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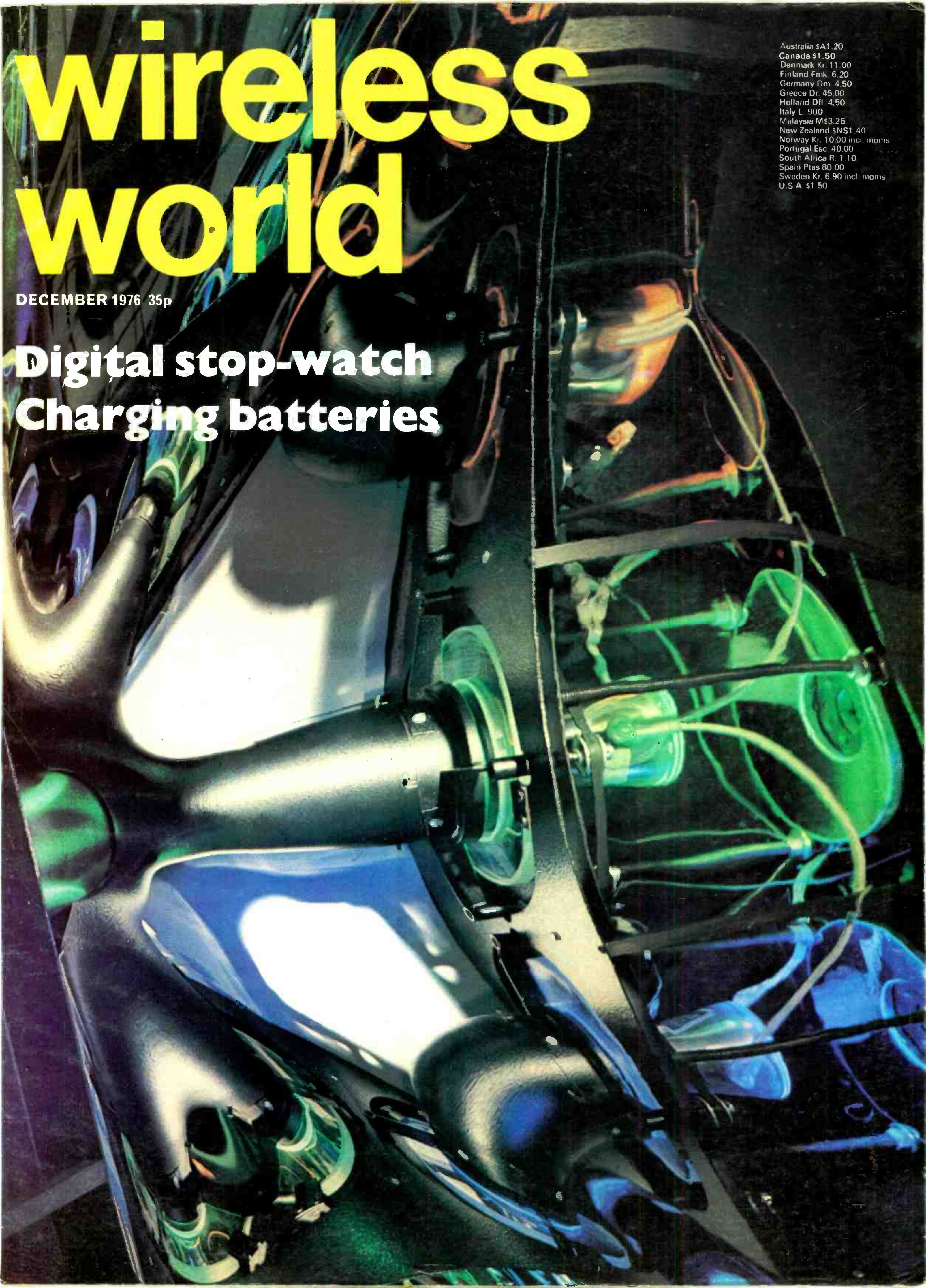

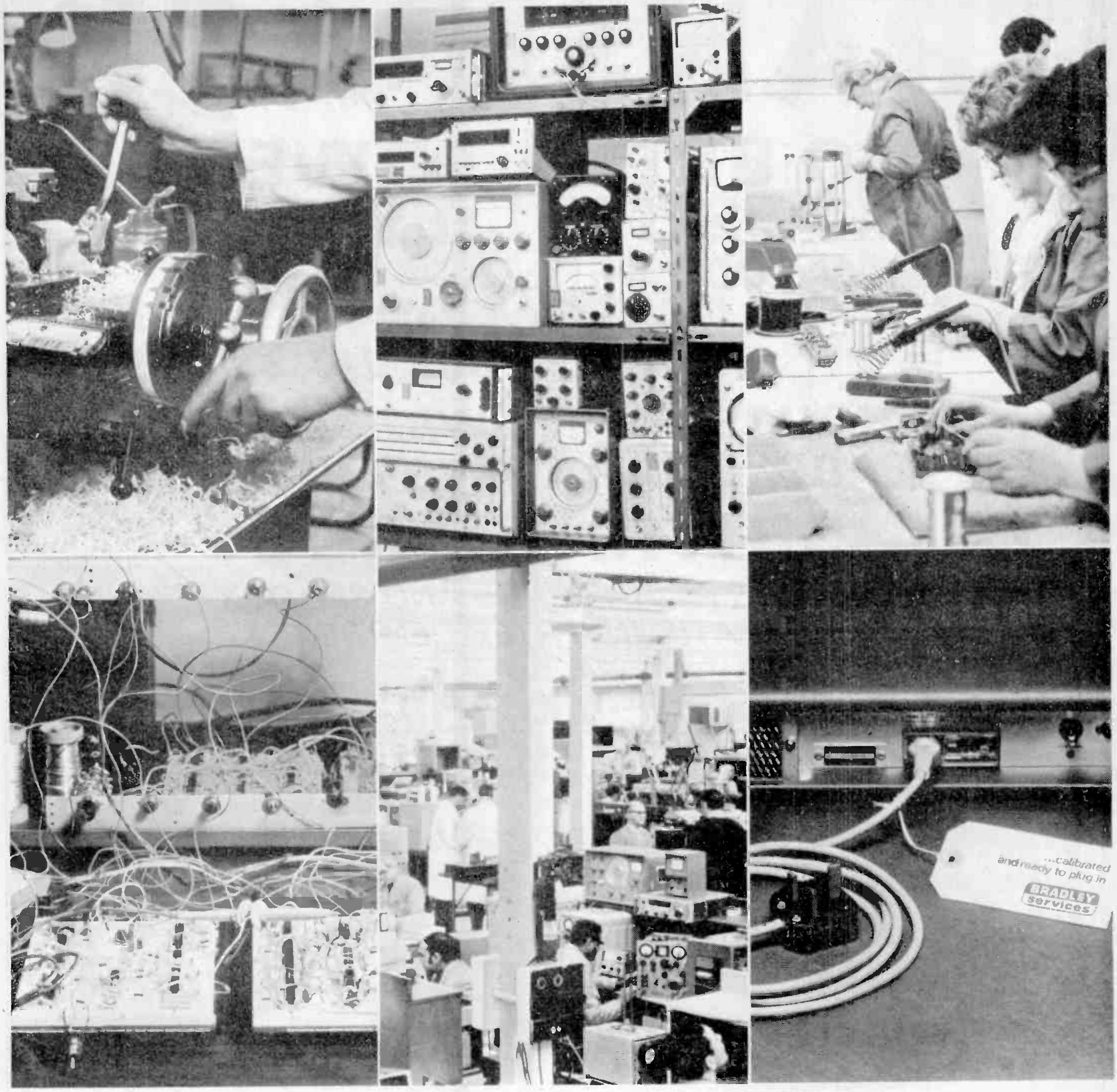

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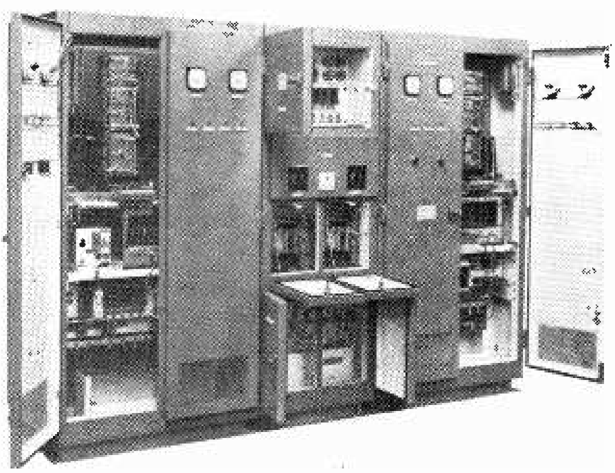

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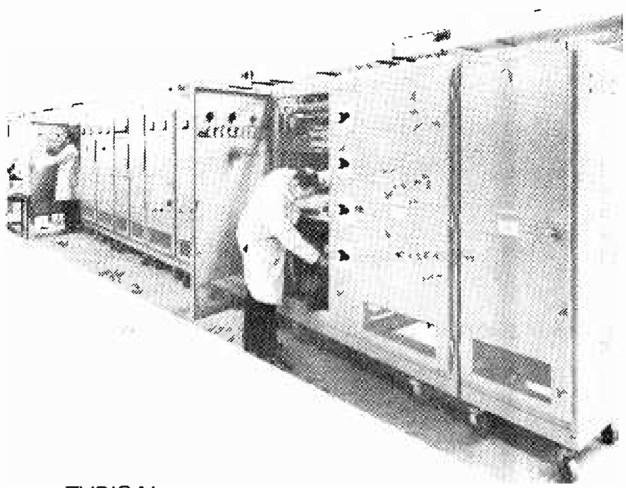

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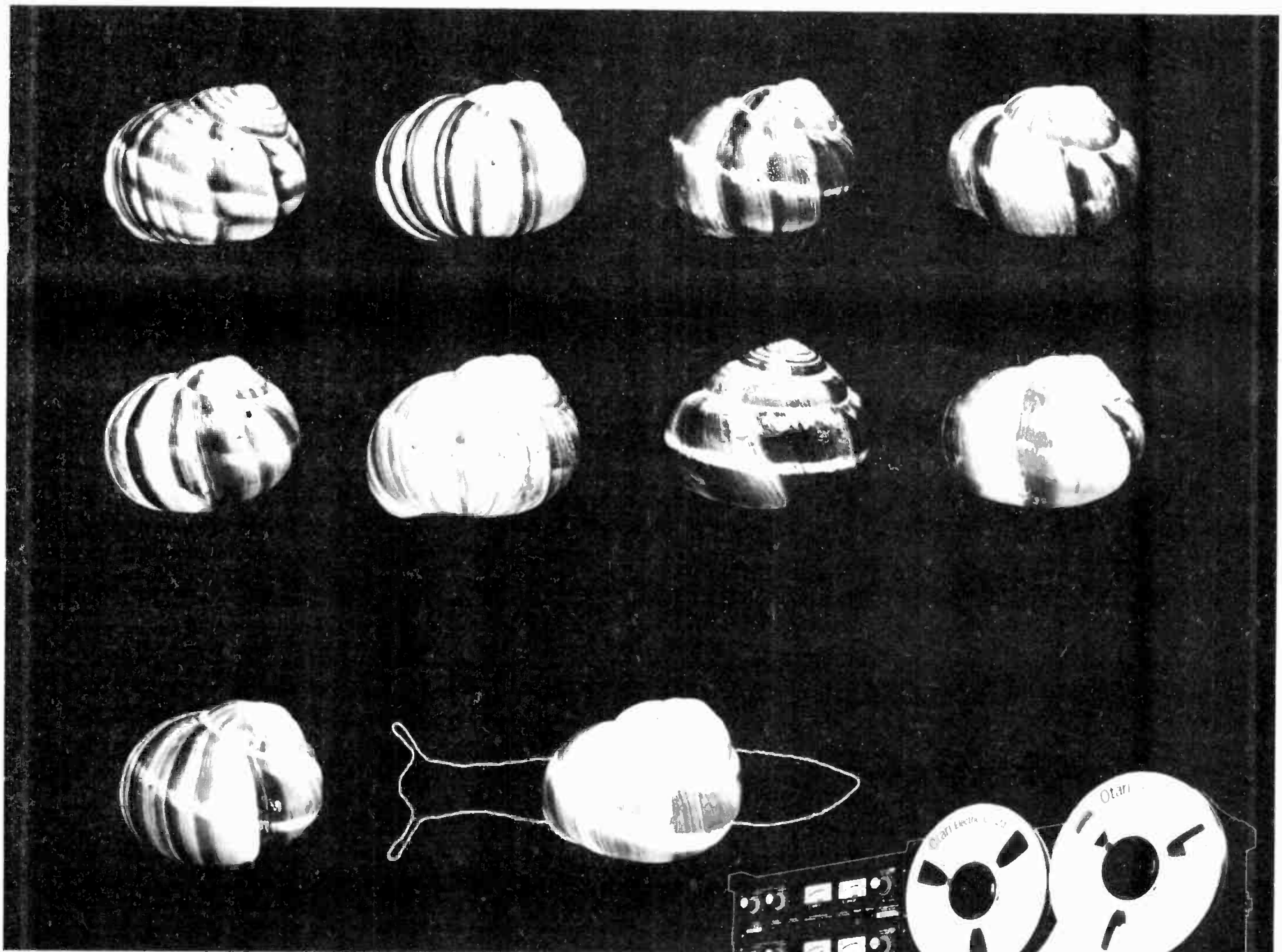

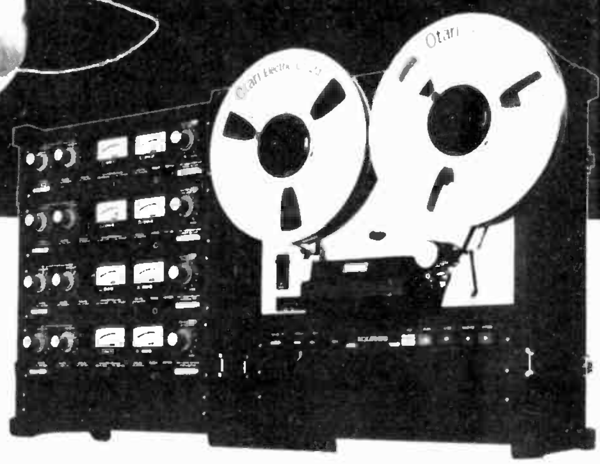

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From Continental Specialities.

US Patent Design No 235554.

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Now you can put circuits together as quickly as you think them up.

Just plug your devices in, pull them out, plug them in again, as many times as you want.

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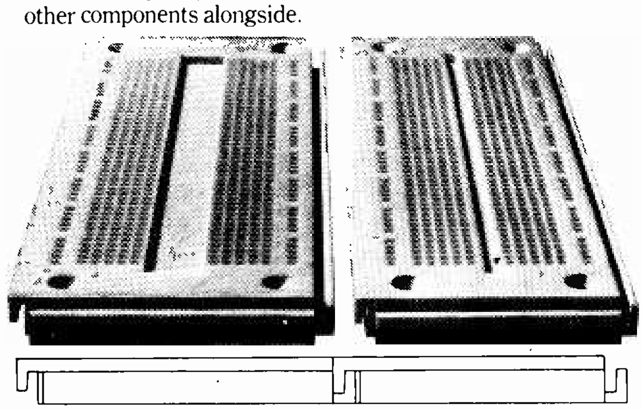
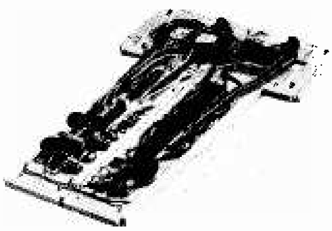
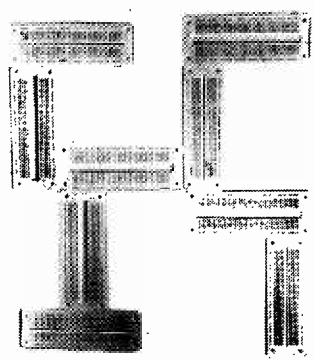
Experimentor 600.
The world's first breadboard specially designed for 0.6 pitch devices. It gives you all the fan-out you need for complex MSIs, Micro-processors, Memories, Displays etc., (40 pins or more) with plenty of room for other components alongside.

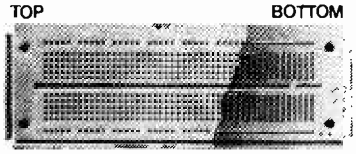
Experimentor 300.
This one is designed to be ideal for 0.3 pitch DILs, any kind, from 6 pins up. Excellent fan-out. (You can also use it for 0.6 devices, though for these the 600 version is recommended.)







TOP BOTTOM



Apart from ICs, both versions take TO-5 transistors, diodes, LEDs, capacitors, resistors; any component with lead size between .015 and .032 inch diameter. And for interconnections you use standard solid hook-up wire.

Unique Construction.

Each version of the Experimentor gives you 94 five-contact terminals, arranged in two rows of 47, plus two integral bus-strips for Ground and Power, with 40 contacts on each.

That's 550 contacts in all! (See diagram).

All terminal strips are recessed into the bottom of the plastic body, and covered with a stick-on vinyl backing, so you have no insulation problems.

The contact rows are numbered 1-5-10 etc. and A-B-C---J lengthways, so each position is clearly defined. The bus-strips are labelled X-Y, each end.

The plastic body is rigid, strong and longlasting, with a recessed screw-hole at each corner, and all four edges have a special quick-locking lip so that you can build rigid arrays of two or more boards.

The Domino Theory.

See how the Experimentor boards fix together, side by side, end to end, or at right-angles, to give unlimited scope for circuit building, planning, extending, rearranging.

You can mix 0.3 and 0.6 DILs in any arrangement you like.

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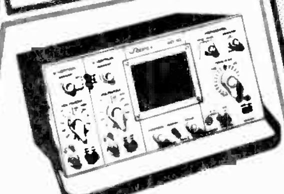

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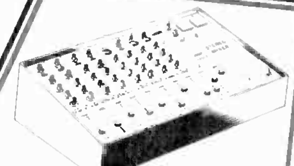

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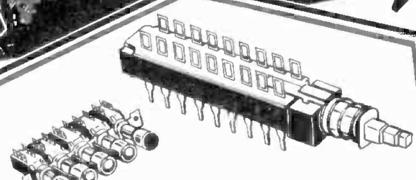

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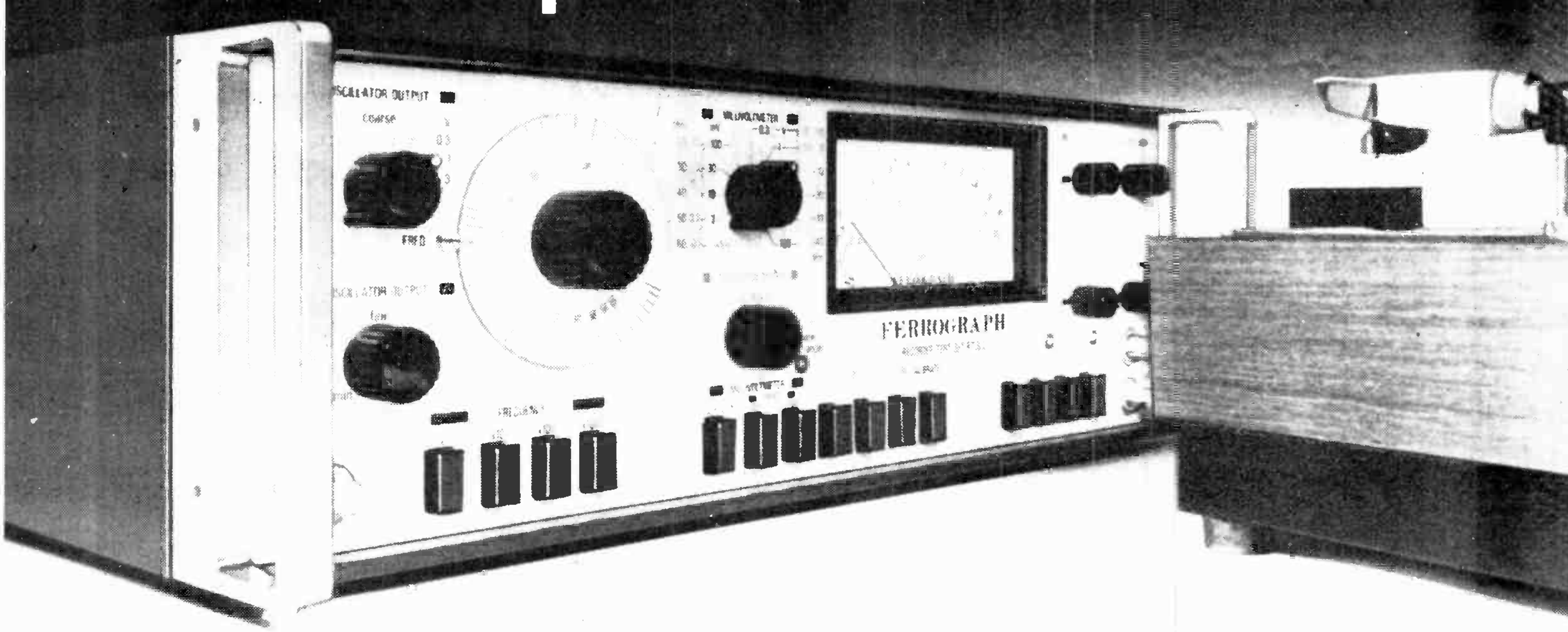

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Photograph by courtesy of Sewards in Reading.

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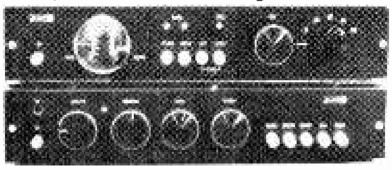

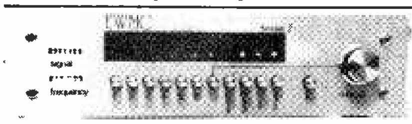

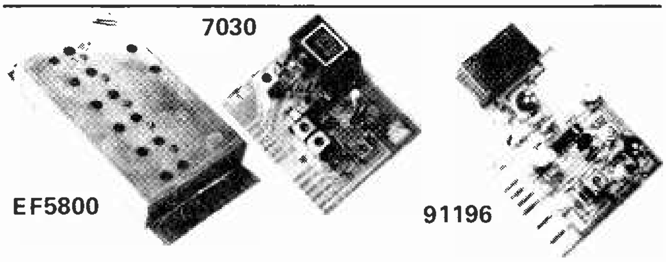
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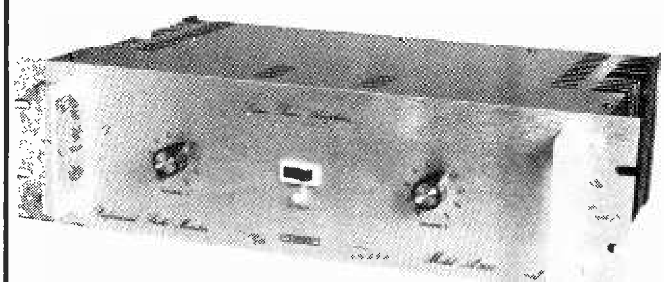

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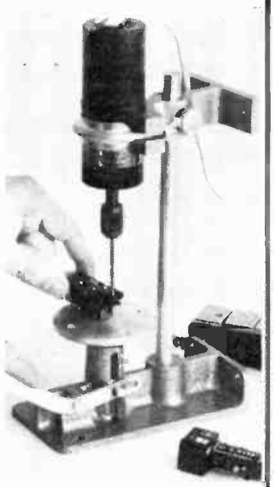

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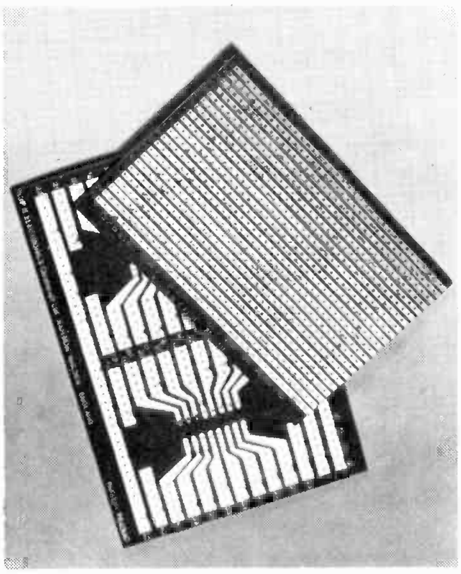

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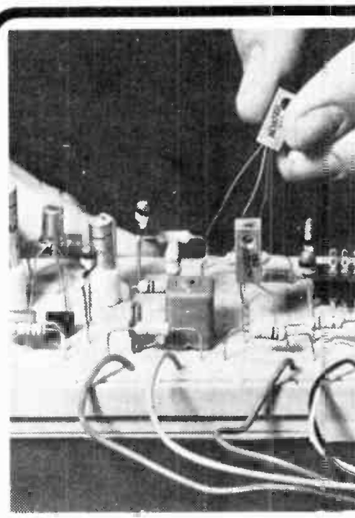
T-DeC



If you are using IC's to build circuits use T-DeC for 1 chip circuits and U-DeC A for 2 chip circuits. Draw circuit on graph paper, plug IC into Adaptor and plug into DeC. No soldering, no bent leads, no wasted IC chip. Lines on DeC show contact rails, plug discrete components in. Cross overs, connections are made using different coloured leads. Circuit completed and working unplug components and use for next circuit. No soldering, no damage to components. Use your DeC and small stock of components over and over again. T-DeC send £4.30. U-DeC "A" send £4.60. Adaptor send £2.30.

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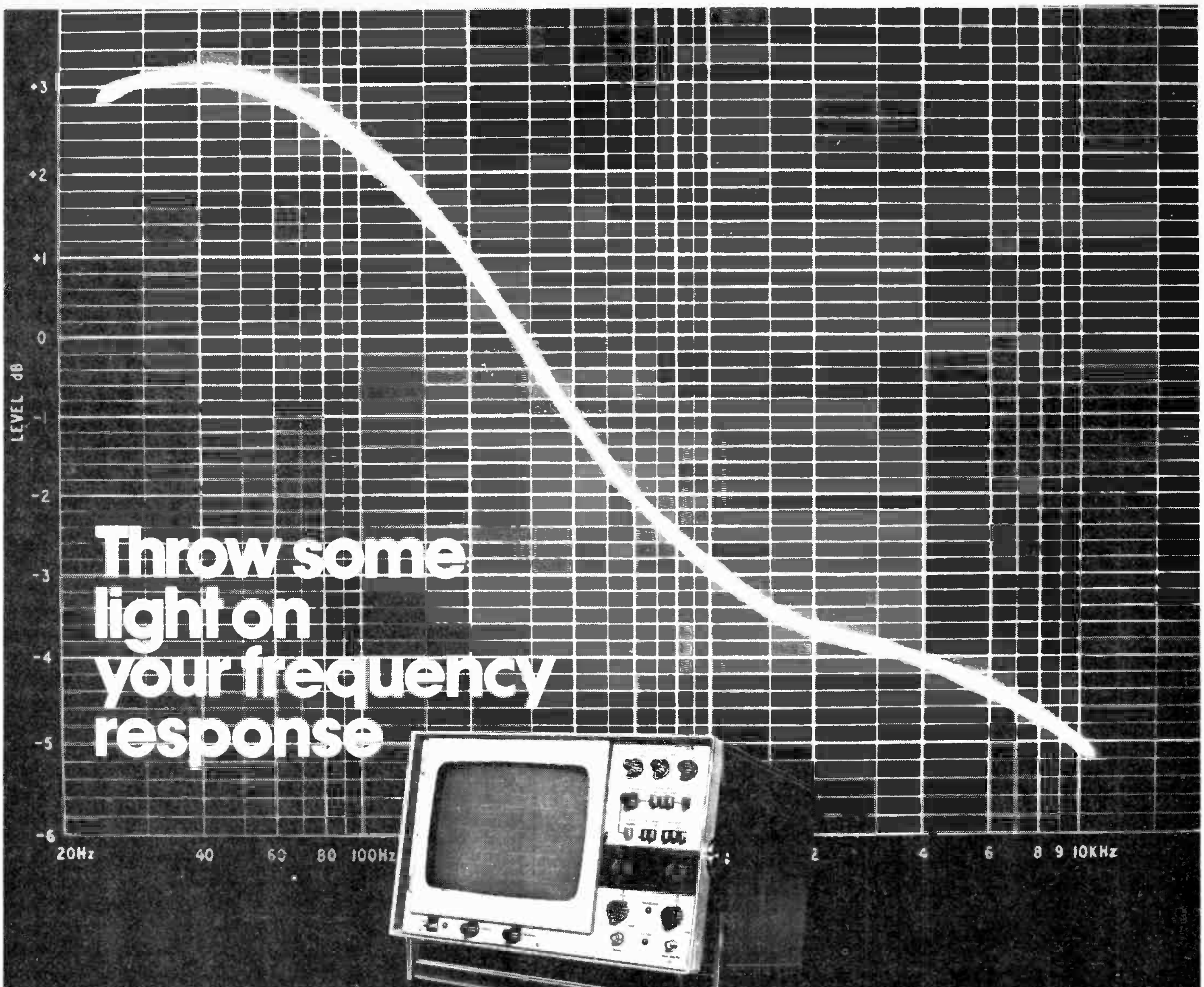

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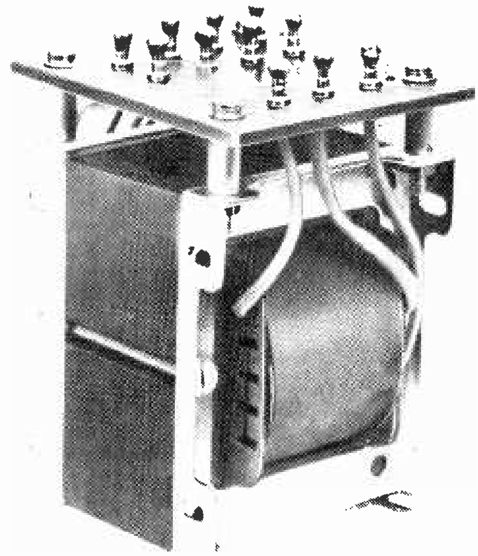

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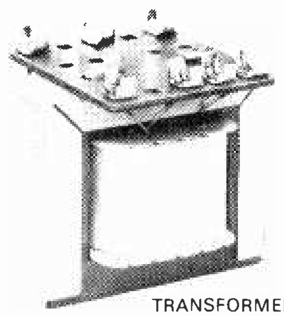

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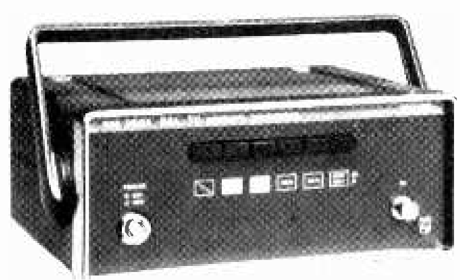

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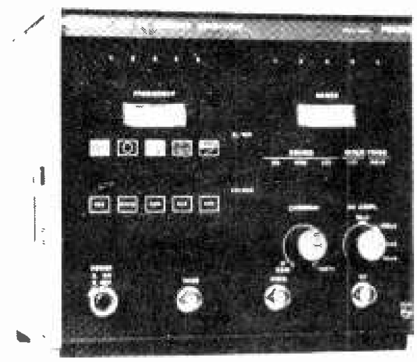

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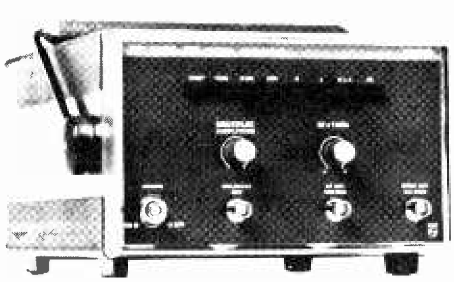

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DECEMBER 1976 Vol 82 No 1492

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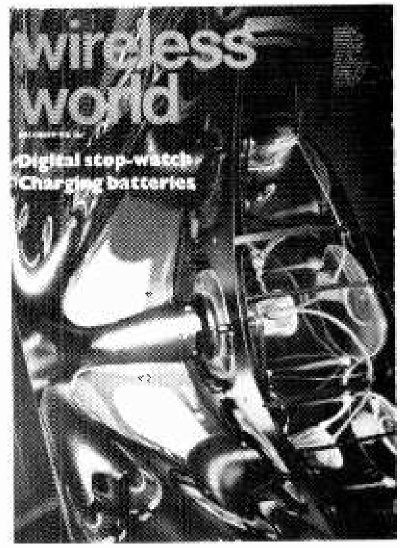

Front cover shows an impression of the CV3 Superscreen colour television projector marketed by Speywood Communications. The three separate Schmidt optical systems are mounted in line and use 75mm tubes.

IN OUT NEXT ISSUE

Distortion in audio amplifiers is discussed by Professor Matti Otala in a paper on static and dynamic non-linearity distortion.

Logic design. The first in a series of articles on logic, this part dealing with the use of Boolean algebra. The series will cover a range of topics, from basic, combinational logic to microprocessors.

Identification of European TV stations consists of a series of photographs of test cards from continental stations, together with brief notes about the transmitters.

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WARC TALK

At the Communications '76 conference in Brighton this summer, Professor James Merriman, senior director of development at the Post Office, emphasized the responsibility which lay on the British delegates to the 1979 World Administrative Radio Conference in Geneva: "It seems obvious," he said, "that the processes of creating the briefs for that conference . . . should give ample opportunity for open debate for appeal and for resolution of conflicting claims."

The need for open debate does not seem obvious to the Home Office, which will be responsible for presenting our case at that conference, the first in 20 years. Two years ago it entrusted an engineer at the Radio Regulatory division with the preparation of a series of reports intended as a basis on which to brief delegates as to the "British view" about the reallocation of radio frequencies.

Two reports, on broadcasting and mobile radio, have been prepared and a third is being written, but they are secret. A formal request by *Wireless World* to see the documents has been refused. So although the Home Office has invited comments on them from a small coterie of discreet trusties the delegates will' otherwise go to the conference armed, not with the results of a full public debate conducted among all those interested enough in radio to put forward a point of view, but with the politically preordained baggage of a small number of self-interested bureaucrats.

That those who wish to perpetrate this misuse of their influence are well-meaning men who believe they act honourably is not in doubt. Neither is it relevant. There are many others in and out of the communications industry who are concerned, for example, that BBC is not obliged to relinquish any of the frequencies its self-avowed poverty prevents it from using efficiently, that it and the IBA continue to hold on to Band I and III frequencies no longer needed anywhere but on the edges of the British Isles, and that the Home Office should prepare a secret report on broadcasting before the Annan Committee has finished its work. The man in the street wonders whether any serious thought has been given to growing demands for greater public use of radio. Or will the functionaries have nothing more in their minds as they fly to Geneva at his expense than closing the loophole in the 1969 Post Office Act that allows the sun to communicate to him, by electromagnetic means, the time of day. The man in the street may have something worthwhile to say on such matters, the readers of this journal certainly so, yet they continue to be taxed too much and told too little.

We are determined that, for once, something which affects us will be widely discussed in advance; lamentations in the face of a fait accompli carry a certain futility. No discussion which takes place after the British delegation leaves Heathrow can have any effect. If that discussion does not begin now the sickness that grips so much of the administration of British life will have overtaken radio and telecommunications, and our leaders' recent absurd protestations that the only alternative to themselves is totalitarianism will be seen, after all, to have been trailing all too far behind events.

Digital event timer — 1

A versatile and compact c.m.o.s. design

by P.A. Birnie

This timer is intended to replace the expensive mechanical stop watch counterpart by offering a small size of around 100 x 70 x 25mm, about 600 hours of continuous operation from a set of inexpensive mercury cells, and several facilities including two timing channels. Discrete i.cs are used, instead of an l.s.i. device, because they reduce the cost and increase the number of facilities.

When the design of this stopwatch commenced, I expected that an l.s.i. integrated circuit would be used with a few discrete i.cs added to increase the number of facilities. Several designs were constructed using a commercial stopwatch/counter i.c. driven from a 100kHz crystal oscillator, and an l.e.d. display. These were functionally satisfactory but suffered from high power consumption, the need for two different supply voltages, small display size and poor legibility in mild sunlight. The circuit was also difficult to adjust due to the critical monostable elements.

Calculation showed that c.m.o.s. devices, driving a 4½-digit liquid crystal display from a 5V supply, would require only a few hundred microamps and could give over 600 hours continuous use. The final design allows timing of two events with simultaneous start times, and displays up to 19min 59.9s. After this time the tens of minutes stays at 1 and the units cycle through 0 to 9. A split facility enables the display to be temporarily held while individual events are timed independently from the two channels which continue to count. Cumulative timing of several consecutive events on one channel is also possible and remains independent of the other channel, which can be timing a continuous event. The design can be modified to increase or decrease the number of facilities as required. A block diagram of the circuit is shown in Fig. 1.

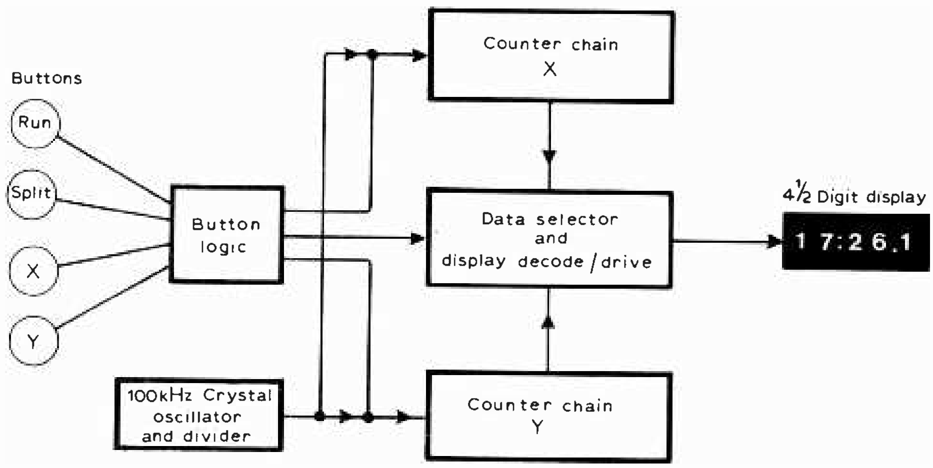


Fig. 1. Block diagram of the stopwatch. Total power consumption for this circuit is between 200 and 300µA.

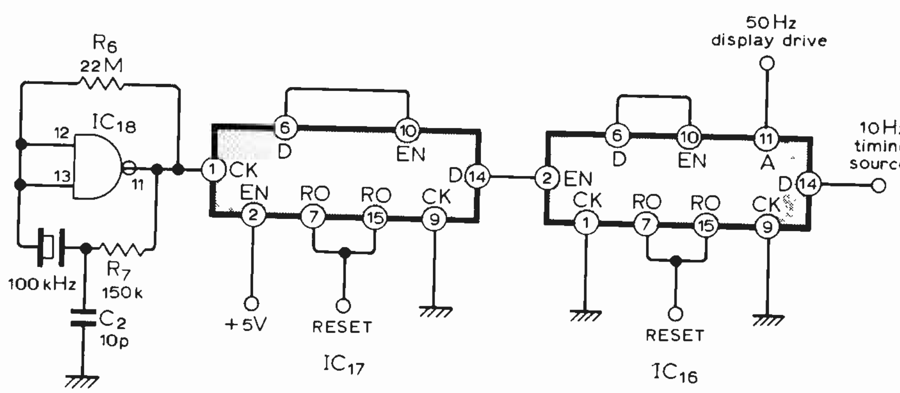


Fig. 2. Crystal oscillator and dividers. A standard Pierce circuit is used with the crystal, C_2, and input capacitance of the gate acting as the feedback network.

