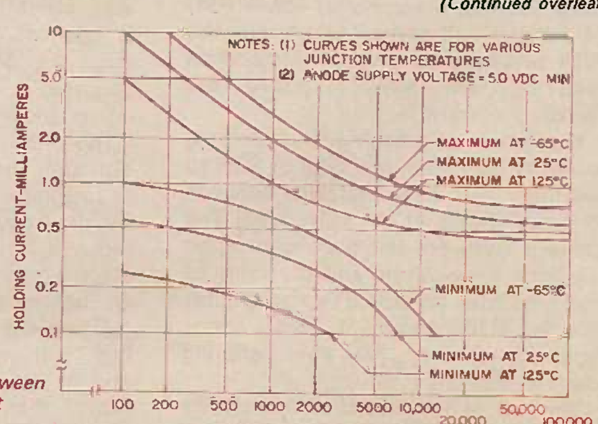


Fig. 7. Relationship between bias and holding current (C106).

A PRACTICAL GUIDE TO SCR's

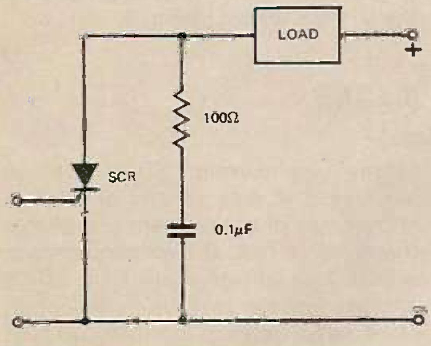


Fig. 8. Resistor/capacitor combination connected across the SCR provides dv/dt suppression (see main text).

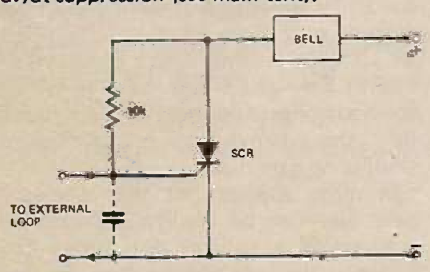


Fig. 9. This basic alarm circuit is in common use, but is prone to false triggering — see main text.

LATCHING

A basic SCR switching circuit is shown in Fig. 6. In this circuit the SCR is in series with the load. The SCR is normally non-conducting (i.e. no power is applied to the load), but if a positive potential is applied to its gate — for example by closing SW1 — the SCR will be switched on and the load energized. The SCR will then remain switched on, even if SW1 is subsequently reopened. This action is called 'latching'.

A certain minimum current must pass through the SCR for the device to switch to the 'on' state and to remain in the 'on' state (latched) after the cessation of a gate triggering pulse. But once latched, a somewhat lower level of current will suffice to prevent the SCR reverting to the 'off' state. This latter current level is called the 'holding' current.

The level of latching and holding currents vary from one type of SCR to another — and indeed between different SCRs of the same type. The current levels are also dependent upon ambient temperature and the value of the gate bias resistor. (Typical figures for the C106 range, at 25°C, are = holding current, 3.0 mA; latching current, 4.0 mA.)

The use of resistive bias also affects the level of latching and holding current required. The greater the amount of bias the higher the current required for reliable holding. Figure 7 shows the relationship between bias and holding current for a typical 4 amp SCR.

(Some difficulty may be experienced in obtaining reliable latching in circuits where the load is primarily inductive, as for example with relay coils, even though the steady state current exceeds the latching requirements. Here the remedy is to connect an appropriate resistor across the inductive load. The resistor should be selected to ensure that it alone can pass enough current to effect latching.)

FALSE TRIGGERING

In some SCR circuits the SCR will tend to 'switch on' the moment the dc supply voltage is applied, at the SCR's gate. This is because the SCR is sensitive to the rate at which the supply voltage is applied, and if this rate of rise exceeds a certain level, switch-on will occur. The effect may be eliminated by connecting a series resistor/capacitor combination across the SCR. This is known as dv/dt suppression and its effect is to slow down the rate of voltage rise. A diode, connected in the same effective polarity as the SCR, may be paralleled across the resistor for maximum effectiveness. In most applications the values shown in Fig. 8 will prove effective.

False triggering can also be caused by transients induced into the gate circuits. This is a very common problem with a number of burglar alarms — even commercially made ones from manufacturers who should know better.

The most commonly used SCR burglar alarm circuit is basically that shown in Fig. 9. In this configuration, the gate of the SCR is connected to the positive rail via a 10k resistor, but an external loop interconnecting a number of normally closed trip switches, effectively clamps the gate at zero potential. However if any switch is opened, or if the external loop is cut, the SCR will immediately be triggered into conduction, thus energizing a series connected bell.

The problem with this circuit is that although the gate of the SCR appears to be held very firmly at zero potential by the external loop, transient energy induced into the external loop by electro-magnetic phenomena (caused by lightning, arc welders, fluorescent lighting starters etc) can reach quite high voltage levels at the 'open' SCR end of the loop. And these levels are more than sufficient to trigger a sensitive SCR.

In some instances this type of false triggering can be overcome by connecting a 1.0uF capacitor between the SCR's gate and cathode but generally speaking it is bad practise to connect long 'aerials' directly to the gate circuit of an SCR.

A better solution is to use a UJT as a 'buffer stage' — as shown in Fig. 10. This will ensure that the gate circuit is totally immune from false triggering no matter how long the external circuit, (UJT and other triggering circuits will be described in greater detail in the second article in this series).

False triggering may also be caused by switching transients if long external leads are used in the anode or cathode circuit of the SCR. This sometimes occurs with burglar alarms and other control and warning systems if a bell (or other load) is located some distance away from the SCR.

This problem can almost invariably be overcome by using dv/dt suppression (as shown in Fig. 8). In extreme cases it may be necessary to use a 5uF capacitor and a 5k series resistor, but values of 1uf and 1k will generally suffice.

STATIC SWITCHING CIRCUITS

As may be seen from the examples shown so far, the SCR in a dc circuit is analogous to a static latching switch, making it an ideal replacement for relays, contactors, and other electromechanical devices. Where latching action is undesirable, latching may be eliminated by driving the SCR from an ac supply. In either case the SCR doubles as a power switch with all the advantages of a solid state component — small size, high speed, ruggedness and long life — and as a high gain amplifier.

The second part of this series — to be published next month — shows how SCRs are used in logic systems, and describes how phase control systems operate. Many practical circuits will be included. ●

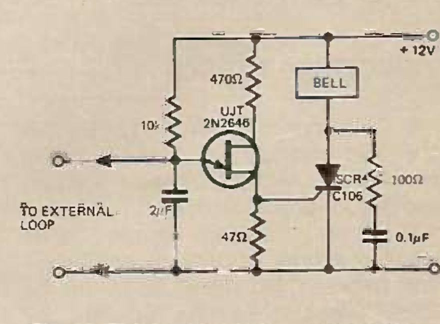


Fig. 10. This is a greatly improved version of the circuit shown in Fig. 9. The addition of the 2N2646 UJT effectively isolates the gate of the SCR from signal transients.

PART 5

TRANSDUCERS IN MEASUREMENT AND CONTROL

In this, the fifth article in this series, Peter Sydenham, M.E., Ph.D., M. Inst. M.C., continues his discussion of position measurement and control.

SO FAR we have seen how lengths, angles, tilts and alignments are converted into a convenient electrical form for purposes of measurement or control. This article describes how these one dimensional techniques are combined to yield positional information of an object or a point lying in a plane or within a space — for there are many alternatives available where multiaxial measurements are needed. Examples are the shape of an aircraft frame, the positioning of the turbine blades inside a jet engine or a steam turbine, the control of numerically controlled machine tools to form complex shapes, the cutting of steel plates and their assembly into super-tanker ships, the measurement of the profile of radio telescope dishes, control of automatic tractors in ploughing — the list appears limitless.

CO-ORDINATE SYSTEMS

Before describing just how transducers are combined, it is necessary to become familiar with the ways in which a point in space can be defined relative to some reference system by a number of individual, single-dimension, measuring devices.

Position of a point in space can be defined by three parameters using lengths and angles. (A point has no size so orientation is of no consequence.) At least one measurement must be a length to define the physical position. Most important is that three measurements must be made relative to some kind of established reference system. Figures 1a and 1b show the two most commonly used methods using lengths only. The cartesian, or rectangular, system defines the position of P by extending lines perpendicular from each axis to give the x, y and z values. The triangular concept defines P by the lengths S_1, S_2 and S_3 which extend from the corners of a fixed-size reference base triangle. It is also quite reasonable to determine P using the angles between the base triangle and the S sides if the length of the sides of the base triangle are known. The concepts of rectangulation and triangulation are often combined for reasons of expediency. For example, using the cartesian framework we could have an $\mathcal{R}\,\Theta\,\phi$ polar system (Figure 1c) in which the length to the origin is $\mathcal{R}$ and the other co-ordinates the angles made between that line and the cartesian axes.

Position in a plane needs only two dimensions, for the third is held constant by definition. Again, at least one dimension must be a length. If the point moves along a line, two of the possible three dimensions are constant, so only one needs considering and this must be a length. Alignment could be considered as a zero-dimensional measurement, for no lengths are measured along the line. It is, however, really a 2-D case as deviations in a plane perpendicular to the line are the parameters of interest.

If the object of interest has physical size, the orientation of its shape in space is also important. As three

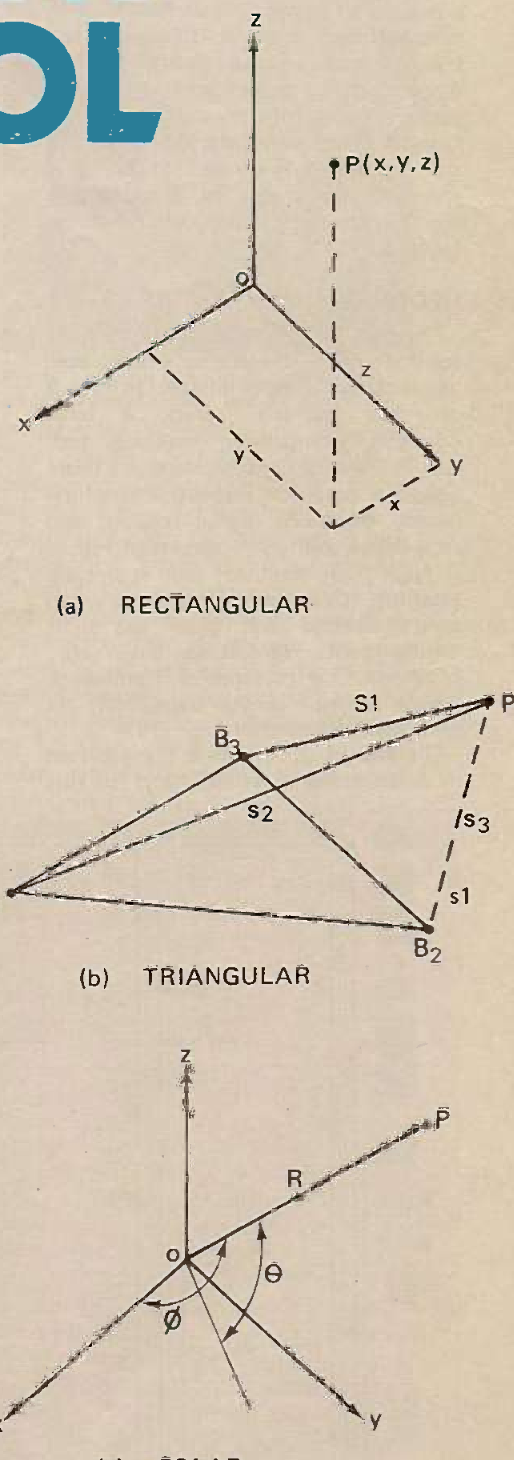


Fig. 1. Reference frameworks for multiaxial positional systems.

degrees of rotation are possible, it may be necessary to measure as many as six variables to define position adequately. A missile in flight will have pitch, roll and yaw components, as well as dimensional position values. By now, it should be clear why lengths and angles are inter-related in the practical measurement of position. The choice of reference used is largely a matter of convenience. Rectangular systems become difficult to use when sizes extend beyond several metres. Above this, polar and triangular systems come into their own. Smaller range measurements are able to utilize the rectangular arrangement for it is economically viable to manufacture the necessary mechanical reference framework.

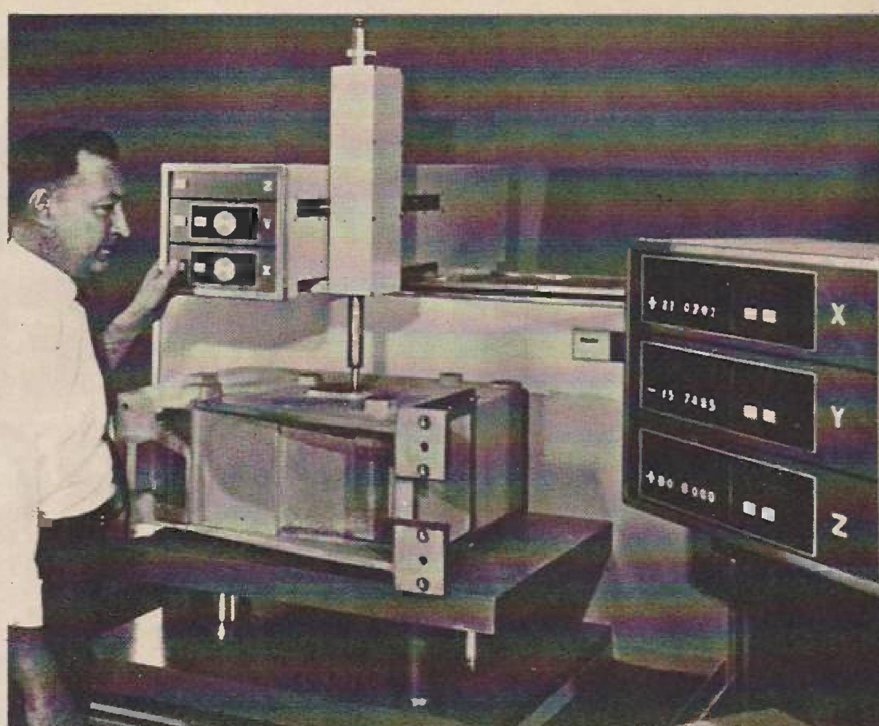


Fig. 2. The Sheffield "Cordax" measuring machine being used to inspect the critical dimensions of a machined part.

RECTANGULAR METHODS

The bulk of industrial machines built for making or measuring work-pieces use rectangular co-ordinates. In Part 2 of the current series, a large numerically-controlled machine tool was illustrated. Smaller units are more usual. A precision inspection machine having three-axis digital readout and recording facilities is shown in Figure 2. High grade machines such as this are accurate to a few micrometres when used correctly and given the right environment. Translating axes are provided as a rectangular framework having separate length transducers on each axis of movement.

The end of the stylus is the position in space being measured, and for this to be accurate, the three slides must be straight to within a micrometre, and square to within seconds of arc. Furthermore, the travelling cantilever arm must hold this angle as it translates: yet it must be stiff enough not to sag significantly as the vertical axis is moved out along its arm. These requirements can be met but at considerable cost. Inspection machines need to be more accurate than the manufacturing machine that produces the components to be checked, but as there are no machining forces involved in the structure, they can be lighter in construction. Inertia of the slides is kept to a minimum to allow the operator to move the stylus more rapidly. The framework of a numerically-controlled tool, however, needs to be especially stiff, for the inertial forces produced by its rapid movements greatly exceed the static forces. Dynamic accuracy is important to retain precision and stability from the control system.

The requirement however, is not always for three axis measurement. In printed circuit-board inspection or drilling, in map making, in bubble chamber photograph digitizing and in automatic flame cutting of sheet, to name just a few examples, the need is for only two axis measurement.

Automatic draughting machines are used extensively and many companies are in this market. Coupled to a computer they are able to produce drawings of extreme precision and complexity. For example, integrated circuit manufacture relies on them. An example of precision artwork of a Honeywell integrated circuit is shown in Figure 3. Another use for drawing machines is to check out numerical control tapes before they are used on the machine tool. This is especially useful in the ship building industry where individual varied shapes are nested together on a single stock-size plate.

If the two axes having readout are free to move, rather than being held by position servos, the machine can be

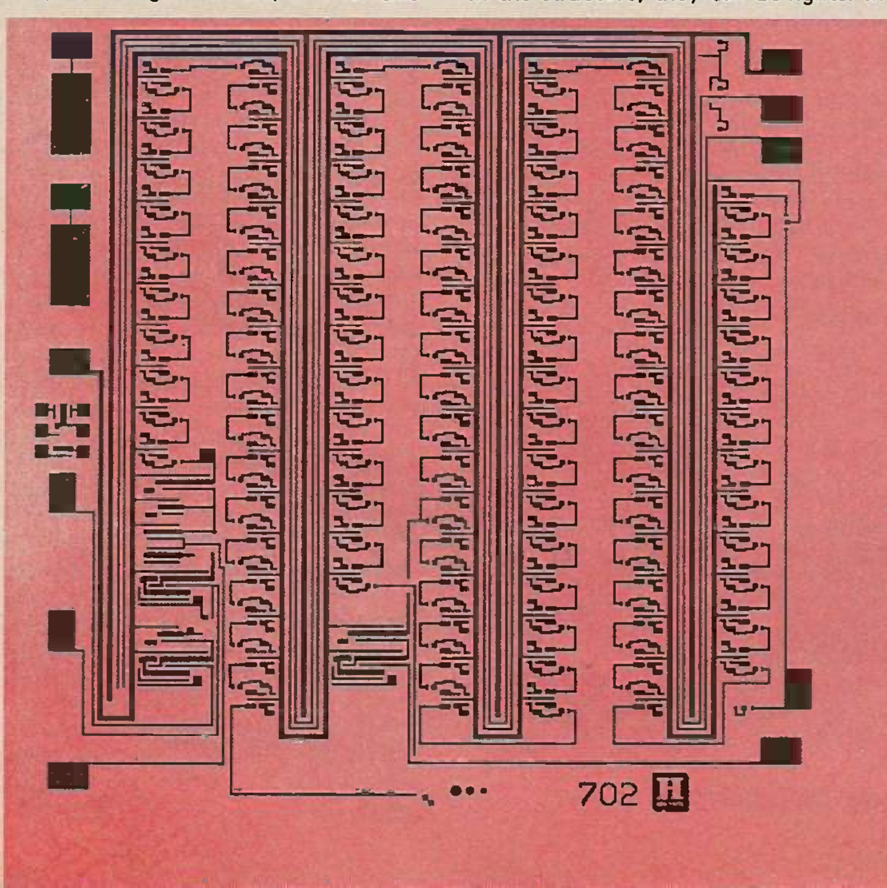


Fig. 3. Precision artwork generated on a Gerber automatic draughting machine.

used to digitize drawings. Several drawing readers and chart digitizers are available. One unit is pictured in Figure 4.

It is also possible to build a three dimensional equivalent of the drawing reader that can produce co-ordinate data as well as drawings of a free-form shape. Several car factories have automatic tracing units, one type is illustrated in Figure 5. The part to be drawn (a clay model or plaster flash of a panel) is placed inside the framework and the stylus driven down into contact. Whilst the horizontal carriage is being driven along over the part, the vertical axis follows the surface contours automatically. On each axis are length transducers that provide the three coordinate values on punched tape. An unusual feature of the unit shown in Fig. 5. is that it also draws the three views as it moves; most machines draw them on another plotter. On each side of the frame is a drawing table. The common axis of the two side view drawings drawn on each board is mechanically tied to the stylus, the other axes being electrically linked to the cross horizontal and vertical movements. The third drawn view is produced on a separate end-view board controlled by the two electrical signals.

IN-SITU OR COMPONENT-SUPPORTED MEASUREMENT

As the size of the part to be measured or manufactured increases, it becomes increasingly expensive to hold the framework stable and accurate. For instance, 20 metre bed boring mills are made at the rate of three or four per year but their cost of a million dollars each is rarely justified. Secondly, not all multi-dimensional objects can be moved to a machine for measurement or manufacture. The surveyor cannot take a building plot into the office to measure it. So for large sizes the object is measured by taking the measuring devices to them, mounting them upon or around them.

In large-scale industrial measurement this has become known as the component-supported or in-situ method of measurement. The work piece acts as a stable precise bed frame and only a small work head and measuring system is needed to provide measuring and precision manipulation facilities.

In the optical tooling procedure, light but accurate slide ways with calibrated scales are placed around, say, an aircraft frame to form x and y axes. On these move precision alignment telescopes, (see Part 4) that project a point on the fuselage out to each scale. In this manner the contour of the airframe can be checked.

This procedure has been automated by the British Oxygen Company for flame-cutting large plates by computer control. Their developmental equipment is shown in Figure 6. Two precision slides carrying motor-driven carriages are mounted at right angles around the plate to be cut. On the top of each is a telescope having an inbuilt optical position-sensitive detector that senses small errors of position between the carriage and the vertical strip light source seen on top of the cutting head. If the light source is not exactly at the intersection point of the lines of sight of the two telescopes, error signals are generated that redirect the tractor. In this way the cutting head is made to contour by following the carriages. The tractor itself is worthy of description. On each side of the square support frame are driving tracks. In the track links are small rollers that enable the track to slide sideways whilst driving forward. In this arrangement the direction moved by the tractor depends upon the relative velocities of each pair of tracks. The overall concept is capable of control over very large areas, the limits being set by the optical turbulence of the sight paths. Alternative methods of performing the same task have been developed as will be seen below.

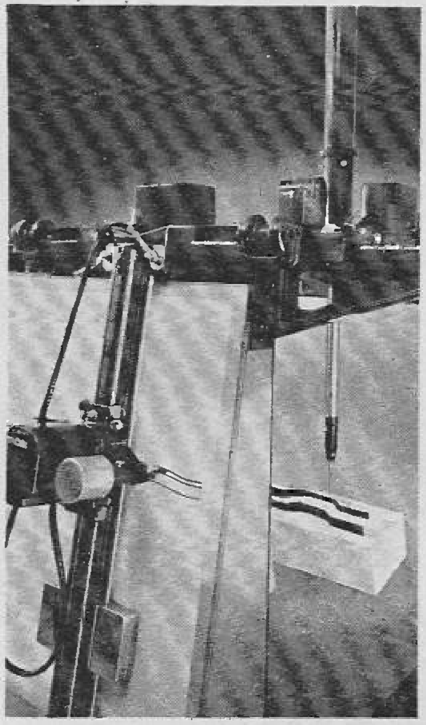


Fig. 5. This type of tracing and digitizing system is used in many automotive plants.

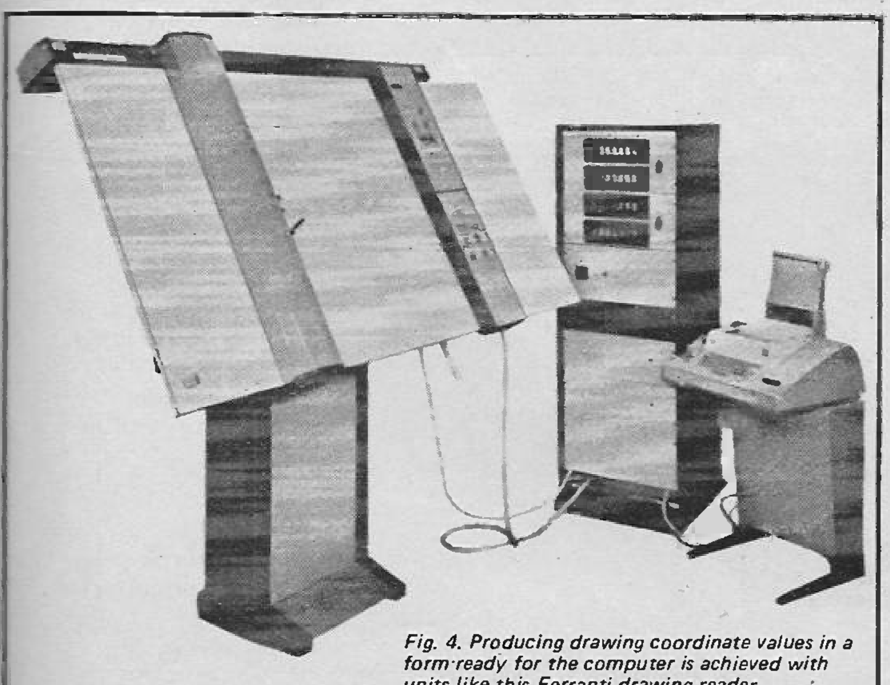


Fig. 4. Producing drawing coordinate values in a form-ready for the computer is achieved with units like this Ferranti drawing reader.

TRIANGULATION METHODS

If position within a plane of large extent is needed, the use of a triangular basis of measurement is attractive, for only two fixed points are needed as a reference instead of two slideways. There are many alternative combinations for defining the points position. If a base line is fixed, two lengths will complete the triangle giving the position of the apex with respect to the ends of the base line. Other combinations use two angles and the fixed baseline or one side and one angle between it and the base line direction. In three-dimensional triangulation there are over twenty different schemes so the choice depends upon other factors of individual applications. For example, a radar unit can most simply track an object in flight by using the R, Θ, ϕ arrangement shown in Figure 1, for only one radar unit is needed.

