Wireless World

Electronics and Telephone Exchanges

In the early years of *Wireless World* the mention of cables in the journal was taboo; there was a war on between the protagonists of the two means of communication — cable and wireless. Eventually, however, a marriage was arranged and, indeed, electronic techniques are now an essential part of long-distance cable links. Despite this marriage, we have not drawn within the purview of the journal the telephone service which has, by-and-large, remained dependent on electro-mechanical switching devices. There are, however, one or two aspects of the U.K. telephone service which it would not be out of place for us to consider.

It is now some years since the first, so-called, electronic telephone exchange was installed by the British Post Office. This was, however, an abortive attempt to change from the old Strowger electro-mechanical exchange to its electronic counterpart, although at the time it was seen as setting the scene for the future. Since then there has been considerable research both in Europe and the U.S.A. on electronic exchanges. Nearly a year ago the Post Office ordered from Standard Telephones and Cables, the British subsidiary of the American I.T.T., the first 18 of a new type of electronic exchange called the TXE4. Although Mr Bill Ryland, chairman of the Post Office Corporation, has said that the Post Office is not committed to the TXE4 for future expansion, British manufacturers are more than a little concerned about the future policy of the Post Office. They are still supplying crossbar electro-mechanical exchanges, although doubtless carrying out R & D of electronic equipment in this field. As Mr Ryland said at the annual dinner of the Telecommunication Engineering and Manufacturing Association a few months ago, the problem of deciding when to stop researching and developing and when to start manufacturing was probably the most acute that faced any management.

The adoption of electronic techniques by the Post Office is of considerable importance to our industry and the fact that the TXE4 equipment is of American origin called forth strong criticism in the House of Commons. In reply, the Minister of Posts and Telecommunications stated that no decision will be taken on the next generation of exchange equipment before he asks the House (within the next 12 months) to extend his powers to finance the long-term investment programme. It has been suggested that an investment of as much as £2,000M is involved in re-equipping the exchanges. The value of such investment, technically as well as financially, to the electronics industry of this country is obvious, but it is also of paramount importance if the industry is to be in a position to meet international competition in world markets.

Of, perhaps, more direct interest to the telephone user is the present monopolistic attitude of the Post Office which prohibits the connection, other than by its employees, of equipment to the subscriber's terminal. A similar situation existed in the United States until last year when what is known as the Carterphone decision was taken by the Federal Communications Commission. This decision permits the telephone subscriber to connect the device of his choice — whether it be a normal receiver, answering machine or data terminal — to the outlet from the telephone system.

Commenting recently on this decision Sir John Clark, chairman of Plessey, said 'In the United States following the Carterphone decision . . . . there exists an environment where technology can flourish and innovatory product development is the order for the successful company. Here in the United Kingdom restrictive regulations and the maintenance of monopoly interest in the Private Sector must go. There is no wish by industry to change the role of the Post Office, simply a desire by industry to be allowed to do its vital job of supplying the demand in the best possible way. The necessary public protections to ensure adequate performance and quality standards can be quite simply introduced via an equivalent of the American F.C.C. If the Industry is not to be allowed to work in such an environment to the benefit of the subscribers – the ultimate beneficiaries – then its world competitive ability will be substantially diminished'.

10-80 Metre Amateur Transceiver

1: Design objectives and system discussion

by D. R. Bowman, G3LUB

The transceiver, called 'The Cumbrian' by the designer, will be described in four articles. It is a high performance equipment currently giving good service at the designer's station. The transceiver is necessarily complex and the decision to construct it should not be taken lightly. A great deal of work is involved and it is recommended that the task should be undertaken only by experienced constructors. It is good policy to read all four articles before making a start. It is of course necessary to have a licence to operate this equipment.

The desire to replace and modernize the author's now rather dated radio station led to the decision to undertake a design study followed by the construction of a 10–80 m transceiver. Although not universally accepted the multiband transceiver has become very popular. One of the reasons for this is the use of a common tuning control for both transmitter and receiver, a feature only fully appreciated by the operator fortunate enough to have used one.

The advantages of a transceiver can be outlined as follows:

- Single tuning control for both transmitter and receiver.
- Reduction in the size of the station when compared with the separate receiver and transmitter.
- Reduction in cost mainly due to the use of one i.f. filter common to both transmit and receive.

The disadvantages should also be noted:

- The basic transceiver does not lend itself to split frequency operation although the inclusion of i.r.t. (independent receiver tuning) goes some way to alleviate this problem.
- From the construction point of view it has to be admitted that the transceiver is more complicated than either the separate receiver or transmitter.
- Cross-band operation is virtually impossible.

Methods of s.s.b. generation

The first problem which confronts the designer is to decide which of the various methods of generating the single sideband signal should be used.

The phasing system once popular is now much less often used. This technique depends upon the stability of a phase shift network which in practice drifts with temperature and time. This system does not lend itself to transceiver use as a network common to both transmit and receive is not possible.

The second method depends upon the use of a very sharp sided, flat topped filter so arranged as to reject the unwanted sideband. There are a number of different types of filter available as outlined in Table 1. The main advantage of an i.f. filter is that it can be readily switched from the transmitter to the receiver thus allowing a considerable cost reduction. All the filters with the exception of the *LC* type are rather expensive, but they do mean that a common b.f.o. and carrier frequency generator can be used allowing the system to be simplified.

The third method of single sideband generation, rarely used, is considerably more complex, involving numbers of balanced modulators and critical *LC* circuits.

It would seem not to be a good idea to use a filter, say in the receiver and then a phasing network in the transmitter even though the latter does have some advantages where it is required to generate the s.s.b. on the higher frequencies. In the last few years the emergence of h.f. crystal filters has tended to oust the phasing system altogether. Therefore it was decided to use the second method, i.e. one of the filters noted in Table 1.

Typical transceiver arrangement

The use of a fixed frequency band-pass s.s.b. generating filter means a single conversion system for both transmitter and receiver can be used. At first sight it would seem straightforward to direct the signal through the filter in the same direction on both transmit and receive. If this is done the output from the receiver's mixer is connected to the end of the filter nearest to the transmitter's i.f. amplifier and the receiver's amplifier input to the same end as the transmitter's mixer; thus capacitive coupling will occur around the filter, degrading the filter performance.

The system employed (Fig. 1) has no such stray feedback paths and as long as the receiver's i.f. amplifier, mixer, r.f. amplifier and the transmitter's microphone amplifier and mixer circuits are muted no filter deterioration will occur. The variable frequency oscillator (v.f.o.) and the carrier oscillator/beat frequency oscillator (b.f.o.) circuits appear at convenient points in both the block diagram and the practical layout. This is a considerable engineering advantage, allowing short oscillator leads which in turn make it more easy to contain the oscillator signals and reduce the generation of spurious output signals.

The intermediate frequency

All the various filter types outlined in Table 1 exhibit the necessary sharp cut-off required to eliminate the unwanted sideband. If we ignore cost then it is obvious that the h.f. crystal filters have an overriding advantage in that they require only one frequency conversion process to produce a s.s.b. signal in any of the 10–80 metre amateur bands. If the i.f. is far removed from the mixer frequency then the difference between the image and required signals becomes small and the image rejection deteriorates. This can be overcome by using further frequency conversion stages

Table 1: Filters Available

Type	Range kHz	Makers	Can be home constructed	Conversions required	Approx. cost £
LC	50	—	Yes	2–3	low
Ceramic	455	Brush Clevite	No	2	15
Mech.	455 100	Collins Kokusai	No	2–3	14–17
Crystal	100 10,000	Collins K.V.G. Cathodeon S.E.I.	Yes	with 9MHz units one conversion only	10–20

with the inherent risk of further spuriae. The low cost attractiveness of the *LC* filter is far outweighed by the requirement of at least three conversion processes to bring the basic s.s.b. signal up to the required output frequency.

The K.V.G. series of 9MHz crystal filters recommended have a stop band rejection of at least 80dB and the shape factor measured from 6 to 60dB is better than 1.7 with a 6dB bandwidth of 2.4kHz. These filters have two other advantages in that they are electrically reciprocal and extremely small in size. Complete with their upper and lower sideband generating crystals they cost about £17 and although many articles have been written describing home constructed h.f. filters the author's attempts have been singularly unsuccessful. Any prospective constructor could well make an attempt at the home construction of a filter and save an appreciable amount in the process.

Local oscillator frequency

Having decided upon a 9MHz i.f. filter this narrows the choice of local oscillator frequencies. It is intended that the transceiver should operate on the h.f. amateur bands i.e. 10–80 m covering only 500kHz per switch position. The obvious solution would be to use a v.f.o. switched to cover the necessary ranges. This method has a number of important disadvantages:

- It would be almost impossible to arrange a common tuning rate on all bands.
- The v.f.o. frequency stability would inevitably suffer because of the coil switching.
- Even by placing the v.f.o. on the lower side of the received signal excessive drift would be inevitable when operating on the higher frequency bands.

For these reasons it is necessary to examine other ways of generating the local oscillation.

Table 2

Range		Local osc. MHz	h.f. osc. crystal MHz
Metres	MHz		
80	3·5 - 4·0	5·5 - 5·0*†	none
40	7·0 - 7·5	16·0 - 16·5	11
20	14·0 - 14·5	5·0 - 5·5†	none
15	21·0 - 21·5	30·0 - 30·5	25·0§
10	28·0 - 28·5	37·0 - 37·5	32·0§
	28·5 - 29·0	37·5 - 38·0	32·5§
	29·0 - 29·5	38·0 - 38·5	33·0§

*tuning direction reversed †sideband selection reversed §3rd overtone

If a stable v.f.o. with a frequency tuning range of 500kHz is mixed with an appropriate fixed crystal oscillator a final output on any frequency can be arranged. This provides a substantially constant calibration and drift rate from range to range. This system does detract somewhat from the advantages inherent in the single conversion system but by careful choice of crystal frequencies the spurious responses can be minimized.

When the actual frequency range to be used for the v.f.o. is considered the posssibility arises of using the basic v.f.o. on at least two of the l.f. ranges. This has the advantage, at least on these two ranges, of producing a receiver which is extremely clear of spuriae and unwanted responses. There are of course some disadvantages. The tuning direction and therefore the sideband selection will change from band to band, but there will be, to set against this, the saving of two crystals. A not so obvious practical advantage of this hybrid system is that signals can be received on these two bands at a much earlier stage in the construction than would otherwise be possible. This tends to help the constructor retain his interest and is a good confidence booster. If a v.f.o. range of 5 to 5.5MHz is used then the 20 and 80 m bands can be tuned by resonating the r.f. amplifiers appropriately; the one range being the image of the other and *vice versa*.

The actual choice of h.f. crystal frequencies is governed as follows. The frequency of the local oscillator is positioned on the h.f. side of the received signal as this reduces the spurious responses resulting from mixer action with the harmonics of the l.o. Being on the higher frequency side means that these harmonic responses are further removed from the required signal frequency.

Throughout this analysis I have dealt with receiver problems, but the discussion is equally relevant to the transmitter.

The final frequencies chosen are listed in Table 2.

Transceivers, the problems

To the commercial manufacturer one of the attractions of the transceiver is the opportunity that it offers of reducing the total number of stages by making some of them common to transmit and receive and thereby allowing a reduction in cost.

These stages can be grouped into those where the savings are great and those where they are marginal. These marginal cases may be important to the commercial producer but the saving is insignificant for the amateur, particularly if they add to the constructional problems. The use of a common i.f. filter and b.f.o. crystal oscillator

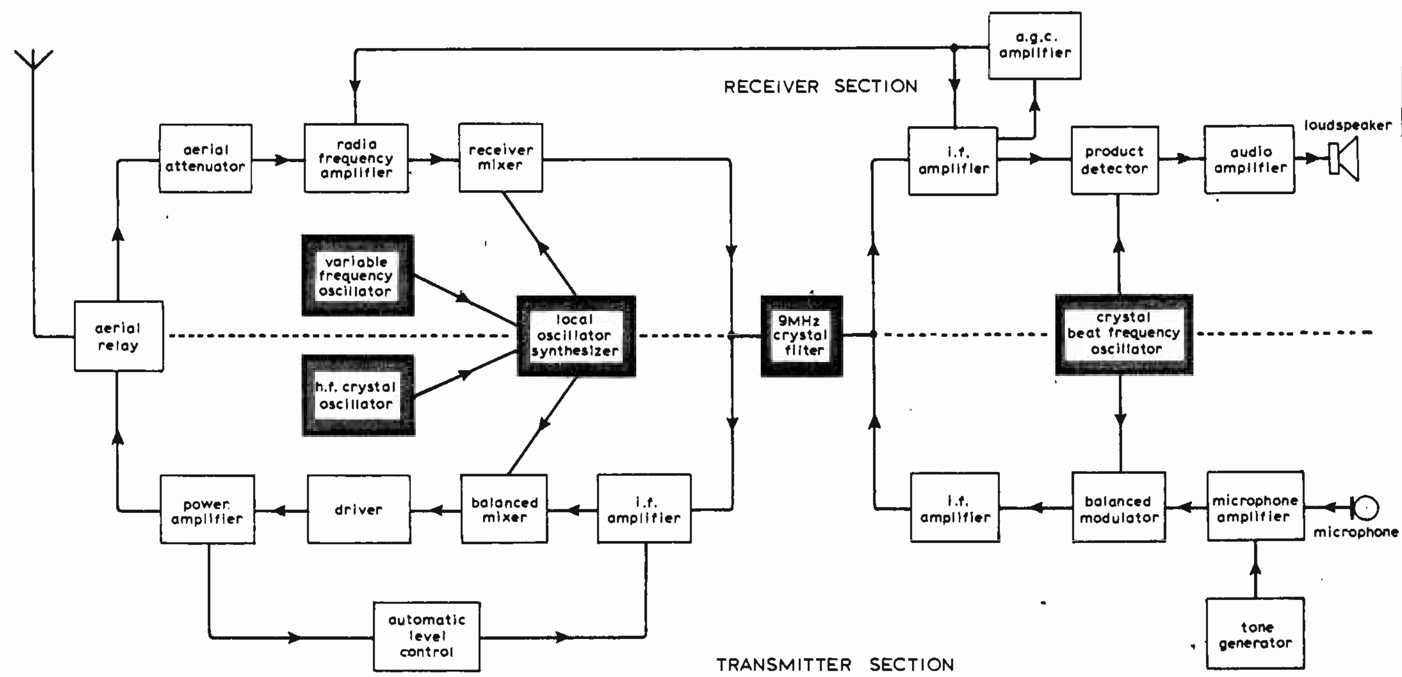


Fig. 1. Transceiver block diagram. The shaded areas are common to transmit and receive.

is a considerable saving and it facilitates common channel operation, i.e. automatic transmit and receive on the same frequency. The use of a common v.f.o. synthesizer is a considerable operating advantage, producing the common tuning control that has already been discussed. The author considers the use of common r.f. amplifiers, mixers and audio stages as not necessarily advantageous. Some readers will disagree, but it was decided to keep these stages independent of each other.

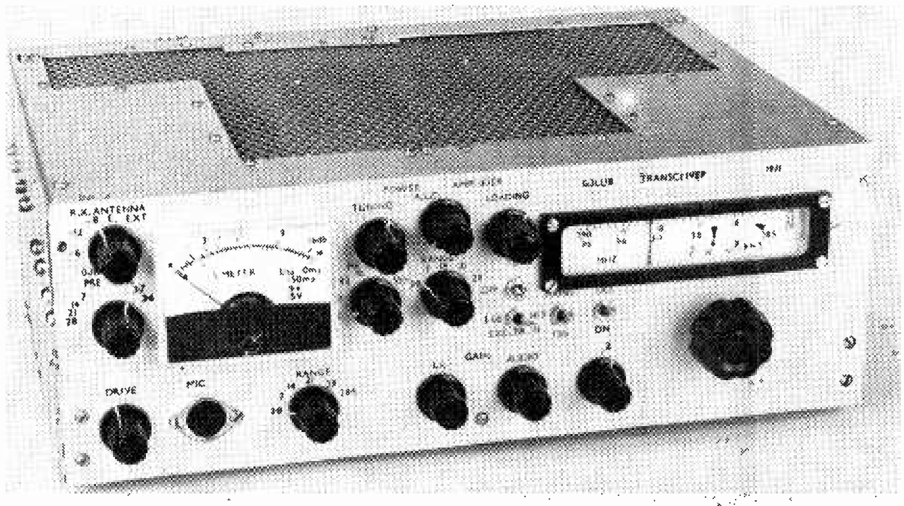
It is necessary to switch off (mute) various stages when they are not in use. It is easier to avoid unwanted feedback paths if not too many stages are common to transmit and receive.

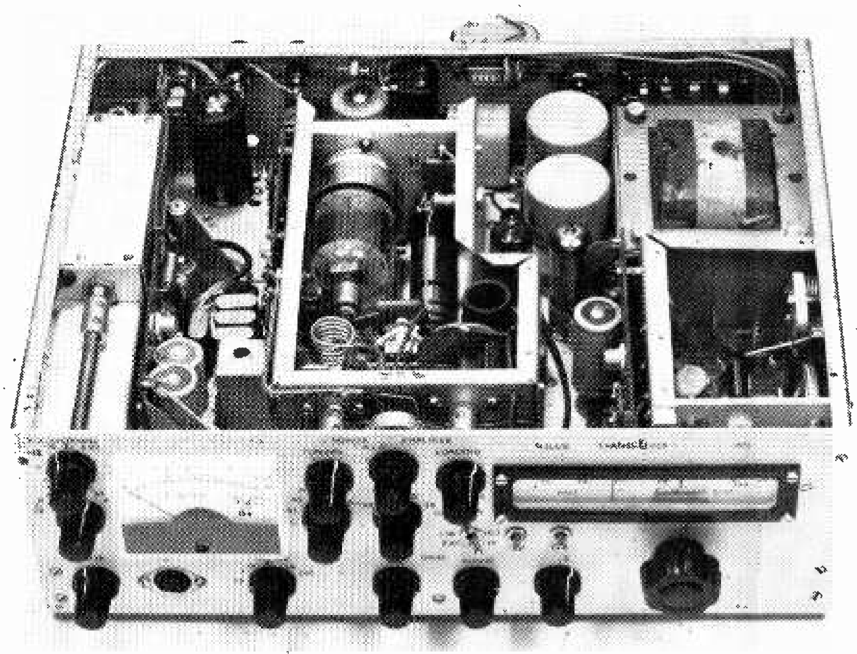
Discrete components vs. integrated circuits

Throughout this discussion the order of importance of the various parameters is as follows. Performance and cost are closely followed by ease of construction and circuit commissioning, with miniaturization way down the list.

The author's recent experience with dual gate field effect transistors, both in mixer and amplifier circuits, has shown these devices to far outshine bipolar transistors and the available integrated circuits. This leaves the possibility of using integrated circuits in the receiver i.f. and audio amplifier stages. Careful examination of the i.f. integrated circuits shows that, with the exception of a National device, use of these would have restricted the author's control over the circuit performance without reducing the size or complexity very much. Most of these i.f. integrated circuits require quite a large number of external components and in addition the author has found fault-finding more arduous than when using discrete components.

The final problem was to decide whether to use one of the many audio integrated circuits available. All would have worked perfectly well but many of these devices do have one disadvantage. They require an excessive standing current. Once again due to the large number of external components the overall size of the audio amplifier would have been no smaller than the discrete component equivalent and probably slightly more expensive. The reader will have gathered that the author decided against using integrated circuits at this time but it must be admitted that he is unlikely to build further equipment using discrete components only.





Two views of the completed prototype showing the neat layout used by the author.

Transistors vs. valves in the power amplifier

The design requires a multi-band power amplifier with a reasonable output of say 50W p.e.p. Although this power output is well within the capabilities of available semiconductors it was decided that the design would be more straightforward if valves were used. The matching networks which would have been necessary had transistors been used would have been particularly complex in a multiband system. One of the great advantages of using semiconductors is the low voltage supply lines which can often be compatible with car battery voltages thus allowing simplified mobile operation. This is very difficult when considering s.s.b. linear amplifiers as they do not work efficiently from low voltage h.t. supplies (12V). This would have made the use of an up-voltage inverter mandatory and thereby would have defeated one of the main advantages of semiconductors. Thus it was decided to use 12V heated valves both in the p.a. and driver stages. This allows the use of a well tried design, thus further simplifying the final construction.

Power output

The power output was decided by the availability of valves together with the d.c. power capability of reasonable sized transformers. The 6146, 20W anode dissipation valve is almost universally used at this power level, although its linearity is not excellent. It does compare with other similar types, i.e. third order distortion products are about 30dB below the 50W s.s.b. output. The output from a single 6146 is quite adequate for most portable and daytime operations on the amateur bands and this power is more than enough to drive most linear amplifiers.

(To be continued)

Target Specification

The performance requirements listed below were, in the main, met by the prototype.

Receiver

image rejection required > 60dB
second channel rejection > 60dB
i.f. breakthrough > 60dB
a.g.c. performance—no more than 6dB change in audio out for 80dB input change.
Linear v.f.o. calibration and if possible a 1 Hz readout facility.

Transmitter

sideband suppression > 40dB
carrier suppression > 50dB
All other spurious outputs should be greater than 50dB below the wanted signal.

News of the Month

Colour TV sales doubled

A huge increase in the number of colour television receivers delivered to U.K. markets — the result of accelerating public demand — is revealed in the 1971 annual report of B.R.E.M.A., the set makers' trade association. From 467,000 sets delivered in 1970 the figure jumped to 824,000 in 1971. The number of colour receivers actually installed in households was more than doubled. Largely as a result of this, the turnover of the set making industry has been almost doubled in two years – from £111.5 million in 1969 to £204.5 million in 1971.

At the same time the British manufacturers are worried about foreign competition. The total number of imported colour receivers rose sharply from 37.000 in 1970 to 97,000 in 1971 — the value of the Japanese imports being multiplied a thousandfold, from £3000 to £3.5 million!

In contrast, the U.K. market deliveries of British monochrome receivers fell slightly, from 1,670,000 to 1,543,000, while the U.K. deliveries of sound receivers (excluding car radios) went up only slightly, from 696,000 to 709,000.

Lord Thorneycroft, president of B.R.E.M.A., in presenting the report, spoke of the Japanese competition as a 'threat' and said that his association was 'concerting its views' with those of the Government in order to 'prevent any repetition of what has happened to our radio receiver industry and to the television industry in the United States'. The situation of the set makers complaining about foreign competition has provoked some people to ask what this sector of the electronics industry will do when Britain enters the E.E.C. When we put this question to the managing director of Rank Bush Murphy, Mr. J. P. Collis, he told us he was confident the set makers will be able to meet the challenge of the Common Market.

Slant polarization

Some of the B.B.C's local radio stations are now using slant polarization instead of the horizontal polarization which has been used previously for all the v.h.f. radio services. With slant polarization, the electric field is at 45° to the horizontal and perpendicular.

Vertical and horizontal aerials are equally suitable for receiving signals with slant polarization and satisfactory reception, with the vertical rod aerials used on many cars and portable v.h.f. receivers, will be better maintained toward the limit of the nominal service area. The effect is equivalent to the use of 6dB or more additional transmitter power, thus doubling the signal strength. There will be substantially no effect on reception in the home with receivers using built-in aerials, because the passage of a signal through a building tends to mix the polarization. On an outdoor horizontal aerial at roof level, slant polarization will give slightly less pick-up (about 70% or −3dB).

At most receiving sites, it is unnecessary and inadvisable to adjust existing outdoor horizontal aerials for slant polarization because the resultant improvement is unlikely to be significant. If such adjustment is made, the correct slant position is obtained by turning the aerial 45° from the horizontal, anticlockwise when looking toward the transmitter.

The following B.B.C. local radio transmitting stations use slant polarization: Radio Blackburn 96.4MHz, Radio Derby 96.5MHz, Radio Leicester 95.2MHz, Radio Manchester 95.1MHz, and Radio Nottingham 94.8MHz.

World weather watch link

The first phase of a £750,000 project in Britain's Meteorological Centre at Bracknell, which will link it with other major meteorological centres round the world, has been completed by Marconi Communication Systems Ltd, for the Procurement Executive of the Ministry of Defence. A computer-based message switching system, MARS (Marconi Automatic Relay System), is now in operation which provides a high-speed link with other major centres on the world weather watch network, and will enable Bracknell to undertake the first stage of its role as a Regional Telecommunications Hub on the meteorological world trunk circuit. This is the main circuit planned to carry both raw data and processed information required by all countries under the World Meteorological Organization world weather watch plan.

Each hub has the responsibility for collecting, collating and retransmitting weather information over its own region and relaying it to the other hubs. Bracknell is responsible for collating information from an area which includes the United Kingdom, Ireland, Iceland, Greenland, Gibraltar, the Netherlands, and several Ocean Weather Stations, as well as from merchant shipping in the Eastern Atlantic.

The system is designed to accept a flow of alphanumeric data and, in analogue form, facsimile charts from each adjacent centre, Washington, Paris and Offenbach (Federal Republic of Germany), store this information and retransmit it as required to the other centres.

Moscow and Melbourne are the other two World Meteorological Centres on the network and further Telecommunications Hubs are sited at Prague, Cairo, New Delhi and Tokyo.

Amateur recording contest

The Audio Video Tapes division of BASF U.K. Ltd are holding a contest for amateur tape recording enthusiasts. The prizes are four CC9300 radio cassette recorders, one for first prize in each section, and four CC9200 portable cassette recorders as second prizes; 500 cassettes and tapes will be given to runners-up. The contest is divided into four sections, and entries may be submitted for each, providing they are recorded on a BASF cassette or reel-to-reel tape.

The first three categories are: 'Birdsong' — for wild life enthusiasts; 'Music' — either instrumental or voice; and 'Children' — simply doing things that children do. The fourth section is 'Talk Us Into It' — a novelty category where the entrant is invited to state as persuasively as possible just why he deserves to win a prize.

All tapes will be returned after the contest closes at the end of July. Competition entry forms and details are available from tape stockists throughout the country.

Safety in logic system design

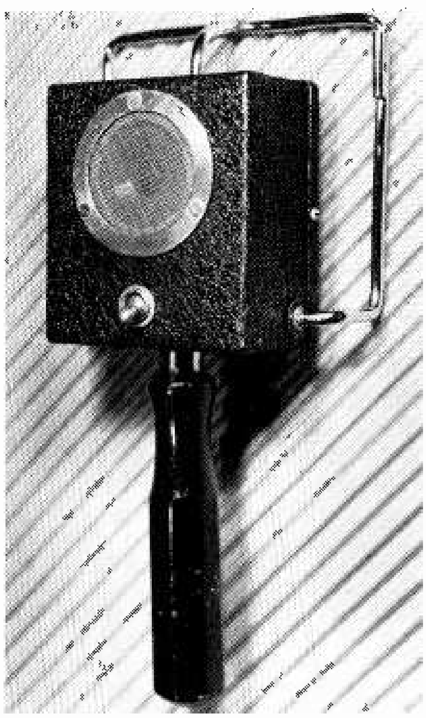
When high reliability is paramount in logic system design the engineer might justifiably turn away from the many forms of semiconductor logic and choose magnetic (ferrite core) logic. This is what ICI did when they needed a protection system for their petrochemical plant at Wilton, Teesside. The equipment, known as the high integrity voting equipment, has been installed in addition to the normal protection systems by GEC-Elliott Automation and has been in operation for three years without a failure. The reaction section of the plant is potentially hazardous because the materials used are near to their flammable limits. Due to this and the size of the plant, the magnitude of the hazard which could result in equipment failure demands that reliability should take precedence. To ensure also that spurious signals do not trigger the protective system all initiating instrumentation is in triplicate and a system of two-out-of-three voting is used, in that no action is initiated unless two-out-of-three instruments show a change beyond normal operating limits. In all 50 parameters (150 instruments) are monitored.

To date magnetic logic devices have survived 70 million device operating hours without a failure.

The origin of the radio microphone

The Science Museum has been presented with two very early radio microphones by their designer Reg Moores. Mr Moores was an ice skater and an amateur electronics engineer and before 1939 was trying to develop a radio microphone which could be used for ice shows.

The first use of one of his radio microphones was in 1949 for the ice show "Aladdin" which was held at the Brighton Sports Stadium.



A very early (the first?) radio microphone built by the designer Reg Moores in 1947. It operated on 70MHz and used amplitude modulation.

Prizewinning wildlife sounds

The results of the 1971/72 Scotch Wildlife Sound Recording contest organized by the 3M Company revealed a range of subjects from a corn bunting via spawning toads to the 'dining room' of a Roman snail. Winners of each of the three classes and their respective subjects were as follows. Class 1 (birds) won by R. Goodwin with a corn bunting. This recording also won the overall title and included the 'applause' of the bird's wing claps as it flew off after its solo musical performance. Class 2 (mammals and insects) won by A. Acland who recorded a hedgehog. Class 3 ('atmospheric' recordings) won by P. Radford whose subject was the River Dovey Estuary in Cardiganshire. An award for the most original entry went to R. Goodwin who recorded for posterity the noisy consumption of a lettuce leaf by a Roman snail.

The main prize was a £150 birdwatching and natural history holiday organized by Ornitholidays, plus a selection of Grampian recording equipment. Entry forms for the 1972/73 contest are available from 3M United Kindom Ltd, 3M House, Wigmore Street, London W1A 1ET.

Association of control manufacturers

Manufacturers in the Appliance Control Section of the British Electrical and Allied Manufacturers' Association Ltd have formed a new organization called The Association of Control Manufacturers (TACMA). Federated in BEAMA it will operate from the BEAMA offices, 8 Leicester Street, Leicester Square, London WC2H 7BN. The members concerned are manufacturers of manual and automatic switches, thermal and time controls for household, commercial and industrial uses.

The chairman of the Association is R. Lloyd, of GEC Electrical Components, with D. G. A. Davies, of Teddington Autocontrols, as vice-chairman.

Queen's Award to Industry, 1972

Half of the twelve awards to the electronics industry were for technological innovation. The recipients were:

The management services department of B.O.A.C. for their Boadicea computer system. This system employs some 40 interlinked computers situated in various parts of the world which handle such tasks as flight booking, check-in, weight and balance, hotel reservations, shipping reservations, flight planning, etc.

Cossor Electronics for work in secondary surveillance radar for air traffic control and Decca Radar for their 66AC anti-collision radar.

Ferranti for the design of automatic draughting equipment.

The develpment of transistors which have to work for years and years in submerged repeaters in submarine cable links won the award for the Post Office.

Raychem received the award for heat-shrinkable plastic components for the termination of high-voltage power cables.

The Queen's Award for export achievement was received by: Gunson's Sortex, Marconi Marine, Medelec, NCR, the Oxford Instrument Co. and Racal-Mobilcal.

Electronic head shrinking

While a big question mark hangs over the commercial future of the video telephone* — namely, will the public buy it? — telecommunications engineers are continuing to look into ways of making it economically viable. One of the big problems, of course, is the bandwidth requirement and information rate of the vision signal. Although a 1-MHz, 319-line, 50.15Hz-field/s picture is successfully being sent along conventional telephone subscribers' pair-type cables in British Post Office trials*, the video telephone is not intended to come into public service in the U. K. until the vision and sound information can be put on the p.c.m. data/'phone/vision network which will come into general use probably in the mid 1980s. Consequently the engineering research is concentrated on reducing the data rate — here the number of binary digits per picture element (called bits/pel) — required to send an acceptable picture. This general objective, known as data compression, will enable pictures of our heads to be sent along the narrowest possible channels.

The data compression techniques are based mainly on removal of redundancy and 'efficient' coding — giving best possible utilization of a given channel capacity. Some of the latest work was described at an I.E.R.E. conference on digital processing of signals held at Loughborough University of Technology in April. (A report on the conference in general, which was attended by 300 people, 71 from overseas, will be published later.) For example, J. E. Thompson and G. A. Gerrard, of the Post

* Called Picturephone in the U.S.A., where a service has already started, and Viewphone in the U.K. The Post Office is conducting an 'in-house' trial of Viewphone between various buildings in London (*Post Office Telecommunications Journal*, Spring 1972 Vol. 24 No. 1).

Office, described and demonstrated a differential p.c.m. (d.p.c.m.) encoder for Viewphone signals — so called because it transmits only quantized *differences* between picture elements instead of all the samples as in 'straight' p.c.m. This accepts an 8-bit p.c.m. signal and reduces it to give a 4-bit d.p.c.m. output. Working on a similar principle was an 'adaptive' coder, described by B. Wendland and F. May, of AEG-Telefunken, which examines the picture signal and varies the bit rate according to the amount of detail in it. This approach is based on the fact that the human eye will tolerate coarse resolution of amplitude levels in high-detail areas of the picture.

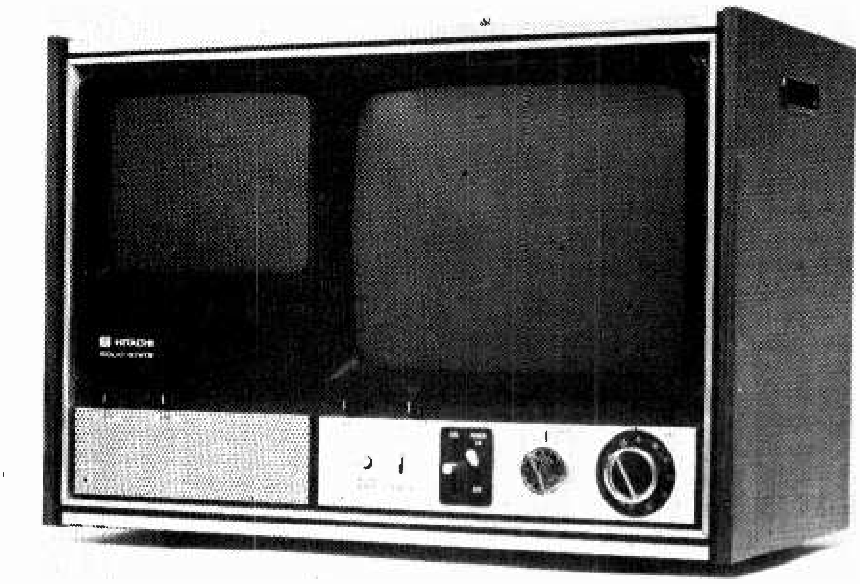
In a Picturephone coder described by D. J. Connor, B. G. Haskell and F. W. Mounts of Bell Labs, the picture information is separated into moving areas and background areas, and the moving areas are transmitted by a number of data compression techniques, such as sending frame-to-frame differences during slow movement. Most elaborate of all was a study of a system called transform coding in which the picture is first divided into a number of sub-pictures, a linear transformation is performed on each sub-picture and the resulting coefficients are quantized. P. A. Wintz, of Purdue University, U.S.A., claimed that such a technique will give data rates as low as 1 bit/pel, compared with 3 bits/pel for d.p.c.m. and 6-8 bits/pel for conventional p.c.m. Unfortunately, such a system, though a highly efficient form of coding, would be extremely expensive to put into real hardware.

Netherlands wiring regulations

The Netherlands represents a substantial market for many kinds of electrical equipment, from consumer goods to large factory installations, but wiring regulations are stringently enforced and these, like the contents of any foreign-language technical document, can be a stumbling block for the British exporter. The regulations, laid down in publication NEN 1010 'Wiring regulations for low tension installations (not exceeding 500V)', produced by the Netherlands Standards Institute, constitute a general code of practice which applies to all installations below 500V and is accepted as the official wiring regulations by the Netherlands Factory Inspectorate and the electricity supply companies.

A provisional translation of the code has now been published by THE (Technical Help to Exporters) a service of the British Standards Institution. The price is £8 for THE members and £10 to non-members.

Copies of the translation can be obtained from Technical Help to Exporters, BSI, Maylands Avenue, Hemel Hempstead, Herts.



Hitachi's twin-tube TV receiver with magnetic disc memory (see below).

Freezing pictures at home

A twin-tube black-and-white television receiver will shortly be marketed by Hitachi which incorporates a magnetic disc memory! Programme material is displayed on a 14-inch tube in the normal way. On pressing a memory button the picture currently displayed on the tube is stored on the disc and displayed as a still frame on an ancillary 9-inch tube. The magnetic memory consists of a 100mm diameter disc and the stored picture can be erased and replaced with a new picture at will.

Although a new approach and an ambitious move by Hitachi, one has to ask what value the storage facility will be to the average viewer. Apart from the obvious novelty value, which would soon wear thin, one is hard pressed to find any justification for spending the extra money.

Rank prize for opto-electronics research

Dr. F. E. Jones, managing director of Mullard, was recently appointed chairman of a committee of scientists who will advise the trustees on the administration of a prize fund set up by the J. Arthur Rank Group Charity. This fund, of £500,000 will provide awards and encourage research into the science of opto-electronics for the public benefit for knowledge, education and learning. The committee is as follows: Prof. D. J. Bradley, Queens University, Belfast; Prof. J. D. McGee, Imperial College of Science & Technology, London; Prof. A. F. Huxley, University College, London; Dr. T. P. Maclean, Royal Radar Establishment, Malvern; Dr. P. Schagen, Mullard Research Laboratories, Redhill; Dr. R. A. Smith, Heriot-Watt University, Edinburgh. Funds will become available and prizes will be awarded in the Spring of 1973.

Telex exchange in Hong Kong

What is claimed to be the first stored programme computer controlled, fully automatic, telex exchange for both international and transit traffic was brought into operation recently by Cable and Wireless in Hong Kong. The exchange, which cost about £1M and was designed and built by Hasler Ltd of Berne (Switzerland), will handle up to 1,000 telephone calls and has a capacity of more than 4,000 lines. Work is already in progress on equipment which will double this capacity.

Statistics for all calls are recorded and continuously updated on magnetic tape. The tapes are then used to produce monthly bills and to print out full details of how the exchange is being used.

An immediate commercial benefit to Hong Kong's business community is that with the introduction of the new exchange the earlier three-minute minimum call charge has been reduced to one-minute.

Hong Kong Trade Council's U.K. office

The Hong Kong Trade Development Council has expanded its operations in

Britain with the opening of an office in Manchester. The extension of the Council's activities in Britain follows one of the Colony's best trading years with the United Kingdom. Exports to Britain, its second largest market after the U.S.A., rose 31% last year, reaching a total of £133M. U.K. sales to Hong Kong during 1971 showed a 5% gain over the previous year at a value of £109M. The new office is at 4 St. James's Square, Manchester.

P.O. cable laying engine

The first production model of an improved machine which simplifies the laying of modern undersea telephone cables left Manchester Docks for Canada recently. It is a linear cable engine, developed by the Post Office Research Department and bought by the Canadian Government. On arrival it will be installed in the coastguard ship *John Cabot*, which is to lay the Canadian end of the new high capacity cable CANTAT 2 early next year.

Another engine of the same design is now under construction at the Wolverhampton works of Dowty Boulton Paul Ltd, who make it under licence from the Post Office. This machine is for the Cable and Wireless cable-layer *Mercury* which will lay the transoceanic section of CANTAT 2. Both engines are improvements on one that has operated successfully on the Post Office cable ship *Alert*.

The new engine cuts out problems caused by the repeaters when laying cable using earlier methods. The repeaters are heavy metal cylinders up to 3m long and 360mm in diameter and in the past a scheme which allows them to by-pass the cable gear has been used. This meant slowing the ship to 1-2 knots and needed a team of several cable-hands. But modern high-capacity systems such as CANTAT 2 with repeaters every 6 miles make this method unwieldy. The new linear engine allows the repeater to pass straight through at about 4 knots, and eliminates all manhandling.