Accuracy of the stopwatch is determined by the characteristics of the crystal oscillator components, and in the prototype a 100kHz Statek device was used because of its small size. This type of crystal is stable and rugged, with an initial setting accuracy of ±0.02% and a temperature coefficient of +0.0075 to —0.032% from 0 to 70°C. If required a trimmer may be used in the oscillator circuit for more accurate tuning of the resonant frequency. Variations in supply voltage are kept small by using mercury batteries, and the effect of these variations is minimized by selection of the feedback resistor R_7 in the oscillator circuit of Fig. 2. The crystal oscillator output is divided in two dual decade counters to provide a 50Hz drive waveform for the display and a 10Hz timing signal. Four buttons control two 4½-digit counter chains which count up to 19m 59.9s, and a 2:1 data selector is used to route one of these chains to the decoder drivers. The button logic and the main circuit diagram are shown in Figs. 3 and 4.

Circuit operation

The crystal is used in a standard Pierce oscillator circuit with one gate of IC_{18} acting as an inverting amplifier. The crystal, C_2 and the input capacitance of

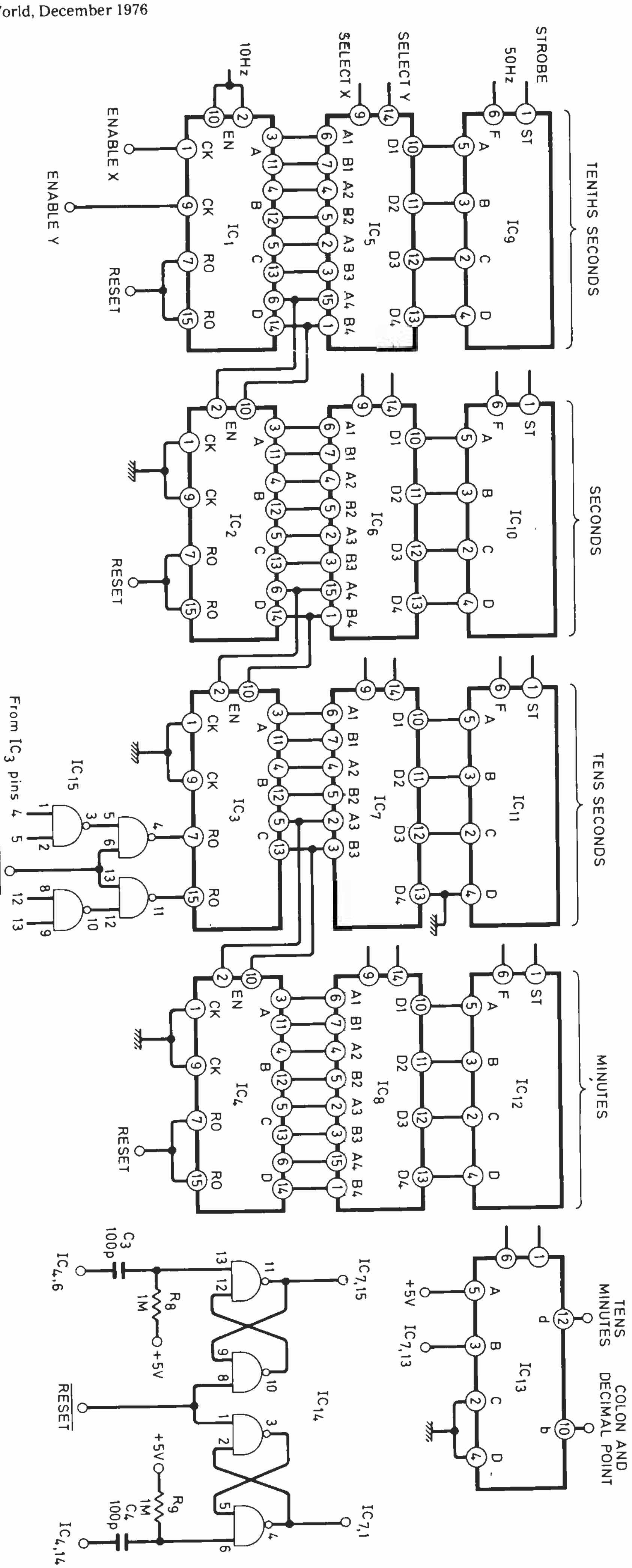
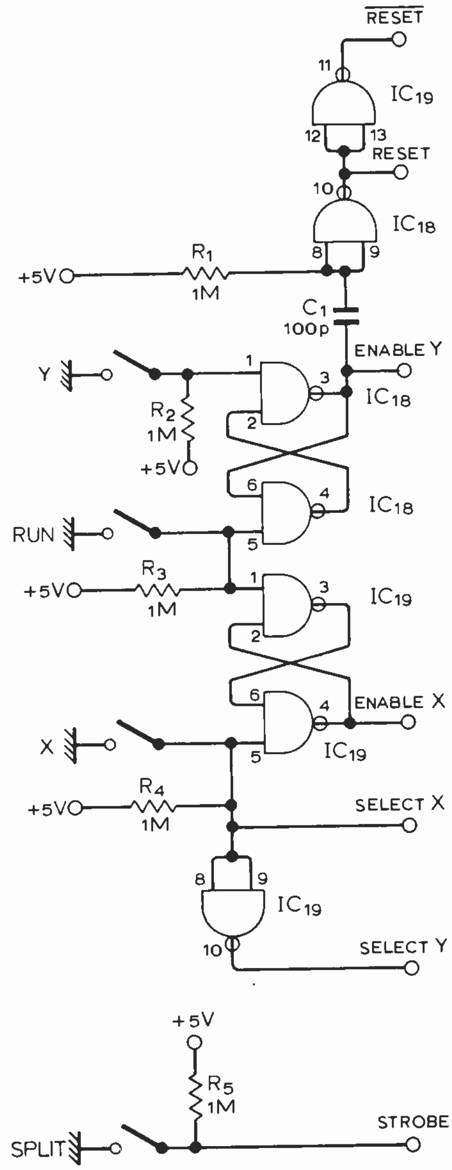


Fig. 3. Main counting and decoding circuitry. Note that $IC_{10,11,12,13}$ have pins 1 and 6 connected as IC_9 also, $IC_{6,7,8}$ have pins 9 and 14 connected as IC_5.



Operation	Timing function
Run	Resets all logic and starts counters
Split	While depressed, the display is held without interfering with timing functions
X	Stops channel X and displays content. When the button is released the channel can be restarted by operation of Run without affecting channel Y.
Y	Stops timing of channel Y. Subsequent depression of Run resets all logic.

Fig. 4(a) Button logic, (b) timing function for the buttons.

the gate act as the feedback network. Care has been taken to limit the crystal drive voltage to below 2V pk-pk for reliable operation. A physically larger crystal has been tried in the circuit and, with the addition of a 3-30pF trimmer from the gate input to ground, proved to be entirely satisfactory. The manufacturers of the specified crystal do not recommend the use of such a trimmer. A decoupling capacitor, C6, of 0.01μF should be placed across the supply and as near to IC_{18} as possible to prevent 100kHz appearing across the supply lines to other devices. If an oscilloscope is used to check the oscillator a 10:1 or, better still, 100:1 probe is necessary to prevent significant loading of the circuit.

The oscillator output is applied to the clock input of an up decade counter, ½ of IC_{17}, and the D output is fed to the enable input of the other half of the device. This produces a 1kHz waveform on the second D output which is fed to the enable input of IC16 which also divides by 100. Use of the enable inputs rather than the clock ensures that a negative-going edge is only produced after 100 × 100 input pulses when the two devices have been reset. The second stage of IC_{16} produces a 50Hz square wave for driving the display, and a 10Hz waveform for timekeeping purposes.

When the "run" button in Fig. 4 is depressed, the bistable NAND gates are set which makes the enable X and Y lines go low. A negative-going pulse is therefore applied to IC_{18} via C_1 which produces a high reset pulse for a short period, determined by the time constant C_1R_1. Because two parts of the circuit require a negative-going reset pulse, a gate of IC_{19} is used to generate the $\overline{\text{reset}}$ function. The reset pulses act on all of the divider and counter stages in the circuit. When these pulses end, division and counting begins.

Because both clock inputs of IC_1 are low, the first 10Hz falling edge to arrive at the enable inputs of IC_1 causes one increment of the X and Y counters. If no buttons are depressed at this time the select X line will be high and the select Y will be low which causes IC_5 to accept data from the Y counter. This data is passed to IC_9 where it is decoded and used to drive the display. Subsequent negative-going 10Hz clock edges cause further incrementing of the counters in IC_1 until negative-going edges at the two D outputs cause incrementing of the X and Y counters in IC_2. This process continues until a further button depression displays the contents of the Y counters. The gates in IC_{15} are used to modify the count sequence so that IC_3 counts from 0 to 5 and then resets. This circuit uses the $\overline{\text{reset}}$ pulse at the start of a timing sequence. Gates IC_{14} forms two edge-triggered bistable circuits which are set when the D outputs of IC_4 produce a negative-going edge. Because IC_3 counts up to 5, IC_7 only has to select a 3-bit word. The spare selector is used to choose the X or Y output from IC_{14}. The last-mentioned circuit therefore stores the state of the ½ digit used to indicate tens of minutes.

Depression of the "split" button disables the data inputs of the decoder drivers and the internal data latches in these devices hold the information until the split button is released. The X button has two functions. Firstly, IC_{19} is reset which produces a high on the enable X line to disable the X counter input in IC_1. This prevents further incrementing of the X counter chain. Also, while this button is depressed, the select X line is kept low and the Y line high which allows $IC_{5, 6, 7, 8,}$ to display the X counter information. When the button is released the Y counter information is again displayed. The Y button resets IC_{18} and produces a high on the enable Y line. This disables the Y counter in IC_1 and stops further incrementing of the Y counter chain. Note that until the Y button is depressed, the reset pulse is not operated if the run button is used. This feature allows cumulative timing using only the run and X buttons.

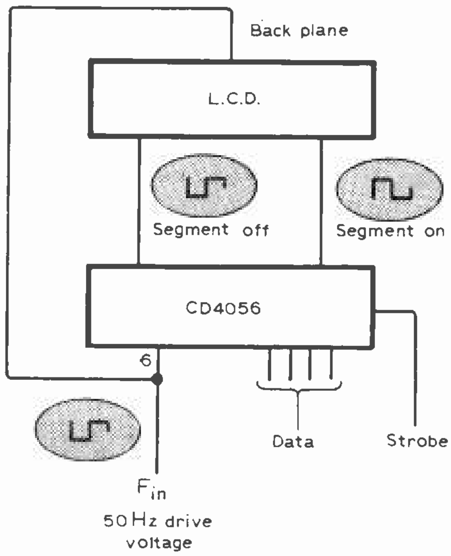


Fig. 5. Generation of the alternating drive voltage. Voltage doubling and cancellation causes the segments to turn on and off respectively.

Display

A reflective field-effect display was used in the prototype, which can be powered from 3 to 10V. An alternating drive voltage prevents degradation of the display cell and the circuit arrangement for producing this is shown in Fig. 5. The 50Hz square wave is a compromise between a minimum frequency set by flicker, and a maximum set by increasing display dissipation due to the charge and discharge of display segments. The CD4056 display driver produces anti-phase square waves for segments which are to be displayed, and in-phase signals for segments which are turned off. These waveforms are relative to the square wave on the backplane so voltage doubling and cancellation occurs. Display corrections are shown in Fig. 6.

Components List

Integrated circuits	
1,2,3,4,16,17	CD4518
5,6,7,8	CD4019
9,10,11,12,13	CD4056
18,19	CD4011
Resistors all 1/10 W	
1-5	1MΩ
6	22MΩ
7	150kΩ
8, 9	1MΩ
10	1kΩ
Capacitors	
1	100pF polystyrene
2	10pF silvered mica
3, 4	100pF polystyrene
5	47μF 6.3V tantalum
6, 7, 8	10μF ceramic

Display — LXD 7545 (Transworld Scientific, High Wycombe, Bucks)

Crystal — SX-1V'A'S, 100kHz (Interface Quartz Devices, Crewkerne, Somerset)

Battery — 4 × RM675H mercury cells

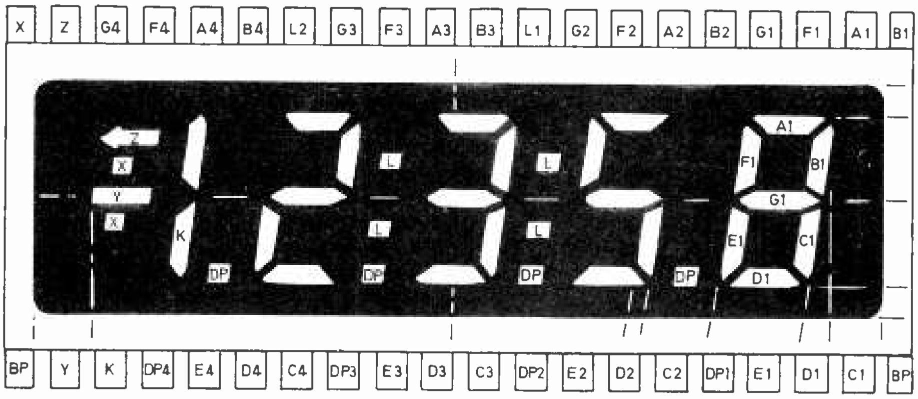


Fig. 6. Liquid crystal display connections.

Printed circuit boards

Two double-sided p.c.bs will be available for this design. The boards, which are based on the author's layouts to be described next month, are priced at £6.00 for the set and are available from M. R. Sagin at 11 Villiers Road, London N.W.2.

Re-invention — how often?

Why does engineering history repeat itself with such uncanny accuracy?

F. G. Canning F.Inst.R.E.E.(Aust) *Consulting Electronics Engineer*

Whether through ignorance, insularity, chance, plagiarism or some other cause, inventions and ideas that once held great hope are abandoned then resuscitated, often without any credit being given to the originator. The author offers a few case histories and leaves us to draw our own conclusions.

Anyone like myself, whose personal experience covers almost the same time interval, must have found *Wireless World's* feature "Sixty Years Ago" a stimulant to long-dormant memories. I wonder if such readers may have been reminded, as I was, of the frequency with which certain inventions or developments, well-known and even commercially exploited in those distant days, have seemingly sunk into oblivion only to be re-discovered or even claimed as new inventions after the passage of relatively few years.

Musing over such things, one must wonder how far these duplications may be due to chance, to national insularity, to conscious plagiarism, or (more seriously, perhaps) to inadequate familiarisation with prior art at the educational level. Illustrations of all these causes could probably be cited, but the last-mentioned seems to me the most serious and intractable problem, given the breakneck and accelerating pace of development in the electronics and allied fields. How *can* time be found in an undergraduate course to trace the historical development of even a limited sector – e.g. radio transmission of intelligence – from, say, the beginning of this century? How many of today's engineers-in-training have ever been told, for instance, how an electric arc can be, and was, used commercially for long-distance radio transmission? Obsolete the method may be, but the principle underlying it is still valid and further use may yet be found for it, perhaps in a very different context. Later, I will mention one similar case within my own knowledge.

Permeability Tuning

One day late in 1939 my managing director said "what are we going to do about this?" He handed me a letter from a gentleman in the USA (no names, no pack-drill) claiming retrospective royalties for several years' use, in broadcast receivers, of "his patent covering the tuning of radio-frequency circuits by movable iron-dust cores." The claim was, of course, laughable to anyone acquainted with European activities, but memory stirred in its sleep and suggested a really resounding anticipation of this "invention." Reference to the local public library produced the files of *Wireless World* for the years 1919 and 1920 and in the issue of February 1920, pages 672/673, we find some details of the Marconi Amplifier Type 55B, then in commercial production, and also mentioned a year earlier in the issue of February 1919. This was a radio-frequency amplifier intended for, roughly, the 200-600m wave-band, having *six* radio-frequency amplifier stages and a detector, with *ganged* permeability tuning of the r.f. stages using a single control! The tuning cores were, admittedly, crude, consisting of fine iron filings dispersed in cores of hard wax mounted on a single control handle and the tuning was broad, but no one could dispute the anticipation of the principle. This gives some indication of how far Capt H. J. Round and his Marconi engineering team were ahead of their time in certain directions at that period.

Cone Loud-speakers.

The moving-coil speaker with cone-shaped diaphragm is nowadays generally credited to Rice and Kellogg in the USA and indeed they probably produced the first commercially-successful design. But how many people realise that this design was really little more than the wedding of two features, both derived from Europe, which were already many years old?

The cone diaphragm, in principle very much as it is used today, first came to my notice in the remarkably efficient "Type A" headphones of S. G. Brown in England. I do not know their year of origin but they were already well-established when I first wore a pair in 1918. The original diaphragms in those headphones were exactly analogous to today's cone speaker – a very light cone, of spun aluminium in this case, suspended by a ring or "surround" of very thin and flexible parchment paper between its edge and a more substantial cylindrical aluminium support which carried the whole assembly in proper relation to the magnetic drive system; this latter was, not a moving coil, but a tuned steel reed attached to the apex of the cone. The paper surround ring was later found unduly susceptible to moisture and failure of the glueing and was replaced by a flexible aluminium surround integral with the cone. I know of at least one pair of these remarkably sensitive headphones still perfect and in regular use.

As for the moving-coil drive, that certainly goes back at least to a patent of Sir Oliver Lodge of much earlier date and perhaps even further. Once, when attending a lecture on loudspeakers where I mentioned this patent, I was called to order by someone who pointed out that it was for a moving-coil relay and had nothing to do with loudspeakers. Granted; all the same, anyone who has ever dissected one of the first commercial moving-coil speakers (a Magnavox model with metal diaphragm and gooseneck horn, circa 1916) is likely to suspect the origin of the idea. The coil and its attachment to the metal diaphragm might have been made directly from one of Lodge's patent sketches. Coincidence, perhaps?

Compressed air and the loudspeaker

A fair example of re-invention seems to have occurred here. Around 1921 there appeared in England what may have been the world's first loudspeaking gramophone, the "Stentorphone," whose source of sound was compressed air rather than a vibrating diaphragm. It was, I believe, a brain-child of Mr. Gaydon, at that time Chief Engineer of the Creed Printing Telegraph Co. of London. It was a large cabinet-type instrument whose tone-arm carried, not the conventional sound-box with diaphragm but a clever spring-balanced comb-type valve whose motion, when displaced laterally by the stylus, released a proportional amount of compressed air at around five pounds per square inch into the tone-arm and thence to a large horn built into the cabinet. A small motor-driven compressor in the cabinet base supplied the air. By the simple action of a by-pass valve in the air line the volume of sound could be controlled smoothly from zero to an overwhelming roar. I fancy that anyone who ever heard a Stentorphone in full cry will clap his hands over his ears at the mere memory. I have a clear recollection of an occasion when Caruso's top note in "O Paradiso," from "L'Africaine," drove us pell-mell into the street and brought the neighbourhood running to the scene of the supposed crime. Yet in skilled hands and with delicate adjustment of the comb valve the quality of reproduction was ahead of its time.

Time passed and by 1926 or so the Stentorphone might never have been, so completely did it seem to slip from public ken. However, in the mid-1930's the identical principle re-appeared in the USA with a blare of publicity as an American invention intended primarily for the exhortation of mere groundlings by announcers in slow-cruising aeroplanes. "The Voice from the Sky" was, I think, ostensibly aimed at traffic control and military uses, but it was speedily enlisted in the eternal struggle to sell more of so-and-so's soap and like commodities and in this capacity it soon became such a day-long public pest that within a short time it was made illegal in Australia and other countries and disappeared from current knowledge. But it re-appeared, once again as a nominally new invention, during the 39-45 war, this time as a maritime loudhailer and no doubt for other good uses. By that time, presumably, the air-valve was being operated by a transducer driven by an amplifier from a microphone.

The Quenched Spark Gap

I am not sure in what year the quenched gap went into service commercially in radio transmitters, chiefly through the painstaking work of the Telefunken Company in Germany, but by the early 1920's it was well-established in many countries, including America, as possibly the best device for spark transmission (when properly maintained) and was in wide-spread use in ship-to-shore telegraphy. Its operating principle was by no means as simple as it looked and was worthy of study. Used in the primary, high-voltage circuit of a spark transmitter, it aimed to give a very rapidly-quenched spark discharge consisting of only one or two oscillatory cycles, thus providing, in effect, pulsed excitation of the tuned secondary and aerial circuit which was then left to oscillate at its own frequency. Reflection of energy back to the primary circuit was prevented by the open-circuit at the gap. The result was a sharply-tuned, highly efficient spark transmitter with a beautiful note, at the receiving end, of 800 to 1000 Hz, but this depended heavily on proper operation and maintenance. The "gap" consisted of a number of finned air-cooled spark gaps in series, of a number just sufficient to be broken down by the available primary voltage; one gap too few could spoil the quenching action somewhat and broaden tuning, while one too many would sometimes give sparking at half the proper frequency, i.e. on every second cycle. The theory of the device involved the combined quenching effects of rapid cooling, magnetic blowout by the radial field surrounding the discharge, and the difficulty of maintaining an arc between pure silver surfaces in an atmosphere of nitrogen. The effect aimed for was a single spark per cycle as nearly as possible – not a continuing arc. If the silvered gaps were made absolutely air-tight, a period of operation would burn out all oxygen and thereafter quenching could be almost perfect.

However, the early twenties saw the rapid development of the thermionic valve in continuous-wave transmission and by 1925 or so the spark transmitter, of whatever type, was on its way out and presumably was no longer mentioned in engineering education. So when, around 1943, a Government-owned laboratory, manned mostly by the cream of recently-graduated electronics engineers, was working on a specialised radar transmitter and decided that a spark discharger was the simplest quickly-available device for use with a pulse-forming line, effort was concentrated on a rather simple and crude version of the Marconi rotary spark gap, a type never notable for very good quenching. Enquiry produced the surprising information that no one involved had ever heard of the quenched gap and they were glad to be told about it, though it was already too late to be of use for that project.

So it seems that a highly developed and commercially effective device had disappeared from engineering training and knowledge in the space of little more than fifteen years; it was not even known as a historical fact.

En passant, Telefunken was responsible for many other design features of high efficiency, especially in radio reception. We tend to think of small, totally-enclosed and robust signal rectifiers as a very modern product of the semiconductor age, but I have not forgotten my astonishment when, in 1920, I saw the radio operator of a German-built ship pull the crystal detector of his receiver out of its two-pin socket and nonchalantly drop it into his pocket prior to going ashore. And this was not even the relatively robust but insensitive carborundum rectifier of those days – it was a galena crystal, quite the most delicate and tricky detector then in use, which normally responded only to infinitely careful and breathless searching with the point of a long wire "cats-whisker" and could become insensitive at the lightest jar.

Telefunken's insistence on air dielectric tuning capacitors when competitors were mostly committed to solid – and lossy – dielectrics, their careful use of ceramic insulation in radio-frequency circuits, their introduction of "Litzendraht" (specially stranded) conductors in tuning coils to reduce r.f. resistance and their use of the low-capacitance "bank-winding" in these coils to further reduce r.f. losses, all testified to their recognition that in those days the only signal you heard was one that developed enough r.f. voltage to operate a rectifier, unaided by any amplification whatsoever except that of the "Q" of tuned circuits. I wonder how many engineers could bank-wind a coil now, though the method is still a sound one for raising coil efficiency at the lower radio frequencies.

Negative-resistance Oscillators

In the very early 1920's some interest arose in amateur radio ranks over what became known as the "Numans" oscillator. At that time the Dutch Philips concern had made available what was possibly the first valve having two concentric grids. The application of a modest positive voltage to the extra grid partially neutralised the space charge and so enabled the anode voltage to be reduced to, I think, something under 20V, very low for those days. Mr. Numans, a Dutch radio amateur, used one of these valves (by means which were probably not then understood by anyone) to produce what I recall as a two-terminal oscillator with no obvious means of feedback – and a good frequency-stable oscillator too. I no longer have a record of the actual circuit, but looking back it does seem possible that Mr. Numans may have independently invented, and perhaps forestalled, the Dynatron negative-resistance tube of Dr. L. M. Hull, of the General Electric Co., USA. However, I cannot be sure of the relative dates and have not tried to confirm them. Later, of course, other specialised negative-resistance valves were designed and, to a limited extent, produced; for example the "Negatron" of J. Scott-Taggart which was, I think, used in certain marine receivers.

These reminiscences may or may not be relevant to the initial question of how far, if at all, historical survey of prior art should rightly have a place in engineering education. But few as my examples are, I rather think that most of them will be unfamiliar to the present generation of active engineers. If they stimulate any thinking on the subject, that might perhaps be no bad thing.

Designing battery chargers

Difficult-to-find design curves and an inexpensive over-charging protection circuit

by Thomas Roddam

Have you ever seen a simple account of how to design a battery charger? It was with some surprise that I realised recently that I could not recall any description at all of the design characteristics of a transformer-rectifier system for pumping energy into a battery. Yet we are all using batteries nowadays. In my earliest days there was a simple procedure: you seized the leather strap, and headed for the local bicycle shop. Later there was the great array of cells in a battery room: two lots at 13 volts and two at 24 volts. Fred, in permanent attendance, living in a permanent sulphuric atmosphere, spent all his day charging and discharging 'his' batteries. Now we have float operation and if we are very rich, sensors for cell temperature, electrolyte specific gravity, the F.T. index, and a small computer to decide just what current to deliver.

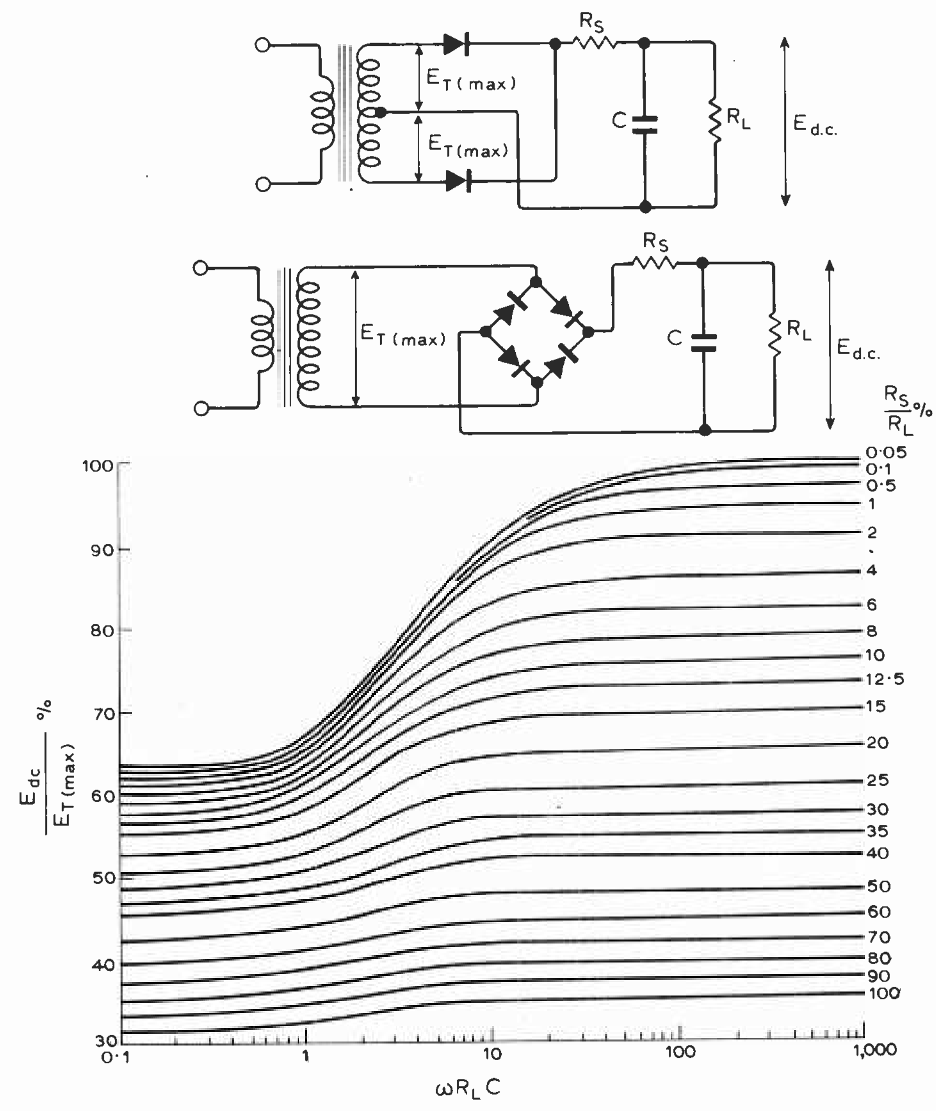
I just want to charge my batteries, though I may add a cut-off device. How do I choose the transformer and the rectifier. The essential conditions really boil down to the following. If the mains voltage is high, and the battery voltage is low we must not overheat the transformer or overload the rectifiers. I assume we are not in a mad panic to get the battery charged again, so that we are well below the safe charging current of the battery. If the mains voltage is low and the battery is not particularly low we want to go on feeding energy into the battery.

There is a G.E. application report which can be used to guide the designer, although I found, when I tried to use the equations provided, that I fell rather quickly into confusion. The alternative method which I have now adopted involves some guess and try, but does provide a very simple approach. The starting point is a very useful set of curves for the design of rectifier circuits with capacitor input filter which are out of print in the original publication and which are reproduced in Fig. 1.

To use these curves we consider what happens when we charge a battery. The charging current is, or so the meter says, a direct current, while the terminal voltage remains nearly constant. This is very much the behaviour of a parallel capacitance and resistance. The only difference is that instead of thinking of a load current we must now think of a charging current. The battery capacitance is very large, so that we can replot the ratio curves as a single graph for ωCR large, with simply output voltage as a function of the ratio of source resistance to load resistance. This is what we have in Fig. 2.

Let us assume that we are dealing with a nominal 24-volt battery, with 12 cells. The float level of this battery will in practice be 2.25 volts per cell, giving 27 volts. The reason for operating at 2.25 volts per cell is that this is the point at which we have the maximum energy storage combined with the longest possible life. When a battery has been used it is not uncommon to boost it up

Fig. 1. $E_{dc}/E_{T(max)}$ % as a function of $\omega R_L C$ for full-wave circuits. C in farads and R_L in ohms, $\omega = 2\pi f$.



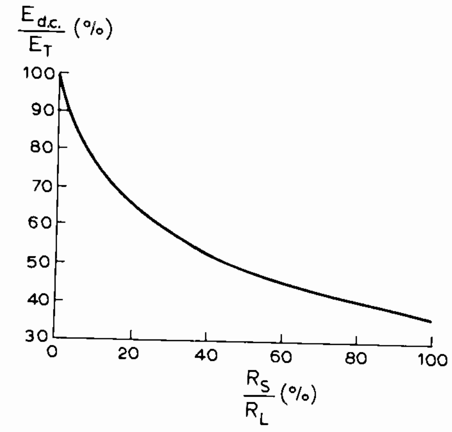


Fig. 2. Characteristics of full-wave rectifier for ωCR large, as is the case in battery charging.

to 2.6 to 2.7 volts per cell. I am not sure why, but it may be to make sure that all the cells are fully charged. This can bring us to a terrifying 32.4 volts, when lamps and transistors start to pop. Actually, the terminal voltage falls back once the charging current is cut.

Let us allow a meagre 1.2 volts drop in the rectifier bridge and our extreme condition corresponds to a direct voltage of 33.6. For the purpose of this analysis I shall assume that on a day when the mains input is 6% low it will take forever to reach 2.7V per cell. I shall therefore have $I_{load}=0$, so that $R_{load}\rightarrow\infty$ and $R_S/R_L=0$. For a peak voltage E_T of 33.6 we must have $E_{rms}=23.8$V. This, however, is for a low mains input, and the nominal value must be 6% higher, or 25.3V r.m.s. We have thus defined the turns ratio of the input transformer.

When the mains are 6% high we shall get $E_{rms}=26.8$V, and $E_T=37.8$V. Now we must subtract, say, 1.3V for the rectifiers, and we have an effective E_T of 36.5 volts.

It must be accepted that if you are sharing a battery, the other users will run it down to 1.8 volts per cell. When at last you can switch on the charger the terminal voltage will be only 21.6 volts. Sooner or later this condition coincides with the high mains input and we must consider the condition where $E_{dc}/E_T=21.6/36.5$, which is pretty close to 60%.

This max-min-max-min rate gives us our entry point to Fig. 2. We find that we must have a value of $R_S/R_L=27\%$. Let us say that to save money, not time, we have a nominal charge rate of 6 amps. For this current, and 24 volts, the value of R_L is 4 ohms. Immediately we see that we must make R_S 1 ohm. This includes the resistance of the transformer secondary and the primary resistance as seen at the secondary. Usually we can simply take twice the secondary winding resistance as a reasonable approximation. The transformer is, roughly, a 150W size, and will certainly not have 36 watts of copper loss: a physical resistor will be needed.

We do not know if this design is even roughly right, however. Let us go to design centre conditions. We shall then have a nominal 23.5V r.m.s., giving $E_T=33.2$, from which we take off 1.2V (the exact figure is chosen to get round numbers) to get $E_T(\max)=32$V. The battery voltage is assumed to be at the 2.25 volts per cell level, or 27V so that $E_{dc}/E_T=85\%$. Returning to Fig. 2, we find $R_S/R_L=4\%$, to that R_L must be about 25 ohms. At the float level, then, the charging current is only a little more than 1 amp. We probably need to change something. What has happened is that we have been overcautious with our boost condition, but I shall stick with this transformer for a moment longer.

I do not work with a simple float system, because it is really too noisy and although it does not affect the way my equipment works, it gives a fuzzy trace on the oscilloscope. Now a battery which is roughly 20 to 80% fully charged is operating fairly close to 2 volts per cell. Under these conditions, when the battery is being topped up at lunchtime, for example, $E_{dc}/E_T=24/32=75\%$. This means that $R_S/R_L=10\%$. If we take a desirable charging current as 4 amps, this will make $R_L=6$ ohms, and so $R_S=0.6$ ohms. My guess for the effective copper loss resistance of the transformer is 0.2 to 0.3 ohms. We then have the possibility of putting in an external resistor to give the extra 0.3 to 0.4 ohms, with an additional 0.4 ohms which is switched into circuit to limit the current under flat battery conditions. We could have changed the resistance to suit 2.25 volts per cell, but then we should have needed to check the 2.0V condition. However, let us see what happens at 2.25 volts per cell with 0.6 ohms. We have $R_S/R_L=4\%$, so that R_L must be 15 ohms. The charging current has fallen from 4 to 1.8 amps. At a rough guess, I should say this was about the right size of float unit for a system in which the load varied from, say, 1 to 3 amps.

It is quite easy to work out the charging current at various values of E_{dc}, an invented regulation characteristic for the charger. If the current is found to be excessive, a new value of R_S must be used, and we can choose to switch this into circuit. There are advantages in putting this resistance on the primary side. In our example the transformer will be roughly 10:1 for 240 volts working. It is much easier to find a 33-ohm resistor than a 0.33-ohm unit. At 6 amps the dissipation will be about 12 watts. An inductor, in the a.c. part of the circuit, can be used. A 1mH inductor will give 0.3 ohms effective impedance at 50Hz, and will reduce the amount of heat generated – at a price.

Rectifier circuits

A figure for rectifiers in the ordinary power supply is shown as Fig. 3. Again we just use the right-hand edge of this set of curves. We had a condition of 6 amps average with $R_S/R_L=27\%$, and 4 amps average with $R_S/R_L=10\%$. For use in Fig. 3 we need to take $R_S/2R_L$, because the rectifier is full-wave, and so we have either $(2.1 \times 6)/2$ or $(2.5 \times 4)/2$ as our criterion. It boils down to a rectifier r.m.s. current of 6 amps as our design figure. The reverse peak voltage follows the usual rule of being either E_T or $2E_T$ but everyone is conservative

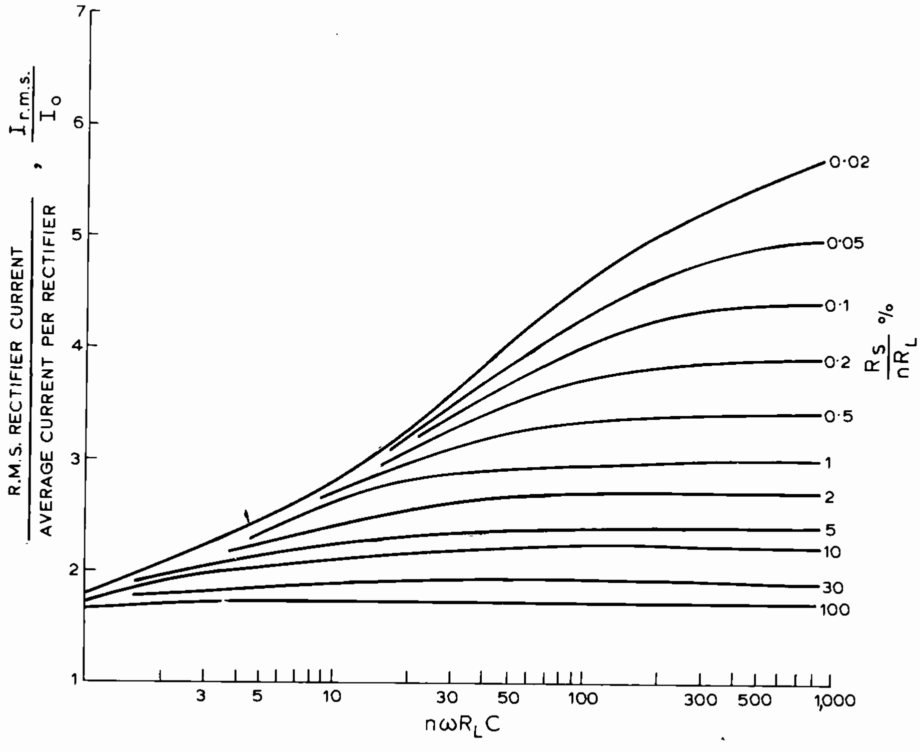


Fig. 3. The ratio r.m.s. rectifier current/average current per rectifier plotted against $n\omega R_L C$. C in farads, R_L in ohms. n = 1 for half-wave, n = 2 for full-wave and n = 0.5 for voltage doubler.

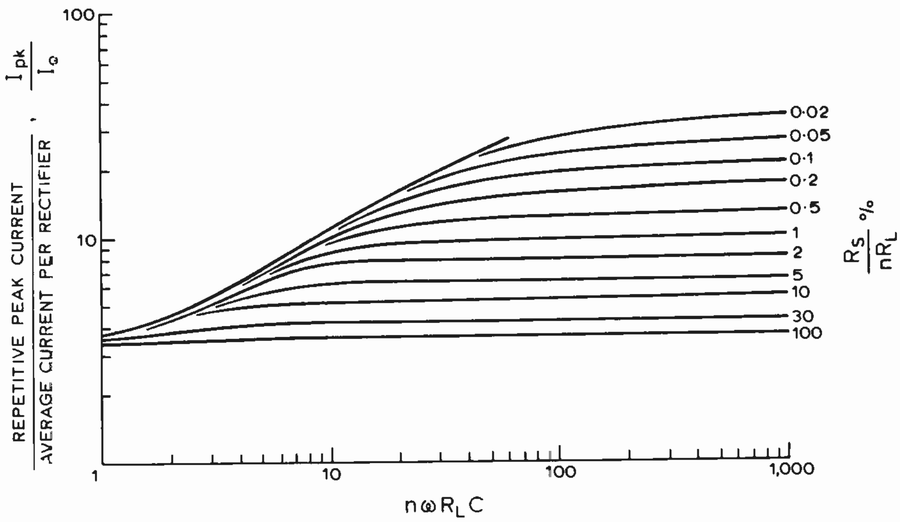


Fig. 4. The ratio repetitive peak current/average current per rectifier, plotted against $n\omega R_L C$. C in farads and R_L in ohms, $\omega = 2\pi f$ and f is line frequency. $n = 1$ for half-wave, $n = 2$ for full-wave and $n = 0.5$ for voltage-doubler.

when it comes to the choice of rectifier and step-down circuits are notoriously sensitive to mains spikes.