Alternatively, two units at the ends of a known length baseline are often used

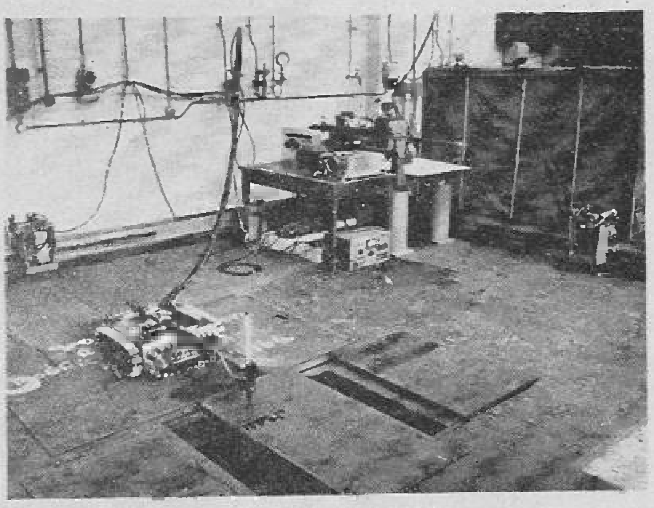


Fig. 6. Automated optical-tooling procedure for cutting large steel plates by computer control.

Fig. 7. A polar co-ordinate digitizer needing no framework.

to avoid the need to measure range distance.

One important factor that needs consideration is the attainable precision of angle measurements versus length measurements in such cases, for extreme precision angle transducers are costly. Let us now consider equipment that has proven practicable using non-rectangular methods.

Coradi, a Swiss company who specialise in mathematical instruments, have marketed a polar co-ordinate drawing digitizer that has the convenience of being useable merely by placing the unit on a drawing as shown in Figure 7. The operator places the cursor cross-hairs over the point of interest, position being recorded as the length of arm extended from the frame and the angle it makes with the base plate.

In nuclear research, bubble chambers are used to record tracks of nuclear reactions. These vapour trails are photographically recorded and their positions digitized ready for processing in digital computers. Each exposure needs hundreds of points to define it and literally millions of photographs are taken each year. Data processing is, therefore, a major problem in this research. One solution to the digitizing problem which yields a moderate rate of information coding uses a device first developed by a French team who called it a "Bidule a fil." Later it became known by the Italians as a "Mangiaspago" or "string-eater".

A schematic of one of these devices is shown in Figure 8. Thin wires, tensioned with hanging weights, pass around drums placed at the ends of a base line member. The two wires join at a viewing puck to complete a variable size triangle. As the puck is moved, each wire rotates a drum which is connected to an angle transducer thus giving a signal equivalent to the length of the wire between the puck and the drum. The Brookhaven Laboratory units are improved versions of the earlier French equipments and can digitize position within an area of 150 by 60cm — to within 10μm.

The potential of triangular measurement in industrial automatic control for large component inspection and manufacture was recognised independently in the late 1960's. Figure 9 shows an experimental trilateral equipment that can control its tool head position (seen on the cantilever arm of the printed-armature motor-driven tooling actuator) to within a few parts of a million in areas of up to 20m by 10m. The demonstration angle-iron base line holds two fast-response spring-tensioned wire-drum length transducers at a fixed distance. The wires join to form the apex of a triangle by connection to two large-bore ball races. These effectively project the wires to form the triangle apex while allowing a tool to be placed at the intersection, thus observing Abbes principle of direct measurement as closely as possible. On the right is the electronic unit that derives two-axis cartesian coordinate error signals from the trilateral wire error signals. These are then used to control the axes movements of the portable tooling head.

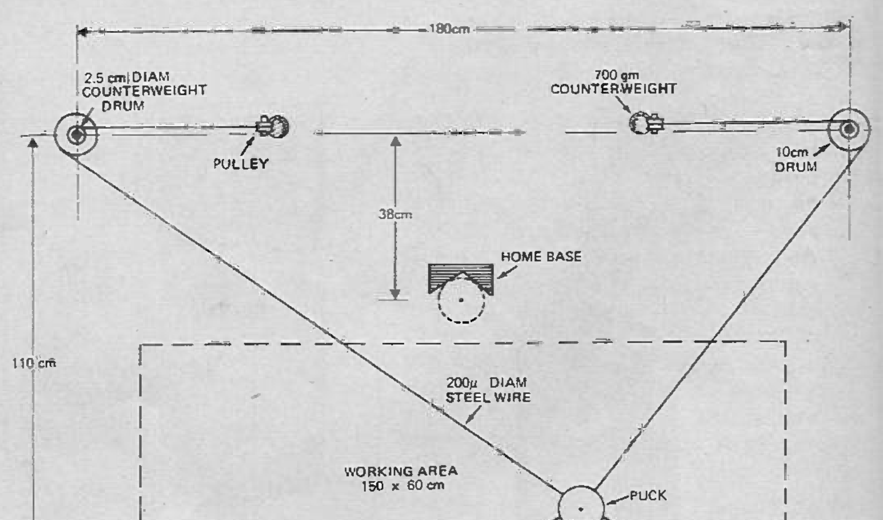


Fig. 8. Schematic of the "Super Mangiospago" of the Brookhaven National Laboratory.

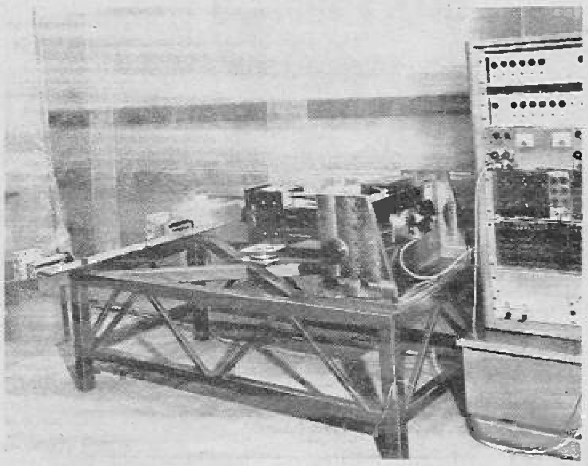


Fig. 9. Automatic position control system using trilateral co-ordinates.

The shape of some large engineering structures dictates a need for non-cartesian methods due to sheer size and immobility. Radio telescopes are good examples of cases needing extreme accuracy shape measurements. The Arecibo telescope in Puerto Rico is over 300m in diameter, and proposals were recently under study for resurfacing it to an accuracy of 3mm. Smaller, but still large, units such as the steerable 210ft. Parkes telescope in Australia have a surface accuracy of 0.2in. The accuracy of the shape largely decides the upper frequency of operation and the antenna gain, so it is most important. Absolute shape is initially obtained using conventional surveying methods, but special devices have been produced using triangulation formed visually with pentaprisms and ruled scales. Shape changes under various loading conditions were measured in Australia using a central scanning camera that photographed the relative positions of hundreds of reflective targets placed over the dish surface. To date it has not proven economic to build automated measuring systems for the dishes. Photogrammetry has proven useful but this also is not completely automatic. This method is outlined later.

Surveyors rarely use rectangular co-ordinates, for they are inappropriate due to the difficulty of defining the x, y, z axes lines from which a line is projected to the point of interest. Instead tapes and electromagnetic distance (EMD) measuring instruments (discussed in Part 2) are used to define distances between triangulated bench marks, in conjunction with angles measured by manual or digital recording theodolites. In geodetic survey, trilateration (lengths only) is now used predomimantly as greater precision is possible with E.M.D. devices for a given amount of effort.

Satellites have also been employed for accurate global measurement. Reflecting balloons 41m in diameter, and known as Echo, are spotted on film from stations located around the Earth. Data derived from the time-correlated satellite and star image background enables the position of the Earth stations to be determined relative to each other. An observation station in Canada is shown in Figure 10. These methods are able to measure to within a part in a million over intercontinental distances. The photographic plates are measured with small x-y digital readout co-ordinate tables.

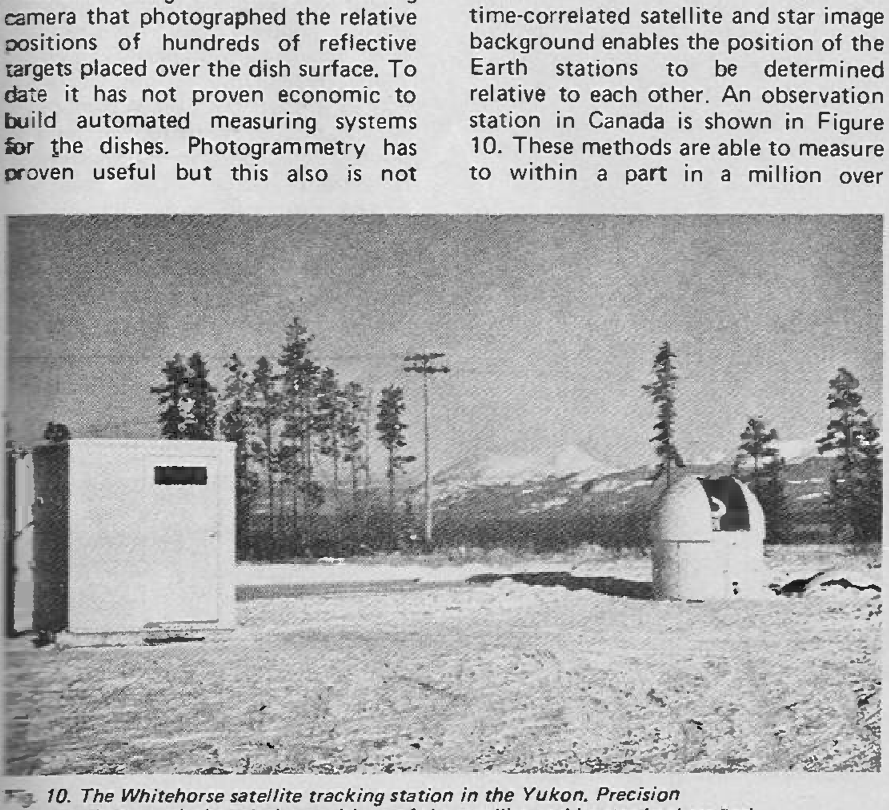


Fig. 10. The Whitehorse satellite tracking station in the Yukon. Precision cameras photograph the relative positions of the satellite and its star background.

But what if observation between ends of a line is not possible, such as inside a mine? In these cases inertial navigation can be used. The gyroscope, shown diagrammatically in Figure 11, provides a fixed direction reference in space. Boeing 747 superjets, Mace and Titan missiles, space vehicles, marine vessels and the military, each use inertial guidance. In the Boeing Carousel IV navigational unit, three accelerometers measure the magnitude of the aircraft acceleration components from which velocity is obtained by integration and position by a second integration. Three gyros hold the accelerometers in the same spatial directions. These units operate with a reliability equal to running a colour T.V. set for forty years without failure. For an hour of flying, the navigational error is less than 2 nautical miles.

Gyros are also used in conjunction with theodolites in surveying situations where triangulation is difficult. The unit shown in Figure 12 has a gyro reference in the underhung cylinder below the theodolite. This unit can define directions to within 1 min of arc for a 15 min observational period. If longer observations are made, it is possible to obtain 10 arc second accuracy.

PHOTOGRAMMETRY AND AUTOMATIC MAP-MAKING

Until recent years, photogrammetry was confined to use in topographical mapping. An aircraft flying at constant speed is used to take aerial photographs of over-lapping areas of ground as it flies. Successive, high-quality photos are then viewed together in a special way as a stereoscopic pair, producing a three-dimensional scene to the observer. Stereoplotting machines convert the pictures to maps. With these machines, the operator controls the movement of a floating point in the 3-D view and moves it over the contours of the 3-D image as though following a path in reality. Photogrammetry is a way to scale down (or up) a 3-D object and reconstitute it somewhere else. The x, y and z co-ordinate values are either recorded or plotted as maps via mechanical or electrical links. The equipment is costly as can be realised from the illustration in Figure 13 – but map making is a big industry.

In the last decade, photogrammetry has been used for other purposes; in medical research for physiological shape change assessment, for checking radio dish and car body shapes and even for recording car accident scenes.

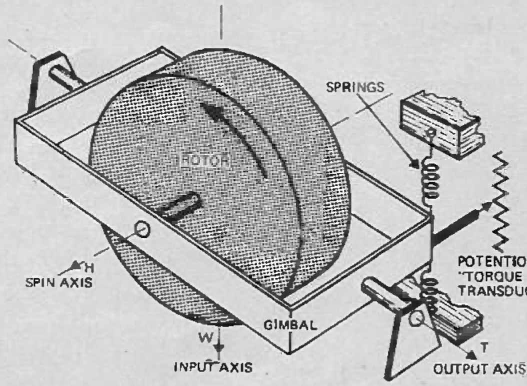


Fig. 11. Schematic illustrating the gyroscope as a reference direction producing device.

Fig. 12. A surveyor measuring underground with a gyro-assisted theodolite.

In Australia, B.H.P. use it for monitoring the stock piles of ore, etc at the end of each day's operations. In the States it has been used to map the sea floor by lowering cameras to the bottom.

As can be guessed, operating the stereo plotting machine is an exacting task requiring a skilful operator, and in recent years research has been directed at automating the process from photo-pairs to finished maps. The difficulty is that although the human computer is not fast or reliable compared with electronic computers, it does have the power to handle vast numbers of variables and come up with a decision using unknown methods. Machines have difficulty in deciding what to do in mapping tasks, so maps made automatically still have a lot to be desired because of the limited rules that can be programmed in.

HOLOGRAPHY

Twenty-two years ago Gabor proposed a method known now as holography. In this, coherent radiation is used to illuminate an object. Some of the original radiation is optically mixed with that reflected from the object, thus forming a two-dimensional interference pattern which looks nothing like the object. This is recorded on film as a hologram. If the hologram is viewed with rear illumination from a coherent source, the object is apparently reconstructed as a 3-D image having depth and form. In a way the hologram is akin to a stereo pair of photos as they both have recorded a 3-D shape on a plane medium for easier viewing elsewhere. Holography, however, operates on an interference basis using short wavelengths and, therefore, has extreme resolution. For example, in time-resolved holography, an exposure of the object is made. The developed picture is the combined pattern of two holograms and exhibits moire-fringes representing surface errors of small magnitude.

The method has been used with visible radiation, for testing cylinder liner accuracies, turbine blade stresses, optical mirror blanks, for studying how insecticide falls on insects and for car-tyre inspection.

I.B.M. have a computer programme that produces holograms without an object to start with. These kinoforms, therefore are synthesised visual experiences.

Holography is not confined to the visible. Microwaves and radio frequencies can be used for seeing in the fog or in darkness or for looking into opaque materials. Ultrasonic radiation has been used for mapping the geology and sands of the sea floor in exploration uses.

SCANNING SYSTEMS

At the smaller end of position measurement is the electron microscope which magnifies the size of an object so that it can be more readily observed and measured by the unaided eye. The most recent technique is called scanning electron microscopy for it uses a scanning principle to build up a two dimensional picture of an object with only a single-point intensity determining detector. A block diagram of the Cambridge Stereoscan instrument is given in Figure 14. The electron beam is focussed to an ultrafine probe on the specimen. Scanning coils deflect this beam to sweep it in a line across the surface of the object. Emitted (or transmitted) electrons are collected as a current related to the reflectance (or absorption) of the specimen. Successive scan lines are placed side by side on a C.R.O. tube to build up a 2D picture. This concept of scanning is common to conventional television cameras, remote-sensing thermal radiation scanners, ultrasonic prospecting and physiological diagnostic instruments.

Ultrasonic distance transducing techniques usually use the pulse return method so are able to measure at only one place at a time. In the Sonogram instrument used in livestock fat assessment, a curved frame is held over the live animal's body. The measuring head moves automatically along the frame producing various reflection echoes at each position. A camera also slowly tilts in synchronism and the photographic plate is exposed where reflections occur. The composite picture produced shows the position of the junctions of the various layers of fat and muscle enabling the quality of, say, chops to be determined

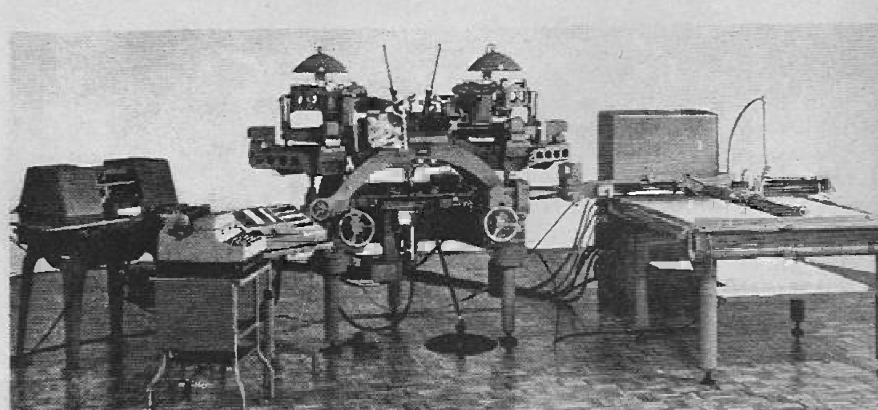


Fig. 13. This machine complex is used to plot maps and other contours from a stereo pair of photos.

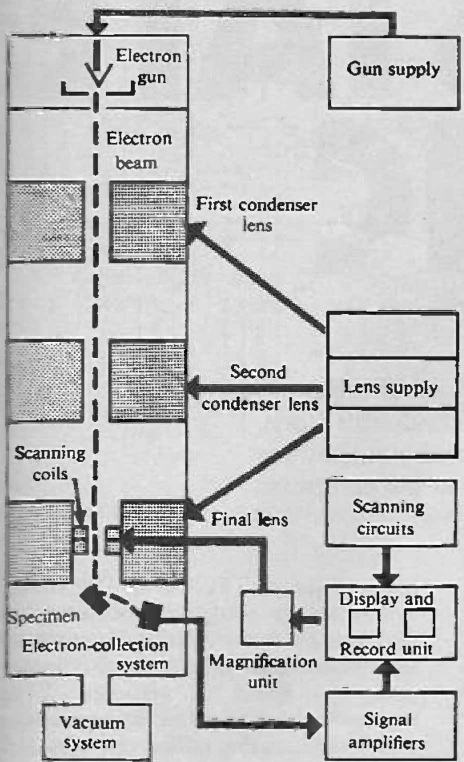


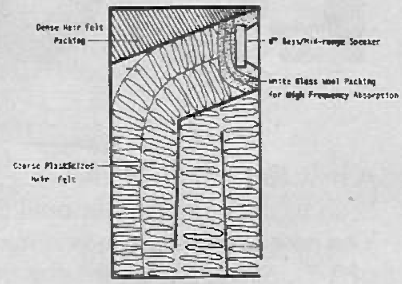
Fig. 14. Block diagram of Cambridge stereoscan electron microscope.

without the need for slaughtering. Similar instruments are used in medical diagnosis for they give different information to the X-ray picture which yields a contrast proportionate to absorption rather than distance information. Although the end result of scanning is a cartesian picture construction, the physical conversion is formed by using a combination of lengths and angles.

It has taken many parts of this series to cover dimensional measurements for these are the most commonly and widespread transduction. In Part 6 we shall discuss how to measure temperature and other parameters concerned with heat. ●

BOWERS AND WILKINS DM2 SPEAKERS

(Continued from page 40)



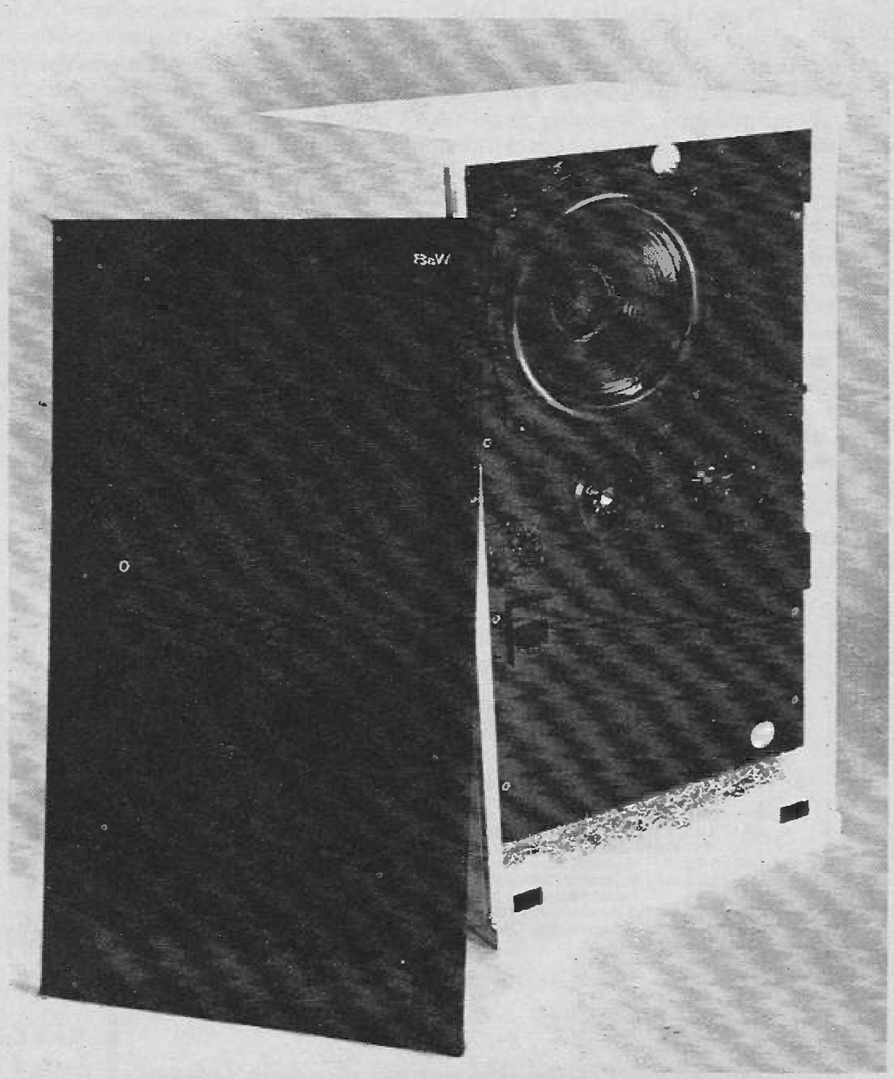
Section through Bowers & Wilkins DM2 speaker showing tapered folded horn.

right up to 10kHz. At 10kHz and above, the harmonic distortion is inaudible and therefore of no real consequence.

The cone resonance in the enclosure was the hardest we have had to detect, mainly because of the very effective dampening of the hair felt.

As with all Bowers and Wilkins monitor speakers the DM2s are supplied with individual frequency response curves, measured in Bowers and Wilkins' main anechoic chamber. They also have a production line test chamber where the speakers pass through in pairs on a conveyor belt and are checked for matching performance. The curve supplied with the speaker reviewed correlated well with our frequency response, the main difference being the smoother curve obtained by Bowers and Wilkins who use pen writing speed five times slower than that which we use.

The Bowers and Wilkins monitor speakers, Model DM2, provide an exceptionally smooth frequency response especially in the middle and upper frequency ranges. They are ideally suitable for the audio purist. ●



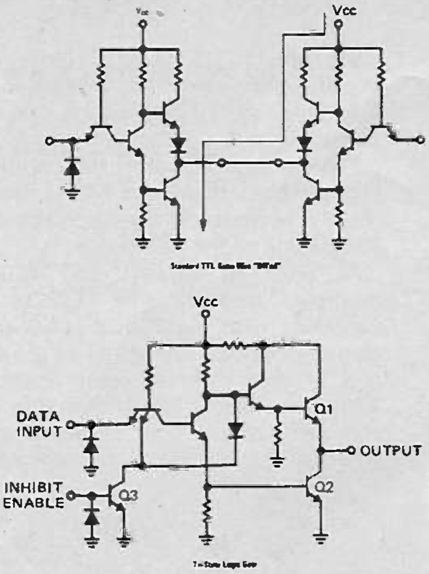


Fig. 1a. Standard TTL gates wire "OR"-ed.
Fig. 1b. TRI-STATE logic gate.

TRI-STATE LOGIC

A new form of logic known as TRI-STATE has been introduced by National Semiconductor Corp. The new devices overcome many of the limitations of TTL and are of particular value in the computer and data processing fields.

AS the state of the art progresses in digital integrated circuits, each newer logic family generally has features superior to those of its predecessor. The evolution from RTL to DTL to TTL (resistor-transistor to diode-transistor to transistor-transistor logic) improved speed, drive capability, and noise immunity.

However, when DTL was upgraded to TTL, busconnectability was lost. This function, usually called "wire-OR'ing," is a very important one in the system designer's toolbox. It not only reduces hardware but is absolutely indispensable to the bus-structured architecture so common in the computer field. The loss resulted from replacing DTL's passive-pullup output with TTL's active-pullup output to increase speed and drive.