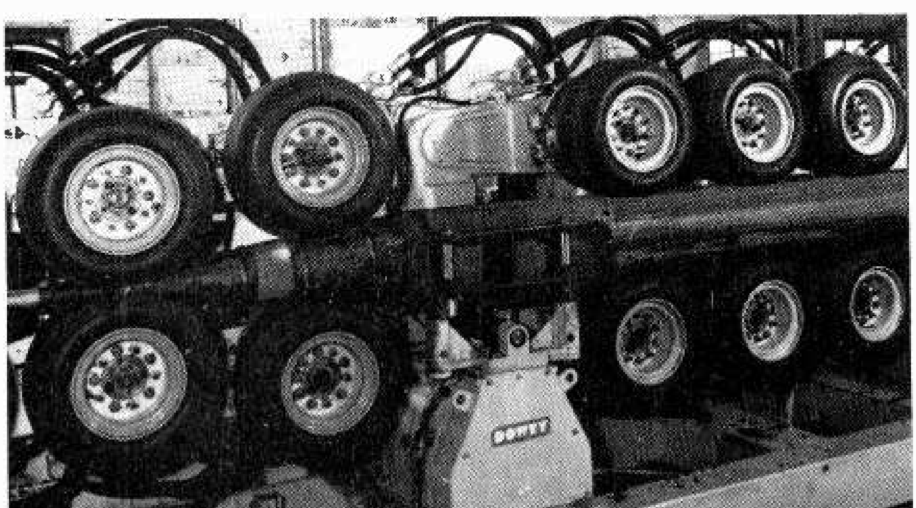
Semiconductor seminar

Texas Instruments are to hold three identical, one-day, seminars at the Talk of the Town in London on June 6th, 7th and 8th. The subjects to be covered are: opto-electronics, new digital and linear bipolar integrated circuits, audio design techniques, power control and m.o.s. For a fee of £8.50 delegates will be able to attend the seminar and will receive a set of papers with illustrations, a text book and a four-course lunch. Applications should be sent to Texas Instruments Ltd, Manton Lane, Bedford.

Pro Electron data book

The international association for the assignment and registration of type numbers for electronic components, Pro Electron, held its sixth annual meeting in Brussels recently. The number of the members is now 36 and in the year 1971 the association registered 1543 device types (about the same as the number registered in 1970).

The second edition of a data book, 'Pro Electron Semiconductor Reference Book 1972', giving essential information of all discrete semiconductor devices sold under a Pro Electron type number was announced.



Part of the Post Office's submarine cable laying machine showing a repeater passing through (see above).

Those higher quality Apollo 16 pictures

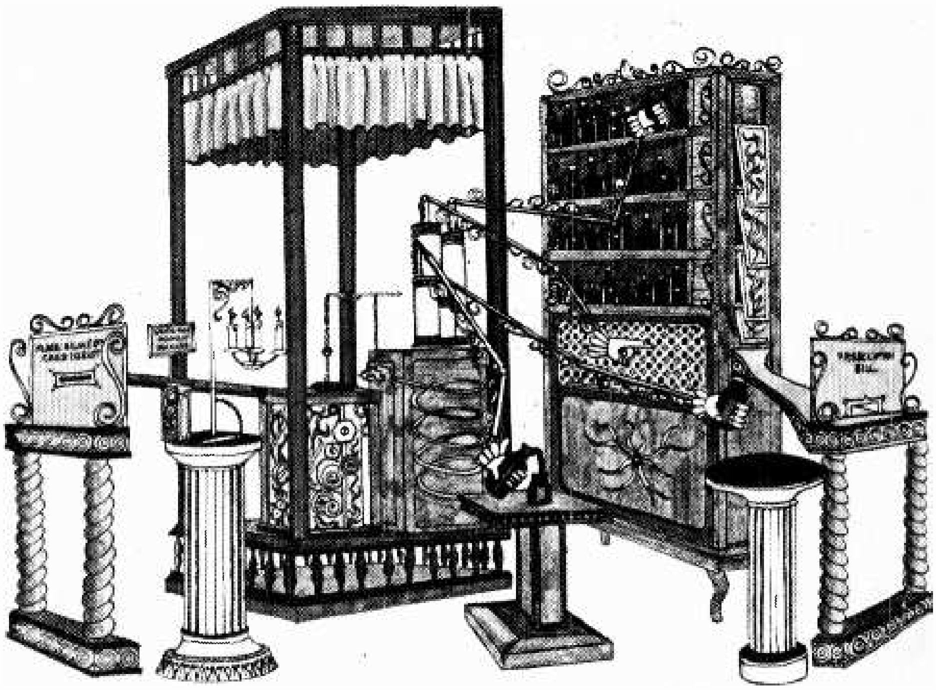
Everyone watching the broadcast television pictures originating from the surface of the moon during the Apollo 16 mission was impressed by their high quality, compared with those seen during previous lunar explorations. Some, if not all, of this improvement was due to a technique of information processing applied to the vision signals after they had been received at Houston, Texas, U.S.A., and before they were distributed to the public broadcasting networks. This signal processing technique was devised by J. D. Lowry, a Canadian, who is a vice-president of a new company with two branches, Image Transforms of Canada Ltd., Toronto, and Image Transforms Inc., North Hollywood, California. It was to the Hollywood premises that the signals were sent for processing from Houston and back, entailing a delay of about 0.2s.

From a report in the *New York Times* (22nd April) it would appear that Image Transforms are anxious to keep their technique secret and have not even revealed it to N.A.S.A.; hence the procedure of sending the signals across half of America rather than install the processing equipment at Houston. At the time of going to press Image Transforms had not released even the principle of their device, on which there are seven existing and two pending patents. All that has been reported is that it involves "a certain amount of computer usage", that it applies corrections to avoid the "streaking in Apollo 15 pictures" which "was the result of a lack of low-frequency responses in the equipment used" and that the correction process "was equivalent to . . . using a bigger antenna, or more power from the spacecraft".

Informed opinion in the U.K. suggests three possible methods which might be used in the processor, either singly or in combination. The first is straightforward adjustment of the amplitude/frequency characteristic of the vision signal by means of a variable equalizer. The second is averaging over a short sequence of pictures so that highly correlated parts of the image structure tend to be reinforced while random noise tends to be cancelled out. The third method suggested as a possibility is examining the vision signal continuously to distinguish high-frequency information (e.g. sharp edges and detailed structures) from low-frequency information (gradually shaded areas) and automatically reducing the bandwidth of the channel during transmission of the l.f. parts so that the noise — most obvious on the picture during these l.f. parts — is also reduced. However, the "running bandwidth adjustment" method is difficult to achieve on high-quality pictures, while the averaging process would be very noticeable on sudden movements in the picture.

Some of the picture quality improvement may be attributable to the RCA ground controlled colour camera, which has a new type of pick-up tube target.

Paint a computer competition for children



Computerized family doctor depicted by 14-year-old Nicholas Wingfield in the Paint a Computer competition organized by the 'Observer' and Honeywell.

Recently the Young Observer section of the *Observer* colour magazine, in association with Honeywell, organized a Paint a Computer competition for children. The winner, 14-year-old Nicholas Wingfield, of Gravesend, designed the computerized family doctor illustrated.

The complete Honeywell report on the event is reproduced *in toto* as a little light relief.

"This computer turns dead people into useful things like dogs, flowers and bubble gum." Michael Green, aged 7, of Brighton, Sussex.

"Our computer shrinks animals. This would be useful if the world had no more room for crops. The crops would grow where the large animals used to be." Gillian Williams, aged 10, of Rhiwbina, Cardiff.

"This machine is made to count how many measle spots there are in the British Isles at a given time. It should help doctors know where to go." John McPherson, aged 10, of Bishop's Stortford, Herts.

"For testing people and testing their blood and finding out if they smoke, eat eggs, bacon, potato and if they run. It measures a person's height." Shona McKinnon, aged 6, of Bearsden, Glasgow.

"One day a computer made a boy and out he came." James Cheseldene, aged 5, of Leeds.

Five gems from among many. There were the predictable UFO detectors, space stations, homework computers ("satchel size"), time machines, weather or football forecasters, kitchen computers. There were conveyor belts, cogs, brains, buttons, steam, tubes, wire, plugs and pipes.

But there were also the extraordinary flights of imagination that no computer could ever have predicted. Like the blackberry counting computer; or the one that is used to wipe your nose and switch on television; or that tells you what to do when you are in the WC when the WC is locked; or that makes red, green, black, brown, orange and purple toothpaste; or that blows out candles ("for the man who has everything"); or that finds out how many bees are in the area by hearing the buzzing and converting it into numbers; or that translates animal language into human language; or that makes apples into tennis balls; or that puts answers into your head before you ask the questions.

It was the everyday chores of life, however, that came in for the most attention — mostly those faced by Mum dashing madly about in the morning getting breakfast and doing housework. Washing dishes and making tea; cleaning shoes; taking the dog for a walk; doing the gardening; getting up in time to get to school by way of the Bakerloo line; minding the baby; cooking; letter writing; and, of course, homework. Division seems to cause problems to many a 10-year-old; and one at least applied a computer to "working out the best excuse if you did not do your homework".

Some of the serious issues of the day were also covered. There were several machines designed to clear the atmosphere of pollution, and others for deciding strikes. Master C. C. Wheeldon, aged 15, of Plymouth, reckoned to have solved the unemployment problem at a stroke with his computer "as it will take at least 300 people to build it". On the other hand, Duncan Chapman, aged 8, of Hoylake, Cheshire, produced a computer to control "the machines in a factory, so only two men are needed". And there was many an entry aimed at crime in the person of the burglar who came in for some pretty gruesome punishment. There is a sadistic streak lying crust deep in many a young mind!

There was one "primeminister" computer — "he will listen, sip tea, tax things and generally flap about all day" — sent in by Robert Jones, aged 14, of Redditch, Worcs; and one "Mrs. Thatcher computer" entered by Frances Williams, aged 14, of Helston, Cornwall, which had its free school meals dispensers labelled "out of order".

Other teacher-prompted suggestions were also in evidence — the computer for working out school timetables did not, somehow, ring true as the idea of a 9-year-old.

Then, finally, there was some evidence of real computer appreciation. "The computer I have illustrated will give you the answer to any of the subjects I have stated provided the machine is fed properly" was one phrase that struck a chord in the heart of the man from Honeywell.

As did the use of a toilet-roll for print-out ("perforated for easy tear off"); and the provision of a "steam boiler in case of power cuts" that Hugh West, aged 9, of Didcot, Berks, made for his computer for house and garden work.

And when it came to acronyms, the computer industry had nothing to teach some of the entrants. Honours here were equally divided between two 12-year-olds, Timothy Wilcox, of Oadby, Leics., and M. Everest Phillips, of Mill Hill, London. Timothy coined P.E.S.T. for Pocket Embassy Spy Tracker Mk 1 for embassy officials to detect the presence of spies; and young Phillips, S.C.R.A.P.S., for School Cook's Ration Allocation Programming System.

Almost to a child, all assumed that the computer was infallible. Occasionally, however, there was a hint that the machine could falter — like the "computer that predicts the football pools absolutely correctly . . . (usually)". Or — and this must be the last word — 11-year-old Tessa Howe's, of Forest Row, Sussex, wind forecasting computer: "to work the computer, you pull back the lever and the incorrect wind forecast will fall slowly into the bucket".

PEAL a clanger?

Engineers' demands for personal services were the subject of a joint examination by the Council of Engineering Institutions and the Engineers' Guild Ltd. The formation of the Professional Engineers Association Ltd, PEAL (see *Wireless World* September 1970 p.428) was proposed but the response from members of constituent institutions was below the target set for a viable organization and PEAL was, therefore, still-born.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Stereo cassette tape decks

It is always disconcerting to find that what one thought was obvious is, in fact, untrue. Clearly, a good quality open-reel machine with a tape speed of $7\frac{1}{2}$ i.p.s. must be capable of a better musical performance than a good quality cassette tape deck with a $1\frac{7}{8}$ i.p.s. tape speed It is, therefore, distressing to find that human beings don't seem to realise this.

Your contributor (March and April issues) used two panels of listeners. The first panel, who had no special technical or musical knowledge, voted overwhelmingly in favour of the cassette machine. This had to be explained away as 'the inexperienced panel may have grown accustomed to listening to small radio sets and medium-priced radiograms and had come to prefer this kind of music'. Having safely, in your contributor's opinion, dealt with that group, it was now necessary to examine the expert panel's results in such manner as to bias the figures in favour of the open-reel machine. How else can one explain the fact that he totally ignores, on some occasions, those experts who decided that they could tell no difference between the two machines, whereas he takes full account of them when it suits him? I quote, 'Overall, the experienced listeners preferred the Tandberg by 9 points to 5, a ratio of about 2:1'. In fact, 9 people preferred the Tandberg out of 16 votes cast for overall performance, and therefore the experts were almost equally divided. Yet, consider the wow and flutter figures. Here, three points were given for the open-reel recorder and one point for the cassette recorder. Your correspondent correctly reaches the conclusion that 'Both machines were rated the same for wow and flutter'. To apply his previous system of analysis it would be said that three times as many points were cast for the open-reel as for the cassette, which he realised on this occasion was a ridiculous way, although arithmetically correct, of assessing the significance of the findings. Adding up the total votes cast for the various performance items given in Fig. 11(b), further emphasises the point that although both machines were apparently unsatisfactory in certain respects, there was nothing to choose between them overall.

One would hope that in all future trials of this sort, such statements as 'It is probably fair to assume that the distortion of the high frequencies on the Tandberg was an isolated case and does not occur on all machines of this type. If this was indeed so . . .' should never be made. This again smacks of bending over backwards to bolster one's own convictions.

Could it be that the inexperienced panel was composed of somewhat younger persons and that their hearing in the high-frequency range was more acute than that of the possibly older, albeit more experienced, panel? The lack of treble response in the cassette as opposed to the open-reel which was noticed by the experienced panel would perhaps not be given such emphasis by those whose hearing was more sensitive to the higher frequencies, whereas distortion would be noticed by both groups.

It is quite clear that there is no marked difference in overall performance between a good cassette machine and the open-reel machine used. The statement that one sacrifices performance for convenience by using the cassette machine is quite unproven by these tests.

H. V. Hempleman,
Gosport,
Hants.

The author replies:

I cannot agree with Mr Hempleman's interpretation of the listening tests. There was little difference between the machines as far as wow and flutter goes we agree, because most of the panel said so. Mr Hempleman is also right in saying 9 people out of 16 preferred the Tandberg overall but it is also true to say that only 5 out of the 16 preferred the Bell and Howell (2 could not tell the difference). It is obviously incorrect to conclude that there was nothing to choose between the machines overall.

It is ridiculous to imply that I was 'bending over backwards to bolster my own convictions' presumably on the superiority of the reel-to-reel machine. In fact the converse might be true in that I mentally overcorrected for my preference for the cassette recorder in an attempt to be fair. You see I bought one of the cassette machines mentioned in the survey (after carefully assessing my needs) several months before it was suggested we might carry out a survey. I think cassette machines are very much more convenient and I am very happy with the one that I have. By the way, members of each listening panel covered a very wide age range.

Brian Crank.

Why cassettes?

Your comparative report (March & April) was most helpful. Certainly the standards achieved are remarkable but one is left wondering why anyone bothered to develop 'fixed' stereo recorder-players in cassette format — the real advantages of which are small size, one-hand-operation convenience and the ability to run on one flea-power. These are enormous advantages in a portable machine able to run at least optionally on batteries, but largely irrelevant to a mains-driven table model used as an adjunct to a fixed high-quality set-up. I very much doubt whether the developers of the format had in mind the latter use.

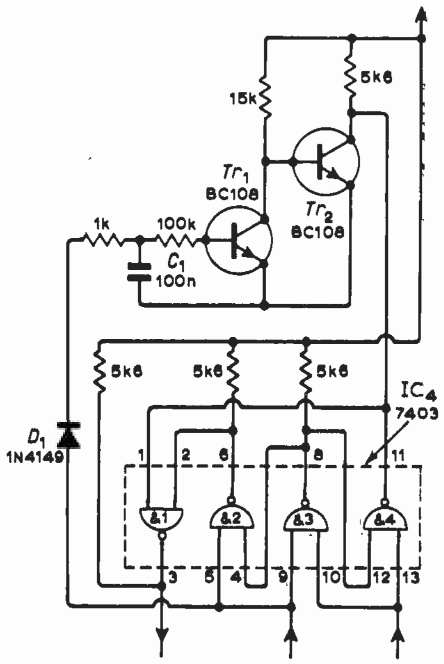
Surely one of the *basic* uses of a tape recorder in a hi-fi set-up is simply to record inconveniently-timed broadcasts for later hearing. Two things rule out the cassette for this purpose: (i) apparently none of the machines could be satisfactorily operated by a time switch, and (ii) the absolute maximum uninterrupted recording time of 60 min. is too short for many concerts. Flexibility has been too severely restricted in the interest of standardization. Too late now, but wouldn't a somewhat larger cassette have been *almost* as convenient and much more useful?

Ian Leslie,
London, N.10.

White noise generator

While the method of noise generation described by Mr. Beastall is very effective, his circuit can suffer from one very serious defect. If it happens that all the stages of the shift register are at 0 at switch on, the exclusive OR will give an output of 0 and thus the noise generator will not start.

This difficulty can be easily overcome by the addition of the circuit shown. So long as the output from the register (input to pin 9 of IC_4) switches between 0 and 1, D_1 will switch on, periodically charging C_1 and keeping Tr_1 bottomed. This switches Tr_2 off so that the circuit does not interfere with the normal running of the noise generator. However, should the output be 0 continuously, Tr_1 will turn off, turning Tr_2 on and earthing the input to gate 1. This injects a 1 into the input of the shift register thus causing the noise generator to start. Note! This modification will



Mr Waddington's modifications to Mr Beastall's white noise generator.

not work if a 7400 gate package is used as the 'wired OR' used at the input of gate 1 would cause gate 4 to burn out!

D. E. O'N. Waddington,
St. Albans,
Herts.

The ASP strikes again

An ASP should be approached with caution, as H. Harper points out in his letter in the March issue. As it is, the ASP has struck again. Unfortunately Mr Harper gives no details regarding his analysis or the transistors used in his experiments. His results are rather misleading if it is assumed that transistors belonging to the class of popular small-signal audio transistors are used in the circuit. Typical examples are the BC107, BC109, BC169, BC257, etc.

Before I advanced the approximate analysis in my letter in the January issue, an exact analysis of the circuit shown in Fig. 1 was made. Approximations were made only after an experimental investigation. With the equations given, results should be within a 30% margin of error, which is not too far off the mark if all approximations are taken into account. The basic assumption was made that transistors with small values of h_{re} would always be used. I quote the following experimental results, which were obtained from the circuit shown in Fig. 1 — essentially the same as the circuit in my previous letter. A BC257A was used for Tr_2, and five different BC169Cs for Tr_1.

Using the approximate formula and manufacturer's data, the limits of the voltage gain using these transistors was calculated as approximately $600 < |A_v| < 2200$.

The following are the measured results with a 1mV r.m.s. input voltage:

1. Voltage gain

frequency: 1000Hz

transistor Tr_1:	a	b	c	d	e
output V r.m.s.	1.45	1.15	1.54	0.90	1.40
voltage gain:	−1450	−1150	−1540	−900	−1400

2. Frequency response

frequency (Hz)	100	1k	10k	80k	100k
output V r.m.s.	1.39	1.40	1.40	0.99	0.88
| voltage gain |:	1390	1400	1400	990	880

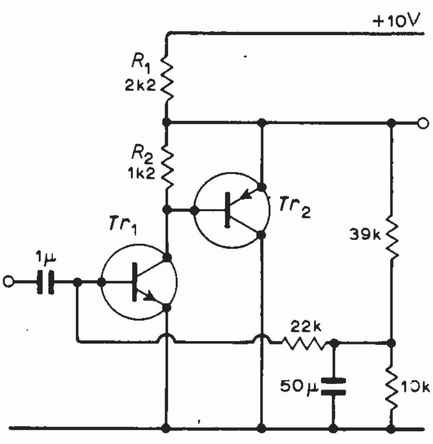


Fig. 1.

Because Mr Harper furnished few details, I am at a loss to explain why his measured values were so low.

Referring to the case where the collector resistor of the transistor Tr_1 is connected to the 10-volt line, maintaining the same biasing levels and with no resistance in the emitter circuit of Tr_1, the voltage gain of the circuit is given to a good approximation (assuming h_{re1} is small) by

$$A_v = -h_{fe1}R_2/h_{ie1} \approx -g_{m1}R_2 \approx -I_{E1}R_2/25.$$

With the transistor Tr_1 biased at 0.5 mA, this comes to −20, as measured by Mr Harper, and not to −9, as predicted by his computer analysis.

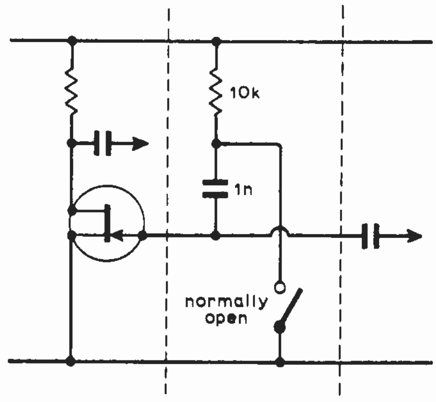
Although the circuit could conceivably go into a state of oscillation when driving a capacitive load, and with the base of Tr_2 capacitively loaded, I have never experienced this in normal applications.

P. W. van der Walt,
University of Stellenbosch,
South Africa.

Voltage-controlled oscillators

Having a requirement for a voltage-controlled oscillator I constructed a 'lash-up' of circuits 2 and 4 of D. T. Smith's article 'Multivibrators with Seven-decade Range in Period' (February issue). Using 2N5458 (MPF 104) devices for the f.e.ts it was found that the oscillators were not self-starting, but required a negative-going pulse to one of the gates to trigger it. It was further found that if the input voltage was not limited the circuit would 'latch-up'.

The addition of a resistor, capacitor and switch to one gate circuit, as shown, was found to be sufficient to start and restart the oscillator. The resistor and capacitor alone were sufficient to provide self-starting on switch-on, the switch only being necessary to re-trigger the circuit should the control voltage be allowed to get out of hand. Once started the circuit proved to be quite suitable for the function required of it.



Mr Stiles' addition to Mr D. T. Smith's circuit.

D. B. Stiles,
Bristol,
Somerset.

Automatic telephone exchange

I would like to thank Mr P. F. Gascoyne and Mr N. Monk for their useful comments (April issue) on my design of an automatic telephone exchange (February issue). They have both criticized the power supply section, and I feel I should clarify the situation.

The first point is to assess the merits of using the switched power supply as in my original circuit, or to have a 'permanently on' power supply as suggested by Mr Gascoyne. Both methods have their advantages, and I based my original decision on the expected use of my exchange. Since there were liable to be prolonged periods of inactivity, I felt that a switched power supply would be most suitable. In practice this has worked very well, particularly as the small auxiliary battery lasts over a year. However, if heavy use of the exchange is expected, then perhaps a simpler 'permanently on' power supply would be more appropriate.

Mr Monk is correct to draw attention to the possibility of getting a shock from the mains switching relays. This danger can be avoided by ensuring that the exchange is adequately housed, and that the mains is switched off while it is being handled. Alternatively the contacts could be shielded by commercially available dust covers. More important is the possibility of mains contacts shorting with low-voltage ones. This is indeed possible if they are both wired into the same springset. However, the type 3000 relay has two sets of spring contacts side by side separated by a porcelain insulator; by using one set for mains only and the other set for low-voltage, the danger is overcome.

If it is considered desirable to use separate relays for the mains switching, then Mr Monk's suggestions should be adopted. His circuit can be simplified slightly by omitting RLA/1 and RLB/1, and bridging across their positions. RLB/1 is not required because its function is served by RLB/3. Coils of RLA and MSA become paralleled and their resistances should be chosen to total about 5kΩ. If the resistance is made too low the applied voltage will drop because of the 5.6kΩ series resistance of R_1-R_{20} and the relays may fail to operate.

A 'permanently on' power supply avoids the necessity for mains switching and leads to considerable simplification of the original circuit. RLB is no longer required; its coil is replaced by an 800Ω resistor and RLB/1, RLB/2 and RLB/3 are bridged. Also not required are R_{21}, R_{22}, RLA/1, RLA/3, RLD/3 and U_{2B}, the 800Ω resistor being connected directly to the junction of Tr_1 and D_5. The 45V battery is not required and the lead from the coil of RLA that was connected to it is instead connected to the negative supply just to the right of RLD/2.

G. F. Goddard,
London, W.5.

Illegal listening

In a recent London court case three people were successfully prosecuted by the Ministry of Posts & Telecommunications for illegally listening to messages transmitted by the Fire Brigade.

I have fitted a Bluespot v.h.f. radio in my car. When using the set within 100 yards of a mobile radio transmitter (be it Police, Fire Brigade, Ambulance Services, etc.) its transmission causes a breakthrough on my car radio. My problem is, am I listening illegally to a private broadcast, or, are they illegally interfering with my private listening?

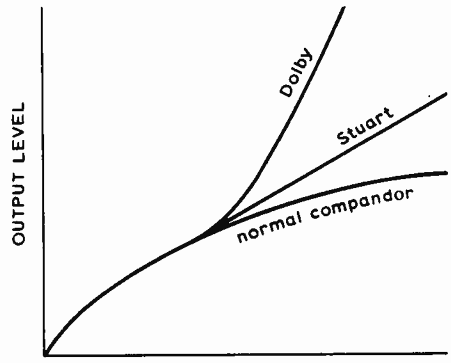
R. Cox,
Chessington,
Surrey.

Tape noise reduction

Having been experimenting with low-noise tape recording systems for several years, I would like to comment on J. R. Stuart's article in the March issue.

First, the author's active system based on his Fig. 7(b). which is similar to the Dolby in that compression ceases at some signal level short of peak amplitude (−20dB in the author's case), would appear to suffer two disadvantages invariably overlooked.

During the expansion of the recorded signal, the (reduced) noise must increase by the amount of the expansion, to reach its normal level coincident with the cessation of expansion. The signal available therefore to mask the noise at any given signal level during expansion must be 20dB smaller than with the conventional compandor and thus less easily masked. This assumes, of course, the same degree of compansion and a similar law in each case.



Put another way, the conventional compandor would yield the full noise reduction at a signal level 20dB larger than in the author's design.

A second point concerns the ability of the two systems to deal with the shortcomings of the tape itself. Anyone who has observed, on an oscilloscope, the replay of a constant tone, will be familiar with the random changes of signal level throughout. These become exaggerated by compansion and by a factor related to the rate of compansion. It is, therefore, desirable to keep this at a minimum; a requirement which is antagonistic with limiting the compansion to some amplitude short of peak.

Mr Stuart states that his compansion system has a characteristic similar to his Fig. 7(b). This also represents the Dolby characteristic and on this basis one could be excused for assuming that there was little difference between them when in fact this is untrue. The essential difference becomes lost through the use of axes scaled in decibels. If we re-draw Fig 7(b) to linear scales as shown, the situation becomes clearer.

Mr Stuart's characteristic is a straight line above the level −20dB and is tangential to the curve representing a normal compandor. The Dolby curve, on the other hand, can be made to turn upwards. This results from the linear component in the Dolby output which, at large signal levels, all but swamps the compressed component.

Both systems are capable of reducing overshoot compared with the conventional compandor but the mechanism in each case is very different.

Mr Stuart's design relies solely on providing the detector with more time in which to respond to the information it receives. The overshoot will still be determined to some extent by the attack time constant.

In the case of the Dolby, the attack chosen is relatively unimportant. Its output on receipt of a large input signal is predominantly the linear component and whatever happens in the compressor channel will make little difference.

W. H. Myall,
Watford,
Herts.

The author replies:

I am somewhat saddened that Mr Myall chose to comment only on the experimental active compandor which, from the point of view of noise reduction ideas, was the least important. However, I shall deal with his points in order.

It is quite correct to say that stopping the compression at a level 20dB below the peak amplitude means that signals at this level are required to mask the reduced noise. However, reference to Harvey Fletcher or Moir (references 1 and 2 in the article) show that at the loudness levels discussed in the article a tone 20dB below the maximum level is quite capable of masking this noise. This is after all the *rationale* behind the Dolby system.

Mr Myall's second point is accepted. We have, after all, an engineering problem in designing a noise reduction method, the performance being judged on programme. The problem to which Mr Myall alludes must be balanced against the problem of the detector which I explained in detail.

I am disappointed that my remarks on the Dolby system were misinterpreted to the effect that I had suggested the compandor was like the Dolby system. I thought that I had made it quite clear in the article not only that this suggested approach to compansion was entirely different to the Dolby being not of a differential type, but also, as Mr Myall goes on to say, that my design relies upon a detector which has a longer time in which to respond.

In my view the importance of the article lay not in the suggested approach to the compandor, but in the design of the passive method of noise reduction, which is a highly desirable one from the point of view of economy and simplicity.

J. R. Stuart.

June Meetings

LONDON

1st. RTS — "Single-tube colour cameras" by J. E. Attew at 19.00 at I.T.A., 70 Brompton Rd, S.W.3.

13th. AES — "Transformers and the audio engineer" by P. J. Baxandall at 19.15 at the Mechanical Engineering Dept., Imperial College, Exhibition Rd, S.W.7.

15th. RTS — "Microwave links for television O.Bs" at 19.00 at I.T.A., 70 Brompton Rd, S.W.3.

29th. RTS — "Teldec video disc" by R.W. Bayliff and K. G. Thorne at 19.00 at I.T.A., 70 Brompton Rd, S.W.3.

Doppler Effect

In radio and other electromagnetic waves

by 'Cathode Ray'

Having studied Doppler effect at some length last month as it concerns sound waves, we might suppose that all we had to do to adapt that treatise to radio (or light) waves was to make V (the speed of the waves in metres per second) 299,792,800 instead of 342. That is certainly what is often implied by people who mention Doppler in connection with radio or light and want to make sure that their less enlightened readers know what they are talking about. And unless we are in the astronomy or space travel business, it is probably fair enough in practice. But in theory at least it is a fallacy. And of course we are not going to be fobbed off with anything like that.

If a gunman, approaching us in his car, were to use us for a bit of target practice, and we took the trouble to measure the speed with which the bullets approached us, we would find that it was equal to their speed as fired from a fixed point, plus the speed of the car in our direction. If however the driver was merely sounding his horn, the speed with which the sound waves reached us would be quite unaffected by the movement, if any, of the car. The higher pitch of sound when its source is moving towards us is due, not to faster sound waves, but to the fact that they are radiated from successively closer positions, so reach us at shorter intervals. However, the speed of the waves does depend on whether there is a wind blowing. The speed of that wind, which is the medium that carries the sound waves, has to be added to or subtracted from their speed in still air to get their net speed relative to the listener. Knowing (1) the wave speed in still air, and (2) its actual speed relative to us, we could find the wind speed very simply as the difference between the two.

If electromagnetic waves, of which radio and light waves are examples, were like sound waves in this respect, then one could (if sufficiently well equipped) measure the speed of the medium that was carrying them. But even before Einstein, experiments designed to do so, and which should have done so, failed completely to show any difference in speed or to reveal the existence of any medium. This surprising result has many times been confirmed since then in much more sophisticated experiments. And so scientists have been obliged to accept as a very remarkable fact that the speed of light in empty space is always the same, even to observers who are in rapid motion relative to one another. This speed is one of the fundamental constants of the universe, denoted by **c** and equal to 299,792,800 m/s, as nearly as has been measured.

In material media the speed is less than **c**; very little less in the atmosphere, but much less in solids.

Not only is light (or radio) unable to travel faster than **c**; nothing can (except of course in Star Trek, but even Mr Spock won't reveal how). For if it is a fact that **c** in space is unchangeable in any circumstances, it follows that distance, mass and time are not the absolute things that common sense tells us they are, but that measuring rods shrink, masses increase and clocks go slower when they are measured by an observer who is moving relative to them. And when the rate of movement reaches **c** they go to zero or infinity and things cannot go farther than that.

In view of **c** being so very much faster even than the sort of speeds we read about in connection with flights to the moon—let alone what we do ourselves on the motorway when pushed for time—we might suppose that the relativistic effects could safely be ignored. At a relative speed of 10,000 km/hour (over 6000 m.p.h.) they amount to only about one part in ten thousand million. But in domestic colour television the voltage used to accelerate the electrons in the picture tube is about 25,000, which on a non-relativity basis would give them a speed of about one third that of light, at which the relativity correction is far from negligible. And on the same basis the voltages used nowadays on overhead power lines would make electrons break the light barrier by exceeding **c**. However, their gain in mass as predicted by relativity prevents this impossible thing from happening. (It is worth noting that electrons can easily be made to go fast enough to exceed the lower-than-**c** speed of light in solids and liquids; this breach of the light barrier causes no loud bang but only a silent blue glow called the Cerenkov effect.)

But it is the Doppler effect we are supposed to be studying. The point is that with radio and light waves there is only one speed to be taken into account—the *relative* speed between source and observer—whereas with sound waves the speed of the medium comes into it too. In our numerical example we got slightly different values of the Doppler change in frequency for the same relative movement of source and observer, depending on which was stationary relative to the air. If radio waves had a medium to carry them, corresponding to the air, then the precise amount of Doppler effect would likewise depend on the source and observer speeds relative to it. No difference amounting even to one thousandth part of what would be expected if there were a medium (aether) has ever been detected in any circumstances, so—no medium.

This complication being absent, we might hope that the calculation of Doppler effect for radio waves would be even simpler than for sound waves. But alas. Owing to the relativistic changes in time and distance with speed the calculation is so complicated that I'm not going to trouble you with it here. It was done by 'Quantum' in *Electronic & Radio Engineer*, Oct. 1957, pp. 371 and 372, if you want to see it. For nearly all practical purposes (mainly radar) the Doppler effect is the same in principle as for sound waves where there is no wind:

$$f' = \frac{f(\mathbf{c}+v)}{\mathbf{c}} \quad \text{or} \quad f\left(1+\frac{v}{\mathbf{c}}\right)$$

where f is the actual frequency radiated by the source and f' is the frequency as we find it when we and the source are getting nearer at a speed v, reckoned in the same units as **c**.

Even with supersonic aircraft $v/\mathbf{c}$ is a very small fraction. The correction to take account of relativity depends on $v^2/\mathbf{c}^2$ so is very much smaller still and quite negligible in the world of transport. Even $v/\mathbf{c}$ is so small at, say, 50 m.p.h. that you might wonder how police radar can detect the difference between f and f'. 50 m.p.h. is only 22.4 m/s, so compared with **c** is only 1 in 13.4 million. The answer is that f is under control and can be made quite large. For easily portable short-range equipment it would have to be large anyway. Suppose it is 10 GHz (= 10,000 MHz) for example; then 1 in 13.4 million is more than 740 Hz, which is easy to detect, and in fact to measure as the beat note between f and f'.

Now that we are coming down to brass tacks (or even more practical symbols; most tacks actually used seem to be of baser metal) it will be necessary to remember as we are hurrying along a speed-restricted road that the term 'observer' doesn't really fit us now; we are playing the quite different role known as 'target', and the constabulary are doubling for observer as well as source. So this is rather a different case from any we have considered so far.

The officially operated source generates and radiates short radio waves beamed in our direction. When these strike our car they induce in its metallic structure weak electric currents, just as if it were an untuned receiving aerial. Because the distance between it and the source is more or less rapidly diminishing, the frequency of these currents is very slightly higher than that being radiated, to an extent calculable by the Doppler formula just given. Since any receiving aerial also radiates, our car is also a moving source, radiating waves at this slightly raised frequency. (The whole action of the car in this matter is usually referred to by the one word 'reflects'.) The police, who are the observers, also operate a receiver which detects the reflected waves. And because the distance between secondary source and receiver is diminishing at the same rate there is a second rise in frequency, equal to the first. In other words, the rise in frequency between original source and observer in the reflector mode is twice what it is in the simple source-to-observer modes we considered last month. That makes it easier still to detect and measure. All that is needed is a suitable frequency meter, usually of the pulse-counter type, which can be scaled in m.p.h. of the reflector, such as the one we are driving.

Equipment of this kind was devised during the last world war to detect enemy movements. The ordinary sort of radar that had been used so effectively against air attacks enabled aircraft to be detected and their distances and directions to be ascertained. But in trying to do the same sort of thing for land assaults by tanks etc. it was often difficult or impossible to pick them out from assorted fixed reflectors such as trees and structures. So Doppler radar was invented, which was able to distinguish moving reflectors from stationary ones. The same principle comes in useful, of course, even when targets are clear from 'clutter', for measuring the speeds of aircraft or missiles.

As we have just seen, the frequency of the beat note between the radiated and the Doppler-affected reflected waves is proportional to the speed of the reflector relative to the radiator. The higher the speed, the higher the frequency. But the shorter the time to cover a given distance. So whatever the speed, the total number of beats caused when the reflector moves a given distance is always the same. Each half wavelength the reflector moves towards the radiator introduces one extra cycle into the reflected signal. So if the total number of cycles is counted (instead of their frequency as in measuring the speed of movement) the distance moved can be measured, provided of course that the wavelength is known. Since the frequency f of the transmitter, and therefore the wavelength, can be known to very high accuracy indeed, correspondingly accurate measurements of distance can be made.

An obvious practical requirement for accuracy is that the number of half-wavelengths in the distance to be measured should be large. So for measuring such things as the dimensions of mechanical parts, or coefficients of expansion, radio frequencies are too low and light beams have to be used. Ordinary light is no good, because it is what we would call a random noise signal. What is needed is a light signal of a definite, accurately known frequency. This is what a laser can provide. So a laser beam, with conversion of the beats (or 'interference fringes') into an electrical difference signal by a suitable photodetector, can be used for making extremely accurate measurements of length.

It seems that what was in effect Doppler radar was discovered before it had been invented as such. Reports were published of mysterious whistles heard by experimenters with short-wave receivers. These differed from the continuous whistles which were beat notes between different sets of oscillations (such as a broadcast carrier wave and the unlawful oscillations set up by over-indulgence in 'reaction' by a listener with one of the regenerative receivers of the period) in being short and rapidly falling in pitch, like the whistles often uttered by starlings. This phenomenon was eventually traced to the varying beat notes between a carrier wave and its Doppler-affected reflections from meteors entering the earth's atmosphere.

Effect on standard frequencies

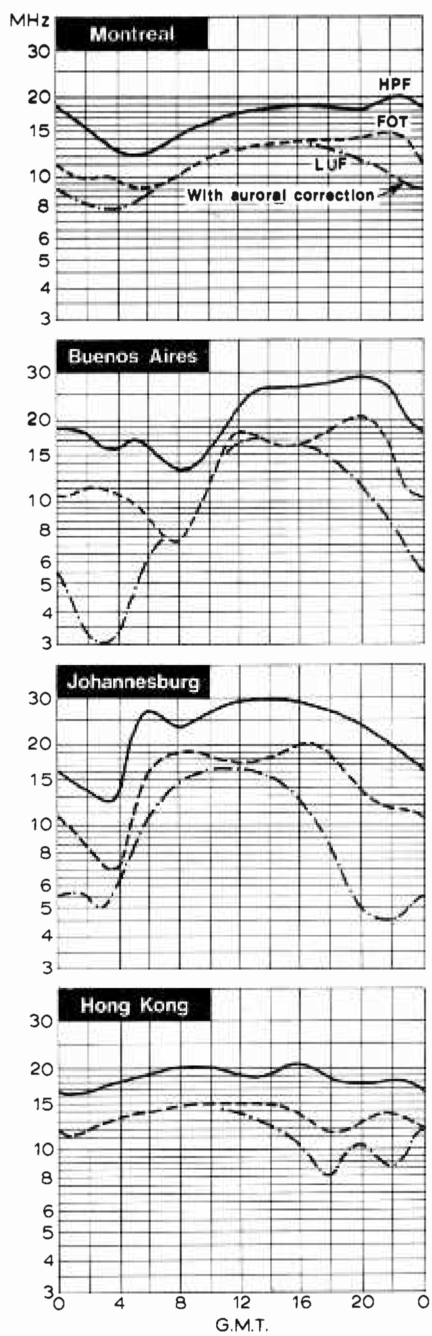
Another naturally occurring Doppler phenomenon is the variation in frequency of signals received from distant standard-frequency transmitters. Their frequencies in the present advanced state of the art are very steady indeed and are actually known to a few parts in ten thousand million. But at long distances they are received as reflections from the layers in the upper atmosphere (ionosphere). As these layers are not rigidly fixed relative to the earth, the received frequency fluctuates and so is reduced in value as a high-grade standard.