It is useful to check the rectifier peak circuit, using Fig. 4. There is no single inrush problem with a battery, as it is a charged capacitor when it starts. Under running conditions we shall get a ratio of I_{pk}/I_o of about 6.5 or a current of about 13A. The rectifier designer has usually taken this into account, but this figure enables us to guess an order of magnitude for the ripple voltage. A battery will have an internal resistance in the region of 10 milliohms, though it is not easy to get more than a rough number. But 10 milliohms will give 0.13 volts peak-to-peak ripple on the battery. It is a spiky ripple, as the peak-to-average current ratio indicates and is acoustically more of a nuisance than the numerical value indicates.

The use of half-wave rectification for battery charging was quite common at one time. Whether this was simply an economy measure in the days when copper was cheap and rectifiers were expensive, or whether it was the result of a mildly magical belief that the battery needed 15 milliseconds rest after a 5 millisecond current injection it is hard to know. Half-wave circuits have been used recently with thyristor controllers and it is useful to have on record the essential design curves, even if only to use them for their original purpose. Fig. 5 is the half-wave version of Fig. 1 and, as before, we can construct Fig. 6 to cover the very-large-capacitor or battery application. The regulation is seen to be even worse than the regulation of the full-wave system. The curves for the rectifier requirements are applicable to both modes of operation, so that we have a complete basis for the design of the half-wave system.

Information about the transformer, and all those odd factors which appear as utilisation factors, can be found in any reference book and in a good many rectifier catalogues. It is hardly necessary to repeat them here. One detail is worth mentioning, however, because it does sometimes get designers confused. If we use a half-wave rectifier we naturally have current flowing in the transformer secondary only for, say, the positive half-cycles. This means that a meter will show d.c. flowing through the winding. We all know that if you have d.c. in an iron-cored coil you will probably need to provide an air gap in the core. The unwary designer thinks of his transformer secondary as an inductor carrying d.c. and arrives at an unnecessarily large structure. The conditions in the core are set by the applied voltage: the flux density is the time integral of the voltage, with turns and area as factors, and the voltage is symmetrical. The use of half-wave rectification does not produce any flux offset under any normal operating conditions. The high I_{rms}/I_{dc} ratio makes the transformer pretty inefficient anyway, but there is no advantage in making it even worse.

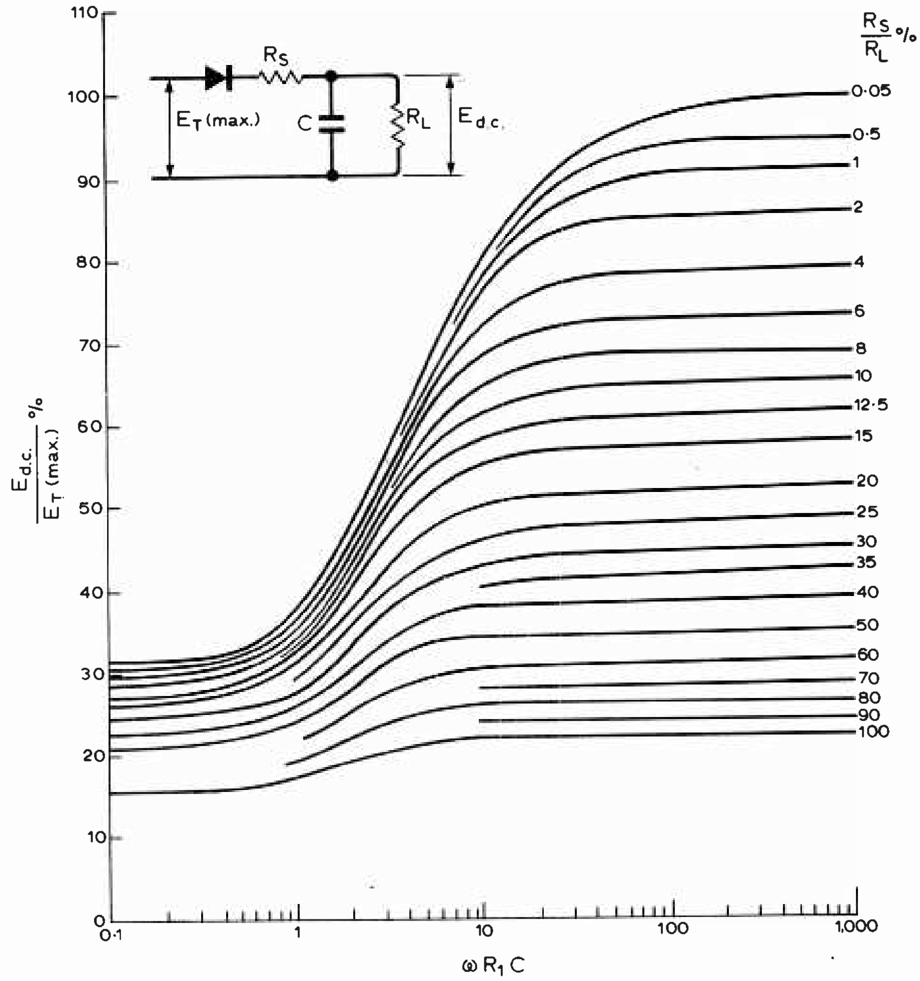


Fig. 5. $E_{dc}/E_{T(max)}$% as a function of $\omega R_L C$ for half-wave circuits. C in farads, and R_L in ohms, $\omega = 2\pi f$.

The full-wave rectifier circuit was designed as an example to show the use of the design curves and with the criterion that it should just haul the battery up to the 'boost' voltage, combined with a maximum current at the start of charge, we found that the charging current fell smartly as charging progressed. We should call this 'taper charging' if we wanted to sell a cheap charger with this performance, and would point out the essential safety of the drooping current characteristic. Some users, however, do not want to wait forever, to get a really full charge into the battery.

Examination of Fig. 2 shows that the curve is pretty close to

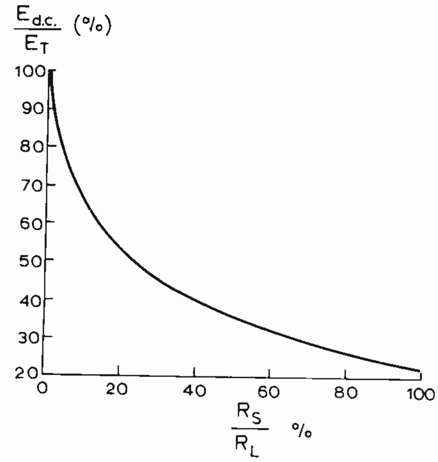


Fig. 6. Characteristics of half-wave rectifier for ωCR large.

$$\frac{E_{dc}}{E_T} = \frac{R_L}{R_L + 2R_S}.$$

Let us choose to have 6 amps charging at 21.6 volts, which makes R_L 3.6, and 4 amps charging at 27 volts, the normal float level, which makes R_L 6.7. We can then write

$$\frac{E_T}{21.6} = \frac{3.6 + 2R_S}{3.6}$$

and $$\frac{E_T}{27} = \frac{6.7 + 2R_S}{6.7}.$$

It is a quick step to get $E_T = 37.2$ volts and $R_S = 1.3$ ohms.

We can, if we wish, construct a full regulation characteristic, but the resistor is now going to be rated at, in practical terms, 48 watts. This charger, left on indefinitely, will try to bring the battery up to just over 3 volts per cell.

Over-charging protection

It is not expensive to provide some protection against over-charging. The cost starts to rise if we write a very tight specification. At one time the method was to use a voltage-sensitive trip circuit, but it is probably cheaper to use solid-state switching, and we can make the system fully automatic. This means that it will be permanently connected to the battery. The disadvantage is battery noise, but in many applications the equipment must be designed to put up with this, anyway.

The circuit is shown in Fig. 7. Ignore D_2 and R_4, which are simply there to provide 50 to 100 mA trickle into a charged, idle battery, and possibly some lamps. The main charging path is through the thyristor Th_1. If Th_2 is not conducting, Th_1 will start to conduct as soon as point P rises enough above the battery voltage to get triggering current through R_1 and D_1. For a BTY79, which can be obtained easily, and which will carry the 6 amps of d.c., we might make R_1 100 ohms, and D_1 a small half-amp rectifier diode.

As soon as the voltage at P reaches about 3 to 4 volts above the battery voltage the thyristor triggers and current flows into the battery.

Now let us operate Th_2. The cathode of Th_1 is at not less than 21.6 volts, while P will peak up to 37.2 + 6%, say 40 volts under worst mains conditions. We can make $R_2 = R_1$, and the gate of Th_1 will only be 20 volts above the negative line, so that Th_1 will not trigger. The current through $R_1 + R_2$ will be, at its peak, 40/200, or 200 mA, which makes Th_2 a small device and R_1 and R_2 conveniently 3-watt resistors. A suitable cheap device (£0.50) for Th_2 is the BTX18, which needs up to 5mA to trigger it, and which may trigger at anything from 0.5 to 2 volts. The trigger current is provided by the capacitor, C, which is only needed to be, say, a 5-volt unit and can be 10 to 100μF. Resistor R_3 is needed to let C leak away, and 1000 ohms is as good a value as any.

The choice of P_1, the resistor in series with it, and the zener diode are pretty arbitrary. For a 24-volt battery it seems reasonable to choose a 10 or 12V zener diode. Value of P_1 is conveniently 1000 ohms, and the series resistor should be worked out so that the slider of the potentiometer is fairly near the top. Indeed, it is probably better to use a 500 or 200-ohm potentiometer and put resistors both above and below it, to limit the range of adjustment.

There are three phases of the control operation. If the battery is low, Th_1 fires but Th_2 does not. As the critical region is approached, after Th_1 has fired, the ripple voltage across the battery will be enough to tip Th_2 on, although as Th_1 has already fired this does not matter. When the battery voltage is high enough for the necessary few milliamps to be flowing through the zener diode, Th_2 will fire as soon as its anode volts permit. This is before Th_1 has reached the trigger point, and the firing of Th_2 cuts off the trigger supply to the gate of Th_1. Charging, except through D_2 and R_4, stops.

The circuit can be set up fairly quickly if a large capacitor and, say, a 6-ohm resistor are used in place of the battery. The low current through the zener diode and the range of values for the trigger conditions of Th_2 make it impossible to calculate the exact setting. In practice a unit of this kind will have a transition region of about half a volt, which is good enough for general applications. The use of an operational amplifier or comparator, in a control section of the style shown in Fig. 8, will give a very high precision, but such precision is meaningless when the ripple voltage is greater than the setting accuracy.

Perhaps the only justifiable improvement is to go the whole hog. The equipment is supplied from a stabilised power supply and the battery is merely a stand-by system. The problem we have considered is basically different from, and simpler than, this. The design curves are the necessary aids to its construction.

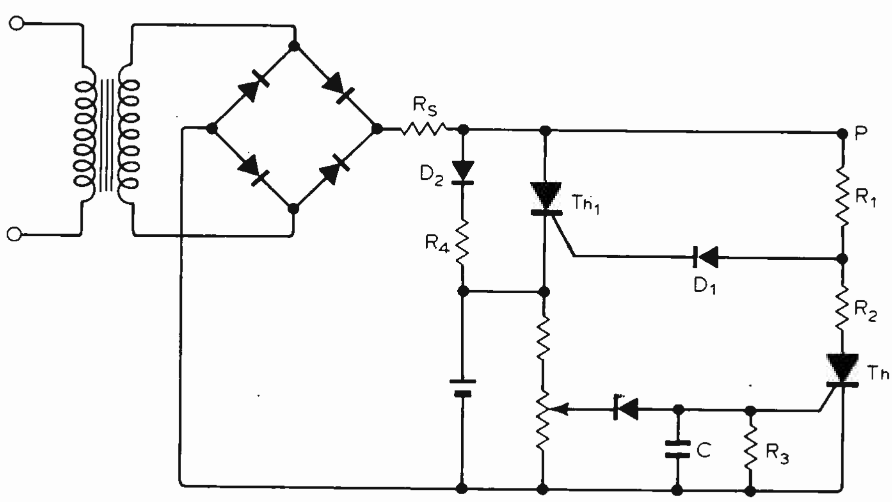


Fig. 7. Automatic charger control. Circuit can be simply set up by using a large capacitor and suitable resistor in place of battery.

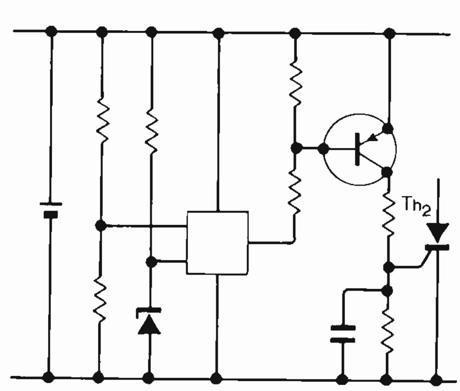
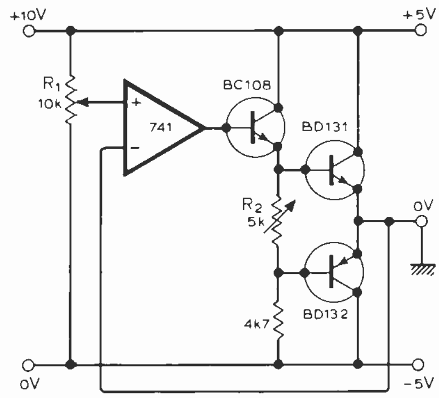


Fig. 8. Use of precision control section is only meaningful if ripple voltage is less than required setting accuracy.

Circuit Ideas

Voltage divider



When working with i.cs it is often necessary to have positive and negative supplies, and it is desirable that each supply remains steady with changes in load current. This circuit has been a useful addition to an adjustable 0 to 15V stabilized supply. For +5 and −5V, potentiometer R_1 is set to the mid position and the current through the output transistors is set to 20mA by R_2.

Voltage difference between the non inverting input and the output earth varies by about 1mV when the input voltage is adjusted between 4 and 15V, or if the current from one half is changed from 0 to 100mA.

C. H. Banthorpe,
Northwood,
Middx.

Two-phase v.c.o.

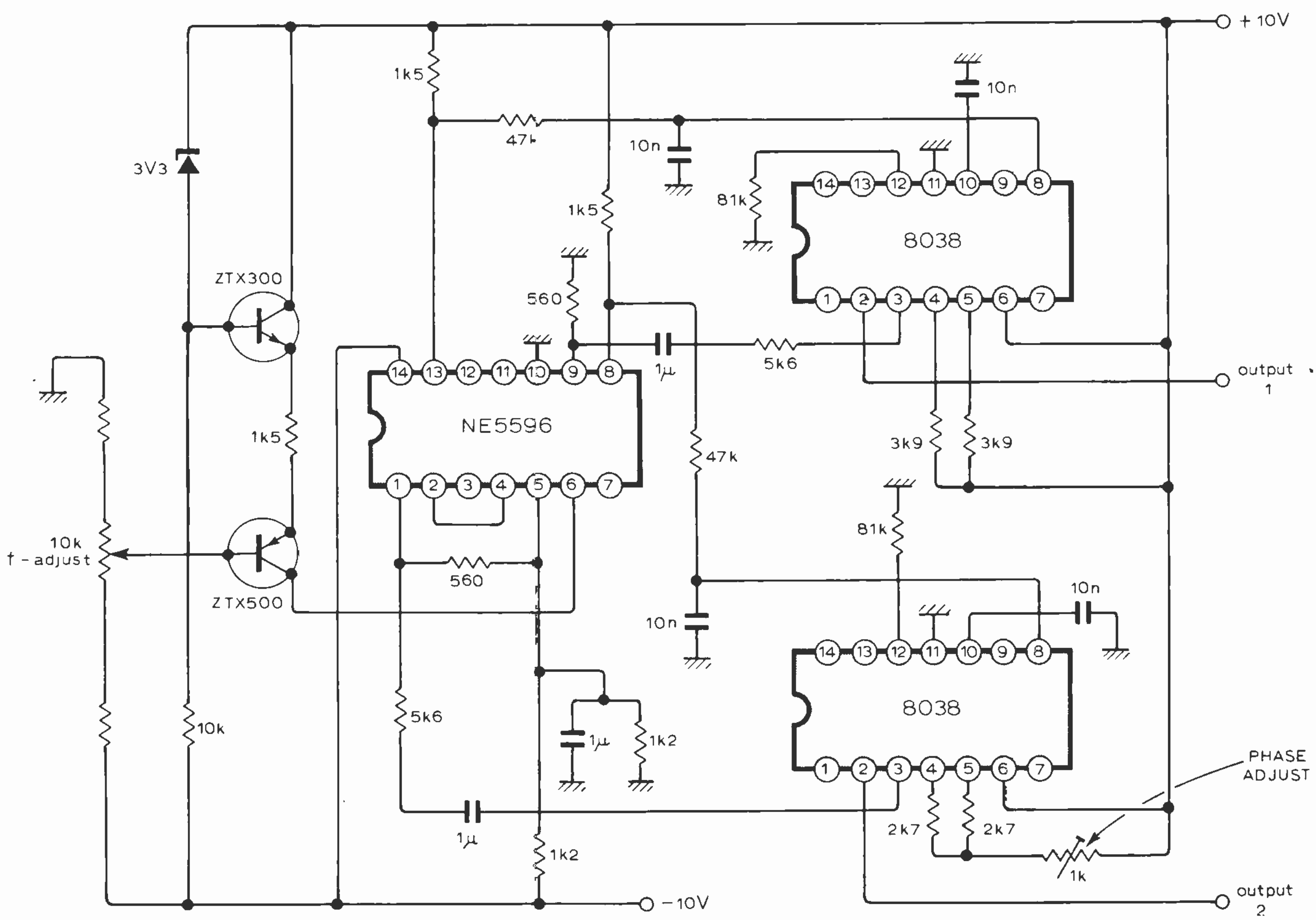
The standard method of obtaining an oscillator that will deliver a two-phase output (i.e. sin and cos) is to follow a conventional oscillator by a phase-locked loop, thus generating the quadrature signal. This has the disadvantage that, if a variable frequency is required, the capture range of the p.l.l. may be exceeded, or there could be a large phase error.

This oscillator is based on the above approach, but is a symmetrical version which does not have a restricted range or phase error. The circuit consists of two v.c.os, and pin connections are shown for the 8038 which gives a sinusoidal output. The i.cs are driven from a standard NE5596 multiplier circuit via a low pass filter. The two oscillators are locked together in frequency and 90° apart in phase by taking their triangular outputs to the multiplier inputs. A 90° phase difference between them causes equal d.c. collector voltages, and any deviation from 90° produces a voltage difference across the collectors which restores the phase.

Frequency of the oscillators is varied by producing a common-mode output voltage in the multiplier. This is achieved by altering the bias current. Thus, the oscillator is tuneable over a wide range, with nominally zero phase error.

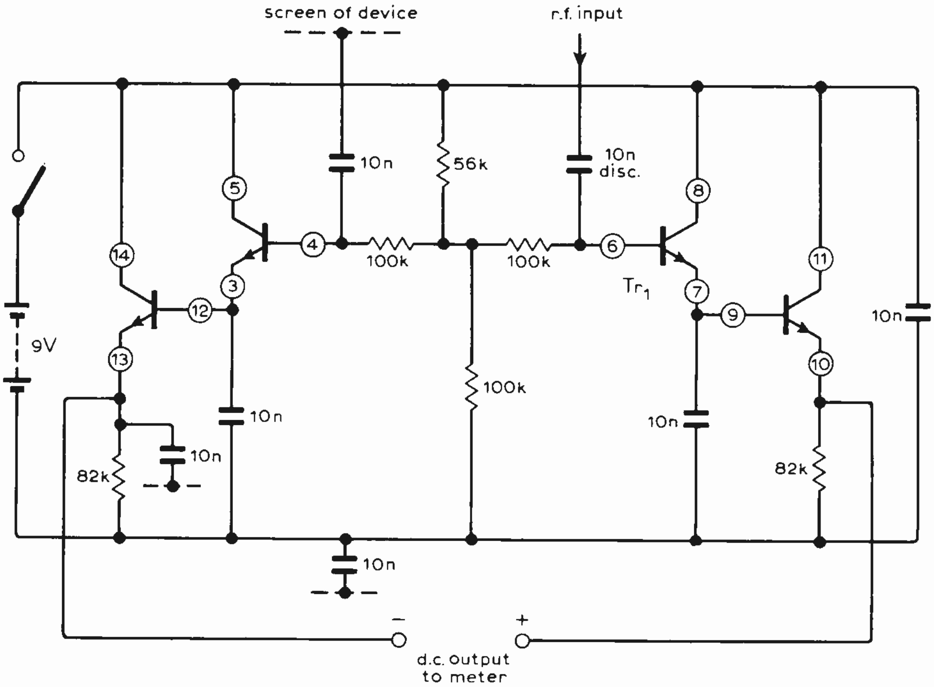
The frequency adjust potentiometer and resistors are set to give the required range, but the potentiometer can be eliminated if v.c.o. operation is required. If sinusoidal outputs are not needed the cheaper 566 type of v.c.o. can be used.

J. M. Worley,
Colchester,
Essex.



Peak reading r.f. probe

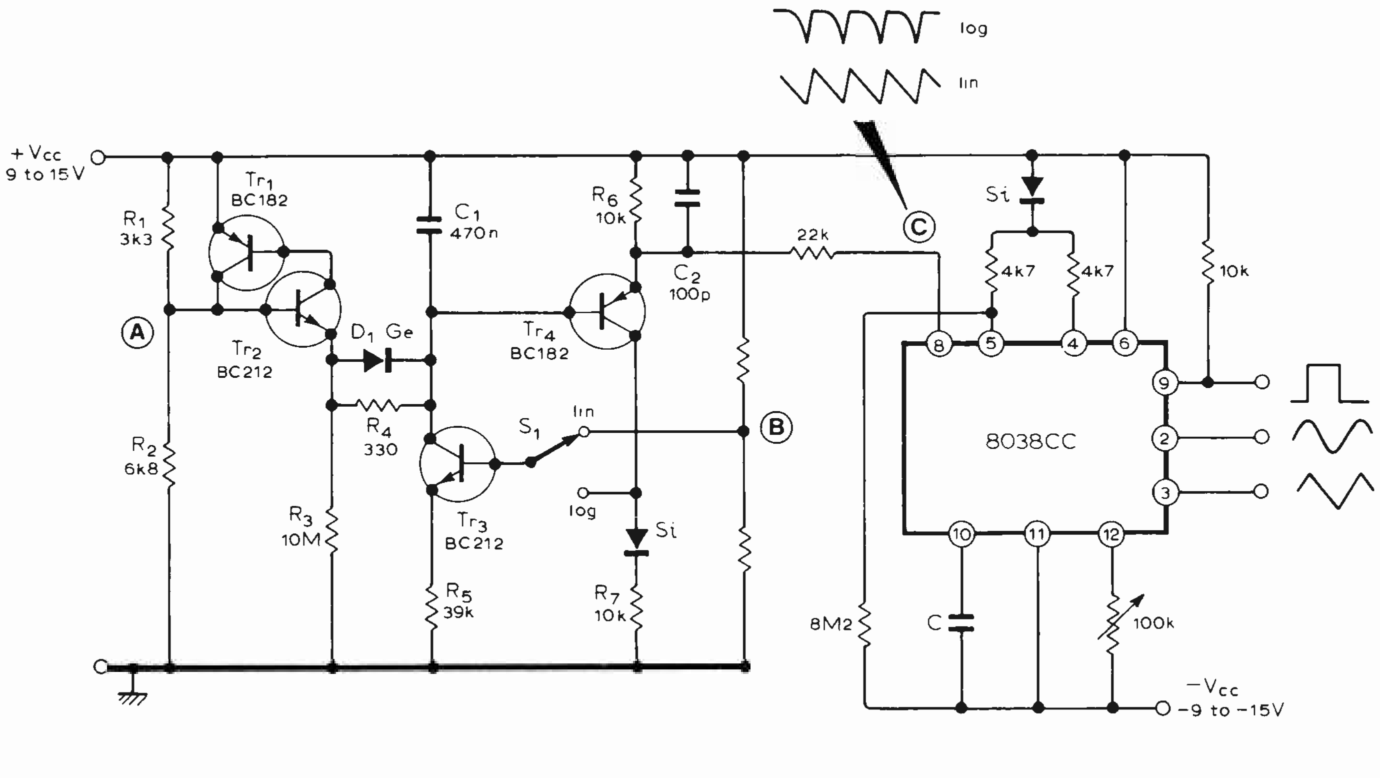
This peak-reading r.f. probe has no d.c. offset adjustments, does not suffer from temperature instability, and is capable of measuring r.f. levels from 1mV to about 4V. It is designed to be an add-on circuit, for a multirange meter, and measures frequencies in excess of 100MHz. A CA3046 is arranged as two symmetrical d.c. Darlington pairs, and the maximum output offset was found to be 700μV. The temperature coefficient is (according to the CA3046 data) 1.1μV/deg C, and the input impedance is 50kΩ in parallel with 3pF. To maintain this low capacitance the circuit must be constructed in a small screened case with a short probe tip and no i.c. socket. Current consumption is under 1mA.



Linear/logarithmic sweep generator

This circuit provides a logarithmic or linear sweep facility for the Intersil 8038 function generator i.c. In the linear mode Tr_3 acts as a constant current generator which charges C_1 almost linearly. Transistors Tr_1 and Tr_2 reset the capacitor as the voltage across it reached about $1/3V_{cc}$ +0.9V. In the logarithmic mode, positive feedback allows exponential charging of the capacitor. Capacitor C_2 shunts the narrow spikes that may occur from the circuit, and R_3 sinks a low starting current without affecting the sweep characteristic. D_1 improves the stability of frequency versus temperature but can be omitted with R_4 to extend the range of the output waveform. Point A has a short positive pulse which may be processed to reset the 8038 capacitor, and to sync an oscilloscope. Voltage at point B must be set experimentally, and is dependent on V_{cc}. An overall frequency control may be achieved by making R_5 variable.

Sergio Villone,
Turin,
Italy.



Waveforms-in-quadrature generator

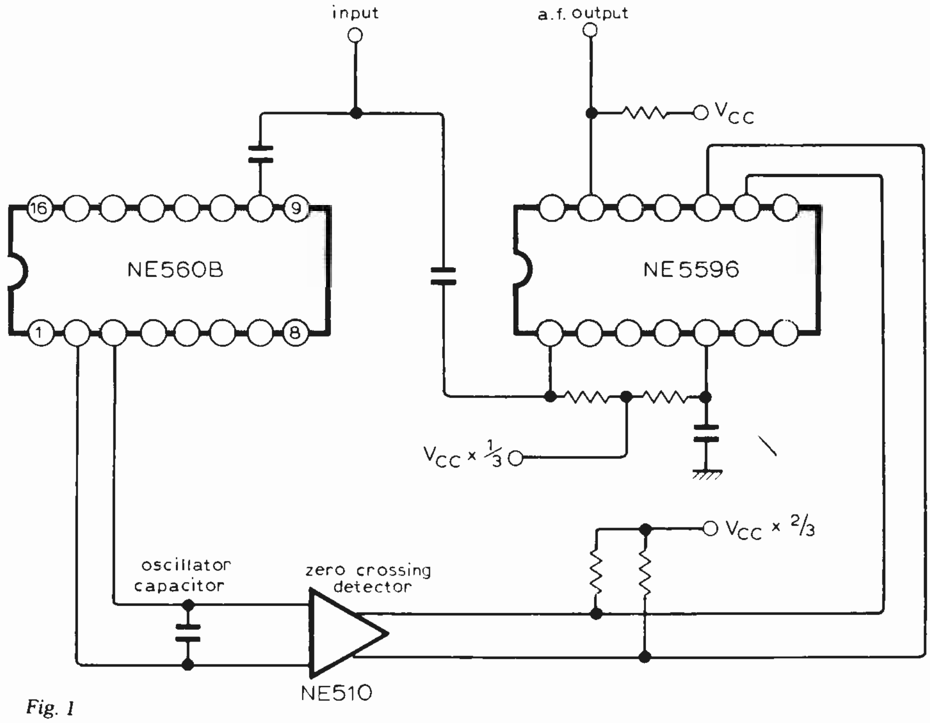
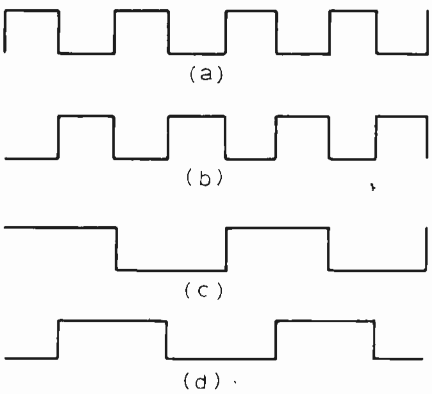


Fig. 1

Phase locked loop systems used for the detection of a.m. signals require either a two-phase signal or a two-phase local oscillator, the phases being $\pi/2$ radians apart. The Signetics a.m. phase locked loop i.c. requires the signal to be split into two phases, which causes the lagging phase to be attenuated. If the system is to be tuned over a range of frequencies, the phase relationship is only correct at one frequency. However, sufficient information is present to extract the other phase from the local oscillator signal without using any time-sensitive components. In addition, it is possible to make a circuit using the same configuration of transistors that would use this principle to detect a.m. The additional element required is ½NE510 and a block diagram is shown in Fig. 1. It is not possible to make a connection to the input of the second multiplier in the p.l.l. because it is internally connected to the output of the Schmitt trigger. Therefore an external connection is used.

When making a p.l.l. from scratch, t.t.l. can be used to obtain quadrature signals as shown in Fig. 2. To obtain two waveforms in quadrature, information is required at twice the repetition rate of the output. A Schmitt trigger is used to square a sinewave oscillator at twice the required frequency or as a v.c.o. Its output is inverted by the second Schmitt trigger in the i.c. Waveforms at either side of this inverter are shown in above. These waveforms are divided by two using the 7474 flip-flop. Output waveforms from the flip-flops are at half the input frequency and in quadrature. This system has only one time sensitive component which makes tuning over a large range possible. High speed circuitry such as e.c.l. can also be used to extend frequency range of the quadrature signals.



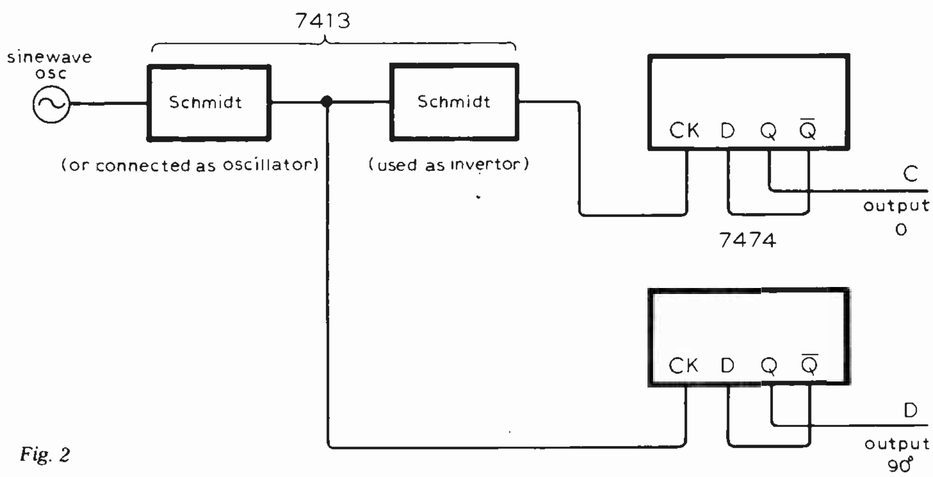
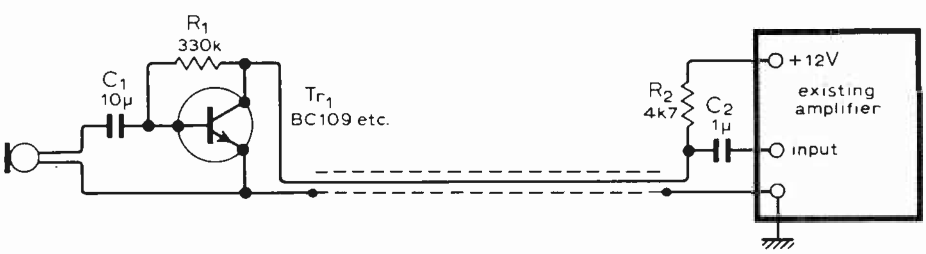


Fig. 2

John de Rivas,
Harlow,
Essex.

Line-powered microphone pre-amp



In this circuit the usual collector resistance R_2 is built into an existing amplifier. The rest of the circuit can be fitted into the microphone case.

W. H. Jarvis,
Rannoch School,
Perthshire.

News of the Month

North Sea communications mess

Some of those responsible for North Sea communications have been guilty of ineptitude if the word of Plessey subsidiary EAE Group Ltd's telecommunications director, Mr Laurie Buttriss, is to be believed. Speaking at the World Offshore Oil Conference in London on October 5 he accused Government, oil companies and equipment manufacturers of lack of organisation and foresight. The weaknesses, he said, were that essential and sensible regulations had taken too long to be compiled and issued, government departments had been slow to set up facilities onshore to cope with either traffic of different kinds or back up engineering, oil companies had been slow to invest in equipment, and major manufacturers had been slow in delivery and had taken too long to recognise the oil field as a source of sales, failing to produce the necessary specialised equipment in time.

Mr Buttriss would not name the companies or departments involved, but he told *Wireless World* that he could back up everything that he had said. EAE was formed in 1970 as a dedicated company to supply a service for North Sea oil development. In that capacity they bought in equipment and built a range of communications equipment for barges and oil rigs. They had about 30 such h.f. radio stations in the North Sea, he said, and, excluding more sophisticated equipment of the tropospheric scatter type, this represented about 80% of the market. During the last few years, Mr Buttriss said, "no preference was given to the oil field by manufacturers. The Americans expect immediate attention and good service, and it's only in the last two years that any attention has been paid to the needs of the North Sea oil producers. In the past we have been let down on many many occasions by poor deliveries."

He emphasised, however, that his remarks had not been aimed at the people supplying sophisticated systems, such as tropospheric scatter equipment. As to the government departments mentioned, the criticisms could also apply to the Post Office. All, he said, "were generally slow on the uptake".

As to the regulations needed, one difficulty was that vessels which were not self-propelled could not be classed as merchant navy vessels, and the regulations governing oil rigs and other towed vessels should have been made clear 10 years ago.

In his paper to the World Oil Conference Mr Buttriss contended that the use of satellites for the European oilfields, while initially expensive, is an attractive proposition for the future. "Starting with a survey to be carried out in the not too distant future by a major British company, I believe we can look forward to European oilfield satellite systems operational in the early 1980s."

Here he was referring to a report that Marconi has been asked by the European Space Agency to conduct a survey of satellite communications in the North Sea.

Who's recording profits?

In their annual report, Decca say they made increased profit from records and tapes, although depressed conditions in the home market meant that television contributed hardly anything. On the consumer side, turnover was down by £1 million to £81,800,000, producing a profit before tax on the year to March 31, 1976 of £5.8 million compared with £6.7 million in 1975. According to Decca's report, "Sales of consumer products in the current financial year to date are lower than last year." Profits on capital goods increased, however, with Navigator and Decca Radar going up by an unspecified amount and profits in Decca Survey decreasing. Total turnover in capital goods increased by £6.7M to £88.2 million, making a profit of £10.5 million, an increase of nearly 17%.

Usually the entertainment industry does quite well in a recession but sales of records and tapes have been depressed for two years now. According to a report in *The Times* record sales are steady or increasing in the under-25 age range, but older people find recorded music easier to go without. The top 20 accounts for something like half the total record sales, which at retail prices were worth about £250 million last year and are expected to reach £273 this, an increase largely due to price inflation. It has been suggested that the industry would have benefited from the slump but for the illegal copying of records; last year 25 million blank cassettes were sold, and they can't all have been used to record birdsong.

Switched liquid crystal prism

Two scientists at the Royal Radar Establishment have devised an electrically switched optical prism which uses liquid crystals to deflect a laser beam. Angular deflections up to $\pm 20°$ have been obtained with a layer of liquid crystal 1mm thick, according to a statement issued by the National Research and Development Corporation, who backed the project, but owing to electromigration effects the device only works with an alternating field. Until now the only comparable deflections have been those obtained using revolving mirrors. The Kerr cell, a device which rotates the plane of polarisation according to an applied potential, gives deflections of only a fraction of a degree, and acousto-optic methods also give less than 1° deflection. It consists of a cell 1 to 2mm thick and 3 to 4mm wide containing a positive nematic crystal. The crystal molecules can be aligned parallel to the cell walls by applying a transverse alternating electric field using four electrodes. In this state a polarised beam will pass through undeflected since the device acts as a uniaxial crystal with its optic axis parallel to the cell wall. If, however, the ratio of electrode potentials is altered the optical axis can be curved, and the light will follow a curved path through the cell. The effect is to alter the refractive index electrically instead of, as with a conventional device, altering the thickness of a material with a constant refractive index. "The angle through which the beam is deflected depends on the cell dimensions, the optical anisotropy of the liquid crystal and the ratio of the electrode potential. The absolute values of the electrode potentials determine the speed of the deflection only." The angle of deflection varies across the cell since the optical path length is constant.

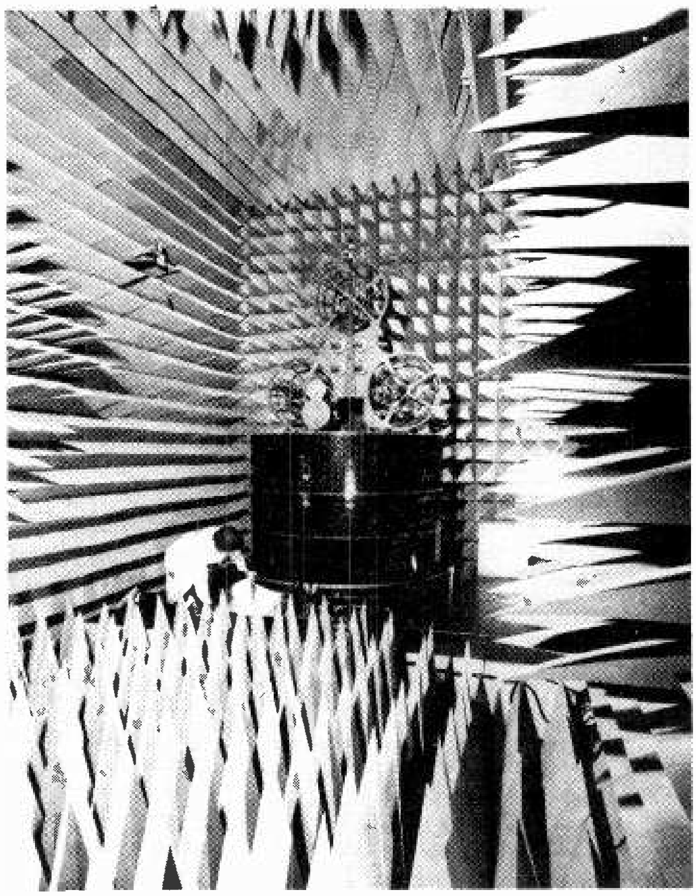
An obvious application of the device is in scanning, but the region producing maximum deflection, say the NRDC, is that in which switching produces turbulence in the crystals, so continuous scanning is not possible at maximum deflection. In this region the device is still capable of optical switching. At 1kV the beam can deflect full scale and return is less than 1ms, though return is faster than deflection. Losses due to absorption and scattering are greater than half.