Designers of bus-organized systems had to retain DTL or use open-collector TTL elements with external pullup resistors on each data line. This limits system speed to that of the bus-interface elements, typically 2 or 3 MHz for open-collector TTL versus 10 MHz or better for standard TTL. Most of the loss in speed is due to the RC time constant of the pullup resistor and bus capacitance, which generally adds more than 100 nanoseconds to the data transfer delay time. In addition, open-collector TTL has twice as long gate delays as standard TTL. Drive capability is also poorer.

Speed and power may not be important in some areas of logic design, but these parameters are paramount in systems which depend for efficency upon quick transfer of data via buses. The solution to the problem is provided by tri-state logic (TSL). Tri-state logic is essentially TTL with output stages, or input and output stages, that can assume three states. Two states are normal low-impedance TTL "1" or "0" states. The third as a high-impedance state that allows many tri-state devices to time-share bus lines. These devices have the speed of standard TTL, higher line-drive and noise immunity, and by eliminating pullup resistors, cut bus delays to a few nanoseconds.

TRI-STATE CHARACTERISTICS

Maximum leakage current is 40nA when the output is at either the 2.4V or 0.4V levels and does not increase substantially at the 5.0V level. When the device is placed in its active (low-impedance state) it has all the desirable qualities of TTL logic, such as speed, power, and noise immunity. The device however may be connected to the outputs of similar devices, because of its ability to be switched to an OFF state (high-impedance) where it appears to the bus as a 40μA leakage path.

Another important factor in driving a bus line is device current sourcing and

Currently available TRI-STATE devices:

DM7093	quad 2-input buffer
DM7123	quad 2-input multiplexer
MD7214	dual 4:1 multiplexer
DM7230	2:4 multiplexer and bus interchange switch
DM7551	quad D flip-flop
DM7598	256-bit expandable read-only memory
DM7598AA	sine table look-up read-only memory
DM7599	64 bit random access read/write memory
DM7831	quad single-ended/dual differential driver

The following devices will be available shortly

DM7552	decode counter/latch
DM7553	eight-bit storage latch
DM7554	hexodecimal counter latch

DM7000 series devices are to MIL-SPEC, commercial devices are the DM800 series; eg. DM7093 is equivalent to DM8093 commercial.

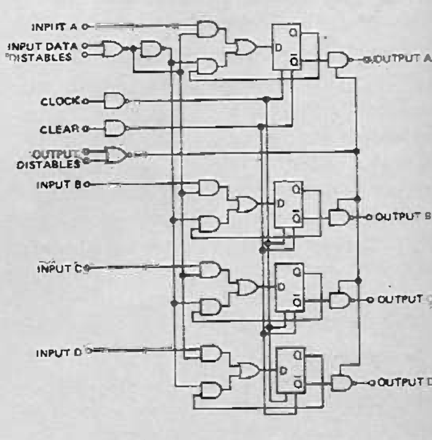


Fig. 2. Logic diagram of TRI-STATE quad flip-flop type DM8551

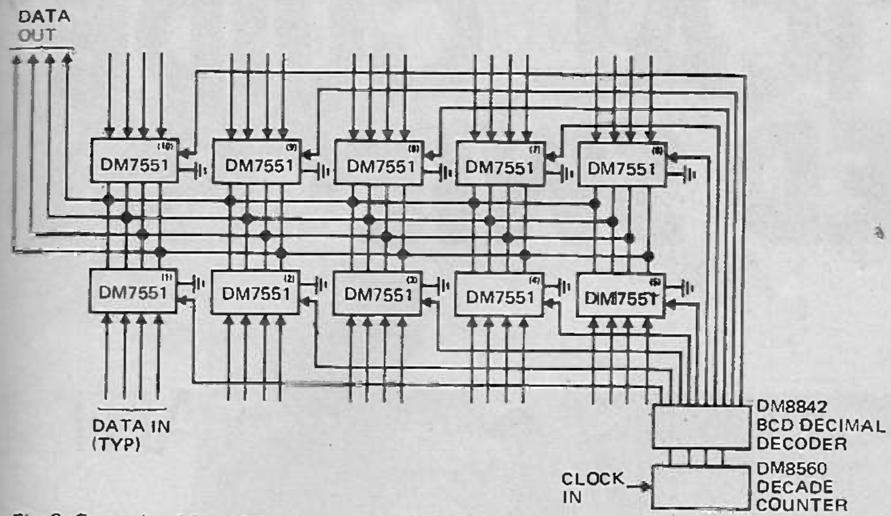


Fig. 3. Example of Bus-Multiplexing with decoder control.

sinking capability. For this reason, the tri-state output stage was designed to source 5.2mA at 2.4V and sink 16 mA at 0.2V. This is 13 times more sourcing capability than a standard TTL gate. This high sourcing capability will permit as many as 128 TSL outputs to be tied to a common bus and still provide enough sourcing current to drive three standard TTL loads.

Another advantage of the high current sourcing feature is that the standard TTL gate with 400μ maximum sourcing capability can only drive about 10 to 12 inches of line before noise problems become prohibitive. The TSL output will drive over 10 feet of line reliably. The greater sourcing capability also provides a far superior "1" level noise immunity, approximately a factor of 10 better than standard TTL devices.

LOGICAL CONTROL

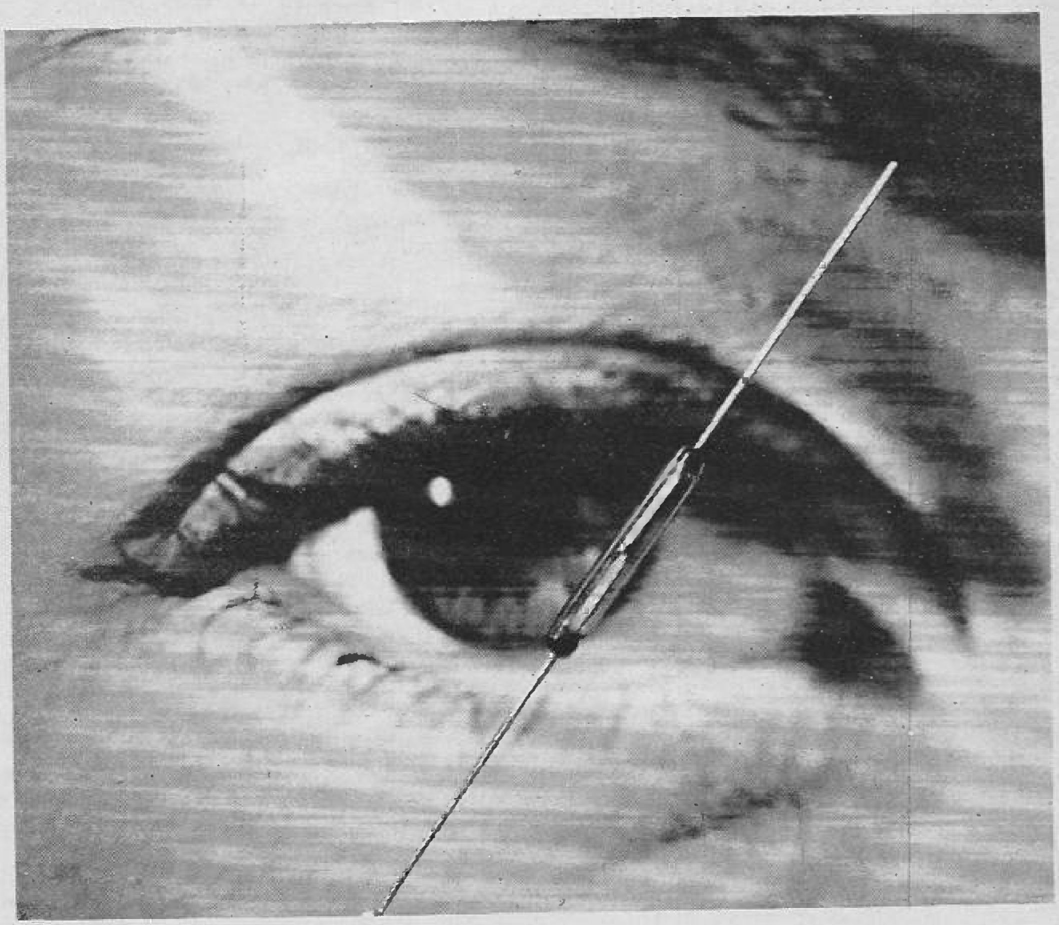
It is the output stage of a standard TTL device that prohibits its use in the wire OR configuration. If the outputs of two TTL gates were connected and one of them was placed in the logical "1" condition and the other placed in the logical "0" condition, a low-impedance path would result from Vcc to ground, resulting in a catastrophic failure in one or both of the gates. (Fig. 19.) The solution to this problem (which developed into the TSL concept) is to provide a separate input that would have priority over all others and force both of the totem-pole output transistors into the OFF state. (Fig 1 b). When this inhibit input is true, the output will be in the high impedance state and any number of such outputs may be connected together without damage. If the inhibit is false (output enabled), then the output will provide a low-Z logical "0" or "1" depending upon the states of the inputs other than the inhibit/enable input. It is worth noting also that the upper device consists of a Darlington stage. This provides the increased sourcing current typical of the TSL output stage.

For some MSI/TSL devices (DM8551 for example), the inhibit/enable line input is brought out as a two input NOR gate. This permits enabling the device when both inputs are logical "O"s. This is done so that large numbers of TSL packages may be selected with TTL decoders, such as the DM8842 (BCD to decimal decoder). Such devices have active low outputs. This enables the selection of one out of 100 TSL devices with the use of only two decoders.

TYPICAL TRI-STATE APPLICATION

One of the key tri-state devices is the DM8551, a synchronously clocked quad-D latch with tri-state outputs. Its logical organization is illustrated in Fig. 2. The internal latch outputs are enabled to the device outputs through four TSL buffering gates. These gates are controlled from a single two-input NOR gate. The outputs are placed in their third state if either of the two NOR inputs is taken to the logical "1" level (high). This arrangement facilitates the selection of up to 100 DM8551's from a single pair of DM8842's (BCD to decimal decoders). This application is illustrated in Fig. 3.

PRACTICAL GUIDE TO REED SWITCHES



PART 2

In the second article in this series, Collyn Rivers explains how reed switches may be electrically actuated.

REED switches are actuated by a magnetic field.

This field can be generated by a permanent magnet, or by an electrically energised coil. When coils are used, the reed switch is simply inserted within the coil former and it is then closed (or opened) when current is passed through the coil.

It operates, in fact, as a relay, and in this form reed switches are used by the million, in telephone systems around the world.

When a reed switch is to be electrically actuated, an indication of the magnetic field strength that is required is generally quoted by the manufacturer in terms of so many ampere-turns. This figure may range from 50 AT to 250 AT (but as

Turns		7,520		9,600		11,900		15,000		19,500		25,000		36,000		43,100		53,000		66,500		86,800
Ohms		219		355		550		855		1,390		2,380		4,320		6,380		9,900		16,000		25,000
Switch Sensitivity	50AT	1.5	6.5	1.8	5	2.3	4.2	2.8	3.3	3.5	2.5	4.8	2	6.1	1.4	7.3	1.2	9.4	0.8	12	0.75	15.7	0.6
	100AT	3.0	13	3.6	10	4.6	8.4	5.7	6.7	7.1	5.1	9.5	4	13	2.8	14.7	2.3	19	1.9	24	1.5	31	1.2
	150AT	4.5	20	5.3	15	6.9	12.6	8.5	10	11	7.6	14	6	18	4.2	22	3.5	28	2.7	36	2.3	47	1.8
	200AT	6.0	26	7.0	20	9.2	17	11	13	14	10.2	19	8	24	5.6	29	4.6	38	3.8	48	3.0	94	2.4
	250AT	7.5	33	8.8	25	11.5	21	15	16	18	12.7	24	10	30	7.0	37	5.8	47	4.6	60	3.8	110	3.0
		v	ma	v	ma	v	ma	v	ma	v	ma	v	ma	v	ma	v	ma	v	ma	v	ma	v	ma

Table 2. Data for standard size reed switch operating coils – bobbins to be 2" long x 0.220" inside diameter, winding build up will be approx. 0.2".

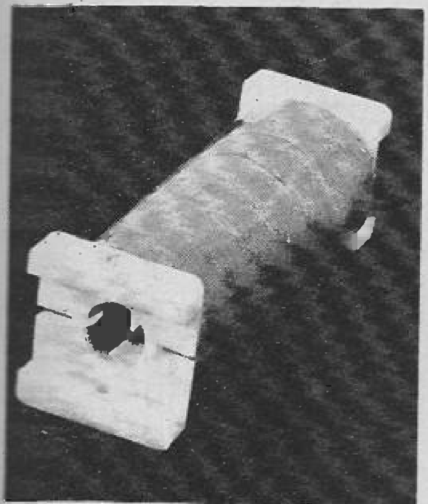


Fig. 11. Bobbin for standard sized reed switch.

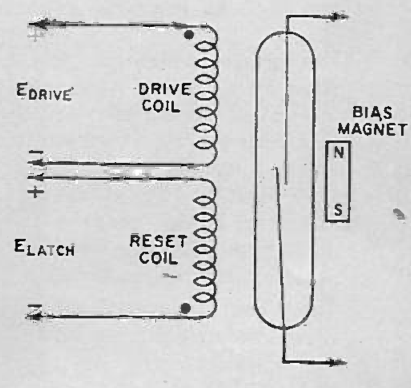


Fig. 13. In this circuit, reed switch is latched by aiding permanent magnet, and reset by magnetic opposition from reset coil field.

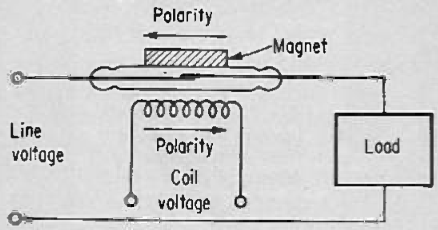


Fig. 14. Normally closed operation using magnetic bias.

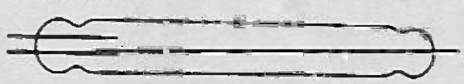


Fig. 15. This type of reed switch may be used for either change-over or normally closed operation.

explained later, this may be substantially reduced by the judicious positioning of a bias magnet).

Various combinations of turns, wire sizes and dimensions may be used to close any specific type of switch, and these parameters will in turn be determined not only by the required number of ampere-turns, but also by the circuit voltage and current that is available. For example a switch that requires 100 ampere-turns may be actuated by a 220 ohm winding drawing 13 mA at 3.0 V., or by a 25,000 ohm winding drawing 1.2 mA at 31 V.

Table 2 provides all the data required to design operating coils for a wide variety of standard sized reed switches, (i.e., 2.75" overall, 2.0" long, 0.217" diameter).

The operating coil may either be wound on a bobbin manufactured specifically for the purpose (Fig. 11) or made up from a length of paper, aluminium or plastic tubing that is a neat fit over the outside diameter of the glass reed.

Another method of making operating coils is to wind them, using a cement coated wire, onto an arbour that is shaped to create the desired final form. After removal from the arbour, the winding should be protected by a layer of insulating tape.

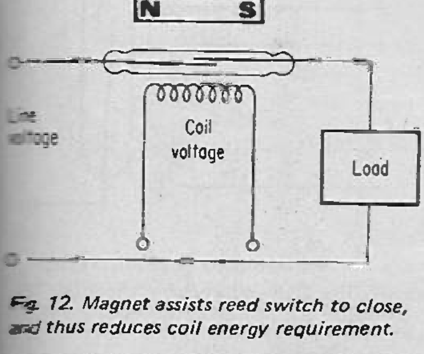


Fig. 12. Magnet assists reed switch to close, and thus reduces coil energy requirement.

EXTERNAL MAGNETIC FIELDS

A reed switch is influenced by a magnetic field regardless of whether that field is produced by the operating coil or by some other magneto-motive force. The magnetic force generated by the field winding can be modified or even completely cancelled by the field from a nearby permanent magnet, or by the alternating flux from a nearby choke, transformer or other inductive device. Even the proximity of a sheet steel chassis may affect the energy at which a reed switch will just actuate.

But the effect of external magnetic influences may be usefully exploited to modify the characteristics of the basic reed switch assembly.

For example the ampere-turns required to close any given switch, can be halved by placing a magnet a short distance away from the coil — the magnet's polarity must be the same as that of the operating coil. The positioning of the magnet is fairly critical and is best determined by trial and error, (Fig. 12).

A similar method can be used to obtain a latching action. In this case the method exploits the magnetic hysterisis of the reed switch. The magnet is placed far enough away from the coil so that it does not close the reeds magnetically, but sufficiently close so as to hold the reeds closed once they have been actuated by an electrical signal through the coil.

In this example the reed relay can be unlatched only by physically removing the magnet, or by applying opposite polarity drive through the operating coil.

A further modification of the magnetic latching principle is shown in Fig. 13. Here, whilst magnetic latching is still used, the operating coil has two windings, one of which is used to actuate the relay, and the other, which is connected in opposite polarity, is used to unlatch the relay.

A magnet may also be used to convert a normally open reed relay to normally closed operation. This is done by locating the magnet sufficiently close to the reed so that the contacts are held closed. (Fig. 14). The coil is wound so as to produce a magnetic flux of opposite polarity to the magnet. When the operating coil is energised, the resultant magnetic flux will cancel out that from the permanent magnet, and the reed will open.

Change-over action may be obtained either by using a reed switch specially made for the purpose (Fig. 15) or by using a magnet and two normally open reed switches actuated by a common operating coil (Fig. 16).

It is possible to actuate a number of separate reed switches located inside one large operating coil, but due to variations in the sensitivity between one reed and another, and the positioning of individual reed switches within the operating coil, it is not possible to predict the contact action sequence. All other things being equal the most sensitive reed will operate first. This will then act as a magnetic shunt, retarding the operation of the remaining reed switches. This is a major difference from conventional electro-mechanical relays where a single armature or card drives all of the movable contacts and any pair of contacts can be adjusted to ensure synchronous operation or a specific contacting sequence.

Nevertheless if a current at least

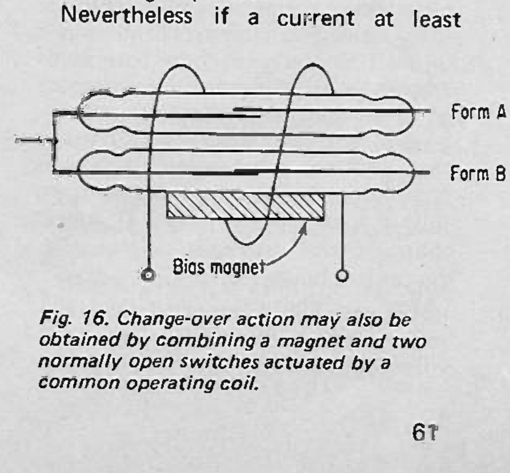


Fig. 16. Change-over action may also be obtained by combining a magnet and two normally open switches actuated by a common operating coil.

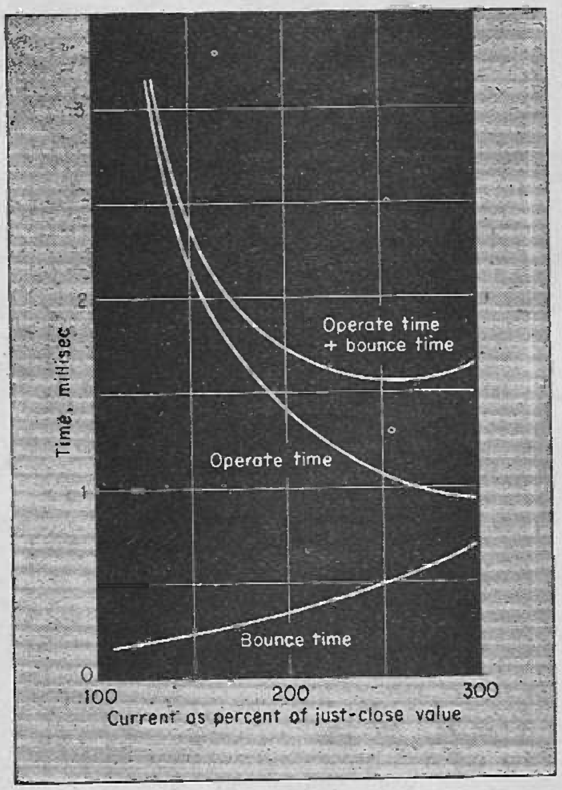


Fig. 17. Variation of operate and bounce time with energizing current.

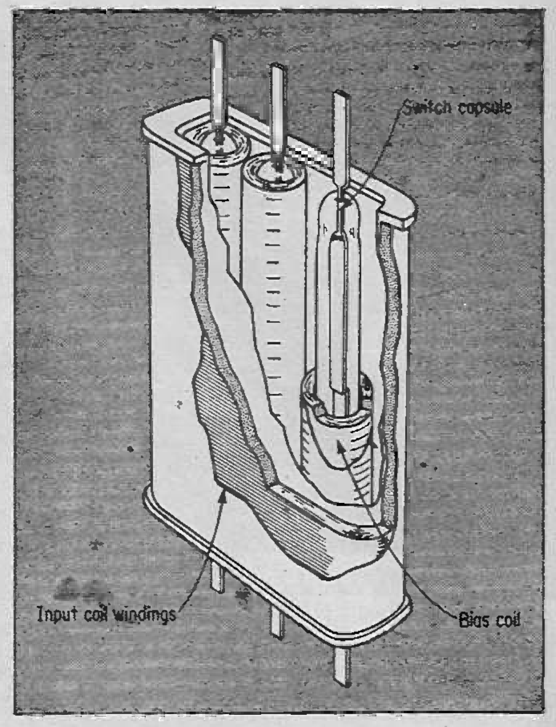


Fig. 18. Reed switch logic module.

150% of the just-operate ampere-turns of the highest rated switch of the group is applied suddenly, this effect is less noticeable, and in most applications may be virtually neglected.

SWITCHING CHARACTERISTICS

The moving blades inside a reed switch have very low mass and move only a few thousands of an inch. The operating coil is not iron cored and so has little self-inductance thus allowing a magnetic field to build up very rapidly. These factors combine to ensure that a reed relay is an inherently quick-acting device, in fact, operating times of less than one millisecond are quite typical.

The speed at which any specific reed relay closes is primarily a function of the number of ampere-turns in the operating coil. But when the contacts close they normally bounce two or three times and the harder the relay is driven (i.e., the greater the number of ampere-turns) the greater the number of times that the contacts bounce. In general reed relay coils are designed so that nominal rated voltage produces approximately 50% more ampere-turns than the just-operate value. This gives optimum total operate time including the contact bounce time. (Fig. 17).

After the contacts have closed and have stopped bouncing, the reeds continue to vibrate for a short time. This vibration produces magnetostriction contact noise — a damped oscillatory voltage that decays to zero — and this may cause problems in low signal level circuits.

With no suppression devices across the operating coil, reed release time is very fast — it may be as short as 25 micro-seconds. Adding a suppression diode has little, if any effect on the operate or bounce times, but it does significantly lengthen the release time. For example, the release time of a standard type of reed without a suppression diode may be 50 micro-seconds, but with a diode the release time may be extended to a milli-second or so.

Due to the geometry of the reed switch construction, the capacitance between contacts is low, and with standard sized reed relays this will be about one pico-farad. The capacitance between the reeds and the operating coil will be about 2.5 pico-farads but this can be reduced to approximately 0.5 pico-farads by interposing a grounded electrostatic shield between the coil and the reed.

Some thermal EMF will be generated at the junction of dissimilar metals in reed switches due to the heating produced by energizing the coil. This thermally-generated EMF may be undesirable if the reeds are used to switch low level analogue signals — as for example in data-logging or thermocouple measurements.

For applications where the thermal EMF must be held to the minimum a bi-stable latching reed relay should be used. A short pulse to the set coil operates the relay, no heat generating holding current is then required. Another short pulse to the reset coil releases the relay. Using this type of operation, the latching relay thermal EMF remains below five micro-volts, compared to as much as 100 micro-volts for continuously energized relays.

REED SWITCHES AS LOGIC ELEMENTS

The reed relay is almost an ideal buffer between solid state devices and higher power output elements. The winding impedance and current levels is well suited for the collector or

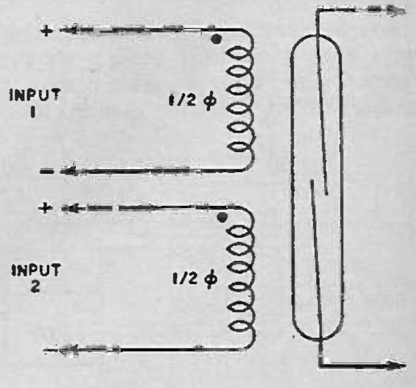


Fig. 19. The reed relay as an AND gate. Each coil can produce ½ a 'flux unit', and an output is obtained only when voltages are applied to inputs.