Doppler radar is one of the resources used in the exploration of space, and how effective it is for that purpose can be judged from the fact that relative velocity can be measured by it to about 1 mm/s. But simple c.w. radar doesn't indicate range, so pulsed or modulated radar has been devised to provide both kinds of information.

Finally, in connection with optical Doppler effect, which has been used by astronomers since before radar or even radio for measuring the speeds with which the stars are flying away from us, it is interesting to note that sometimes spectral lines are not only shifted towards the red end of the spectrum but are broadened. When this happens it is because the star is rotating around an axis inclined to the straight line between it and earth, making some parts of its surface recede faster than the average and other parts slower. And if all this seems to be outside the scope of *Wireless World*, that isn't necessarily so. The more distant parts of the universe are receding so fast that the Doppler effect shifts some lines right out of the optical frequency band into ours.

H.F. Predictions—June

Observed solar activity so far this year has been consistently around 10% higher than that forecast by smoothed sunspot numbers. In relation to an eleven-year cycle this short-term observation does not merit modification of current predictions. The forecast is of electron content of the ionosphere and this was found to have a high correlation with smoothed sunspot numbers. No direct relation with sunspots has since been established but there are several adaptions of the correlation feature in use today as an ionospheric index which all give adequate results though the necessary smoothing precludes their use for predictions less than three months in advance. On a more practical note the familiar depression of daytime HPFs (highest probable frequencies) during the summer months is most striking on the Hong Kong chart. In all cases LUFs (lowest usable frequencies) are closer to FOTs (optimum traffic frequencies) as a result of this seasonal effect.



Frequency Synthesizers

The principles employed in both direct and indirect methods of synthesis

*by J. R. Philpott**

A frequency synthesizer is a piece of equipment capable of producing a wide range of output frequencies, singly or simultaneously, from one master or reference source. The stability of each output frequency is controlled entirely by the reference source. In general the frequency or frequencies are selected by a number of decade switches, although for some applications binary control is required. The two main fields where frequency synthesizers find application are in communications equipment and instrumentation.

Fig. 1 shows the block diagram of a typical modern up-converting communications receiver in which the three mixer injection signals are produced by a frequency synthesizer. To provide good image rejection, the first intermediate frequency is high compared with the received frequency. For an aerial frequency range of 0-30MHz and an i.f. 35.4MHz, the required synthesizer range is 35.4-65.4MHz. To provide good selectivity, a second conversion to a lower frequency, in this case 1.4MHz, is necessary for which the synthesizer must produce a fixed output at 34MHz. Finally a frequency of 1.4MHz is needed for the product detector for the reception of s.s.b. signals. The front panel switches on the synthesizer would, of course, be calibrated in terms of the received frequency. In the laboratory, the synthesizer is useful as an accurate variable frequency source and has the advantage that instant control of frequency is possible without the need to check the frequency on a counter.

In communications systems, the current preference for s.s.b. working and the requirements of the various operating and frequency allocating bodies demand channel frequency accuracies of within a few hertz of the nominal frequency so that crystal control is essential. For the user who is going to operate at one frequency only, e.g. for broadcast stations, the appropriate frequencies may be obtained from temperature stabilized quartz crystal oscillators. For the user who may wish to change frequency, the cost of a frequency synthesizer may well be less than a number of crystal oscillators, and has the advantage that only one accurate stabilized source is necessary.

The demand for frequency synthesizers and the demands on their performance have increased enormously in recent years. The increase in traffic especially in the h.f. band sometimes necessitates frequent changes of operating frequency. Frequency synthesizers are also invaluable in remote-control applications and computer-operated frequency switching systems when the operating frequency may be switched rapidly either in surveillance use or to maintain traffic secrecy.

Performance requirements have become more stringent with the improvement in receiver front-end dynamic performance, and the appearance of special transmission systems, e.g. Kineplex and Lincompex.

The principal performance parameters of interest to the designer are:

(a) frequency stability;
(b) short-term stability;
(c) in-band noise and spurious signal levels;
(d) out-of-band noise and spurious signal levels; and
(e) lock-time.

Clearly the ideal synthesizer when locked would produce an output of constant amplitude and frequency. In practice the requirements for constant amplitude are easily met by the use of a.g.c., since in most cases the synthesizer output becomes the high-level (or switching) drive to the appropriate receiver or transmitter mixing chain. A signal of constant frequency may be considered as a signal whose phase increases linearly with time, and the impurities listed in (a) to (d) above may all be considered as departures from the ideal linearly increasing phase, at differing rates. Thus in (a) the departure might be quoted over a period of, say, one month, while in (d) the departure might occur at a rate of, say, 1MHz. It is perhaps worth considering the parameters briefly and the effect they have on the system.

(a) Frequency stability of a synthesizer is controlled entirely by the frequency standard, although second order transient effects may occur if the synthesizer circuitry is subject to ambient temperature variation. In a low-cost h.f. packset for s.s.b. use a typical stability would be 3p.p.m. per year, while in point-to-point equipment the stability might be an order better than this.

(b) Short-term instability causes effects commonly known as warble and phase jitter. Warble is most objectionable when listening to s.s.b. tone transmission, while phase jitter causes telegraph distortion in digital transmission systems such as Kineplex. A typical phase jitter performance resulting from say a 50Hz impurity or sideband might be 2-3 degrees and the corresponding peak deviation is 1MHz.

(c) In-band noise and spurious signals result in a degradation of the receiver's ultimate signal-to-noise ratio by causing a background hiss or an audible tone when carrier or sidebands are present. A typical level might be −55dB in the band 300Hz to 3kHz from the carrier.

(d) Out-of-band noise and spurious signals result from impurities beyond, say, 10kHz from the carrier and cause a degradation of the receiver signal-to-noise ratio either by reciprocal mixing in the receiver front end with a relatively high level interfering signal, or, if the impurities occur at the receiver i.f., may be present at all times at the output. Typical performance from a point-to-point communications synthesizer would be −90dB (spurious level) or −100dB in a 3kHz band (noise level). The noise level might be expected to fall to say −120dB at frequency offsets far removed from the carrier.

(e) Lock-time is a parameter which is becoming increasingly important when the equipment is to be used for surveillance or in scrambling systems. A typical requirement is that the output following a frequency change, should be within 1kHz of the new frequency within 5ms.

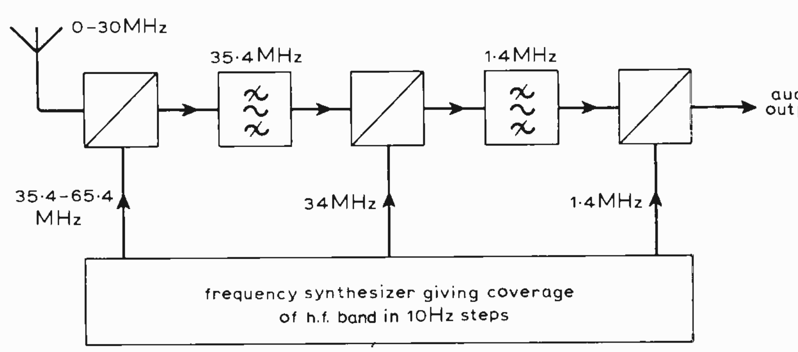


Fig. 1. Simplified block diagram of synthesized receiver covering the h.f. band.

* Racal Communications Ltd.

For general communications systems, a lock-time of 100ms would be adequate.

Synthesis principles

Frequency synthesizers may be divided into two broad categories – direct and indirect. The direct method of synthesis, although popular at one time, has been largely superseded by the indirect method for economic reasons, and will be described only briefly. The principle is that the required output frequency is derived from the successive mixing and subsequent filtering of frequencies selected from a comb. The comb of frequencies is obtained by filtering harmonics of an internal reference frequency and is then switched electronically into the various mixers either directly or after subsequent frequency division. The system requires a large number of filters of quartz crystal or discrete component type, and performance depends critically on the efficiency of these filters in removing unwanted sidebands, harmonics, and mixer intermodulation products. It is largely the cost of these filters that has led to the decline in direct synthesis. Direct synthesis does, however, have one outstanding advantage over the indirect method. The speed of switching from one frequency to another is limited only by the bandwidths of the filters in the signal path. Careful choice of the system of synthesis can result in a switching speed measured in tens of microseconds. A further objection to the method is the difficulty of miniaturization, again largely because of the number of filters required.

In the indirect synthesis system, the required output frequency is derived from a voltage-controlled oscillator which is maintained on frequency by some form of servo loop. Any tendency for the oscillator frequency to change is corrected to a varying extent by the control loop. The degree of correction is related to the rate of the disturbance in comparison with the loop cut-off frequency.

The type of loop which is most commonly used in synthesizer work is the phase-locked loop (which may be of first or second order), the essential components of which are a voltage-controlled oscillator (v.c.o.) and a phase detector. We will not go into a mathematical treatment of the performance of the loop; only the practical implications will be considered. The v.c.o. is typically a Hartley or Colpitts oscillator with varactor diodes as tuning elements. It is usual to limit the tuning ratio f_{max}/f_{min} to about 1.3, but the use of hyper-abrupt junction diodes together with a large control voltage range enables tuning ratios of 2.0 or greater to be obtained.

The purpose of the phase detector is to provide a control voltage for the v.c.o. by comparing the phases of the two applied signals, one of which is a reference signal. Provided that the sense of the detector output is correct and that the loop has the necessary phase and gain margins, the v.c.o. may be made to lock onto the reference signal. Popular phase detectors are the Foster-Seeley type

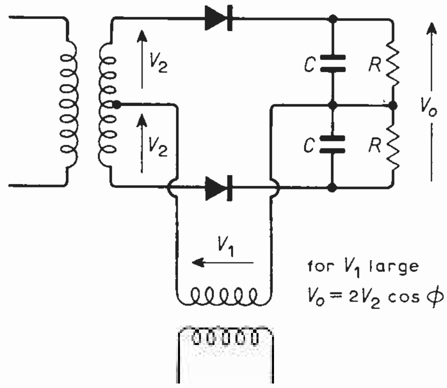


Fig. 2. Foster-Seeley phase detector.

shown in Fig. 2 and the sample-hold type. In the Foster-Seeley detector, the output voltage is obtained as the difference between the rectified vector summations of the two input signals and is a maximum when the input signals are in quadrature. With sinusoidal signals of unequal frequency the output is the difference frequency. The detector suffers from one serious disadvantage. Although the capacitors C can be readily charged through the diodes, the only discharge path is through the resistors R. To follow a rapidly changing phase, therefore, R must be kept small which results in a high level of comparison frequency ripple content. A more satisfactory detector is the sample-hold circuit and generally consists of a field-effect transistor or diode quad switch. The principle is that the instantaneous value of one of the input signals is sampled by the second input signal which must be in the form of a narrow pulse. A capacitor stores the voltage until the next sample. The attractive feature of this detector is that the sampling switch is bi-directional, and the comparison frequency ripple can be kept to a low level, thereby minimizing unwanted modulation of the v.c.o.

A popular method of frequency synthesis uses the divide-and-add principle in which the digits of the required output frequency are derived from cascaded decadic loops. An example of this system is shown in Fig. 3 in which a frequency in the range 6.00-6.99MHz is generated. A comb of ten frequencies in the range 5.4-6.3MHz is first generated from a 100kHz p.r.f. and a bank of crystal filters. One of these frequencies, when fed into the loop 1 mixer, together with an input of 600kHz to the phase detector, will drive v.c.o. 1 to any 100kHz increment between 6.0 and 6.9MHz. This output, divided by ten, becomes the phase detector input to loop 2 which again has the mixer driven via a separate switch from the 5.4-6.3MHz comb. It will be seen that S_2 controls the 100kHz digit while S_1 controls the 10kHz digit. Any number of such loops may be cascaded to produce frequency increments as small as is necessary.

One element that has not been mentioned is the loop filter. This filter is very important to the loop as it determines the stability margins in addition to defining the loop bandwidth and reducing unwanted ripple from the phase detector. The Bode diagram for the open loop gain is line A on Fig. 4. As a result of the loop integrator, the loop gain falls monotonically from infinity at $\omega = 0$ and is unity at $\omega = K$, where $K = K_1K_2$, K_1 being the v.c.o. transfer characteristic in rad/sec per volt, and K_2 the phase detector transfer characteristic in volts per radian. Typical values for the loops shown in Fig. 3 might be $K_1 = 10^6$ rad/sec per volt, and $K_2 = 5$V per radian, from which $K = 5 \times 10^6$ rad/sec. The phase comparison frequency in loop 1 is 600 kHz $= 3.8 \times 10^6$ rad/sec, i.e. less than the open loop unity gain frequency K. This loop would be unstable and it is necessary to insert a lag/lead network (Fig. 5) loop filter to reduce the unity gain frequency ω_c to a value very much less than the comparison frequency; such that the phase margin at ω_c is greater than 45° and typically 60°. A typical design approach would be to draw the open loop line on log/linear paper with a slope of 20dB per decade, choose a value for ω_c based on considerations listed later, then draw the line between ω_2 and ω_1 at

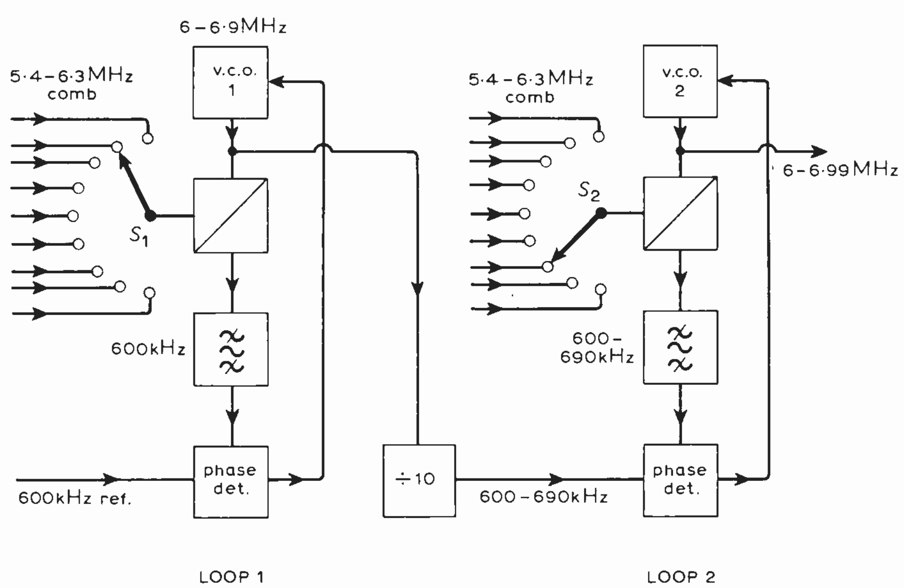


Fig. 3. Divide-and-add synthesis.

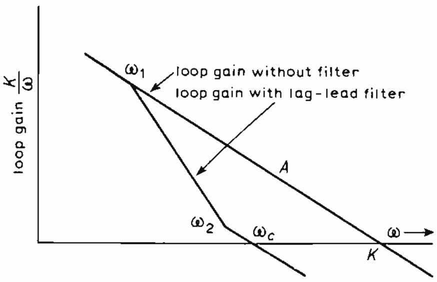


Fig. 4. Bode diagram of phase-locked loop.

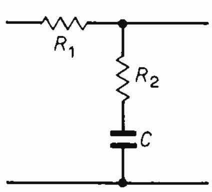


Fig. 5. Lag-lead filter.

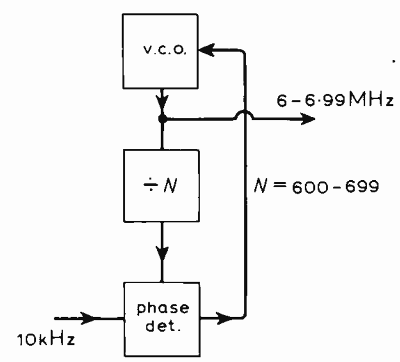


Fig. 6. Digital divider loop.

40dB per decade where ω_2 is typically 0.4 ω_c. Then R_1, R_2 and C are chosen from the relationships $C(R_1+R_2)=1/\omega_1$, and $CR_2=1/\omega_2$. Correct choice of the loop cut-off frequency is of fundamental importance to loop performance. If a 'noisy' oscillator is to be locked to a 'clean' reference, a wide loop is preferred, i.e. a high value for ω_c. Conversely if the reference signal is noisy, best results would be obtained with a low value for ω_c. The maximum permissible value of ω_c is that at which the phase margin falls to about 45°. Contributions to the loop phase shift are:—

(a) 90° at all times from the loop integrator.

(b) A contribution of $\frac{180\ \omega_c}{\omega_s}$ where ω_s is the angular frequency at the phase detector. This is caused by an effective pure time delay at the detector of $\tau/2$ where τ is the sampling period.

(c) The phase detector time constant. This causes a pure lag to be added to the Bode diagram at a frequency $\omega_p = t_{on}/(CR_{on}t_{off})$ where C is the 'hold' capacitor, R_{on} is the effective 'on' resistance of the sampler, and t_{on}/t_{off} is the ratio of sampling pulse width to the hold time. Notice that for very narrow sampling pulses, this ratio becomes small.

(d) Filters or tuned circuits within the loop, e.g. the 600 kHz bandpass filter in Fig. 3 loop 1, may well add a contribution to total loop phase shift at ω_c.

(e) The loop filter itself adds a phase shift at ω_c given by

$$\tan^{-1}\frac{\omega_c\,(\omega_2-\omega_1)}{\omega_1\,\omega_2+\omega_c^2}.$$

Other contributions to total phase shift are generally second order effects and may be ignored. The effect of all these contributions is to reduce the maximum value of ω_c and therefore ω_2. What then determines the minimum value? Too low a value will slow the loop so that oscillator disturbances such as microphony and close-in noise will not be eliminated. In extreme cases, excessive noise from the oscillator may cause the loop to go out of lock because of the cyclic nature of the phase detector. It will also reduce the capture range of the loop, i.e. the maximum oscillator error frequency that can be pulled into lock by the loop. It will reduce the rate at which the oscillator may be slewed in frequency by a ramp change in the reference frequency. The one advantage of a narrow loop, however, is that it minimizes the generation of spurious sidebands on the v.c.o. output such as may be caused by the ripple present on the phase detector output. Summarizing then, a wide loop is required for easy phase-lock and reduction of v.c.o. disturbances, while a narrow loop is required for reduction of noise and sidebands from the reference signal or from the phase detector. The final choice for ω_c is generally a compromise.

The second class of indirect synthesis systems is the digital divider type loop, an example of which is shown in Fig. 6 where again the output is 6.00-6.99MHz in 10kHz steps. This arrangement is clearly very much simpler than the analogue system and for this reason, digital-divider type synthesis has become popular. The previously listed comments on loop performance apply equally to digital synthesis, although it should be noticed that the loop gain K is now equal to $(K_1\ K_2)/N$ where N is the division ratio of the variable divider. Since N may be large, e.g. 100,000 or greater, it is clear that loops used in digital synthesis are generally very much narrower than in the analogue system.

The variable divider shown in Fig. 7 would consist of five integrated circuits, the output being in the form of a narrow pulse. The divider in this case consists of a chain of decade dividers, an AND gate which detects that the counter chain has reached a certain count, say 699, and a strobe pulse generator. The principle of the counter is that at the instant of detecting the state 699 (i.e. the maximum division ratio), parallel data on the b.c.d. control lines from the switches is strobed into the counter by the presence of the strobe pulse. The b.c.d. code present on the control lines corresponds to the complement of the division ratio required. The parallel data on the control lines to counter C_3 is set permanently to zero so that it always counts up to 6. Thus the largest division ratio of the circuit is 699 and the smallest 600. As an example, if in Fig. 6 the frequency is to be 6.51MHz, the 10kHz control lines to C_1 would be set to the b.c.d. equivalent of 9 − 1 = 8, i.e. 1000, while the 100 kHz control lines would be set to 9 − 5 = 4, i.e. 0100. The counter then counts between 48 and 699, i.e. it divides by 651. The output strobe pulse can conveniently be used to produce the sampling pulse at the phase detector. The main problem with digital synthesizers having large division ratios is to maintain the sampling frequency sidebands from the phase detector at a sufficiently low level. The f.m. sideband level of a carrier with peak deviation f_d and modulating frequency f_m is $f_d/2\,f_m$, assuming f_d is small. In a system in which 100Hz steps are required, the phase detector input frequency would be 100Hz so that f_m= 100 Hz. Now the oscillator sensitivity K_1 is typically 200kHz per volt from which, for a reasonable sideband level of say 40dB, f_d=2 Hz and the v.c.o. ripple must be less than 10μV. Very great care therefore must be taken over the design of the phase detector.

Practical frequency synthesizers generally use a combination of the analogue cascading system and the digital divider loop to generate the required output range, although with the present downward trend in the price of integrated circuits and the increase in the number of functions available per package, the tendency is to minimize the use of analogue circuits.

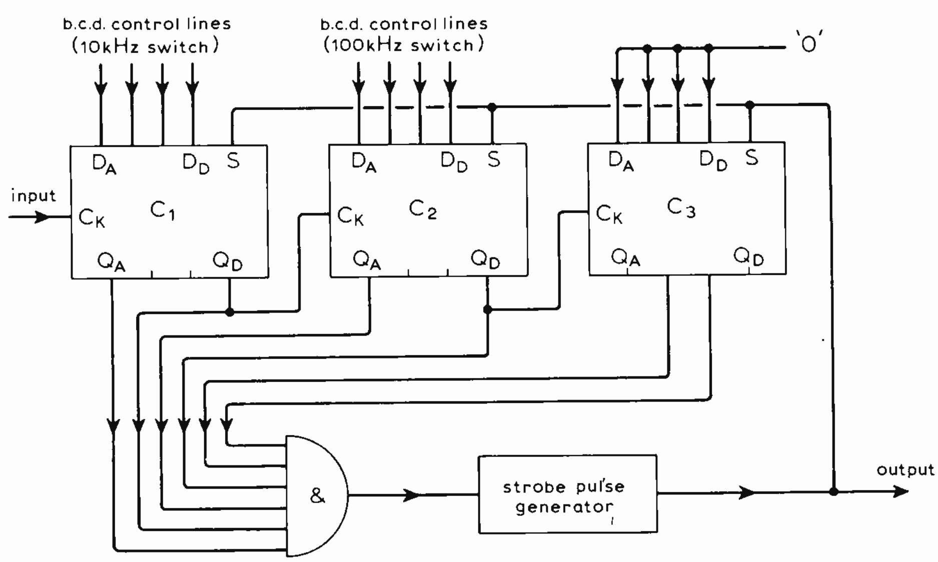


Fig. 7. Variable divider.

Experiments with Operational Amplifiers

Learning by doing — a series designed to familiarize you with op-amp capabilities and limitations

by G. B. Clayton, B.Sc., F.Inst.P.*

Integrated circuit operational amplifiers are now so cheap that it is economically possible to use them freely in all types of electronic instrumentation. Their use invariably simplifies design and construction, compared with circuits using discrete components. Also, op-amp modules make it easier for the non-electronics specialist to construct for himself the instrumentation circuits he needs for his particular field of work.

If one is to grasp the capabilities and limitations of the op-amp approach to instrumentation one must understand the parameters used to describe the electrical characteristics of the amplifiers and also the theoretical principles underlying operational feedback. A study of these matters is reinforced by experimentation with practical circuits. The material in this series of articles is offered as a guide to such experiments and as a supplement to material previously published by the author[1,2].

The experimental circuits described are easily and quickly connected up on commercially available breadboards (T-DeC† boards were used). Many of the experiments use a single op-amp and a few discrete components; others use several op-amps and a slightly more complex circuit arrangement. The suggested measurements require only standard laboratory test equipment—a signal generator, oscilloscope, meters, etc. Component values are given in all circuits. These are meant as a basic guide, for it is always instructive when evaluating circuit behaviour to note the effects of changing component values. Theoretical discussion of the circuits is minimal, but the experimental work could be accompanied by a reading of a more general treatment of operational amplifiers and their applications[2].

The first two experiments give test circuits for the measurement of amplifier parameters. Readers to whom op-amps are unfamiliar will find it worth while doing these experiments in order to gain an initial familiarity with amplifier pin connections and performance characteristics. The other experiments demonstrate some of the many possible applications of op-amps. All the experiments have been tried out, and in many cases typical experimental readings and circuit waveforms to be expected are given. Many of the experimental circuits can, with minor modifications, be used for practical applications.

To simplify experimental procedure all circuits use the same amplifier type, the 1741CG. This op-amp—the Motorola version of the familiar '741'—was chosen first for its ready availability through various distributors (Athena Semiconductor, Jermyn Industries, A. M. Lock etc.), secondly for the circuit protection it incorporates and thirdly for the fact that it requires no external frequency compensating components in most applications. The internal circuit protection means that amplifier damage caused by an inadvertent wrong connection is likely to be avoided. Internal frequency compensation, although it restricts the amplifier slewing rate, simplifies experimental circuits and makes closed-loop circuits less prone to instability. The 'slowing down' of the amplifier is no real disadvantage for experimental purposes; it serves to emphasize those applications in which amplifier slewing rate is a limiting parameter. If any of the experimental circuits are adopted as the basis of practical applications it may be necessary to use an alternative op-amp type in order to meet the requirements of some limiting performance specification. The reader is referred to Ref. 2 for considerations involved in the selection of an amplifier type to meet a required performance specification. The experiments to be described are listed below.

Amplifier Tests

Exp. 1. Measurement of open loop transfer curve. Allows values of open loop gain, output limits and open loop output impedance to be deduced.
Exp. 2. Measurement of input offset voltage, bias current and input offset current.

Experiments on Basic Amplifier Applications

Exp. 3. Resistive feedback circuits. Inverter, non inverter, adder, subtracter, current to voltage conversion.
Exp. 4. Operational integrator. Integrator action, integrator drift, integrator used to produce a linear staircase waveform.
Exp. 5. Operational differentiator. Frequency compensation, differentiator action, application of differentiator.

Op-amps with Defined Non-linear Response

Exp. 6. Straight line approximated non-linear response.
Exp. 7. Logarithmic response using log. characteristic of a bipolar transistor. Simple log. and antilog. converters, temperature compensated converters, log. circuits for computation.

Basic Switching Circuits

Exp. 8. Comparators. Simple comparators, regenerative comparators with hysteresis.
Exp. 9. Multivibrators. Free running, monostable and bistable circuits.

Signal Processing

Exp. 10. Precise rectification with an operational amplifier, diode combination.
Exp. 11. An op-amp phase sensitive detector.
Exp. 12. An op-amp used for pulse width modulation.

Information Conversion Circuits

Exp. 13. Pulse height to time conversion.
Exp. 14. Time to voltage conversion.
Exp. 15. D.C. voltage to time conversion.
Exp. 16. Voltage to frequency conversion.

Op-amps used for Signal Generation

Exp. 17. Sinusoidal oscillators. Wien bridge circuit, quadrature oscillator.
Exp. 18. Function generators.

Op-amp Circuits for Component Testing

Exp. 19. Measurements of transistor parameters.
Exp. 20. Capacitance measurements.
Exp. 21. Resistance measurements.

*Department of Physics, Liverpool Polytechnic
†Made by S.D.C. Products (Electronics) Ltd. of Runcorn, Cheshire, and available through components dealers.

1. Measurement of the open loop transfer curve

The open loop transfer curve for an operational amplifier shows graphically the way in which the output voltage of the amplifier depends upon the differential input voltage applied to it. A practical display of the curve gives a convenient test for the satisfactory functioning of the op-amp and allows several amplifier performance parameters to be deduced.

A test circuit for an oscilloscope display of amplifier transfer curve is illustrated in Fig. 1.1. The principle of the test is quite straightforward. Horizontal deflection of the oscilloscope is produced by a voltage proportional to the op-amp input voltage, the output voltage of the amplifier produces vertical deflection and the curve is displayed directly by the oscilloscope, which functions essentially as an X-Y recorder.

A slow ramp is used as the sweep signal to avoid any double trace which might otherwise be obtained because of the time taken by the amplifier to recover from saturation. A retrace which is much faster than the sweep means that the retrace is effectively blanked off from visual presentation. In order that the amplitude of the X and Y signals presented to the oscilloscope shall be of the same order of magnitude a resistive divider is placed at the input of the amplifier.

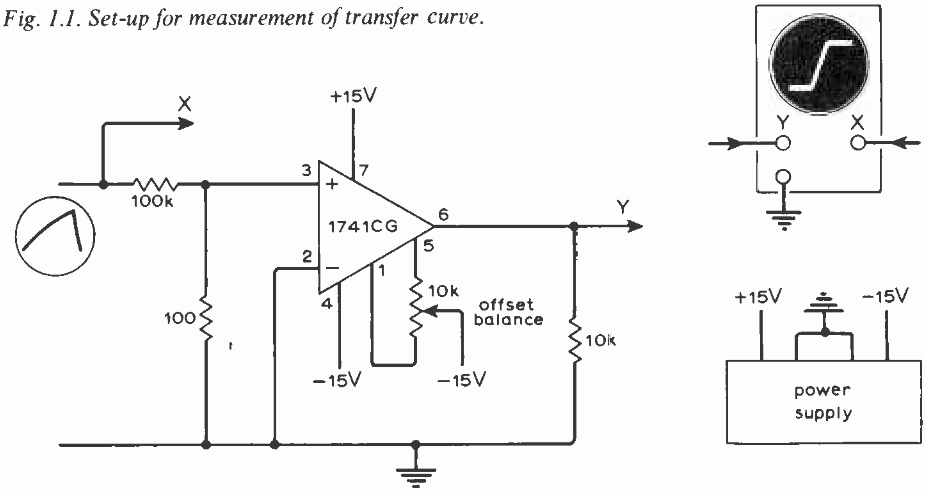
The sweep signal is produced by a simple u.j.t. relaxation oscillator, Fig. 1.2. This circuit may be dispensed with if the oscilloscope in use has a timebase waveform available at an external terminal. Under these circumstances the timebase waveform, suitably attenuated, may be used as the test signal and the connection to the X deflection terminal omitted.

It is convenient to establish the central graticule lines as the horizontal and vertical zero reference lines, and the oscilloscope writing spot should be positioned accordingly before the application of deflecting signals. When the deflecting signals are applied the input sweep amplitude is turned up sufficiently to drive the amplifier into both positive and negative saturation. The 10 kΩ offset balance potentiometer can be adjusted so that the trace passes through the central zero.

Vertical calibration of the display is obtained directly from the setting of the oscilloscope vertical amplifier gain. If the horizontal amplifier of the oscilloscope is uncalibrated, the horizontal deflection may be calibrated by measuring the amplitude of the horizontal sweep with the oscilloscope after the transfer curve has been recorded.

Typical recordings of transfer curves taken under different circuit conditions are illustrated in Figs. 1.3, 1.4 and 1.5. All curves show varying degrees of non-

Fig. 1.1. Set-up for measurement of transfer curve.



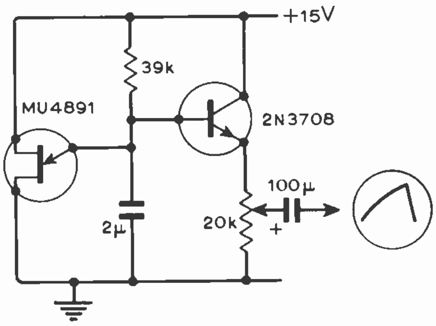


Fig. 1.2. Unijunction transistor circuit for generating test signal.

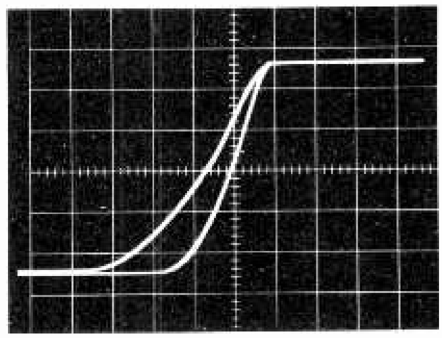


Fig. 1.3. Open loop transfer curves with load resistances of 10 kΩ (right) and 3 kΩ (left). Vertical scale: 5 V/div. Horizontal scale: 2×10^{-4} V/div.

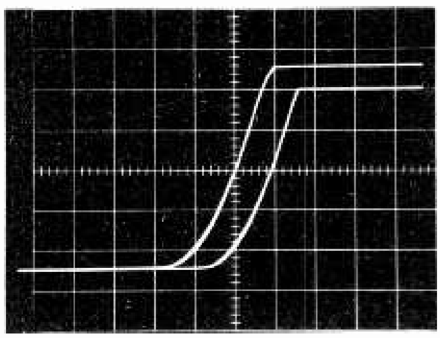


Fig. 1.4. Open loop transfer curves with different positive supply voltages: ±15 V (upper) and +12 V, −15 V (lower). Vertical and horizontal scales as in Fig. 1.3.

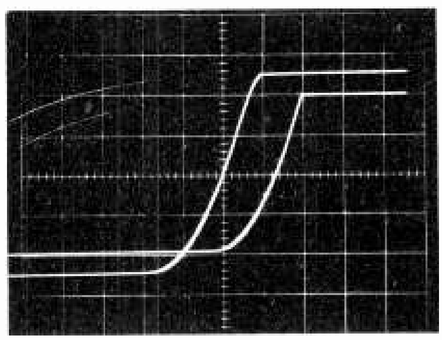


Fig. 1.5. Open loop transfer curves with different positive and negative supply voltages: ±15 V (left) and ±12 V (right). Vertical and horizontal scales as in Fig. 1.3.

linearity. Positive and negative output limits may be measured directly from the curves. Small signal gain may be deduced from the slope of each curve at the output zero crossing.

Consider Fig. 1.3. Output voltage swing is seen to be approximately ±13 V. The gain, as measured from the maximum slope, is approximately 7×10^4 and 4×10^4 for loads, R_L, of 10 kΩ and 3.3 kΩ respectively. The two values of gain can be used to deduce an approximate value for the output resistance of the amplifier, R_O, for the measured gain is related to unloaded gain by the relationship

$$\text{Measured gain} = (\text{Unloaded gain})\cdot\frac{R_L}{R_O+R_L}$$

Substitution of the measured values allows the equations to be solved for R_O.

In Fig. 1.4 the effect of changing the value of the positive supply voltage is shown. A change from +15 V to +12 V causes a change of approximately 3 V in the positive saturation limit and a change in input offset voltage of approximately 0.2 mV.

The curves in Fig. 1.5 show the effect of a simultaneous change in both positive and negative power supplies.

References

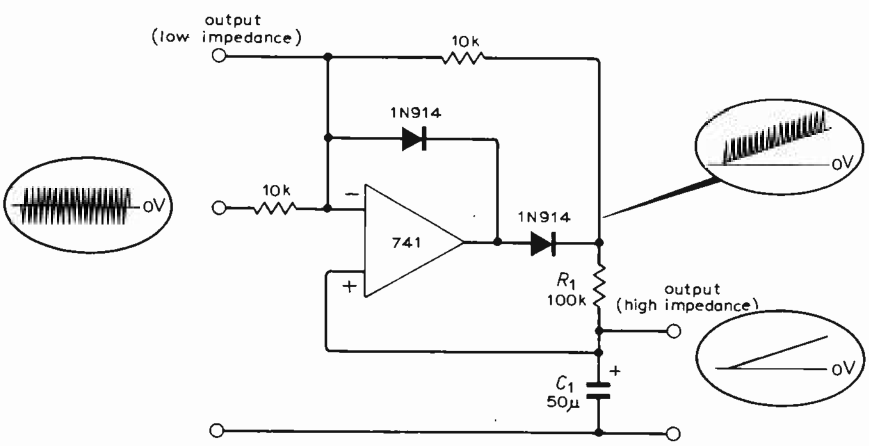
1. Clayton, G. B. 'Operational Amplifiers', *Wireless World*, Feb. 1969 and subsequent issues until Dec. 1969.
2. Clayton, G. B. 'Operational Amplifiers' (book), Butterworth, 1971.

Circuit Ideas

Diode pump

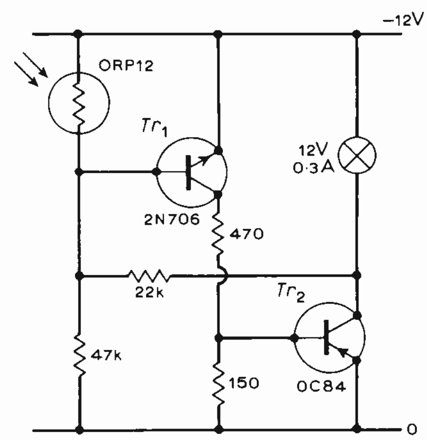
The circuit is derived from the standard op-amp half-wave rectifier, by the addition of R_1 and C_1 and connecting the non-inverting input to the top of C_1. This d.c. bootstrap connection provides constant current charging for C_1, thus ensuring good linearity. For positive input signals, when the a.c. output is zero, this bootstrapping prevents C_1 from discharging. The discharge current is approximately equal to the amplifier input (bias) current, which for the 741 is of the order of 200nA. (It is possible, using the offset null of the 741, to cancel the small discharge current for a small range of output voltages.) The output may be taken across C_1, in which case a high impedance buffer will be needed; alternatively, an output may be taken from the amplifier inverting input at a lower impedance level.

R. Barrett,
St. Albans,
Herts.



Automatic car parking lamp

In the simple feedback circuit shown, hysteresis is sufficient to prevent spurious triggering by passing vehicles, day or night. In the off state both transistors are non-conducting.

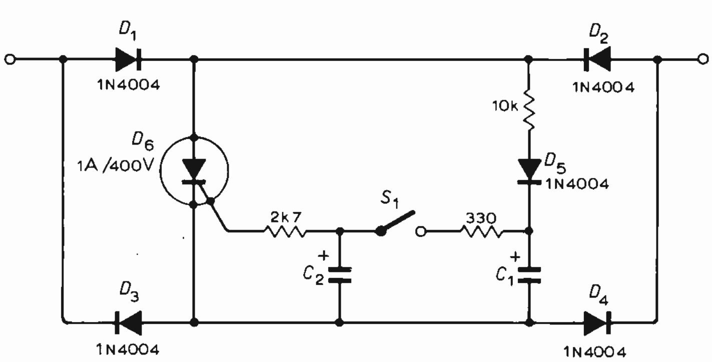


P. Lacey,
Crediton,
Devon.

Prolonging effective switch contact time

The capacitor C_1 charges through the 10kΩ resistor and D_5. When the press-button switch is closed, the charge is shared with C_2 and this results in the thyristor striking via the 2.7kΩ resistor. Due to the charge in C_2, the thyristor remains on when the button is released for a length of time dependent on the value of C_2 and the thyristor used (e.g. if C_1 is 64μF, then delay is typically 1s).