Possible uses, say the NRDC, include laser beam deflection in computer storage, image modulation for pyroelectric devices; coherent or incoherent light torches for hazardous environments; as an artificial horizon for instrumentation; and as an optical waveguide switch. The inventors were Dr D. Jones and Mr A. Fray of RRE, now RSRE, Malvern.

Air traffic control advances

The United States' Federal Aviation Administration has placed a $1.5 million contract to revise and redesign its Enroute air traffic control system. Enroute is the computer based system which gives control information during the bulk of an aeroplane's journey, the beginning and end of the flight being handled by Terminal Area computer systems. It is a real time central monitoring system used by air traffic controllers in 20 centres to store and manipulate information about cross-country flights.

The contract, placed with Computer Sciences Corporation, is to add equipment to compare all flight plans for times and places of "potential conflict" between flights; to compute and display for air traffic controllers several alternatives to predicted conflicting demands for air space; to speed delivery of routine messages through teleprinters or computerised voice terminals; and to compute and improve the timing of aircraft arrivals at busy airports. The equipment will be interfaced with existing automated terminal systems, and its installation is expected to take about three years.



A radio frequency test on Marisat 3 in the anechoic chamber at the Hughes Aircraft Company plant in California. Launched on October 14, it supplements Marisats 1 and 2 launched in February and June and will be in stationary orbit over the Indian Ocean.

The announcement of the contract comes at a time of great activity in ATC circles, much of it stimulated by the recent mid-air collision over Zagreb. In September pilots, airline representatives and aircraft manufacturers met in Washington to see if they could agree on a system that would make mid-air collisions less likely. There are two main computer-based alternatives, the Beacon-based Collision Avoidance System (B-CAS), a secondary radar system which involves putting a computer aboard each aircraft and allowing the pilot to make the decisions necessary to avoid a collision, and the Conflict Alert system, which is also a secondary radar system but which allows a computer on the ground to make the pilot's decisions for him. Primary radar systems are entirely ground based, and provide only white dot displays on the traffic controllers radar screen, making no distinction between one plane and another. Secondary radar labels each dot with the help of information from a radar source on each plane.

The B-CAS system is on test in the United States, but the British Civil Aviation Authority is thought to favour the ground based conflict alert system. It may be significant that Computer Sciences Corporations statement announcing the order places emphasis on the need to make better use of existing computers and avoid the expense of new equipment, and on the requirement to interface with existing automated terminal equipment.

Although the Zagreb tragedy has focussed attention on air traffic control problems a feeling has grown steadily over the last few years that ATC secondary radar systems will need to adapt to the growing volume of traffic. At the moment beacons at the airport send out interrogatory pulses on 1030MHz and a transponder replies at 1990MHz, shutting off for 100ms or so. With the number of radar signals reaching aeroplanes the transponder may be unable to shut off, and radar signals emanating from other aircraft would complicate the problem. If B-CAS systems are to be acceptable they will have to overcome the difficulties caused by information saturation, and the US and the UK each have a different proposal for such a system. Work is now under way, however, to devise a compatible system combining the merits of the two.

Radio research move

Responsibility for radio propagation research at the Appleton laboratory under the auspices of the Science Research Council has been transferred from the SRC's Astronomy, Space and Radio Board to the Engineering Board, who will now decide the level of expenditure and the programme. According to the SRC's annual report, "Measurements have been made in collaboration with the Royal Signals and Radar Establishment, Malvern, of optical scattering by water vapour. At relative humidities above 95% the scattering is greater than that corresponding to a linear dependence on water vapour pressure, a result which provides further evidence of the presence of molecular complexes at high values of relative humidity."

The laboratory has also investigated, with the Post Office, the effect of precipitation (rain) on microwave links in the waveband 8mm to 3cm. Analysis so far of the investigation, finished at the end of 1975, has shown that for links operating over distances of a few km or more, the effects of multipath propagation in areas such as Suffolk, where conditions favour this type of propagation, are at least as important as the effects of precipitation.

The possibility of changing responsibility for such work was first mooted in mid-June and has since been confirmed by the council. The decision may have been the result of a feeling that, while astronomy and space research were moving closer together, the best example of this being Ariel 5, research on such matters as Post Office links was much more an engineering matter than the purer science being conducted by the ASR Board. Radio research funded by the SRC in British Universities has been under the control of the engineering board for some time, and the change merely brings all the work under the same umbrella. Although responsibility for the work at Appleton will change once enough time for the takeover to take effect has elapsed, the work itself will carry on there.

Britain ahead in X-ray astronomy, for how long?

Ariel 5, the first satellite dedicated to X-ray astronomy and described by the director of the Appleton Laboratory, Dr Saxton, as "the UK's most successful scientific satellite", may continue in full operation for another year and limited operation for perhaps another year after that. When the satellite was launched two years ago on October 14 it was expected to produce good results for only a year. "It has put this country right in the forefront of this new and very important branch of astronomy," Dr Saxton said. But he added: "It may also be the last. Funds for space and astronomy are being eroded, and there is little possibility of another satellite of this kind."

There are many reasons why Ariel 5 is considered a success. The satellite carries six experiments all of which, say the Science Research Council, who funded the project, have produced outstanding results, partly because they were so complementary and so well co-ordinated. Five of the experiments are British, Imperial College London's experiment is a scintillation telescope, Leicester University has two, including a sky survey experiment supported by another experiment conducted by NASA's Goddard Space Centre all-sky monitor, and Birmingham University and the Mullard Space Science Laboratory of University College London collaborated on a rotation modulation collimator experiment, Mullard also having a proportional counter spectrometer aboard.

The last four experiments point along the spin axis and together form an X-ray observatory pointed by ground commands from Appleton's Ariel 5 control centre to various points in the sky. The commands go via NASA data links to ground stations at Quito, Ecuador, or the Ascension Islands, where they are radioed up to the satellite as it passes over once every 90 minutes. At the same time data is taken from memories aboard the spacecraft giving information gathered from the experiments in the preceding 90 minutes.

The attitude of the craft is altered by propane jets, and one of the limits of the life of the craft is set by the amount of fuel the craft has left. At the moment 70 per cent has been used, and some problems have been caused by the corrosion of the reducing valves controlling the gas. Sun sensors used to determine a position reference have also failed but a reserve set has been brought into use.

Ariel 5 has updated the catalogue of 162 X-ray sources produced by its predecessor, UHURU, launched four years before it. Ariel has added something like 60 new sources, and, just as important, failed to confirm another 30 sources previously catalogued. The most exciting finds have been the "burster" and "transient" sources. The transient sources turn on rapidly and then decay, reaching a pitch of brightness in a few days and dying over the next few hours, days or weeks. Since they are so difficult to observe, only four had been detected before Ariel 5, but the spacecraft has enabled observation of 14 over the last two years. "They probably occur at a rate of about 100 a year," said Professor Willmore of Birmingham University, the project scientist. Two more transients were found to be modulated with periods of 6.75 and 1.73 minutes. Mullard Laboratories, who also have an experiment aboard the Copernicus satellite, subsequently found six more such stars, the modulation being caused by slowly spinning neutron stars.

Bursts and black holes

Even more important, possibly, are the burst sources, which emit isolated bursts of X-rays at intervals, usually of several hours, though one emitted bursts every 15 to 20s. A possible explanation of the phenomenon is that material, emitted by the companion star in a binary system in which that star orbits a neutron star, collects in the atmosphere of the neutron star. The neutron star has a gravitational pull 10^{13} times that of earth, and when the material cascades down on to the star's surface a burst of X-rays is emitted, and material begins to collect for the next burst.

The possible significance of the burst sources provided an interesting illustration of conflict between scientific schools of thought. Imperial College suggest that X-ray bursts and cosmic gamma ray bursts are connected, and go on from this to say that most of the evidence for the existence of "black holes" in space, areas so dense that not even light can escape from them, has come from X-ray astronomy. The experiments on Ariel 5, they say, tend to confirm the existence of black holes. When B. A. Cooke of Leicester University was asked whether he would agree, however, he remarked wryly: "It depends how anxious you are to have a black hole there." Those for and those against the black hole theory tended to stretch the available evidence in either direction to suit their case, he said.

Professor Elliot, chairman of the Astronomy, Space and Radio Board of the SRC, was asked if the Ariel 5 satellite or the information it was transmitting would be put to any military use. He replied that he didn't think so. "This is a purely scientific project which produces knowledge and information, although like other knowledge and information it usually can be put to some military use." The SRC's statement notes that their agents for the procurement of the spacecraft were the Ministry of Defence, and that the research and development authority was the Royal Aircraft Establishment at Farnborough.

Typical of our current obsession with national housekeeping to the exclusion of almost anything else, most of the questions at the press conference, as at the one launching the SRC's annual report a few days later, were concerned with the cost effectiveness of such research. Professor Elliot, asked to say of what benefit the Ariel project would be, said, "We are not the richest country in the world, but we are not the poorest. The future of technology and the wealth that flows from that is dependent on work like this and it is incumbent on those nations that do have the resources to uncover the basic laws of nature on which the future of man depends. In this respect we have been pulling our weight compared with other nations. Another benefit is the importance of these activities in the training of our people. Universities are always being accused of training people who are pure scientists with no knowlege of the outside world. Projects such as this help students to know industry and how it works and the need to produce things to a time scale and so on, to see how things work outside." Another advantage was that technology tended to act as an accelerator to progress, the best example being the US space programme. Ariel 5 offered the opportunity to do basic physics one couldn't do in terrestrial conditions. It was no good trying to decide which science you could afford and which you couldn't: "Science can only advance on a broad front," he maintained, "or it doesn't advance at all."

Although the SRC has had to make extensive cuts in its forthcoming programme — the annual report points out that by 1980 the council's budget in real terms will be at least one sixth less than it was in 1973 — plans for Ariel 6 are so far advanced, and the project has such high priority, that it is unlikely to be cancelled. In any case it largely replaces the aborted Skylark mission. Ariel 6, however, will carry only a limited number of X-ray experiments, and is not expected to produce anything like the information about this branch of science that Ariel 5 did.

In his opening remarks Dr Saxton defended expenditure on space research by pointing out that the money spent on Ariel 5, between £4 million and £6 million depending on how you work it out, came to two or three gin and tonics per family. The total spent on astronomy was "one or two per cent of the cost of feeding the dog population. I find it personally hard to believe," he continued, "that people would wish to see our scientific pre-eminence thrown away." It was no good saying we could leave such projects and pick them up again when the nation was in better shape. "Once the edifice crumbles it is difficult to re-erect."

Any energy you like — as long as it's nuclear

None of the studies of geothermal and solar alternative energy sources made so far by the UK Atomic Energy Authority has indicated that they would make any significant contribution by the year 2000. This announcement was made by Sir John Hill, chairman of the UKAEA at a press conference on publication of the UKAEA's annual report. His rather unsurprising conclusion was that it was therefore essential to continue with the nuclear programme.

"The world energy situation is no better now than it was in 1973-4: it is just that we have forgotten about it." Pointing out that the world's largest user of energy, still mainly derived from fossil fuels, the United States, was still increasing its demands, and that what we could produce from the North Sea would barely keep up with America's annual increase in demand, his deputy, Dr W. Marshall, said that we would be in serious difficulty long before the world's oil ran out: "It is when the amount of energy available stops increasing that the trouble starts — not when you have used the last drop of oil."

● The method of reviewing alternative energy sources reveals a serious lack of intent on the part of the Energy Department. The studies to which Sir John referred have been carried out by the UKAEA's Energy Technology Support Unit, which the Department set up in April 1974 to liaise with international organisations, such as the EEC and the International Energy Agency, on energy matters and to assist the Department of Energy to review and develop alternative sources of energy. Until now the assessment of these alternative sources of energy has been a major part of the ETSU's work but it is now gradually taking over the management of some research projects and will, for example, be spending £1 million over the next two years on a feasibility study of wave power.

So far the ETSU has already submitted to the Department of Energy reports on geothermal and wave power, both of which have been published, and a submission on solar energy is in the course of publication. A spokesman for the department of Energy said they did not intend to commission a full-scale feasibility study on tidal power as this would be too expensive, but they would be examining both barrage closing and the effect of such closure on tidal regimes. Studies of wind-power, the last of the five with which they were immediately concerned, "are at an early stage." Another part of the Study Unit's work is to report ways in which consumption of energy, from whatever source, can be cut down, and to this end the unit is about to publish a separate report on energy conservation. The clash of interests between ETSU and the UKAEA is, or should be, intense, yet ETSU is not only responsible to the UKAEA, it is even based at Harwell.

Wireless World asked the Authority how objective its assessments of other energy sources could be. Dr W. Marshall, Deputy Chairman of the UKAEA, replied: "A high proportion of the growth in ETSU is made up of people who have not been concerned in the reactor research programme in the past." They would be "pretty dispassionate," he said, and in any case the studies would be published so that people could judge for themselves how objective the studies were. He added that a considerable amount of work was being done elsewhere on alternative energy sources, of which the Energy Department would be aware. "We will make our own assessment from our own study of the facts without being influenced by the work done by these other groups." The way to alternative energy sources would be "an iterative process."

Dr Marshall, as well as being deputy chairman of the UKAEA, is chief scientist of the Department of Energy.

SITE successor

The Indian government is constructing ground transmitters in the six village "cluster" areas served by the Satellite Instructional Television Experiment to resume the educational television programmes in early 1977.

SITE, now concluded, was described by Jack Dinsdale in our September issue. Because of their limited range the new transmitters will reach only about 40% of the villages covered previously, but other villages near the transmitters will be added to the audience, according to NASA. The Indian Space Research Organisation is also defining an operational satellite system for the whole of India which could be operating by 1980. ISRO will have finished evaluating the results of SITE by the middle of 1977. Already, however, some beneficial effects have been noted. The popularity of children's programmes, for example, increased school attendance. A teacher in Mahya Pradesh village said he thought moving pictures of distant places made a lasting impression in Geography lessons. Other examples were the preparation of more nutritious food as a result of the programmes and the insistence on better hygiene.

"One year of experimental television is not going to change the face of our villages," said the director of ISRO's space applications centre in Ahmedabad, Professor Yash Pal, "but it has had many wholesome effects."

According to a report in *Forbes Magazine* in September, the Russians are considering a competitive international system to be called Intersputnik. The system would compete with Intelsat, and the Russians are said to have approached the Indian Government to see if it is interested in using Intersputnik for rural educational tv, the service provided until now by the American ATS-6.

Traffic information experiment

A system of traffic-information broadcasting, which has been in use in West Germany since June 1974, is being tested in this country for one month. The system, known as ARI (automotive road information), was developed by Blaupunkt Radio, the West German company, owned by Robert Bosch Limited. ARI decoding equipment has been fitted to thirty journalists', police, and other public representatives' vehicles to help them tune to radio LBC on 97.3MHz v.h.f./f.m. or 261m medium wave whenever traffic information is broadcast. The system works as follows: before each traffic-information broadcast the radio station transmits a single almost-inaudible 2.35kHz tone, frequency modulated with a 123Hz squarewave, from a prerecorded tape. This tone triggers the decoder and one second later the message is broadcast. On manual receivers the tone triggers an audible note overriding the tuned station and a pilot light. This indicates to the listener that their traffic information is about to be broadcast and he can then manually tune to the only audible station, which will be the LBC station. On automatic receivers the ARI station will be tuned in automatically. At present the decoder does not facilitate the automatic return to the initial station, but this refinement is expected within a year. If the radio is switched off the decoder may be arranged to switch the radio on for the duration of the traffic information broadcast only. The decoder, which will cost £10-£28, may also be used to switch a cassette player in and out for reception of the traffic information broadcast. When the system was first developed in Germany it was used with long and medium wave receivers, but was modified for v.h.f./f.m. when it was later introduced to some European countries. Yugoslavia also use the system for their tourist information services. It is hoped that if the system tests, which are taking place from October 19 to November 18, are successful other commercial stations throughout Britain will follow LBC's lead to provide the motorist with a more widespread ARI service. Hitachi, Grundig and Philips already manufacture the decoders for the European markets.

Acoustic noise units

A pathway through the decibel jungle

by James Moir, F.I.E.E.

The proliferation in recent years of Acts and Statutes setting limits to the level of acoustic noise inside and outside the home, in public places and in workshops, has resulted in an almost equal proliferation of units in which the noise level may be measured. It is very difficult indeed to duplicate by objective measurements the brain's analysis of its pleasure or annoyance. Thus we now have a large number of units in which the "loudness" (using the word in its widest sense) of a noise may be measured, all of them attempting to achieve agreement between objective measurements and subjective impressions. This article is an attempt to present a coherent picture of the problem.

The first sound level meter was merely a microphone, amplifier and indicating meter, the whole system having a repsonse that was substantially independent of frequency. The readings obtained were the mean (average) value of the input waveform, oxide-type rectifiers being used to convert the amplifier output to d.c. to operate the moving-coil meters. The parameter measured was the average value of the sound pressure at the microphone diaphragm and, within the limitations of the microphones available at that time, the reading was independent of the acoustic frequency.

To deal with the vast range of sound pressures met in nature, the system had to read over a sound pressure range of roughly 10^6:1 so a logarithmic unit, the decibel, was adopted from the telephone industry. Any logarithmic scale requires an empirically chosen zero point and this was fixed at a sound pressure level of 0.0002 dynes/cm^2 (now 20μ newton/m^2, 20μ pascal.) At the time this was thought to be the minimum audible sound level but it is now known to be about 5dB higher. Using this base, sound pressure levels in dB are then expressed as:

$$\text{s.p.l. (dB)} = 20 \log_{10} P/P_0$$

where P_0 is the reference pressure of 0.0002 dynes/cm^2, and P is the measured sound pressure.

Early experience indicated that there was only moderate agreement between the objective readings taken with the meter and a subjective judgement of the loudness of the noise by a group of observers. It was soon appreciated that the discrepancies were in part due to the sensitivity/frequency relation of the hearing system. Experiment indicated that not only did the sensitivity of the hearing system vary with frequency but that it also varied with the absolute intensity of the noise, particularly at the low-frequency end of the spectrum. Thus the hearing system has a substantially uniform frequency response to sound at high intensity but it is relatively bass deficient at low sound intensities. Fletcher and Munson, and later Robinson and Dadson, found that the frequency response of the hearing system to pure tones was as shown in Fig. 1. The Robinson and Dadson data is now an international standard.

Decibels A, B, and C

This change in frequency response with intensity was dealt with by adding a switch to the metering system to change the amplifier frequency response in the three steps shown in Fig. 2. The response labelled 'A' was to be used when making measurements at sound levels below about 40dB, response 'B' when the sound level was between about 40 and 70 dB and the flat response, labelled 'C' used for all levels above about 70dB. The weighting used was indicated by adding the appropriate suffix to give, for example, dBA or dB(A). In practice the only safe course was to record the A. B, and C readings for every noise, for it was rarely clear which switch position should be preferred. A noise with much of its energy in the low frequency range might well measure 35dBA or 60dBC and the correct switch position was then rather indeterminate.

The use of a three-position switch was a logical decision in the light of the data then available, because it matches

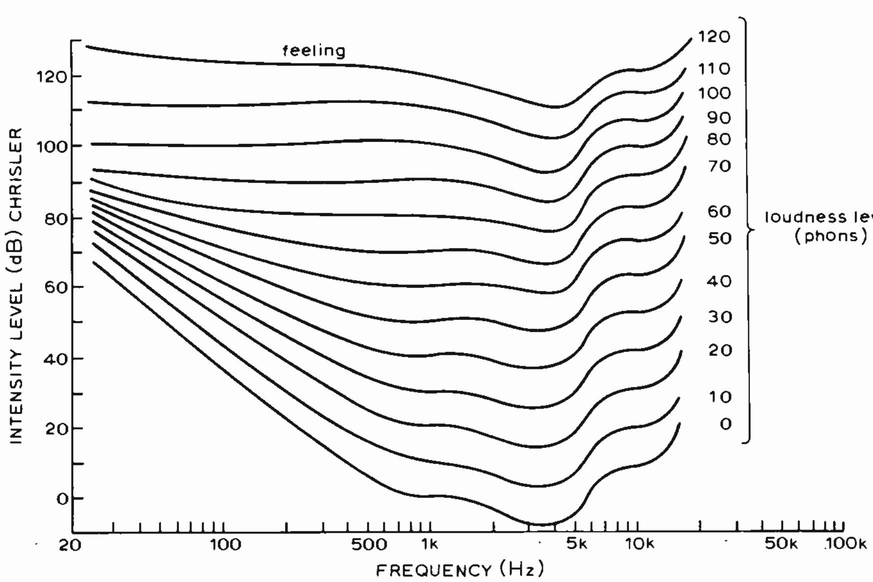


Fig. 1. Fletcher and Munson equal loudness contours . (Note that the loudness level of a sound is defined as n phons when it is judged to be equal in loudness to a pure 1000Hz tone with a sound pressure level of n dB above the standard reference pressure.)

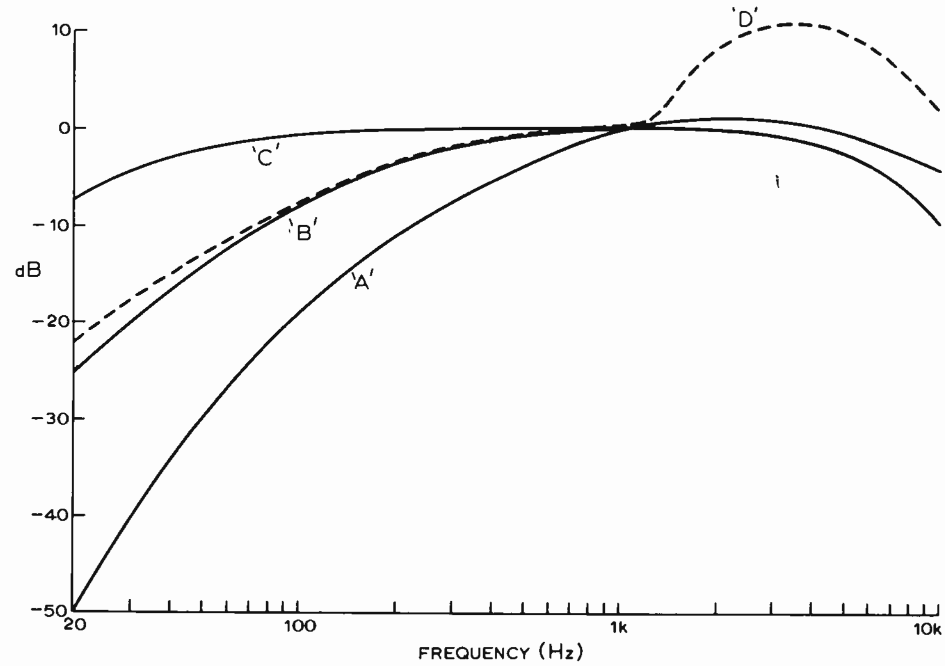


Fig. 2. Weighting curves showing the significance of dBA, dBB, dBC and dBD.

the frequency response of the meter to that of the ear at the sound level being encountered, but increasing experience began to suggest that the best agreement between meter readings and a subjective judgement of the "loudness" or "noisiness" of a sound was obtained by using the A weighting, quite irrespective of the intensity of the noise. This has now been substantiated for many kinds of noise and in consequence noise level readings relating to annoyance are now almost always quoted in dBA. Indeed, many later versions of the standard sound level meter only include the A-weighting network. This apparent contradiction of the earlier data has been shown to be due to the assumption that the ear's reaction to a wide-band noise would be indicated by its reaction to pure tones. It is now known that the hearing system does not sum the energy in bands of noise in the way suggested by the Fletcher-Munson curves for pure tones, the summation/frequency response being more accurately indicated by the A-weighting curve at all intensity levels.

Decibel 'D'

Though general experience and many investigations have shown that noise levels measured in dBA are in good agreement with subjective opinion of the loudness of most intruding noises, it appears probable that the agreement could be improved in a specific situation by the adoption of a special weighting curve for each type of noise. Kryter has shown, for example, that the noisiness of jet aircraft can be more accurately assessed by the adoption of a weighting curve that places greater emphasis on the higher frequencies and the relation shown in Fig. 2, the D-weighting curve, also known as the N curve in (ISO) Draft Recommendation 1761, has been internationally standardized for this purpose. However ISO Recommendation No. 507 requires the noise level in the vicinity of an airport to be expressed in still another unit, the Perceived Noise Level (PNdB). This is to be obtained from measurements of the sound pressure level in octave bands and the perceived noise level determined from these readings by a summation process detailed in the Recommendation.

In general, use of D weighting results in readings some 13dB higher than a measurement of the same noise using the A-weighting curve. The increased accuracy of agreement between objective measurement and the subjective opinion of the "noisiness" of the noise from jet aircraft is not thought to justify the confusion that has resulted from the introduction of D weighting. The environmentalists in particular have often reached alarming conclusions by comparing aircraft noise measured using D weighting, or the deduced level in PNdB, with road traffic or similar noise measured using A weighting. Similarly alarming conclusions can be reached if the A-weighting noise level of an existing type of aircraft is compared with the D-weighted noise produced by Concorde. It is reasonably certain that agreement with subjective judgement could always be improved by adoption of a weighted curve appropriate to each type of noise source but the overall result would be mild chaos, for the noise levels of different sources could not be compared.

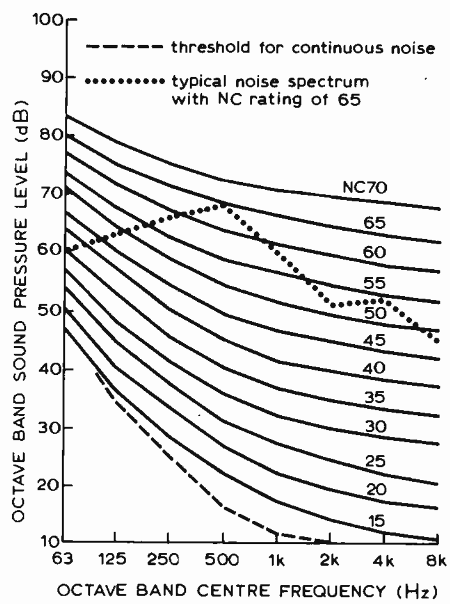


Fig. 3. Noise criteria curves of Beranek for obtaining better agreement between measured values and subjective loudness of a complex noise.

Noise Criteria system

In an attempt to obtain better agreement between measured values and subjective opinion of the loudness (noisiness) of a complex noise, Beranek introduced the Noise Criteria system, still widely used in the heating and ventilation field. Instead of taking one reading of the weighted average value of the sound pressure of a wide band noise (i.e. dBA), he proposed to take readings with a frequency selective meter at each of eight octave band frequencies and to plot these on special graph paper (see Fig 3). An NC (Noise Criteria) rating was obtained by quoting the NC reading on the right hand scale immediately above the highest octave band sound pressure level. Thus a noise having the frequency spectrum shown in Fig. 3 would be given a Noise Criteria rating of NC65, the curve immediately above the highest sound pressure reading in any octave band. This appears to be good common sense and the system is widely used.

In Europe a slightly different set of contours was produced following the same basic approach but these were quoted as Noise Rating curves, the number obtained being quoted as NR 65. Except for special noise spectra there is no significant difference between the NC and NR numbers and in retrospect there appears to be no good reason for the existence of two sets of Noise Rating and Noise Criteria curves. In practice the situation was further confused by the appearance of a third set of Noise Rating curves in the 1967 issue of British Standard 4142. Experience suggests that they have no real advantage over either of the earlier NR or NC curves. Indeed many users believe that they are not as useful as the earlier curves and that they have only served to add further confusion to an already confused situation.

Though this curve fitting procedure should take into account the shape of the frequency spectrum of a complex noise, experience has shown that there is a substantially constant numerical difference between the NC or NR value and an instrumental reading in dBA of the same noise, the NC or NR level being 5 units lower than the measured level in dBA. A determination of either the NC or NR level requires an octave band analyser to produce separate readings of the noise level in the eight octave bands and plotting of the data on special graph paper. Thus the technique can only be justified if experience shows it to have some considerable advantage over the single measurement of noise level in dBA, for this only requires a relatively simple sound level meter. Surprisingly, perhaps, experience appears to show that NR or NC numbers do not have any real advantage over the use of dBA to express noise levels, but the curves have considerable advantage when analysing noise data to obtain guidance on which part of the noise spectrum is responsible for criticism.

The phon

There are obvious advantages in having a unit that is an indication of the "loudness" of the noise and for this purpose the phon was originally proposed. British Standard 661 defines the phon as:

"The loudness of a noise in phons is numerically equal to the sound pressure level of the 1000Hz tone that is judged to be equally loud."

This apparently simple definition is the real reason for the failure of the phon to achieve widespread use. It requires a group of people to judge the level at which a locally-generated 1000 Hz tone is considered to be as loud as the unknown noise being assessed. This is a subjective judgement and it is one that is extremely difficult to make even by a skilled observer. Thus as phons cannot be measured directly by a meter the phon has died.

The sone

Though the decibel scale is almost universally used for the measurement of sound intensity, its logarithmic structure makes it difficult for the non-technical to use or even understand. A unit so fashioned that a noise level of two units is twice as loud as a noise of one unit should have advantages in such situations. This requires units that express loudness on a simple arithmetic scale. Such a unit is the sone, defined by British Standard 661 as:

"The unit of loudness on a scale designed to give scale numbers proportional to the loudness."

The reference loudness of one sone is that of a 1000Hz note having an intensity of 40dB, the relation adopted being shown in Fig. 4. Thus a sound intensity of 2 sones corresponds to an intensity of 50dB and 10 sones to 73dB. Surprisingly perhaps the sone scale is not widely used, though the reasons for its neglect are not very obvious. There are no simple meters available that read in sones directly and as it is easy to remember that an increase in sound intensity of 10dB generally corresponds to a doubling of the subjectively judged loudness, the sone, if not dead, is not prospering.

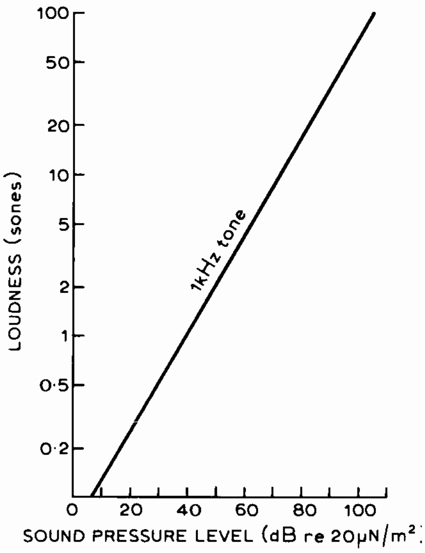
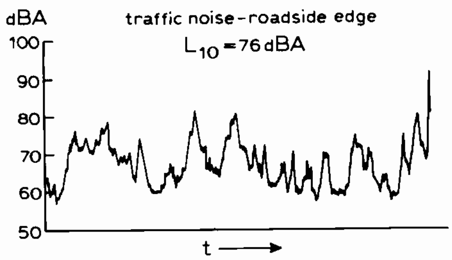


Fig. 4. Relation between loudness in sones and sound pressure levels in decibels. Scale numbers on the sone scale are proportional to loudness.



Fg. 5. Recorded chart of typical traffic noise.

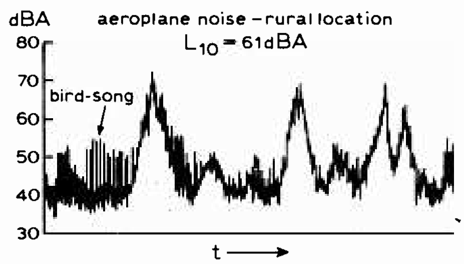


Fig. 6. Recorded chart of typical aircraft noise.

Time-varying noise levels

Except in some industrial situations, noise is rarely constant, the more usual situation being one in which the noise level is varying continuously rather as shown in Figs. 5 and 6, charts of typical road traffic and aircraft traffic noise. In such a situation there is a real problem in deciding on the objective level of the noise that is related to the level of subjective criticism. This is likely to depend not only on the noise in dBA but also on the fraction of the relevant time that the noise reaches or exceeds this acoustically effective level.

There have been many attempts to define a single-number parameter that includes both the noise level in dBA and the length of time that the noise reaches or exceeds this level. The simplest is merely to specify the noise level that is exceeded for 10% of the length of time that is significant in the particular situation. Thus when dealing with the noise from road traffic it has been found from social surveys that the extent of criticism is related to the level that is exceeded for 10% of the 18 hours between 6 a.m. and midnight. In traffic planners' parlance, the significance noise level is the "18-hour L_{10}".

Other aspects of a time-variable noise that are significant are the level exceeded for 90% of the 18 hours, effectively the minimum level, denoted by L_{90}, and the "average" level L_{50}, the value exceeded for 50% of the 18 hours. Note that all these levels are measured in dBA. A statistical analysis of the time-varying noise level data is required to obtain L_{10}, L_{50}, L_{90} etc., but analysers are now available that provide a continuous display of the required parameter over the period up to the time of display.

Noise and Number Index

Robinson has shown that the subjective annoyance aroused by an intruding noise is a function not only of the noise level but also of the extent of the excursions above the mean average level and the frequency with which these excursions occur. Much personal experience in other applications supports this view: A client's bedroom having an ambient noise level of 20dBA with occasional peaks up to 40dBA was pronounced as "noisier" than another room in which the ambient level was around 38dBA, but with excursions of only about ±2dBA. To evaluate the noise climate around airports, Robinson first proposed the use of a "Noise and Number Index" (NNI) that takes into account both the average noise level in dBA, the extent to which the noise level rises on peaks and the number of times in twenty four hours that the peaks appear. This is the unit used in the Report on Noise by the Wilson Committee. The Noise and Number Index can be calculated from:

$$NNI = \text{Average peak noise level} + 15\log N - 80$$

where N is the number of aircraft per day.

On this basis a reasonable Noise and Number Index for the areas adjacent to an airport is around 50 during the day, but probably around 35 during the night.

Noise pollution level

At a later date, Robinson suggested another unit, the "Noise Pollution Level", that also takes into account the effect of the variability in level on the nuisance rating of typical noises. This parameter can be computed from:

$$L_{NP} = L_{eq} + 2.56\sigma$$

where σ is the standard deviation of the instantaneous noise level and L_{eq} is the equivalent noise level. There is sound justification for the use of this unit for it would appear to be applicable to all forms of nuisance noise and to allow the "noisiness" of different forms of noise to be compared. At present it is really waiting large scale confirmation of its value, for though noise experts are almost unanimous in approval, it has not been specified in any legislation.

Traffic noise index

The Building Research Station have also suggested a unit that is directly applicable to the specification of the "noisiness" of a noise of variable intensity, though it is primarily intended for dealing with traffic noise. It has been shown by social surveys that there is a high degree of correlation between this Traffic Noise Index and the degree of dissatisfaction expressed by residents exposed to high levels of road traffic noise. The Traffic Noise Index is defined as:

$$TNI = L_{90} + 4(L_{10} - L_{90}) - 30$$

and as this is likely to be used in legislation both here and in America it will presumably displace the other units suggested, although it does not appear to have such a sound theoretical base as L_{NP}. Note that the noise levels used in all these units that combine level and variability are expressed in dBA.

Hearing damage and L_{eq}

High levels of noise, 90dBA and above, are known to result in eventual damage to the hearing, the damage being approximately proportional to the product of noise level in dBA and duration of the exposure. In the simplest case where the noise level is constant, the damage to the hearing system is directly proportional to the length of exposure. However, this is not the usual condition, for in an industrial situation the noise level is fairly constant at one value for a few seconds (or minutes) and then changes to a higher or lower level which is only maintained for a short period.

In such a situation an equivalent noise level can be defined that would, if held constant for the whole 8-hour working day, result in the same damage to the hearing system as would have resulted from the noise of variable level. This is known as the equivalent noise level, L_{eq}, and again is expressed in dBA. The Department of the Environment Code of Practice specifies 90dBA as the maximum permissible value for L_{eq} in an industrial situation.

Units and their application

It will be seen that there are a bewilderingly large number of units that can be used to indicate the "quantity" of noise present in a situation. A reasoned choice requires that we be sure that we know what we are trying to measure. If we are trying to measure sound intensity, i.e. power flow/unit area, then the sound pressure level in dBC is the appropriate unit. However, sound intensity is rarely the aspect that is really significant in a situation involving human exposure to noise. More usually we are trying to measure something that might be described as the "loudness", "noisiness", "annoyance" or "intrusiveness" of the noise.

Loudness, noisiness or the degree of intrusion are not always the same thing, though the noisiness or intrusiveness usually increases with increase of loudness, provided there is no change in the spectrum of the noise. If the noise is the subject of complaint and we wish to have a measure of the "noisiness" then the sound pressure level in dBA is the best of the current units, but this simple measurement of noise level in dBA fails as an indication of "intrusiveness or annoyance" if the noise being measured contains pure tones or is characteristically irregular. At the moment irregularity in occurrence or the presence of pure tones requires the measured noise level in dBA to be empirically corrected by the addition of 5 or 10 dBA to the measured levels (see British Standard 4142). This corrected level is then known as the "Corrected Noise Level" (CNL) and is expressed in dBA (CNL).

However, the degree of annoyance aroused by a noise is a function not only of the intensity of the noise, but also of the duration of the noise and of the "time on/time off" ratio in the period of time that is significant, usually the day of 18 hours. The level of the ambient noise is then best indicated by L_{90}, the level exceeded for 90% of the time, while the level of the intruding noise is indicated by a statement of L_{10}, both in dBA.

NC or NR ratings, though widely used at the moment, particularly in the heating and ventilating industry, do not appear to have any significant advantage over the simple measurement of sound pressure level in dBA when attempting to estimate annoyance and in consequence these units do not appear to have any future.

Where the noise levels of individual aircraft are being compared, dBD or PNdB is the correct unit, but the semi-empirical addition of 13dBA to the level measured in dBA gives a very good indication of the degree of annoyance or the intrusiveness of the noise from one aircraft. If it is required to have an indication of the overall level of annoyance due to aircraft activity at an airport, then NNI or L_{np} (Noise Pollution Level) are the proper units to employ, but L_{NP} values are not yet in widespread use in spite of their basic merits.

Where damage to hearing due to exposure to high noise levels is under consideration, there is in this country only one unit, L_{eq} to consider. Other countries use different rates of 'trade-off' between time and noise level although using dBA units in which to indicate the noise level, so this may lead to some further changes in the unit of noise exposure to obtain a greater degree of international agreement.

When assessing traffic noise, DBA is the appropriate indication of noise level, but it is now rarely that value read from a sound level meter directly. The quoted noise level is derived from a statistical analysis of the meter data, the quoted value being that exceeded for some specified percentage of the relevant time period, usually 18 hours in this country. Thus we have L_{10}, L_{50}, and L_{90} as the levels exceeded for the quoted fraction of the total time.

Traffic Noise Index (TNI) or the Noise & Number Index (NNI) or L_{NP} are met more infrequently and then chiefly in official publications, but this may change for they have real merit in indicating the nuisance value of a noise over an extended period.

This discussion covers the majority of units now in use in measuring the loudness of acoustic noise but there are many others waiting to make their appearance. Annoyance as subjectively judged, is a difficult reaction to quantify and, though many of the present units achieve this fairly well, there is need for a unit that will allow widely different types of noise to be rated on a common scale of annoyance.

Further reading

Sound level meters	British Standard 4197
Equal loudness contours for pure tones	British Standard 3383
Airport noise measurement	ISO Recommendation No. 1761
Noise rating curves	ISO Recommendation 1996
Method of rating industrial noise	British Standard 4142
Glossary of Acoustical terms	British Standard 661
Housing and road traffic noise	Dept. of Environment
The Noise and Number Index	Wilson Committee Report on Noise
Noise Pollution Index	NPL Report No. AC59
The Traffic Noise Index	BRS Report No. CP38/68
Hearing damage assessment	DOE Code of Practice

Letters to the Editor

PHASE

I have followed with interest the articles by Harwood and Moir on aural phase sensitivity, and have seen very little in the subsequent correspondence which, I feel, importantly detracts from their viewpoint. I would not have prolonged the discussions, but it is one thing to describe Moir's review of the subject as "not good enough" (C. F. Coleman, his letter, September issue) and quite another to use false or ill-considered arguments in support of that opinion.