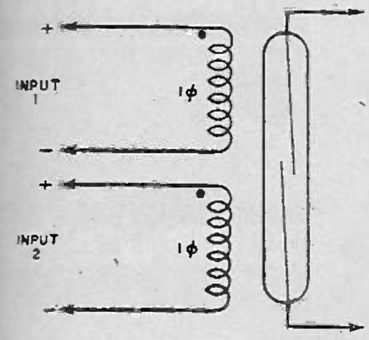


Fig. 20. Reed relay OR gate. Either coil can close reed switch.

emitter circuits of standard transistors, and it can also be driven by many IC elements.

With the recent introduction of the 'pico-reed' switch, a single pole relay is now available in a dual-in-line package, making it both physically and electrically compatible with integrated circuit components. And as reed relays become smaller their operating speeds increase, so that a pico-reed relay can be made to follow 1 kHz pulses.

Reed switches are finding increasing use as logic elements for use in adverse environments. They are capable of performing a large variety of logic functions including AND, OR, EXCLUSIVE OR, and NOT operations. The relays can be used to construct flip-flop circuits, and these can be used in binary, binary coded decimal and decimal counters, ring counters, up-down counters and shift registers.

Whilst operating speed is very considerably slower than with solid state logic elements, there is not the same necessity for precise voltage and frequency regulation, nor the susceptibility to voltage transients. And for these reasons reed relay logic circuits are becoming increasingly used in industrial equipment.

A wide range of reed relay logic elements are commercially available — generally in a configuration similar to that shown in Fig. 18. The individual reed switches are surrounded by bias coils, and these in turn share a common input winding coil. By adjusting the ampere turns level to both input winding and the individual bias windings, a multiplicity of functions can be obtained. A permanent magnet can also be used in this type of logic element to provide memory or latching functions.

When designing reed relays as logic elements, the amount of magnetic flux that is required to close the relay is regarded as one flux unit. Thus a two input AND gate consists of one reed switch surrounded by two windings each of which can generate one half a 'flux unit'. (Fig. 19).

It is possible to expand the concept to produce three, four or five input AND gates by providing a separate winding for each input, such that each winding provides $\frac{1}{n}$th of the total required flux.

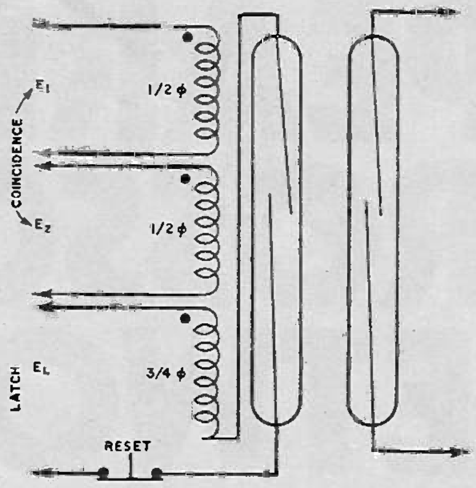


Fig. 22. How a 'memory' may be incorporated in a matrix element.

An OR gate is produced by providing two windings either of which can be energised to the level of one flux unit, (Fig. 20). Thus a voltage in either winding can cause the relay to close. Again as with the AND gate, a number of windings may be used provided each one can provide one full flux unit.

The basic OR gate can be used as an exclusive OR gate simply by reversing the direction of one winding. In this application if either one or the other winding is energised then the relay will close, but if both are energised then the resultant magnetic fields will cancel out and the relay will remain open.

Inverted operation is provided by using relays that are magnetically biased into normally closed operation.

Cross-bar matrix switching is readily achieved by using a double wound relay, in which each winding provides half a flux unit, at each selection point, i.e., A1, A2, A3, etc., (Fig. 21). The appropriate relay will close whenever both coils of any given relay are coincidentally energized.

The cross bar switching system may be used with a magnetic or electrical memory if required. Fig. 22 shows how two reed switches can be used, together with a latching winding, to provide an electrical memory in a reed relay cross bar switching system. In this form the matrix will remember the inputs after they have been removed, until the latching power supply is interrupted.

The final article in this series, which will be published next month describes a number of ways in which reed relays are used in sophisticated equipment.

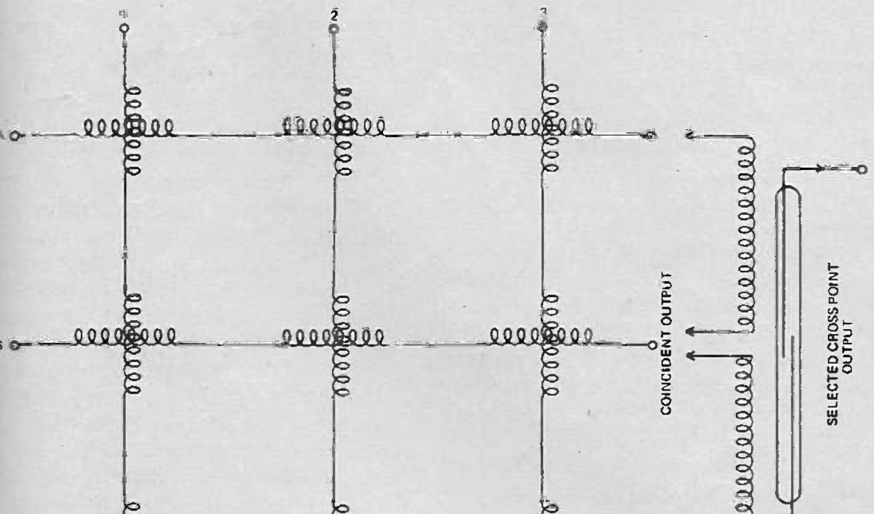


Fig. 21. Cross-bar matrix switching, the appropriate relay will close whenever both coils of any given relay are coincidentally energised.

SPEAKER CROSSOVER NETWORKS

–and how to design them

Speaker crossover networks are quite simple to design – if you have a computer to calculate the component values. So we presented our Honeywell computer time-sharing terminal with the task. Here are the results – crossover design made easy.

IN MODERN high-fidelity systems the loudspeaker must cover a range of frequencies from 30 Hz to at least 15 kHz.

Generally this requires the use of two or more speakers in each enclosure, each speaker operating within a controlled frequency range.

The extent of that part of the sound frequency spectrum handled by each speaker is controlled by 'crossover' or 'frequency dividing' networks consisting of two or more filters.

A two speaker system usually has a two-way network consisting of a high-pass filter and a low-pass filter. The high-pass filter limits the low frequency response of the high frequency speaker, and the low pass filter limits the high frequency response of the low frequency speaker.

A three speaker system will usually have a three-way network. This will consist of a high-pass filter, a band-pass filter, and a low pass filter. The high and low-pass filters act in a similar manner as those in a two-way system. The band-pass filter controls the frequency range of the mid-range speaker.

The effect, in theory at least, is a smooth transition from one speaker to another over the total frequency range of the system.

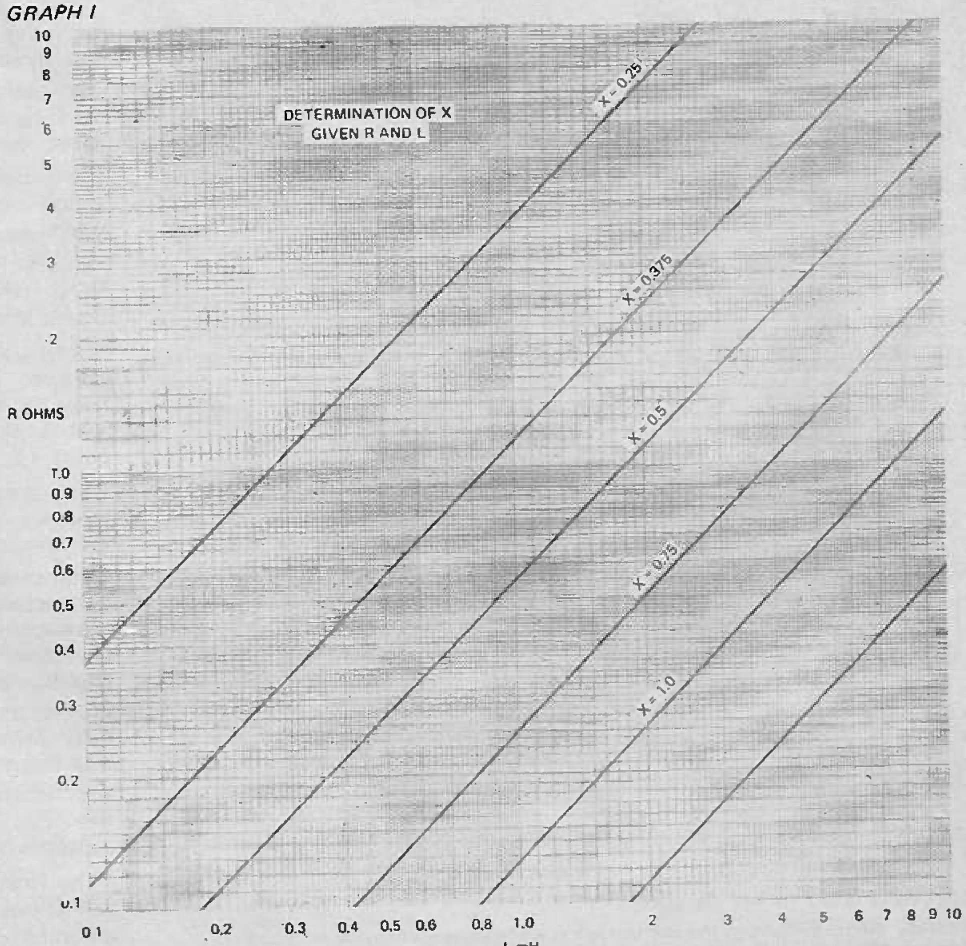
For a multi-speaker system to have a substantially flat response, it is essential that each speaker in the system has a usable frequency range overlapping the next. For example the bass speaker in a two speaker system may have a response that is substantially flat from say, 70 Hz to 3 kHz. The high frequency speaker chosen for this system would probably have a usable frequency range from 500 Hz to 15 kHz. Thus the overlap is 2.5 kHz.

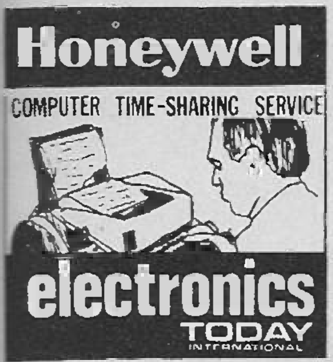
DETERMINING THE CROSS-OVER POINT

A crossover network for the system outlined above would be designed to operate somewhere between 800 Hz and 1 kHz.

A three-way system would probably be designed to crossover at 400 to 500 Hz and again at 5 kHz.

GRAPH I





The optimum crossover frequency may be easily determined by studying the frequency response curves of the speakers to be used and arranging for the crossover to take place before the response of a given speaker unit falls off, or the movement of the diaphragm becomes non-linear. Few bass speakers, for example, have any really usable response beyond 2 to 3 kHz. The range of the frequency spectrum covered by the mid-range unit must be restricted to those frequencies at which the displacement of the diaphragm does not exceed the manufacturer's rating.

It should of course be quite clearly understood that the sole purpose of a crossover network is to control the operating range of each speaker. It is to prevent a tweeter with a cone travel of a few thousands of an inch from being driven by a 50 Watt amplifier at 35 Hz — and to ensure that a bass speaker does not have hysterics trying to emulate Victoria de los Angeles.

A crossover network cannot be used to correct for deficiencies in the record player, amplifier, speaker drive units or enclosure design.

DIFFERENT TYPES OF FILTER

Figure 1 shows a typical frequency response for a crossover network (operating point 1 kHz) consisting of a low-pass filter and a high-pass filter. The graph does in fact show three different pairs of filters, each having a different rate of attenuation.

In practise an attentuation of 6 dB per octave is generally inadequate. The rate of cut-off is not always sufficient to protect the mid-range and high frequency drive units from being overdriven.

An attenuation rate of 12 dB per octave is commonly used, although 18 dB per octave filters are sometimes chosen. For amateur design it is advisable to stick to the 12 dB per octave filter.

Both series and parallel filters are used. Series filters are used only in two-speaker systems. Most commercially built networks use the parallel configuration because component values are the same for each filter and this reduces inventory costs. Apart from cost the parallel

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SYD 0134

HONEYWELL G265 TIME-SHARING SYD.

ON TTY 41 AT 18:52   MONDAY 6/12/71

USER NUMBER---S85004
MODERN MAGAZINE H.

PROJECT ID---BARRY
SYSTEM---BAS
NEW OR OLD--NEW
NEW FILE NAME--FILTERS
READY.

TAPE
READY

15  PRINT USING 18
18:FREQ.      C1     C2     C3     C4     C5     L1     L2     L3     L4     L5
20 PRINT
35  READ R
37  READ M
40  DIM F(25)
50  FOR I=1 TO 22
60  READ F(I)
70  LET W=2*3.14159*F(I)
80  LET Z=R*W
90  LET X=2E6/Z
110 GOSUB 500
120 LET C1=X
130 LET X=1E6/(Z+Z*M)
150 GOSUB 500
160 LET C2=X
170 LET X=1E6/Z
190 GOSUB 500
195 LET C3=X
200 LET X=1E6/(2*Z)
220 GOSUB 500
230 LET C4=X
240 LET X=1E6*(1+M)/Z
255 GOSUB 500
260 LET C5=X
270 LET X=1000*(1+M)*R/W
280 GOSUB 500
285 LET L1=X
290 LET X=1000*R/W
295 GOSUB 500
300 LET L2=X
310 LET X=1000*R/(2*W)
320 GOSUB 500
330 LET L3=X
340 LET X=2*1000*R/W
350 GOSUB 500
360 LET L4=X
370 LET X=1000*R/(W+W*M)
380 GOSUB 500
390 LET L5=X
450 PRINT F(I);TAB(10);C1;TAB(16);C2;TAB(22);C3;TAB(28);C4;TAB(34);C5;
460 PRINT TAB(40);L1;TAB(46);L2;TAB(52);L3;TAB(58);L4;TAB(64);L5
480 NEXT I
500 IF X<100 THEN 520
505 LET X=INT(X+.5)
510 GOTO 600
520 IF X<10 THEN 540
525 LET X=INT(X*10+.1)/10
530 GOTO 600
540 IF X<1 THEN 560
545 LET X=INT(X*100+.5)/100
550 GOTO 600
560 LET X=INT(X*1000+.5)/1000
600 RETURN
700 DATA 8
710 DATA 0.6
720 DATA 100,150,200,250,300,350,400,500,600,750,1000,1250,1500
730 DATA 2000,2500,3000,3500,4000,5000,6000,7500,10000
999 END

RUN

USED       33 UNITS
BYE

TOTAL TTY MINUTES =     35

TOTAL CRU'S USED. =     33

***OFF AT 19:27    MONDAY 6/12/71
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This is the computer programme used to calculate the circuit component values in the crossover networks. Copyright – Electronics Today International.

SPEAKER CROSSOVER NETWORKS

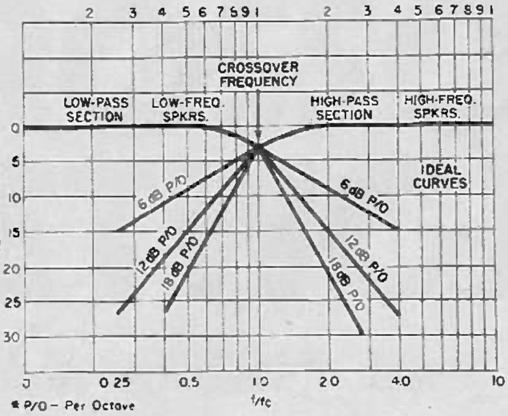


Fig. 1. Typical frequency response curves of a two-way crossover network. The graph shows three different pairs of filters, each having a different rate of attenuation.

Fig. 2

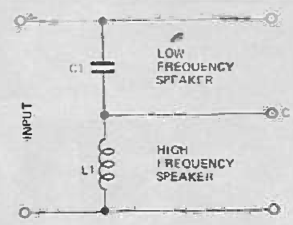


Fig. 3

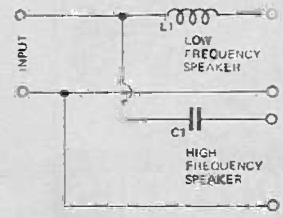


Fig. 4

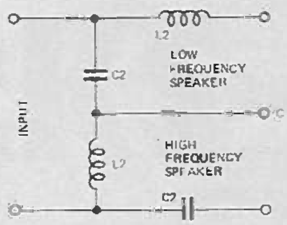
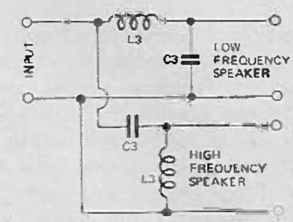


Fig. 5



Constant k crossover networks. Fig. 2 – series type, 6dB/octave. Fig. 3 – parallel type, 6dB/octave. Fig. 4 – series type, 12dB/octave. Fig. 5 – parallel type, 12dB/octave.

FREQ.	C1	C2	C3	L1	L2	L3
100	199	281	141	12.7	9	18
150	133	188	93.8	8.49	6	12
200	99.5	141	70.3	6.37	4.5	9
250	79.6	113	56.3	5.09	3.6	7.2
300	66.3	93.8	46.9	4.24	3	6
350	56.8	80.4	40.2	3.64	2.57	5.14
400	49.7	70.3	35.2	3.18	2.25	4.5
500	39.8	56.3	28.1	2.55	1.8	3.6
600	33.2	46.9	23.4	2.12	1.5	3
750	26.5	37.5	18.8	1.7	1.2	2.4
1000	19.9	28.1	14.1	1.27	.9	1.8
1250	15.9	22.5	11.3	1.02	.72	1.44
1500	13.3	18.8	9.38	.849	.6	1.2
2000	9.95	14.1	7.03	.637	.45	.9
2500	7.96	11.3	5.63	.509	.36	.72
3000	6.63	9.38	4.69	.424	.3	.6
3500	5.68	8.04	4.02	.364	.257	.514
4000	4.97	7.03	3.52	.318	.225	.45
5000	3.98	5.63	2.81	.255	.18	.36
6000	3.32	4.69	2.34	.212	.15	.3
7500	2.65	3.75	1.88	.17	.12	.24
10000	1.99	2.81	1.41	.127	.09	.18

COMPONENT VALUES FOR CONSTANT-K LOUDSPEAKER CROSSOVER NETWORKS
INDUCTANCE IN MILLIHENRIES
CAPACITANCE IN MICROFARADS
SPEAKER IMPEDANCE = 8 OHMS

network has slightly better electrical characteristics in the transmission and attenuation bands. Nevertheless the design data given later in this article covers both series and parallel networks.

Apart from the series and parallel configurations, filters used for crossover networks are known as 'constant k' or 'm derived'. It is not essential for the amateur to understand the difference between the two types. Basically the 'constant k' networks are limited to a cut off rate of 12 dB per octave, whilst the 'm derived' networks can operate at cut off rates of 18 dB per octave. The 'm derived network' is often used by designers of top quality speaker systems as the design approach permits closer control of impedance and attenuation characteristics.

INSERTION LOSS

One of the most important design considerations is that the filter does not introduce any appreciable loss (this is called 'insertion loss') between the amplifier and the speaker drive units. The insertion loss – which is usually quoted in dBs – is caused by the dc resistance of the coils, together with the shunt and series reactance of the circuit elements. The insertion loss of a well designed filter should not exceed 0.5 dB (preferably less than this for high power systems).

For speaker systems driven by amplifiers of less than 30 Watts or so, an insertion loss of 0.5 dB is quite acceptable. But a manufacturer of high power systems will usually try to reduce the insertion loss below 0.5 dB if economically feasible – for the power absorbed by a 0.5 dB filter at 100 Watts input will exceed 10 Watts.

Insertion losses are minimized by using coils of low dc resistance, and capacitors of low power factor.

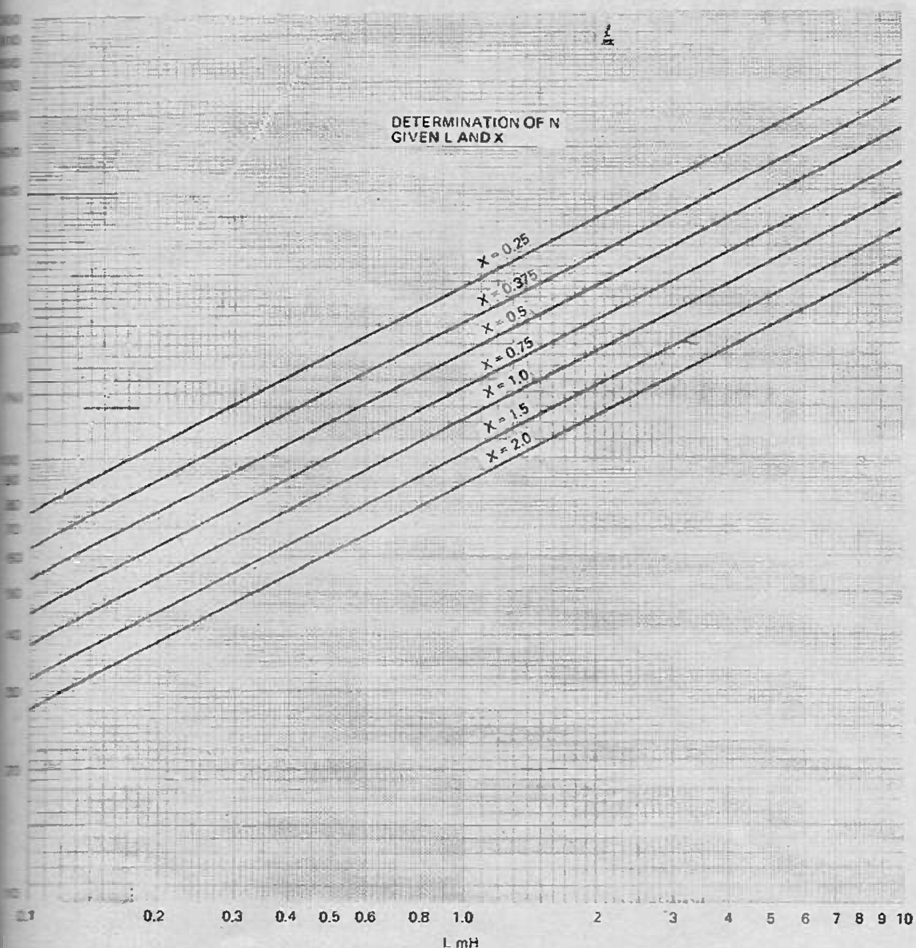
(Apart from the insertion loss, a further loss of approx 3 dB will occur at the crossover frequency. This is because the amplifier power is divided more or less equally between the two speakers at this frequency. This loss is inevitable whenever a crossover network is used – but in practise it is hardly ever apparent to the ear.)

Speaker drive units used in multiple speaker systems should all have similar nominal impedances. Thus, if the bass driver is an eight ohm unit so also should be the mid-range (if used) and high frequency units. If twin units are used for any part of the spectrum – such as twin tweeters – then each speaker should be twice the nominal impedance of each of the remaining speakers, the twin speakers should then be connected in parallel. (Two 16 ohm speakers connected in parallel will reflect an 8 ohm load impedance to the crossover network.)

CALCULATING COMPONENT VALUES

Calculation of the component values for crossover networks is a long tedious business. Unless you have a computer that is!

But as readers will be aware, we have just that – a time-sharing terminal connected to the Honeywell system –



GRAPH II

and this was used to calculate the values of all components required.

The programme — specially written by our Engineering Manager, Barry Wilkinson — is reproduced elsewhere in this article. Component values have been calculated for both 'constant k' and 'm derived' filters and for speakers of both 8 ohm and 15 ohm nominal impedance; complete design data is given for all crossover frequencies from 100 Hz through 10 kHz.

CONSTRUCTION

The actual construction of filter networks is quite simple. Air-cored coils are normally used (iron-cored coils can introduce distortion) and these are very simple to wind. (Design data for winding these coils is included in this article.)

Standard (non-polarized) electrolytic capacitors are not suitable for crossover networks, as even low leakage types have an unacceptable power factor for this application. Special non-polarized electrolytics are made by some firms specifically for crossover networks — but it is significant that many of the top speaker manufacturers will only use paper capacitors for this purpose.

When choosing capacitors for crossover networks ensure that the capacitors' rated dc working voltage is never exceeded by the peak voltage of the signal.

DESIGN PROCEDURE

1. Determine crossover frequencies and attenuation required (i.e. 6dB, 12dB or 18dB per octave).
2. Decide whether filter is to be series or parallel — as explained earlier the parallel type has some advantages over its series counterpart.
3. Select the appropriate circuit from Fig. 2 — 9.
4. Establish component values for required speaker impedance (and either 'constant k' or 'm derived' design) from computer print-out.
5. Design coils using data provided.

COIL DESIGN

Any coil used in a crossover network has a certain amount of dc resistance — and this resistance will dissipate a proportion of amplifier power. Thus, the dc resistance of the coils should be as low as economically possible. A reasonable compromise — where the amplifier power does not exceed 30 Watts continuous power output per channel — is to keep the dc resistance below one ohm.