A. C. Grillet,
London.



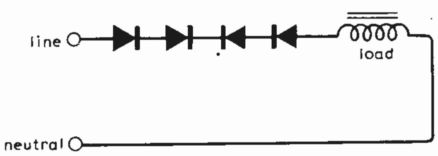
Voltage dropper

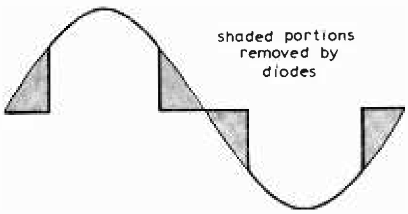
This idea is very simple and is often overlooked. It was required to lower the supply voltage to a small vibrator-type air pump to decrease the rate of air delivery. The most obvious methods, such as series resistances, auto transformers or thyristor controllers were out because of cost, heat dissipation or the bulk of the components.

Small silicon diodes were connected 'back to back' in series with the pump. They were nominally of 75 p.i.v. rating and naturally they 'break down' when this voltage is exceeded on each half cycle of the supply. The current is limited by the pump, however, and the diodes are not destroyed.

The net effect is that portions of the waveform are switched off by the diodes; current flow and hence air flow is reduced. By using four diodes, the supply was effectively halved.

By using appropriate diodes, some

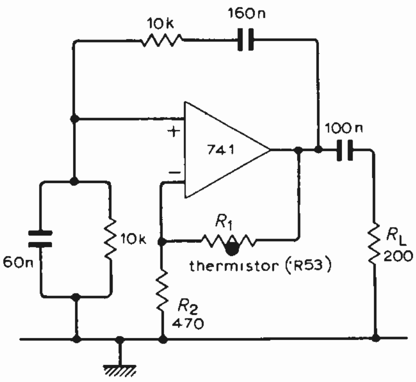




110V equipment which is not critical of waveform shape may be operated from 240V. For practical purposes, heat dissipation is nil and the diodes may be fitted inside the equipment.
P. Rice,
Northampton.

Wien bridge oscillator

The Wien bridge network is frequently used in oscillator circuits, since at the frequency of zero phase shift, the voltage loss is only times three. The circuit below uses a 741 op-amp in the non-inverting



mode with the gain stabilized by a thermistor in the feedback loop. The gain of the amplifier is·

$$G=V_{OUT}/V_{IN}=(R_1+R_2)/R_2$$

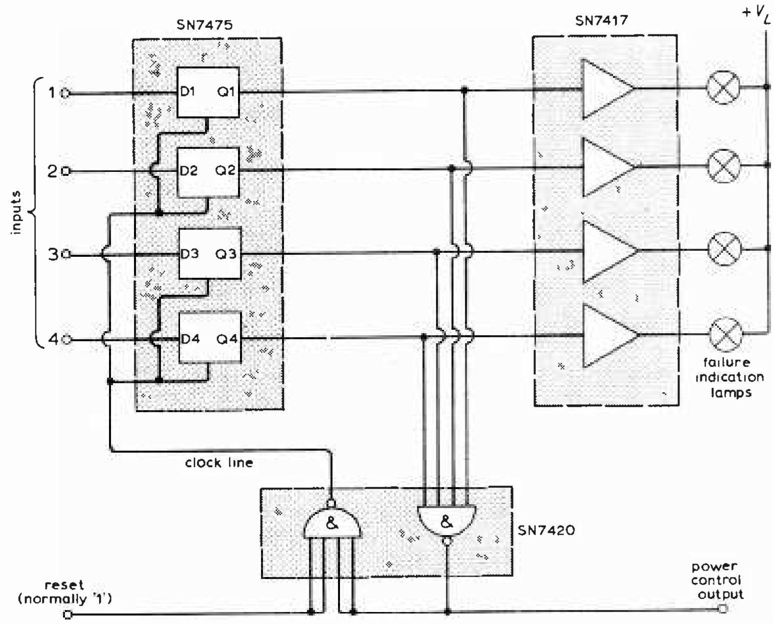
and is required to be equal to three. Hence, $R_1 = 2R_2$ at the working temperature of the thermistor. An increase in output level causes heating of the thermistor and a reduction in its resistance and hence amplifier gain, thus returning the output to a stable level. The prototype worked at 1kHz and gave an output of 3V (pk to pk). With a supply variation of 4 to 15V, the output level and frequency changed by less than 0.1%. The amplifier can drive loads down to 200Ω with negligible drop in level. Distortion was predominantly second and third harmonic at 74dB and 71dB down on the fundamental respectively.
L. D. Thomas,
London.

Failure indicator

The indicator will detect the first input out of four to go from a logic 1 level to a logic 0 and can be used for monitoring power systems to indicate supply failure. Once an input fails, a signal is generated for controlling power to the monitored power system. All inputs are inhibited and a lamp illuminates to indicate the failed supply.

After reset, the clock line will be held high due to a feedback loop. If any one input goes to a logic 0, then the output of the multiple input NAND (SN7420) will go high, driving the clock line to zero via the reset NAND gate, thus inhibiting all the inputs to the quadruple latch (SN7475). The logic 0 will be retained by the latch and only one failure will be indicated, even when the other inputs go low with loss of power to the monitored system.

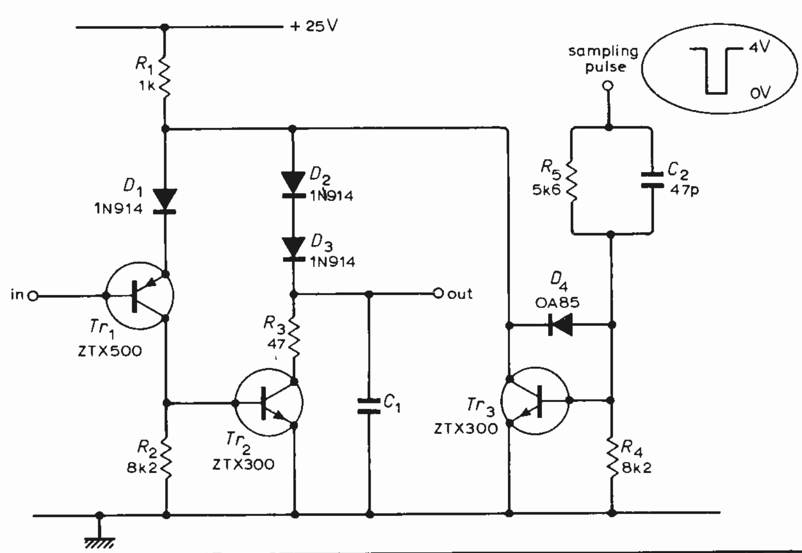
After the failure has been corrected, power is restored by taking the reset line momentarily to logic 0.
J. George,
Portslade,
Sussex.



Sample-and-hold circuit

The circuit can operate over a wide range of input voltages, with small offset between input and output.

During 'follow' operation Tr_3 is off and Tr_1 and Tr_2 form a simple voltage follower, with low output impedance, driving C_1. Transistor Tr_1 may be easily replaced by an f.e.t. (a p-channel type like 2N3820 for the polarities shown), though the low offset is then lost. To hold the output at any time, Tr_3 is turned on, which turns off D_2, D_3 and Tr_2 via Tr_1 thus isolating C_1. Diode D_1 is required to protect Tr_1 against too much reverse base-emitter voltage, and D_2 to balance the voltage drop across D_1 during 'follow' operation. Both may be removed if a suitably low rail voltage is used and the input and output can approach correspondingly closer to the positive rail. Diode D_4 may be almost any germanium type and stops Tr_3 saturating if the fastest operation is required. Resistors R_4 and R_5 match the input to t.t.l. levels.
J. Kilvington,
Oxford.



Paris Components Show

After trudging round an exhibition the size of the Paris Components Show (which seems to include anything even if the connection with electronics is fairly remote), one is bound to ask if these big diverse shows are worth while. Like most questions there is more than one side to this one. When talking about the value of an exhibition it is necessary to know if we are talking about the value to the exhibition organizers. the exhibitors or the engineers who visit the show.

The exhibition organizers of regular trade shows have to think in the long term. If the exhibitors are happy then they will take space again next year and this will satisfy the organizers if there are enough of them and, presumably, there will be enough if they are happy with the results they get.

The exhibitors are there to sell their products. One hears the phrases, "to meet my customers", "for the prestige value", "because my competitors are here". . . ., which all boil down to the same thing in the end — sales. However, sales are difficult, if not impossible, to measure because a contact made at an exhibition might result in a sale months, if not years, after the event. Results can be measured, however, in terms of the interest attracted by engineers who can use, and who are in a position to buy the goods on show. An exhibitor will therefore be happy with his participation if enough of this sort of interest is shown.

Which leaves us with the engineer who visits the exhibition. Without his presence the justification for the others being there collapses completely. He might be there for a variety of reasons. Whatever they are he must see things that arouse his interest or which answer the particular problem he has on his mind to make his visit worth while.

What all this seems to boil down to is that a sufficient number of the right type of engineers must visit the exhibition and these engineers must find something that is directly concerned with the work that they are doing at the moment. If these requirements are met the exhibition will be a success and everybody will be happy.

Electronics is a vast subject that has split into a number of specialist activities which can be thought of as the spokes of a wheel originating from a hub of fundamental knowledge. Some of these spokes criss-cross and there are areas in between where disciplines merge; the closer to the hub the harder it is to separate the spokes.

Deciding on the coverage of an exhibition is like drawing an arc concentric with the hub of the wheel; the radius and the length of the arc define the degree of speciality of the exhibition.

With exhibitions like the Paris Components Show, and our own I.E.A., the arc cuts a large number of spokes. The justification probably is that with such a huge coverage a lot of engineers will visit the show and there must, at least, be a small proportion who are interested in all the individual products on show.

This argument ignores human nature and endurance. Next time you are at a large exhibition look at the visitors, say about half way through the afternoon. A large proportion who have managed to stick it that long will be looking through glazed, unseeing, eyes carried round on heavy feet. Also an engineer is likely to become side-tracked by something that catches his eye which dilutes his effort as far as his main purpose for being there is concerned. Another difficulty facing the engineer at such a show is one of geography; the stands he wishes to visit may be scattered all over the exhibition and may even be in different buildings. All these factors add to the strain experienced by visitors to an exhibition. In a foreign country this strain can be multiplied by a factor of two at least.

Large exhibitions are losing popularity as is reflected by the falling attendance figures in America, Paris and elsewhere. Surely the answer lies in smaller specialist exhibitions like Seminex and Communication 72 as it would appear that these are most likely to meet the needs of all concerned with the minimum of strain all round.

The statistics provided by French Trade exhibitions relating to this year's Paris Exhibition show that there were exhibitors from 26 countries and visitors from 65 countries.

	1971	1972
exhibitors	1,106	1,064
stand area	30,000m^2	30,000m^2
visitors (total)	64,215	56,783
visitors from G.B.	852	740

This year's exhibition was one day shorter than last year's. Next year it is planned to hold a new event "Audio Visual and Communications Exhibition" at the same time as the main components show.

From the plethora of devices and equipment on show in Paris we have selected the following.

Japanese products

Several Japanese manufacturers were present at the Electronic Industries Association of Japan stand, with a range of products which were descriptive of the rest of the show, i.e. from semiconductors to audio equipment.

Export items from the Denki Onky Co. include a range of TV components. The Model CDY-86 deflection yoke is designed for use with a 110° deflection, 29.1mm neck diameter colour picture tube. The assembly is part of a single unit consisting of deflection yoke, convergence yoke and static/dynamic blue lateral purity magnet assembly, which can be easily moved axially on the picture tube neck for the best adjustment. The items shown by Nichicon Capacitor Ltd were electrolytic capacitors (for radio and TV receivers and telecommunications), ceramic capacitors (for high-frequency power factor correction, telecommunications, radio and TV) and positive temperature coefficient thermistors.

Paris Electronic Corporation were exhibiting a range of small and medium size brushless (Hall effect) motors. In 1968, Pioneer developed a formula for the quantity production of Hall elements using the vacuum evaporation method and subsequently different types of brushless d.c. motors have been developed. The small size motors may be used for drive or control purposes in data recorders, other industrial applications and also in consumer products in the audio field such as cassette tape recorders.

Synthesizer

The Model 6100 manufactured by Adret Electronique is a new fully programmable frequency generator/synthesizer which has a series of plug-in units for a range of applications (as a generator, generator with modulation capabilities, sweep generator etc.). The main operating characteristics with the TN6101 plug-in are: frequency range, 10kHz to 109.999,999 MHz, digital setting in 1Hz steps. Interpolation oscillator, switch-selected deviation ranges of ±1Hz to ±1MHz (in powers of 10). Accuracy and stability; 2 parts in 10^8 per day. Noise level, at least 100dB down over the entire frequency range.

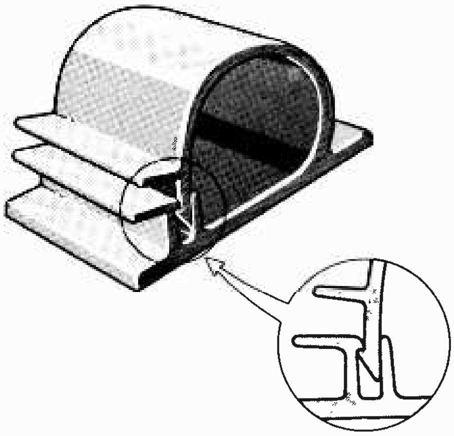
The TME6100 plug-in is used for both f.m. and a.m. In the a.m. mode, the modulation percentage is adjusted using a potentiometer and is displayed on a galvanometer graduated in percentage. In the f.m. mode, it depends on the interpolation range chosen and the level read on the galvanometer.

The TWM6100 plug-in has the same capabilities as the TME6100, but the modulation percentage is set using a graduated knob. In addition, a sweep function can be provided by an internally-generated triangular waveform, whose duration can

be adjusted from 10ms to 10s, and markers are available at intervals of 0.1Hz, 1Hz etc., up to 1MHz, depending on the interpolation range used. Adret Electronique Ltd, Avenue Vladimir Komarov, 78-Trappes, France.
WW503 for further details

'Cable tidy'

A 'zip-up' plastic tube was shown by Zipper Technique (71 Avenue Jean-Jaures, 92-Clamart, France) designed to protect



cable runs. Six sizes are available with internal diameters of 4.8, 6.5, 9.5, 12.5, 16 and 19mm.
WW507 for further details

Line output transistor for 110° colour tubes

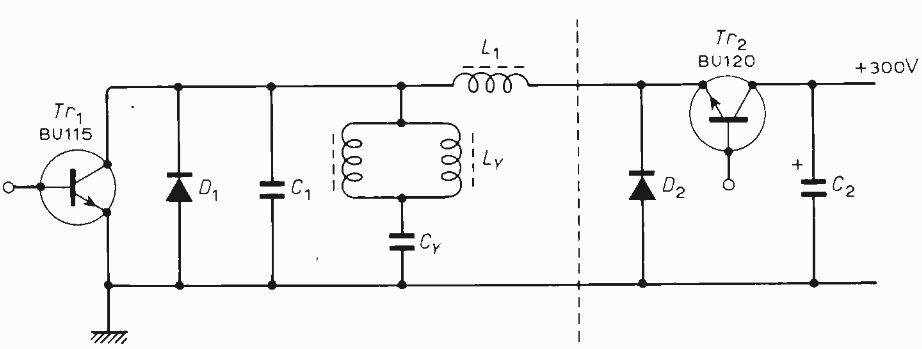
A triple diffused power transistor, designated BU115, has been developed by Ates to meet the new 110° tube demands.

A simplified circuit diagram is shown of a typical line deflection stage using the transistor. To the left of the dotted line is a traditional parallel recovery circuit: if synchronized driving of the two transistors is maintained, and Tr_2 is allowed to saturate for a given fraction of Tr_1 conduction time, the inductance L_1 can store energy from the supply rail. This in turn will supply the circuit during flyback with enough energy to make up for losses. Inductance L_1 may be the primary of the e.h.t. transformer.

The horizontal scan output transistor (BU115) works with a peak collector current (I_{cm}) of 10A, and a peak voltage (V_{cm}) of 600V. The chopper transistor Tr_2 (BU120) has a peak collector current of 3A, and a peak collector voltage of 300V.

In a complete circuit using the device the yoke current is 12A, and is stabilized against mains and load variations; e.h.t. voltage variation is approx. 900V with a beam current excursion from 0 to 1.5mA with an internal impedance of 0.6MΩ.

The circuit includes pincushion correction and overall protection against short circuit and e.h.t. discharge and, in addition, will provide the 30V supply required by the vertical deflection stage. Ates Electronics Ltd, Planar House, Walton St., Aylesbury, Bucks.
WW508 for further details



Skeleton line output circuit using the BU115.

Touch-button keyboard

The Société de Diffusion D'Equipments Electroniques showed a novel key-board assembly in which the push buttons and their surrounds were printed on a single piece of card. The movement required to make contact could not be detected when a particular button was 'pressed' and was probably a millimetre or less. We understand that the area behind each printed button is covered with a specially constructed metal grid which is forced into contact (when the button is 'pressed') with two large area terminals. The effect is to produce a large number of 'micro-contacts', which make almost simultaneously reducing contact bounce and maintaining a low, constant, contact resistance. The assembly is called 'Wild Rover' and we believe it is of American manufacture. Société de Diffusion D'Equipments Electroniques, 6 rue Louis Pasteur, 92 Boulogne, France.
WW511 for further details

500MHz counter, extendible to 12.6GHz

Intended for measurement and maintenance on mobile radio installations, the type PM6645 frequency counter from Philips Industrie employs a direct gating technique. The advantage of this over the much used pre-scaling method is a reduction in measurement time. For instance, the PM6645 will measure a 500MHz input signal with a resolution of 1Hz in 1 second.

Input impedance can be switched to either 1MΩ (15pF) or 50Ω and maximum sensitivity is 5mV r.m.s. An automatic gain control circuit obviates the need to adjust the instrument's input signal trigger level control for accurate operation and substantially reduces noise as well as increasing the dynamic range.

There are three ancillary plug-in units which can be used to extend the usefulness of the counter: a pre-scaling unit consisting of a divide-by-five and a tunnel diode divide-by-two stage increasing the frequency range to 800MHz; an input pre-amplifier which increases the sensitivity to 0.5mV; and a yig tuned converter which extends the input range to 12.6GHz.

The standard crystal reference oscillator runs at 10MHz with an ageing rate of $\pm 1 \times 10^{-7}$/month but other standards are available. Other optional extras include b.c.d. output and remote control facilities. Philips Industrie, 105 rue de Paris, 93 — Bobigny, France.
WW513 for further details

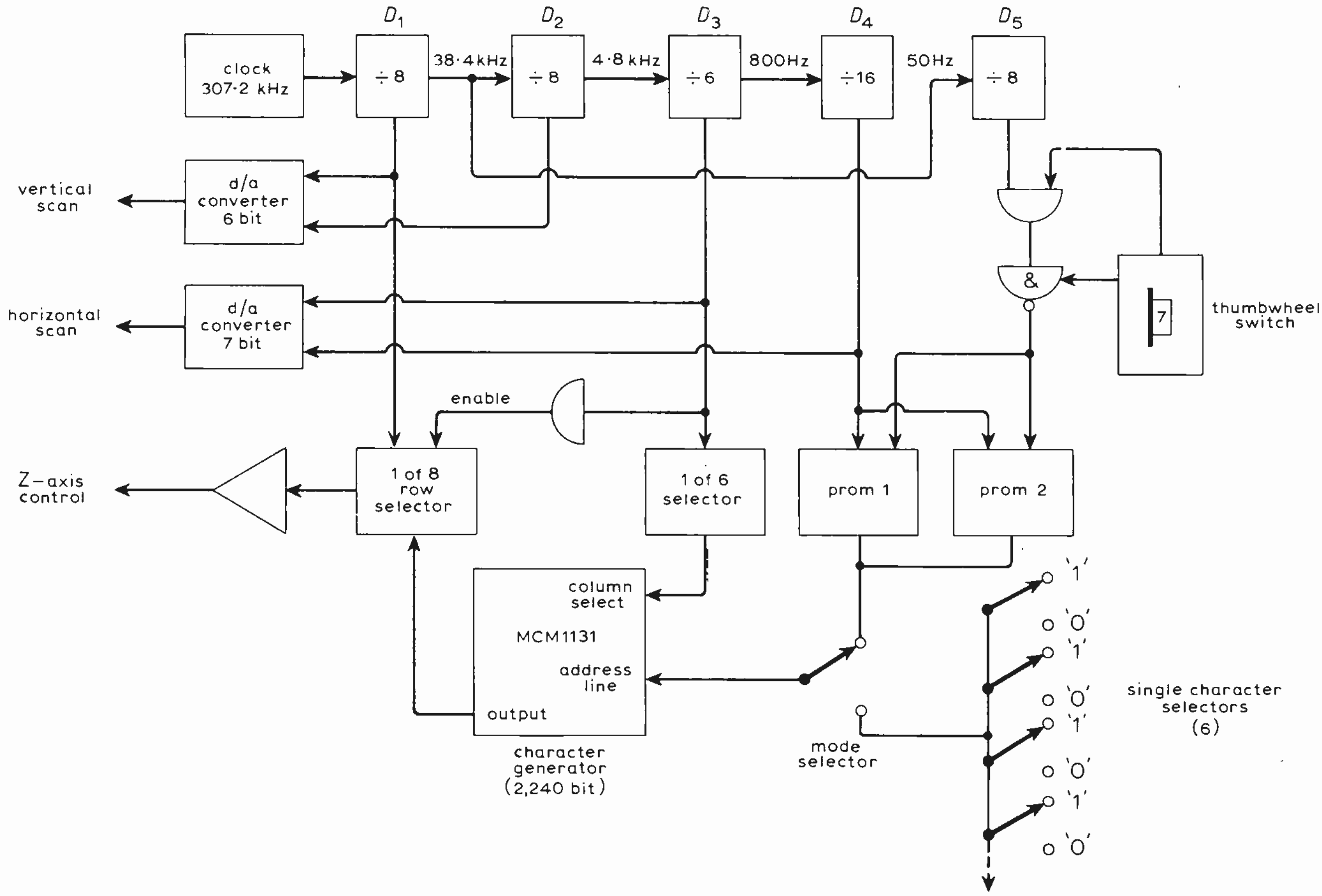
Central processor for vehicles

The main purpose of the electronic 'central processor' shown by RCA, is to reduce weight and cost of the wiring harness in a vehicle and hence reduction of installation cost.

Such a system was demonstrated by RCA. The heart of the system is a c.o.s./m.o.s. processing unit (in fact a micro-computer), which receives input signals from switches and transducers, performs the necessary operations and sends them out in a pulse coded form over two small gauge wires. The input signals can be proportional or on/off. A number of decoders can be connected anywhere to the signal wires, each decoder being wired to decode a certain position and switching on the appropriate load. The system demonstrated provided input signals for switching head-lights, sidelights, indicators, emergency flashing, pause controlled windshield wipers, horn and stop lights. A more advanced processor will take care of electronic fuel injection, anti-skid braking, air conditioning, gear box setting, pollution control, ignition and ignition retard. The system uses digital and linear i.cs, some low power devices and p-n-p power transistors as switches. It is stressed that the system is experimental and not a commercial product. RCA Ltd, Marketing Services — Europe, Sunbury-on-Thames, Middx.
WW502 for further details

Display system

The USASC11 character generator, manufactured by Motorola Semiconductor Products Inc., is used to generate a programmed text pattern onto the screen of any standard oscilloscope. The programmed text consists of 8 rows with 16 alphanumeric characters per row. To programme the text, two exchangeable MCM 5003 programmable read only memories (p.r.o.ms) are provided which can be programmed by the user. By means of a mode switch, it is possible to disable the two p.r.o.ms and to enable six address switches for selection of any desired alphanumeric character. A thumbwheel switch provides selection of 1



Logic arrangement of a 128 (16 × 8) alphanumeric character generator.

out of 8 programmed text lines, which is then displayed on all the 8 rows. The c.r.t. display has 3 outputs which have to be connected to the scope, the vertical scan, horizontal scan and the Z-axis control for blanking. Two different blanking outputs are available, one with an output voltage of 5V pk-to-pk, another with an output voltage of 20V pk-to-pk. A block diagram of the c.r.t. display system is shown. Data sheets on the i.c. MCM113 series of character generators and MCM500 and MCM530 series of programmable read only memories with a full description of the c.r.t. system are available from Motorola Semiconductor Products Inc., York House, Empire Way, Wembley, Middlesex.
WW501 for further details

Cathode-ray tube

Under type designation D 14-220, AEG-Telefunken are marketing a new cathode-ray tube for transistor wideband oscilloscopes. The tube is provided with an aluminized flat screen 80 × 100mm, and has an overall length of 380mm. In order to obtain the desired high deflection sensitivity it is fitted with a mesh electrode between the deflection and post-acceleration systems. The ratio between post acceleration voltage and mean plate potential and first acceleration voltage respectively, could be increased to max. 15:1. Overall acceleration voltage has a maximum of 20kV. A rotary coil, which brings the deflection planes into coincidence with the screen centre line or an internal graticule if fitted, is permanently mounted on the tube. By means of a further pair of coils (quadripole coil), any orthogonal deviations may be accurately corrected. For the measurement of oscillograms free of parallax the tube is also supplied as type D 14-220 GH/18 with an internal graticule measuring 8 × 10cm. A matching lighting set for the internal graticule as well as Mumetal shield and external connection caps are supplied as accessories. AEG-Telefunken, D 6000 Frankfurt 70, Germany.
WW506 for further details

'Vidicon' tube and thermal TV

A new silicon diode array 'vidicon' tube, manufactured by Thomson-CSF, has a mosaic of almost a million photodiodes giving a very high sensitivity and a spectral response of up to 1.1μm. Its target is impervious to damage by over-illumination and its transfer characteristic is linear.

There are two versions, the TH9820 sensitive in the visible range, and the TH9825 sensitive in the infrared range. Thomson-CSF Electronic Tubes Ltd, Bilton House, Uxbridge Road, Ealing, London W5 2TT.
WW504 for further details

50MHz oscilloscope

S.E. Laboratories have entered into an agreement with the German company Hameg and each will be called SE-Hameg. SE Labs will look after the high-frequency end of the product range while Hameg will concentrate on the medium and low frequencies. Both the product ranges and the market areas covered by the two companies are complementary.

Hameg showed a new 40MHz double beam 'scope, the HM712, which has been upgraded, and was shown at the I.E.A. as a 50MHz instrument.

bandwidth	—	d.c. to 60MHz (−6dB)
sensitivity	—	12 positions, 5mV to 20V/cm in a 1, 2, 5 sequence
input impedance	—	1MΩ and 28pF
max. Y input	—	500V
Y linearity	—	2%
timebase	—	100ns to 1.5s/cm in 21 steps
X amplifier	—	0.5MHz, 1MΩ, 30pF, 0.1V/cm, × 1 to 10

SE-Hameg Ltd, North Feltham Trading Estate, Feltham, Middlesex.
WW510 for further details

French invention?

Finally, a device, manufactured by CO.RE.MA. (Conception et Realisation de Machines), was described in their literature as a 'cutting off and nibbling machine', it being an entirely new invention: rugged, silent, easy to handle, and with a 2-speed suction device incorporated!

Simple Electronic Multimeter

A meter with low power supply voltage and current consumption for high impedance measurements

by J.L. Linsley Hood

The availability of high gain silicon planar transistors has made possible the construction of stable current multiplier circuits which will operate with very low supply voltages and currents, and also allow a substantial improvement in the sensitivity of the conventional moving-coil 'multimeter', especially on the a.c. ranges.

The basic circuitry employed in the d.c. and a.c. modes of this instrument is shown in Fig. 1(a) and 1(b). In these, the d.c. system is a conventional operational amplifier voltage comparator, used as a current multiplier, with a moving-coil microammeter in the path from the amplifier output to the feedback resistor R_{fb}. In the a.c. system, a modified version of the excellent a.c. millivoltmeter circuit due to Waddington[1] is employed. Once again the product $I_{out} \cdot R_{fb}$ is compared with E_{in} $(I_{in} \cdot R_{in})$ and the available gain of the amplifier is used to minimize the difference between these two voltages. A conventional integrated circuit operational amplifier could be used to perform this function, but the voltage, and possibly the current, requirements would be greater than those of an equivalent system employing discrete semiconductor components.

Circuit

A suitable, and very versatile, three transistor operational amplifier arrangement is shown in Fig. 2, in which the d.c. current multiplier configuration is illustrated. Tr_1 and Tr_2 are high gain n-p-n silicon transistors, such as the BC184 or BC109 and Tr_3 is a p-n-p Darlington transistor such as the Motorola MPSA65 or 66. (This is preferred to a Darlington connected pair of discrete transistors).

The variable resistor in the tail load of Tr_1 and Tr_2 serves as a 'set zero' adjustment on the d.c. ranges and in practice needs little use provided that the ambient temperature does not change widely. The a.c. ranges are self zeroing and need no 'set zero' facility so long as the instrument is reasonably well screened against external a.c. fields. Ideally, transistors Tr_1 and Tr_2 should have a high gain (for example a 'C' coding, such as BC184C) and should be reasonably well matched for current gain, to improve the thermal stability of the input long-tailed pair. With high gain transistors the base circuit resistor chain could well be as high as 100kΩ (giving an input sensitivity of 1MΩ/V, on a 100mV full scale deflection). However, to allow some margin in performance, the circuit values chosen for the prototype provide an input base-emitter chain resistance of 50kΩ, which gives a final instrument sensitivity of 2μA f.s.d. and an impedance of 500kΩ/V on both a.c. and d.c. ranges.

The resistance from base to the common line on Tr_2, in series with the meter, determines the amount of negative feedback and thereby the gain of the system, and is adjusted to give the required full scale deflection. This adjustment is made separately for the a.c. and d.c. ranges.

As can be seen from the circuit of Fig. 3, the power supply requirements are very modest. A pair of 1.5V pen cell batteries, preferably of the 'manganese' type provide a very low static current consumption of 300μA (approx.) on the d.c. ranges, and 600μA (approx.) on the a.c. ones. Under

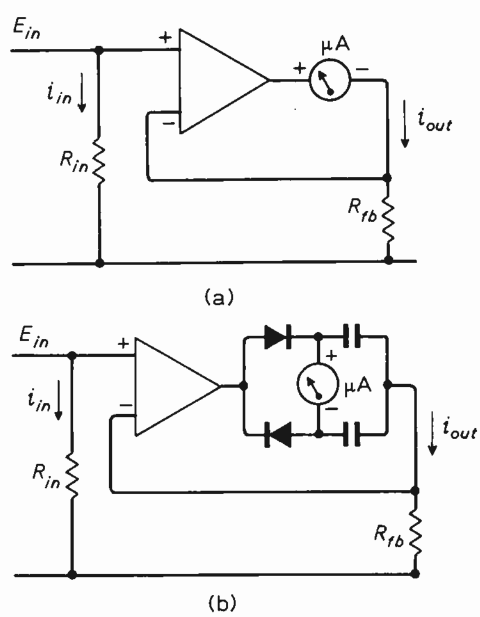


Fig. 1. (a) D.C. current multiplier system (b) a.c. current multiplier system.

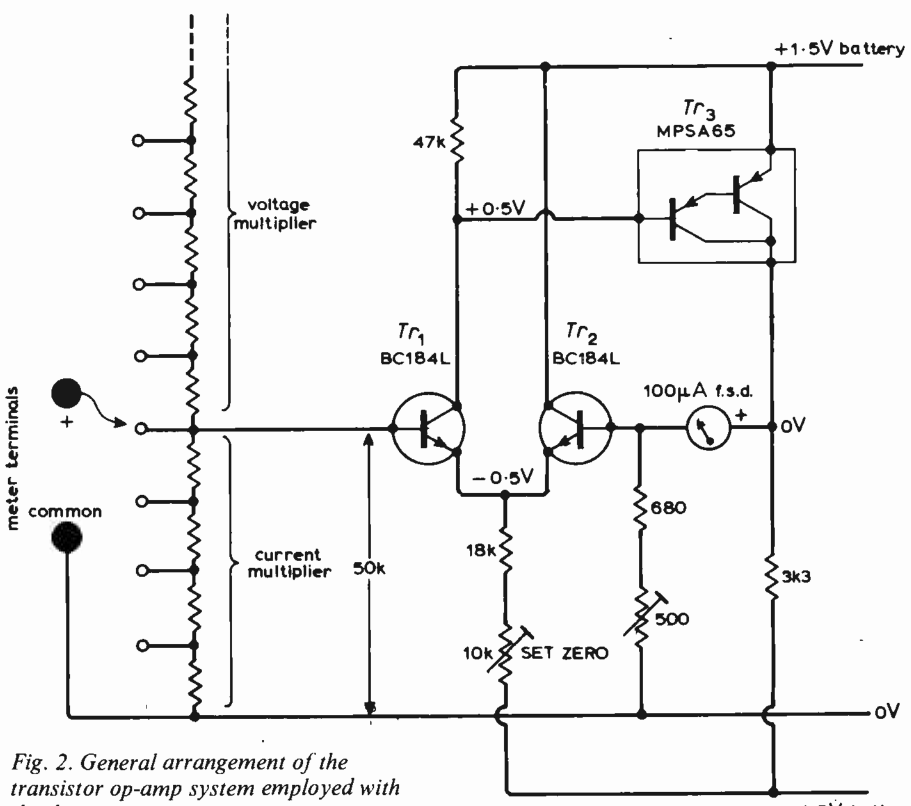


Fig. 2. General arrangement of the transistor op-amp system employed with the d.c. meter circuit.

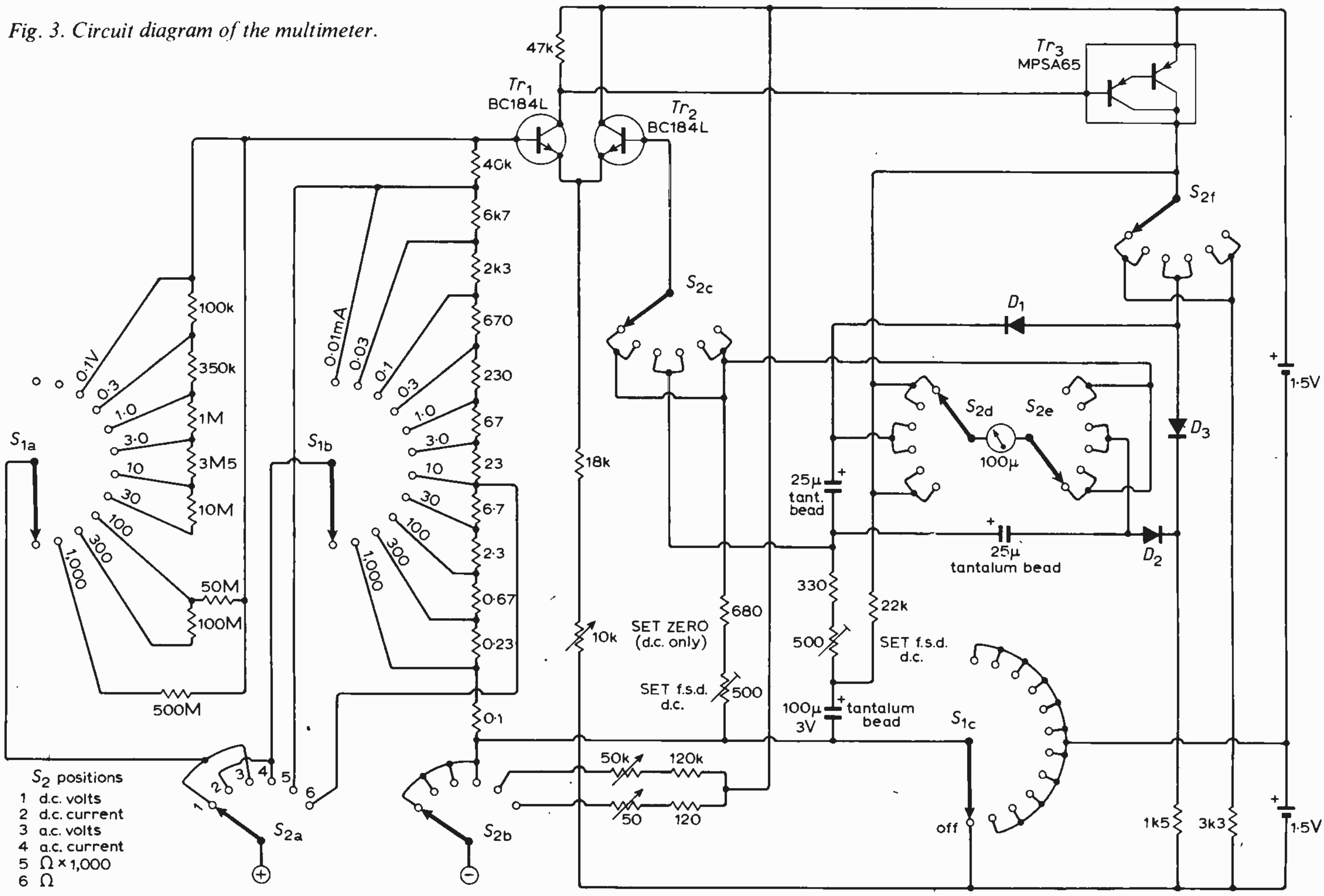


Fig. 3. Circuit diagram of the multimeter.

these conditions the batteries will last for many weeks even if one occasionally forgets to switch the instrument off immediately after use.

The instrument has proved very useful in practice, particularly for measurements on high impedance circuitry. An idea of the appearance of the prototype can be gained from the photograph.

The resistances in the voltage and current multiplier chains can be as precise as one wishes, and the required values can either be purchased, where these are in the 'preferred value' series, or made up from other values in series or parallel. The formula $R_1 = (R_2 R_D)/(R_2 - R_D)$ is useful in this context, where R_1 is the required value of the shunting resistor, R_2 is the actual value of the resistor available, which is of a somewhat higher value than that of R_D, the desired end value. For example, in the case of the 6.7Ω resistor in the current chain, this can be made by putting a suitable high value resistor in parallel with the 'preferred series' value of 6.8Ω. In this case $R_1 = 6.8 \times 6.7)/(6.8 - 6.7) = 456\Omega$. A 470Ω shunt resistor gives a resultant value of 6.703Ω which is within the required tolerance.

Construction

Some care should be exercised in the wiring up of the switches and the current and voltage multiplier chains, to avoid excessive stray capacitances, which will introduce errors into the a.c. voltage readings at the higher voltages and operating frequencies. Similarly, it is a good idea to interpose some form of electrostatic screen between the instrument internal wiring and the outside environment and to connect this to the common negative terminal of the multimeter, to prevent the readings (and the a.c. zero) being influenced by a.c. fields outside the instrument. In the prototype, the instrument case was made of Paxolin sheet lined with aluminium cooking foil.

With the proviso noted above, the bandwidth of the a.c. system extends from below 10Hz to above 100kHz. A 100μA f.s.d. meter was used, scaled 0-3 and 0-10 to conform with the scales chosen for the instrument, which range from 2μA to 1000mA, and 100mV to 1000V. Since 12-way switches were available, as a 3-gang wafer, the lowest two voltage ranges were left open, with these positions used only on the 30μA and 10μA current settings. The 100mV range gives the 2μA current position, and the voltage drop on all current ranges is 100mV.