The frequency proportional phases which Coleman so laboriously describes are, of course, steady-state quantities and are applicable when equilibrium has been reached, not during the transient response times of the systems (loudspeaker or room) under consideration. Perhaps it was these factors which deserved more consideratioin in the review.

This is not to say that there is no evidence of the audibility of steady-state phase differences, introduced into periodic functions. Schroeder used a flat spectrum sin*t*/*t* function of 10ms period, whilst I have used a tone-burst waveform, and varied the phase of the carrier or tone. It is true that upper frequency linear distortion from a loudspeaker can be easily detected, during the few milliseconds of its transient response to music spectra, or following each transition of a periodic transient test function, such as those described. This is so even when this response is greatly diluted by phase randomising room reverberation.

Finally, I am not aware that a "linear phase" loudspeaker does not introduce phase errors which are not linear functions of frequency. The steady-stage phase distribution of *any* loudspeaker does at least show that it is a dispersive system, exhibiting not only group-delay changes but many smaller deviations from a mathematically "smooth function" behaviour.

The Quad electrostatic system, to which others have referred, is not a "linear phase" loudspeaker, it is a minimum-phase system, and in this respect may be likened to other designs, not just the "linear phase" types with their space-staggered baffles. At low frequencies, of course, a loudspeaker is designed to radiate usefully at its bass resonance frequency, and then (steady-state) acoustic phase distortion is inevitable.

Roger C. Driscoll,
Polytechnic of North Ldondon.

I am sorry that Mr Coleman feels that I should have dealt more fully with the problem of defining phase shift in a circuit excited by a number of sine waves of different frequencies. It would require several issues of *Wireless World* to cover all the information we have on phase shift and its effects, but I doubt whether many readers would find it of sufficient interest to justify reading all that could be written. The definition of phase shift under conditions that are of no importance is clearly a subject of no great interest.

The phase shift arising from a particular circuit configuration, or the phase shift that results in a stationary wave system can certainly be defined by the choice of a reference time to which all times are referred, but this is not of value in a circuit where the amplitudes, frequencies and phases of all the components including those that are not integral multiples of the basic wave are continuously changing as they do in any programme circuit. It complicates the issue without adding to our understanding.

I do not invite anyone to believe that it is unnecessary to maintain wave shape to maintain the quality of the sound. Rather I invite everybody to test the suggestion for themselves, but I would say that after many years experience we cannot find any such requirement provided always that the differential time delays are inside the CCIR specified limits. The failure to find any effects are not due to the use of loudspeakers in lively rooms as Mr Coleman suggests, for the waveform distortions due to phase are no more obvious when the best available headphones are used.

I am very familiar with Whitfield's work on the brain's reaction to waveforms, but it's a field in which there is a great deal of contradictory evidence. The work of Galambos, Whitfield and others have shown that there appears to be a constant *phase difference* between the applied acoustic wave and either the peak or the axis crossing at which the resultant nerve impulse appears. However this is an area in which only the most highly refined experiments will produce significant data, but it is not of real significance in considering the acoustic effects of phase and as I noted earlier it is impossible to include a discussion of every aspect of the subject in any one contribution.

Instead of criticising all the experiments that apparently show that phase effects are of little significance I would invite the critics to suggest an experiment that shows it to be important.

James Moir,
Chipperfield,
Herts.

CITIZENS BAND

There has been a lot of talk recently about Citizens Band, with articles appearing in many publications. The UKCBC (United Kingdom Citizens Band Campaign) was formed in the summer of 1975 after discussions with many interested persons and radio amateurs. Our format is based upon CB clubs abroad, with emphasis on 27Mhz, although any frequency band allocated for a CB would be welcome. We were represented at the last European CB Convention in Elsbach, West Germany and we encouraged our members to take an active interest in 27Mhz by listening and exchanging "QSL" cards; in this way interest is extended and not lost after a time. We at present have some 80 members, many of whom are licensed amateurs.

There are many who say CB is a bad thing. Introduction in Germany recently (0.5W 12chs. 27 Mhz) has been an enormous success, the model control fraternity have their existing channels, and equipment has to meet government (FTZ) approval to ensure non-interference. Many CBers go on to become radio amateurs.

CB means company for the sick and disabled, for the old and infirm, for the motorist, for mountain rescuers and national disasters, and can be operated by citizens of all ages. Is it not time we had a secondary means of communication available to all in the United Kingdom?

R. C. S. Withers, G8KZH, GCB009
Secretary UKCBC
Halesowen

WAS BAIRD FOOLING THE PUBLIC?

R. W. Burns comments at length in your issue of October 1976 regarding my letter (April 1976) arising from the article by Dr. Waddell, V. W. Smith and J. Sanderson (January 1976). Other letters appeared in *Wireless World* of June and August.

Being well aware of the events, I do not choose the references to Baird publicity as a history of his achievement. Headings such as "Television Perfected (1926)", "First public demonstration Selfridges' (1925), 'Television, first successful test of new apparatus' (1926), 'Radio motion pictures, now we see by radio' (1926), etc., etc., belong to fiction rather than technical reporting. According to Mr Burns, as many as fifty Baird related articles can be found in *Wireless World* over the period or one each month. These were not, I think, descriptive articles of Baird's work, the absence of such reports being the cause of much complaint. An assurance that the Selfridge demonstration would make full disclosure, that questions would be answered and photographs permitted proved to be a disappointment. Instead, the demonstration stand was boxed in, maybe for light exclusion, though it was ascertained that but a single revolving shaft provided both scanning and viewing. There was no synchronizing, no phasing and no photosensitive device, the accepted essentials of the Baird elementary system. Members of the public, invited by posters to see television, came in their numbers. They saw images of thick black line drawings to the accompaniment of a machine-generated flicker. The audience was not impressed yet misguided into believing that this was television. Such is the history of one important event, typical of others of 1925-28.

Broadcasting was bringing new enterprises into being. New capital issues to suit inventors and investors filled much space in the daily papers. Dr Waddell in his *Wireless World* article, tells us that Baird filed no less than 178 patents. These were made available for constructor use by licence issued through Television Press Ltd., a rather unpalatable idea to experimenters, whatever their interests.

Obviously, neither the Post Office nor the B.B.C. would act in a way to support or condemn. To cite the names of experienced senior officials is inappropriate to the 1925/28 situation.

Mr Burns mentions photocell use. Selenium was unsuitable. The practical caesium cell (G.E.C. and B.T.H.) was in common use for picture transmission, sound on film, alarm devices, etc. Baird, however, gave attention to the soft potassium cell (Cambridge SI Co) in uncertain combination with a three-valve ex-service C M. II amplifier. As early as 1926 Baird revealed his visual purple cell, first in confidence and later mentioned in print through a contributor. This biological cell shown in the form of a 2 oz. glass container with a colourless clear liquid is of no interest. It was a stupid notion that dispelled belief in genuine demonstration.

I trust that Mr Burns will see that I have not consulted primary documents, unpublished and published, as he recommends that I should. So much was published yet so little is known of essentials.

F. H. Haynes,
Overleat,
Bovey Tracey,
Devon

FUTURE OF TELEVISION

With the recent increase in TV display sources, may I voice a plea for standardization before we are presented with the confusion that besets so many other aspects of electronics today.

The television set is about to become the main display unit of a variety of new devices. To date the foremost is still off-air material, but already available are "games" of varying complexity; teletext decoders; v.c.r. and v.t.rs and cameras. In the foreseeable future we will also have the P.O. Viewdata, microprocessors and display memories (for short-term messages and notes?); video synthesizers for use with stereo hi-fi for sound-to-visual displays; and gimmicks like 'phone and door-bell indication on screen, baby-alarms, alpha-rhythm feedback, etc.

May I therefore make the following suggestions:

i) television sets as such be phased out in favour of tuners and monitors;

ii) manufacturers adopt a standard video and audio signal level. Video is already fairly universal at 1V p-p, 7:3 video to sync, earthed and unbalanced, negative sync.

A modular approach has several advantages: expansion and improvements to an individual's equipment is simplified; servicing is easier and a faulty device will not incapacitate the whole system.

May I further suggest a central video/audio switcher analogous to the contemporary hi-fi amplifier. A simple switcher would be mechanical, while a sophisticated unit may include a processing amplifier to clean up noisy signals, a simple colourizer for games and displays. This unit will route signals from tuner, v.c.r., memory, camera and synthesizer to a suitable monitor and hi-fi amplifer, or v.c.r., memory, etc.

Should this modular approach be adopted, I would recommend manufacturers do so at once before further development of the "half-line" chassis type of power supply for colour TV sets. Already v.c.rs sport every conceivable combination of u.h.f. and video inputs and outputs on a bizarre array of plugs. Some games incorporate modulators, others not. The excellent sound broadcast by the television companies is still forced through "toy" loudspeakers on even top price colour sets.

I should just like to register my plea for a little sane forward planning before the domestic TV begins to incorporate odd games or simple teletext and Dad still has to change leads behind the set when the kids want to play noughts and crosses with the home computer or Mum wants to check the microprocessed accounts.

Mike Feeney,
Morpeth,
Northumberland

In a recent letter by Dr D. A. Bell (October "Letters") entitled 'The future of television', questions were asked regarding where and when 3D. colour television would appear. Mention was also made of discarded experiments in 3D. colour television colour: discarded by whom?

The question is not where and when such a system will appear but rather when will it re-appear. The first demonstration of such a system was by John Logie Baird in London during 1928[1, 2]. Professor Cheshire of Imperial College, President of the Optical Society of Britain stated in an article on Baird's system[2], 'a man sitting at the transmitter was very clearly seen in the receiver in another laboratory in the same building, in perfect relief'. A colour demonstration with a c.r.t. receiver was given to the Lord Selsdon TV Committee in 1934 and colour television was given to cinema audiences in London from late 1937 until the outbreak of World War II. Baird, now reduced to two assistants, Mr W. Oxbow and Mr E. G. Anderson (still alive and well, in Hythe) and no income, produced and demonstrated in the garage of his bombed house at Sydenham no less than six different variations of 3D. colour television. Systems included to 1000 line definition, all electronic scanned, screen sizes to thirty inches by twenty-four inches and 3D. imaging with and without viewer glasses.

Wireless World and other magazines favourably reported his demonstrations[3]. It was little wonder that a record attendance of over 600 attended Baird's lecture on 3D. colour television at the I.R.E. in London, November 1943. One article[4] referring to Baird's images, stated, 'the images were in colour as natural as any colour film . . . and the effect of distance on the screen was quite natural'. Baird was using the world's first multi-electron gun single c.r. tube receiver, the "Telechrome". The bandwidth used by Baird was stated to be the same as that used by the BBC in 1939 and Baird's sets could also receive the normal black and white BBC images.

Regarding holographic 3D. colour television, even with greatly reduced bandwidths, it may prove to be a sledgehammer to crack a nut. Interesting military work on 3D. colour displays, of a non-holographic nature, is being presently undertaken and there may be a spin off into civil television.

The Hankey Committee in their 1945 white paper, referring to 3D. colour television, clearly stated, 'vigorous research on such a system should begin immediately, staff are available etc., the adopted system should not embody any patented devices which might be prejudicial to the general interest of British manufacturers'. One wonders how that statement bears comparison with the existing state of affairs today. Since Baird, until late 1945, was the only person to publicly demonstrate such a system, the Hankey Committee were in fact endorsing Baird's system as the proposed new British system. Baird's premature death in 1946 removed all effective competition for 3D. colour television.

Teletext is a descendant of Baird's 1944 facsimile television. Video recording is descended from Baird's video recording on gramophone records (1926) and magnetic discs (1927) and Baird also demonstrated the first public colour television in July 1928. Eurovision was preceded by Baird in the Germany - Britain - Denmark - Holland link (1929-1932), the Telstar satellite was preceded by Baird's transatlantic television of February 1928 and for the future with crowded bandwidths we should have television over fibre optics, again pioneered by Baird, of course, in 1926!

Dr P. Waddell,
East Kilbride,
Glasgow.

References

1. Tiltman, R. F. 'How Stereoscopic Television Is Shown'. *Radio News*, November 1928, pages 18-19.
2. Verne, D. A. 'The Stereoscopic Televisor'. *Television*, September 1928, pages 20-21.
3. 'Baird Telechrome'. *Wireless World*, August 1944, page 316.
4. 'Baird Gives Television, Colour and Depth'. *News Chronicle*, August 16, 1944.

CRYSTAL DETECTION

It says a great deal for the regard in which the carborundum wireless detector was held ca.1915, that a ship's receiver was adequately equipped with this kind of detector alone, supposing its spares had not been stolen (Sixty Years Ago, *Wireless World*, October 1976, page 81).

I have started to assemble a history of the early years of the crystal detector, with particular emphasis on the carborundum detector because of its commercial importance. The most curious feature that has come to my notice (K. Weedon, private communication) is that patent applications for crystal detectors (e.g. Dunwoody) and articles and papers on crystal detectors (Braun, Brandes, Pickard etc.) for use in wireless, only begin to appear (1906) *after* Fleming had publicly demonstrated the use of his thermionic diode as a wireless detector (Feb. 1905).

If readers of *Wireless World* have pertinent information of any kind, particularly relating to the first decade of this century, that would amuse, instruct, or generally help to resolve the enigmas of this topic, I should be grateful if they would write to me.

Dr. D. P. C. Thackeray,
Dept. of Chemical Physics,
University of Surrey,
Guildford

MAGNETIC PICKUP PREAMPLIFIER

It appears that Mr Wolfenden, in his magnetic pick-up preamplifier design published in your September issue, has ignored the reason why designers have, in the past, avoided placing a stage with gain before an R.I.A.A. equalization stage, namely the problem of overload capability.

R.I.A.A. equalization initially boosts signals at 20kHz by 20dB with respect to signals at 1kHz; these subsequently receive 20dB less gain than signals at 1kHz, in the preamplifier. For this reason, high frequency (20kHz) signals appear 20dB greater at the input *and output* and $IC1_A$ than 1kHz signals and therefore have 20dB less overload margin. This leaves an overload margin of only 20dB at 20kHz, which is not compatible with high fidelity reproduction.

A. N. Barker,
Bradford-on-Avon,
Wilts.

Mr Wolfenden replies

Mr Barker appears to have only presented part of the story. An examination of the figures presented by S. Kelly (*Wireless World*, Dec. 1969) shows that the maximum theoretical velocity that a stylus with an effective tip radius of 0.25 thou can attain is approximately +18dB with reference to 5cm/sec (the chosen reference in my article), and this occurs at a frequency of approximately 2kHz. Even this situation is unlikely to arise since the maximum velocity accepted by the recording industry is shown as being approximately +9dB, occurring at a frequency of about 3kHz. These peak levels are well within the capabilities of the preamplifier and hence no overload problems should arise.

This situation is born out by tradeability figures published for some pick-ups. For a Shure V15 in a SME3009 arm tracking at 1gm the figures quoted are 26cm/sec at 400Hz, 38cm/sec at 1kHz, 35cm/sec at 5kHz and 26cm/sec at 10kHz. These figures show the expected peak at frequencies around 1kHz, the maximum velocity being approximately 17.5dB above 5cm/sec.

It should be mentioned that this situation in no way precludes the use of the high frequency boost used during recording since the energy content of a musical signal declines rapidly above 1kHz and hence very large stylus velocities are most unlikely to occur. The use of pre-emphasis on recording and de-emphasis on playback in this way does, however, result in a reduction in noise at the frequencies where it tends to be most audible.

DIGITAL FILTER DESIGN

With reference to the article on digital filter design which appeared in the October 1976 issue, there are one or two points which I would like to make.

Firstly, there seems to be some confusion over the title, which is given in the contents as "Use your pocket calculator as a digital filter" and in the article as "Programming a microprocessor to act as a digital filter". If a calculator is to be used, then considerable dexterity will be needed to operate the filter program in real time!

Secondly, it is not clear from the article that the two coefficients "a" and "e^{-aT}" are constant and thus do not have to be calculated in real time. The algorithm for the first order low pass filter thus reduces to:

$$y_n = Ax_n + By_{n-1} \quad \left(\begin{array}{l} A = a \\ B = e^{-a\tau} \end{array} \right)$$

Where x_n and y_n are the input and output values at sample n and y_{n-1} is the previous output value. Indeed, one of the virtues of this digital filter is that the calculation only consists of two multiplications and one addition per sample.

Thirdly, the speed of the microprocessor must be carefully considered. If we take high quality speech with a bandwidth of 5kHz as a typical input waveform, Nyquist's sampling theorem requires a minimum sample rate of 10kHz or a sample period of 100 microseconds. This means that two multiplications, an addition and some housekeeping functions (input/output, storing the last output etc.) must be done in 100μs. The time problem is exacerbated by the use of double precision arithmetic to increase the resolution as the most common microprocessor wordlength is only eight bits. One particular microprocessor takes 46μs to perform a subroutine jump. To be fair, this is the slowest but the example serves to illustrate that microprocessors are (with a few exceptions) really quite slow.

We will not see the combination of microprocessors and digital filters until cheap processors and stores which are an order of magnitude faster are available.

J. Brazier,
Dept. of E.E.S.,
Univ. of Essex,
Colchester.

PHASE IN THE EAR

I should like to comment on Mr Neate's letter in the October issue. He says that each fibre in the basilar membrane of the ear has its own natural frequency, responding only to that frequency. Hence he argues that the ear is not sensitive to phase. Also, he is seeking an explanation for how the ear can insert a missing fundamental when only the 2nd and 3rd harmonics can be heard.

The ear is a complex mechanism, but I will try to describe both its mechanism and its preceptiveness. Alternating air pressure is converted into movement at the eardrum and this is 'geared down' (i.e. amplitude reduced, force increased) by a system of small bones called ossicles, which move a membrane, the oval window in the cochlea. The cochlea is a helical tube filled with fluid, and is shaped like a snail, with 3 turns. The tube is divided along its length partly by a bony shelf and partly be the basilar membrane, but a small hole, the helicotrema of area 0.25mm^2, which is situated at the centre of the "snail", connects the two chambers. The basilar membrane carries the organ of Costi which has hair cells connected to the brain by several thousand nerves.

Forces applied through the oval window set up wave motions in the fluid such that transverse displacement occurs in the basilar membrane. The position of maximum displacement of the membrane corresponds to the sound frequency, the position along the length of the membrane being logarithmicly related to frequency, with high frequencies causing maximum displacement near the oval window (i.e. at the wide end of the snail, but the basilar membrane is narrowest at this point, the remainder of the dividing wall being formed by the bony shelf).

From the foregoing description it would be difficult to argue that the ear is similar to a large number of very sharply tuned resonant circuits. Measurements of the ear's ability to perceive sounds indicate a response time far less than that which would be obtained by sharply resonant circuits. The circuits seem to be about criticially damped. The fine discrimination of pitch possessed by most people is achieved by analysis in the brain itself, but approximately 200ms is needed for accurate discrimination of pitch. The intensity of a sound is signalled to the brain by the number of impulses persecond (up to about 300) along the nerves. Also, nerve fibres ending close to a given point on the basilar membrane have a range of sensitivities.

Sounds reaching each ear will differ

1) In intensity
2) In time of arrival (transients)
3) In phase (continuous tones)

At a frequency of 700Hz, the spacing between one's ears is about ½ a wavelength, and below this frequency phase differences can be perceived, but such differences will decrease with frequency.

Above 700Hz, the difference in intensity is an important factor in determining the location of a sound. Also, time differences of less than 1ms can be perceived. Just how we locate the direction of a sound is one of the mysteries of the brain itself, but it is believed that a process of cross-correlation takes place between the signals from each ear. It is interesting to note that frequencies below 100Hz are signalled to the brain by direct modulation of the periodicity of nerve impulses. There is no doubt that phase information can be conveyed by this method of signalling. However, phase differences from a point source would be 25° or less at such low frequencies.

From the above description of the hearing process the aim should be

1) At frequencies above 700Hz, to concentrate on balancing the frequency response between the two (or more) channels
2) At frequencies below 700Hz, to concentrate on balancing the phase response of the channels

These two aims are far more important than the overall frequency or phase response from microphone to loudspeaker. The ear is very poor at determining changes in the level of sounds, so an overall frequency response of ±2dB should be undetectable provided the various channels are balanced.

The ear has a limited ability to perceive distortion products. For example a tone of 1200Hz at a level of 60 phons raises the threshold of audibility of its 3rd harmonic by 10dB. Allowing for the lower threshold level of these higher frequencies, this means that a sound pressure level of about 6dB of 3rd harmonic is required to overcome the masking effect of 60dB sound pressure at 1200Hz. This means that low order harmonic distortion of 0.2% is only just audible. At higher sound levels the masking effect is even greater, and at lower sound levels the absolute threshold of hearing is the limit.

However, high order harmonic distortion is more audible due to the decrease in the masking effect, and intermodulation difference frequencies are also audible due to the rapid decrease in masking effect at frequencies below the masking tone. Hence a sound of 8dB pressure level at 500Hz could be heard simultaneously with a sound of 100dB pressure level at 1200Hz.

Thus intermodulation distortion of only 0.0025% could be heard under these circumstances. Although the ear can itself produce distortion at high sound levels, the "Tartini" effect described by Mr Neate is probably an effect of the brain itself and not in the ear.

D. T. Ovens, B.A.(Cantab),
Havant,
Hampshire.

Mobile radio communication—2

Aerials, equipment and systems used in the UK

by D. A. S. Drybrough, B.Sc., M.I.E.E., *Drybrough Communications Ltd.*

All the mobile radio services use vertical polarization, basically because it is easy to obtain an omni-directional polar diagram with simple aerial configurations. The standard low-band mobile aerial is a quarter-wave whip, mounted on the roof of the vehicle or some other metallic ground plane as high as possible above ground. In the higher bands, collinear arrays or end-fed half-wave aerials are usual. Low-profile units, encased in tough plastic covers are available for use when height is limited.

Aerials for base stations are open or folded half-wave elements, suitable for mounting on tubular masts or lattice towers. In the u.h.f. band, more gain is usually necessary and arrays of separate dipoles, mounted in a tapering fibreglass tube or individually, are then fitted. The last-mentioned may also be so mounted that gain is obtained in both horizontal and vertical planes. Directional aerials, usually of the Yagi type, are used for links and some discrimination against unwanted signals may be obtained by using cross-polarization.

Portable set aerials are limited in length by their environment and so helical types, about 0.1 wavelength long, are popular, despite their narrow bandwidth and low efficiency. Body absorption distorts the radiation pattern of aerials mounted close to the body and dips of 15 to 20db according to band, are normal.

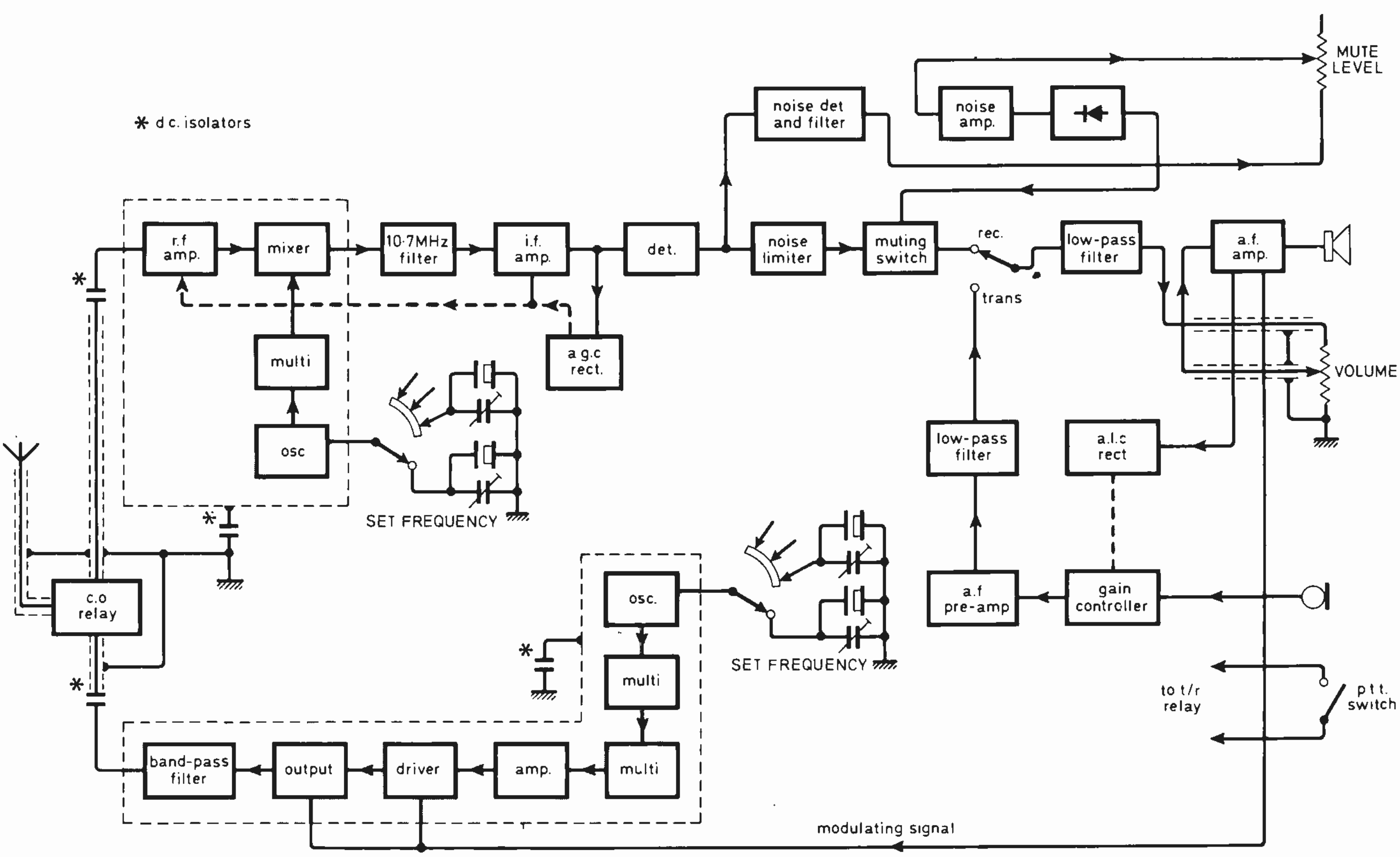
Attempts have recently been made to reduce the amplitude of signal fluctuations which are so evident when a moving vehicle is involved. Trials have shown that it is possible to reduce such fluctuations from peaks of over 27dB to 15dB or less. Such aerials with their associated circuitry are somewhat expensive but may well be justified for important long-range f.m. systems or where data signalling is in use.

As systems multiply so the better sites are becoming more and more crowded. Some relief from the consequent maze of aerials is sometimes achieved by using multiplexing devices to combine several transmitters or receivers from one aerial.

Typical equipment

A block diagram of a typical low-power a.m. mobile transceiver is given in **Fig. 4.** The receiver output signal to noise ratio is at least 8dB for an input e.m.f. of $1\mu V$ with 30% modulation and the unmodulated transmitter output is 6W, averaged over the v.h.f. bands. All but the heavier components are mounted

Fig. 4. Block diagram of typical low-power a.m. mobile transceiver.



on a single printed circuit board, alongside which is fitted the transmitter strip in a screened box. The whole assembly is mounted in an aluminium case with a plastic front bezel, flanged to protect the controls without constituting a hazard in the event of an accident to the vehicle. The loudspeaker and microphone are connected to the main unit by multiway leads, the latter coiled to prevent it dangling round the feet of the operator. A pair of heavier leads connects the unit to the battery supply of the vehicle.

The receiver is a single superhet with an i.f. of 10.7MHz, shaped by a multi-pole crystal. A peak-clipping noise limiter precedes the dual-purpose audio amplifier which feeds the loudspeaker on receive or modulates the transmitter on transmit. Operating controls are limited to an on/off switch volume control, channel selector and mute level adjuster, all on the front panel of the main unit, plus a press-to-talk switch on the microphone. Current demand at 12 volts is about 250mA on full receive and 1.5A on transmit.

Public radiotelephone mobile units are basically commercial high-power f.m. v.h.f. mobile units, modified to meet the requirements of the UK Post Office Radiophone service. They operate in the upper maritime band in one of ten preset frequencies, one of which is a control channel to which it returns after a call. A mobile unit is simplex but the base station is duplex. The selective calling system adopted for this service is similar to the maritime C.C.I.R. system but with different tone frequencies for each digit of a five-unit code number.

Point-to-point radio links may be employed by almost any type of service to interconnect control points to distant base stations when suitable telephone lines are not available or would be too expensive to install. The simplest installations comprise outward and return links, using one radio-frequency channel in each direction, and carrying one voice channel, possibly with some superimposed tone or control signalling. These operate mainly in the v.h.f. and u.h.f. bands. More complex systems, using '1 + 1' multiplexing circuits to provide two speech channels or one speech channel plus many signalling and control tones, usually operate in the u.h.f. band, whereas larger-capacity multichannel installations employ frequencies in the 470MHz, 1500MHz or s.h.f. bands. Directional aerials confine radiations to the required direction, and powers are kept low in accordance with the type approval specifications for these systems, which usually cover the performance of complete installations as well as of individual transmitters and receivers. Link transmitters, at least for the return path, usually radiate continuously to enable supervisory signals to be sent at all times to the control point. When more than one speech channel, or when speech combined with important data or control signals are carried, the radio units are usually duplicated and operated from low-voltage d.c. power supplies, derived from storage batteries with float-charging facilities to safeguard communication for at least the time needed by a serviceman to reach the base station and repair a power fault.

In spaced-carrier systems, the control point has to feed signals in several directions simultaneously to its base stations. The link transmitter in such cases may have two or more parallel output stages feeding two or more directional aerials, arranged in such a way that failure in one section has little effect on the remainder. Except in special cases, the frequency stability of link transmitters and receivers need not be higher than for normal base station units but it is advisable for their audio fidelity to be as high as possible to minimise degradation of the signals carried by them.

Paging systems

Probably the most important services using the mobile radio bands but not strictly mobile radio are the paging services, in which one carries a receiver which alerts the wearer when called by a base station. There are many variations on the basic theme, ranging from the fireman's call system, in which relatively large numbers of receivers are alerted by each call, to systems in which a few receivers are fitted to accept not only individual calls but also several different coded signals per call. In some systems a verbal message is permitted and in some a voice reply can be transmitted using a very low power v.h.f. or u.h.f. transmitter. Such systems are scarcely paging systems as a reply by radio is excluded in the C.C.I.R. definition.

In addition to the many private paging systems the Post Office is about to open a service similar to that in the Thames Valley area covering the London area. Up to 100,000 rented pagers will be catered for and calls will be possible from anywhere in the UK. The Home Office operates an extensive system of paging for firemen, whereby a selected crew can be called out for duty at any time if they are within the range of the high-band v.h.f. base stations fitted at fire stations.

On-channel repeaters

It sometimes happens that a small but important area within the nominal coverage of a base station is not adequately covered. By the use of on-channel repeater techniques such areas can be covered without involving extra frequencies and without the complication of the selective switching-in of transmitters and receivers. The technique is based on achieving very good front/back ratios for two aerials, between which is interposed an amplifier. So far, such systems have been confined to the u.h.f. band because of the problems in achieving sufficiently good isolation with small aerials in the lower bands. The aerial looking towards the main base station has high directivity to exclude unwanted signals and maximize pickup of the wanted signal. The other aerial is arranged to cover the required area which must overlap on the beam of the first. Beamwidths of up to 150° are practicable. A second set of similar aerials provides the return path, the signals traversing this link in the opposite direction.

Working gains of up to 90dB are possible with a margin of stability to guard against changes in effective isolation between the aerials due to aircraft and other movements or changes to path losses. This gain, and the auxiliary control functions, are not readily obtainable by straight amplification and a drift-cancelling frequency-changing system is used with most gain at an i.f. of about 21.4MHz. Great care is necessary in the design of amplifiers for both inward and outward paths. In the inward case, the input signal is fairly constant and at a good level, and the problems are to ensure that the output to the second aerial does not exceed the permitted power level and that it contains the minimum possible distortion products and noise. In the return amplifier, the input signal is variable and probably low in level, and it is necessary to avoid re-transmitting a very poor signal, or even just noise, and so the gain of the amplifier must not be allowed to rise so high that oscillation takes place. In both cases, spurious responses and emissions must be low in the presence of an on-channel signal. Repeaters may be used in tandem, and can be extended to cover a linear area such as a railway or a motorway when the numbers of vehicles does not exceed the capacity of one radio channel.

Selective signalling

The average land-mobile radio system, consisting of a base station and 10-12 mobiles, is similar in essence to a party line in telephone practice. It therefore suffers from the same difficulties of lack of privacy, of lack of guaranteed immediate access and, to a rather smaller extent, of limitation to the numbers of subscribers who can share the circuit. One school of thought claims that the fact that all users in one channel hear all messages on the channel leads to very efficient use of that channel because the users naturally queue up and interject their messages in breaks in traffic as they occur. This is true if the users can all pay close and continuous attention to traffic on the channel for some time before making a call, but this is not always possible and could be time-wasting. A stream of messages of no direct concern to the listener can be very tiring to listen to and leads to inattention or to irritation, with consequent action to reduce audio level to the extent that intended calls are missed. In such circumstances, and where the channel is exclusive to one user such as the power industries, selective calling can be of great benefit. The use of selective calling on shared channels is not encouraged because the calling tones could cause more irritation to users not fitting the system than the usual voice calling.

A large number of selective signalling systems have been developed, and there has been little standardisation in the land services except that signals emitted when calling must not exceed the channel width allowed for speech. The tones used for the codes may be in the audio band or may be below it. When subaudio tones are used, the bandwidth available is narrow and so the spacing between tones in a system with sufficient code numbers for normal use has to be very small. In the American EIA system known as continuous tone-coded selective signalling, two groups of tones are specified between 67 and 250.3Hz, 33 in all, with a ratio of about 1.15:1 between successive tones in each group.

Frequency stability of generators and of detectors must be good, and small reeds have been widely used to control their frequencies with minimum demands on space. This use of high-Q factor circuits prevents rapid keying of tones, and it is customary to switch the calling tone on for the duration of a transmission, so that it serves as an unlocking signal rather than a code call. This is specially useful when a mobile wishes to call one of a number of control points or base stations operating on the same frequency, or when control wishes to contact only one of several groups of mobiles. Because of the narrow bandwidth, modulation depth for the tone can be low, and it can readily be filtered out from the speech path.

Where a large number of alternative codes are required, one of the many systems using in-band tones must be chosen, since there is little, if any, space above the audio speech band in 12.5 kHz channel systems. Popular choices are the multiple, simultaneous-tone systems and the sequential tone systems. The signalling time rarely exceeds 2s and may be shorter than 0.5s and thus does not use up excessive channel airtime. In the maritime services, the sequential tone system specified by the CCIR is used both for v.h.f. and for m.f. and h.f. calling.

This system is a sequence of five digits, each represented by a specific tone except when a digit is repeated in the number, in which case an eleventh tone is used to indicate second (repeated) digit. Each call is repeated twice, and there is provision for the insertion of additional information, such as the identity of the calling station, between the repeats. An 'all station' call is possible by the transmission of the whole series of ten tones in rapid succession several times. In the international aeromobile service, the standard system consists of two pulses, each of two simultaneous tones (Selcal). The tones lie in the range 312-1047 Hz and are modulated on the carrier to a total depth of at least 60% at peak.

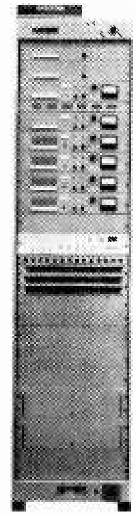
Area coverage systems and voting

When the area to be covered by one v.h.f. or u.h.f. system exceeds that provided by one base station, special arrangements can be made to obtain the required result. One method is to provide selector switches for several base stations so that the operator can choose the station which he thinks will provide the best communication. As a refinement on these arrangements, the base-station receivers can be fitted with a signal-level assessor which transmits back to the operator a level-indicating signal. Next, automatic means can be provided at the control point for selecting the best signal from the outstations and switching it to the operator (voting system), usually with control of the associated transmitter. Time constants are made short enough to allow change from station to station when signal levels change but not to switch for normal fades lasting some tens of milliseconds. The next step is to activate all transmitters simultaneously, especially where there is a need to reach all mobiles urgently.

The first successful method, proposed by Brinkley in about 1946, was the a.m. spaced-carrier method in which all the transmitters operated in the same channel but their carrier frequencies were spaced by several kilohertz, a spacing so chosen that the beat notes produced in receivers when two or more signals were received simultaneously were at frequencies higher than the unwanted audio band and could be filtered out. This arrangement was widely adopted by the police and aeromobile services and is still in use today, although the channel widths of 25 kHz now in force allow only three carriers, spaced 6 or 8 kHz apart and kept closely to these spacings by highly stable crystal oscillators at each transmitter.

Alternative f.m. systems were also developed about the same time, using synchronous or quasisynchronous carriers. Great care was taken to equalize phase shifts in the links from control to outstations and to make audio and modulator responses alike for all transmitters. In the early systems, the link frequencies were used as reference frequencies for the main area-coverage carrier frequency. The outgoing link carrier frequency was chosen to have some simple numerical relationship, such as 3/2, to the area-coverage carrier frequency and so could easily be translated to it by simple dividers and multipliers.

Later systems have used rather less exact relationships and a stable offset frequency has been added to obtain the required carrier frequency. In other schemes very stable crystal oscillators generate the desired carrier frequency at each outstation, and the oscillators are set to yield carrier frequencies within a few hertz of one another and of the nominal frequency. Good results have been obtained using such systems in 25 kHz channels, and satisfactory operation in 12.5 kHz channels has been demonstrated.



Base station assembly (Pye)

Difficulties, in the shape of distorted signals, are met in some areas of overlap between coverage areas of two or more base stations, but radiated powers can sometimes be manipulated and aerial directivities chosen to position such poor areas where they cause least upset to the service. In all cases, the maintenance of equipment, once set up, must be of a high standard if good results are to be sustained.

Under the aegis of the Home Office, the University of Swansea has carried out field trials of three alternative area-coverage systems, simultaneously in South Wales. The systems used were the a.m. and f.m. systems based on stable crystal oscillators and a similar system using double-sideband diminished carrier (d.s.b.d.c.) modulation which was selected by the university as a likely alternative to the existing police 50kHz systems, usable in 25 kHz or narrower channels. This system did show good results but the a.m. system was also acceptable and has been developed into commercial installations with good results. The work is continuing with more emphasis on independent sideband signals, especially for data transmission.

Other simpler systems may be adopted where the area to be covered is comparatively small. The on-channel repeater system is one such arrangement, and Fig. 5. shows one large system which uses several o.c.rs, in one case two in tandem, to help cover the Greater London area.

Where permitted by authority – and permission is generally restricted to thinly populated areas with a low density of radio systems – hill-top repeaters may be used to extend coverage for mobile-to-mobile working or for mobile to a 'fixed mobile' used as a control point. It is highly desirable that a specific unlocking code be provided for each repeater, since their high sites may be subjected to many cochannel interfering signals from distant installations. Subaudio tones are often used for this purpose.

In future it is possible that satellites may be used by the more important services covering very large areas. Such satellites are already under intensive study for maritime and aeromobile-communication services. They will also provide navigational information and rescue facilities which will be of great value in these services. Frequencies in the L band, around 1500 MHz, have already been allocated for these satellite services. Designs for shipboard equipment are available, and operational systems are in an advanced planning stage.