The coil design that will provide the highest inductance in proportion to the dc resistance is that shown in Fig. 10. In this drawing the radius of the circular winding bobbin is shown as 'x' and all other dimensions are related to this.

Construction of the bobbin is not critical and it can be made from cardboard, or a combination of a wooden core and cardboard cheeks. Metal must not be used.

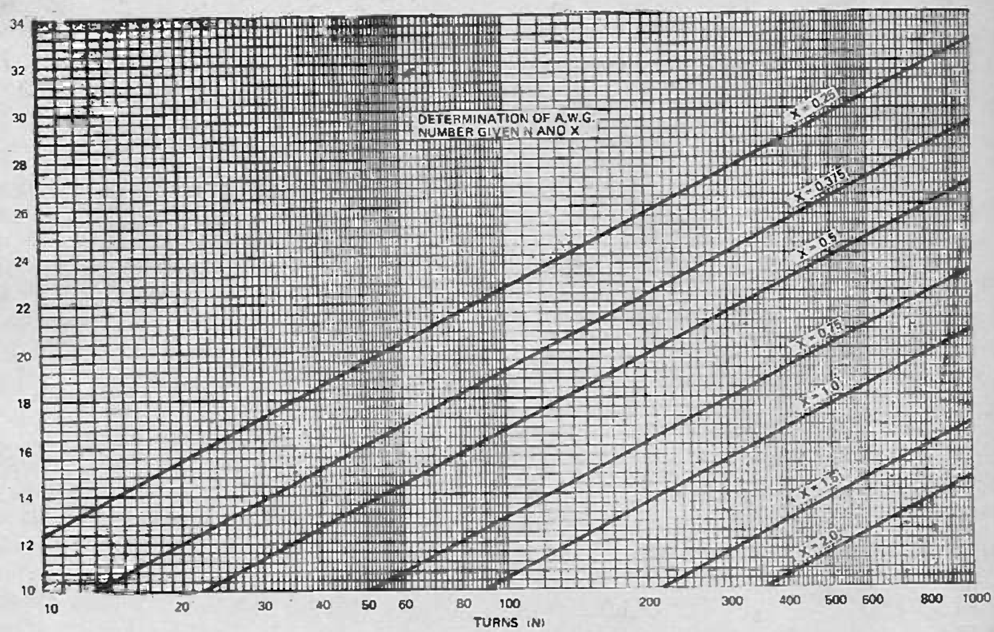
The design procedure is as follows:—

1. Determine the bobbin size required. This is done by using Graph I. This graph indicates bobbin size ('x' measurement) required to accommodate coils of different sizes and dc resistances. For example a 5.5mH coil wound on a 0.75" former (remember that this refers to the measurement shown as

FREQ.	C1	C2	C3	L1	L2	L3
100	106	150	75	23.9	16.9	33.8
150	70.7	100	50	15.9	11.3	22.5
200	53.1	75	37.5	11.9	8.44	16.9
250	42.4	60	30	9.55	6.75	13.5
300	35.4	50	25	7.96	5.63	11.3
350	30.3	42.9	21.4	6.82	4.82	9.65
400	26.5	37.5	18.8	5.97	4.22	8.44
500	21.2	30	15	4.77	3.38	6.75
600	17.7	25	12.5	3.98	2.81	5.63
750	14.1	20	10	3.18	2.25	4.5
1000	10.6	15	7.5	2.39	1.69	3.38
1250	8.49	12	6	1.91	1.35	2.7
1500	7.07	10	5	1.59	1.13	2.25
2000	5.31	7.5	3.75	1.19	.844	1.69
2500	4.24	6	3	.955	.675	1.35
3000	3.54	5	2.5	.796	.563	1.13
3500	3.03	4.29	2.14	.682	.482	.965
4000	2.65	3.75	1.88	.597	.422	.844
5000	2.12	3	1.5	.477	.338	.675
6000	1.77	2.5	1.25	.398	.281	.563
7500	1.41	2				

COMPONENT VALUES FOR CONSTANT-K LOUDSPEAKER CROSSOVER NETWORKS
INDUCTANCE IN MILLIHENRIES
CAPACITANCE IN MICROFARADS
SPEAKER IMPEDANCE = 15 OHMS

SPEAKER CROSSOVER NETWORKS



GRAPH III

Fig. 6

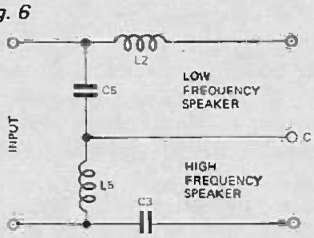


Fig. 7

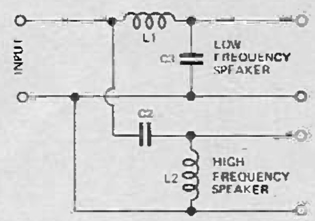


Fig. 8

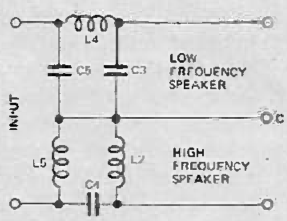
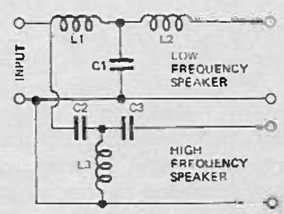


Fig. 9



M-derived crossover networks. Fig. 6 – series type, 12 dB/octave. Fig. 7 – parallel type, 12 dB/octave. Fig. 8 – series type, 18 dB/octave. Fig. 9 – parallel type, 18 dB/octave.

FREQ·	C1	C2	C3	C4	C5	L1	L2	L3	L4	L5
100	398	124	199	99·4	318	20·3	12·7	6·37	25·4	7·96
150	265	82·9	133	66·3	212	13·5	8·49	4·24	16·9	5·31
200	199	62·1	99·4	49·7	159	10·1	6·37	3·18	12·7	3·98
250	159	49·7	79·5	39·7	127	8·15	5·09	2·55	10·1	3·18
300	133	41·4	66·3	33·1	106	6·79	4·24	2·12	8·49	2·65
350	114	35·5	56·8	28·4	90·9	5·82	3·64	1·82	7·28	2·27
400	99·4	31	49·7	24·8	79·5	5·09	3·18	1·59	6·37	1·99
500	79·5	24·8	39·7	19·9	63·6	4·07	2·55	1·27	5·09	1·59
600	66·3	20·7	33·1	16·5	53	3·4	2·12	1·06	4·24	1·33
750	53	16·5	26·5	13·2	42·4	2·72	1·7	·849	3·4	1·06
1000	39·7	12·4	19·9	9·95	31·8	2·04	1·27	·637	2·55	·796
1250	31·8	9·95	15·9	7·96	25·4	1·63	1·02	·509	2·04	·637
1500	26·5	8·29	13·2	6·63	21·2	1·36	·849	·424	1·7	·531
2000	19·9	6·22	9·95	4·97	15·9	1·02	·637	·318	1·27	·398
2500	15·9	4·97	7·96	3·98	12·7	·815	·509	·255	1·02	·318
3000	13·2	4·14	6·63	3·32	10·6	·679	·424	·212	·849	·265
3500	11·3	3·55	5·68	2·84	9·09	·582	·364	·182	·728	·227
4000	9·95	3·11	4·97	2·49	7·96	·509	·318	·159	·637	·199
5000	7·96	2·49	3·98	1·99	6·37	·407	·255	·127	·509	·159
6000	6·63	2·07	3·32	1·66	5·31	·34	·212	·106	·424	·133
7500	5·31	1·66	2·65	1·33	4·24	·272	·17	·085	·34	·106
10000	3·98	1·24	1·99	·995	3·18	·204	·127	·064	·255	·08

COMPONENT VALUES FOR M-DERIVED LOUDSPEAKER CROSSOVER NETWORKS
INDUCTANCE IN MILLIHENRIES
CAPACITANCE IN MICROFARADS
M=0·6
SPEAKER IMPEDANCE = 8 OHMS

'x') will have a dc resistance of 1.4 ohms – if wound on a 1" former the resistance would be 0.7 ohms. As the dc resistance should be preferably less than 1.0 ohm, the 1" former should be used.

2. Graph II shows the number of turns required to provide the required inductance for various bobbin sizes. In our example 290 turns are required.
3. Graph III shows the wire gauge required. In our example 290 turns on a 1" bobbin would require 15.3 B&S. The nearest standard size is 16G so this is the wire size used.
4. The coil should be layer wound using enammeled copper wire. As the operating voltage is quite low, no interlayer insulation is required.

Graph IV shows the dc resistance of the coil given the wire gauge and former size, providing the former is filled completely. In our case the resistance shown is 1.0 ohm – but as we have only 290 turns whereas the filled bobbin accommodates about 350 turns the resistance would be about 0.8 ohm. This is sufficiently close to our design requirement and

(Continued on page 71)

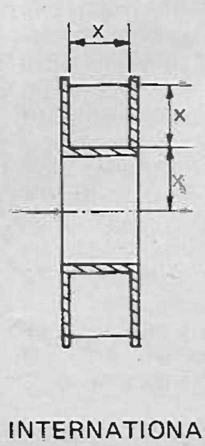


Fig. 10. Recommended dimensions of bobbin design. All dimensions are related to 'x' – thus if the measurement specified for 'x' is 1" then the winding width and depth are both 1", and the bobbin internal diameter is 2".

THE CONTRIBUTIONS OF EDSEL MURPHY TO THE UNDERSTANDING OF THE BEHAVIOUR OF INANIMATE OBJECTS

I. INTRODUCTION

IT HAS LONG BEEN the consideration of the author that the contributions of Edsel Murphy, specifically his general and special laws delineating the behaviour of inanimate objects, have not been fully appreciated. It is deemed that this is, in large part, due to the inherent simplicity of the law itself.

It is the intent of the author to show, by references drawn from the literature, that the law of Murphy has produced numerous corollaries. It is hoped that by noting these examples, the reader may obtain a greater appreciation of Edsel Murphy, his law, and its ramifications in engineering and science.

As is well known to those versed in the state-of-the-art, Murphy's Law states that "If anything can go wrong, it will". Or, to state it in more exact mathematical form:

1 + 1 ☞ 2 (1)

where ☞ is the mathematical symbol for hardly ever.

Some authorities have held that Murphy's Law was first expounded by H. Cohen when he stated that "If anything can go wrong, it will during the demonstration". However, Cohen has made it clear that the broader scope of Murphy's general law obviously takes precedence.

To show the all-pervasive nature of Murphy's work, the author offers a small sample of the application of the law in electronics engineering.

II. GENERAL ENGINEERING

II.1 A patent application will be preceded by one week by a similar application made by an independent worker.

II.2 The more innocuous a design change appears, the further its influence will extend.

II.3 All warranty and guarantee clauses become void upon payment of invoice.

II.4 The necessity of making a major design change increases as the fabrication of the system approaches completion.

II.5 Firmness of delivery dates is inversely proportional to the tightness of the schedule.

II.6 Dimensions will always be expressed in the least usable term. Velocity for example, will be expressed in furlongs per fortnight.

II.7 An important Instruction Manual or Operating Manual will have been discarded by the Receiving Department.

II.8 Suggestions made by the Value Analysis group will increase costs and reduce capabilities.

II.9 Original drawings will be mangled by the copying machine.

III. MATHEMATICS

III.1 In any given miscalculation, the fault will never be placed if more than one person is involved.

III.2 Any error that can creep in, will. It will be in the direction that will do the most damage to the calculation.

III.3 All constants are variables.

III.4 In any given computation, the figure that is most obviously correct will be the source of error.

III.5 A decimal will always be misplaced.

III.6 In a complex calculation, one factor from the numerator will always move into the denominator.

IV. PROTOTYPING AND PRODUCTION

IV.1 Any wire cut to length will be too short.

IV.2 Tolerances will accumulate unidirectionally toward maximum difficulty of assembly.

IV.3 Identical units tested under identical conditions will not be identical in the field.

IV.4 The availability of a component is inversely proportional to the need for that component.

IV.5 If a project requires n components, there will be n-1 units in stock.

IV.6 If a particular resistance is needed, that value will not be available. Further, it cannot be developed with any available series or parallel combination.

IV.7 A dropped tool will land where it can do the most damage. (Also known as the law of selective gravitation.)

IV.8 A device selected at random from a group having 99% reliability, will be a member of the 1% group.

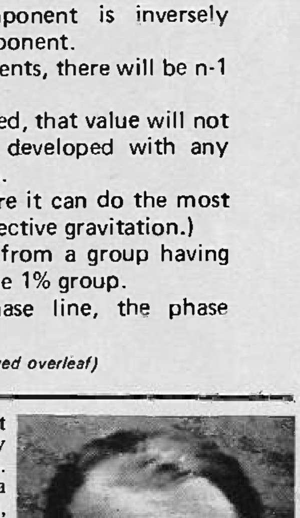
IV.9 When one connects a 3-phase line, the phase sequence will be wrong.

(Continued overleaf)

The man who developed one of the most profound concepts of the twentieth century is practically unknown to most engineers. He is a victim of his own law. Destined to a secure place in the engineering hall of fame, something went wrong.

His real contribution lay not merely in the discovery of the law but more in its universality and in its impact. The law itself, though inherently simple, has formed a foundation on which future generations will build.

In fact, the law first came to him in all its simplicity when his bride-to-be informed him that his boss had 'gazumped' him to the altar.



This hitherto unpublished photograph of Edsel Murphy was taken just after he had heard his ex-fiancée's news.

Edsel Murphy's laws must surely deserve as much recognition as Parkinson's laws or the Peter Principle. In this feature, his law is stated in both general and special form and examples are presented to corroborate the author's thesis that the law is universally applicable.

IV.10 A motor will rotate in the wrong direction.

IV.11 The probability of a dimension being omitted from a plan or drawing is directly proportional to its importance.

IV.12 Interchangeable parts won't.

IV.13 Probability of failure of a component, assembly, sub-system or system is inversely proportional to ease of repair or replacement.

IV.14 If a protoype functions perfectly, subsequent producton units will malfunction.

IV.15 Components that must not and cannot be assembled improperly will be.

IV.16 A dc meter will be used on an overly sensitive range and will be wired in backwards.

IV.17 The most delicate component will drop.

IV.18 Graphic recorders will deposit more ink on humans than on paper.

IV.19 If a circuit cannot fail, it will.

IV.20 A fail-safe circuit will destroy others.

IV.21 An instantaneous power-supply crowbar circuit will operate too late.

IV.22 A transistor protected by a fast-acting fuse will protect the fuse by blowing first.

IV.23 A self-starting oscillator won't.

IV.24 A crystal oscillator will oscillate at the wrong frequency – if it oscillates.

IV.25 A pnp transistor will be an npn.

IV.26 A zero-temperature-coefficient capacitor used in a critical circuit will have a TC of – 750 ppm/^{o}C.

IV.27 A failure will not appear till a unit has passed final inspection.

IV.28 A purchased component or instrument will meet its specs long enough, and only long enough, to pass incoming inspection.

IV.29 If an obviously defective component is replaced in an instrument with an intermittent fault, the fault will reappear after the instrument is returned to service.

IV.30 After the last of 16 mounting screws has been removed from an access cover, it will be discovered that the wrong access cover has been removed.

IV.31 After an access cover has been secured by 16 hold-down screws, it will be discovered that the gasket has been omitted.

IV.32 After an instrument has been fully assembled, extra components will be found on the bench.

IV.33 Hermetic seals will leak.

V. SPECIFYING

V.1 Specified environmental conditions will always be exceeded.

V.2 Any safety factor set as a result of practical experience will be exceeded.

V.3 Manufacturers' spec sheets will be incorrect by a factor of 0.5 or 2.0, depending on which multiplier gives the most optimistic value. For salesmen's claims these factors will be 0.1 or 10.0.

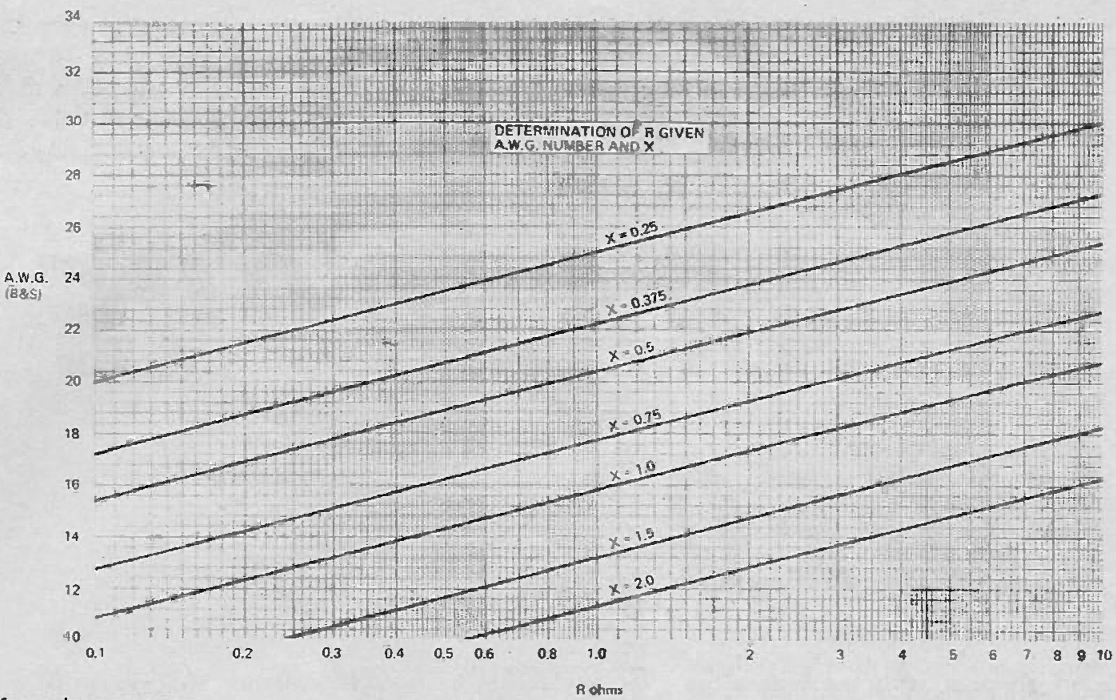
V.4 In an instrument or device characterized by a number of plus-or-minus errors, the total error will be the sum of all errors adding in the same direction.

V.5 In any given price estimate, cost of equipment will exceed estimate by a factor of 3.

V.6 In specifications, Murphy's Law supersedes Ohm's. ●

SPEAKER CROSSOVER NETWORKS

(Continued from page 68)



GRAPH IV

would be acceptable for a low power amplifier.

Figure 11 provides the approximate weight of wire used for fully wound coils of each size.

THREE-WAY CROSSOVER NETWORKS

These differ from two-way networks only in that they include a mid-range filter.

A three-way 12 dB per octave parallel crossover is shown in Fig. 12. The midrange section is a bandpass filter consisting of a low pass filter (L3B and C3B) and a high pass filter (L3A and C3A).

The design procedure is firstly to establish the values of the low pass section L3 and C3.

Circuit elements L3A and C3A, in the mid-range filter, must also cross over at the same frequency as the low pass filter, and thus have the same values as L3 and C3.

The values of L3B is the same as L3C as also are C3B and C3C. The values of these components are determined for the changeover frequency of the mid-range and tweeter speakers.

Four and five way networks are designed in a similar fashion.

'x' inches	Weight (ozs.)
0.25	0.5
0.375	1.75
0.5	4.25
0.75	14
1.00	33
1.50	110

Fig. 11 — This table shows the weight of wire used for fully wound coils of each size of 'x'.

FREG.	C1	C2	C3	C4	C5	L1	L2	L3	L4	L5
100	212	66.3	106	53	170	38.2	23.8	11.9	47.7	14.9
150	141	44.2	70.7	35.3	113	25.4	15.9	7.96	31.8	9.95
200	106	33.1	53	26.5	84.8	19.1	11.9	5.97	23.8	7.46
250	84.8	26.5	42.4	21.2	67.9	15.2	9.55	4.77	19.1	5.97
300	70.7	22.1	35.3	17.6	56.5	12.7	7.96	3.98	15.9	4.97
350	60.6	18.9	30.3	15.1	48.5	10.9	6.82	3.41	13.6	4.26
400	53	16.5	26.5	13.2	42.4	9.55	5.97	2.98	11.9	3.73
500	42.4	13.2	21.2	10.6	33.9	7.64	4.77	2.39	9.55	2.98
600	35.3	11	17.6	8.84	28.3	6.37	3.98	1.99	7.96	2.49
750	28.3	8.84	14.1	7.07	22.6	5.09	3.18	1.59	6.37	1.99
1000	21.2	6.63	10.6	5.31	16.9	3.82	2.39	1.19	4.77	1.49
1250	16.9	5.31	8.49	4.24	13.5	3.06	1.91	.955	3.82	1.19
1500	14.1	4.42	7.07	3.54	11.3	2.55	1.59	.796	3.18	.995
2000	10.6	3.32	5.31	2.65	8.49	1.91	1.19	.597	2.39	.746
2500	8.49	2.65	4.24	2.12	6.79	1.53	.955	.477	1.91	.597
3000	7.07	2.21	3.54	1.77	5.66	1.27	.796	.398	1.59	.497
3500	6.06	1.89	3.03	1.52	4.85	1.09	.682	.341	1.36	.426
4000	5.31	1.66	2.65	1.33	4.24	.955	.597	.298	1.19	.373
5000	4.24	1.33	2.12	1.06	3.4	.764	.477	.239	.955	.298
6000	3.54	1.11	1.77	.884	2.83	.637	.398	.199	.796	.249
7500	2.83	.884	1.41	.707	2.26	.509	.318	.159	.637	.199
10000	2.12	.663	1.06	.531	1.7	.382	.239	.119	.477	.149

COMPONENT VALUES FOR M-DERIVED LOUDSPEAKER CROSSOVER NETWORKS
INDUCTANCE IN MILLIHENRIES
CAPACITANCE IN MICROFARADS
M=0.6
SPEAKER IMPEDANCE = 15 OHMS

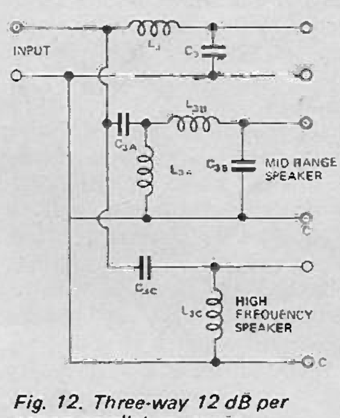


Fig. 12. Three-way 12 dB per octave parallel crossover.

The component values quoted for the three way 'constant k' 'network described above can be converted to an 'm derived network' by the following equations.

$$L3, L3B = (1 + m)\frac{Ro}{\omega c} \text{ Henry}$$

$$L3A, L3C = \left(\frac{R}{\omega c}\right) \text{ Henry}$$

$$C3A, C3C = \left(\frac{1}{1+m}\right)\left(\frac{1}{\omega c Rc}\right) \times 10^6 \mu F$$

$$C3B = \left(\frac{10^6}{\omega c Rc}\right) \mu F$$

Electronics Today International would like to thank Mr I.C. Hansen for his very valuable assistance in providing design data for the coils described in this article.

RESHAPING BY ANALOGUE VIDEO

An analogue reshaping system has been developed at the University College, Cardiff, by Dr R M Appleby and Mr G L Jones, under the sponsorship of the Natural Environment Research Council. This equipment has many potential applications, chiefly as a design aid, since it enables the image of an object, displayed on a closed circuit TV display, to be controllably altered in either dimension.

By simultaneously and independently modifying the linearity of the line and frame time bases by means of function generators under the control of an operator, the immediate effect of changes in image can be visually assessed, thus circumventing the conventional approach to product design of long and often tedious draughtsmanship in the search for an ideal shape.

The original purpose in developing this equipment was to facilitate the comparison of botanical and zoological outlines which, among members of any one biological group, will often follow fairly simple rules of cartesian projection. The potential applications clearly range much further than this, however, and might include product design in many industries.

For example, in the textile, carpet and wallpaper industries, a basic design pattern may be elongated, compressed and rearranged in other ways to fit different areas of product whilst, in the ceramics and glass industries, household pottery and glassware may be designed by first establishing an optimum shape with maximum 'eye appeal' and then completing the design with an appropriate decorative pattern. Similarly, this concept can be applied in many other fields of product design such as clothing, shoes, cars, television sets and consumer items in general.

To give an example of such an application, figure one shows a Mini car as photographed from the display with the video system controls set for nil distortion. Figures two, three and four illustrate the visual effects upon the Mini outline and the corresponding effects upon the reference grid of modifying the line and frame time bases.

Rather different applications may be found in the opportunities it could give to art designers working in advertising, television, the cinema and the theatre. The instrument has many applications also as a serious research tool and the prototype equipment at the University College, Cardiff, is used frequently by the departments of geology, zoology and archaeology, and the University of Wales Dental Hospital. Research topics to which it has contributed include the transformation of map projections, comparative studies in anatomy, child dentistry and geological analysis.