Since a 6-way switch was available for the a.c./d.c./ohms selector, only two 'ohms' ranges were used on the prototype, these being 'ohms' and 'ohms × 1000'. Since the 'ohms' range covers from 2Ω to 20kΩ, there is a degree of overlap between these ranges. However, if a switch with more available positions is employed, the scope of the 'ohms' ranges can be widened. An alternative arrangement for the 'ohms' ranges is shown in Fig. 4. This has the advantage that a single adjustment potentiometer only is required, set so that the meter gives f.s.d. with the 1.5V positive battery line. The mid-scale reading is then that for a resistance value equal to that chosen in the switched resistance range arm.

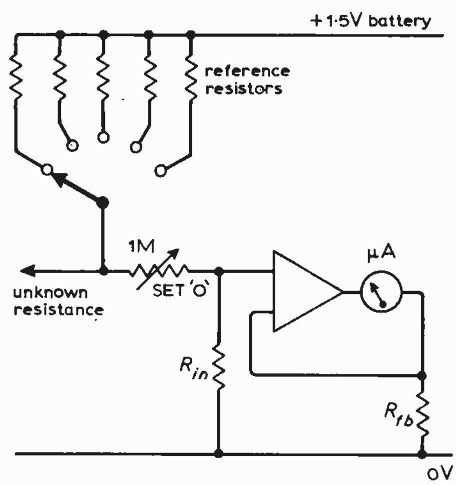


Fig. 4. Alternative arrangement for the 'ohms' scale. Gives '∞' reading at full scale and mid-scale value equal to the value chosen for the reference resistor.

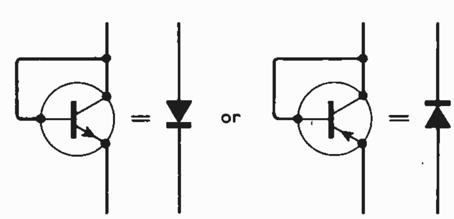
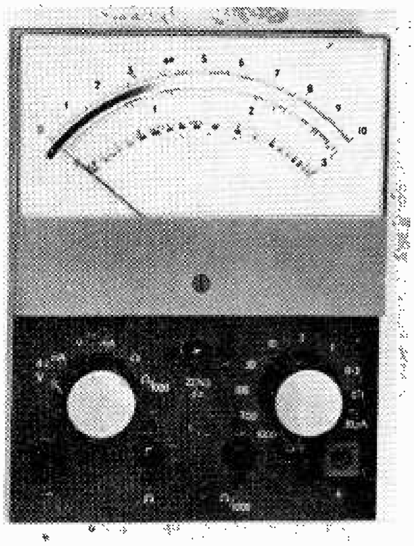


Fig. 5. The 'super diode' configuration. Typical forward voltage drop is approximately 0.52V at 100μA using any small signal silicon transistor.



The completed electronic multimeter.

The only limitations are that current flow through the chain should not make too big a demand on the battery nor should it be too small in relation to the 2μA consumed by the measuring system. If the range resistor is left as an externally connected component, in this case, the instrument can be used as a rapid comparator for resistance values.

The particular ohmmeter arrangement shown in Fig. 3 was chosen in the prototype because this gives a wider resistance spread, which was convenient with only two 'ohms' range positions available.

The rectifier diodes used in the a.c. section can be normal small signal silicon diodes, but D_1 and D_2 can, with advantage to the scale linearity, be cb–e connected silicon transistor 'super diodes'[2] as in Fig. 5. Although the instrument has a good degree of rejection of d.c. on the a.c. ranges (and conversely), it would be possible to overload the measuring circuitry if an a.c. signal were measured in the presence of a substantial d.c. voltage. In this case a suitable d.c. blocking capacitor should be interposed in series with the multimeter leads. Similarly, a complete a.c. rejection on the d.c. ranges, with full avoidance of any overload possibility down to quite low frequencies, can be obtained by shunting the input to Tr_1 on the d.c. ranges by a suitable capacitor, but this will probably be unnecessary in practice.

The scale linearity of the prototype instrument, which used a Sangamo-Weston taut-band suspension 100μA movement, was better than 2% on both a.c. and d.c. ranges when 'super diodes' were used in the rectifier bridge, as indicated above, but with normal small-current silicon diodes there was some small loss of linearity above 96% f.s.d. on the a.c. ranges.

References

1. Waddington, D.E.O'N. 'Silicon Transistor Millivoltmeter', *Wireless World*, March 1966, pp.111-3.

2. Linsley Hood, J. L. 'Letters', *Electronic Engineering*, January 1964, p. 48.

Announcements

A two-week **residential vacation school** on Hardware and Software of Computer Systems for Engineers is being organized jointly by the Electronics Division of the I.E.E., the I.E.R.E., and the British Computer Society. It will be held at the University College of Swansea from 11th-22nd September. Further details from the Secretary, The Institution of Electrical Engineers, Savoy Place, London WC2R OBL, quoting reference LS(E).

The Mullard Educational Service is to stage a five-day exhibition of **educational visual aids** for use in the teaching of semiconductor physics. It will be held in the Electronics Centre at Mullard House, London WC1, from 19th-23rd June.

The **SIMA trade mission** to South Africa, approved by the Department of Trade and Industry, assembled on the 21st May in Johannesburg and over the succeeding fortnight undertook a programme of visits to agents and companies concerned with the scientific instrument field.

A repair, maintenance and calibration network for laboratory equipment, computers, nuclear instruments and TV equipment, which will cover the whole of Europe, is planned by **EMI Service,** the British-based technical-equipment servicing organization of the EMI Group.

SGS, Societa Generale Semiconduttori, of Italy, has signed an agreement with **Honeywell** Information Systems Italia for the mechanization and production of some types of m.s.i. bipolar integrated circuits to H.I.S.I. specifications. The logic functions covered include driving, receiving, multiplexing, adding and very fast latching.

Racal-Zonal Ltd, Holmethorpe Avenue, Redhill, Surrey, has signed a marketing agreement with Mastertape (Magnetic) Ltd, of Colnbrook, Bucks. Racal-Zonal will be principal world distributor of **Mastertape** manufactured disk packs under the name 'Calculus'.

Muirhead Co. Ltd, Elmers End, Beckenham, Kent, the electrical and mechanical engineering group, is to expand its components division with the acquisition of **Vactric Control Equipment** for £330,000 from Rotax Holdings and Lucas Aerospace, both part of the Joseph Lucas group.

The **SGS/ATES Group** has set up a subsidiary in the United States of America – SGS-ATES Semiconductor Corporation – with headquarters at Newtonville, Boston, Massachusetts.

Pye Dynamics Ltd, of Bushey, Watford, Herts, has introduced a consultative and leasing service for automatic test equipment.

Triangle Digital Services, 13 Park Road, London NW4, designs and constructs **custom electronic instrumentation,** test gear and specialized equipment.

A new range of **heat shrinkable shapes,** produced initially in p.v.c., is being offered by Shrink Tubes & Plastics Ltd, 31 Holmesdale Road, Reigate, Surrey.

Adcola Products Ltd, Adcola House, Gauden Road, London SW4 6LH, has signed a contract with Univerzal of Belgrade, to assemble and distribute the Adcola range of soldering instruments throughout Yugoslavia, Bulgaria, Czechoslavakia and Rumania.

ATES Electronics Ltd, Aylesbury, Bucks, has appointed ITT Electronic Services, of Edinburgh Way, Harlow, Essex, as a franchised distributor for its range of semiconductor products.

Balsbaugh Laboratories, Massachusetts, U.S.A., manufacturers of process water instrumentation, has announced the appointment of Martron Associates Ltd, of 81 Station Road, Marlow, Bucks.

The range of rotary and push-button switches manufactured by **Jean Renaud,** of France, is now available from the Electromechanical Product Division of ITT Components Group Europe at West Road, Harlow, Essex.

Rastra Electronics Ltd, 275 King Street, Hammersmith, London W6, is appointed the sole U.K. representative of **Cycon Inc.,** of California, manufacturers of digital-to-analogue converters, analogue-to-digital converters, bipolar and f.e.t. instrumentation amplifiers and d.c. power supplies.

The Ferrograph Co. Ltd, has moved from London to Auriema House, 442 Bath Road, Cippenham, Slough, Bucks, SL1 6BB. Tel: 062 86 62511.

Ambersil Ltd, manufacturers of a range of silicone-based aersols, has moved from Mitcham, Surrey, to a new factory at Whitney Road, Daneshill, Basingstoke, Hants.

Molex Incorporated, of Downers Grove, Illinois, U.S.A., manufacturers of a range of electrical connectors, terminals, inter-connecting systems and modular connecting devices, has opened a sales and service office at 14 Yeading Lane, Hayes, Middx, and a factory in Ireland.

Racal Instruments of Windsor, has now received orders totalling £500,000 subsequent to a further order from the Ministry of Defence for its 125MHz digital frequency meter, Model 801M.

The Meclec Company, of Great Wakering, near Southend-on-Sea, Essex, has been awarded a £7,000 export contract by Honeywell of Italy, for the supply of a range of specialized precision dynamic pressure transducers and associated equipment to be used in a British-designed air-blast tunnel.

Following the successful outcome of trials of Clansman **h.f. radio equipment** in Iran, the M.E.L. Equipment Company has been awarded an initial order worth over £500,000 for its UKVRC321 medium-power h.f., s.s.b. 1.5 — 30MHz transceivers designed for military use.

Conferences and Exhibitions

LONDON

June 13-16 — R. Hort. Soc. Hall
Engineering Design Show and Conference
(Mercury House Business Publications Ltd, Mercury House, Waterloo Rd, London, S.E.1.)

June 23 & 24 — Connaught Rooms
APRS 72 Exhibition
(E. L. Masek, Assoc. of Professional Recording Studios, 23 Chestnut Ave, Chorleywood, Herts.)

BRIGHTON

June 13-15 — Metropole Convention Centre
Communication 72 — Conference and Exhibition
(E.T.V. Cybernetics Ltd., 21 Victoria Rd., Surbiton, Surrey.)

OVERSEAS

June 6-8 — Atlantic City
Frequency Control Symposium
(US Army Electronics Command, AMSEL TL-SF, Fort Monmouth, New Jersey 07703)

June 6-9 — Cambridge, Mass.
Switching Symposium
(P.O. Box 188, Waltham, Massachusetts 02154)

June 21-23 — Boulder
Joint Measurement Conference
(G. Goulette, University of Colorado, 130 Academy Bldg, 970 Aurora Ave, Boulder, Colorado 80302)

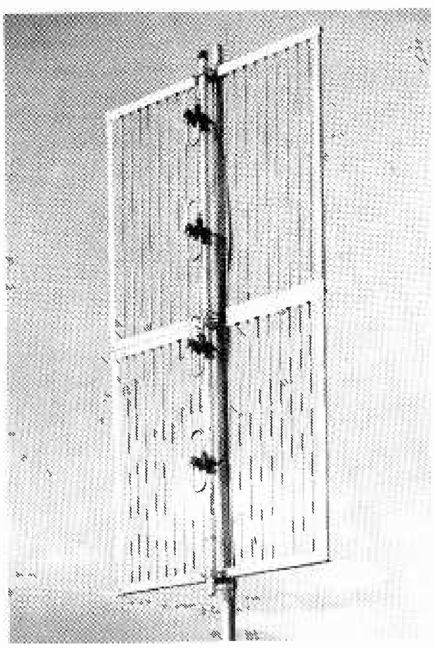
June 26-30 — Paris
Electronics and Civil Aviation Colloquium
(Secretariat due Colloque International, 16, rue de Presles, Paris 15e)

Communication '72

List of exhibitors

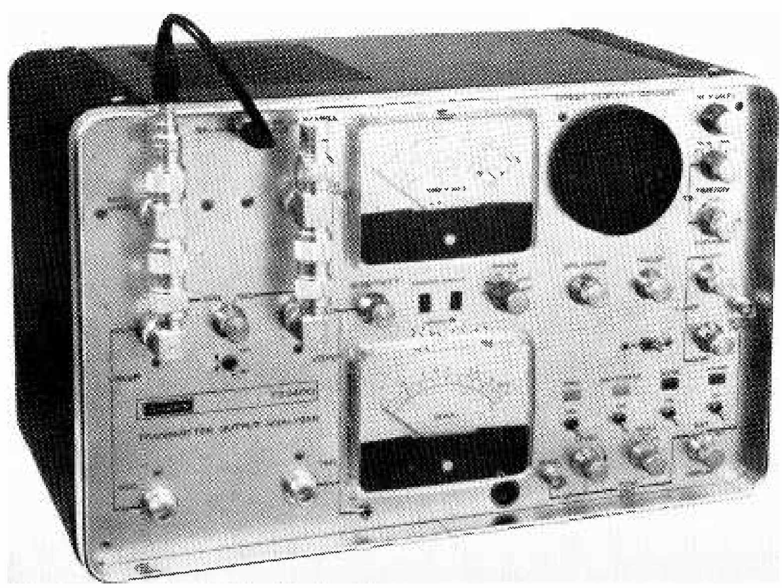
Communication '72 — which is to be held at the Metropole Convention Centre, Brighton — will be inaugurated on June 13th by Admiral of the Fleet, The Earl Mountbatten of Burma who is chairman of the National Electronics Council. The conference and exhibition will be open for three days. The mornings will be devoted to the conference, full details of which were published last month on page 214. The exhibition will be open from 11 a.m. to 6 p.m. each day and will cover the entire communications field from telephone answering machines and mobile radio to data communications and automatic test equipment as can be seen from the list of exhibitors.

Complimentary tickets for the exhibition are obtainable from E.T.V. Cybernetics Ltd, 21 Victoria Rd, Surbiton, Surrey, the organizers. The fee for the three-day conference, which has been organized jointly by *Electronics Weekly* and *Wireless World,* is £25, including the full text of all 33 papers. Alternatively admission to the conference for a single day costs £10 (including the day's papers). Full details from E.T.V. Cybernetics Ltd.



(left) On-channel repeater aerial from J Beam Engineering for 450 to 470MHz. The aerial is for a repeater "booster" station receiving and transmitting simultaneously on the same frequency. Isolation between the two sections is better than 65dB.

(below) Transmitter output analyzer from Green Electronic and Communication Equipment Ltd replaces the six conventional instruments normally needed to carry out transmitter tests.



AB Electronic Components
Airtech
Alkaline Batteries
Alpha Ometric
Amplivox
Anglo-European Radiophone
Ansafone
Astro Communication Laboratory

Bantex
BEPI Electronics
Boss Industrial Mouldings
Boyden Data Papers
Bradley, G. & E.
British Communications Corp.
Brown, S. G.
Burndept Electronics

Cable & Wireless
Collison Goodwell, H. F.
Computer & Systems Eng.
Computer Terminals
Com-Rad Equipment
Cossor Electronics
C & S Antennas

DEAC (GB)
Digital Systems
DME Electronics
Dymar Electronics
Dynamic Electronics

Electro-Acoustic Industries
Electromagnetic Systems Labs.
E.M.I.

Farnell Instruments
Ferranti
Flann Microwave

GET/Datach
Granger Associates
Green Electronic & Comm. Equip.

Hatfield Instruments
Hawker Siddeley Dynamics
H.C.D. Research
Hewlett Packard
Home Office
Honeywell

International Aeradio
Intertechnique
Italtel
ITT Creed
ITT Mobile Communications

J Beam Engineering

K. & N. Electronics
Knowles Electronics

Microwave Associates
Ministry of Defence
Motorola
Muirhead
Mullard
Multitone Electric
Murphy Telecommunication

Nombrex

Panorama Radio
Park Electronics (IAL)
Post Office

Racal Electronics
Rank Precision Industries
Redifon Telecommunication
R.F.L. Electronic

S.A.G.E.M.
Scot Forward
S. E. — Hameg
Siemens (UK)
Solartron Electronic Group
Sperry Gyroscope
Storno

Texas Instruments
Trend Electronics

Ultra Electronics

Wandel & Goltermann (UK)
Watkins Johnson International
Wayne Kerr
Wragby Plastics

Special-purpose Amplifier

Defined gain with input and output at the same d.c. level

By W.T. Cocking, F.I.E.E.

The circuit of a negative-feedback amplifier with some unusual characteristics is shown in Fig. 1. Apart from the shunting effect of an input resistor such as R_{B1}, it has a high input impedance of the order of 1MΩ. It has a fairly low output impedance of, perhaps, 50Ω. It gives a voltage amplification substantially governed by the ratio R/R_{B2}, which is consequently well-defined and stable. Other circuits are available with these properties. However, the really unusual characteristic is that, measured with respect to $-V_{CC}$, the base of Tr_1 and the collector of Tr_3 are ideally at the same potential. Even in practice they differ very little, so amplifiers of this type can readily be cascaded with direct coupling.

If Tr_1 and Tr_2 are identical transistors and the current I is zero, both bases must be at the same potential V_{BB}, and the emitters must be at $V_{BB}-V_{BE}$. Currents I_{C1} and I_{C2} are also equal. The base current of Tr_3 is the collector current of Tr_1 less the current in R_{C1}, and the collector current of Tr_3 is h_{FE3} times the base current of Tr_3. To make $I = 0$, we must then have $I_{C3}R_{C3} = V_{BB}$. The proper circuit values are settled on the basis of these relations. It is assumed that the base circuit voltage drops of Tr_1 and Tr_2 are negligibly small.

When a signal is applied to the base of Tr_1, the emitter voltage must follow it to keep the base-emitter voltage constant at V_{BE}. This means that the base voltage of Tr_2 must follow it also and be V_{BE} above the emitter voltage. Thus, V_{B1} and V_{B2} are always equal. For this to occur, any voltage change ΔV_{B1} on the base of Tr_1 must produce a current change $\Delta I = \Delta V_{B1}/R_{B2}$ to make $\Delta V_{B2} = \Delta V_{B1}$. This current must flow through R to produce a voltage $\Delta IR = \Delta V_{B1}R/R_{B2}$ across it. Consequently,

$$\frac{\Delta V_{C3}}{\Delta V_{B1}} = A = 1+\frac{R}{R_{B2}} \qquad (1)$$

Analysis of the circuit by the usual procedure fails to produce sensible results. The reason is that the base-emitter voltages are normally assumed to be constant because they are small compared with other signal voltages. As Tr_1 and Tr_2 do not have individual emitter resistances and as their base voltage drops I_BR_B are assumed to be negligibly small, there is then no way of deciding how the total current in R_T, which is almost constant, divides between them. In this case it is not permissible to assume that the base-emitter voltages are constant. It is actually these voltages which govern the current division ratio.

For nearly, but not quite, all changes of resistance values and transistor characteristics, the circuit tries to maintain equality of V_{B1}, V_{B2} and V_{C3}, measured with respect to $-V_{CC}$. It does not quite succeed because the open-loop gain is finite, but the departures from equality can be quite small. Something has to change, however, and this is the ratio I_{C1}/I_{C2}.

Because the base-emitter voltages of Tr_1 and Tr_2 are important it is necessary to invoke the fundamental diode equation. This expresses the exponential relation between base-emitter voltage and collector current. However, its direct use renders the equations insoluble and it is necessary to resort to an artifice.

This is to design the circuit initially on the assumptions that Tr_1 and Tr_2 are identical transistors and that the current I is zero, using typical values for all transistor characteristics. The effect of *changes* of circuit values from these assumed ones is then easily calculated.

Now with $I = 0$, $V_{B1} = V_{B2}$ and with identical transistors, $V_{BE1} = V_{BE2}$ and their collector currents must be equal. Therefore,

$$V_{BB}-V_{BE1} = 2I_{C1}R_T \qquad (2)$$

Also, in the collector of Tr_1 and base of Tr_3 we must have

$$I_{C1} = \frac{V_{BE3}}{R_{C1}}+\frac{I_{C3}}{h_{FE3}} \qquad (3)$$

and, finally,

$$V_{C3} = V_{BB} = I_{C3}R_{C3} \qquad (4)$$

Consider now the collector-emitter voltages. By inspection,

$$V_{CE1} = V_{BB}-V_{BE1}-V_{BE3}$$

$$V_{CE2} = V_{BB}-V_{BE2}$$

$$V_{CE3} = V_{CC}-V_{BB}-V_{BE3}$$

and if $V_{BB} = V_{CC}/2$ they are all less than this by only one or two base-emitter voltages. A collector-emitter voltage of one-half of the supply voltage is the optimum for output. It follows that unless V_{CC} is unusually small, the optimum condition is almost achieved by making $V_{BB} = V_{CC}/2$.

The choice of V_{CC}, the current I_{C3} and the type of transistor for Tr_3 are governed by the output required and follow normal practice. In the example to be considered here, choose V_{CC} = 12V, I_{C3} = 4mA and assume a BC157 transistor for Tr_3; this has typical values of 0.65V for V_{BE3} and 140 for h_{FE3}. Then V_{BB} = 6V and from equation 3 R_{C3} = 6/4 = 1.5kΩ.

For Tr_1 and Tr_2 assume an identical pair of BC107 transistors for which $V_{BE1} = V_{BE2}$ = 0.6V. Choose $I_{C1} = I_{C2}$ arbitrarily as 100μA, whence from equation 1

$$R_T = \frac{6-0.6}{0.2} = 27\text{k}\Omega.$$

Then from equation 3, resistance R_{C1} is

$$\frac{V_{BE3}}{I_{C1}-I_{C3}/h_{FE3}} = \frac{0.65}{0.1-4/140} = 9.1\text{k}\Omega.$$

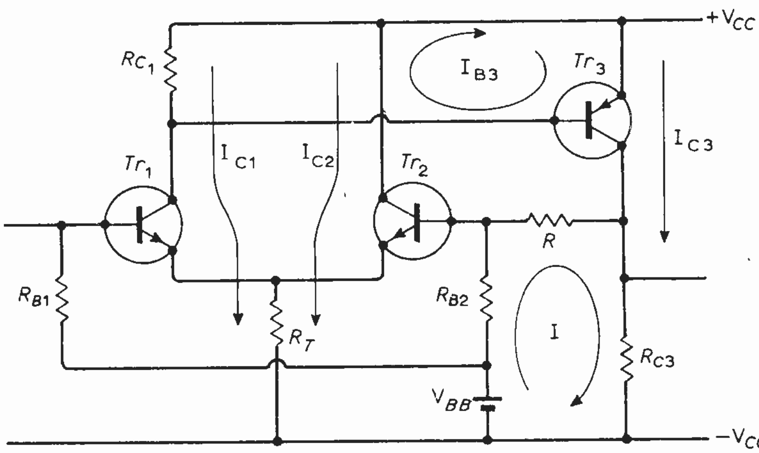


Fig. 1. Basic circuit of amplifier.

This is a non-preferred value, but one which could almost be obtained from two 18kΩ resistors in parallel. However, we might well choose to make R_{C1} = 10kΩ. Also, h_{FE3} may vary over the range of 75 to 260, while V_{BE3} may vary from 0.6 to 0.75V, apart from temperature effects.

It is now necessary to determine how such changes affect V_{C3}. In the conductive region, the collector current and base-emitter voltage of a transistor are related by

$$I_C = I_S \exp(KV_{BE})$$

where I_S is the reverse saturation current and $1/K \approx 0.026$V at room temperature. Then $dI_C/dV_{BE} = KI_C = g_{fe}$, the forward mutual conductance. As $I_C = 0.1$mA, $g_{fe} = 0.1/0.026 = 3.84$mA/V for Tr_1 and Tr_2.

If V_{B1} is constant and V_{B2} increases by a small amount ΔV_{B2} with respect to $-V_{CC}$, this increase also exists with respect to V_{B1}. If, also, the total current $I_{C1}+I_{C2}$ in R_T is unaltered, as is almost the case if R_T is large enough, then any change of one current is accompanied by an equal and opposite change of the other. It then follows that the changes of base voltages with respect to the emitters must be equal and opposite. A change ΔV_{B2} thus appears as a change $\Delta V_{B2}/2$ with respect to the emitters and a change of $\Delta V_{B2}/2$ of V_E with respect to $-V_{CC}$. This is equivalent to a change $\Delta V_{B1} = -\Delta V_{B2}/2$.

Of course, if the emitter voltage rises by $\Delta V_{B2}/2$, the total current in R_T must rise by $\Delta V_{B2}/2R_T$. Because of this, the magnitude of the change of I_{C1} is a little less than that of I_{C2}. In fact, Tr_1 acts as if it had an emitter input resistance of $1/g_{fe} \approx 260\Omega$ and ΔI_{C1} is less than ΔI_{C2} by the current taken by R_T in shunt with this. As R_T is here 27kΩ, the error is only about 1%.

Because ΔV_{B2} is divided almost equally between the two transistors, the effective mutual conductance is one-half of that for either transistor. We shall call this $g = g_{fe}/2$. We then have

$$\Delta I_{C2} = g\Delta V_{B2}$$

$$\Delta I_{C1} = -g\Delta V_{B2}$$

All this is, in fact, the usual small-signal derivation of quantities. To calculate the effect of changes of circuit values we actually apply it to changes which may not strictly be small enough. Because of this results may not be precise.

From earlier equations

$$I_{C1} = \frac{I_{C3}}{h_{FE3}} + \frac{V_{BE3}}{R_{C1}}$$

If every quantity changes by an amount ΔI_{C1}, ΔI_{C3}, etc. this becomes

$$I_{C1}+\Delta I_{C1} = \frac{I_{C3}+\Delta I_{C3}}{h_{FE3}+\Delta h_{FE3}} + \frac{V_{BE3}+\Delta V_{BE3}}{R_{C1}+\Delta R_{C1}}$$

Subtracting the first from the second, equating ΔI_{C1} to $-g\Delta V_{C3}/A$, and substituting $I_{C3} = V_{C3}/R_{C3}$, $\Delta I_{C3} = \Delta V_{C3}/R_{C3}$, we get

$$\frac{\Delta V_{C3}}{V_{C3}} = \frac{\frac{\Delta h_{FE3}}{h_{FE3}} + h_{FE3}\cdot\frac{R_{C3}}{R_{C1}}\cdot\frac{1+\Delta h_{FE3}/h_{FE3}}{1+\Delta R_{C1}/R_{C1}}\left\{\frac{V_{BE3}}{V_{C3}}\cdot\frac{\Delta R_{C1}}{R_{C1}} - \frac{\Delta V_{BE3}}{V_{C3}}\right\}}{1+\frac{gR_{C3}h_{FE3}}{A}\left(1+\frac{\Delta h_{FE3}}{h_{FE3}}\right)}$$

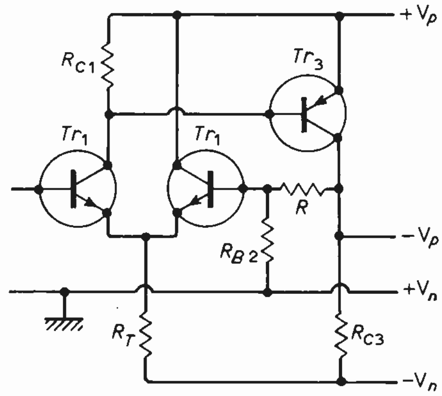


Fig. 2. Common practical amplifier circuit with two power supplies and input and output at earth potential.

The denominator of this equation represents the open-loop gain of the amplifier. The expression looks formidable but in practice one usually calculates the effect of different changes separately. As an example, it was mentioned earlier that the design centre value for R_{C1} is 9.1kΩ in the example, but that usually 10kΩ would be used. How much does this affect matter?

As $\Delta h_{FE3} = \Delta V_{BE3} = 0$, the equation reduces to

$$\frac{\Delta V_{C3}}{V_{C3}} = \frac{h_{FE3}\cdot\frac{R_{C3}}{R_{C1}}\cdot\frac{V_{BE3}}{V_{C3}}\cdot\frac{\Delta R_{C1}/R_{C1}}{1+\Delta R_{C1}/R_{C1}}}{1+gR_{C3}h_{FE3}/A}$$

$$= \frac{140\times\frac{1.5}{9.1}\times\frac{0.65}{6}\times\frac{0.9}{10}}{1+1.92\times1.5\times140/10} = 0.00543.$$

This is an increase of V_{C3} by 0.543% or 32.6mV.

From the design centre values (R_{C1} = 9.1kΩ), the tolerances on V_{BE3} are 0.6 to 0.75V, so that ΔV_{BE3} is -0.05 to $+0.1$V. The resulting changes of $\Delta V_{C3}/V_{C3}$ are -0.465 to 0.93%. The tolerance on h_{FE3} is 75 to 260, and so Δh_{FE3} is -65 to $+120$ and $\Delta V_{C3}/V_{C3}$ is -2 to $+1.1$%.

Of the three tolerances considered here that of h_{FE3} is the biggest and has the biggest effect. The 2% fall of V_{CE3} with a low h_{FE} transistor for Tr_3 is $0.02\times6 = 0.12$V. At the base of Tr_2, it is less by the gain of the amplifier, so it becomes 12mV for a gain of 10. Therefore, I_{C2} falls by g times this, or $12\times1.92 = 23\mu$A and I_{C1} increases by this amount. Instead of these currents being each 100μA, I_{C1} becomes 123μA and I_{C2} is 77μA, so I_{C1}/I_{C2} changes from 1:1 to 1:1.6.

The change of h_{FE3} is 46.5% and it produces a 2% change of V_{C3}, and a 23% change of I_{C1} and I_{C2} in opposite directions. The effect of changes in the closed loop is thus mainly taken up by changing I_{C1} and I_{C2}.

Changes between V_{BE1} and V_{BE2} are much more important, for the feedback does nothing to reduce these. The difference between these two has the same effect as an input signal of that value. The total variation of V_{BE} for a BC107 transistor is 0.15V. If one transistor is at one limit of tolerance and the other is at the other limit, there must be 0.15V between the base potentials of Tr_1 and Tr_2. Then V_{C3} will have a tolerance of ±1.5V, or ±25% for the example.

This so far exceeds all other tolerances that the others are almost negligible in comparison. It can be tolerated only in very non-critical applications of the amplifier. There are three remedies. The first is to include some pre-set control to nullify it. This can be a potentiometer between the emitters of Tr_1 and Tr_2 with R_T taken to its slider. To be effective, the voltage drop across it with one collector current in it must not be less than the V_{BE} difference. In our example, this means a minimum value of 0.15/0.1 = 1.5kΩ. To allow for tolerances, it would probably have to be 2.5kΩ. A disadvantage is that the local feedback due to this reduces the effective value of g and so the open-loop gain. An alternative is to provide some bias adjustment to Tr_1 or Tr_2. This can be better but does introduce difficulties.

The second remedy is to select the transistors used for Tr_1 and Tr_2 so that they have as nearly as possible the same value of V_{BE}. This is troublesome. The third remedy is by far the best. It is to use a dual transistor for Tr_1 and Tr_2. It is best because it is not only the simplest, but because the dual construction ensures that the junction temperatures are more nearly equal than is practicable to obtain with separate transistors. This means that temperature effects are reduced.

Dual transistors are much more expensive, of course, but it is doubtful if there is much difference in cost between using the BCY89 and two separate transistors with a good quality pre-set balancing control. This transistor has a maximum V_{BE} difference of 10mV, so that with it and with A = 10, V_{C3} is within ±0.1V, or ±1.66%. It thus reduces the effect of V_{BE} differences in Tr_1 and Tr_2 to the same order of magnitude as the other tolerances. The BCY88 (6mV) and the BCY87 (3mV) are still better, but more expensive.

So far nothing has been said about the values of R and R_{B2} save that it is their ratio which sets the gain. It is normally desirable that their sum should be large compared with R_{C3}. If it is not, some equations will be slightly modified. It is desirable, too, that R_{B1} and R_{B2} should be about equal, so that any slight effects of the base currents of Tr_1 and Tr_2 will tend to balance out.

With the circuit arrangement of Fig. 1, the input resistance of the amplifier will not be much below R_{B1} and will be of only moderate value. From the point of view of avoiding base current effects a value of the order of 10kΩ is desirable and for A = 10, this means R = 90kΩ. This is reasonable for stray capacitance to have but little effect. If this is not important, the values can be ten times as great, but 1μA in 100kΩ means 100mV change of base voltage!

Apart from the shunting effect of R_{B1}, the

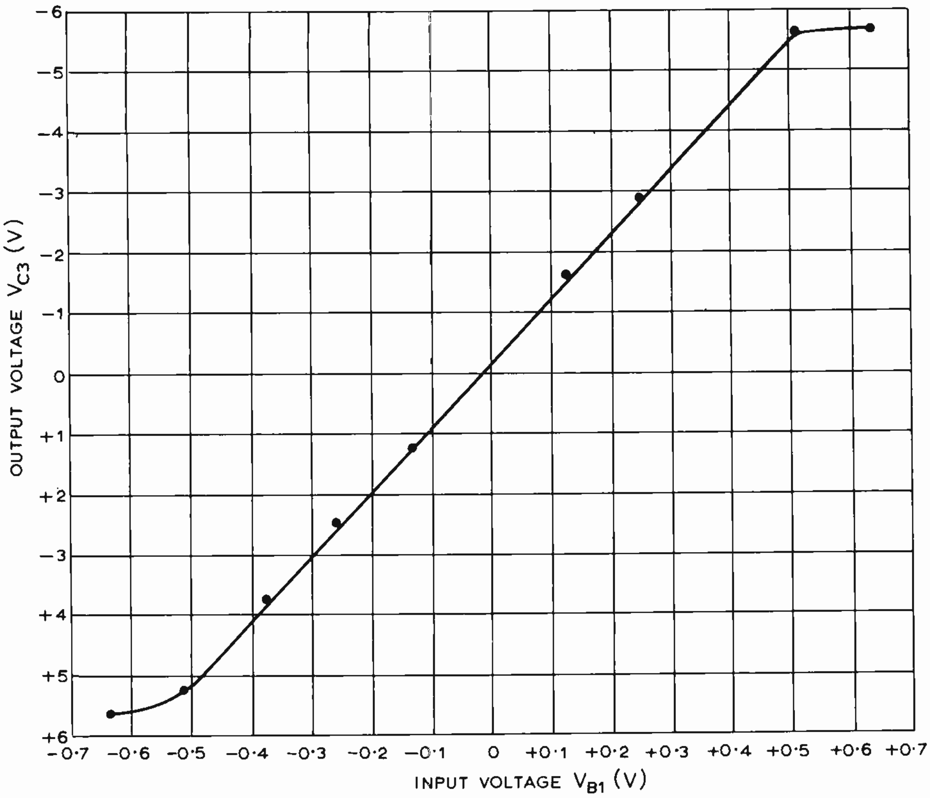


Fig. 3. Input-output curve for the circuit of Fig. 2. Voltages are measured with respect to earth and both power supplies were 5.7V.

input impedance is high. If it were not for Tr_2, the impedance would be $h_{fe1}R_T$. Both bases move together, however, and only one-half of the total current in R_T is supplied by Tr_1, so the input resistance is $2h_{fe1}R_T$. In our example, it is 405kΩ to 1.4MΩ depending on the h_{fe} tolerance. The nominal value is 865kΩ.

The use of R_{B1} can sometimes be avoided by rearranging the circuit as shown in Fig. 2. Two equal supplies V_p and V_n are needed and $V_p + V_n = V_{CC}$ and $V_n = V_{BB}$. The input and output are then at earth potential save for the effect of tolerances. If R_{B1} is used it is connected to earth, but if the signal source is conductive at d.c., and has the sort of value that would be used for R_{B1}, it can itself form the d.c. path for the base of Tr_1.

The output resistance can be computed by imagining a voltage δV_{C3} applied externally across R_{C3}. This appears as $\delta V_{C3}/A$ on the base of Tr_2 and as a change of collector current of Tr_1 as $-g\delta V_{C3}/A$. This change is the base current change of Tr_3 and so the change of I_{C3} is $-h_{fe3}g\delta V_{C3}/A$. Thus, applying a voltage positive to earth in Fig. 1 to the anode of Tr_3 causes a reduction of I_{C3}. As this voltage is negative with respect to the emitter of Tr_3, the voltage and current are in phase as far as Tr_3 is concerned, so the negative sign can be dropped. Then

$$\frac{V_{C3}}{I_{C3}} = \frac{A}{h_{fe3}g} = R_0.$$

Nominally for our example,

$$R_0 = 10/(140 \times 1.92) = 37.1\Omega$$

Enough has been said to show the main characteristics of the amplifier and they are mostly very desirable ones. The performance is but little dependent on the supply voltages, especially in the version of Fig. 2. Unstabilized supplies are usually quite satisfactory.

There is one disadvantage, however. As there are three transistors in a closed loop, there is quite a probability that the closed-loop gain will be greater than unity when the phase shift round the loop reaches 180°. The circuit is, therefore, liable to oscillate at some high frequency. The usual remedy of making one time constant dominant (e.g., by shunting R_{C1} by capacitance) will remedy this. Alternatively and usually better, R_{C1} can be shunted by resistance and capacitance in series; that is, the usual 'step' circuit. Unfortunately, it is very difficult to calculate the open-loop frequency and phase responses, for most of the factors involved are not known with sufficient accuracy. The stabilizing circuit cannot readily be 'designed', therefore.

Because of this it is sometimes said that the amplifier is unsuitable for frequencies above about 1MHz. I have used such an amplifier and found it stable without extra devices. Above 1MHz, however, the gain rose and was still rising at 10MHz. It was easy to add stabilizing components to obtain a flat response to 10MHz. There is no doubt at all that an amplifier of this type can be made to work up to at least 10MHz by adjusting components empirically. What is not then known, however, is how tolerances affect the response and the stability.

It is worth noting that a low closed-loop gain A is more likely to result in instability problems than a high gain. The reason is that the components R_{B2} and R which determine the closed-loop gain act in the reverse direction as the β path $(1/A)$ of a feedback amplifier, and the open-loop gain increases as A is reduced.

Because of the large amount of negative feedback used the amplifier is highly linear and is capable of a peak voltage output quite close to $V_{CC}/2 - V_{CE\,sat}$. The linearity is usually very good for peak outputs up to about 1V less than $V_{CC}/2$. Fig. 3 shows the experimental results obtained with the circuit of Fig. 2 and supply voltages of 5.7V each.

60 Years Ago

June 1912. *The Marconigraph* of this month, sixty years ago, was devoid of anything at all significant from the technical point of view. A great deal of space was devoted to the opening of Marconi House in the Strand and the wireless aspects of the inquiry into the *Titanic* disaster compiled from reports in *The Times* and other newspapers. An article on early experiments with wireless in aeroplanes revealed that, due to major advances, it was no longer necessary to have a trailing aerial. Unfortunately the Flanders monoplane being used for tests, crashed, killing the pilot, considerably delaying further experiments.

Additions and corrections

The following is additional coil winding data which was omitted from the article **Hand-portable Transceiver** by D. A. Tong (April 1972).

6	- $3\frac{1}{2}$t, centre tapped
16	- $5\frac{1}{2}$t tapped 1 turn from earthy end $\frac{3}{16}$in internal dia.
18	- $3\frac{1}{2}$t, $\frac{1}{4}$in i.d., $\frac{1}{4}$in long
12 (Fig. 5)	- 1t, $\frac{3}{16}$in i.d.
28	- 5t, $\frac{5}{16}$in i.d. $\frac{5}{16}$in long
29	- 3t, $\frac{5}{16}$in i.d. $\frac{3}{16}$in long
22	- 4t, $\frac{3}{16}$in i.d. $\frac{1}{4}$in long
23	- 3t, $\frac{5}{16}$in i.d. $\frac{3}{16}$in long
30	- 1t, $\frac{3}{16}$in i.d.
25	- 4.7μH l.f. choke (Painton)
26	- 3t, $\frac{3}{16}$in i.d.

T_1 wound with 32 s.w.g.

In **Electronic Building Bricks** No. 23, May issue, p.238, the diagrams over the captions Fig. 3 and Fig. 4 have been transposed in the production process.