Cellular systems

Public radiotelephone services require better than average coverage over wide areas. Once contact has been established between a mobile and a base station connected to the public telephone network it should preferably not be broken during the conversation, however far the mobile travels in that period. On the other hand, the maximum number of conversations should be handled by the available channels. One system of achieving these ends is the 'cellular' system in which groups of cells, each tailored in area to suit local conditions, use a small group of frequencies which are repeated for other groups of cells not far removed geographically. Base stations are of low power to reduce cochannel interference and cell sizes are very small, about 1.5 to 10 km radius, to ensure capture within the cell by the local transmitter. Cell radii are chosen to cater for average journeys within them but a 'hand-off' system is provided, by computerized control of the base stations, so that the mobile is passed automatically from one cell to another when signals materially change in level. No system of this type is yet installed in the UK but its attractive frequency economy has made it the subject of recent study.

Interrogating systems

The power industry operates interrogating systems for the collection of data from outstations, some of which may be fixed and located at fairly inaccessible points and some, especially in other applications such as in public transport, may be mobile, e.g. in buses. A central base station sends out a selective call to each outstation in turn and receives from each the data stored in a memory at that point and sent, with an identifying code, back to base. A similar system is under study and experimental investigation by the Home Office for the rapid transfer of data to and from police vehicles.

Because these fleets of vehicles can be large, and rapid updating of information is desirable, fairly high data rates are necessary, and systems working at around 1200 bauds are under test. Such systems would feed into automatic displays and recording systems at the control point and into the police computer. One of the facilities under study is the provision of a vehicle-location map, kept constantly up to date by signals from each vehicle according to data entered by the driver, possibly on a gridded touch map of the area.

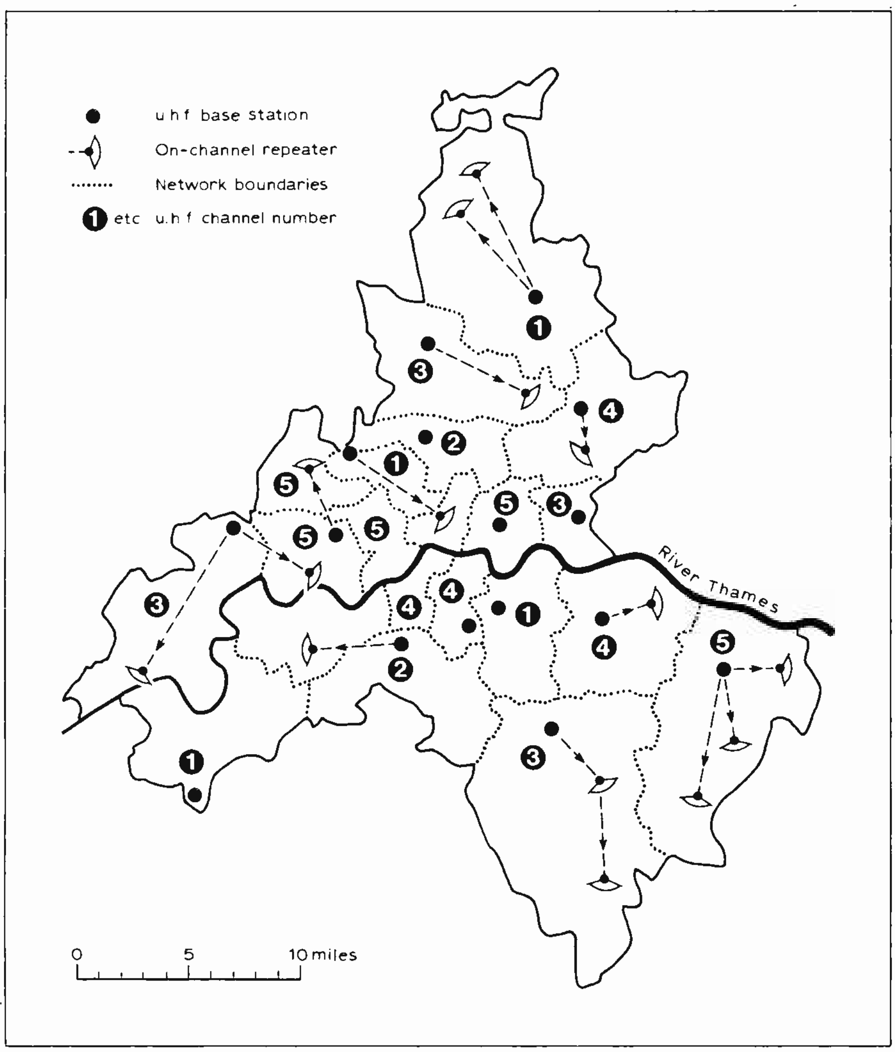


Fig. 5. Typical use of "on-channel repeaters" in an area-coverage system for Greater London.

Other systems

Data transmission. Although a mobile radio system is very far from the ideal medium over which to transmit data signals, pressure on the available radio spectrum is high and the saving in time to be achieved through the use of data is too great to be ignored. Equipment and systems specifically designed for data transmission have therefore increased greatly in numbers in recent years and are proving their value in all but the simplest schemes. Problems of flutter and noise are still not fully solved and signal levels higher than could be used for speech signals are often necessary to guarantee reliable results. Some systems manage to combine speech with data signals by inserting the latter in a slot filtered out of the speech band, but data rates are then necessarily slow. Automation is also being applied in another area, that of base station control. The choice of the best signal and the best transmission path can be made by computer instead of by an operator, leading to economies in systems in which a number of people may wish to contact mobile stations.

Leaky-cable systems Recently, a partial answer has been found to the problem of transmitting radio signals down tunnels or in severely screened areas. It has been found that the signals leaking from a cable laid along the tunnel can be received by portable sets of standard design up to a few metres from that cable. Transmissions from the portable sets is also transmitted by the cable to a receiver coupled to it at a suitable point. Tunnels many kilometres long can be covered by using several cables in series, possibly with a return link by telephone line above ground.

(To be continued)

Remote control servo

An alternative design to that proposed in M. F. Bessant's article on multichannel proportional control

by J. H. Cook

In a time-division multiplex system, the command to an individual servo amplifier has to be expanded so that the motor current will be sustained in the interval between commands, which in this case is approximately 20 milliseconds.

In the original design[1] this expansion is realised by charging C_E during the control pulse and maintenance of this charge keeps the motor turning. In practice, the charge leaks away after about 5 milliseconds. This causes the motor to turn slowly, since it is not supplied with current for most of the cycle time. Another disadvantage is that, as the servo nears its end point the pulse charging C_E becomes narrower; hence, there is less charge on C_E and the servo movement is even slower. Increasing the value of C_E to 4.7 μF. causes the servo to move faster but then the dead space becomes impractically wide and renders small, accurate movements of the servo impossible.

New design

The present circuit completely separates the mechanisms which set the dead space and which ensure that the motor is driven hard even when it is near its end point. It can be seen from the circuit in Fig. 1 that it is developed from the original and I_2, G_9 and G_{10} in Fig. 1 are equivalent to I, G_1 and G_2 in the original. G_5 and G_6, G_7 and G_8, G_{11} and G_{12}, G_{13} and G_{14} form set-reset latches, while I_1 and G_1, I_4 and G_3, I_5 and G_4 give negative-going pulses on a positive-going edge[2]. I_3 and G_2 are similar but the pulse length is longer and variable. This pair acts as a monostable which is used to set the dead space time.

It is necessary for G_{15} and G_{16} to be open-collector gates and one package can be saved by also making G_9 and G_{10} open-collector gates, providing them with 1kΩ resistors at their outputs. These four gates are in an SN7401N package. The rest of the gates are in

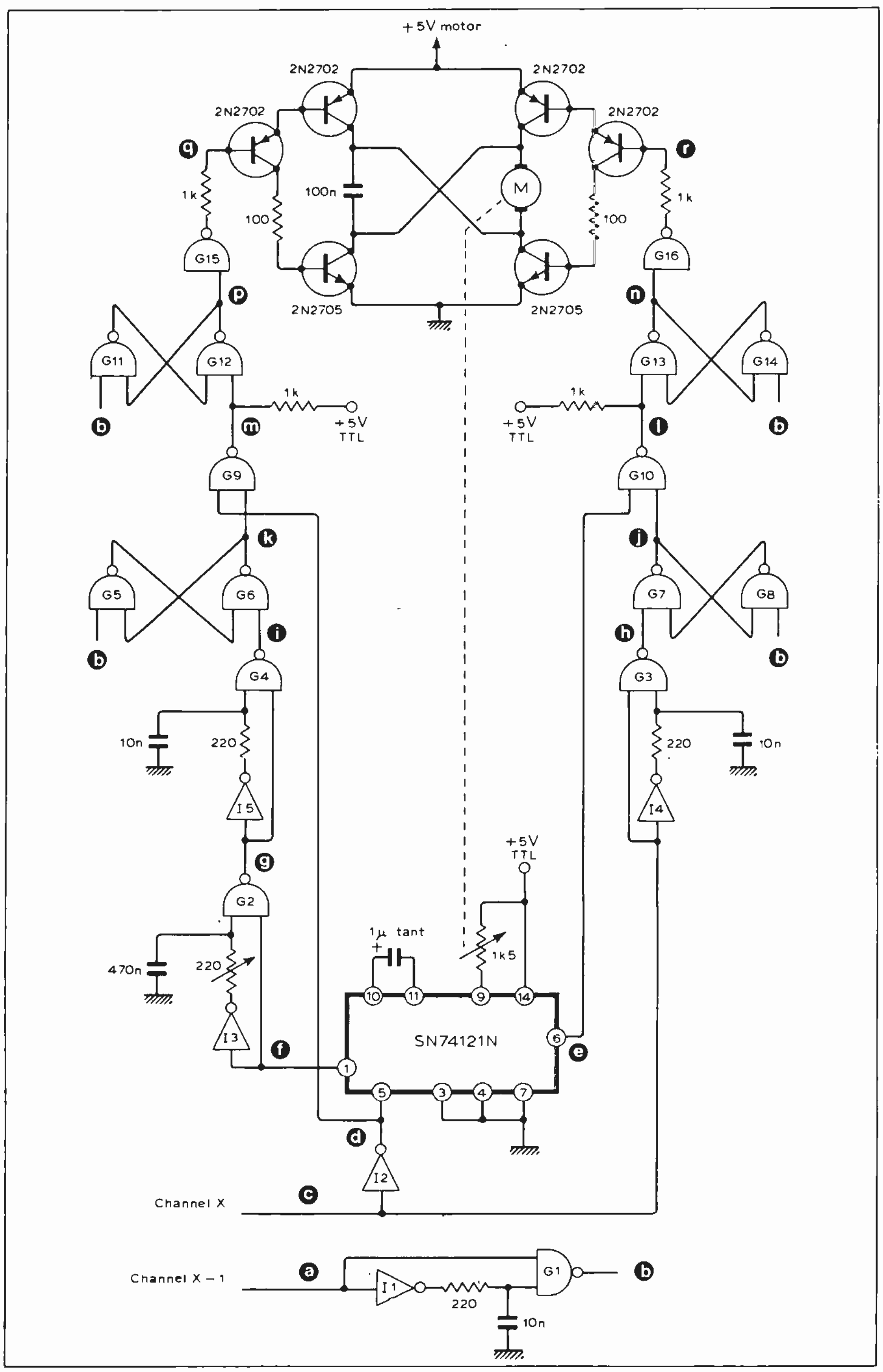


Fig 1. Circuit of improved servo design.

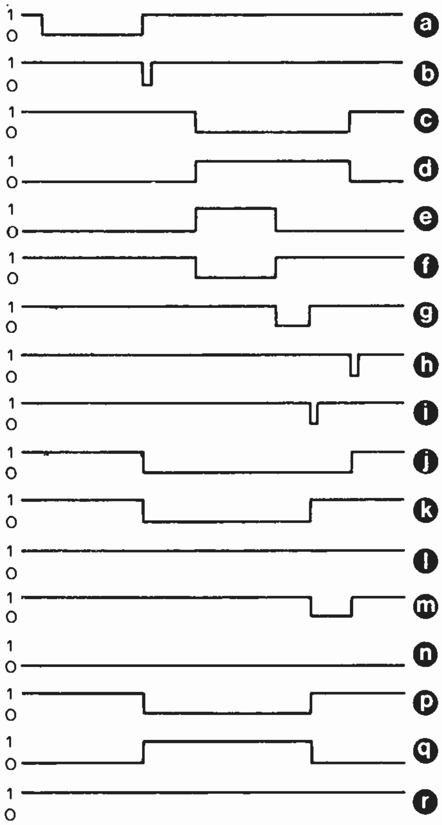


Fig 2. Waveforms when servo is stationary.

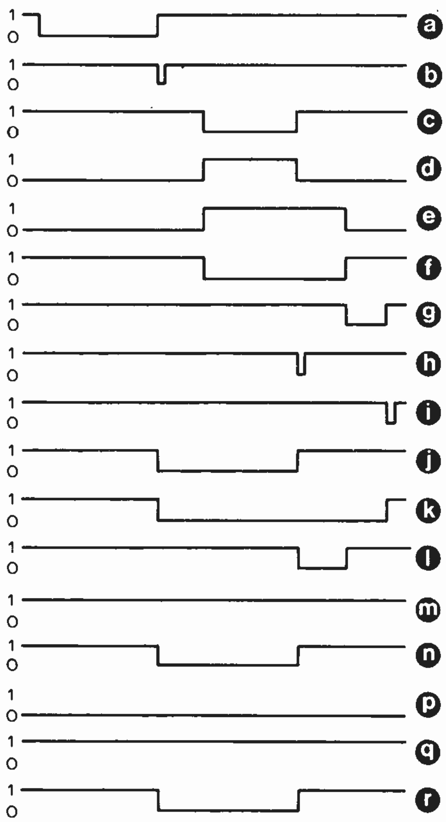


Fig 3. Waveforms when input pulse length at c is shorter than the output pulse length from the monostable SN74121N.

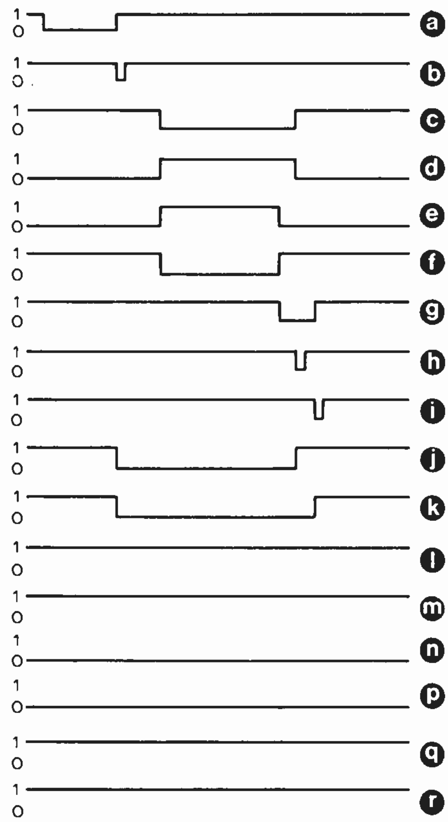


Fig 4. Waveforms when the output pulse from the monstable SN74121N plus I_3C_2 is shorter than the control pulse at c.

SN7400N packages and the inverters are an SN7404N.

Channel X is the channel currently controlling the servo and channel X-1 is the previous channel. If X is the first information channel, then X-1 is the synchronizing pulse.

The functioning of the servo circuit can best be followed by study of the waveforms at the points marked in lower case letters in Fig.1. These waveforms are shown in Figs. 2, 3 and 4 for different states of the servo; **b, g, h,** and **i** are shown longer than they actually are for clarity. Pulse **b** is derived from a as explained above and resets all the set-reset latches, while **c** is the control pulse for the servo.

Fig. 2 shows the waveforms when the servo is stationary. For the motor to turn there must be a negative going pulse at either **m** or **l** to set one of the latches G_{11}, G_{12} or G_{13}, G_{14}. In the conditions as in Fig. 2 neither of these things happen. It is arranged that **k** becomes logic 0 before **d** becomes logic 1. If both these are switched "simultaneously," there is sufficient propagation delay through the gates for a momentary pulse to be present at **m**, enough to set G_{11}, G_{12}. It is also arranged that **d** reverts to logic 0 before **k** becomes logic 1, again to ensure no pulse at **m.** (The same applies to **e, j, i,** G_{13} and G_{14}.) Hence both **q** and r remain at logic l and the motor does not move.

Fig. 3 shows the waveforms when the input pulse length at **c** is shorter than the output pulse length from the monostable SN74121N. In this case, j will revert to logic l before **e** becomes logic 0. Therefore a negative-going pulse will appear at l. This will set the G_{13}, G_{14} latch, which will cause n to go to logic l and r to become logic 0. This will turn on the motor, which will turn until the conditions in Fig. 3 prevail, when the motor will stop.

It can be seen that once the set-reset latch is set it will remain set for nearly the whole cycle time (20 milliseconds). It does not matter how short the pulse at l is, which means that the motor speed is independent of the distance from the end point.

Fig. 4 shows the waveforms when the output pulse from the monostable SN74121N plus I_3G_2 is shorter than the control pulse at **c.** In this case the servo is driven in the opposite direction, in a similar manner to that described above.

The dead space is adjusted by setting the 220 ohm trimmer to as small a value as possible compatible with the servo not hunting.

References

1. Bessant, M. F. "Multichannel proportional remote control," *Wireless World*, vol. 79, No. 1456, pp. 479-482, Oct. 1973.
2. Cole, H. A. "T.t.l. trigger circuits," *Wireless World*, vol. 78, No. 1435, pp. 31-32, Jan. 1972.

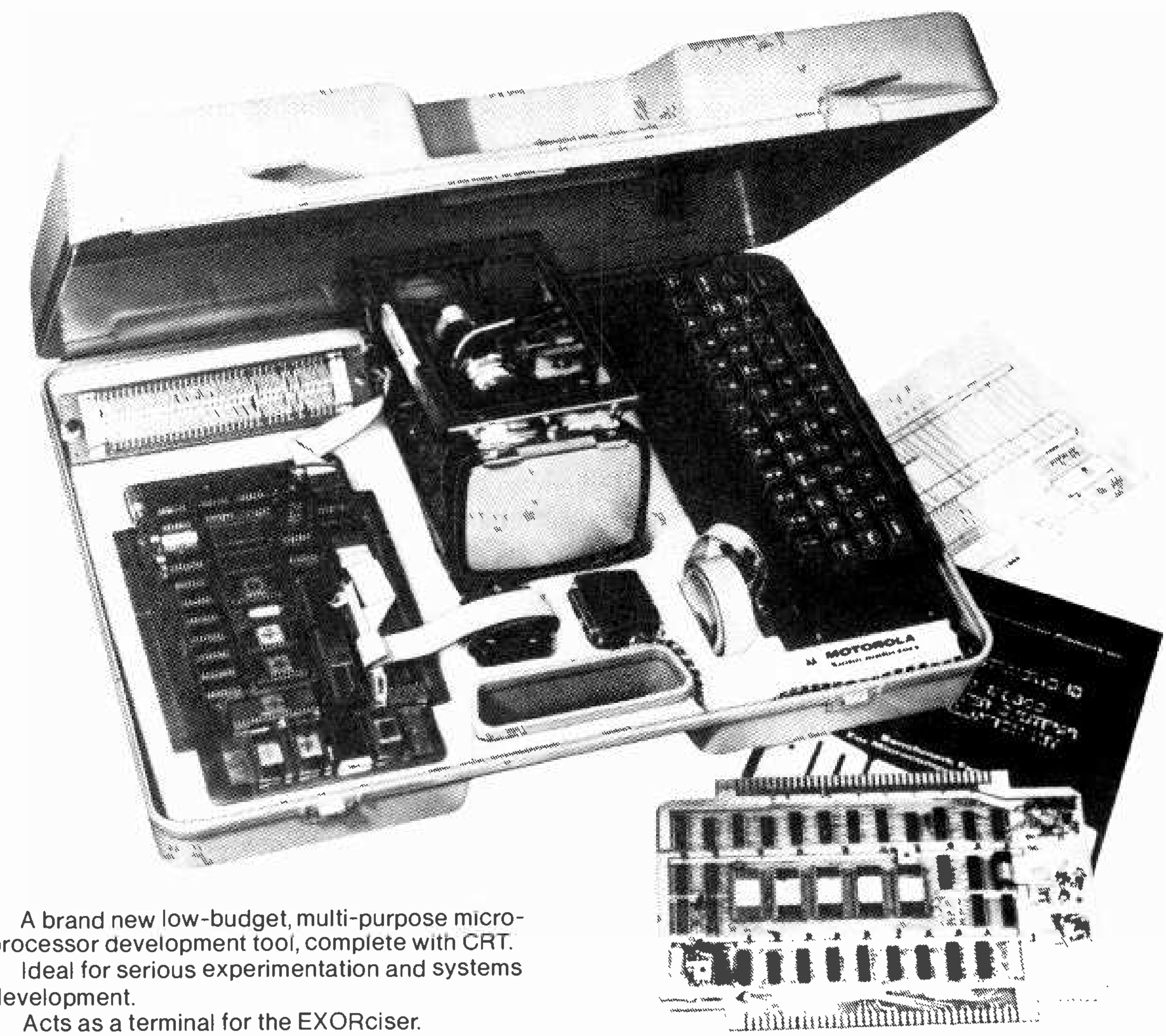
Announcements

Repairing semiconductors

On page 52 of the November 1976 issue we published a letter from a reader who had found it possible to remove the protective casings from some defective transistors and effect repairs. We have since received a number of letters pointing out that many semiconductor devices contain poisonous substances. The danger of beryllium oxide poisoning particularly concerned readers. It appears that semiconductor manufacturers are aware of this and other dangers – beryllium oxide is only one of many toxic substances used in semiconductors. At least one manufacturer, concerned about his liabilities under the Health and Safety at Work Act, wrote to his customers in October to point out that the dangers from breakage in use and disposal, though small, did exist and were worthy of the customer's attention. The equipment maker is responsible for any such danger and would normally be obliged to label the product accordingly. In the case of semiconductor components, however, there is usually no room for a label.

In view of all this we must strongly advise against any tampering with the packaging of transistors. We thank those who drew our attention to the problem.

Motorola introduces POLYVALENT Development System.



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WW—066 FOR FURTHER DETAILS

Earthing, shielding and filtering problems

4—Magnetic pickup problems

by R. C. Marshall, M.A., M.I.E.E. *Xerox Research (UK) Ltd.*

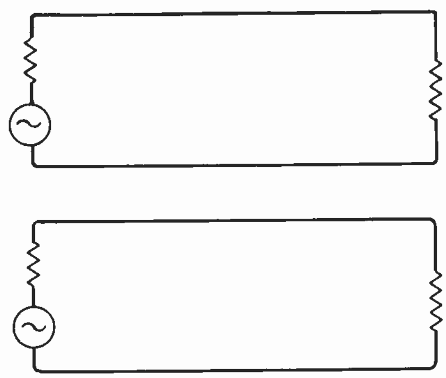
Problems resulting from ineffective or insufficient grounding, shielding or filtering are not easily anticipated or understood, yet this is one of the least-taught aspects of the electronic engineer's art. Difficulties arise from components not shown on circuit diagrams, modes of operation not contemplated by the designer and, worst of all, several such modes operating at the same time. Cure of one mode may not eliminate the symptom — only when all spurious couplings are removed at the same time will correct operation occur.

Magnetic coupling is a problem in low frequency, low impedance systems. The relevant distinctive design techniques are discussed in this, the last article of the present series.

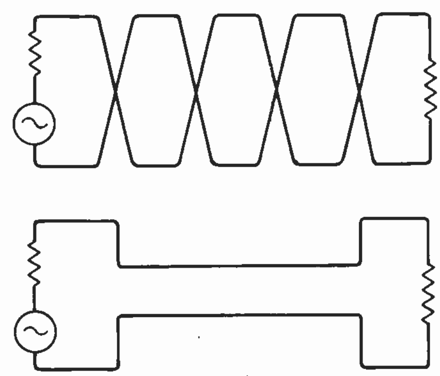
Current flow around one circuit induces a voltage in series with another circuit in accordance with the laws of electromagnetism. The effect exceeds electrostatic couplings only in low impedance, low frequency circuits. Power supplies, dynamic microphones and industrial magnetic transducers are commonly involved. White[13] has concluded that for frequencies below 100kHz, magnetic coupling will be dominant if the product of the impedance of culprit and victim circuits is less than 300ohm^2, and electric coupling will be the major effect if the impedance product exceeds a value of 10,000ohm^2. The exact breakpoint depends on the circuit geometry.

Case 8

Situation: Two circuits running adjacent to one another as in Fig. 8(a).
Symptom: Signal transferred from one circuit to the other, despite non-ferrous shielding.
Problem: Inductive coupling (that is, transformer action) between current flow in the source circuit loop and the receiving circuit loop[14].
Cures: Reduce the area of either loop, thus reducing the flux generated or



(a)



(b)

linking the receiving loop. This can be done by careful layout particularly of printed circuit boards, by avoiding ground returns and by twisting together go and return conductors[15] see Fig. 8(b).
Separate power and signal cables into distinct bundles.
Re-route cables.
Enclose ground and return conductors together in one magnetic shield, such as steel conduit or a lapping of high-permeability magnetic tape.

Case 9

Situation: Two circuits adjacent to one another, one involving a transformer, motor, saturable reactor, relay, or electromagnetic transducer. These may be physically separate from each other.
Symptom: Signals, particularly at supply frequency, are transferred from one circuit to the other, despite non-ferrous shielding.
Cures: Reduce loop areas. Separate or shield cables as in case 8.
Shield transformer with magnetic material[16]. Attenuation of 30 to 60dB at 50Hz is normal. Copper or aluminium boxes only provide such attenuation at 10kHz and above, but will be useful for high-frequency power transformers and line-scan components for cathode ray tubes.

To be effective, magnetic shielding boxes should be made of high permeability material, and be of small physical size. They are therefore best used around signal transformers rather than power transformers. To preserve the high permeability, these shields should not be bent, cut or drilled after annealing. Joins should be overlapped.

Two concentric magnetic shields are much less prone to poor performance caused by leakage at joints. One shield will also protect the other from saturation, allowing the use there of a very high permeability alloy.

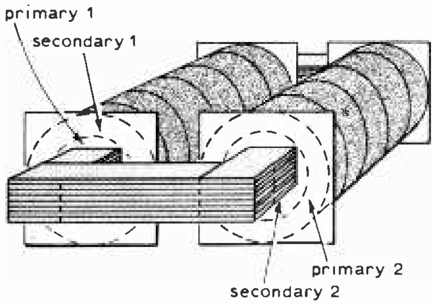
Provide a thick copper shading ring around the whole transformer, coaxial with the windings. Unlike a magnetic material, this cannot be saturated, but attenuation is limited. However, the technique is used in American TV receivers.

Were there are transformers in each circuit, orient them so that there is minimum coupling. Likewise, in the vicinity of cathode ray tubes transformers should be so positioned that their stray field is along to the electron beam.

Often the transformers will be in different pieces of equipment and this technique cannot be used. (Try standing an audio pre-amplifier on top of a large constant voltage transformer!).
Use a uniformly-wound toroidal transformer or a balanced construction such as the double-bobbin transformer of Fig. 9.

Avoid the use of signal transformers by using amplifiers with balanced inputs.

Concluded on page 66



Avoid the use of saturating power devices such as megnetic amplifiers and constant-voltage transformers.

Conclusion

The four articles are a brief survey of a wide subject, intended to ease design synthesis and problem solving. Sometimes this seems a black magic subject, but the magic lies in being methodical and considering all sources of interference, abd being careful to solve one problem without causing another.

Where a design comes close to the limits of what is possible, reference should be made to the bibliography.

References

13. EMI control methods and techniques, in Electromagnetic Interference and Compatibility Series, vol. 3, D. R. J. White, Germantown, Maryland, 1973.

14. Interference coupling – attack it early, R. J. Mohr, *EDN* July 1969, p.33. Theoretical treatment of unshielded cable coupling, for short cables over a ground plane. Bibliography.

15. Shield grounding and circuit grounding effectiveness in interference reduction in the 15kHz frequency region, G. M. McDonald and G. R. Taylor. *IEEE Trans.* vol. EMC8 no. 1 March 1966. In shielded twisted-pair systems no single-shield grounding scheme is optional for all circuit grounding schemes. Balancing a circuit gives about a fold improvement.

16. Magnetic Shielding, publication T28/1274/DP Telcon Metals, Crawley, Sussex.

Literature Received

A wall-chart of U.S. minicomputer makers and their equipment available in the UK is being distributed free. Forty companies are listed and the tabular information is concerned with c.p.u., I/0, main memory, software, peripherals and prices. The chart can be obtained from Computer Automation, Hertford House, Denham Way, Maple Cross, Rickmansworth, Herts WD3 2XD . . WW401

Voltage regulators are the subject of a booklet, sent to us by Lambda. Devices are available in TO-100, TO-23 or chassis-mounting package, covering the range 150mA-30A and up to 30V. The address is Lambda Electronics Ltd, Abbey Barn Road, High Wycombe, Bucks............ WW402

A c.m.o.s. data book, part of Motorola's Semiconductor Data Library, is now available. In 566 pages, the book gives full specifications of 13 series components and includes information on rèliability and handling. It is obtainable from Motorola franchised distributors at £2.50.

Measuring instruments, repair and calibration services offered by Euro Electronic Instruments are described in a new brochure, which can be had from Shirley House, 27 Camden Road, London NW1E 1YE . WW403

A a.m. signal generator, the SG2000 from Advance, is described in a new leaflet. Frequency range is 160kHz to 230MHz and leakage radiation is quoted as less than 1 microvolt below and better than 3μV above 35MHz. The leaflet is obtainable from Gould Advance Ltd, Roebuck Road, Hainault, Essex WW404

Moving-coil meters and accessories are shown in a brochure, sent to us by BPL. Four ranges of instruments are described, including the sub-miniature full-scale movement. BPL, who are approved to Defence Standard 05-24, are at Radlett, Herts, WD7 7HJ. WW405

Paper tape formats for the programming of p.r.o.ms and field-programmable logic arrays are specified in a leaflet from Rapid Recall. ASCII/hexadecimal, ASCII/octal, binary and BPNF formats are described for p.r.o.ms and binary and ASCII/hexadecimal for f.p.l.as. Rapid Recall Ltd, 9 Betterton Street, Drury Lane, London WC2H 9BS . . . WW406

The Newport series of electromagnets are illustrated and specified by Oxford Instruments in a new brochure, NEM10. The magnets are designed for wide application in industry and in teaching. Oxford Instruments, Osney Mead, Oxford, OX2 0DX WW407

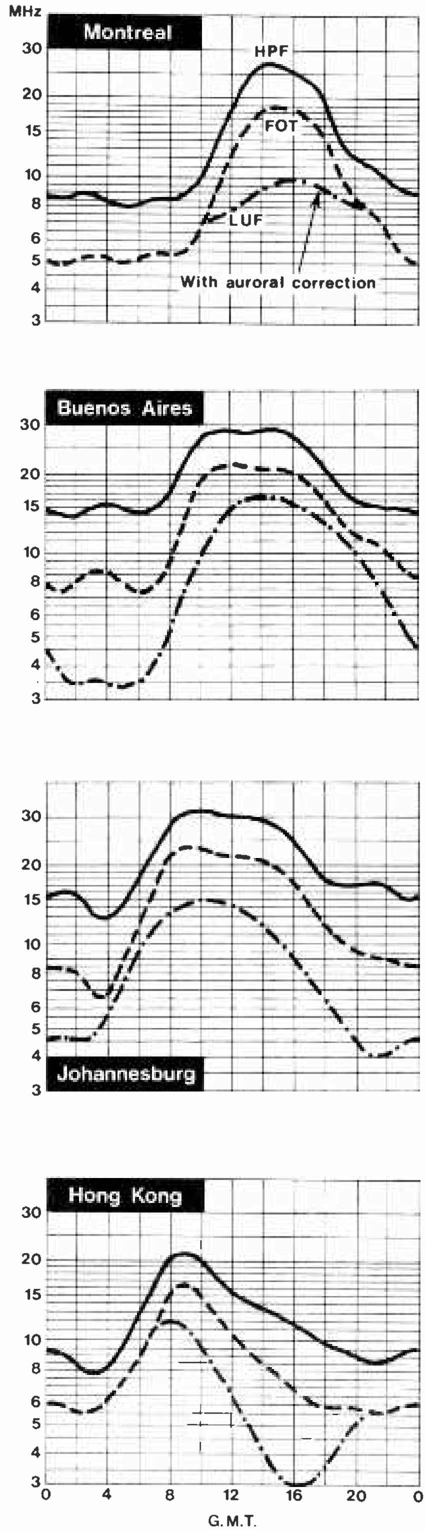
High-reliability devices is the title of a data book from RCA, which describes c.m.o.s. and bipolar integrated circuits, m.o.s.f.e.t. devices, low and high-frequency power transistors, thyristors and triacs for applications where reliability is essential and application note abstracts are included. The book is available from RCA Ltd, Solid State – Europe, Sunbury-on-Thames, Middlesex.

Linear transducers of both potentiometric and differential-transformer types are made by Penny and Giles, who describe the range in a new publication. Full mechanical and electrical information is included. Penny and Giles Ltd, Mudeford, Christchurch, Dorset WW408

BSI has just published BS 5394 – Radio interference limits and measurements for lighting equipment: Part 1 Luminaries for tubular fluorescent lamps. This is another in the series of specifications dealing with the abatement of radio interference. It is divided into three parts, Part 1 dealing with radio interference from fluorescent lighting equipment. The other two parts are still under consideration. BS 5394 may be obtained from BSI Sales Department, 101 Pentonville Road, London N1 9ND. Price £2.40.

HF predictions

As previously reported there were first signs of a new sunspot cycle in September and October of 1975 but no further evidence appeared until March 1976. The new cycle does now seem to be firmly established.



Optical fibre communication — 2

Transmission equipment for field demonstration

by M. Ramsay, A. W. Horsley and R. E. Epworth *Standard Telecommunication Laboratories Ltd*

The introduction of an optical-fibre communication system into an existing network is possibly a more far-reaching step than any that has been taken since the inception of these networks. Because of this, a great deal of engineering confidence has still to be established. A large-scale field demonstration could achieve this, but many sub-systems must be engineered before this can be held. With careful design, such a demonstration will assist in determining the targets to be set for a field trial.

This article (part 1 appeared in the November issue) describes work being carried out to produce the key sub-systems which will enable realistic field demonstrations to be mounted, thus paving the way to field trials of optical fibre communication systems.

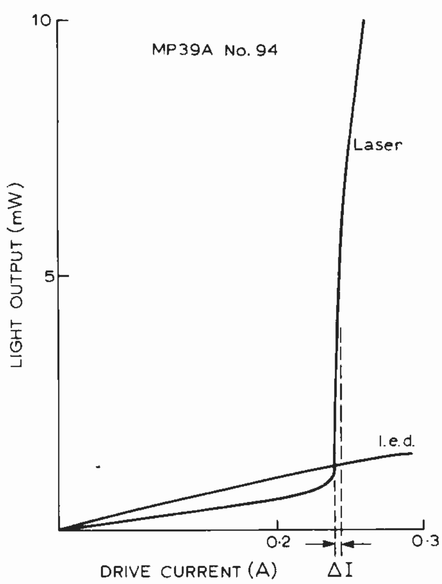


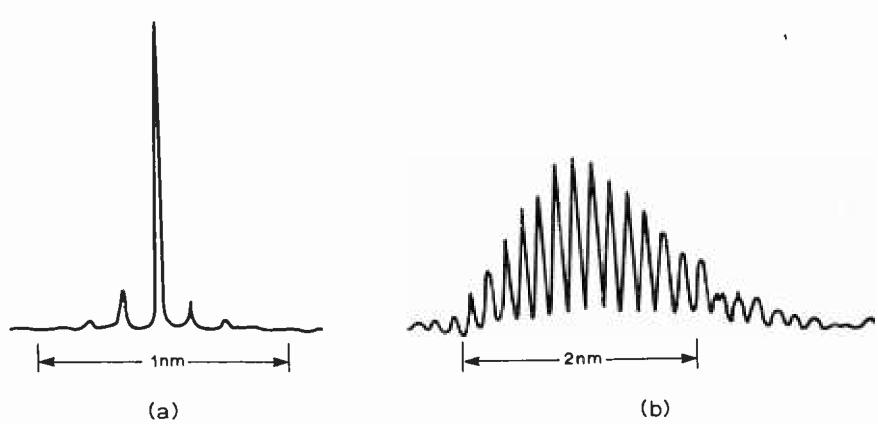
Fig. 3. CW laser output versus drive characteristic shows almost linear relation for an l.e.d. and abrupt threshold for laser.

Optical transmitter

The drive requirements for l.e.ds and lasers differ considerably; l.e.ds have a light versus current characteristic that is nominally linear, whereas lasers produce little light until the current reaches a threshold. Above that current the light output increases very rapidly for a small increase in current, full output being obtained with typically about 20mA additional current (Fig. 3). The laser threshold might typically be 150mA; therefore such a laser would require 160 ±10mA direct modulation current. On the other hand, l.e.ds are simpler to drive but require a high modulation current.

When lasers are modulated at high bit rates, it is very important that the laser never be allowed to fall below threshold, e.g. during the zero level in a binary signal. The reasons are twofold. Firstly, lasers exhibit a turn-on delay of several nanoseconds when driven from below threshold and this would cause considerable intersymbol interference, particularly for a non-return-to-zero (n.r.z.) code[27]. Secondly, when low dispersion fibres are used, material dispersion becomes significant. This is a function of source spectral width, and lasers driven from below threshold with short pulses exhibit spectral widths of 3nm or so, whereas biasing above threshold ensures spectral widths of only 0.5nm[28]; and thus minimizes material dispersion see Fig. 4.

Fig. 4. Variation of spectral width of laser biased just above threshold (a) and just below (b) (after Selway & Goodwin, see ref. 28).



If the laser bias is set too high there is the possibility of damage due to the high optical power levels. Also, operation at high power levels is often associated with excessive laser noise. The range of operation of the laser must be tightly controlled if its advantages are to be used to full effect. The laser threshold increases with temperature and life, and varies from device to device, so it is essential in any practical system to provide optical feedback to control the laser bias. This can be done by monitoring a fraction of the light from the laser with a photodetector, and comparing the output with a reference which sets the demanded light output, then feeding back to increase or decrease the bias current accordingly. Thus the bias current is made to track any variations in threshold. A current limit may be incorporated to prevent excessive current being drawn and to allow the signalling of incipient laser failure towards the end of its life.

The same variations that occur in laser threshold also apply to the laser slope efficiency. These can also be corrected by a second feedback loop in which the modulation depth is measured, compared with a reference and the error signal fed back to adjust the modulation current appropriately (Fig.

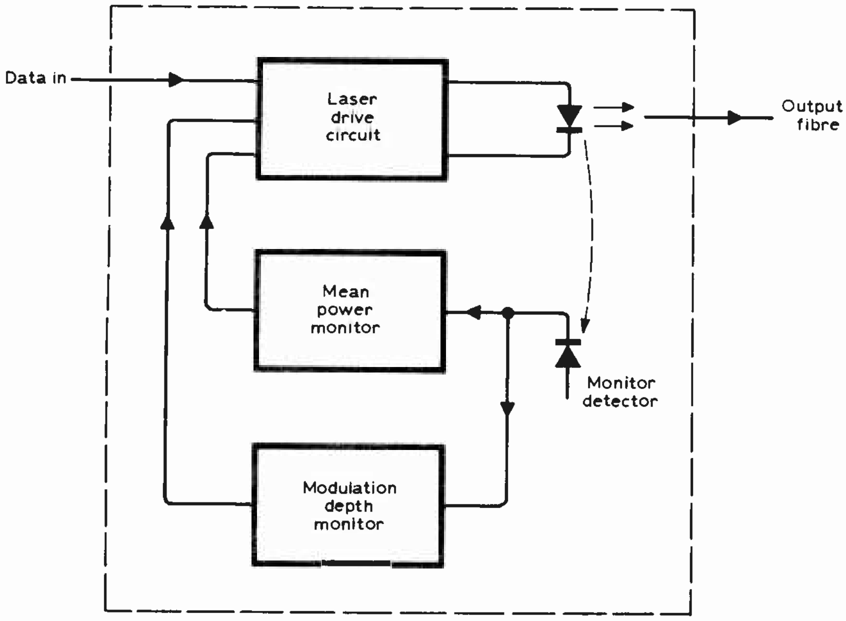


Fig. 5. Feedback from laser output ensures correct laser bias despite variations in threshold due to temperature effects and ageing.