(74)

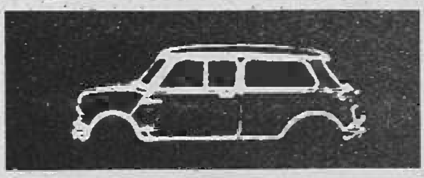


Fig. 1

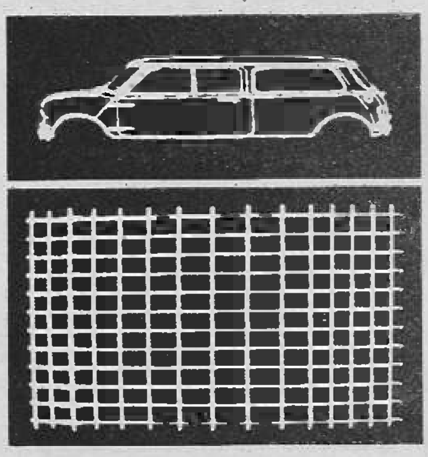


Fig. 2

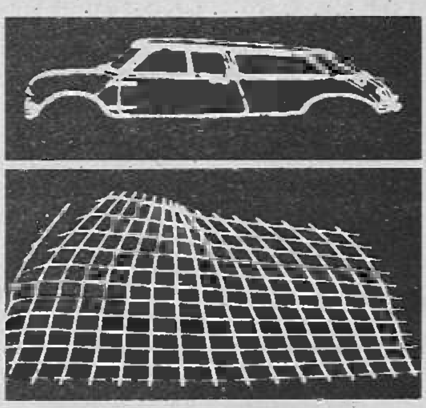


Fig. 3

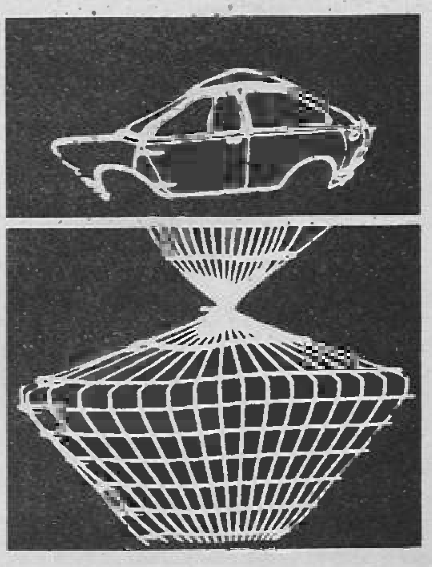
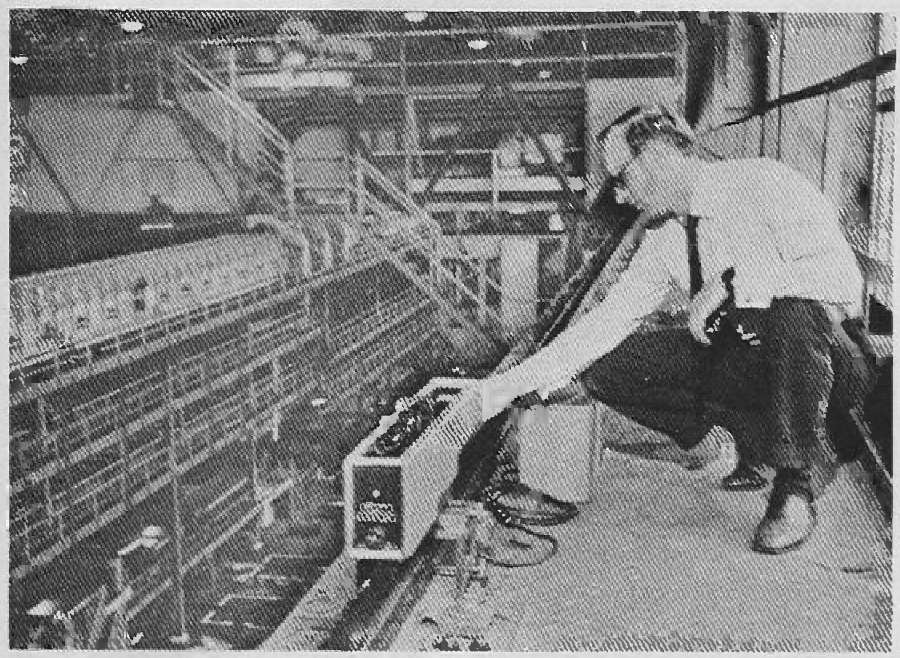


Fig. 4

EQUIPMENT NEWS

LASERLINE



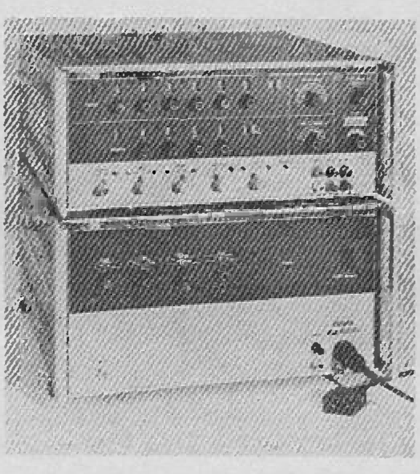
Laserline, a portable laser beam projector designed specifically for field survey operation, provides an accurate linear reference in pipe-laying, tunnel guidance and other civil engineering applications. It is rugged and waterproof, is fitted with a sighting telescope and levelling bubble and operates from a 12V battery supply. Advantages of a laser beam are that, once aligned, it operates unmanned, is not disturbed by people or vehicles passing through the reference line, penetrates haze and can be set up very quickly.

Illustration shows laserline used by British Steel Corporation surveyors in the steel works at Ebbw Vale, South Wales, where the rails are some 60 ft above floor level and heat haze makes visual sighting difficult and confines survey work to the few hours when the plant is not fully operating. **(92)**

PRECISION AC CALIBRATION

A wide range, high, precision AC calibration system for both the calibration lab and production testing, unveiled recently by Fluke International, consists of the Model 5200A AC calibrator and the Model 5205A precision power amplifier. Range of the Model 5200 is 10Hz to 1.2MHz; of the Model 5205A power amplifier DC to 120KHz. There are 5 frequency ranges with 4 digit resolution from 100Hz to 1MHz and 20% overranging on all ranges, and seven ranges of amplitude from 1mV to 1000V with six digit resolution. Model 5200A offers outputs from 100uV rms to 120V rms at 50 mA. Model 5205A extends both voltage and current capability to 1200V rms at 200 mA rms. Outputs, protected by current limiting, have amplitude accuracy of ±0.02% and amplitude stability of ±0.01% of setting for six months. Frequency accuracy is 1%.

All functions and ranges are DTL/TTL programmable. The model 5205A can be programmed by either the 5200A or another control source so that it amplifies any external DC or AC signal. **(93)**



POCKET CALCULATOR

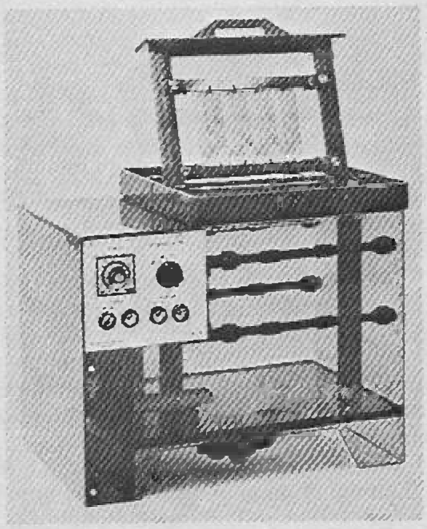
A new British designed and manufactured personal electronic calculator with 'touch plate' keyboard and recessed keys is claimed to have a larger display than any other pocket-sized calculator.

It is both mains and rechargeable battery operated. The heavy duty Ni-Cd cells are claimed to improve reliability and minimise running costs and permit 500 complete discharges (an average of five hours work) before recharging is required.

CALATE has an 8-digit display, a full floating decimal system and an automatic constant. It is capable of all four rules of arithmetic, both chain and constant multiplication and division, algebraic logic and mixed sequential calculations. It weighs 8½ oz and measures 5½ x 3 x 1¾ inches. **(94)**

SPRAY ETCHER

A new laboratory bench-mounting spray etcher selling at under £400 and known as the Type DL-1d, has a double-sided fixed-spray system and has been designed particularly for the production of prototypes and small batches of single or double-sided circuit boards. The bodies of the etcher and the pump are constructed of PVC and titanium, thus permitting the use of most commercially available etchants. The fixed-spray

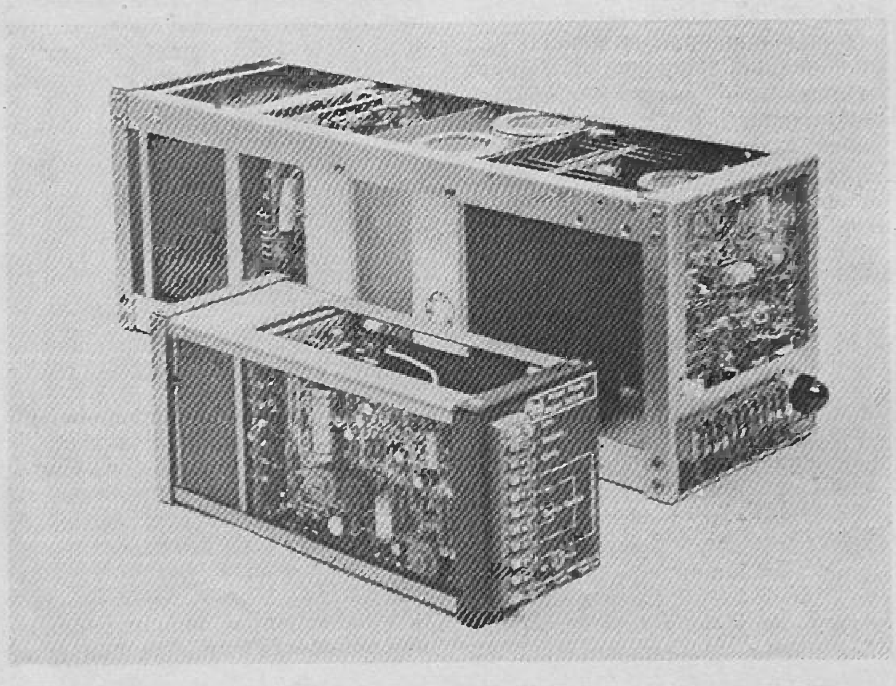


system is housed in a transparent chamber so that the process can be observed. The heating is thermostatically controlled and a timer for automatic setting of the etching time is available if required. The DL-1d is provided with a work-holder which will take boards up to 220 x 290 mm (8½" x 11 3/8"). **(89)**

POWER SUPPLIES

Now available ex-stock from APT is the complete range of 22 models in their SCV series of general-purpose compact dc power supplies. These modular units are in three standard sizes and provide output voltages ranging form 1 to 500V and currents from 100 mA to 10 Amps.

Other features include line regulation of 0.005%, ambient operating temperature range of −10 to +60°C, temperature coefficient of 0.01%, etc. **(90)**



SCIENTIFIC CALCULATOR

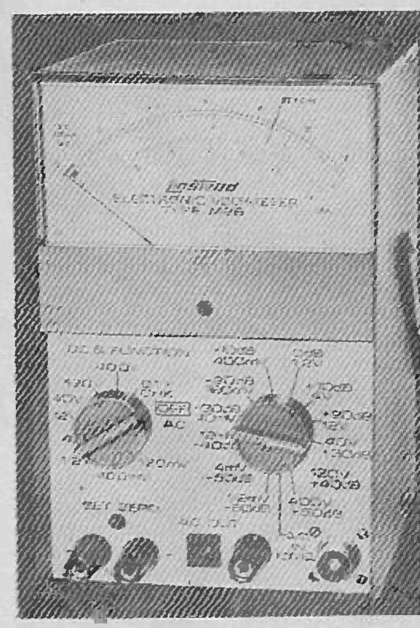
Model 1259S Scientific Calculator is designed for the Scientist, Architect or Engineer, or anyone requiring fast accurate answers to complex calculations. It provides advanced mathematical functions enabling protracted and repetitious trignometric, logarithmic, square and cube roots, conversions and other intricate operations to be per-

formed without necessity to program. The answers are provided in a fraction of the time required for slide-rule calculation, or in looking up log and trig tables, and with greater accuracy.

The calculator weighs 5.2 lb and measures approximately 9½" wide x 12" deep x 3" high and is priced at £275. **(91)**

mV METER

The Linstead M2B millivolt meter has 12 ac ranges from 1.2mV to 400V fsd and 8 dc ranges from 120mV to 400V

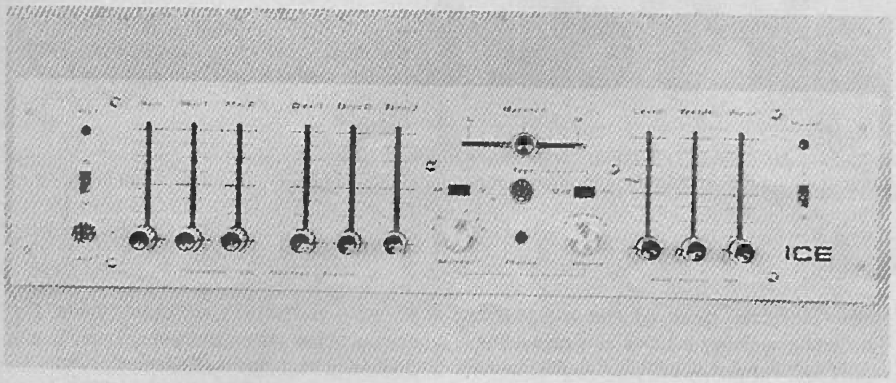


fsd. Because of the use of a special feedback circuit, the ac scale is linear permitting readings down to 60mV on the 1.2mV range. The instrument may also be used as an ac amplifier with a low output impedance and a flat frequency response from 10Hz to 300kHz (±1dB at 500kHz). The voltage gain is approximately 600 when used on the 1.2mV range. Input impedance is 10 Megohms protected against overload. **(85)**

MIXER PRE-AMP

The SMP 101 stereo mixer preamplifier for the hi-fi, recording and professional user, said to be the first of its type to be introduced, has six inputs: two microphones, three discs (record decks), and an auxiliary (tape recorder or tuner). Each input has its own slider control together with treble and bass. The whole unit may be switched to either mono or stereo and has a balance control centrally positioned on the front panel.

Outstanding features include facility for making stereo tape recordings and



for premonitoring, or "queueing up' on all six inputs except mic 2. Monitoring or PFL (pre-fade listening) is through stereo headphones with a separate volume control. Other features are low crosstalk level, high overload capability and ability to drive up to four power amplifiers of 480 watts total.

Applications in addition to hi-fi and recording are: discotheque mixing, microphone mixing, disc mixing, tape recording and editing, preparing sound tracks for home movies, and background or foreground sound for entertainment — in dance halls, at exhibitions, in hotels and public buildings. **(97)**

SEE-IN-THE-DARK TV CAMERA

A new surveillance aid introduced by EMI, to enable factory security staff, police, armed forces and oceanologists or marine salvage experts to 'see' in near-darkness conditions is a CCTV developed for a variety of portable and fixed surveillance roles from perimeter security to deep sea search operations.

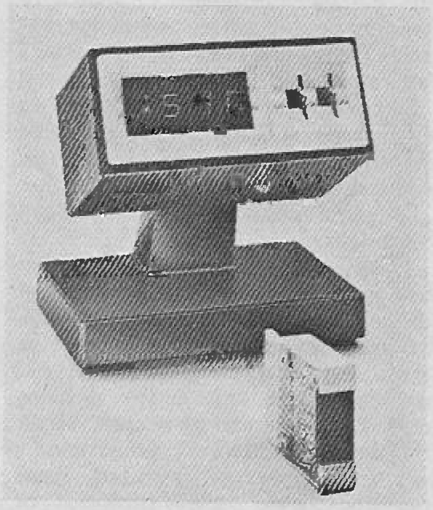
Known as the MTV-1, this monochrome camera, said to be the smallest and most sensitive of its type in the world and 500 times more sensitive than a standard vidicon TV camera, provides bright pictures in 'half moonlight' conditions and can identify darkened scenes or objects which may be invisible to the human eye.

The MTV-1 can be fitted with a variety of lenses and housings for specific applications and a complete range of accessories is available for remotely-controlled operation and 24-hour surveillance watch.

In its portable role, it can be used with a standard portable video tape recorder to obtain a permanent record of scenes viewed with the camera. The camera is also equipped with a built-in microphone which can be used for recording a commentary on to the video tape. **(95)**

GaAsP DISPLAY

Contraves I P Ltd have announced a new gallium arsenide phosphide 7-segment and decimal point display module, ZG002, with BCD decoder/driver having 'lamp test' and 'ripple



blanking' facilities. The module has single plane character presentation and requires only a single 5V dc supply to support both decoding and display functions. It is said to be very economical in panel area requirement and depth behind panel. The illustration shows its use in a 24-hour desk clock. **(96)**

MILLIWATT TEST SET

Test Set EPM-1, designed principally as a standard laboratory or test instrument for extremely accurate measurement of the levels OdBm and OdB in telecommunications systems, is also suitable for calibration of noise sources, checking the calibration of signal generators and measuring instruments, and as an auxiliary, constant-level amplifier for frequency response measurements.

The equipment features include expanded scale ±0.2dB, calibration with built-in dc supply and full overload protection circuit for test probe. **(99)**

Spin-flip laser measures air's dirt

By Dr. John Lenihan, Director,
Department of Clinical Physics and Bio-Engineering,
Western Regional Hospital Engineering Board, Glasgow, Scotland.

Over much of the modern world the greatest threat to the future of mankind is not war, disease or famine. It is pollution — the destruction of the environment through careless use of technology. In the face of pollution, modern man is the Sorcerer's Apprentice, unable to hold back the disaster that he has made by playing about in his master's laboratory.

Some forms of pollution are obvious enough — stinking rivers, poisoned lakes and filthy beaches — and a few cities already have a perpetual blanket of smog, a mixture of smoke, fog and poisonous industrial fumes.

These are examples of pollution that has gone too far; but there are other dangers which may, in the long run, be just as serious, though at present we know little or nothing about them. In particular, the atmosphere is being continually polluted by aircraft vapour trails, rocket and missile exhaust and a witches' brew of assorted gases resulting from the progress of technology.

ATMOSPHERIC UMBRELLA

Many scientists fear that permanent harm has already been done by changing the composition of the atmosphere. It is not always realised that the air above us has a vital role in letting through the useful parts of the sun's radiation and holding back the dangerous parts.

By tampering with the make-up of the atmosphere we could produce a steady cooling of the earth; there is some evidence that this has already begun and that another Ice Age may be on the way.

SIMPLE QUESTION

It begins with a question: why is the sky blue? This simple problem was first answered about a century ago by the English physicists, Tyndall and Rayleigh. They showed that the light of the sky is sunlight which has been scattered by molecules of air or microscopic dust particles. The scattering is greater for light of short wavelength (that means blue colour) than for other parts of the spectrum. The sun's yellow colour is simply the result of removal of blue light; seen from the airless moon, the sun is a brilliant white.

The blue sky was a familiar sight to Chandrasekhara Raman when he was a student in Madras nearly 70 years ago; when, after ten years as a civil servant, he became professor of physics in Calcutta, the scattering of light by air and water was his main research interest.

The Raman effect, which he discovered in 1928, brought instant fame — a knighthood in 1929 and a Nobel prize in the following year — but was for a long time a scientific curiosity of no obvious value in the world outside the laboratory.

But now the Raman effect is being used in experiments which may lead to important new techniques for the measurement and control of atmospheric pollution.

INFRA-RED SOURCE DIFFICULTY

A good way of analysing a transparent sample, such as a liquid is to send a beam of light through it and measure the intensity of the light which comes out at the other side. Ultra-violet and visible light are often used in this technique; for many purposes, infra-red light would be much better, but until now there has been no suitable source.

The difficulty is that there is no really sensitive detector for infra-red radiation. This would not matter much if the analyst could find a powerful source for his experiment.

Any hot body emits infra-red radiation but with a great mixture of wavelengths. White light contains a range of wavelengths which can be split into red, blue, green and all the other colours of the rainbow, allowing the chemist to choose whatever wavelength he wants for his experiments.

A simple infra-red source can be treated in the same way — but unfortunately the intensity remaining at any particular wavelength is not enough for the analyst. This is the problem that has now been solved.

The Raman effect is simple. When an intense beam of light is focused on a liquid or transparent solid, most of it goes straight through but a small percentage is scattered sideways, and this light is of a different wavelength to the original beam. The reason for the change is that molecules in the sample have absorbed energy from the light beam; removal of energy in this way means an increase in wavelengths.

IMPURITIES IDENTIFIED

The chemist learns a lot from this experiment because the change in wavelength is characteristic of the molecule concerned; by analysing the scattered light he can identify impurities in the sample, even at very low concentrations.

For the study of atmospheric pollution, a strong source of infra-red radiation is needed. The analyst would like also to be able to tune it to different wavelengths — something that has never been possible until now.

The particular form of Raman effect used in the Edinburgh experiments (by Professor S. D. Smith and colleagues at Heriot-Watt University) involves an unusual process graphically named spin-flip. The electrons which congregate in the outer part of every atom and molecule appear to be spinning like tops. For this reason each electron acts as a tiny compass needle.

If a sample of material is put between the poles of a magnet, most of the electrons line up in the direction of the magnetic field; if they are given a kick they can be turned over and will then go on spinning happily in the reverse direction. This process is the spin-flip.

ONE STAGE FURTHER

The Raman effect supplies the kick — and reveals itself by the change in wavelength of the scattered radiation. The Edinburgh team (and, simultaneously, another group at the Bell Telephone Laboratories in the

United States of America) have gone a stage further.

The energy required for the spin-flip depends on the strength of the magnetic field — just as an inside-out umbrella is more easily restored in a light wind than a gale.

The wavelength of the scattered radiation depends on the energy removed from the original light-beam in flipping the electrons. So if the magnetic field (which fixed the spin-flip energy) is varied, the wavelength of the scattered light can be varied also.

In the Edinburgh experiment, a powerful laser gives a beam of infra-red light which falls on a small block of indium antimonide held between the poles of a powerful magnet. The scattered radiation is on an infra-red beam and its wavelength can be altered simply by changing the current driving the electromagnet.

UNPRECEDENTED SENSITIVITY

With this new tool it will be possible to detect and monitor most of the common atmospheric pollutants with a sensitivity never previously available; even substances likely to be used in chemical and biological warfare will alert the electronic eye before they reach dangerous levels.

The research is still at an early stage of development but the infra-red spin-flip laser is a heartening sign that science can do something about the pollution that it helps to create. ●

PIONEER PC-50 PHONO CARTRIDGE

(Continued from page 34)

from 20Hz to 20kHz. This is far better than that offered by previous Pioneer cartridges that we have tested.

The channel separation on the PC-50 cartridge is particularly good, except at the high frequency end where the 20kHz resonance results in an increased coupling between the two axes of the cartridge. The channel separation is the best we have ever recorded in the range 100Hz to 5kHz. The stylus has a 0.5 mil conical point diamond (whilst most top of the line cartridges offer an elliptical stylus as an option, Pioneer have not followed suit).

Whilst the claimed static compliance of the stylus arm is only average, the performance that we obtained on warped records was excellent. We do not usually conduct this test but we did note that this cartridge easily tracked warped records that other cartridges were simply unable to follow. The cartridge assembly conforms to the EIA ½" (12.7mm) mounting standards and mounts in any arm, with the screws supplied, in only a few minutes. Four gold plated pins at the back of the cartridge are coded and the stylus protector can be used with advantage in the early stages of balancing the tone arm. The cartridge is supplied with an additional backing piece to fit behind the cartridge and increase the cartridge weight should this be necessary.

Our overall impression is that this is the finest cartridge that Pioneer have yet produced. It is very good value for money. ●

MEASURED PERFORMANCE PIONEER PC–50 MAGNETIC CARTRIDGE

Frequency response (at 2.1 grams tracking weight)	– 20Hz to 20kHz $^{+0}_{-2}$ dB	
Channel difference at 1kHz	½dB	½dB
Channel separation	100Hz	29dB
	1kHz	29dB
	10kHz	19dB
Output sensitivity (re 1kHz signal 5cm/sec)	3.8mV	
Price	–recommended retail: £17·01	

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:

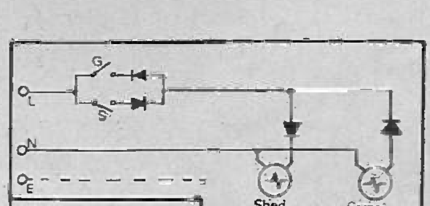
PROBLEM 006: A circuit for a strobe unit, or the strobe unit device itself, whose flashes can be triggered by a synchronising pulse such as the one obtained from a car ignition unit.