Electronic Building Bricks

24. Noise

by James Franklin

So far in this series we have assumed that all the building bricks described have functioned exactly as they are intended to do, and that all signals and information have the ideal waveshapes drawn in the graphs. The reality, in practical electronic equipment, is somewhat different. Errors are introduced into the electrically represented information by distortions of signal waveshapes. These are caused partly by non-ideal functioning of the building bricks and partly by unwanted electrical disturbances entering the circuits of the bricks. The electrical disturbances may come from various sources. They may be what we experience as 'interference' on radio and television sets — caused by heavy electrical machinery or natural phenomena such as lightning discharges; they may be meaningful signals from other electronic apparatus (known as 'cross-talk' or 'break-through'); or they may be random, uncontrolled movements of electrons within the building-brick circuits themselves.

Of the various sources mentioned, the 'random, uncontrolled movements of electrons' in building-brick circuits is a permanent problem to the electronics engineer because it is present, to some extent, in all electronic circuits. These random movements are, in fact, movements of free electrons (Part 3) in different directions, and are occurring all the time in conductors (e.g. wires, resistors) regardless of whether an e.m.f. is applied to the conductor or not. What causes this generally prevailing agitation is heat, even the heat of the surrounding air at normal air temperatures.

In addition, when an e.m.f. is applied to some components there is a small random fluctuation in the resulting controlled electron flowrate (current), because the aggregate electron flow produced in a given direction (Part 3) is still made up of individual electron movements in different directions.

It might be thought that random electron movements in different directions would tend to cancel out. This is so, algebraically, over a period of time, but at any given instant there is likely to be a slight preponderance of electron movements in a given direction. In practice this means that the fluctuation of electron flowrate in, say, a length of conducting or resistive material will be a small alternating current (Part 17) with an irregular waveshape, as shown in Fig.1. Fig.2. shows a similar irregular fluctuation graph, taken from an oscilloscope.

Electronics engineers describe this kind of irregular fluctuation as 'noise'. This is simply because when random, uncontrolled movements of electrons are converted into sound by, say, a radio receiver or other audio equipment*, they are heard as a noise, something like steam escaping or a continuous exhalation of breath. But in many electronic systems the 'noise' waveform may not be something which is actually heard. For example, on a television picture it appears as an all-over speckling, a scintillating 'graininess', while in a digital computer it may distort pulses representing digits and possibly cause numerical errors. The 'noise' represented in Figs. 1 and 2 is often termed 'random noise'. This draws attention to the fact that there is no repeated cycle of values, or periodicity, in the waveform (Part 10).

One thing that's important to the electronics engineer about a random noise fluctuation in a particular part of a circuit is the average electrical power it possesses. But more important to know is *how much greater* the average power of the wanted signal is, in that part of the circuit, than the average power of the noise (see Part 8). In a building-brick circuit, the successive values of noise current, resulting from random electron movements, add to or subtract from the successive values of signal current at corresponding instants of time. This is illustrated in Fig.3. At (a) is a current graph of part of a signal unaffected by noise; at (b) a noise waveform corresponding to Fig.1 but of smaller fluctuation is combined with it; while at (c) the fluctuations of the same noise waveform are increased to make them roughly equal to the variations of current forming the signal. In the case of (b) the wanted signal information is quite badly affected, i.e. there are errors in successive values of signal current, while in (c) the original signal information, (a), is almost obliterated by the noise.

It is the *relative* signal and noise average powers that are crucial, physically, in determining the accuracy of information. However, the signal and noise relationship — called signal-to-noise ratio — is often expressed numerically as a ratio of signal and noise voltages across a given part of a circuit, or a ratio of currents at a given point in a conductor. This is done because voltage and current are easier to measure than power.

In general, therefore, it seems a good thing to have as large a signal-to-noise ratio as possible. But in practice this may be expensive to achieve, so the ratio is usually made as large as is necessary to provide *adequate* accuracy of signal information in the building brick concerned — depending on its application.

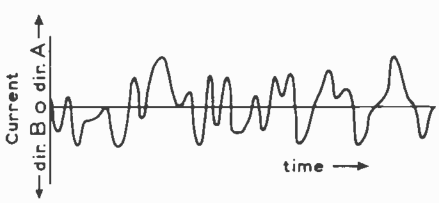


Fig.1. Irregular fluctuation of current (alternating) with time. (Directions A and B refer to Part 17.)

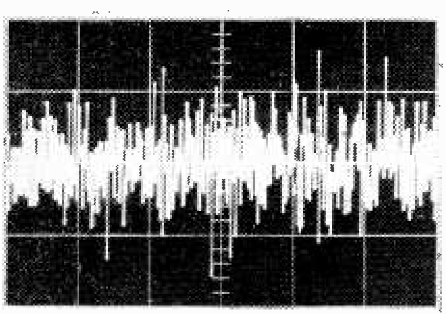


Fig.2. Noise in a circuit displayed on an oscilloscope (courtesy, P. J. Baxandall).

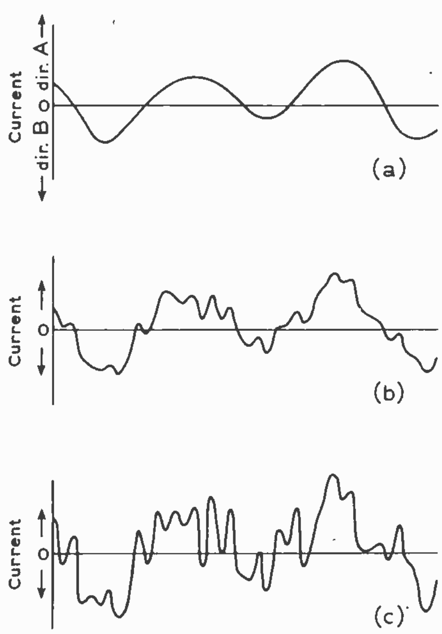


Fig.3. A signal (a) with errors introduced into it by the addition of current fluctuation noise (b) and (c).

* This can be heard if the volume control is turned up when the signal is off-tune or disconnected.

Electric Heater Control

by R.M. Marston

Three circuits are described which employ a triac to switch electric heaters for room temperature control and similar applications. In all the circuits zero voltage switching is employed to eliminate radio-frequency interference. One of the circuits is controlled by a thermostat, the second by a thermistor and the third, which also uses a thermistor, varies the thermal output of the heater. The result is that when the room has reached working temperature the output of the heater balances the heat losses from the room and very stable control of temperature is obtained.

Fig. 1 shows the circuit of a synchronous zero-voltage gating circuit, connected as a thermostat-regulated heater-controller. The circuit can control heater loads in the range 300W to 2.4kW using the specified triac. The circuit works as follows.

Transistors Tr_1 and Tr_2 are connected as a zero-voltage detector that is driven from the a.c. power line via current-limiting potential divider R_2 and R_3; Tr_2 is wired as a common-emitter amplifier, and is driven on whenever the line voltage is substantially positive; Tr_2 is wired as a common-base amplifier, and is driven on whenever the line voltage is substantially negative. The combined effect of Tr_1 and Tr_2 is thus such that one or other of these transistors is driven on whenever the instantaneous line voltage exceeds a certain 'reference' value and both transistors are off when the line voltage is below this value. The reference value approximates to:

$$V_{be}[(R_2+R_3)/R_3]$$

where V_{be} is the forward base-emitter voltage of Tr_1 or Tr_2 (≈600mV).

The collectors of Tr_1 and Tr_2 are coupled to the base of the gating transistor Tr_3 via R_4 (R_5 is the collector load when the thermostat contacts are closed). Resistor R_5 provides base drive to the switching transistor Tr_4, which has R_6 and the triac gate as its collector load. Transistors Tr_3 and Tr_4 are powered from a zener diode regulated 10V d.c. supply derived from the a.c. line via R_1, D_1 D_2 and C_1. The thermostat contacts are closed at low temperatures and open at high temperatures. The combination R_7 and C_2 act as a simple suppression network to prevent the triac from being turned on by line transients.

To understand the circuits action, assume that S_1 is 'on' and that the instantaneous a.c. line voltage is at some value in excess of a reference value of, say 5V. Under this condition either Tr_1 or Tr_2 is driven on and Tr_3 is driven to saturation via R_4. The saturation voltage of Tr_3 is lower than the base-emitter turn-on voltage of Tr_4, so Tr_4 is cut off and no gate drive is applied to the triac.

Suppose now that the instantaneous line voltage falls below the 5V reference value (line voltage almost zero at the start or finish of one half-cycle). Transistors Tr_1 and Tr_2 turn off and remove the base drive from Tr_3 and Tr_4 is driven into saturation via R_5. As Tr_3 turns off current flows into the triac gate through R_6 which turns the triac on and causes it to self-latch for the duration of the half-cycle. Thus, gate trigger current is applied to the triac only in the brief periods when the line voltage is close to zero and negligible radio-frequency interference is generated.

With S_1 in the auto position the heater is controlled by the thermostat. When the correct temperature is reached the thermostat's contacts open circuit the collector of Tr_3 and prevent the triac from being turned on.

The circuit is useful in that it illustrates the use of a triac to control a heater without generating radio interference and enables a thermostat with very light contacts to be used.

The only adjustable component in the circuit is R_3, which controls the 'reference' voltage and the width of the triac's gate pulse. This pulse must not end until the current through the triac has risen above the minimum holding current otherwise the triac will fail to self-latch. However, the pulse must not be too wide, otherwise r.f. interference may be generated when the thermostat's contacts close, or the low-voltage d.c. supply may be overloaded. The pulse width must be adjusted to suit the particular heater load that is used with the circuit. If a multi-value load (a two or three-bar heater) is used, R_3 must be adjusted with the heater in the minimum load position. To adjust R_3, proceed as follows.

Set S_1 to 'on' and R_3 to maximum

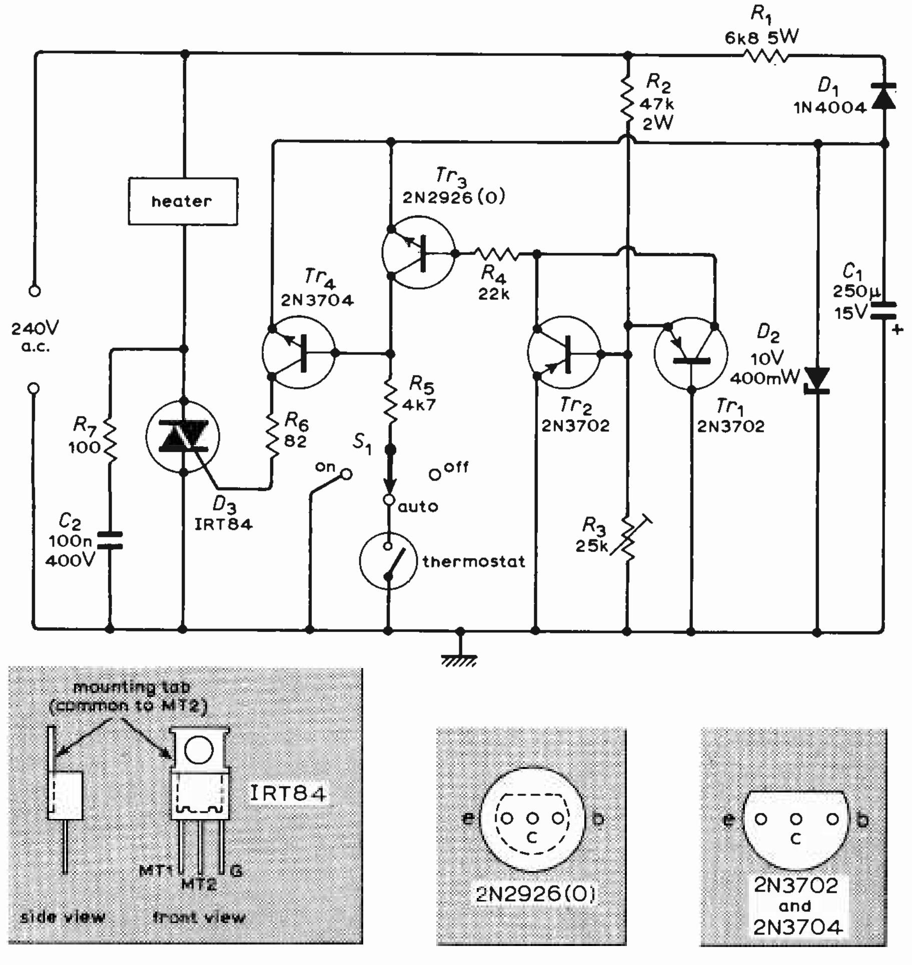


Fig. 1. Basic, zero voltage switching, triac heater control circuit. In this case the temperature sensing element is a thermostat.

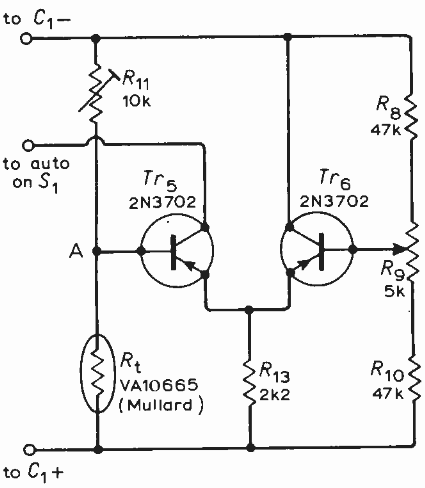


Fig. 2. When the thermostat of Fig. 1 is replaced by this circuit room temperature is measured by the thermistor which is part of a bridge. The bridge and long-tail pair control the triac and therefore the heater.

resistance. Connect a voltmeter across C_1, and apply power to the unit. A reading of approximately 10V should be obtained. Slowly reduce R_3 to the point at which the triac just turns on and applies full power to the heater (if the heater turns on with R_3 at the maximum value, increase R_3 to 50kΩ). Check that a reading of 10V is still obtained across C_1. Remove all power from the circuit and measure the value of R_3. Now set R_3 value to roughly half of the measured value. Finally, reconnect power to the unit and check that the heater turns on and that C_1 still gives a reading of 10V.

Note: The circuit is designed to operate with a minimum heater load of about 300W. If the voltage across C_1 falls appreciably below 10V it is probable that too low a heater load is being used. In this case the circuit should be used with an alternative triac, which should have a lower holding current rating that the device specified.

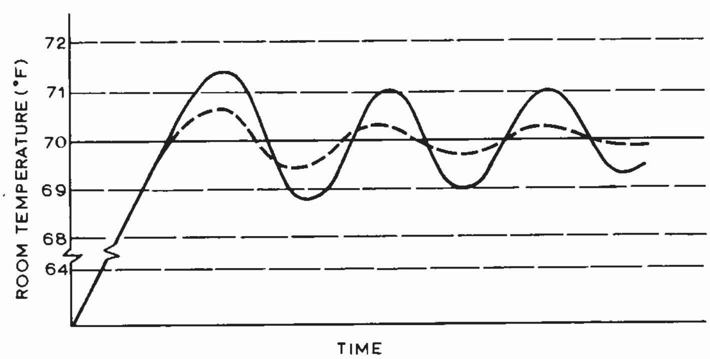


Fig. 3. A comparison of the performance of the thermostat and thermistor controlled circuits of Figs 1 and 2.

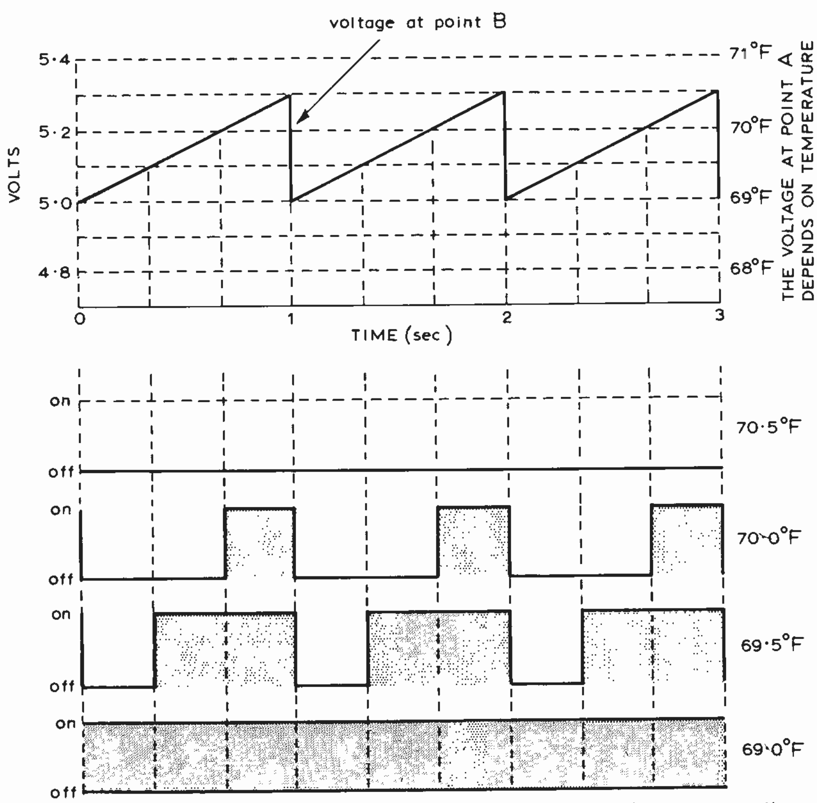


Fig. 4. Showing how a sawtooth waveform impressed on the base voltage of Tr_6 allows proportional control of the heater to be obtained.

Thermostat controlled heater switch

Fig. 2 gives the extra circuitry needed to replace the thermostat of Fig. 1 with a thermistor. The basic synchronous zero-voltage gating circuit remains unchanged except that the thermostat is omitted and the auto position of S_1 is connected to the collector of Tr_5 (Fig. 2). Resistors R_8, R_9, R_{10} and R_{11} and the thermistor R_t are wired as a temperature-sensitive bridge with Tr_5 and Tr_6 bridge-balance detector. Resistor R_5 of Fig. 1 (the inhibit resistor) is used as the collector load of Tr_5.

When the room (thermistor) temperature is low Tr_5 is driven hard on and current is available to R_5, turning the triac, and therefore the heater, on synchronously. When temperatures are high Tr_5 is cut off and no current flows in the heater.

When the temperature is close to the pre-set value Tr_5 is driven partially on, and the magnitudes of the current in both R_5 and the triac gate are proportional to the difference between the actual and the pre-set temperatures. The operating condition of the circuit in this circumstance depends on the magnitudes of these currents, as follows.

The triac in the Fig. 1 circuit is gated on during positive and negative half cycles but the gate drive stays negative. Under these conditions the IRT84 triac has typical gate sensitivities of 35mA for the positive half cycle and 15mA for the negative half cycle. Consequently, if the thermistor temperature is low and the bridge is out of balance sufficiently to cause the application of a gate current in excess of 35mA, the triac is driven on for both (positive and negative half cycles and applies full power to the heater. As the temperature rises the bridge goes closer to balance and the triac gate current decreases. When the gate current falls to a value less than 35mA but greater than 15mA the triac ceases to trigger during positive half cycles and it applies half power to the heater. When the temperature-sensitive bridge is nearly balanced the triac gate current falls to less than 15mA; all power is removed from the heater.

Thus, with the combined circuits of Figs 1 and 2 controlling a heater, room temperatures can be accurately controlled. The procedure for setting up the circuit is as follows.

First adjust R_3 in the same way as described earlier. Turn S_1 to the auto position and set R_9 to mid-value. Raise the thermistor to the required turn-off temperature, and adjust R_{11} so that the heater goes into half-wave operation. All adjustments are then complete, and the circuit is ready for use. Potentiometer R_9 enables the turn-off temperature to be varied a few degrees about the value pre-set by R_{11}.

Fig. 3 shows the typical performance (temperature-regulation) graph of the Figs 1 and 2 circuits when set to maintain a room temperature of 70°F. Room temperature rises fairly rapidly at first and then fluctuates about the pre-set level. There are two basic causes for the fluctuations. One cause is the thermal backlash of the electronic control system or the temperature sensor. The other is the thermal time constant of the room and/or the heater. Heat output does not fall abruptly when power is removed from the heater, so the room temperature continues to rise for a short period after the heater is turned off. This heat permeates slowly through the room, and takes time to warm up the thermistor on thermostat.

The thermal over- and under-shoots of the thermostat-regulated circuit are dictated primarily by the backlash of the actual thermostat, which is assumed to be ±1°F in Fig. 3. The performance of the thermistor-regulated circuit is dictated primarily by the thermal time constants of the room and the heater, but typically, it will hold room temperature to within ±0.3°F of the pre-set level.

Integral-cycle heater controller

Very precise room temperature control can be obtained by varying the output of the heater. Phase-controlled variable-power systems can not be used for heater control, due to the severe radio frequency interference problems that are involved at high power levels.

Fully variable interference free control of heater output can, however, be obtained using synchronous, internal-cycle, switching, in which power is applied to the heater for only a definite integral number of half-cycles. Thus, if power is applied for only fifty half-cycles in each hundred the heater will operate at 50% of full power, and if power is applied for ninety half-cycles in every hundred it will operate at 90% of full power, and so on.

Thermistor-regulated synchronous circuits can be designed to give fully automatic integral-cycle variable power control of electric heaters. Such circuits give very accurate regulation of room temperatures. The operating principle of a self-regulating integral-cycle heater controller can be understood with the aid of Figs 2 and 4.

A repetitive sawtooth waveform, with an amplitude of 300mV and a period of one second, is applied to the base of Tr_6 (point B) via a capacitor, and the circuit action is such that an inhibit signal is fed to the synchronous triac on-off circuit whenever Tr_5 turns off as the instantaneous voltage at point B goes negative to that at A.

Fig. 4 shows the voltages that appear at points A and B under different temperature conditions when the circuit is set to maintain a room temperature of 70°F, and shows the resulting heater output levels at four different temperatures. It can be seen that a low-amplitude saw-tooth waveform is superimposed on a fixed reference potential of 5V at point B in the circuit, and that a steady potential appears at point A but has an amplitude that varies with temperature. Variable resistor R_{11} is adjusted so that its resistance is slightly greater than that of the thermistor at 70°F, so that a potential of 5.2 V appears at point A under this condition.

Thus, when the room temperature is below 69°F the thermistor resistance is high and point A is always negative to point B, so Tr_5 is biased on and full power is applied to the heater, as shown in Fig. 4. As the room temperature rises the resistance of the thermistor decreases, and the potential at point A falls. Consequently, the circuit

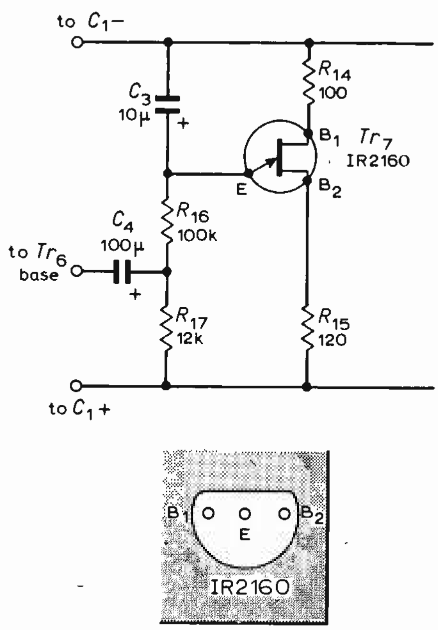


Fig. 5. Sawtooth oscillator which converts the circuits of Figs 1 and 2 to an integral cycle heater controller.

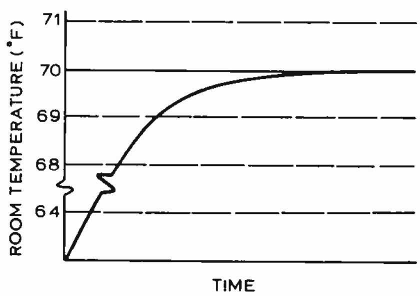


Fig. 6. Typical performance curve for the integral cycle controller.

passes through an area (between 69°F and 70.5°F) where Tr_5 is turned on and off once every second by the sawtooth waveform at point B. When the temperature rises to 69.5°F, Tr_5 and the heater are turned off for one third of each one-second sawtooth period, so the heater output falls to two-thirds of maximum. At 70°F Tr_5 and the heater are turned off for two-thirds of each one-second period, so the heater output falls to one-third of maximum. Eventually, when the room temperature rises to 70.5°F, the voltage at point A becomes positive to that at point B, so Tr_5 and the heater are turned off.

The important point to note about the self-regulating integral-cycle heater control system is that it applies full power to the heater until the room temperature rises to within a degree or so of the pre-set level, and that the heater output then reduces progressively as the pre-set level is approached, the heat output being proportional to the thermal requirements of the room. Eventually, when the pre-set temperature is reached, the heater is not switched fully off, but gives just sufficient output to counterbalance the natural heat losses of the room. The heater is switched off only when the room temperature is raised slightly above the pre-set level by an external cause, such as a rise in outside temperature. The system gives very good regulation of room temperature.

Fig. 5 shows the practical circuit of the sawtooth generator which must be added to the circuits of Figs 1 and 2 to form the self-regulating integral-cycle heater controller.

The output waveform of the unijunction oscillator (Tr_7) is fed to the base of Tr_6 via C_4. The sawtooth is inverted in relation to the waveform shown in Fig. 4 but the basic theory of operation is unchanged. The procedure for initially setting up this circuit is quite simple, and is as follows.

First, connect the selected heater in place, turn S_1 to the 'on' position, and adjust R_3 in the same way as described before. Turn S_1 to the 'auto' position, set R_9 to mid-value, raise the thermistor to the required 'normal' room temperature level, and then adjust R_{11} so that the heater output drops to roughly one third of maximum. All adjustments are then complete, and the circuit is ready for use. Room temperatures can be varied several degrees about the pre-set level with R_9.

Fig. 6 shows the typical performance of the unit. When first switched on the room temperature rises fairly rapidly to within a degree or so of the pre-set level. The temperature then slowly settles down to the pre-set level, with negligible overshoot or undershoot.

Practical points

Construction of the units should present few problems. The layouts are not critical, and the circuits can be wired up on Veroboard or on specially designed printed circuits. Resistor R_1 is a 5W type, and R_2 is rated at 2W; these two resistors should be mounted well above the surface of the board, and should be separated from all semiconductors and from C_1. Triac D_3 dissipates roughly 8W per kilowatt of heater load, and must be mounted on a suitable heat sink.

The triacs used in the prototype circuits are the recently introduced IRT84 types, manufactured by International Rectifier. This is a 10A, 400V plastic device, and is available from a number of suppliers. Other triacs may be suitable for use in place of the IRT84, but they must have low holding-current values. Unmarked triacs are to be avoided in these circuits. Unijunction transistor Tr_7 is another International Rectifier device.

When installing or testing the circuits remember that they are 'live', and that they should be screened so that they cannot be touched by children or other inquisitive individuals. The thermistor or thermostat should be placed remote from the main unit and positioned so that it responds to mean room temperature. It should be mounted two or three feet above ground level, and must be out of the way of draughts and sources of direct heat. The temperature-sensing 'head' should be mounted in a well ventilated but tamper-proof box, and should be connected to the main unit via a screened lead that is safe for use at mains voltages. Do not use the flimsy screened cable sometimes used for microphones and other low-level sources.

Photographing Television Pictures

by Ray E. Knight and David J. Bryant†*

Special precautions need to be taken when photographing a television picture to avoid a 'strobing' interference between the relative movements of the camera shutter and the television scan. An electronic timing unit is described that switches the television picture on for one, two or four fields, when the camera shutter is fully open, after receiving a trigger pulse from the flash contact. It should be possible to apply the principle to a domestic television receiver having an input from a camera flash contact and a switch marked 'tv' and 'photo'. By setting highlight brightness to 85cd/m² at f4 for one television frame, and increasing black level to ensure recording of good shadow detail, a normal colour monitor grey-scale balance produced first-class results on Agfa CT18 film.

While at Thames Television we were asked to photograph the television coverage of the Apollo 11 moon landing. To do this we developed a piece of equipment that eliminated shutter bars, usually present when using a camera shutter speed of approximately 1/25 second. The usual solution to this problem — a longer exposure time — was not acceptable in this case because we wanted to freeze movement at least as well as the moon camera had done.

A television picture is a series of fields, each taking 1/50 of a second to write its 312½ lines from top to bottom of the picture. The lines of each alternate field are traced out between the lines of the previous field. This is called interlace. One complete television frame uses two fields, it lasts 1/25 second and because the persistence or memory in our vision is just longer than 1/25 second, we effectively see a picture of 625 lines. However, because there is no persistence in a photographic emulsion it is possible, by using a fast shutter speed, to catch and record part of the television scan as an incomplete picture. Of course, a longer film exposure time stores up successive fields as the eye would, and a normal looking reproduction is obtained.

Fig. 1 illustrates the action of both a focal plane and a blade camera shutter. The diagram is marked off in television fields. The blade shutter opens quickly and remains fully open for the majority of its exposure time, and then closes quickly (a). On the other hand, a focal plane shutter opens steadily and relatively slowly, and closes in the same way (b). It is only briefly fully open when set to about 1/30 second. If a blade shutter opens in the middle of a field and its open time is longer or shorter than 1/25 second there will be a bright or dark shutter bar across the photograph where either more or fewer than 625 lines have been exposed and recorded.

This effect can be minimized by accurately adjusting the shutter's open time to be 1/25 second. If the photographer happened to press the shutter release in between one field and the next, when no picture information is being transmitted, a good photograph would be obtained. Sometimes the shutter bar falls on an area of picture information of little interest, in which case a part of the negative may be satisfactorily used.

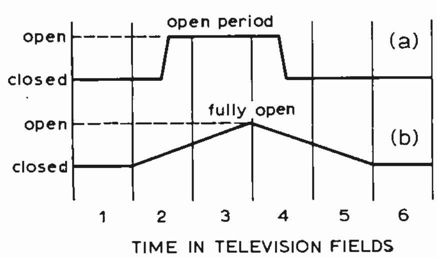


Fig. 1. Both blade-type (a) and focal plane shutters (b) have disadvantages for controlling exposures — overcome by switching two fields as in Fig. 3.

The focal plane shutter is unique in that the speed of the shutter blinds across the film is similar to the speed of a television scan down its picture. This can result in two diagonal lines of exposure demarcation, one for the opening blind and another for the closing blind. The normal photographic solution to this is a longer exposure time, but unfortunately this will not capture any movement.

It is clear that both shutters have inherent drawbacks that prevent them being used to photograph a television display with a shutter speed that both stops movement and guarantees a perfect record each time.

Electronic shutter

A solution to this problem is to pulse two fields on to a picture monitor, but only when the camera shutter is fully open. This may be arranged to occur at precisely the right moment by triggering the electronic shutter from the camera flash contact. Fig. 2 is a block diagram illustrating this arrangement.

Most cameras with focal plane shutters have two sets of flash contacts operating

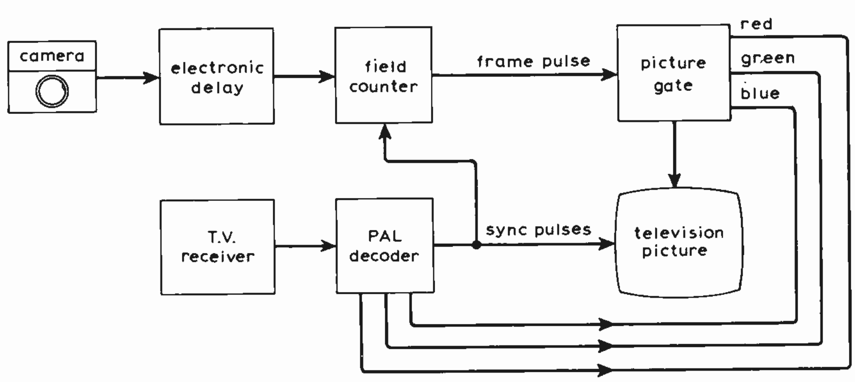


Fig. 2. Closing the camera's flash contact initiates an electronic delay, which in turn starts a field counter to determine the exposure time, i.e. 1, 2 or 4 fields duration. A frame pulse is formed to gate the colour signals to the television monitor. These colour signals are derived from a PAL decoder, which also supplies the synchronizing pulses to operate the field counter and to synchronize the monitor.

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at slightly different times. The M or FP contact, used with flash bulbs, closes as the first shutter blind starts to move, thus giving the flash bulb approximately 25ms to reach its peak brightness coincident with the full opening of the camera shutter blinds. The X contact closes as the shutter reaches its fully open position and is used with electronic flash equipment which reaches its brightness peak instantaneously when triggered.

Operation of the electronic shutter is best described by considering it in use with a focal plane camera shutter timed to open in 1/25 second and using M or FP flash sync on the camera. Fig. 3(a) shows the camera shutter release pressed at the start of field 2.

An electronic delay, adjusted to end when the shutter is fully open, is started by the camera flash contact. After the delay the next two television fields are selected and switched to the monitor. After the exposure is completed the shutter may close. To operate the electronic shutter with the X-synchronization contact, the delay in the electronics must be reduced to negligible proportions.

If the camera shutter was released after the start of field 2, Fig. 3 (b), then the first complete field cannot be seen by the open camera until the start of field 5. In this case the open time of the shutter must be longer to capture the full picture composed of fields 5 and 6. The total

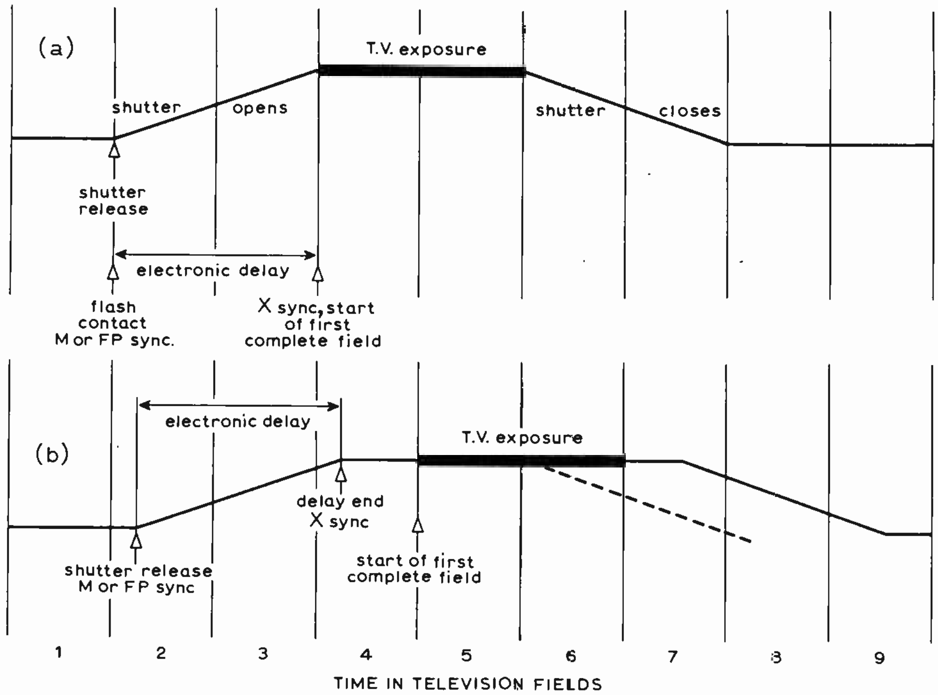


Fig. 3. Operating the camera shutter at the start of a frame starts a monostable delay which switches when the shutter is fully open (a). To allow for a shutter operating during a field scan, camera exposure time chosen must be at least 80ms — ⅛ second in practice (b).

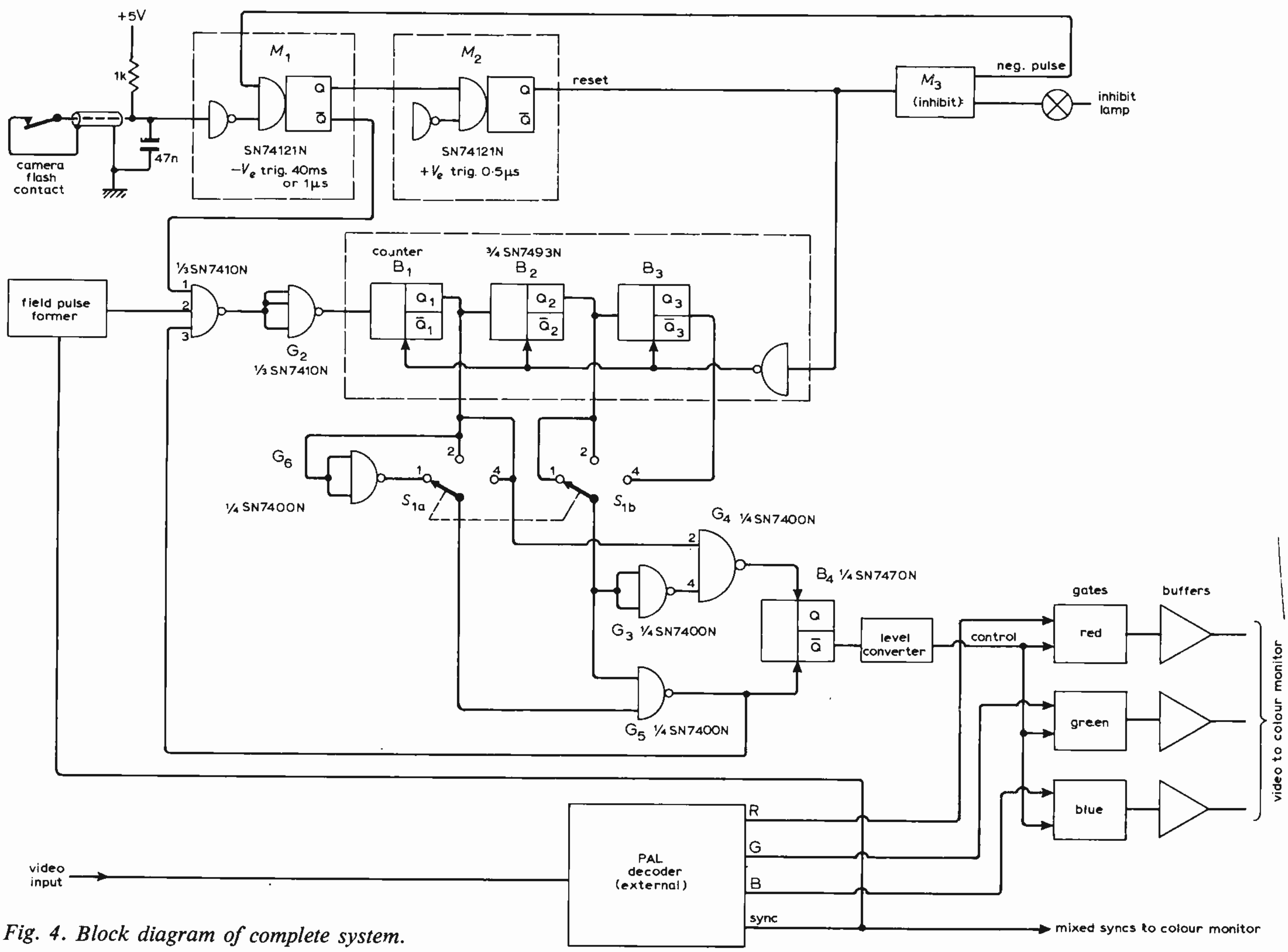


Fig. 4. Block diagram of complete system.