5). This second loop requires a wideband detector and amplifier to the monitor, whereas the first loop alone would only require a slow detector. One detector can provide the monitor signal for both feedback loops. The end result is an optical transmitter with a normalized output level, analogous to the normalized output voltage of the conventional cable driver circuit.

Optical receiver

Avalanche photodetectors have been chosen for the field demonstration as they offer higher sensitivities than p-i-n diodes at high bit rates, for the reasons outlined in part 1. A further advantage is that the amplitude of the electrical signals at the amplifier input will be larger than with a p-i-n diode, resulting in increased immunity to electrical pickup and crosstalk.

Avalanche photodiodes have two main disadvantages: first, they may exhibit tailing, i.e. the frequency response may not be flat, and this will require equalization. There are "reach-through" a.p.ds [29] in which the tailing problem has been overcome but these are more expensive. The second disadvantage is the need for a high voltage supply. Typical a.p.ds require a bias voltage in the range 100 to 500volts for optimum operation which varies with temperature.

There is a great reluctance to use high voltages in PTT systems, but a closer consideration of the requirements suggests that there should be no problem. The diode requires only a few microamperes of current and this can be provided by a small, low consumption d.c. converter. This, together with a temperature-compensated voltage regulator and the diode itself, could be mounted in a sealed module (Fig. 6). Such a module could contain the following amplifier and the detector equalization and therefore becomes a complete optical receiver module.

The avalanche gain characteristic is such that the bias can be varied to control the gain thus enabling manual or automatic gain control (Fig. 7). In its simplest form, the bias supply has a high source resistance R_s (Fig. 8). When more light falls on the detector, the current increases, the bias voltage drops and hence the gain falls, decreasing the current. Conversely, when the optical power decreases, the gain increases. If R_s is infinite, the a.p.d. is biased with a constant-current source. This could be set to $I_c = I_{pmin.} A_{opt,}$ where I_{pmin} is the primary photocurrent ($A = 1$) produced by the minimum optical signal, and A_{opt} is the optimum avalanche gain. Such a biasing technique will produce a flat a.g.c. response over the range of the avalanche gain, the two limits being the point at which the gain falls to unity on larger signals (the diode will saturate unless clamped with a diode) and when the optical power falls to zero in which case all the current will be produced by microplasmas.

One novel means of providing this current source is to use a second photodiode, with no avalanche effects over the range of voltages considered, placed between the bias supply and the a.p.d. and illuminated with an adjustable light source (Fig. 9).

Throughout this discussion it has been assumed that there is no background illumination. In practice this ambient illumination can be eliminated

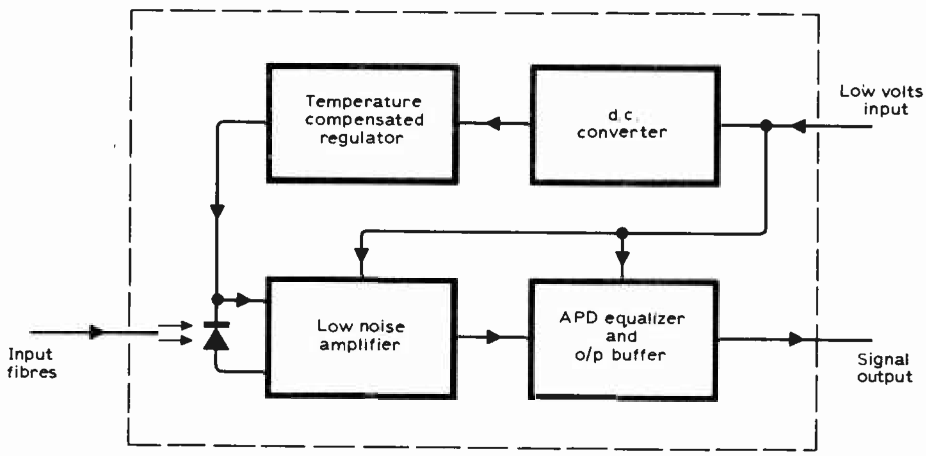


Fig. 6. Optical receiver could include d.c. converter and temperature compensation in sealed module.

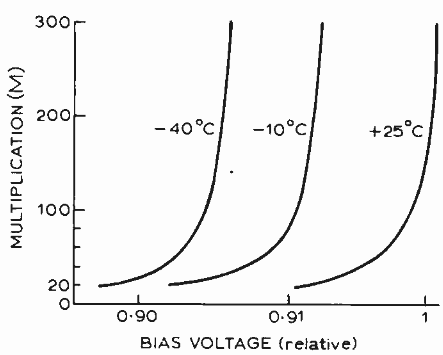


Fig. 7. Avalanche photodiode characteristic allows manual or automatic gain control by bias variation.

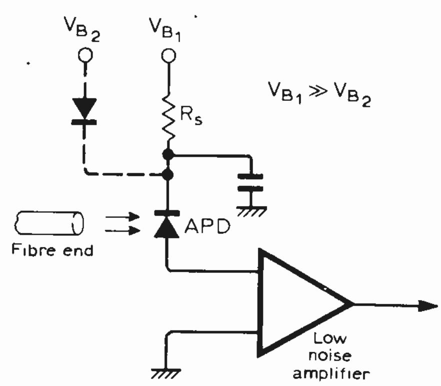


Fig. 8. Gain control of a.p.d. using high source resistance gives flat a.g.c. response.

but there may be some detector leakage which must be taken into account.

The choice of low noise amplifier design depends on the information transmission rate. The photodetector basically looks like a current source shunted with junction capacitance. This capacitance can be made very small as the detector area required is extremely small. Trans-impedance bipolar amplifiers offering a low input impedance are suitable for higher bit rates, whereas high impedance f.e.t. amplifiers and various pre-emphasis/post-amplification de-emphasis techniques are suitable for lower bit rates.

If required, equalization of detector tailing can usually be achieved with a simple RC network but this may have to be tailored to the individual photodiode.

The performance achieved by several optical receivers for binary transmissions is already close to the theoretical limits set by the Poisson distribution of photon arrival time; therefore it is unlikely that there will be any dramatic performance improvements in this area. It is more likely that the high-sensitivity laboratory receivers of today will be refined to make them suitable for use in real systems.

Device packaging

A stripe geometry laser, such as would be used in a system operating at bit rates higher than 50Mbits/s, has a source size of about 20 by 0.2μm and a corresponding beamwidth of 6 and 30° half-angle. The multimode fibre core diameter can be anywhere between 30 and 100 μm, the acceptance angle of the fibre typically varying between 10 and 20°, depending on the system. It is evident that for efficient launching of light into the fibre, positioning of the laser-fibre will need to be accurate to a few microns.

There are two means of laser-fibre coupling, one a simple butt joint, the other a lens coupling. The butt joint will require a small spacing of a few μm between the laser and the fibre to prevent mechanical damage to the front face of the laser. The lens coupling enables us to modify the polar diagram of the laser to optimize the launch efficiency, but involves additional reflection losses and presents considerable difficulties in alignment of the lens elements. Lasers are being developed which will more closely match the fibre, i.e., the beam angle in both axes will match the fibre acceptance angle[30].

There is also the requirement for an optical monitor, as discussed. This can be provided by using the light from the rear face of the laser. It is possible to build a monitor photodetector into the same package; but the choice of detector type predetermines the application for the resulting package, and electrical crosstalk can be a problem. It is more satisfactory to make use of the available optical isolator by placing the monitor photodetector outside the package.

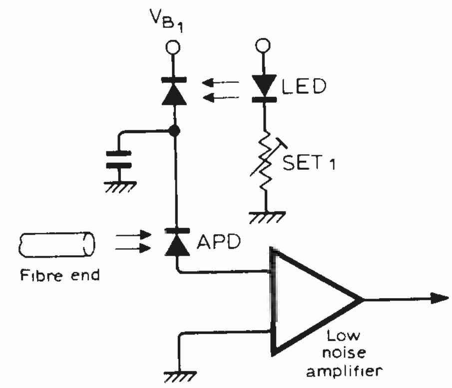


Fig. 9. Novel method of providing current source for biasing uses second photodiode, illuminated with adjustable light source.

This results in a package with one electrical input and two optical outputs. One of these can be an optical fibre for coupling into the system and this fibre can also provide the hermetically sealed window. The monitor output can be a light guide such as a fibre or a simple glass window.

The electrical connection needs to be of low inductance to enable the laser to be used at very high bit rates and this can be provided either by a stripline or by some kind of pill package. Environmental conditions necessitate the hermetic sealing of the package to prevent laser degradation due to contamination. The optical fibre butt joint must be aligned with the front face of the laser and may be combined with hermetic sealing. Two such packages are shown in Fig 10 (a) and (b). These packages are of course also suitable for l.e.ds.

The photodetector package is much less of a problem because the sensitive area is usually many times that of the fibre core which illuminates it; also it has a very wide acceptance angle and so is comparatively insensitive to the direction of illumination. A package developed to meet the laster requirements would be suitable for a detector without much modification. On the other hand, a cheaper simpler solution might make use of an existing windowed package but with the addition of an external lens to focus the light onto the sensitive area.

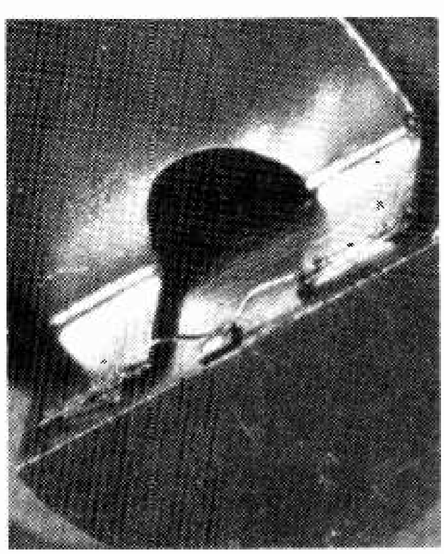
Detector junction capacitance may be dominated by the capacitance of the connections to the package. If the low capacitance made possible by the small detector area required is to be used to most advantage, it may be preferable to mount the detector in the same package as the following low-noise amplifier. This could lead to a hybrid package containing the a.p.d., a high-voltage temperature-compensated regulator, low-noise amplifier and possibly the detector tail equalizer, the complete hermetically sealed package having a fibre input or lens coupling.

Coder/decoder

A suitable code for the field demonstration should have the following properties and capabilities: it should

- have sufficient timing content to satisfy the timing extraction circuit
- remove the d.c. component to enable the receiver to be d.c. coupled and to minimize dissipation fluctuation in the source
- permit in-traffic error rate monitoring at the terminals and possibly also at the repeaters so that faulty repeaters can be located
- make adaptive equalization possible
- make efficient use of the information capacity
- permit the use of simple repeater circuitry.

Discrete pulse-position modulation with its high peak-to-mean ratio is



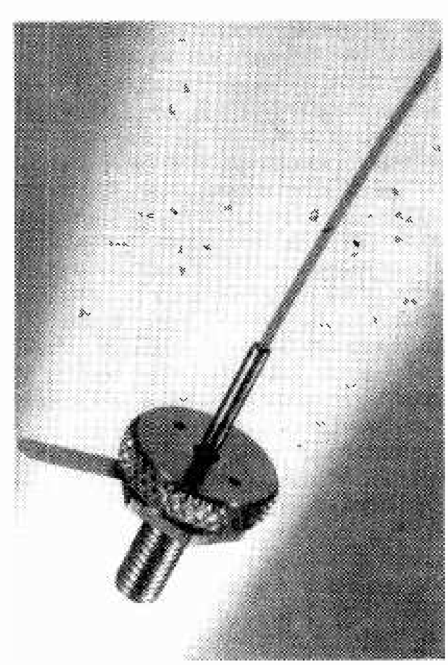


Fig. 10. Hermetic sealing of laser diodes prevents degradation due to contamination. Both stud type (a), above, and planar type (b), right, can also be used for l.e.ds.

attractive for optical systems because of the square-law sensitivity of the photodetector, but is only suitable if the available channel bandwidth is not fully used. Redundant binary coding, in which a block of bits is coded into a longer block, is a possibility (e.g. 5B6B), but it is a compromise between increased transmission bit rate and higher circuit complexity of coders, decoders and error detectors. Errors can be detected by looking for unallowable codes in the regenerated data. Scrambled binary has all the required properties except for the error monitoring and this can be provided by the insertion of a parity bit. The extra redundancy can be very small, but again it is a compromise with circuit complexity at the repeaters.

For a field demonstration a scrambled-binary-plus-parity check seems most appropriate as it will permit evaluation of the optical system without a heavy commitment to a particular code. A field demonstration itself would provide much information from which to choose an ideal code for a future optical field trial. The particular code chosen is one in which a parity check bit is inserted after every 17 bits. This increases the bit rate by 18/17. The reasons for this choice are the small increase in bit rate against the minimum number of integrated circuits required to implement the logic at the regenerator. The parity bit improves the timing content by ensuring the presence of a 1 in a sequence of 17 zeros, and one zero in a sequence of 17 ones. Phase-locked loops would be used at the send and receive terminals to increase and decrease the clock rate respectively.

Dispersion equalizer

Equalization is necessary primarily to correct for distortion introduced by fibre dispersion, although additional equalization may be necessary to correct for photodetector deficiencies. If the dispersion is small compared with the bit period, then little or no equalization will be required as may be the case at low bit rates. If the dispersion is comparable with the bit period, or greater, then it must be equalized out with a resulting power penalty.

The ideal output pulse from the equalizer should reach a peak at time $t=0$ and pass through zero at all instants $t=mT$ where T is the bit period. The signal can then be reconstituted with zero intersymbol interference by sampling at times $t=mT$. This will result in an optimized eye diagram. A good open eye is necessary to ensure low error rates.

Equalization can be performed either by an RLC filter or a transversal filter or a combination of the two. The transversal equalizer on its own is unsuitable when the dispersion has a long tail, since it would require a large number of delay elements.

The main problem of equalization is the varying degree of equalization required. It may vary between samples of fibre and will certainly vary with distance between repeaters. In contrast, specifications on electrical cables are very tight due to the close dependence on skin effect and the many years of development which have taken place. There is also a direct dependence of dispersion on cable length and this, together with the knowledge of launched signal levels, enables equalization to be derived from the attenuation. This is not possible with present day fibres as no similar dispersion-attenuation relationship exists.

It seems therefore that the first equalizers must be flexible to allow for these variations. The ideal solution would be some kind of adaptive equalizer. Such a device could follow slow variations of dispersion with time, such as might occur due to temperature effects, and would avoid complex setting-up procedures. Implementation of this equalizer would require suitable coding to enable the dispersion to be measured by the equalizer.

A possible adaptive equalization scheme is as follows: using a randomized coding technique such as the scrambling technique chosen, it is possible to predict the spectrum of the received signal for the zero fibre length case where no dispersion occurs. If we measure the spectrum of the received signal at the end of a dispersion length of fibre and compare the two, we have an error signal as a function of frequency which can be fed to an adjustable equalizer to minimize the error, thus equalizing the dispersion. In practice it should not be necessary to measure the entire spectrum but merely compare the output from a small number of fixed-frequency filters spaced through the band. If the nature of the dispersion variations is fairly predictable then as few as two filters may be required, one as a reference at a comparatively low frequency and one near the bit rate. Outputs from the filters would be envelope detected with a long averaging time to avoid fluctuations due to data variations and the imperfect randomisation.

A more elegant method of adaptive equalization, also possible with a scrambling technique, makes use of the fact that a comparatively error-free replica of the undispersed transmitted waveform is available at the output of the regenerator. It is possible to cross-correlate between the received signal and the regenerated signal to obtain a direct measurement of intersymbol interference at integral numbers of bit-periods delay. These measurements are integrated over a sufficient period of time to remove any sensitivity to data and fed to the adjustable equalizer to minimize the intersymbol interference which is of course the object of equalization. The transversal equalizer represents a particularly suitable equalizer as the cross-correlation measurements at $t = 1, 2, 3 \ldots$ bit periods are simply fed to the appropriate tap adjustments on the equalizer. This method similarly can be simplified considerably if the nature of the dispersion variations is known, perhaps to the extent of only requiring a single intersymbol interference measurement at one bit delay. This cross-correlation method should allow adaptive equalization at quite high error rates.

Regenerator

The function of the regenerator is to remove noise and jitter from the received signal and thus produce a regenerated replica of the original signal prior to transmission. Main components of a regenerator are automatic gain control to compensate for variations in received signal level; timing extraction, to generate a coherent clock, and a threshold detector, which is sampled by this clock, Fig. 2.

Timing extraction is achieved by narrow band filtering of the component of the signal at the clock rate. This spectral line will always be present if the coding is chosen appropriately. Filtering can be performed by a high-Q tuned circuit or a phase-locked loop.

The tuned circuit method is simple but temperature effects limit the usable Q to 100 or so and this imposes some constraints on the coding. Good a.g.c. is particularly required for this kind of timing extraction if timing jitter is to be minimized.

The phase-locked loop method allows very much larger effective Q values to be obtained, relaxing the coding requirements, but is more costly and consumes more power.

The sampling gate is the decision making circuit which decides whether the received signal is a one or a zero. It is usually some form of comparator which is sampled at the clock frequency, thus retiming the regenerated data.

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References

27. P. R. Selway. Semiconductor lasers for optical communications. *IEE Proceedings*. vol. 123. 1976 pp. 633-41.

28. T. Ikegami. Spectrum broadening and tailing effects in directly modulated injection lasers, IEE Conf. on Optical fibre communications. London, 1975. P. R. Selway, A. R. Goodwin. Effect of d.c. bias level on the spectrum of GaAs lasers operating with short pulses. Submitted to *Electronic Letters*.

29. J. Conrad, P. P. Webb and R. J. McIntyre. Silicon reach-through avalanche photodiodes for dibre optic applications, IEE Conf. Optical fibre communication. London, 1975.

30. M. Chown and K. C. Kao. Some broadband fibre system design considerations. ICC Conf. Proc. Philadelphia, 1972, pp 12-I to 12-5.

Digital angle modulation

Frequency and phase modulation techniques used in the transmission of digital data

by R. Thompson, M.I.E.E., and D. R. Clouting, Ph.D., B.Sc.(Eng.)

The first part of a two-part article on the use of angle modulation for the transmission of digital data over radio links. In this part, methods of generating and detecting angle-modulated signals are described.

The term "angle modulation" covers those systems which convey information by altering the instantaneous phase of a carrier. In normal broadcast systems conveying analogue information, these forms of modulation are described as f.m. (frequency modulation) or p.m. (phase modulation). The difference between f.m. and p.m. in such systems is often minimal, since one form of modulation can be converted to the other with the use of differentiation or integration on the analogue information. In digital systems, the same similarities exist, since frequency is the differential of phase, but differences in implementation tend to be more marked.

Although digital signals are a simple form of analogue information the modulators and demodulators employed are normally more complex than those used in analogue systems. This occurs because the digital links are usually employed where high performance, in terms of spectrum occupancy and noise performance, is required. In these situations it is normally economic to incorporate comparatively elaborate and expensive circuits rather than accept the system penalties involved with simpler ones. It should also be appreciated that digital modulation techniques suitable for data transmission at low frequencies, say by line, are not always satisfactory for radio links. This is not necessarily because of transmission characteristics such as bandwidth and group delay but more usually because of equipment practical limitation such as frequency stability and spurious responses. The modems which are discussed in this paper are presented in terms of their suitability for radio links.

The description "shift-keyed" is often used in association with digital modulation and follows from the simpler form of modulators which simply select one of a number of possible frequencies or phases. As a result of this terminology, digital frequency modulation is normally referred to as f.s.k. and digital phase modulation as p.s.k. It will be seen later that with many modulators "shift-keyed" is slightly misleading because of the gradual transition employed in the modulation. However, the term remains a convenient way of indicating digital rather than analogue modulation.

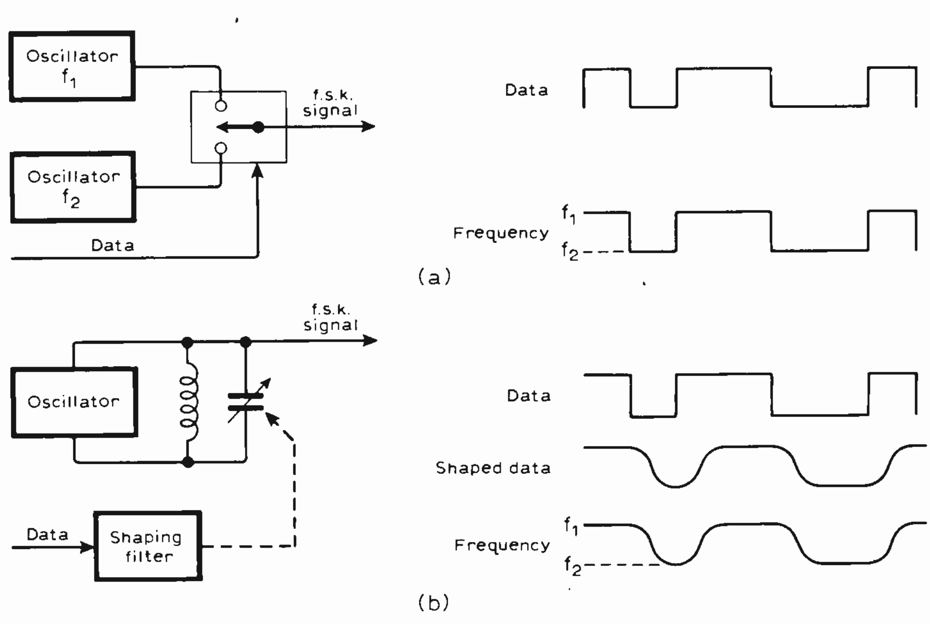
In conveying digital data it is possible for a particular change in frequency or phase to represent any number of digits. The simplest system is binary or two-level, where each change conveys one of two possibilities, a 1 or a 0. In a four-level system each change conveys one out of a possible four combinations of two digits, 00, 01, 11, or 10. The period allowed by the system for a change of frequency or phase to occur is called a "symbol" period.

In binary f.s.k. a data 1 may select an instantaneous frequency of the carrier frequency plus an increment, f_c+f, while 0 selects f_c-f. The selection of f requires consideration of the available bandwidth, noise performance and implementation problems. A case of particular interest is narrow-band f.s.k. where $2f$, the frequency deviation, is about 0.7 times the bit rate of the data. Premodulation shaping of the data is usually employed in order to restrict the tails of the spectrum of the transmitted signal. This, in turn, minimizes the "cross talk" between channels which are adjacent in frequency. The adjacent-channel rejection of a system is a factor of considerable importance when seeking efficient use of available frequency bands.

P.s.k. is the phase-modulation equivalent of f.s.k., with the phase of the modulated signal conveying the digital information. As in f.s.k. it is desirable that the width of the transmitted spectrum is restricted. There are two different approaches to this problem and these have been classified as p.s.k. and p.e.k. (phase exchange keying).

P.s.k. systems employ premodulation

Fig. 1 Two kinds of frequency modulator. The variety shown at (a) simply selects one of two constant frequencies, while the voltage-controlled oscillator at (b) is varied by the data.



shaping which enables the constant-amplitude feature of the modulated signal to be retained. The disadvantage of this method is, however, that strict band limiting of the modulated signal cannot be achieved and finite energy is spread over an infinite frequency band. Some of this energy will therefore fall into adjacent channels and cause interference. The p.e.k. approach to spectrum control is that by using a linear modulation process direct control of the spectrum of the modulated signal can be achieved by passive filtering of the baseband modulating signal. The disadvantage of this method is that it causes amplitude modulation to be introduced into the modulated signal. This means that when it is passed through a practical power amplifier spectrum spreading occurs due to the amplifier non-linearities. In practice, therefore, it is not possible to achieve a strictly band-limited signal.

This paper is concerned with p.s.k. and p.e.k. systems where the information is extracted from the modulated signal by measuring the change in phase between symbols rather than the absolute phase of the signal. Such systems are called differential p.s.k. or p.e.k. and this is abbreviated to d.p.s.k. or d.p.e.k. Four-level forms of d.p.s.k. and d.p.e.k. have received considerable attention during the past few years because of their suitability to radio links between mobile stations.

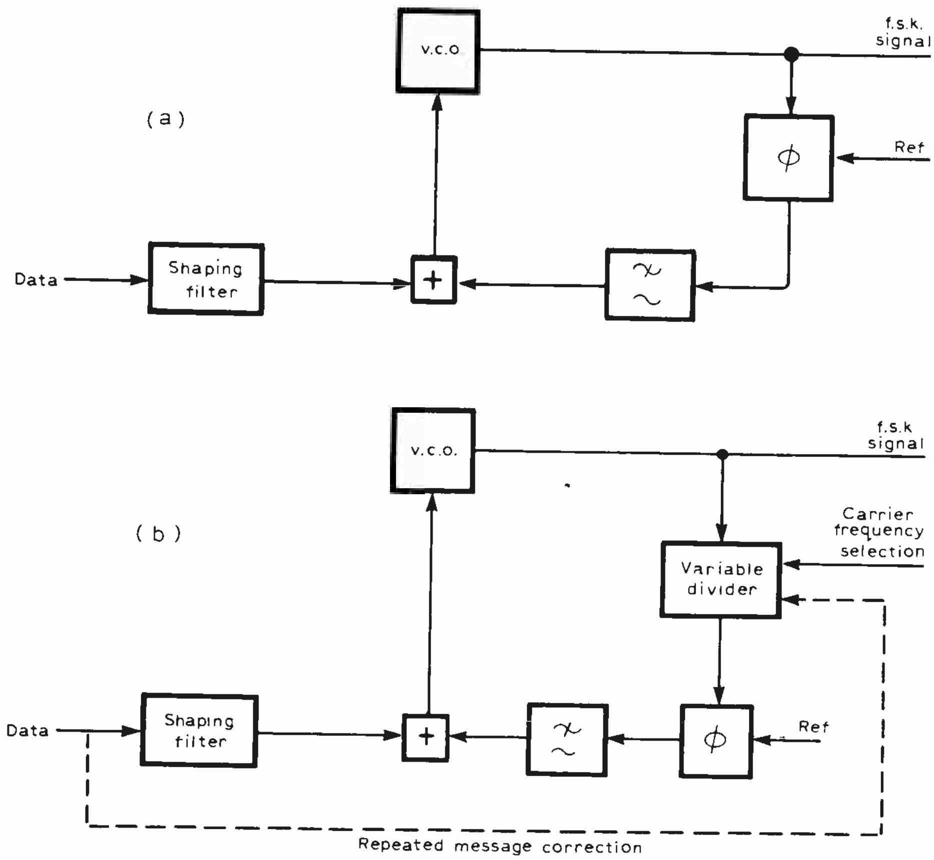


Fig. 2. The v.c.o. of Fig. 1 can be included in a phase-lock loop as in (a) to increase the accuracy of control. In the variation at (b) the variable divider enables the phase comparison to take place at the low reference frequency. *Carrier frequency is altered by varying the division ratio.*

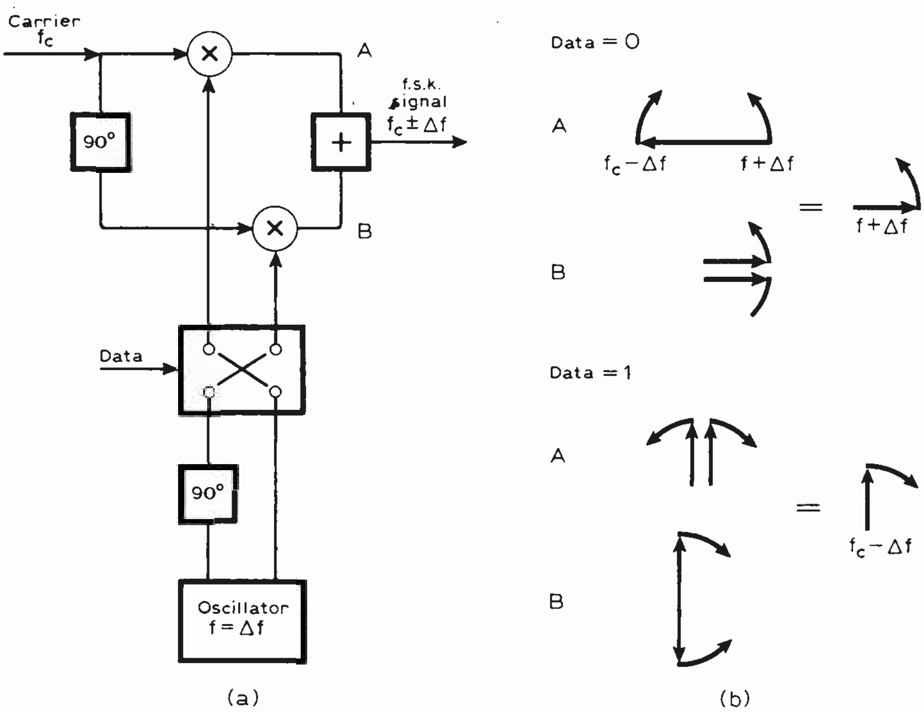


Fig. 3. An f.s.k. modulator using sideband cancellation.

Frequency and phase modulators

Two common forms of frequency modulator are shown in Fig. 1. In (a) the data simply selects one of several available frequencies which are each continuously generated. The arrangement has disadvantages for radio links at high r.f. If the frequencies are generated directly at r.f., high-stability crystal oscillators will be required and it will therefore be difficult to alter the channel frequency. If the frequencies are generated at a fixed intermediate frequency then a frequency translation process is necessary which can lead to difficulties if low spurious levels are required. Another disadvantage of this arrangement is that the transition in frequency is abrupt, resulting in a wide output spectrum.

Arrangement (b) offers a solution to these problems. A voltage-controlled oscillator is used to generate the instantaneous frequency demanded by bandlimited data. Although bandlimiting the data does not produce an equally bandlimited f.s.k. signal it does result in a significant narrowing of the output spectrum. The oscillator can be designed to operate directly at the transmission frequency and this transmission frequency "channel" can readily be altered over a wide band. However, there are difficulties since the oscillator sensitivity, in kHz/volt, will depend on the part of the band in which the oscillator is being operated. It is also a problem to achieve a "carrier" frequency directly at r.f. with sufficient stability.

In Fig. 2. (a) the voltage-controlled oscillator of the previous modulator has been included in a phase-locked frequency-control loop. The output frequency of the v.c.o. is phase compared against a reference and an "averaged" correction voltage generated. In this way the "carrier" frequency can be accurately controlled. The low-pass filter prevents the loop responding to the variation in frequency due to the modulation. However, if the data produces long sequences of the same frequency deviation the loop will eventually cancel this frequency offset. This can be a problem in some circumstances.

The modulator in Fig. 2 (b) shows an extension of that in (a) in which the phase comparator is run at a frequency substantially lower than the "carrier" frequency. A variable divider is used to bring the "carrier" down to the reference frequency. By simply varying the division ratio the carrier frequency can be altered. Also, in some situations the division ratio can be altered by the data so that repeated message frequency offsets are not cancelled by the loop correction action.

Fig. 3. shows an interesting form of f.s.k. modulator which employs the sideband cancellation techniques used in some single-sideband modulators. The "carrier" is generated independently of the modulator and this can be a useful feature. The required frequency deviation of $\pm f$ is generated at low frequency and hence can be accurately defined. Two balanced modulators are used and these are fed with signals which are identical apart from the phasing. The data switches the low frequency signals, f, between the two mixers. With a data 0 the balanced modulators produce double-sideband suppressed-carrier signals and the phasing of the f signals is such that simple addition results in a cancellation of $f_c - f$, leaving a signal $f_c + f$. Similarly, with a data 1 and the f signals exchanged between modulators an output signal of $f_c - f$ is generated.

This form of modulator is very suitable for generating accurate frequency deviations directly at carrier frequencies and operating over a wide bandwidth. The lack of perfect rejections of the carrier and the "unwanted" sideband is not as severe a problem as it is in s.s.b. situations. This is because the modulator output spectrum is symmetric about the carrier, since the data causes the frequency to hop between + and − f about the carrier. It is not necessary to generate a radiation-free band on one side of the carrier as in s.s.b.

Fig. 4 shows a more general form of the previous modulator. The two balanced modulators are fed as before with quadrature-phased carrier signals. Depending on the sign and magnitude of their "baseband" input signals the output signal phase can be controlled.

By choice of suitable baseband signals the resultant output can be a constant-amplitude signal whose phase can be altered by altering the baseband signals. To achieve this the amplitude of the two baseband signals must be sine/cosine related. A versatile sine/cosine function generator for this type of modulator is shown in Fig. 5. The multistage ring counter has the ability to circulate a logic 0 backward or forwards round the ring at a rate determined by the clocking frequency. Each stage in the ring produces a weighted output when the logic 0 is in it.

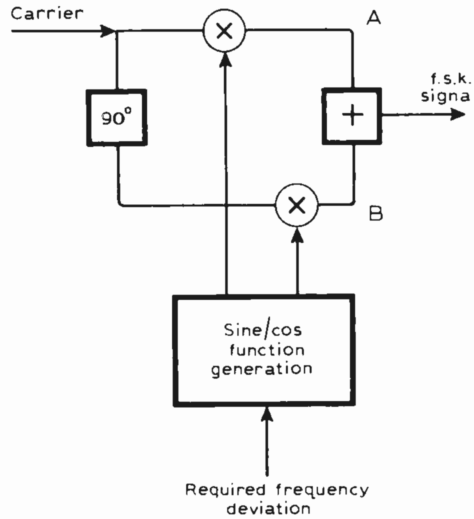
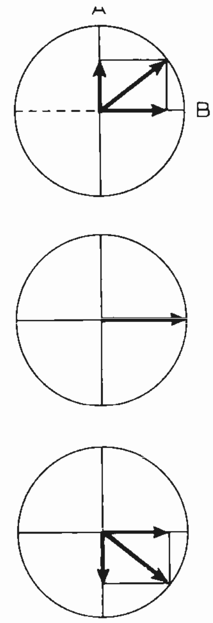


Fig. 4. General form of the modulator shown in Fig. 3.



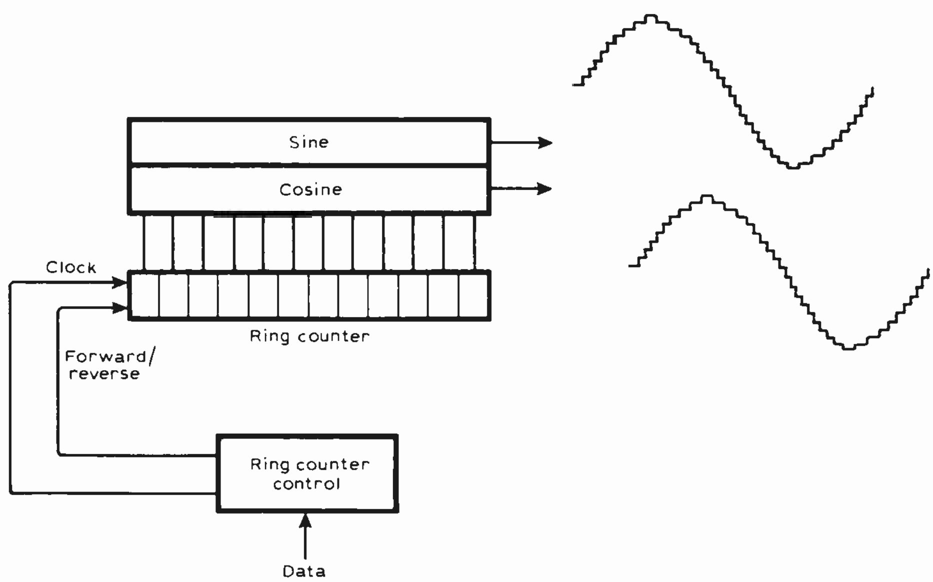


Fig. 5. Sine/cosine generator for the modulator of Fig. 4.

The number of stages and the weightings are chosen such that if the ring is clocked regularly in one direction the output of the "sine" weighted circuits produces a synthesised sinewave of the form shown. By connecting a similar set of weighted circuits to the ring but rotated several stages round the ring a "cosine" output is achieved. Therefore, however the ring is clocked the instantaneous amplitude of the two outputs will always be sine/cosine related. To produce a suitably modulated wave the data selects the appropriate counter direction and clocking rate. The two "baseband" signals produced are fed to the two balanced modulators of the previous circuit to generate the appropriate frequency deviation of the carrier. Shaping of the frequency transitions and multiple level deviation are readily achieved simply by operating on the counter clocking frequency.

This form of modulator provides accurate control of a "carrier" phase and this has been used to produce f.s.k. signals. It is of course also a modulator very suited to phase modulation. As in f.s.k. applications, it is possible to generate "multilevel" signals and spectrum control can be achieved by time-domain shaping of the phase transitions. However, as in the case of time-shaped frequency transitions the output spectrum cannot be strictly bandlimited by this technique. This form of modulator therefore produces p.s.k. type modulation.

Strictly bandlimited phase modulated signals of the p.e.k. type can be generated by the methods shown in Fig. 6, in which a binary modulator is shown at (a). The balanced modulator produces two possible output phases, 180° different, depending on the sign of its baseband input. The balanced modulator provides a linear modulation action and, if fed with bandlimited baseband signals, will produce strictly bandlimited output signals. The binary data is therefore bandlimited, producing changes in amplitude which occur

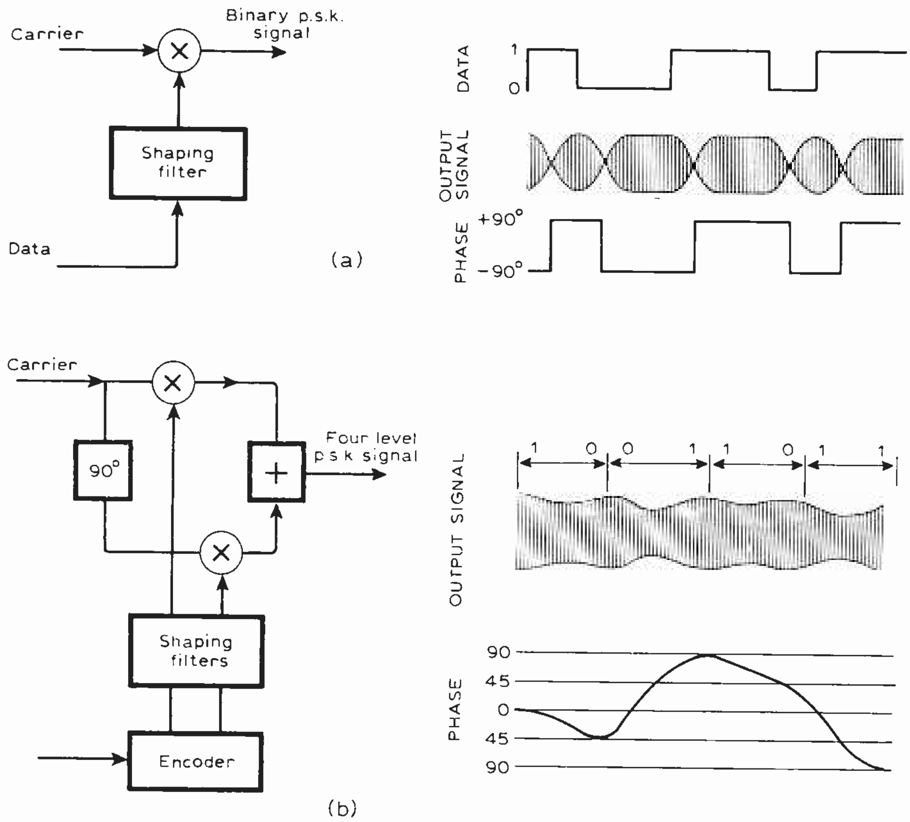
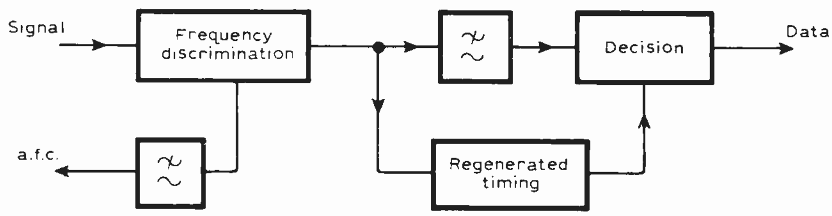


Fig. 6. Binary p.e.k. modulator ▲ producing band-limited output signals is shown at (a) while (b) shows a four-level p.e.k. modulator.