PROBLEM 007: (As an exception, we reveal the source of this problem). The Association of Blind Sportsmen and Sportswomen ('BATS') seeks a design or a cricket ball for their use. The ball should weigh 4 to 6 oz overall, made probably from aerated plastic, to be white on the outside and should contain a directly audible bleeper device emitting a hitherto unspecified frequency note. It will probably use batteries rechargeable in situ. We seek specific equipment specifications for this problem.

Solution to Problem 003: I give below a circuit (Fig 1) which I have previously used to control two motor contactors over two wires. In the lighting application, half-wave rectification should not cause any perceptible flicker in the lamps. Diodes or metal rectifiers of suitable PIV and current rating are easily obtainable.

Congratulations on an excellent magazine!

—E L Brinson, Edgware, Middx

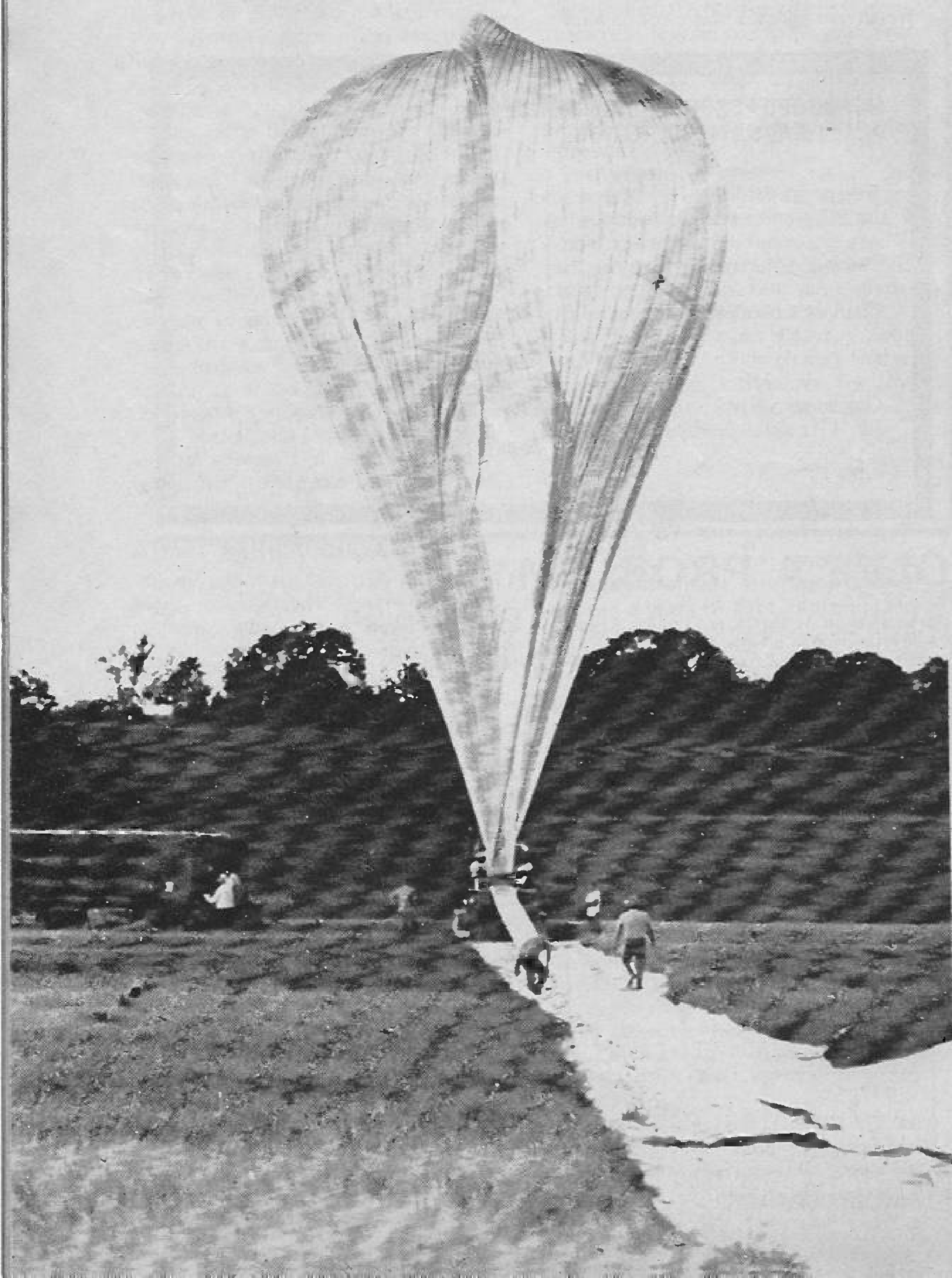


Editor's Note: Mr R Jacques of Grosvenor House School, Harrogate, has sent a similar solution but with the switches parallelling the line diodes (see Fig 2) and also suggesting use of 100W 110V (or 200W 220V) lamp for the garage and 60W 110V (or 120W 220V) lamp for the shed.

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

GAMMA-RAY STAR GAZING

High altitude balloons lift instrument packages in latest astronomy techniques. Here, Dr. Jocelyn Burnell of Southampton University discusses the technique with Electronics Today International correspondent Dr. Peter Sydenham.



DOCTOR Jocelyn Burnell is one of Britain's leading authorities on gamma ray astronomy — a new and difficult area of observational science.

To find out more about her work Electronics Today International went to Southampton University where Dr Burnell has a teaching fellowship, and works with a team continuing research into celestial sources of gamma rays.

Dr. Burnell came to prominence at the end of 1967 as the person who first discovered pulsars while working at the Mullard Radio Astronomy Observatory. From those days she has moved from strength to strength having identified additional pulsars.

Pulsars are single stars within our galaxy. They emit RF broadband noise pulsating with an extraordinary stability. The period is stable to a few parts in 10^8. Pulsars should not be confused with quasars which are thought to be of galatic size — well outside outside our own galaxy — at distances on the limit of our comprehension.

Gamma ray astronomy started about 20 years ago when theoretical studies predicted the existence of gamma ray sources in outer space. It was not until 1962 that meaningful measurements were achieved. The process of measurement involves many complications that make progress slow, so results were often negative.

Gamma (γ) rays are short wavelength x-rays having high energy. They are more difficult to observe in space than radio sources because the frequencies are immensely higher and the signal strengths lower. To add to the problem of basic detection, the Earth's atmosphere screens ground-based telescopes from the source emissions, so observation must be made from the top of the Earth's atmosphere.

Fig. 1. The high altitude balloon unfurles in readiness to carry its instrument package.

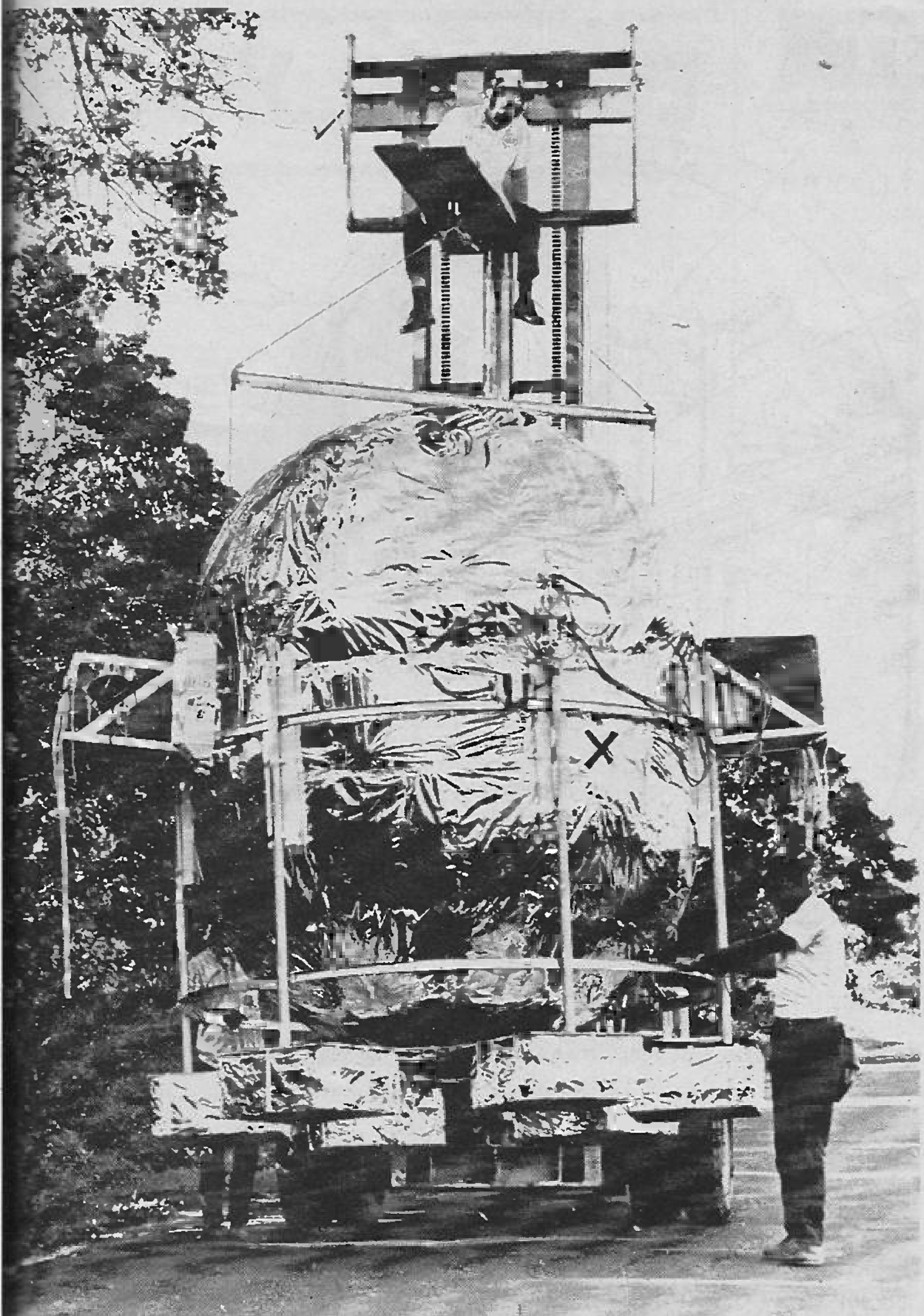


Fig. 2. The complete observatory ready for use.

The Americans launched a satellite (called UHURU – SWAHILI for freedom) as a platform for an x-ray telescope but not all groups can support such an expensive technique, and whilst the Southampton group also found the need to use high altitude telescopes they have chosen to use balloons to carry their equipment.

The balloons are launched at Palestine in Texas (USA) where a suitable serviced site is operated by other groups, (a launch in progress is shown in Fig 1.). The pre-flight path of a balloon necessitates a remote site to avoid danger to aircraft. Also important is the wind pattern, for too violent an area could cause the balloon to drift hundreds of miles – thus creating a navigational hazard and making recovery potentially impossible.

The altitude reached by balloons released at the Texas site is in the region of 40 kilometres. Recovery is quite a procedure. At Palestine a spotter plane is used to locate the balloon on its descent. The pilot has the ability to accelerate the balloon's drop velocity when it is in a suitable location. Vehicles are then guided to the package by the pilot.

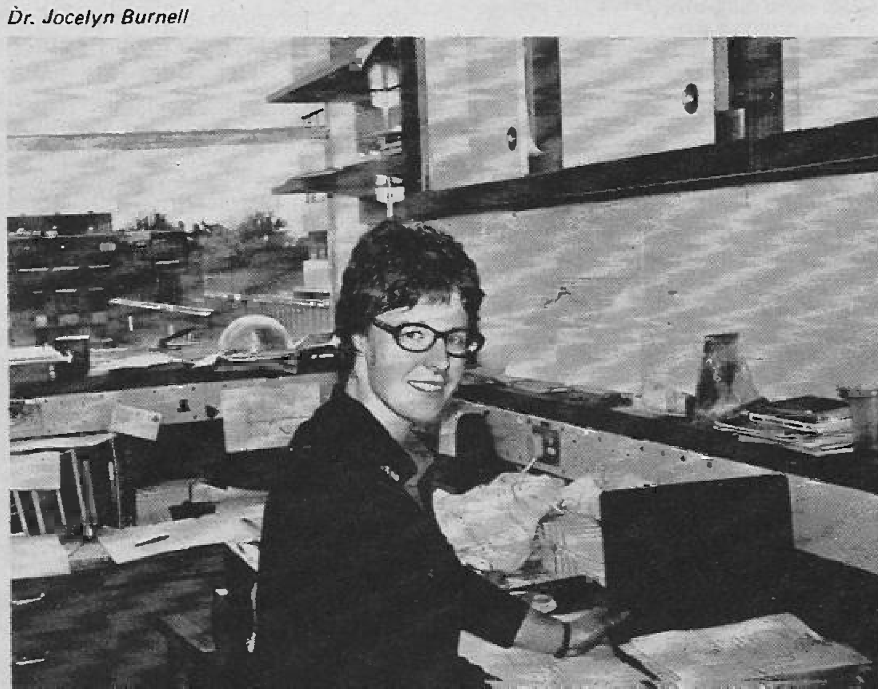
Initial experiments were required to detect the presence of sources without real need for mapping information. Now things are more sophisticated and the one ton packages sent up by Southampton have servo-controls to point the telescope at predetermined portions of the sky.

The system is controllable from the ground using two main telemetry links. One controls the telescope tracking altitude, the other is a data channel.

The process of instrument and package development is by necessity slow. Modifications and repairs cannot be carried out on-site and viewing can only be entertained where visual conditions suit balloon recovery. For these reasons the team consider themselves fortunate to obtain a few hours observation every six months. By contrast, radio astronomy can operate most of the time.

Current aims are to evaluate the feasibility of doing gamma-ray astronomy from balloons and one of the major problems is the noise background created in the atmosphere vicinity of the balloon. Part of the measurement design task is to sort out just what is signal and what is noise. Several designs are used, a typical arrangement being as shown in Fig. 3. A number of flights have been

Dr. Jocelyn Burnell



GAMMA-RAY STAR GAZING

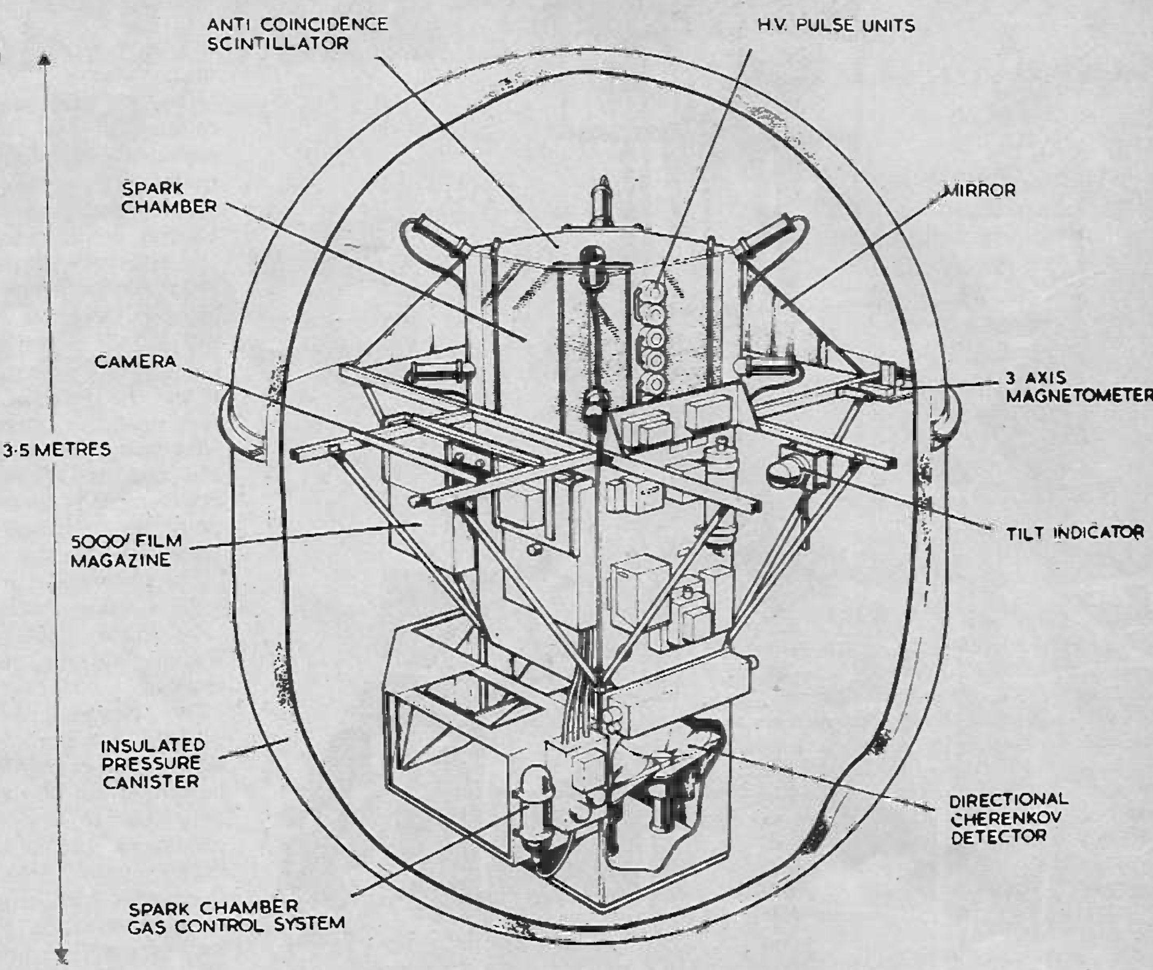


Fig. 3. This schematic drawing shows the contents of the insulated pressure canister used to house the guidance and measurement systems.

completed and the group are currently engaged in analysing the most recent data, much of which is recorded in the package on magnetic tape and film.

HOW THE TELESCOPE IS CONTROLLED

In order to point the telescope at a particular piece of sky the astronomers need to know precisely where the unit is aimed relative to the star-field. Currently, guidance is achieved using multi-axial, fluxgate, magnetometers that sense the Earth's magnetic field giving a crudely reliable sense of direction. The magnetic field, however, is subject to large excursions – of up to several degrees – in an unpredictable manner. Now they are developing an optical star-field sensor that will lock onto a known star. It then is relatively easy for the astronomer to steer the telescope as desired. This is standard practice in optical astronomy. It is only possible to steer within half a degree by the magnetic method. The optical technique should better this.

There are three main types of detector available to detect x-rays and the group have used all at various times. The first is a scintillation counter in which the energy of the gamma rays (1 MeV for the 10^{20} Hz sources of interest) is changed in wavelength to visible frequencies by a suitable crystal. The resultant scintillations are detected by a photo multiplier as electrical current outputs which can be recorded with relative ease.

The second detector is the spark chamber. In this, a series of plates having alternating positive-negative charges are subject to the gamma-ray stream. The energy of the radiation causes the gas between the plates to breakdown thus producing a visible spark which is recorded photographically.

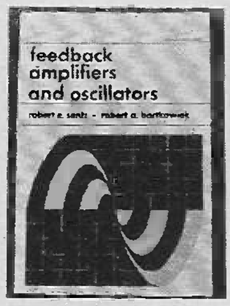
The third method is the Chevenkov detector which also relies on the wavelength change effect. In this, the radiation is guided into a liquid. The path of individual rays causes the trace to become luminous for fractional microsecond periods. With a large enough number of x-rays entering, the glow is a measure of intensity. This also is photographically recorded. Each type can be identified in Fig. 3.

Fortunately the balloon and package structure are transparent to gamma rays so the telescope need not have an optical vision path. The telescope itself is unlike optical or radio structures in so much that it is more of a collimator than a gain device (a lead tube is used) being designed to have a restricted field of view within the star field.

As many of the radio amateurs amongst our readers are keenly interested in radio astronomy, we asked Dr. Burnell whether she felt that this was a field for the amateur researcher. However Dr. Burnell thought that this area of study was not really for the amateur due to the high cost of obtaining the airborne platform from which the observations are made. ●

BOOK REVIEWS

REVIEWER: Brian Chapman



FEED BACK AMPLIFIERS AND OSCILLATORS by Robert E. Sentz and Robert A. Bartkowiak. Published by Holt, Rinehart and Winston Inc. New York 1968. 218 pages 9" x 6", soft covers. £2·25

This text is one of a dozen titles in the publishers Electronics Technology Series which are specifically designed for use as standard texts in conjunction with courses taken at technical colleges and institutes.

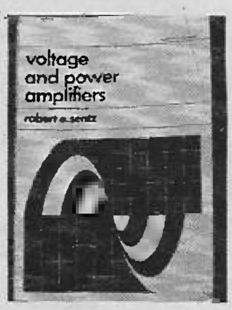
The treatment of the subject is thorough, but the mathematics is kept down to a level appropriate to technical colleges, that is, simple algebraic equations with some complex algebra and no calculus. The book does however assume a prior knowledge of dc and ac circuits, network theorems and basic transistor and valve devices.

The opening section examines fundamental types of feedback and methods of analysis, and this is followed by a section on single stage amplifiers with feedback, and another treating stability, phase shift and frequency response.

The next five sections treat oscillators in considerable detail, beginning with the simple oscillatory circuit and then separately treating crystal, negative resistance, RC phase shift, VHF and microwave oscillators.

The text is clearly written, well illustrated and as well as providing textual examples, poses questions at the end of each chapter, gives a number of problems and a list of references.

In all the format of the book is ideal for classroom use. Excellent value. – B.C.



VOLTAGE AND POWER AMPLIFIERS by Robert E. Sentz. Published by Holt, Rinehart and Winston Inc. New York 1968. 282 pages 9" x 6", soft covers. £2·25

This book is a companion volume to that reviewed above and is by the same author. Hence most of the remarks regarding presentation, format and clarity of that volume, also apply to this.

After an introduction to voltage and power amplifiers, the A,B,AB classification system and methods of coupling, the book deals with the effects of interstage coupling on gain and bandwidth and then discusses factors affecting the input impedance of an amplifier.

The effects on frequency response of incomplete bypassing are followed by sections on the gain – bandwidth product pulse response of wide band amplifiers and frequency compensation techniques.

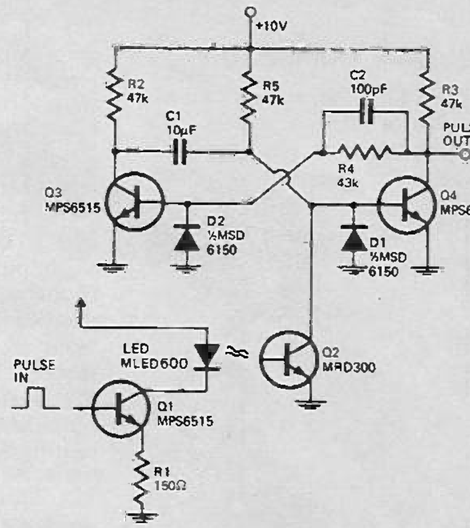
The remainder of the sections deal with specific forms of amplifier in detail. Again each chapter is followed by an adequate number of questions and problems which are vitally necessary to the student.

A 40 page appendix provides transistor and valve data for use in conjunction with the text.

Again excellent value for money. – B.C.

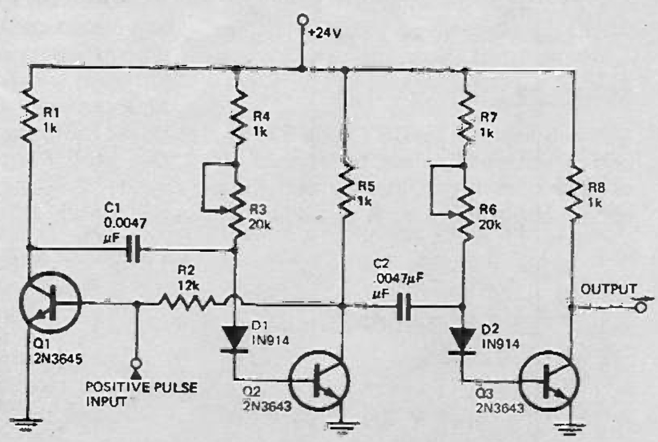
TECH-TIPS

OPTICALLY COUPLED PULSE LENGTHENER



An LED and phototransistor optical-coupler system may be used to lengthen a three microsecond pulse to 55 milliseconds by using the values shown in the diagram. This allows complete isolation between input pulse circuits and the lengthener to be obtained.

ECONOMICAL PULSE DELAY



The circuit shown is of an economical pulse delay which utilizes only three transistors instead of the four normally required for a pair of one shots.

Initially Q1 is off, and Q2, Q3 are on. When an input pulse arrives it turns Q1 on, and Q2 off via C1. Transistor Q2 remains off for a time determined by the time constant of C1, R3 and R4, and when it reverts to the 'on' condition it also turns off Q1. Transistor Q3 which is triggered by the output of Q2 stays off for a time determined by R6, R7 and C2, and thus produces a delayed pulse whose duration is approximately 10µsecs, and is adjustable by R6.