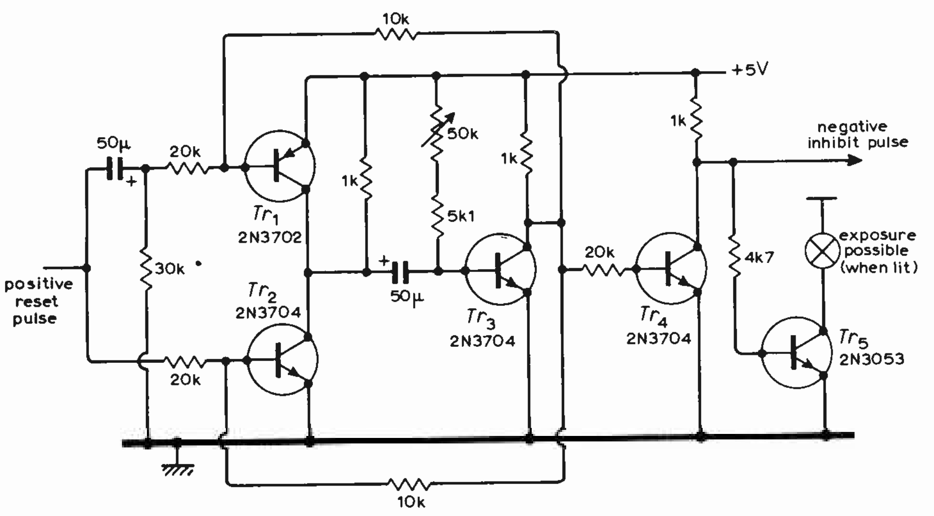


Fig. 5. This inhibit monostable circuit (M_3) is provided to prevent M_1 from being triggered by camera contacts making a second time.

camera shutter time required to fully cover the electronic exposure is made up of 40ms of electronic delay during fields 2 and 3, followed by 20ms wait for the start of field 5 and then 40ms exposure for fields 5 and 6. In practice this sequence is covered by choosing the next longest camera shutter speed which is 125ms — or 1/8 second.

The electronic shutter built for the moon landing photography had two additional features. The flash contact on the camera could bounce and produce a second pulse. To overcome this an inhibit circuit was incorporated that prevented the circuit responding to any pulses other than the first one for about 0.5 to 1.0s. A further refinement was a switch enabling the selection of one field (half a television picture), two fields (one picture) or four fields (two pictures) for photography.

Circuit description

Electronic delay and reset. Closing the camera flash contact triggers the integrated monostable circuit M_1 — Fig. 4. The 40-ms negative-going output of M_1 is used to inhibit the field pulse counter until the camera shutter has opened fully. The 47-nF capacitor at the input prevents spurious signals which may be picked up in a long flash cable from triggering the circuit. The leading edge of the positive output of M_1 triggers M_2. The 0.5-µs positive-going output of M_2 resets the field pulse counter B_1, B_2 and B_3 to the 000 state. When the counter is in this state gate G_5 will have a high output whatever the condition of S_1, and hence input 3 to gate G_1 will be high.

In the X mode of synchronization the timing capacitor of M_1 is removed from the circuit thus reducing the 40ms delay to 1µs which in this context is negligible.

Field counter. At the end of the 40ms or 1µs period of M_1 input 1 to gate G_1 becomes high. Positive-going field pulses from the field pulse former can now pass through G_1 and after inversion by G_2 clock the binary counter. As the counter is clocked into the 001 state by the first field pulse, gate G_4 is enabled as Q_1 is high and Q_2 or Q_3 (as selected by S_{1b}) is low but, after inversion by G_3, appears high at input 1 to G_4. The low output of G_4 sets B_4 thus producing a low on the Q output.

Gate G_5 is enabled on a count of either 010(2), 011(3) or 101(5) as selected by S_1 and when enabled resets B_4, causing the Q output to revert to high. An output pulse has thus been produced starting on the first television field pulse after the delay of M_1 and lasting for a further 1, 2 or 4 fields as selected.

Inhibit circuitry. Transistors Tr_1 to Tr_3, Fig 5, form a monostable circuit (M_3) which inhibits M_1 from triggering a second time if for any reason the flash contacts make a second contact while the shutter is still open. This second contact, sometimes produced as the shutter is in the act of closing, is not a problem with normal flash photography, as a bulb can flash only once in its life and electronic flash equipment has a recharge time of several seconds. As unwanted television 'flashes' disturb the photographer even when the shutter is fully closed, the period of M_3 is adjusted to be less than the minimum wind on time of the camera. Transistor Tr_4 is an inverting transistor, and Tr_5 and LP_1 indicate to the photographer the state of the inhibit circuitry. The monostable is designed with a complementary input to give a fast re-set time, necessary for correct inhibiting when photographing at maximum speed (that is as fast as the photographer can wind on the film).

Field pulse former. Mixed sync pulses derived from the video signal by the PAL decoder are passed *via* the emitter follower Tr_6, Fig. 6, to an integrating circuit (C_A, R_A). The output of the integrator switches Tr_7 at field rate, remaining line-rate information being removed by a shunt capacitor at the collector. In practice the monostable circuit Tr_8 and Tr_9 was needed as remaining broad-pulse serrations in the output of the integrator could produce a double pulse at the output of Tr_7, thus causing the field pulse counter to miscount.

Level converter and signal gates. The negative-going pulse output of B_4 is used to switch Tr_{10}, Fig. 7, to produce a positive-going pulse switching between −12 and +12V with respect to earth. This is used to switch three signal gates, one each for the red, green and blue video outputs of the PAL decoder. Switch S_2 turns off Tr_{10} thus allowing the video signals to be routed continuously to the picture monitor while setting up.

Video switches are of the series-shunt type and were chosen for their good isolation and lack of d.c. offset. The junction f.e.t. gates are driven *via* series diodes to prevent forward biasing of the gate junctions. The gates are decoupled to the control line to improve switching speed and to prevent pick-up at the high impedances produced when the series diodes are reverse biased. A standard Thames Television video buffer amplifier

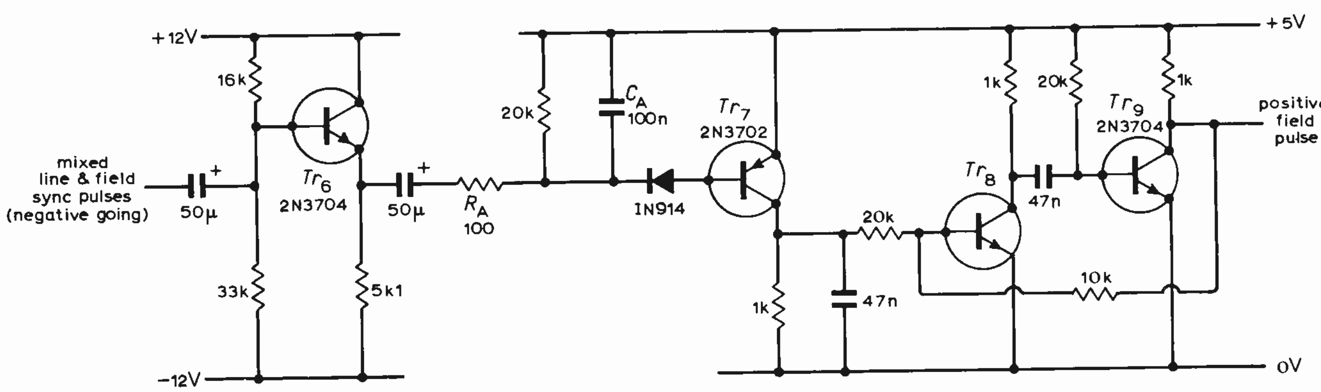


Fig. 6. Circuit for providing positive field sync pulses.

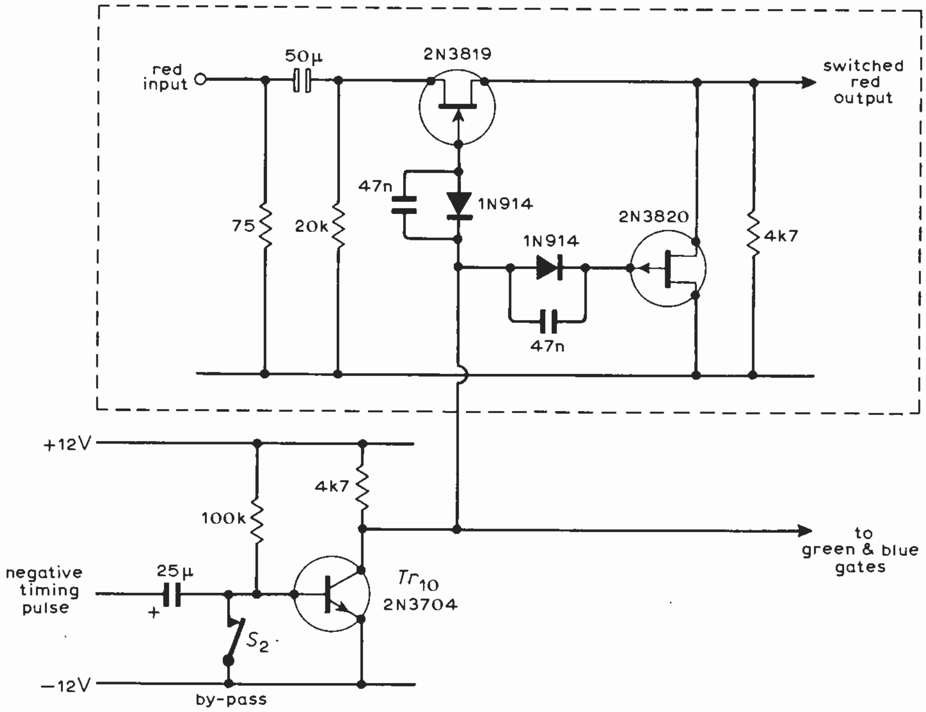


Fig. 7. This level changer converts the timing pulse output of B_4 into a form suitable for driving the three signal gates.

(type VA200) is used in conjunction with each signal gate to make up the small loss of the gate and to provide an output with a source impedance of 75 ohms.

At first sight it might appear more economical to install a single gate at the input to the PAL decoder. This is not possible because the colour decoding circuits must be fed continuously with the colour burst from a video signal as when interrupted they take a finite time to re-synchronize when reconnected. In addition, a supply of mixed sync pulses derived from the video signal by the decoder must also be provided for the colour monitor (which has a relatively long synchronizing time) and for the field pulse counter if the system is to start.

Exposure determination

The active exposure time is fixed according to the number of television fields required — usually two — and is therefore 1/25 second. Although the camera shutter may be open for longer than this, the television screen only lights up for two selected fields of that duration. A series of experiments, with the camera lens set to *f*4 and using Agfa CT18 reversal film rated at 50 ASA, showed that picture whites at a brightness of 85 cd/m^2 reproduced well without undue tonal compression, and shadow detail was optimum with the monitor black level set a little high. It was not easy to measure this increase in black level because it amounts to a very small figure. Because the shutter is open for longer than the active television exposure, this black level increase tends to produce a fogging exposure. This was not found troublesome with reversal film and can certainly be cancelled out in a negative/positive method of photography.

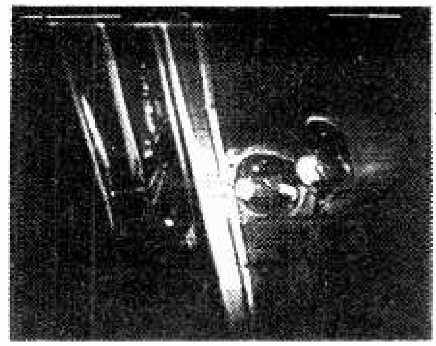
Applications

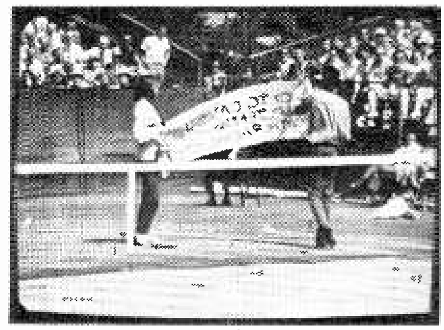
It is possible to apply the principle of this electronic shutter to domestic receivers by using the timing pulse from B_4 either to gate the YRGB or RGB signals to the picture tube or video amplifiers (after synchronizing information has been extracted) or by applying a blanking signal to the tube. Problems are likely to be encountered, however, with the response time of the e.h.t. stabilization circuits and the loss of field interlace which may accompany this. This problem was present on some picture monitors, as illustrated in Fig. 8. To be sure of obtaining precisely the correct picture it would of course be necessary either to use a second receiver or to arrange that the signal is extinguished at the start of the initial 40-ms delay. We see the time when a domestic television receiver could have a camera flash socket at its rear together with a switch marked 'tv' and 'photo' that will enable the enthusiast at home to get first class photographs off his television set.

The benefits of a reliable method of television stills photography was soon realized by production staff who now use this equipment to obtain stills from video taped programmes.

The ability of being able to select and photograph one single television field is particularly useful in recording the effect of pick-up tube lag.

The motion-capturing ability of such a photographic set-up is determined by the television pick-up tube being used and the television field repetition rate. A complete broadcast television picture is transmitted in 1/25 second, as in Fig. 8(c), which in common with motion picture films is fast enough to convey the appearance of continuous motion from a series of such pictures. One field of a televison picture will have a stopping speed of 1/50 second — which can be selected on the electronic shutter — but of course with only 312½ lines. Such effects as smear and lag, visible with today's generation of photoconductive pick-up tubes, will reduce the sharpness of moving pictures still further.


(a)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(c)

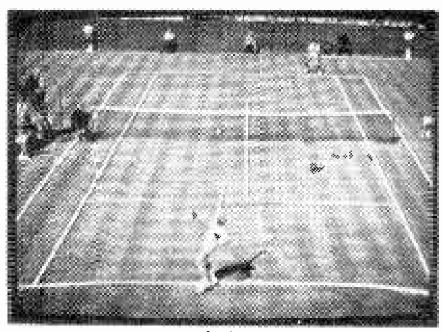

(d)

Fig. 8. Examples of electronic shutter in use. While (a) and (b) are satisfactory (c) shows movement too fast for the frame rate to capture, but almost frozen on each field. With both (c) and (d) poor e.h.t. regulation results in loss of interlace.

The Mirage of Instant Intelligence

A viewpoint on machines that become intelligent

by Michael B. Hawton

'Machines are not substantially more intelligent this year than they were last year', reports the man from *The Times*. They may never be unless we have a change in tactics. We should not expect to be able to build a machine with 'instant intelligence', like some coffee machine, but we might have some hope of building a machine which could *become* intelligent. In man and other animals, intelligence appears as certain types of data are accumulated so that processing operations can take place. Where the information is built-in (as with instinct), intelligence appears to be lacking. Does this also apply to machines? Would it make an intelligent machine an impossibility?

There is something elusive about intelligence in machines. We may decide to build a machine which will do something previously only achieved by intelligent beings, such as the recognition of patterns, mathematical calculations, musical composition, or whatever. When we have succeeded in this task we find, to our chagrin, that it can all be done by an unintelligent machine! Our goal proved to be a mirage, and we are still no nearer to finding out what intelligence is.

A possible way of avoiding this dilemma occurs if we decide to apply the adjective 'intelligent' to the behaviour, rather than to the hardware or pinkware that produced it. In just the same way, we apply the word 'brave' to the behaviour, and leave it to the bump-readers to look for the site of braveness. We may then devote our energies to finding out what sort of a system it is which will produce behaviour of the intelligent kind. When we look at men and animals we find that this is a special kind of system which progressively organizes its outputs on the basis of new input combinations. In this way, the new outputs, or behaviour, become intelligent.

Intelligence appears

It seems that the days when some could hope to knock up a piece of hardware and then say: 'this is an intelligent machine' are passing, except for optimistic computer salesmen. Intelligence appears gradually in living creatures: will this also be true of machines?

Let us suppose that we emulated Bram Stoker, and we 'knocked up' a man, to use the same idiom. Would he be capable of intelligent action? The answer has to be that he would not be capable of responding in an intelligent way—which really means 'in a biologically adaptive way'—without some experience of the world around him to guide his actions. How, otherwise would he know what to do? He would indeed be a monster! Learning by experience provides a way of selecting outputs from data in an almost infinitely large number of possible combinations of input, where only a limited number actually occur. It is a compromise, but the alternative is an equally large number of logic circuits, plus a creator, who has foreknowledge of all that is going to happen.

Much the same applies when we look at a human baby. It is not born with the knowledge of how to behave intelligently. It is equipped with a few reflexes to start it off, and then it learns to select suitable responses, and to build up sequences using previous experiences as a guide. Gradually it becomes capable of intelligent behaviour. Bear in mind that even speech and writing are forms of 'behaviour', considered as outputs.

When we examine an animal of some other species, whether it be a dog or cat, an earthworm or monkey, for signs of intelligence, we follow a fairly standard procedure. We train it to do something. Then we see if it has learned to do what we consider to be the intelligent thing. Some learn to perform well and are rated as intelligent cats, rats, or whatever. Others do not, and are considered less intelligent than their peers (as with humans). What is really being tested is their capacity to learn to do something in response to a signal, i.e. to perform certain data processing operations involving storage of data about a specific input and the outcome of a specific output, and setting up what is tantamount to a simple logic circuit connecting input and output.

What is so tantalizing about this is that if we try to short-circuit this process by artificial means (and this has been done, to some extent), then 'intelligence' disappears as far as this response is concerned. The response will then be elicited whatever overall conditions prevail, even if it is mal-adaptive. Because of this feature we should be able to see that it is likewise not possible to wire in, or programme in the data links in a machine in advance. If we do so, it must also be unintelligent. The intelligent machine must be able to forge its own links as it goes along, in order to preserve its adaptability to variable circumstances.

Adaptive behaviour

When we speak of animal behaviour as adaptive, we mean that the interactions with the world around the animal are directed so that certain input parameters (which correspond to bodily needs) may be held to predetermined limits. This may be direct reaction, as when we are hungry, thirsty, or cold, or it may be long term and indirect, as when hoarding nuts or writing a book. The long term indicates that a rather complex series of logical links have somehow been formed.

Attempts to model adaptive behaviour have been made by a number of people. Dr. W. Grey Walter, of Bristol, was one of the first, with his Machina Speculatrix. Such attempts have still not gone much beyond the stage where some kind of a mobile machine realizes that its batteries are running low and runs off to plug in and recharge. This is only simulation, of course: the sequence is triggered by a 'battery-low' signal which renders the machine sensitive to an approach signal from the plug area. The 'charged-up' signal reverses the sensitivity and the response. In this case reaction is all 'wired in' and seems so very different from the aroma of frying bacon dragging us out of bed . . . . but is it really so different? When we start to think in terms of the transfer of information and processing operations, instead of reflexes and responses, it is sometimes hard to draw the line.

Such machines do tend to exhibit some intelligent-like qualities, and psychological-type effects may appear in the behaviour of groups. The important thing appears to be that they do something. They do not just produce outputs, like a computer. Furthermore, they do things like recharging their batteries which are for their own benefit, i.e. they are adaptive in behaviour. This seems to be a critical factor, and if this is so, intelligent machines must be ones which can do things, and do things for themselves. This means in practice that they must be some kind of robot, but one that is capable of adaptive behaviour.

Adaptive systems

In engineering we have evolved what are known as 'adaptive systems' to cope with situations like flying an aircraft automatically, where there are a large number of simultaneously variable inputs, and many possible outputs. Here again the object is to keep the input parameters within certain predetermined limits by adjusting the behaviour output.

Certain advanced systems are capable of something which is the closest approach to 'thinking' that one could find. They run a test loop which enables a provisional output (set up in accordance with input parameters) to be tested by comparison with stored data within the system. A decision is then made whether to use this output or to alter in accordance with the additional information. This is extraordinarily similar to what happens when we decide to do something, review the consequences, and alter our response. Psychologists call this process 'vicarious trial and error'.

Aircraft and missile systems are concerned with continuous adaptation to many changing inputs. Living systems likewise have to adapt continuously, but they also adapt their whole response upon successive occasions. They have no stored information provided as above, so they have to build up their own store by a process of trial and error, as they go along. It might be not only catastrophic, but also ruinously expensive for machines to do the same. It is this serial improvement of performance which lays the ground for future (and abstract) vicarious trial and error operations. It is at this point that machines and animals diverge sharply. The animal system is not only able to do things, and do them for their own benefit, but they can also *learn* to do better.

Machines that learn

Some kind of learning has to take place to provide a basis for intelligent behaviour. However we look at the question, we always come back to this basic point. If true, it means that we just cannot make a machine intelligent from the word go. It will have to learn to become bright, as we do.

This is acknowledged in some of the machines which were described earlier. Rosenblatt's Perceptron, or Dr. Aleksander's SLAM units are concerned with the problem of learning to perceive patterns in a multi-channel input. With feedback, and working with or without computers, they have tried to modify the input circuitry successively, in order to achieve recognition. This is very important work, for it does emulate some of the processes of nature which, although not working with digital circuits, does appear to store and process the data by altering the circuitry and even the values of the components upon successive occasions. No wonder it is difficult for us to simulate! However, intelligent selection of a response need not depend on multi-channel inputs. This is a useful refinement of the higher order systems, but results can be obtained with an inordinate number of single channels, so it is not the key to intelligence.

'Learning to do', i.e. learning to make a physical response from a repertoire, is another type of learning. The Unimate is an industrial robot able to copy quite a complex series of movements (even pouring a cup of tea) after being run through manually, so that the sequence can be recorded on tape. A profile-following lathe could be rigged not only to record the sequence of movements on tape, which could be used to educate other digital lathes, but could also optimize its own performance on successive occasions. That is, it could learn to do better—another of our criteria.

Another machine which appears to learn to do better, and even to anticipate what might happen, is the machine which plays chess. This is really a rather elaborate conjuring trick, which has been done by many who have mastered the game. Although it may look like a game of chess between man and machine, in reality the machine follows with inexorable (but very complex) logic the moves of the man, who may thus be said to manipulate the machine indirectly, without appearing to do so. Games like this serve to demonstrate that intelligent behaviour requires a means of performing logical operations on a large scale, using both current and stored data. It is a great mistake to suppose that the converse is true. Computers have this capacity for logical operations etc., but it does not make them intelligent, even though they may be much better than us at things like mathematical calculations and I.Q. tests.

Conclusions

All this points to a very high degree of organization of the data inputs and processing operations in the system capable of intelligent behaviour. This is exactly opposite to the view that random collections of units, supplied with quite random inputs, will somehow or other produce some manifestation of intelligence. It seems supremely optimistic to think that such a problem will be solved automatically.

We have seen that intelligence may be regarded as an attribute of behaviour, rather than of the man or the beast, just as we might speak of braveness or timidity. It would not be too difficult for us to build a brave little robot, or a timid one, but an intelligent one is a very different proposition. We would first have to build an unintelligent one, and then enable it to accumulate information, which would gradually transform it into an intelligent one. As we have pointed out, it would have to be able to do things, do them for its own benefit, and learn to do them better as it went along. It would be a self-organizing, adaptive, learning system. Its future outputs would be in accordance with the data stored, which are continuously formed by the various combinations of inputs which have actually occurred (its experience).

For a start, a 'seeing' robot will be linked up with a large scale computer which will handle the data generated by the robot, and perform the logical operations and store the data accumulated. The nearest approach to all this comes in machines such as the Hitachi Hand, where the machine can manipulate blocks in space according to data in a drawing. Its makers have begun to realize the frightful lesson that we have to learn. If we make a machine which can become intelligent, which will be adaptive and self-organizing, then it will only serve its own purposes. It will not be of any particular use for our purposes. We will have spent an enormous amount of money to make a useless machine! Of course it may tell us about the nature of intelligence, but who is willing to pay money for that? When it comes down to brass tacks many people do not want it found out.

The purpose of an intelligent system is simply the survival of that system in a potentially hostile environment. To achieve this it need be no more intelligent than any other machine to start with, but with a bit of luck, this system will survive long enough to learn to cope with some simple problems at a later date: firstly real only, and then perhaps symbolic ones as well. There is nothing magical about this; it is just a matter of considering what kind of data processing operations occur in what we normally call intelligent behaviour, and then simulating them. This approach seems more hopeful than those which suppose that we shall somehow stumble upon a machine with instant intelligence. Then we may see intelligence slowly appear in the machine.

World of Amateur Radio

Oscar 6 in orbit soon?

In the section on 'Space activities' in my March contribution I included a description of the Amsat-Oscar-B (A-O-B) amateur communications satellite being prepared for orbiting as a 'piggyback' package to a 1972 meteorological satellite. This launch is now expected in June or July but, because the development of some sections of the A-O-B satellite has fallen behind schedule, Amsat* have decided to press ahead with a simplified Oscar satellite; this is at present known as A-O-C but once successfully launched into its 1500-km polar orbit would become Oscar 6.

The revised plans include the Amsat 144/29MHz linear translator, but omit the 'Euro-Oscar' and the Australian 432/144MHz translators which it is hoped, however, will be carried on a later occasion.

The main features of the A-O-C satellite will be the inclusion of the 145.98MHz up and 29.5MHz down linear repeater, with an output of between one and two watts p.e.p., a 200-mW 29.45-MHz beacon and a 435.1-MHz beacon of about 400mW power; it is also expected to include the 'codestore' facility for storing and retransmitting short Morse or teleprinter messages. These would be transmitted on the 29.5-MHz translator or the 435-MHz beacon. Operational lifetime is still expected to exceed one year.

If all goes well, it will be possible to put signals through the repeater from quite modest amateur stations — for example a 144-MHz transmitter with 7W output and a four-element Yagi beam at 2000 miles range. The reception of the down-link signals on 29.5MHz may demand rather more critical equipment but the experience gained with Oscar 5 suggests that in practice these signals should be widely heard.

N.A.S.A. has regretfully turned down Amsat's 'Skylarc' proposals to provide a 28-MHz amateur station on the 'Skylab' manned orbiting laboratory planned to be launched during 1973. N.A.S.A. agreed that the proposals appeared 'feasible and reasonable' and the offer was not rejected out of hand.

Amsat nets operate on the second and fourth Sundays of each month at 18.00 G.M.T. on 14.28MHz and at 19.00 G.M.T. on 21.28MHz, with stations outside the United States invited to check-in.

* Radio Amateur Satellite Corporation

Pirates and phone phreaking

From time to time we have reported the fairly large number — up to around 100 a year — of successful prosecutions brought under the U.K. Wireless Telegraphy Act for unlicensed use of transmitting equipment. Some arise from 'pop pirate' stations but some from amateur-type unlicensed operation. These prosecutions are brought by the Ministry of Posts & Telecommunications as a result of investigations made by Post Office engineers. In a high proportion of cases, the court orders forfeiture of the equipment.

'What happens to this equipment?' I recently asked the M.P.T.

Much of it, I was told, is of very indifferent quality which is considered potentially dangerous, falling far below accepted safety standards. All equipment is therefore tested — and if found unsafe is destroyed. And the remainder? This is at the disposal of the Minister — and in practice, I gathered, is often used by Post Office engineers to help them in their task of tracking down suspected offenders. So it would seem that the pirate station of today is the counter-pirate station of tomorrow.

The attractions of amateur radio undoubtedly include the use of technical skill and know-how to obtain free communication with people all over the world. Unfortunately a similar motivation is apparently encouraging the growth of the pseudo-hobby of phone phreaking — the illegal exploitation of telecommunications techniques to make free international telephone calls.

The craze is reported to be worrying telephone companies in the United States and efforts are being made to stamp on the practice.

It is doubly unfortunate that a number of American radio amateurs have been concerned in phone phreaking in Montana and that the very first case of this type to reach the courts in the U.K. involved a 19-year-old Oxford undergraduate who has held a Class B amateur licence since 1969. Amateurs will have to be especially careful that phone phreaking does not become associated by the public — or the Post Office — with amateur transmitting.

On the bands

Conditions on the h.f. long-distance bands, particularly 14 and 21MHz, remained very good throughout most of April, with 'all-continents' coming through at good strength on many days. The appearance of newly licensed amateurs using callsigns in the sequence G4BAA onwards indicates that the 676 calls in the sequence G4AAA were exhausted in just over 12 months. Earlier this year, Ray Naughton, VK3ATN, made 144-MHz 'moonbounce' c.w. contacts with Michael Staal, K6MYC, California, and Lionel Edwards, VE7BQH in British Columbia. Unlike most amateurs attempting moonbounce contacts he uses stacked rhombic aerials; his transmitter has a 4CX250 valve in the power amplifier and his receiver uses a 6CW4 Nuvistor pre-amplifier.

Prof. Franco Fanti, I1LCF, has notified us that 37 amateurs submitted entries for the transmitting section of the recent world-wide slow-scan TV contest: leading station was the American W9NTP with 63 contacts producing 7560 points; runner-up was the Dutch station PAOLAM. Two British stations, G5ZT (who made 41 contacts) and G3ZGO, entered. Four amateurs entered a listening-only section.

The Wireless Institute of Australia is seeking the issue of Novice licences for a trial five-year period: these would have a distinctive callsign and permit the use of up to 10 watts c.w. on limited portions of the 1.8, 3.5, 7, 21, 27 and 28-MHz bands.

A.R.R.L. headquarters now transmits its news bulletins and code practice sessions on a new set of frequencies. They go out simultaneously on, c.w., 1805, 3580, 7080, 14080, 21080, 28080, 50080 and 145588 kHz: phone bulletins are on 1820, 3990, 7290, 14290, 21390, 50190, and 145588 kHz. The r.t.t.y. frequencies are unchanged.

In brief

An R.S.G.B. 'National Mobile Rally' will be held at Woburn Abbey on August 6 . . . Southdown Amateur Radio Society is holding its first mobile rally in association with the Polegate Steam Engine Rally organized by Southern Steam. The site will be at Wilton Gate on the A27 road (8 miles from Lewes), with talk-in stations on 145,70 and 1.8 MHz (details, E. F. Moore, G3JFM 74 Wannock Avenue, Lower Willingdon, Eastbourne) . . . The 15th Longleat Mobile Rally, organized by the Bristol R.S.G.B. Group, is being held on June 25 with overnight camping facilities and talk-in stations on 1.8, 3.5 and 144 MHz . . . Verulam Amateur Radio Club jas a rally on June 17 at Salisbury Hall, London Colney, Herts . . . The special call, GB3FK, will be used during the Festival of Kidderminster, June 23 & 24.

Pat Hawker, G3VA

About People

To commemorate the work of the late Sir Edward Appleton the Royal Society instituted in 1969 the triennial award of the Appleton Prize to a distinguished scientist working in the field of ionospheric physics. The second prizewinner is **Professor R. A. Helliwell,** of Stanford University, California, who has made 'outstanding contributions to the theory of the propagation of electromagnetic radiation in the Earth's magnetosphere and to the understanding of whistler phenomena and very low-frequency noise emissions in this region'. The prize is awarded on the occasion of the General Assembly of the International Union of Radio Science (U.R.S.I.) of which Sir Edward was president from 1934 to 1952. The next General Assembly will be in August in Warsaw. On the same occasion, the Balthasar van der Pol and the J. H. Dellinger Gold medals of U.R.S.I. will be presented to **Dr. B. D. Josephson** and **Professor A. Hewish,** respectively, both of the University of Cambridge. Dr. Josephson, who contributed an article on superconducting devices in our October 1966 issue, has also received the Institute of Physics' 1972 Guthrie Medal 'for his contributions to theoretical physics'.

R. W. Bell, B.Sc., has been appointed technical manager of Jackson Brothers (London) Ltd. Mr. Bell, who was previously senior engineer with the company, now assumes responsibility for all product design, product engineering, quality assurance and inspection and also detailed technical liaison with commercial and government organizations.

Eric A. Sawkins has been elected president for 1972-73 of the Association of Public Address Engineers. Mr. Sawkins is sales manager of the audio communications division of Westrex Company Ltd.

Derek J. Steel, B.Sc., M.E.E., is appointed sales manager of the Specialized Components Division of Marconi Communication Systems Ltd. He originally joined Marconi's as a graduate apprentice in 1958 after three years at Manchester University, and having gained his master's degree in electrical engineering in the United States at Louisville University. He was in the Marconi-Elliott Microelectronics Division, at Witham, Essex, but left and has since worked in the semiconductor marketing field with both Fairchild and G.E.C. **Peter Loweth,** who is appointed to the new position of exports sales manager in the Specialized Components Division. Joined Marconi's in 1959 and has been with the Division since 1964.

Peter Gooding has joined Bell & Howell Ltd as marketing manager for the new data systems product group. Mr. Gooding, who is 31, started his career as a radio officer in the merchant navy and later spent five years with the B.B.C. in television engineering and management services. Prior to joining Bell & Howell, he was with Honeywell Information Systems for six years, initially in the computer engineering and marketing fields, and latterly as a marketing consultant for the U.K. Data Processing Division.

P. Humphry has been appointed works director of Gardners Transformers Ltd, of Christchurch, Hampshire. He joins the board as an associate director with special production responsibilities. Aged 36, Mr. Humphry joined Gardners in 1965 as production

P. Humphry

controller after service with the Royal Engineers. He has been works manager since 1970.

R. J. Gresham, M.I.E.E., has joined Gardners Transformers in the new position of commercial manager with overall responsibility for sales and contracts. Following national service, Mr. Gresham gained further engineering experience with A.E.I., Johnson

R. J. Gresham

and Phillips, and London Transformer Products division of G.E.C. Transformers of which he was director and general manager.

M. P. Mandl has rejoined English Electric Valve Co. Ltd as sales manager. Mr. Mandl, who has an honours degree in physics from Imperial College, London, was previously with English Electric Valve Company from 1958-1968 and then with Raytheon International, first at their London office and later in America as director of their international sales and services. In January 1971 Mr. Mandl returned to England to become general manager of G.E.C. Semiconductors Ltd.

Following Mr. Mandl's transfer from GEC Semiconductors Ltd to the English Electric Valve Company, **C. A. P. Foxell** has become manager. Mr. Foxell joined G.E.C. in 1947 as a student and became manager of the Semiconductor Research Laboratories at the G.E.C. Hirst Research Centre, Wembley, in 1968. He transferred to Witham, Essex, on becoming technical director of G.E.C. Semiconductors in 1971. He will be based at the new manufacturing operation at Wembley, which is in close proximity to the Semiconductor Research Laboratories at the Hirst Research Centre.

The Instrument Division of Advance Electronics has appointed **Tony Grant** as contracts manager. After serving an apprenticeship at the Royal Aircraft Establishment, Farnborough, he entered the industrial electronics field with Ferranti Ltd, where he was concerned with calibration. He later joined Elliotts as an engineer and after moving on to the sales team of Avo Ltd, has been a sales engineer with Advance Electronics Ltd for the past two years.

Richard Osborne has been appointed technical sales executive in the recently formed Marketing Services Division of the McMurdo Instrument Co. Ltd. He will be responsible for customer liaison on technical enquiries. Formerly with McMurdo's parent company, Louis Newmark Ltd, Mr. Osborne has 18 years' experience in electrical engineering within the Group. McMurdo have also announced the appointment of **Brian Woodward** as market research executive in the Marketing Services Division. He has joined McMurdo from De La Rue Instruments Ltd.

N. Dundas Bryce has resigned from Belling & Lee Ltd after 42 years' service with the company which he joined as sales manager. He was a member of the board for many years. Mr. Bryce was an amateur transmitter in Edinburgh before the first world war. He served in the Royal Flying Corps as a wireless operator and instructor, and later in the R.A.F.

Allan Cowley has been appointed product sales manager for power supplies and wound components within the Rectifier Division of ITT Components Group Europe. He will be based at Harlow, Essex. Mr. Cowley joined ITT from McMurdo Instruments where he was marketing manager.

Microwave and Electronic Systems Ltd, of Newbridge, Scotland, have appointed **Chris Childs,** B.Sc., to the newly created position of field sales manager. Mr. Childs (27) studied at Reading University and until recently was with Impectron, where he was head of the Microwave Sales Division.

Daly (Condensers) Ltd, of Weymouth, have announced that **K. S. Oliver** is joining the company. Mr. Oliver joins Daly from the TCC Capacitor Division of the Plessey Company. He spent 30 years with the Telegraph Condenser Co., finally as chief designer.

OBITUARY

Douglas Willis, M.I.E.R.E., who had been with Marconi Instruments for 31 years, died on April 4th aged 50. During his career with Marconi Instruments he had held the appointments of chief design engineer, market development manager, and at the time of his death was divisional manager. Just after the war, Mr Willis spent over two years in the U.S.A. where he played a major part in the inauguration of the Marconi Instruments sales and service operation in New York.

Literature Received

For further information on any item include the WW number on the reader reply card

ACTIVE DEVICES

An 'optimized' microcircuit op-amp chart is available which compares specifications of the Philbrick 1300 series op-amps with those of the standard 741s. Teledyne Philbrick. St. Peter's House. North Street. Chichester. Sussex WW401

A catalogue we have received describes the products of Abbot Transistor Laboratories Inc whose U.K. representatives are Cole Electronics Ltd. Lansdowne Road. Croydon CR9 2HB WW402

Thyristors and triacs are the subject of a data book sent to us by A.E.I. Semiconductors. Carholme Road. Lincoln ....Price £1.85

We have received a data sheet on types BB1-BB100 subminiature silicon rectifier diodes. International Rectifier. Hurst Green. Oxted. Surrey WW403

A leaflet specifying ohmic op-amps from Bourns (Trimpot) Ltd. Hodford House. 17/27 High Street. Hounslow. Middlesex. also includes information on voltage regulators WW404

The main ratings. characteristics and dimensions of f.e.ts from Centralab (U.S.A.) are given on a data sheet sent to us by Joseph Lucas (Electrical) Ltd. Electronics Product Group. Mere Green Road. Sutton Coldfield. Warwickshire WW405

PASSIVE COMPONENTS

Crimp-to-wire type 'PN' terminals. for connecting stranded or solid wire to 0.025in square pins. are described in a leaflet from Berg Electronics NV. S-hertogenbosch. Helftheuvelweg. 1. Holland. P.O. Box 2060 ....WW406

We have received two publications from ITT Components Group Europe. Edinhurgh Way. Harlow. Essex:

- Components review No.2 including information on polyester and polycarbonate film capacitors and potted Si rectifiers.............WW4[illegible]
- Thermistor application report on coil compensation..WW409

'Capacitors and passive components' covers the current range of passive components from Thomson-CSF. Concorde Instrument Co. 28 Cricklewood Broadway. London NW2 ....WW410

Advance information on a range of 'touch' switches is given in a leaflet received from MTE Components Ltd. Leigh-on-Sea. Essex SS9 5LS WW411

B & R Relays have sent us the revised and reprinted version of their manual on dry reed switches. B & R Relays Ltd. Temple Fields. Harlow. Essex ...WW412

APPLICATIONS

We have received two application notes and a data sheet describing Centralab photoelectronic materials and devices from the U.K. distributors Joseph Lucas (Electrical) Ltd. Electronics Product Group. Mere Green Road. Sutton Coldfield. Warwickshire:

- 'Optoelectronics & Light Sensors' (Note G-202) WW413
- 'Survey of Photosensitive Materials and Devices' (Note G-205)........................WW414
- Data Sheet L800-1 describing l.e.d. CL-100 ....WW415

'Semi-conductor test guide' from Philips Electronic Instrument Department. Pye Unicam Ltd. York Street. Cambridge. CB1 2PX. describes semiconductor test methods using Philips test equipment. WW416

M-O Valve Co. Ltd. Brook Green Works. London W6 7PE. have sent us a booklet on the structure. types and future trends of their bi-colour cathode-ray tubes WW417

'Cable fault location using pulse reflection techniques on communication and power cables' is the title of application note 110 from Cossor Electronics. Elizabeth Way. The Pinnacles. Harlow. Essex WW418

EQUIPMENT

The 1972 test equipment catalogue from Z & I Aero Services Ltd. 44a Westbourne Grove. London W2 5SF. contains specifications and prices of oscilloscopes. chart recorders. bridges and meters WW419

A sound level indicator. the CS15B. is described in a data sheet from Custom Electronic Associates (Instrument Division) Ltd. Redbourne House. Queen Street. Scarborough. Yorkshire WW420

Specifications for millivoltmeter TM6 (50kHz to 1,500MHz) are given in Publication T2. Farnell Instruments Ltd. Sandbeck Way. Wetherby. Yorkshire LS22 4DH WW421

We have received a data sheet describing the type 8325A microwave test set for testing r.f. transmission line runs (coaxial and waveguide). Hewlett Packard Ltd. 224 Bath Road. Slough. Bucks. SL1 4DS. WW422

Data sheets sent to us by Aveley Electric Ltd. Arisdale Avenue. South Ockendon. Essex. give specifications of Rhode & Schwarz equipment:—

- SMDA signal generator (a.m.-f.m) WW423
- UIG microvoltmeter WW424
- FAB f.m.-a.m. demodulator WW425
- SBTF TV channel signal generator WW426

All products from Systron Donner Ltd. Leamington Spa. Coventry. are described in the 1971/72 instrument catalogue WW427

A leaflet covering the RF-1500 series of v.h.f.-f.m. two-way radios for mobile or base-station use is available. RF Communications. Inc.. 1680 University Ave.. Rochester. N.Y. 14610 ....WW428

We have received a leaflet describing models 1034 and 1035 portable r.f. power meters. Pacific Measurements Inc.. 940 Industrial Avenue. Palo Alto. CA WW429

The following data sheets and brochures were collected at the recent Electronics from Finland exhibition held in London.