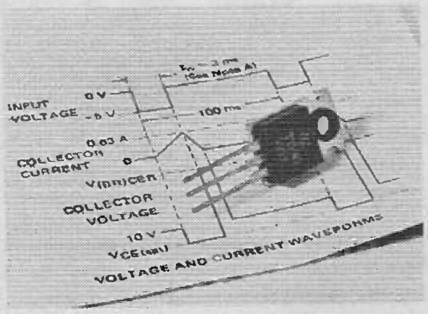
Delay time is adjustable by R3 and for the values shown, is about 10µsecs.

COMPONENT NEWS

HIGH VOLTAGE TRANSISTOR

Type TIP 47 high-voltage silicon power transistor now available in a TO-66 plastic package is suitable for both industrial and consumer applications and features a V_{ce} (when the base-emitter diode is open circuited) of 250V and V_{cb} and V_{eb} of 350V and 5V respectively.

Continuous I_c rating is 1A (with a peak value of 2A) and operating temp-

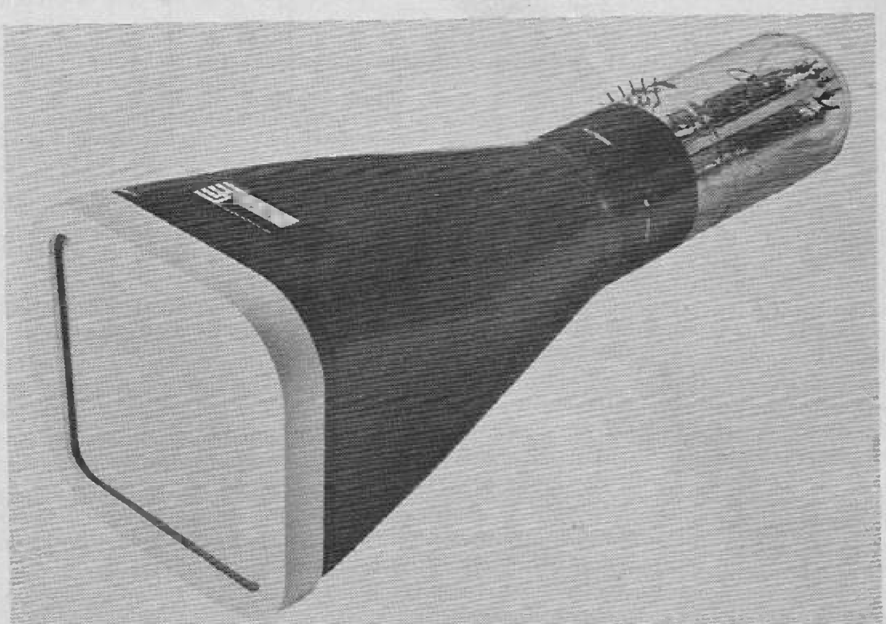


erature range is -65 to +150°C. Other key specifications include a 20mJ reverse energy rating, a 40W continuous power dissipation (at 25°C case temperature) and an f_T of 10MHz minimum at 10V 0.2A. **(59)**

STORAGE CRT

Direct-view storage CRT tube E716A, with a square faceplate, is designed for oscilloscopes and is equally useful for special applications such as medical instrumentation, ultrasonics, computer graphics, radar and sonar equipment. Viewing area is 10 x 10 cm and its deflection sensitivities make it particularly suitable for compact transistorised equipment.

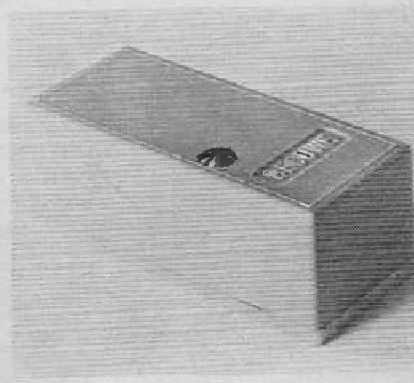
The tube has a robust storage layer, uses an aluminised P31 screen and has a light output in excess of 90ft-lamberts in the storage mode and a variable persistence giving a choice of storage time from several minutes to less than one second. With the flood gun switched off, a storage time of several days is obtainable provided that no further writing is applied. **(60)**



ALARM SWITCH

The BECUWE Alarm Switch is a sensitive vibration detector, intended for use in security alarm systems. It is a compact low-cost device, with a pressure-sensitive adhesive pad for easy mounting onto window frames, display cases, or wherever an intruder could cause vibrations. Screw holes are also provided for mounting on wood or other suitable surfaces.

The alarm contact normally functions as a closed contact which opens briefly under the action of vibration or impact, although it may be adjusted to operate as a normally open contact. A screw-driver adjustment is provided to vary the sensitivity, whilst an additional guard contact, normally held closed by the switch cover, gives alarm if an in-

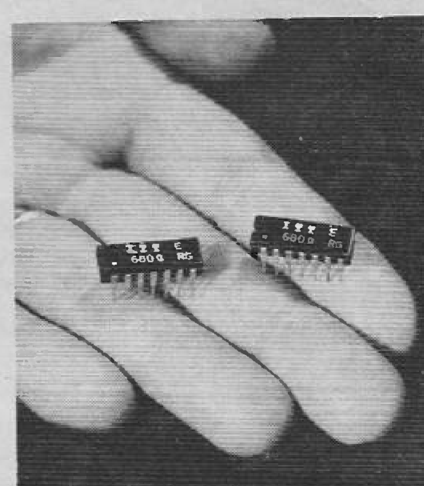


truder attempts to remove the cover.

A number of switches may be connected in series to a source of voltage and to a latching alarm relay, to form a complete security system. Vibration at any monitored position, or an attempt to immobilise the system by cutting wires or by removing a switch cover, will set off the alarm. **(58)**

RESISTOR MODULES

A range of standard resistor networks in 14 pin DIL packages to standard TO-116 outline offers groups of resistors



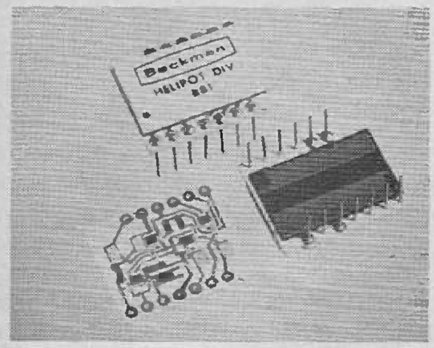
connected in various patterns to meet circuit functions that repeat themselves many times in equipment assemblies. They will help to reduce equipment testing in the production phase.

These networks include seven individual resistors all of equal value, suitable for LED current limiting; thirteen resistors all of equal value in any one unit, common at one end, suitable for use with logic assemblies; twelve resistors all of equal value in any one unit, common at one end plus a capacitor for decoupling, also suitable for use with logic assemblies; and two groups each of six resistors suitable for use with amplifier circuits or as line terminations. **(61)**

ACTIVE FILTER

Model 881 active filter, the hybrid version of an active filter design commonly known as a 'dual-integrator active filter', 'state-variable active filter' and/or a 'universal active filter', has three operational amplifiers and internal feedback elements in the basic hybrid design. A fourth uncommitted operational amplifier is included to facilitate 'odd-pole' filter requirements and add greater system design flexibility to the basic component.

The configuration permits buffered bandpass, low pass and high pass output to be simultaneously available. The

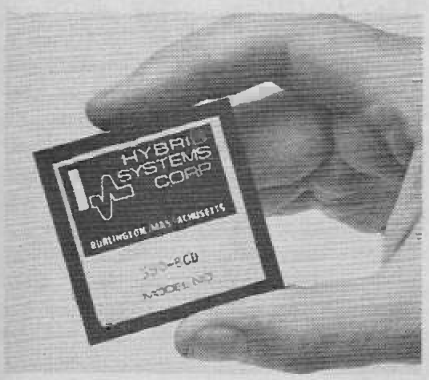


resonant frequency is determined by the value of two external resistors and is adjustable over a frequency range from less than 1Hz to 10kHz.

Ceramic enclosure packaging permits operation over a temperature range of 0°C to 70°C from ±15V power supplies. **(62)**

A-D CONVERTER

Recently added to the Hybrid Systems range of converter modules is a new A-D converter type ADC 590-8. The units are complete 8 bit self-contained A-D converters with an internal reference, clock, logic etc packaged in a



module measuring 2" x 2" x 0.4". The units are fully pre-trimmed and require no external adjustments.

The conversion takes place in under 200uS and is performed by a simple digital technique that incorporates a D-A converter driven by a counter, counting one step at a time. A comparator stops the counter when the analogue input equals the D-A output.

To ensure long life and good stability, the converters have three important reliability features: all active components are hermetically sealed — no plastic transistors or IC's are used, all precision resistors are thin-film type and all converters are burned in, under power, for a minimum of 72 hours. **(63)**

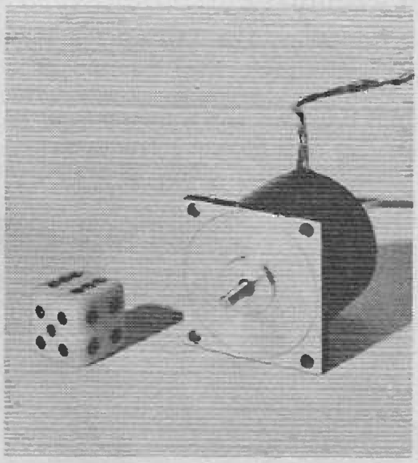
FLASH TUBES

Flash Tubes with end caps sealed directly to the envelope have been introduced by EEV. This new design enables operation at high temperature with simple cooling arrangements.

First in the range to become commercially available is the 400 joule type XL639/4/2.75, intended for laser pumping and other applications where the cooling of flash tubes having conventional soldered end caps is a problem. By using the bright sealing technique which joins the glass envelope directly to the tungsten electrode support rod, EEV say that they have removed the necessity for direct cooling of the ends of the flash tube. The end seals are now said to be as thermally robust as the tube envelope itself and special cooling is needed only in the area of arc discharge.

Of linear design for operation at medium energy loadings, the XL639/4/2.75 uses a Xenon gas filling, and alternative fillings of Krypton or mixtures of Xenon and Krypton are available for special requirements. **(70)**

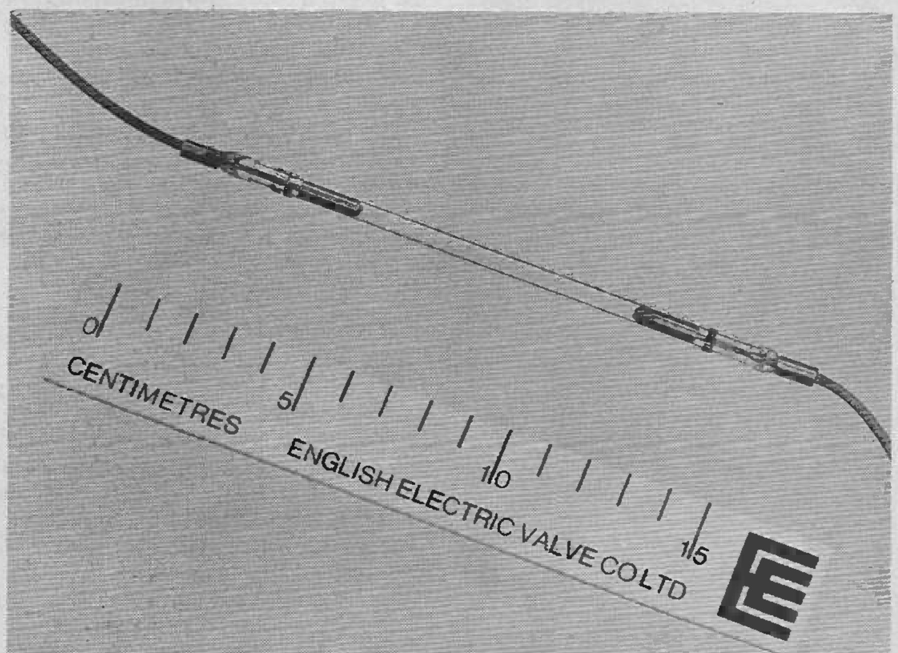
MINIATURE SERVO MOTOR



Portescap have now expanded their operations with a complementary range of 50Hz ac servometors. The first of this range to be announced is the type CC21SB with a high torque-to-inertia ratio giving it a time constant of only 14 msec. At maximum power output (650 mW), a torque of 45 gcm is achieved at 1500 rpm.

The split control phase winding permits the use of either 18V or 9V drive. The reference phase winding requires 36V at a maximum of 125 mA and would normally be derived direct from a winding on the mains transformer. **(71)**

(Continued on page 84)

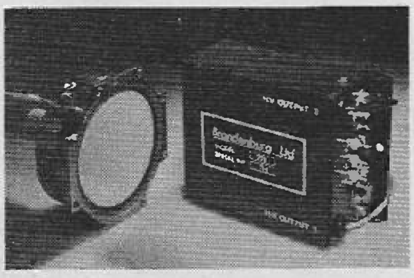


COMPONENT NEWS

(Continued from page 83)

HV MODULE

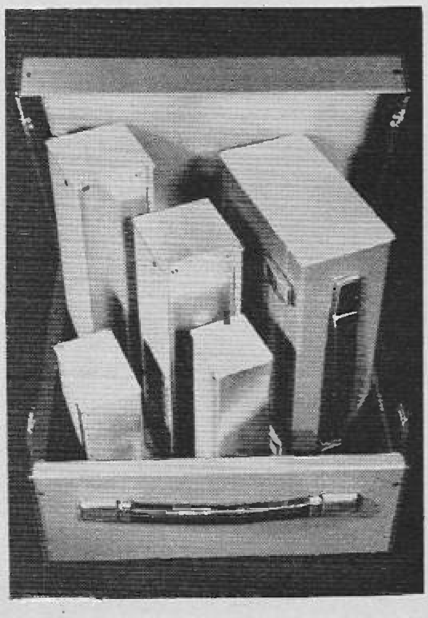
The Model 779 high voltage supply for electrostatically focussed tubes, which provides two outputs, one from 1.2kV to 2kV and a second from 7kV to 12kV, is a compact fully-screened module measuring only 89 x 125 x 48 mm. The output can be controlled by adjustment of the input voltage. The gun supply can be varied between 1.2 and 2kV negative at 3MA with ripple less than 50mV pk-pk, and the focussing supply is variable from 7 to 12kV positive at 200 uA with ripple less than 60V. The illustration shows also a Rank 3" electrostatically focussed tube.



(64)

INSTRUMENT CASES

A range of low-cost, robust, precision built instrument cases is now available from Hilmet Ltd. The cases, in three standard styles, are constructed from 16 SWG aluminum alloy bonded with 0.012" thick PVC with end plates machined from high quality 0.5" thick aluminum alloy. Front panels are normally constructed from aluminum alloy and can be finished and pierced to individual customer requirements as can the end plates. The inside surfaces are protectively treated with Alcrom. The use of 'Bondene' on the exterior enables a wide range of colour finishes.



There are three standard styles and construction methods can be applied to offer wide variations of size. Hilmet, a subsidiary of Hatfield Instruments, produce all the cases currently used in Hatfield's range of test equipment.

(72)

IC PREAMPS

Two now audio IC circuits, called the LM381 and LM382, are dual preamplifiers for Hi-Fi stero systems. Both operate from single 9 to 40V DC supplies.

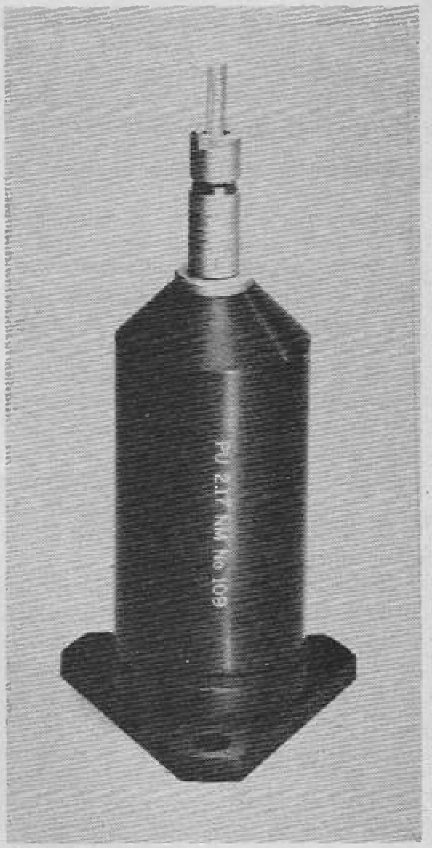
The LM381 is said to be the industry's first monolithic IC preamplifier to offer audio circuit designers the performance of discrete circuits with the cost advantage of an integrated circuit. It has a total equivalent noise imput of only 0.45 uV, well below that of anything available in integrated form and equal to or better than that of the best discrete circuits found in high quality stereo equipment.

Each of the two amplifiers in the LM381 is completely independent; an internal power supply decoupler/regulator provides 120 dB power supply rejection and 60dB channel separation. Other features include gain of 112 dB and output swing equal to V_{CC}-2 volts pk to pk. Besides hi-fi applications, the LM381 can be used in instrumentation tape recorders, hydrophones and other systems requiring extremely low noise amplification.

The LM382 dual preamp is similar to the network for NAB and RIAA equalisation, making it ideal for car and home stereo sets. Both the gain and equalisation are selected by external pin connections. **(69)**

VIBRATION TRANSDUCER

The Model PU2 self generation Vibration Velocity Transducer is suitable for all kinds of vibration measurements where the machine is unaffected by the 450g (15 oz) mass of the transducer. The standard maximum operating temperature of the transducer is 170°C whilst a special version is available for high temperature conditions up to 400°C, for example on jet engines.



Sensitivity is 10 mV/mm/sec with a frequency response from 13 to 1000 Hz, and for all practical purposes is said to be sensitive only to movements parallel to its centre axis.

The transducer can be hand held against the machine or alternatively permanently installed with a single screw fixing or by the standard three hole mounting accessory. For monitoring of plant or machinery the transducer can be used with the Sinus hand held portable vibrator meter, which operates without batteries, or connected directly to an oscilloscope or recorder. It can also be used to provide full safe vibration monitoring of plant and machinery in conjunction with a trip amplifier.

(76)

FLAT CABLE

A new flat flexible data-handling cable, intended as an alternative to ribbon cables using rectangular conductors is the Tekdata S-link cable, available as standard with 10, 20, 30, or 40 ways, or otherwise to special order. As S-link is manufactured by a continuous process any practical length may be ordered, and the design lends itself admirably to automated stripping and termination. The makers say that it will not laminate and will significantly cut harness costs and improve reliability over systems which formerly used rectangular conductors. It is also made in such a way that it folds flat and stays flat. **(79)**

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.

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RECORDINGS... POP TRENDS

REVIEWER: Michael Delaney.

"YEAR OF SUNDAY" – Seals & Crofts. Kinney. Stereo K.46133 When I Meet Them – 'Cause You Love – Antoinette – High On A Mountain – Year Of Sunday – Paper Airplanes – Irish Linen – Springfield Mill – Ancient Of The Old – Sudan Village.

Seals & Crofts released what must have been one of the unsung album classics of last year with "Down Home" – An E.M.I. disc that has now been due to the Bell catalogue transferring over tn Phonogram. In some ways it's probably a good thing that it didn't catch on because they would've found it near impossible to match let alone better. It all goes back to the old truism that you can't improve on perfection. And "Down House" was perfect. It's the same type nf thing as happened to James Taylor except that everybody discovered him at the right moment: "Sweet Baby James" was a recording that had been there from the start – his definitive statement. He'll never do anything to equal it no matter how hard he tries. The situation with Seals & Crofts is exactly the same apart from the fact that their most beautiful album remains essentially unrecognized.

"Year Of Sunday" is going to bring this duo much closer to commercial success simply because the material is less involved. The melodies are not as complicated and their treatment is much more aligned to the basic rhythm. The whole sound differs frnm that on the "Down Home" release due to its immediacy. Seals & Crofts don't seem to put as much depth into what they're doing these days: each song has been skimmed across with a light arrangement that makes them out to be nicely compact songwriters instead of intensely moving performers. It's not all that important because they still do it well. And that's the thing that counts.

It's unfortunate that they've confined themselves as musicians as much as they have because somewhere along the line their songs have lost the intricacy and momentum so much the force hbehind "Down Home". They'll never lose that feeling of insidious delicacy about their music but it's a real shame that it's been forced back in priorities. They used to sound so emotional whereas now they just sound to be on the border of being cute. That is an overly critical statement but I think you'll know what I mean.

If you haven't heard their second album then "Year Of Sunday" is going to come as no disappointment. I'm not disappointed either, it's just that I was lucky enough to hear the full scope of their talent unrestricted by a less flattering production. "Sudan Village" and "Irish Linen" are the two best cuts because they both hold the closest affinity to the style/character first presented on "Down Home". Nevertheless, their third release is highly recommended. It's full of gentle songs thoughtfully composed and expertly played. There's not quite as much impact as on the former but this can be overlooked without a great deal of trouble. If only. . . – M.D.

"HARVEST" – Neil Young. Kinney. Stereo K.54005 Out On The Weekend – Harvest – A Man Needs A Maid – Heart Of Gold – Are You Ready For The Country – Old Man – There's A World – Alabama – The Needle And The Damage Done.

Neil Young writes beautiful songs with the kind of insistently turbulent images that evoke the searcher so much a part of us all. He touches our human spirit, and leaves that touch to work and activate what it may, thus gathering the perspective needed for him to project as a poet/musician. So the thing he does best – the thing that people can't help but follow – is his ability to communicate.

There's a story in this his fifth album – a series of related emotions that can only be told aloud. He paints with his music and his music moves. Each separate song is a chapter ascending to values beyond the sound of the melody. Neil Young has as one of his greatest assets a sense of perception – an awareness and depth that passes the mere use of words: an identity of hoth character and form that can outrule his technical style cramp; a haunting resonance at once innovative and personable yet unscathed by his ego as a performer. Young comes mighty close to being a figure with that self-same mystique that has made Messiahs out of folk like Robert Zimmerman and David Crosby and Donovan Leitch and John Sebastian and John Lennon. The utter naturalness of his music will last simply because it's important. Lennon and Dylan are the same because they're both frank: if it's good it's because it's good. And Neil Young is both frank and good. He's a demi-god.

"This album also rebuts the argument that rock reaches a peak when it more nearly approaches a European tradition or a country/blues/folk/jazz or any other traditinn that's made it. As a poem reaches its most perfect form it approaches the dance." These lines from an unbought Byrds album are universal in their meaning. They can apply to "Harvest" only because it is also a masterpiece of personal expression – free wheelin' and liberated. Young has adopted much of the same idea as the Byrds in that if it isn't felt it isn't to be explained. He writes from his heart:

'I sing my song because I loved a man.
I know that some of you don't understand.

NEW LITERATURE

● Data sheet describing the SCV range of modular power supplies: APT Electronics Ltd, Fernbank Road, Ascot, Berks.

● Literature, including technical drawings, on the Duo-Slim Instrument Case: F T Davis (Kings Langley) Ltd, Kings Langley, Herts.

● Booklet for safety engineers and health officers on the handling and use of chlorinated solvents: Dow Chemical Co Ltd, Heathrow House, Bath Road, Hounslow, Middlesex TW5 9QY.

● Six-page brochure on the Model 848 d/a converter with 11 bit resolution: Beckman Instruments Ltd, Glenrothes, Fife, Scotland.

● Thirty-two page brochure on instrumentation applicable to the water industry: Fielden Electronics Ltd, PO Box 6, Paston Road, Wythenshawe, Manchester M22 4TX.

● New literature on base metal and rare metal thermocouples for industrial applications: GEC-Elliott Process Instruments Ltd, Century Works, London SE13 7LN.

● Full colour brochure describing a range of injection moulding services offered to industry by Fredrick W Evans Ltd, Plastic Works, Long Acre, Birmingham B7 5JS.

● Brochures describing: (1) ESD's portable instrumentation tape recorder which uses standard commercial tape cassettes to record analogue, digital or servo data: (2) a range of engineering consultancy services, undertaken in well-developed laboratories, from development model to production: Engineering System Developments, Allweather House, High Street, Edgware, Middlesex.

● A twenty-two page publication describing the UCO range of relays, contactors, isolators and timing and latching devices: MTE Ltd, Leigh-on-Sea, Essex SS9 5LS.

● Publication No.6510/140E on thermistors and varistors: ITT Components Group Europe, Edinburgh Way, Harlow, Essex.

● Technical data sheet on the '80' series of domestic time switches and controllers: AMF Venner, Kingston Bypass, New Malden, Surrey.

Now available in quantity – the big hit of the Radio Show

On the very first day of last year's Radio Show, you gave us orders for Mr Teleton's whole 1971 quota of Super Twelve Portable Colour Sets. Now, at last, supply is beginning to catch up with demand. And with the lowest RRP (£174.96) in the business, demand for the Super Twelve is going to grow and grow. So ask Teleton today to help you put some of these great shadow-mask colour portables (with built-in loop aerial) on your shelves soon. They won't stay there long.

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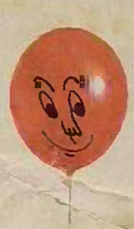

Mr Teleton looks even better in colour