Ollituote Oy. 02320 Kivenlahti. Finland.

- Arterial pressure meter.............................WW442
- Venous pressure meter.............................WW443
- Cardioscope WW444
- Defibrillator WW445

Teletrio Ltd. 124a High St. Sutton. Surrey. Agents for Teleste Oy.

- 'Teleste for modern radio techniques'.....WW446
- 'Teleste brings the sound where it is needed', audio equipment for professional applications WW447

Oy Nokia AB Electronics. P.O. Box 780. SF-00101 Helsinki 10. Finland.

- 'Electronics 72'. General catalogue covering communication systems. data processing. instrumentation etc. WW448
- 'LP4840 Multichannel Analyser' WW449

A publication on Tektronix TV products contains information on picture monitors, test signal generators. oscilloscopes. vectorscopes. sync generators and waveform monitors and spectrum analyzers. Tektronix U.K. Ltd. Beaverton House. 36-38 Coldharbour Lane, Harpenden, Herts. WW450

A.P.T. Electronic Industries Ltd. Chertsey Road. Byfleet. Surrey have produced a leaflet on their new TRU range of d.c. power supplies...................WW451

Adcola Invader and 'A' series of soldering instruments are the subjects of two leaflets from Adcola Products Ltd. Adcola House. Gauden Road. London SW4 6LH WW430

A leaflet describing a 30-channel tape programmer has been sent to us by Joyce Loebl & Co. Ltd. Team Valley. Gateshead. Co. Durham. NE11 OUJ............... ....WW431

Specification sheets from Microwave Associates Ltd. Luton, Bedfordshire, describe:—

- ML 19100 series Class 'C' solid state microwave power amplifiers WW432
- MA 8319 Series p.i.n. tunable diode switches WW433
- MA 1100 Series hybrid mixers and modulators WW434

The 'Cee Wave' docking radar system is described in publication No. G5.37 from James Scott (Electronic Engineering) Ltd. 68 Brockville Street. Carntyne Industrial Estate. Glasgow. E.2. ....WW435

GENERAL INFORMATION

Radio (v.h.f.. l.w.. m.w.) and television (v.h.f.. u.h.f.) transmitter information in the U.K. is given in a booklet 'Television and Radio Stations — 1972'. British Broadcasting Corporation. Engineering Information Department. Broadcasting House. London W1A 1AA.

'Tape Questions — Tape Answers' is the title of a booklet containing information on all aspects of tape recording. BASF United Kindom Ltd. P.O. Box 473. Knightsbridge House. 197 Knightsbridge. London S.W.7 ....Price 40p

We have received the 1972/73 prospectus of The Polytechnic of North London, Central Administrative Offices. Holloway. London N7 8DB.

The Spring 1972 edition of 'Stereosound and News' includes details of the company history and its products. Stereosound Production Ltd. 12-14 Wakefield Road, Brighouse, Yorkshire HD6 1PQ..... ....WW437

Two publications from the British Standards Institution. 2 Park Street. London W1A 2BS. are:—

- BS 9522: 1972 Rules for the preparation of detail specifications for circular electrical connectors of assessed quality (for frequencies below 3MHz)....................Price 85p
- BS 9130: 1972 Specifications for potentiometers of assessed quality: generic data and methods of test..............................Price £2.75

We have received leaflets and a price list describing the 'Master Series' of loudspeaker systems for p.a. and discotheque use. Midland Sound Ltd. 57 Albert Street. Rugby. Warwickshire WW439

Tar Residuals Ltd. Plantation House. Mincing Lane. London EC3M 3HS. have sent us a leaflet describing the Ernst Votsch Kalte Klimatechnik thermal shock test chambers (type VMS) WW440

New Products

Millimetre-wave sweep generator

Model 44015H sweep generator (Hughes Aircraft) has a centre frequency between 58 and 62GHz and swept bandwidths between 0 and 10GHz. It is available in the U.K. from Impectron. The source is an impatt (impact avalanche and transit time) diode mounted in a cavity (44016H) separated from the power supply (44017H) and a flexible coaxial cable. This provides a voltage-adjustable d.c. bias current to the source which can be varied manually by a built-in potentiometer or electronically by an external 15V saw-tooth supply. Power output from the RG98 waveguide is up to 30mW at the frequency specified. Impectron Ltd, 20-31 King Street, London W.3.
WW304 for further details

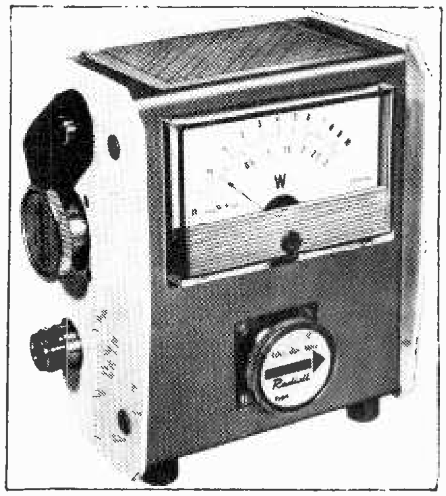
Broadband r.f. amplifier

A modular thick-film amplifier covering the range 10 to 500MHz is available in TO-8 form from Auriema. It is made by Optimax Inc. Known as the AH-52, the amplifier is intended to be inserted directly into microstrip circuits, but accessories such as circuit boards and enclosures can be obtained so that up to four stages can be cascaded in one enclosure. The modules can be operated in ambient temperatures ranging from −55 to +100°C. At V_{dc} = 12V, the minimum gain is 13dB, impedance 50 Ω, d.c. 20mA, maximum noise figure 5dB. Auriema Ltd, 442 Bath Road, Slough SL1 6BB.
WW303 for further details

Digital counter

Dana Electronics' 8000B series of high-speed digital counters is a range of five models, three of them spanning up to 150MHz on direct count. For measurements up to 500MHz a pre-scaler is used incorporating a fast-acting wideband a.g.c. for constant performance with signal fluctuations between 50mV and 1000mV, and full accuracy is maintained up to 99% amplitude modulation of the r.f. signal. All models in the range have an 8-digit display, analogue voltage output of trigger level settings, and a reference oscillator with $\pm 1 \times 10^{-8}$ per day ageing rate. Measurements have an accuracy of one part 10^8.

The Model 8010B at the lower end of the price range has 100ns time interval resolution and a frequency range to 150 MHz, while the higher-cost Model 8035B has 10ns time interval resolution and a frequency range extending to 550MHz. Trigger-level drift is less than 5% of full scale over 10° C and 200 hours operation, after initial setting. Prices range from £595 to £1,225. Dana Electronics Limited, Bilton Way, Dallow Road, Luton, Beds.
WW312 for further details



Wattmeter

A portable directional wattmeter made by Radiall Microwave Components allows both incidental and reflected power to be measured without the need for circuit disconnections when inserted in a coaxial line. This facility is obtained by the use of direction 'plug-in' elements which are reversible in the front panel of the instrument. The instrument has a 50 Ω characteristic impedance and a line v.s.w.r. of less than 1.05. Insertion loss is stated to be less than 0.1dB and the instrument accuracy ± 5% f.s.d. Twelve plug-in elements are available covering the frequency range 27MHz to 1GHz in four bands with a choice of 3, 10 or 30W maximum power rating. Radiall Microwave Components Ltd, Romar House, The Causeway, Staines, Middx.
WW310 for further details

Ni-Cd batteries

A new Alcad, type DLP, range of nickel-cadmium cells, introduced by Alkaline Batteries Ltd, provides capacities of up to 315 ampere hours from cells in plastic containers. The batteries are vented and now offer equal performance to the steel container type. Alkaline Batteries Ltd, P.O. Box 4, Union Street, Redditch, Worcestershire.
WW302 for further details

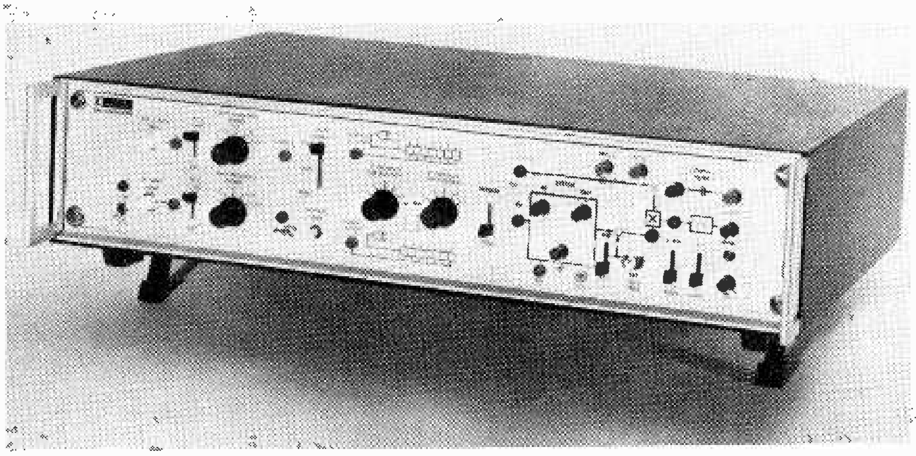
Filter system

The Universal Audio model 565 filter set (Little Dipper) is a filter unit with four separate, continuously tunable, cascaded filters providing low-frequency cut-off, high-frequency cut-off and two band reject (or optionally bandpass) filters. Mounted on a standard rack of 5¼in panel height, it provides the following filter arrangements: (a) Low-frequency background; an 18dB per octave low cut-off filter operates over the tunable range 20-200Hz. (b) Centre frequency enhancement or rejection; two band reject (dip) filters and variable notch width tunable from 20Hz to 20kHz. (c) High frequency noise or harmonics; a second 18dB per octave filter being tunable over the range 2-20kHz. F. W. O. Bauch, 49 Theobald Street, Boreham Wood, Herts, WD6 4RZ.
WW314 for further details

Serial mode correlator

A self-contained serial mode correlator, (model 108A) using a pseudo random sequence as the source signal (max. length 127 bits, max. internal clock rate 40kHz) has been produced by Sigma. The delay time of the signal necessary for processing can be sequentially increased in steps of 0.01 of the sequence generator clock period, at a rate governed by a low-frequency source. This gives rise to a good approximation to a smoothly increasing delay of unlimited length. Post multiplier processing is implemented using a linear phase low-pass filter, thus permitting rapid scan of delay. Correlation functions are thus displayed as continuous traces. An internal noise source can be added into the signal channel to demonstrate operation in the presence of wideband noise. Sigma Associates, 47A Woodville Gardens, London W.5.

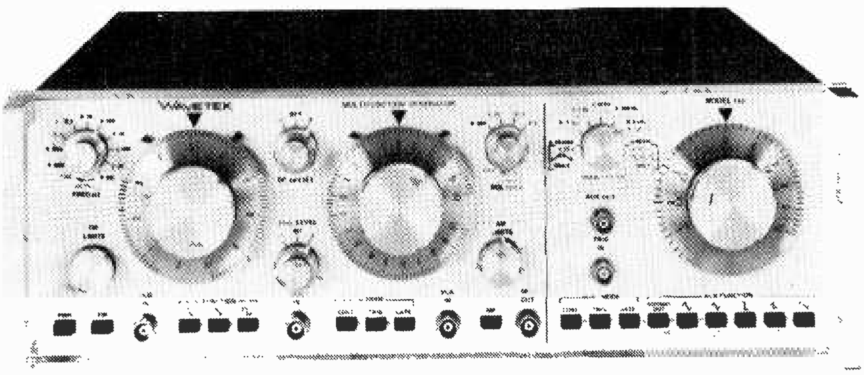
WW311 for further details



Multifunction generator

The Wavetek Model 146 multifunction generator provides sweep frequency modulation, amplitude modulation, frequency shift keying, triggered and gated operation and swept amplitude modulation. It is an integrated unit requiring no external drive modules. Calibrated sweep and calibrated modulation of frequency and amplitude are provided. Within this instrument are two complete generators and it has the capability of using them as two individual sources. One can be used to sweep the frequency of the other with positive, or negative ramp, or to modulate the amplitude and/or frequency of the other with a sine, square, triangle, or ramp modulation envelope. Utilizing Wavetek's voltage controlled generator and voltage control of amplitude circuitry, the main generator provides analogue voltage control over frequency and amplitude of the output. The caliper dial system allows calibration without using an external oscilloscope. Fluke International Corporation, Garnett Close, Watford WD2 4TT.

WW309 for further details



Displacement detector for servo mechanisms

The Photobridge consists of two photoconductive cells each in the form of a right-angled triangle and mounted together to form a rectangle 10mm long × 7mm wide. The mounting is a ceramic strip 25mm long × 10mm wide × 2mm thick and is complete with lead wires. With these two photocells wired into a bridge circuit, they will provide a variable output voltage directly proportional to the position of a slit of light falling across the cells. By using two photocells, variations in illumination level are ignored as the resistance ratio remains the same regardless of the light level. Photain Controls Ltd, Randalls Road, Leatherhead, Surrey.

WW315 for further details

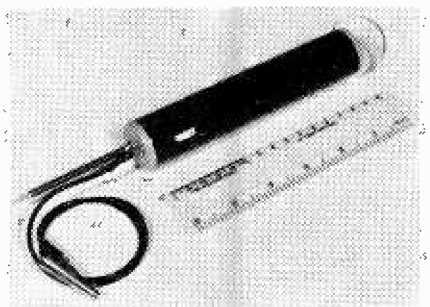
Frequency/voltage converter

The D/VFV/2 converter functions in the voltage-to-frequency or frequency-to-voltage conversion mode, the change from one mode to the other being affected by re-arrangement of readily accessible link connections. The conversion rate in either direction is adjustable from 10Hz/V to 20kHz/V over a nominal range of 0 to 5V with a maximum frequency of 60kHz. The unit is normally supplied with a setting close to 10kHz/V, and with the threshold, which is also adjustable, set so that zero voltage corresponds to nominally zero frequency — usually taken as below 0.1Hz. The conversion accuracy is typically of the order of 0.1%. The converter measures 51 × 51 × 26 mm, requires a +15V and −15V supply and is epoxy encapsulated. Davian (Instruments) Ltd, 52 Cardigan Street, Luton, Beds, LU1 1RR.

WW321 for further details

Logic probe

'Lola', short for logic level analyser, is a self-powered logic probe for use on 4 to 24V logic systems. Specification includes:— transient pulse response 20ns; 0.5MΩ input resistance; operates on



positive or negative logic; detects variations in magnitude of logical 1; detects power supply ripple. Scott Smith Electronics, 4 Glynville Road, Colehill, Wimborne, Dorset.

WW322 for further details

Programmed power supplies

These power supplies, designated series P, are variable-voltage sources in which the voltage control potentiometer is replaced by a resistor chain, segments of which may be called up by logic control signals. The resistor values are selected to give increments of voltage in b.c.d. weighted 1,2,4,8. This permits the output voltage to be varied by increments of 10mV from 0 to rated maximum output voltage. The supplies have a constant-current/constant-voltage characteristic and the current at which cross-over occurs may also be similarly programmed. Resistor selection is effected by reed relays, supplied from the system logic voltage. Power Electronics (London) Ltd, Kingston Road, Commerce Estate, Leatherhead, Surrey.

WW324 for further details

Six-channel oscilloscope

This instrument, type OLLI204, was primarily designed for use in medical applications but there is no reason why it should not be used for monitoring any l.f. phenomena. The OLLI204 is available as a table model or for mounting in a 19in rack.

Specification:

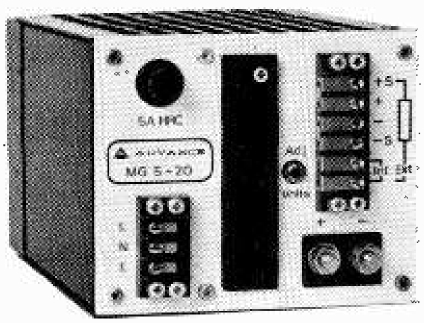
frequency range	— d.c. to 1kHz
max. sensitivity (variable)	— 10cm/V
input impedance	— 5kΩ (100kΩ option)
sweep speed	— 50mm/s
c.r.t.	— 380 × 300mm (19in) with medium persistence (GV) phosphor
noise on screen	— < 1mm
Controls (front panel)	— gain (6), vertical shift (6), marker shift, on/off
dimensions	— 450 × 450 × 400 mm

Ollituote Oy, 02320 Kivenlahti, Finland.
WW328 for further details

Switching regulator

A compact (175 × 215 × 88mm for the 5V 60A version) switching power supply has been announced by Advance Electronics which uses only 11c³ of space for each watt. Essential data are as follows:

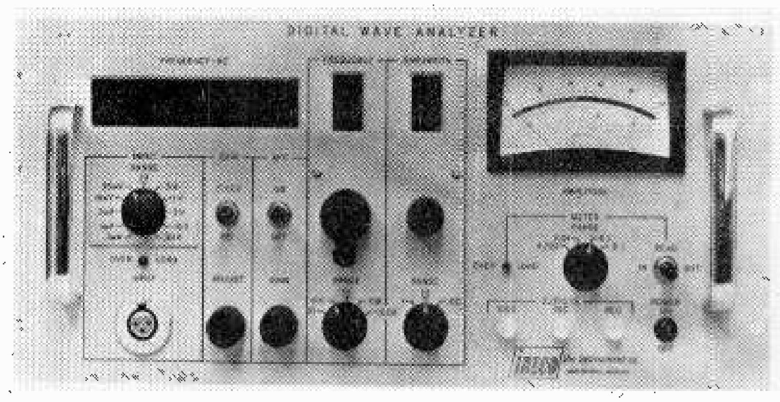
input	220-240V, 45-440Hz
output	5V ± 5% (adjustable) or 1-5.25V with external resistor
line reg.	±0.1% for 10% a.c. line change
ripple	10mV r.m.s., 50mV peak-to-peak
output impedance	50mΩ at 100kHz
overload protection	constant current set at 110% ±5% of full load



overvoltage protection	set at 6.5-7V (output falls to 0V)		
temperature	0.1%/°C, −10 to 70% derate 2.5% per °C above 50°C		
models available	MG5-20	20A	£85
	MG5-40	40A	£115
	MG5-60	60A	£145

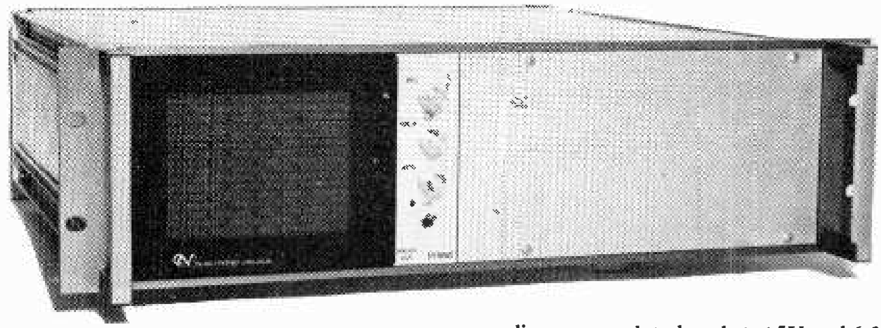
Advance Electronics Ltd, Power Supplies Division, Raynham Rd, Bishops Stortford, Herts.
WW330 for further details

Wave analyser



The model 670 wave analyser, made by the Insco Division of Electro Optical Industries, is a non-heterodyning instrument giving high stability over its frequency range of 1Hz to 100kHz, and incorporates a digital filter, which gives constant bandwidth, adjustable from 0.1 to 100Hz, at any centre frequency. The filter can operate at equivalent Qs greater than 10^8 with high stability. The input stages of the wave analyser are protected against overload, while overload indicators facilitate the setting of range switches over the signal input range of 30μV to 30V. A.f.c. can be switched in if required, giving a hold-in range adjustable up to ± 5% of nominal frequency. Frequency display is by a 5-digit in-line readout, accurate to ± 1% ± 1 digit. The model 670 may be used as a tunable filter, a.c. voltmeter, frequency meter or frequency-locked amplifier, and additional facilities include recorder, filtered signal and b.c.d. outputs. Euro Electronic Instrument Ltd, Shirley House, 27 Camden Road, London NW1.
WW306 for further details

Alphanumeric display



Electronic Visuals' EV8060 is a self-contained display unit providing bright, high resolution displays and is suitable for viewing high density alphanumeric or other low occupance signals. The rectangular cathode-ray tube has a usable screen area of 10 × 8cm and is available with P31 or P7 phosphors. The d.c. coupled, X, Y and Z amplifiers with balanced inputs, are compatible with t.t.l. and d.t.l. logic levels and to obtain maximum stability, power supplies are regulated and ± 15V and 6.3V a.c. outputs are available to power signal processing circuits. For systems applications, a rack mounting facility is available, into which two EV8060 display modules may be fitted in a 5¼in panel height. A customer engineering service is provided by Electronic Visuals for non standard drive applications. Prices from £255. Electronic Visuals Ltd, P.O. Box 16, Staines.
WW318 for further details.

Low power op-amp

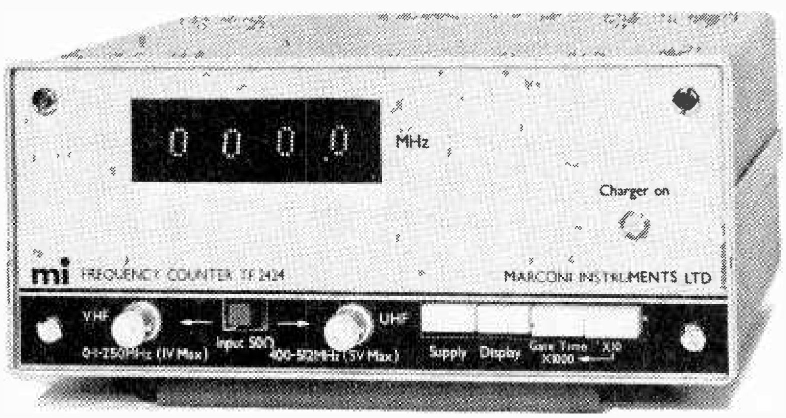
A low power operational amplifier, having a supply voltage range from ±0.75V to ±15V and an operating temperature range from − 55° to 125°C, has been introduced by RCA Solid State (Europe). Designated the CA3078AT, it is an improved version of the previous GA3078, now known as the CA3078T. The CA3078AT has a reduction in maximum input-offset voltage (5 to 3.5mV), input-offset current (32 to 2.5nA) and input bias current (170 to 12nA) as well as a 4dB increase in minimum open-loop voltage gain (from 88 to 92dB). All specifications are at TA = 25°C. The CA3078T and CA3078AT are hermetically sealed in 8-lead TO-5 packages. RCA Ltd, Sunbury-on-Thames, Middx.
WW305 for further details

Navigator receiver

The Redifon Navigator is a receiver for the Omega v.l.f. marine navigation system (a hyperbolic radio position fixing system), which offers continuous indication of vessel position over the entire surface of the globe. The Navigator's alphanumeric line of position (l.o.p.) display identifies the received transmitters, the lane count and centilane measurement. The continuous read-out is then directly related to a chart which is overprinted with the Omega lattice. Applied centilane correction is also displayed. Operational frequency is 10.2kHz; aerial is a 2.4m whip with encapsulated pre-amplifier; tracking sensitivity typically 0.03μV; dynamic range typically 90dB; resolution one centilane; and bandwidth 7.0Hz. The receiver has a 5-digit neon display preceded by two station identification letters. Each of three l.o.ps is held for 10 seconds in turn and the display may be held on any selected l.o.p. Redifon Telecommunications Ltd, Broomhill Road, London SW18 4JQ.
WW301 for further details

Frequency counter

A portable digital frequency counter, TF 2424, is designed for mobile radio testing. The instrument measures 92 × 203 × 178mm, weighs 3.0kg and is powered by an internal battery. Two frequency ranges are provided, 100kHz to 260MHz and 400MHz to 512MHz. A resolution of 10Hz at 500MHz is obtained, which makes the counter suitable for measurements on the proposed new split-channel (6.25kHz) system. The measured frequency is displayed on l.e.d. numerical indicators and a display switch conserves the battery by allowing the operator to switch off the l.e.ds until a reading is required. Marconi Instruments Ltd, St. Albans, Hertfordshire.
WW307 for further details



Broadband mixer

The MD-108/109 double balanced miniature mixer's local oscillator and r.f. ports have bandwidths of from 0.2 to 200MHz and 5 to 500MHz. The i.f. ports of both units extend from d.c. upwards. An input to any two ports will produce the sum and difference frequencies at the input to the third port (within the respective frequencies). These mixers can be used as frequency converters, double sideband suppressed carrier modulators, 180° phase modulators, phase detectors, and voltage or current variable attenuators. The mounting area is 3.1 sq. cm. and the volume is 18 cu. cm. Price £7.95 (small quantity). Manufactured by Anzac Electronics; the U.K. distributors being Wessex Electronics Ltd, Stover Trading Estate, Yate, Bristol, BS17 5QP.
WW326 for further details

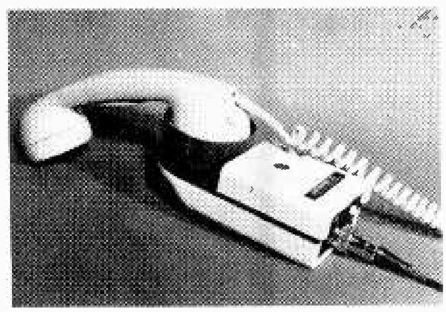
Miniature solid-state switch

The 2SS series of switches is a magnetically operated general-purpose solid-state switch, based on the Hall-effect chip produced by Honeywell. The switches are a tenth of an inch wide and one-fifth of an inch tall (less terminals) and operate at speeds of up to 10,000 operations per second in temperatures from − 40 to + 70° C.

Maximum ratings include: supply voltages of 8Vd.c. continuous and 10Vd.c. pulsed for one second maximum; output of 10mA for each output, with 20mA when outputs are paralleled. Supply voltage range is 4.9 to 5.25Vd.c. Supply current is 15mA maximum. The output voltage is 2.9V d.c. minimum in the on state. Rise time is 0.5μs maximum and fall time is 10μs maximum. Honeywell Ltd, Charles Square, Bracknell, Berkshire.
WW308 for further details

'Over the phone' telemetry system

This telemetry system was designed for monitoring patients' e.c.g. over telephone lines but could probably be used in situations that require an l.f. signal source to be remotely monitored. The equipment consists of a small transmitter unit which is attached to the telephone



handset. The input signal frequency modulates a 1.7kHz oscillator which drives a transducer held in close proximity to the handset's microphone. At the receiving end the signal is demodulated and used to drive a chart recorder in the receiving unit.

Transmitter:

input impedance	— 10MΩ differential
common mode rejection	— > 100dB
temperature range	— 0–50°C
power supply	— two small 9V batteries
dimensions	— 155 × 70 × 50mm

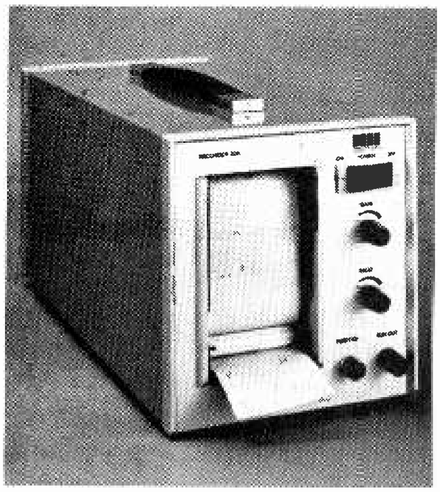
Receiver:

frequency range	— 0.15 to 50Hz, 100mm f.s.d.
chart speed	— 25 or 50mm/s
dimensions	— 240 × 325 × 145mm

Ulmaelektro Oy, Palkaneentie 20, 00510 Helsinki 51, Finland.
WW329 for further details

Single-pen recorder

This is a single-channel, hot pen l.f. recorder primarily intended for medical use which is capable of being remotely controlled.



The recorder, type OLLI206, is available in portable, table or 19in rack forms.

Specification:

frequency response	—	d.c. to 50Hz (−3dB), 50mm deflection d.c. to 100Hz (−3 dB), 10mm deflection
gain (variable)	—	100mV/cm
input impedance	—	100kΩ
noise	—	<0.1mm deflection
linearity	—	1% f.s.d.
trace width	—	50mm
paper speed	—	25mm/s

Ollituote Oy, 02320 Kivenlahti, Finland.
WW327 for further details

Potentiometer and source

The mini-Pot is a miniature, digital, d.c. millivolt potentiometer and source for the measurement of thermocouples and the calibration of recorders, indicators, controllers and data loggers etc. It has an accuracy of 0.015mV throughout the range of 0-50mV. The resistance of the instrument is 0.4Ω/mV. Standardization is made against an integral standard Weston cell. Power sources within the instrument are a Mallory cell and a standard PP3 battery. Design features include a four-digital display of results; a 66cm infinite resolution helical slidewire and a solid-state null detector amplifier. Delristor Ltd, 21 Windsor Street, Uxbridge, Middlesex.
WW325 for further details

Portable oscilloscope

The Tektronix Type 485 is a 350MHz, 1ns/div., portable dual-trace oscilloscope. The vertical system provides wide bandwidth at full sensitivity with selectable input impedances and at 5mV/div., the sensitivity is 350MHz at 50Ω impedance, and 250MHz at 1MΩ impedance. An automatic protection circuit disconnects the vertical amplifier 50Ω input circuit whenever the signal exceeds 5V r.m.s. (or 0.5 watt and 0.1 watt-second). Vertical scale factor is indicated by means of light emitting diodes placed around the input attenuator knobs, the appropriate l.e.d. lighting up when using the recommended × 10 and × 100 probes. For the measurement of pulses in the presence of high-frequency noise, the operator can limit the bandwidth to 20MHz. The 485 has a sweep speed of 1ns./div. without magnification. It employs a 4-inch rectangular c.r.t. with an 8 × 10 division display area (each division is 0.8cm). The accelerating potential is 21kV, giving a writing speed of 7.2 div./ns. An auto-circuit makes it unnecessary to re-adjust the focus each time the intensity is changed. The power supply weighs less than 2.8lb and the overall dimensions are: 521 × 305 × 165mm and it weighs 9.525kg. Price £1917, plus £194 duty. Tektronix U.K. Ltd, Beaverton House, Harpenden, Herts.
WW319 for further details.

Pulse and bar signal generator

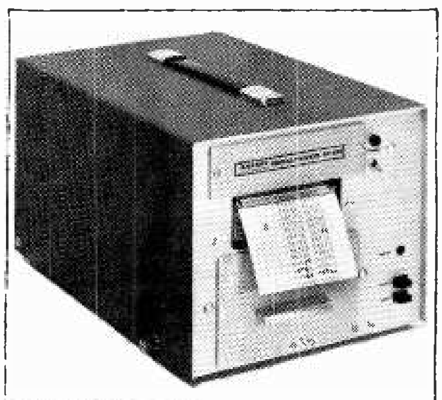
Manufactured by Rohde & Schwarz, the pulse and bar signal generator Type SP1F delivers a line-frequency composite video signal, which contains all the essential components of a monochrome colour television signal. It is equipped with an internal horizontal sync pulse generator, that can be externally synchronized. The sync pulses can be deleted and the output then delivers a picture and blanking signal, which can be synchronized either internally or externally. The picture component of the output signal can be attenuated by 10dB by means of a front-panel switch. The pulse bar signal is composed of a square-wave pulse (bar), a 2T (T) pulse and a modulated 2OT pulse. The modulated 2OT pulse is especially suited to colour television work and can be used to display linear distortions at the colour sub-carrier frequency. All sub-assemblies of the pulse and bar signal generator Type SP1F are fully transistorized and mounted on printed circuit boards. The unit can be supplied for 19in rack-mounting or in its own cabinet. Aveley Electric Limited, Arisdale Avenue, South Ockendon, Essex.
WW323 for further details

Mobile radiotelephone

A new Pye mobile two-way radiotelephone, type PMR2, is claimed to be the first all-solid-state 60W 12V mobile radio produced in the U.K. It is built of modules allowing the addition of optional extras at any time, including tone-lock squelch, simultaneous monitoring of two channels etc. It is available with 20/25kHz channel spacing and single-channel or up to eight-channel versions are included in the range. Single- or two-frequency simplex working is available in the frequency bands 29-38MHz, 38-50MHz, 132-148MHz, 148-174MHz. A duplex version is available for the 132-148 and 148-174MHz frequency bands. Pye Telecommunications Ltd, Newmarket Road, Cambridge.
WW317 for further details

Digital printer

The Electronics & Instruments Division of Bell & Howell Ltd is marketing a 21-column digital printer, the DP 650, which is for applications requiring i.c. compatible input logic levels and a minimum of interface control signals. Provision is made for 1, 2, 4, 8 binary



code inputs for each column containing 16 alphanumeric characters. Floating decimal points can be printed in any of nine columns, and additional input signals can be utilized to initiate print command, busy signal, paper feed command and selection of red or black printout. The instrument accepts either roll or fanfold paper. Paper width is $3\frac{1}{2}$ inches nominal and the maximum print rate is three lines per second. Price £355. Bell & Howell Ltd, Electronics & Instruments Division, Lennox Road, Basingstoke, Hampshire.
WW316 for further details.

Real and Imaginary

by "Vector"

What hath Babbage wrought?

A few weeks ago I read a newspaper report headlined "Cupid from the Computer". The story was that the wedding would shortly be solemnized of the thousandth couple in Britain to be brought together by one particular computer.

This news stopped me dead in my tracks. Let me admit at once that my relations with FUTILE*, the computer in my life, have not always been of the happiest; even in my mellowest moments I've never seen him as a naked little god with a bow and arrow. But now I find myself covertly eyeing him when I think he isn't watching me. And I'm wondering......

For, in fact, nothing short of a crisis is upon us. Mark this, friends, and mark it well. One thousand good men and true have been cut down in their prime by the machinations of one solitary number-cruncher that probably wasn't even trying very hard! And there are others at the same lark, I'm told. The mind boggles at what will happen when this match-making bug spreads to all the other computers in the country. What possible chance will there be for that innocent youth who stares anxiously at me from the shaving mirror every morning?

The answer comes back from those remorselessly rotating drums — 'None whatever!'

Useless for the cynic to retort that any method of mate-selection is preferable to the one now generally in force. And doubly useless for me to reflect that the culprit computer is of American origin and is therefore over-sexed anyway; these aliens greatly outnumber our more gentlemanly native computers and, furthermore there is no indication that the British genius is immune to the match-making virus.

But, relatively speaking this is but a cloud the size of a man's hand. What of the terrifyingly-near future? With the increasing sophistication of self-teaching computers they're soon going to cotton on to this sex business and before we know where we are these dreadful machines will be able to see, hear, taste, detect the presence of Chanel No 5 and will, in general possess all the emotional capabilities of homo not-so-sapiens. And don't delude yourself with the thought that you'll be able to put a stop to all jiggery-pokery by pulling the plug out because the very first thing the monsters will do will be to provide themselves with built-in power supplies.

My guess is that before long we'll notice a gradual change in the external appearance of our computers. The digital machine will become markedly more angular and rugged while the analogue's contours will tend strongly towards the curvaceous, with the machine itself (or perhaps we should now say 'herself') abandoning all logic and exhibiting an inclination towards putting her cableforms into curlers at night. As for the hermaphroditic hybrid (analogue-cum-digital) we must wait and see.

We must particularly look out for trouble whenever there's an 'O' or an 'I' in the month — i.e. in April October and November. The first symptoms will be the appearance of spots on the display panel of the digital computer (the angular one), after which it will likely go off its power supply, just picking at the odd milliamp here and there. Whenever this happens you can bet your boots that somewhere around there's a cute analogue machine emitting curious little sighing sounds from her loudspeaker.

When this happens all normal business activities will cease, for the entire real-time of the pair will be wholly occupied with the exchange of tender teleprinter messages (using a D to A converter as go-between, of course) such as:—

"000101101010111001000111011 1"

which, as everybody knows means:—

"Darling, I love you. Please send me a facsimile picture of yourself with your covers off".

To which the reply will go back via an A to D converter:—

"000000000000000000"

Roughly, this translates to:—

"Oh, you are awful. I'm not that kind of a machine. You'll have to wait until our tapes are spliced sweetie-pie".

This, of course, is calculated to stimulate the digital computer (the angular one, remember?) into furious activity. He buys her an expensive ring-main and showers her with useless soft-wear, including such frivolities as diaphanous black lace-edged printout paper. And if one morning you arrive to find forget-me-nots entwined around the input circuit of your computer it will merely mean that the pair have assimilated "Lady Chatterley's Lover" into their memory stores and that the worst has happened. Before long the computer-room floor will be littered with scores of little adding machines all impatient to start their working lives in the super markets.

Comrades, you have nothing to lose but your brains! Reach for that sledge-hammer, now!

* Flaming Useless Terminological Inexactitude Location Equipment.

Engineers on strike

The Editor has sent me the following letter from a reader:

I would like to correct an error in 'Vector's' contribution in the April issue referring to power station engineers.

At no time have engineers in power stations gone on strike, nor will they ever. The Protection of Property and Conspiracy Act makes this an illegal action.

Last year the Industrial Staff (craftsmen, plant operators, et al) worked to rule and banned overtime. The engineers meanwhile, who worked normally, and in some instances much harder than normal, to maintain supplies were the target of abuse and in some cases violence aimed by the general public.

The confusion arises from the lax use of the word engineer, i.e. 'engineering unions'; 'television service engineer', etc.
R. Bennett,
Westleton,
E. Suffolk.

My regrets for inadvertently maligning the professional power station engineer. It just shows how careful you have to be with words!

Dictionaries don't help, either. The various definitions of an engineer in the "Shorter O.E.D." admit almost anybody. In another source, engineering is defined as "the art or science of making practical application of the knowledge of pure sciences, as physics, chemistry, biology etc." By this yardstick the act of striking a match is engineering!

What we need is a new word altogether.