Fig. 7. F.s.k. demodulator, with strobing to achieve increased noise-immunity. ▼



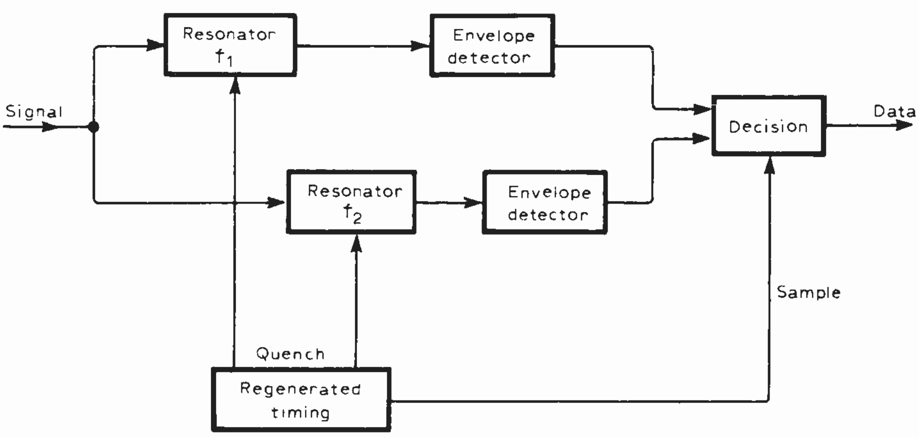
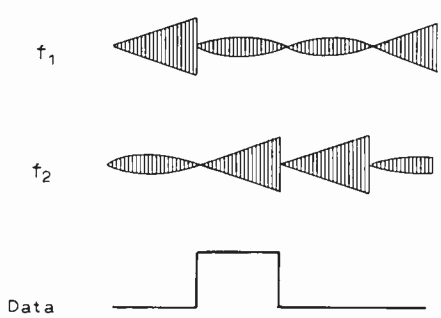


Fig. 8. Quenched-resonator type of f.s.k. demodulator.



slowly and take about one digit period to change from 0 to 1 or vice-versa. As a result of this, the output amplitude of the balanced modulator will vary as shown. It can be seen that in this case bandlimiting the signal results in abrupt phase transitions occurring when the signal amplitude is zero.

The combination of amplitude and phase variations is a characteristic of very narrow band angle modulation.

A modulator for bandlimited four-level p.e.k. is shown at (b). The r.f. portion of the modulator is in the form used in the f.s.k. modulator shown in Fig. 4. It provides the ability to vary the phase of the "carrier". However, in this case the baseband signals do not originate in a sine/cosine function generator. Instead, the data is first arranged in pairs, each pair of digits forming a symbol which is associated with one shift in phase. The required phase is produced by suitable amplitude signals at the two baseband inputs. These are generated in the encoder as abrupt amplitude changes at the start of each symbol. The signals are then passed through bandlimiting filters before reaching the modulators, to produce a bandlimited r.f. output signal. However, since the two baseband signal amplitudes are not always instantaneously sine/cosine related, the output amplitude will vary depending on the message content. The illustration shown is for a form of p.e.k. called symmetric differential p.e.k.

Demodulators

Demodulation in radio equipment is usually carried out at some convenient intermediate frequency. Filtering of the signal may be carried out before or in the demodulator. The filtering referred to here is the narrow band filtering designed to optimise the link noise performance. Wider filtering of the type occurring in r.f. stages does not usually affect link noise performance. In the following demodulators, where filtering is not shown it is assumed that optimum filtering is carried out before the demodulators.

One form of f.s.k. demodulator is seen in Fig. 7. The frequency discriminator generates baseband signals from the frequency modulated input and may be any of the types frequently used in analogue systems such as the Foster-Seeley or pulse counter circuits.

In order to achieve the lowest error rate in regenerating the data, it is essential to sample the baseband signal, with its noise, at a time in each symbol when the instantaneous signal-to-noise ratio has reached a maximum. To achieve this a timing regeneration circuit is required. This is normally some form of very narrow band filter tuned to the symbol rate. Because of its narrow bandwidth it is able to regenerate fairly steady symbol timing even at very poor signal to noise ratios. All the following demodulators use regenerated timing to strobe the decision circuits which produce the data output.

Fig. 8(a) shows an f.s.k. demodulator which employs quenched resonators for detection. The resonators are tuned circuits having very high Q, approaching infinity, and are often LC circuits employing Q multipliers. One resonator is provided for each of the frequency possibilities. These frequencies are usually chosen such that when the output from the required resonator is a maximum, the output from all others is zero.

The operation of the demodulator is illustrated in Fig. 8(b). During the first symbol the received frequency is f_1 and the f_1 resonator integrates the received signal during symbol period. The f_2 resonator also responds to the signal; the fact that it has infinite Q and is not tuned to f_1 does not prevent this. However if suitable frequencies are used its output will be zero at the end of the symbol period. The resonator outputs are envelope detected and sampled to regenerate the data. The resonators are then quenched, that is all stored energy is dumped, and the process repeated on the second symbol.

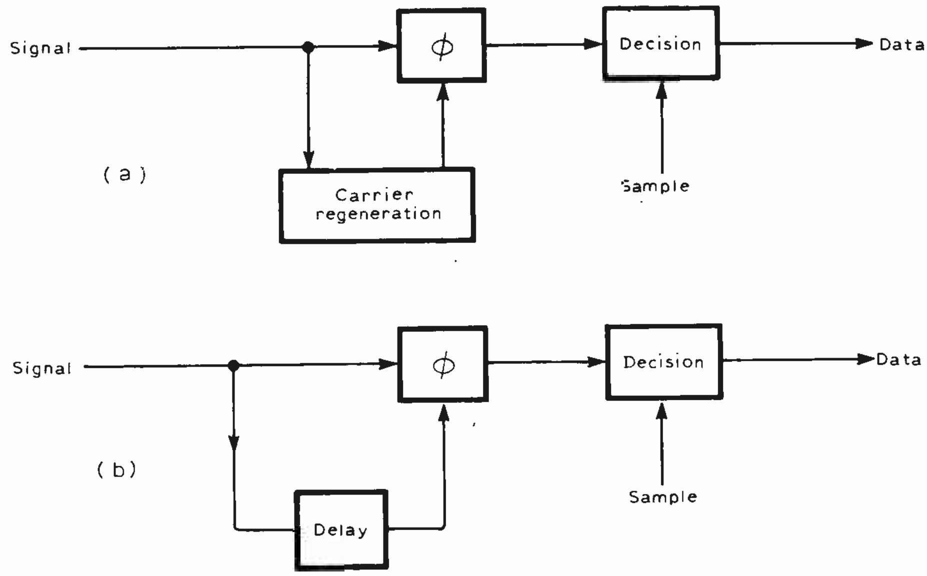


Fig. 9. Coherent (a) and differential (b) binary phase demodulators.

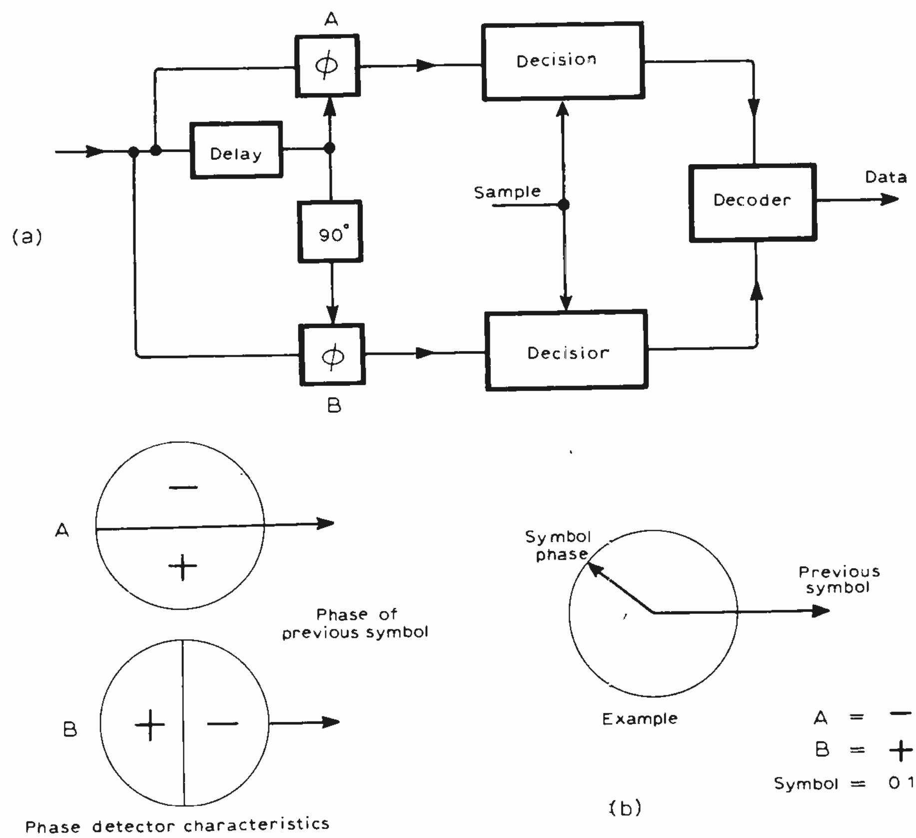


Fig. 10. Demodulator for symmetrical differential phase modulation.

Coherent and differential binary phase demodulators are shown in Fig. 9.

In a coherent demodulator the unmodulated carrier phase is regenerated from the received signal. There are several ways of doing, this, most of which employ very narrow band filters tuned to the carrier (as it appears at i.f.). The regenerated carrier and the signal are compared in a phase comparator. This may be a balanced modulator (or some other device providing a multiplication operation) with a low pass filter on the output. The phase difference between the regenerated carrier and the signal is then sampled in a decision circuit to produce the data.

In a differential demodulator the process is identical except that the regenerated carrier is replaced by a delayed version of the modulated signal. This is usually obtained by a delay line of delay time equal to one symbol period. The phase comparator output is therefore a measure of the phase difference between two adjacent symbols. As before the data is regenerated by sampling this phase measurement every symbol.

For four level differential phase modulation, the form of demodulator shown in Fig. 10 can be used. The circuit shown is specifically for the "symmetrical" type of differential phase modulation. Each symbol will be different from the preceding one by either ±45° or ±135°. The delay and top half of the circuit form a differential detector identical to that in Fig. 9(b). The detection criteria for it can be represented as shown in Fig. 10(b). Phase changes between symbols which fall between 0 and ±90° generate negative phase detector outputs and are read as 0. Changes of 180°±90° generate positive outputs and are read as 1. The lower half of the circuit is similar to the top, apart from the 90° rotation of the delayed signal. This causes a 90° rotation of the decision thresholds of that channel as indicated in Fig. 10(b). The combination of these two decisions in each symbol provides the information to produce the single stream of regenerated data. The delays used in this demodulator have to provide very accurate time delay of i.f. signals. A small time error here produces a large phase error at the phase comparator. Where long symbols are used, that is greater than about 100μs, the accuracy requires the use of expensive quartz delay crystals. It may in fact be impossible to get suitable accuracy.

Fig. 11 shows a very simplified representation of another form of demodulator which does not employ an i.f. delay line. This employs a non-phase-locked i.f. reference to make the phase measurement. Two baseband signals are generated by phase detectors fed with quadrature-related references. At the end of symbol 1 the two baseband signals are sampled to give an instantaneous measure of the signal phase with respect to the reference. The angle is handled in two parts. One is an entirely digital number defining the angle quadrant: as shown it is '0 0'. The

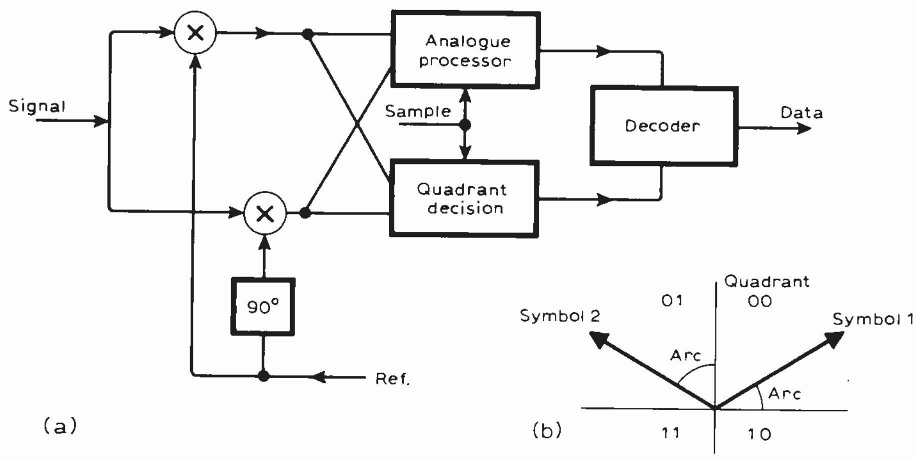


Fig. 11. A further type of demodulator not using a delay line.

other is an analogue signal representing the arc angle within the quadrant. This information is stored for one symbol period, at the end of which the baseband signals are again sampled. The difference between the old and new quadrant number, modified by the change in arc angle, gives the change in angle and hence the required output data.

The virtue of this form of demodulator over the type using a delay line is that it is substantially cheaper. The detailed processing, which I have not detailed here, involves mostly digital circuitry which, when integrated circuits are used, is extremely cheap.

The second part of this article will compare performances of various modulation systems, including aspects such as noise performance, spectrum occupancy and sensitivity to equipment design tolerances.

Surround-sound broadcast

The Radio Clyde experiment in surround-sound reported in our September issue (page 46) was "a little disappointing", as far as off-air listening in the quadraphonic mode was concerned, according to John Lumsden, chief engineer of the commercial station. "But in view of the separation quoted for QS and other systems, it is not surprising — something for nothing being impossible to achieve" he adds. Off-air stereo monitoring, in the absence of a direct comparison, was difficult but "our impressions were that the compatibility was more than satisfactory. This was borne out by the general consensus of opinion from my colleagues and the listeners themselves". As recorded in our September note, off-air mono "provided the biggest surprise in as much as subjective mono compatibility seemed to be better than the normally achieved during normal stereo." The live performance, as monitored from the four microphone channels, "was excellent and considerable realism was noted due to the additional dimension. The impression of the actual shape of the Kelvin Hall and the audience location was also evident."

The experiment necessitated the use of Post Office lines to link the signals from an outside broadcast vehicle to Radio Clyde. "Here lay our first obstacle: although the Post Office supply good music-quality circuits, they at present do not supply stereo circuits, i.e. circuits which are phase equalized." But they can sometimes supply co-routed circuits and usually good phase compatability results. "We obviously required four circuits and the Post Office were very helpful indeed and supplied the circuits co-routed." In spite of this, phase non-compatability existed between the front and rear pairs, and had to be eliminated with phase-corrector circuits.

During the initial listening, mike problems were evident. To achieve good stereo, the mike arrangement (four AKG414's) was moved closer to the orchestra than normal. "This resulted in poorer quad, since the rear mikes picked up a larger ration of the direct orchestra sound than the acoustical reverberant sound. To hold the front pair 'tight' and achieve a good separation on the rear pair, a system of baffling was employed between front and rear, and also between the two mikes making up the rear pair. This was built of dense chipboard and covered with thick rubber-backed carpet in an effort to reduce the reflection at mid frequencies. The arrangement worked well and no phasing effects of the mid frequencies were evident."

"The broadcasts were undoubtedly a success" concludes Mr Lumsden. "However, in quad, we seemed to suffer from an impairment of the signal-to-noise ratio. This was manifest in the rear speakers when facing forward and in the front speakers when facing rearward. It would therefore appear that the human ear is more sensitive, or less tolerant, to noise (hiss) from the rear. Unfortunately, the problem is aggravated further by the generally lower signal level from the rear speakers. The problem might not have been so evident had the "surround" mode been used rather than the "hall" mode.

Radio Clyde would like to continue these experiments and hope that in the near future, with I.B.A. and Home Office approval, "we will be able to broadcast 'surround' mode pop quadrophonics."

Announcements

The Association of Public Address Engineers has organised four exhibitions for November, one each in Bristol, Gateshead, Leeds and Renfrew. The Bristol exhibition will be held at the Unicorn Hotel on the 23rd, that at Gateshead at the Five Bridges Hotel on the 18th, that at Leeds at the Windmill hotel on the 25th, and the Renfrew exhibition will be held at the Normandy Hotel on the 16th. The joint title of the exhibitions, which will be open from 10 a.m. to 6 p.m. on those days and for which admission will be free, is "Circuit 76." The organisers say visitors will be able to see traffic control and crime detection equipment, closed circuit television services, electronic timing devices and scoreboards for sporting events as well as sound reinforcement, internal communication and other sound equipment.

The electronics component show will be held at Olympia from May 17 to 20, 1977. The organisers note that lower cost bench displays without stands, on offer at £200 each for the first time, have not sold well, even though the innovation was suggested by exhibitors at the last show.

The 1977 Audio Fair will be held at Olympia from September 12 to 18.

The inaugural journey of British Rail's high speed train at the end of September should also have been the occasion of the first live television transmission from a moving train. Protracted negotiations between ASLED, the locomen's union, and the British Rail Board, however, meant that the final go-ahead for the service took place too late for arrangements to be made between British Rail, the Post Office and the BBC. The broadcast will now wait until another time, possibly when the London to Edinburgh Route opens in 1978.

In our September issue on page 45 we showed a photograph of the Miranda mobile microwave intercept system. We omitted to say that this was designed at Mullard Research Laboratories and is now being developed by MEL Equipment Co Ltd.

Weather-satellite picture facsimile machine

Hard-copy cloud cover pictures from APT, SR and WEFAX transmissions

by G. R. Kennedy

In order to produce permanent pictures of weather-satellite-viewed cloud cover without the aid of a professional facsimile machine, some form of photography must be used. Photographs taken from an oscilloscope screen have poor definitions because the spot size is relatively large compared with the total screen diameter. Screen persistence, dispersion and refraction within the glass face also reduce the definition. If a large television type c.r.t., having a smaller spot size and larger dynamic range of phosphor than an oscilloscope tube, is used the definition will be better but the picture edges will be distorted.

This means that, for example, successive ATS-3 Mercator projection maps cannot be mated together due to the curved edges of the map grids. A light-sensitive rotating drum facsimile machine does not suffer from these particular drawbacks because there is no glass layer between the picture and the photograph, no phosphor problems and the picture linearity is good. This electro-photomechanical device is not ideal: it requires fine engineering to build it, needs a dark-room environment in its simplest form and, if bought commercially, is very expensive. A scanning galvanometer facsimile machine is generally a better device but beyond the engineering skills of most electronic workshops.

The machine described here is a basic design specifically for producing APT pictures from ESSA-8, whilst still transmitting, SR pictures from the NOAA satellites in the ITOS series and from the Russian METEOR satellites, and WEFAX computer-derived weather maps and orbital written data from ATS-3 and the SMS/GOES series. It is manually controlled, no attempt having

The author
Gerry Kennedy is a Higher Scientific Officer with the Science Research Council at the Appleton Laboratory, Chilbolton Observatory. His private project (ref. 4) was started in the Falkland Islands with Nimbus 3 ice cover pictures. This work was continued on his return to the UK to encompass more recent satellites. He is a radio amateur with the call signs VP8LZ and G3OGK.

This article describes a prototype rotating drum facsimile machine for producing weather satellite automatic picture transmission (APT), scanning radiometer (SR) and weather facsimile (WEFAX) transmission pictures. With the dimensions given in the text, prints approximately 22cm square, with a line width of 0.25mm, can be produced, of sufficient quality for meteorological work. Three magnifications are available for SR pictures by simple switching. All electronics are solid state with the exception of the light source, which is a cold-cathode device. The article offers a basic design for further developments and should be read in conjunction with a previous article entitled "Weather Satellite's Ground Station" published in *Wireless World* November, December 1974, January 1975.

been made to automate the processes. Nevertheless, considerable effort was needed to produce a reliable machine with a modest budget in mind.

The principle of a rotating drum facsimile machine is not new: for many years the world's press agencies have used radio and wire drum picture printers and, more recently, amateur machines using valve circuitry have been described[1,2,3].

The older press "wire photo" receivers used heat or pressure sensitive paper but amateur and general service machines and the newer press machines use photographic materials. The machine described here uses fast-bromide enlarging paper which can be handled and used in a reasonably bright red safelight. Cut film can be used, but this adds the problem of working in total darkness to produce a picture.

The picture is produced as illustrated in Fig. 1. A sheet of photosensitive paper is wrapped around a drum which can be rotated by a motor. A light source is mounted on a traverse platform together with a lens arrangement to focus a light beam onto the paper. The platform is driven slowly along parallel to the rotating drum axis so that the spot of light describes a fine helix on the paper. The light beam is made brighter or dimmer by a modulating signal waveform such that when the paper is removed from the drum and developed, it has a picture on it made up of fine

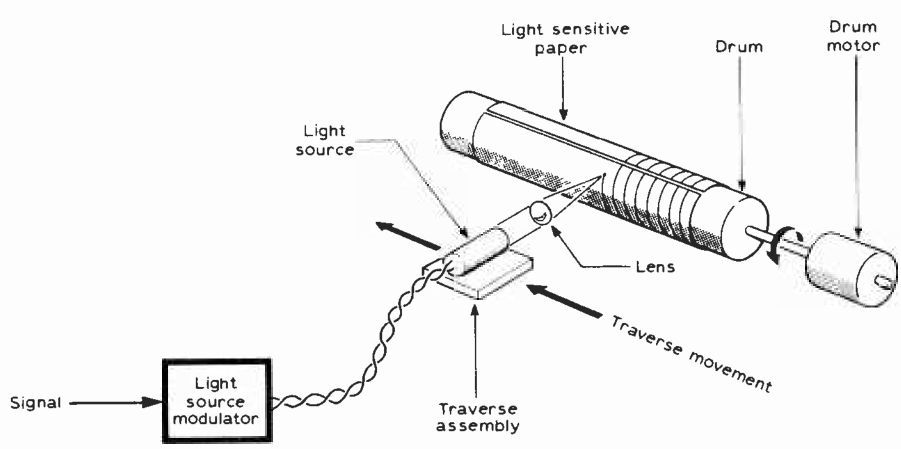


Fig. 1. Cloud cover picture production. This principle requires dark-room (red light) conditions. Traverse, drum rotation and modulation are synchronized to weather satellite transmissions.

lines, dark or light according to the original scene; the lines being very slightly off-square relative to the edge of the picture, but all parallel to each other. The drum motor, traverse drive and modulating signal are all synchronised. If the picture is to be produced in real time, the drum rotation speed should be identical to the line rate of the original picture. The light-source luminous flux, drum rotation speed, drum diameter and paper sensitivity or photographic "speed" are all interdependent. Also, the writing speed of the beam must be sufficient to cause an effect on the paper at whatever rate it happens to be travelling along the paper surface. Further constraints on the system are that the traverse must move smoothly without sticking, that the drum motor responds rapidly without overshoot to synchronising signal rate changes, and that the drum mass is large enough to give some flywheel effect to prevent bearing chatter showing on the print, yet small enough to allow the drum motor to change speed rapidly. In addition the drum must be of constant diameter to prevent de-focusing of the spot of light. The most stringent requirement is that the light source must be capable of being modulated at the input signal rate. Lastly, the paper must be held firmly on the drum to avoid focus variations, yet must be removable without damage for processing.

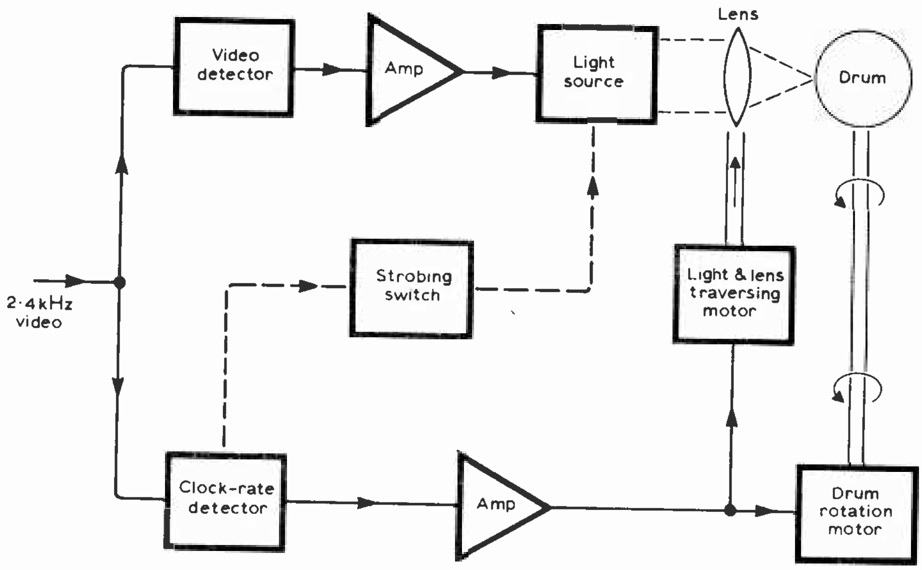


Fig. 2. Basic block diagram of machine.

Block diagrams

Fig. 2 shows the basic block diagram for the machine. The 2.4kHz video input signal, which may be taken directly from the receiver or from a tape recording, is applied to both a video detector and a clock-rate detector. The output signal from the video-detector is amplified and used to modulate a light source, while the clock signal is used to produce a gating or strobe waveform, which turns the light source on and off when SR pictures are being produced, and to drive the drum and traverse motors synchronously.

Fig. 3 shows the complete block diagram for the machine. The input signal is split after the input potentiometer into signals for deriving the clock rate, for detecting the video, and optionally for auto-starting ESSA-type APT pictures. The clock chain comprises a limiter/filter, a phase-lock loop and an output buffer. The voltage controlled oscillator (v.c.o.) signal from the phase-lock loop is used as the clock signal and is buffered out by a Schmitt trigger. This part of the system is not critical and a zero-crossing detector or Wien bridge, followed by a gate or an

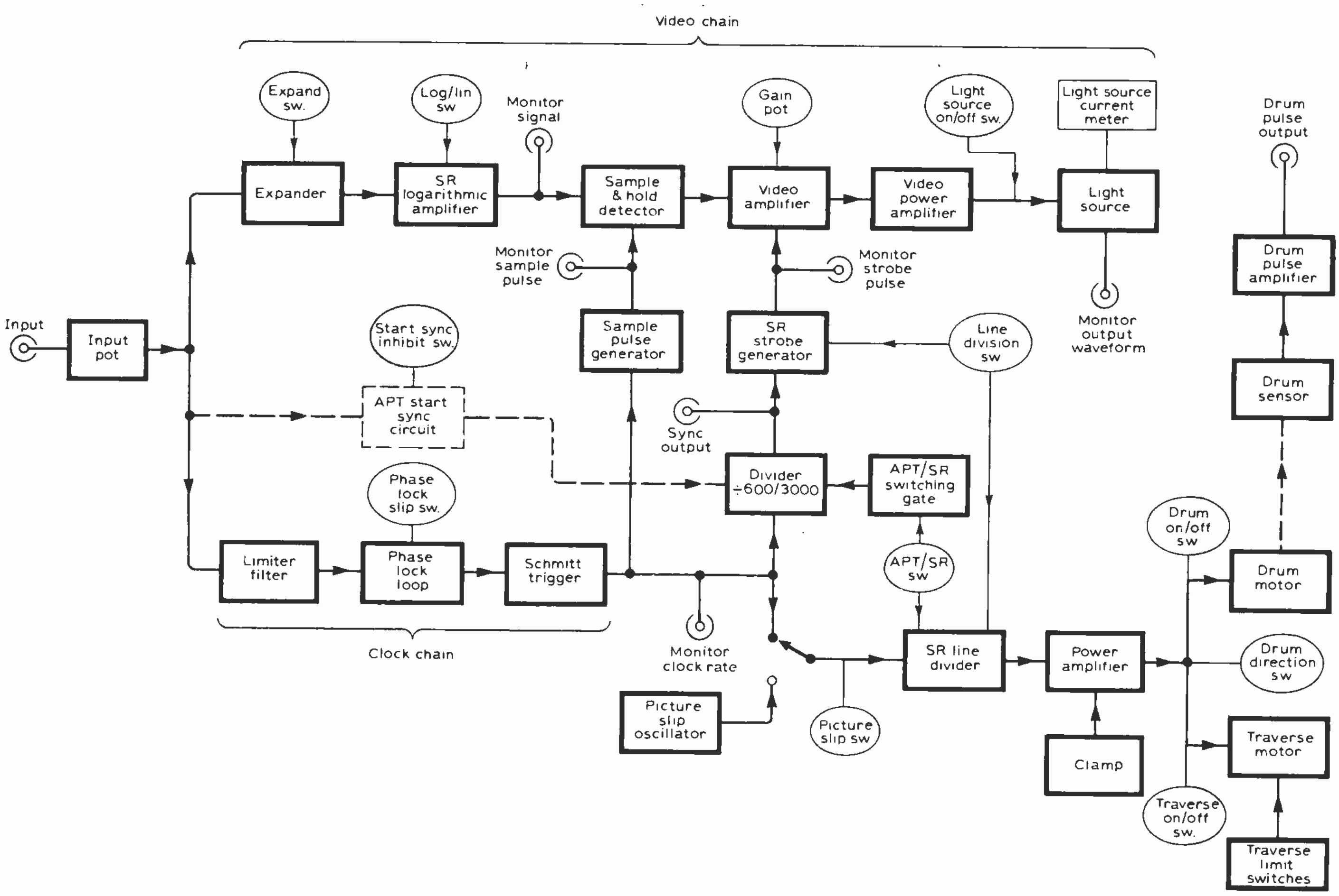


Fig. 3. Detailed block diagram of machine.

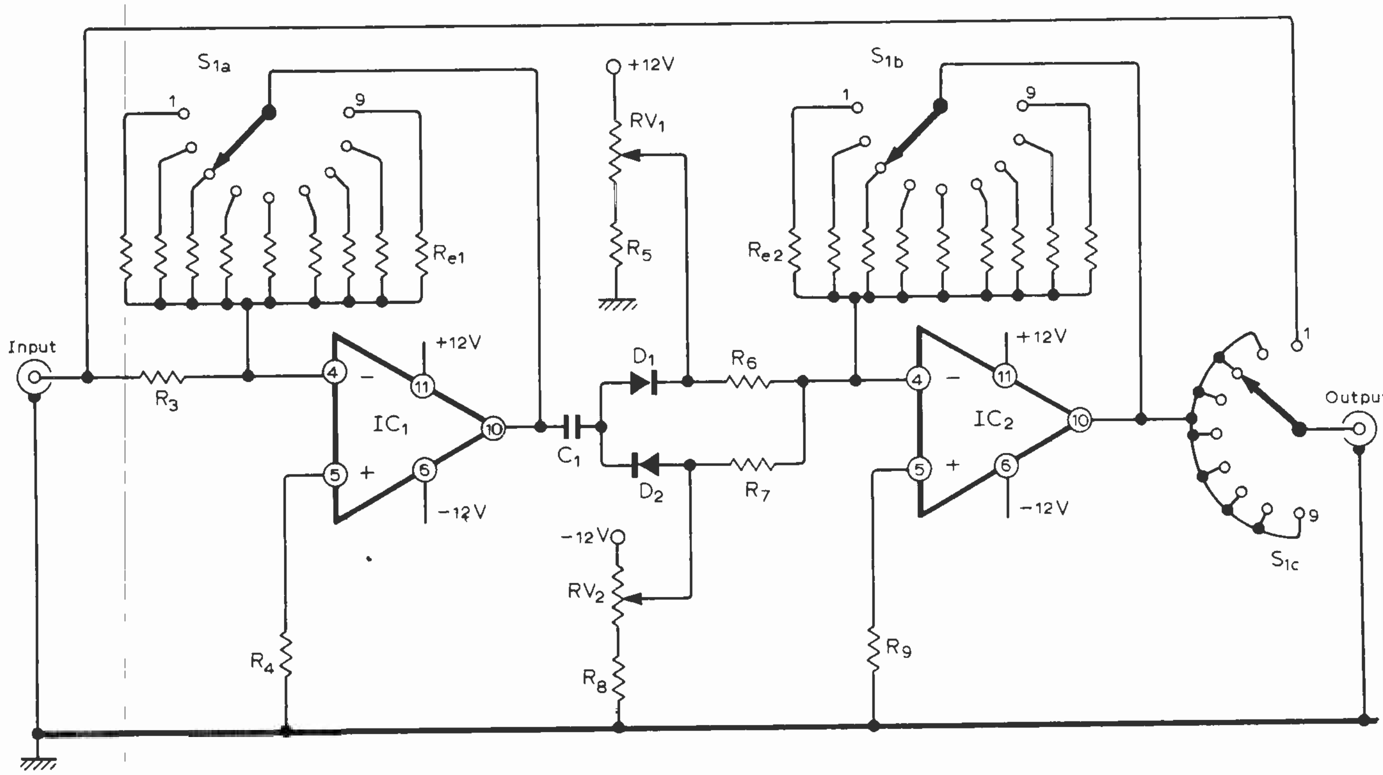


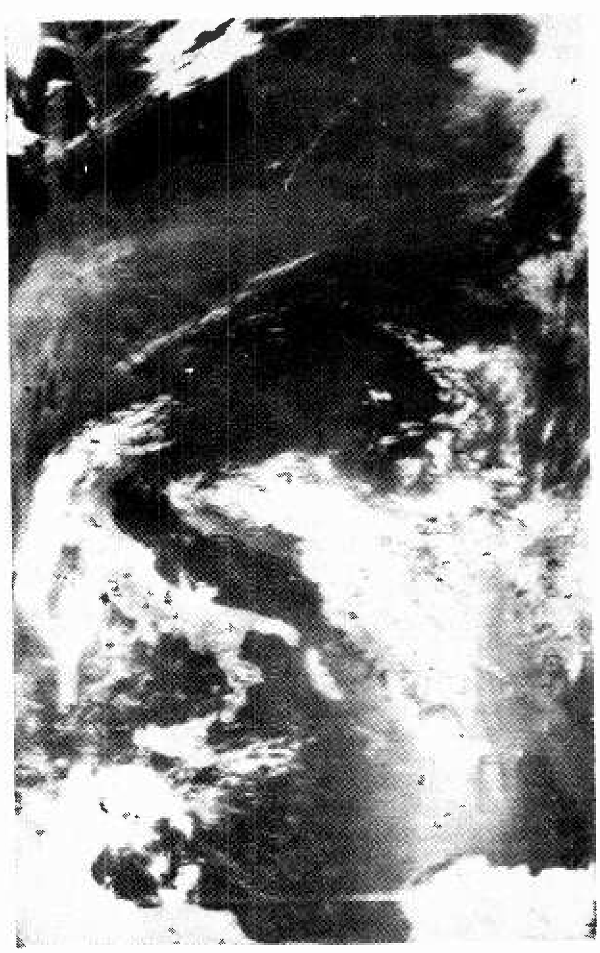
Fig. 4. SR expander.

emitter follower, could be used. The clock signal, which has a square waveform phase-locked to the satellite sub-carrier frequency, is divided to produce a sync signal to trigger the strobe generator. This sync signal may also be used externally. Pulses from the strobe generator, which can be disabled and monitored externally, switch an amplifier in the video chain on or off.

The video chain comprises a contrast expander, a logarithmic amplifier, which is used mainly for SR pictures and can be bypassed, a sample-and-hold detector, the strobe pulse controlled amplifier, which is solely for SR pictures, and a power amplifier which drives the light source. The sampling pulse for the detector is derived by the pulse generator from the clock-rate signal, which is also divided and amplified by a protected power amplifier to give the drum and traverse motor a.c. supply at one of three frequencies determined by the line divider. This is used in producing SR pictures of various magnifications corresponding to 1/3, 1/4 or 1/5th of a complete line width. The drum can also be run from a separate oscillator, for picture edge positioning, and its rotation sensed by a magnetic transducer and amplified to give an externally-available drum position pulse.

Circuit details

Some of the circuits used in this machine were described in a previous article[4] and the reader is referred to this for details of the clock-rate, start sync, divider and APT/SR switching circuitry. (Experience has shown that, in Fig. 23b of this article, C_{93} in the clock phase-lock loop should be switchable in steps of 0.1, 1.0 and 3.3μF Mylar to accommodate both live and tape-recorded signals). The **expander** is the same as the Baylis and Brush contrast expansion processor described in their paper[5], but the feedback resistor values have been altered to utilize standard values. After SR signals have been expanded it is advantageous to compress the white portion while allowing the darker levels to be fully expanded. This is done by the **logarithmic amplifier** (see ref. 6 and Fig. 5). Signals from the expander are full-wave rectified by the pi-connected bridge rectifier D_3, and applied to the operational amplifier IC_3.



Meteor 25 picture. *Visible light scanning-radiometer picture from the Russian Meteor 25 satellite 08.36Z on 28th June 1976, revolution 619 south to north path. Part of Sweden and all of Denmark can be seen in the north, with Italy, Sicily and the North African coast in the south. Note the sun glinting off the sea near Greece. Satellite was at a height of approximately 900 kilometres (560 miles).*

Components list

Resistors (¼W 20% unless otherwise stated).

3	10k		
4	10k	38	100k
5	220	39	1k 1W
6	22k	40	1k
7	22k	41	1k
8	220	42	10k
9	10k	43	100
10	3.3k	44	820
11	3.9k	45	3.9k
12	15k	46	220
13	10k	47	1k
14	15k	48	1k
15	1k	49	390
16	2.2k	50	220
17	15k	51	12k
18	15k	52	470
19	22k	53	4.7k
20	15k	54	4.7k
21	4.7k	55	47k
22	47k	56	47k
23	15k	57	1k
24	1k	58	100k
25	8.2k	59	82k
26	47	60	4.7k
27	100k	61	100k
28	5.6k	62	10k
29	8.2k	63	4.7k
30	10k	64	1M
31	470	65	1k
32	47k	66	100
33	100	67	5.6k 1W
34	4.7k	68	1k
35	100	69	15k
36	10	70	1k
37	10	71	150 1W

Variable resistors (all 10-turn presets unless otherwise stated)

1	1k	—any preset
2	1k	—any preset
3	25k	
4	50k	
5	50k	
6	50	—10-turn wirewound
7	25k	(with turns counting
8	5k	dial)
9	1k	
10	1k	
11	10k	—wirewound
12	10k	—any preset
13	25k	
14	25k	
15	25k	

Integrated circuits

1	SN72741N	12	SN7490N
2	SN72741N	13	SN7492N
3	SN72741L	14	
4	SN72741L	15	
5	SN72741L	16	J-K flip-flops
6	SN74121N	17	(See text)
7	SN74121N	18	"
8	NE562B	19	"
9	SN7492N	20	"
10	SN7490N	21	SN7413N (½)
11	SN7490N	22	SN74121N

Capacitors (μF unless otherwise stated)

1	2.2 Mylar	19	0.015+680p
2	0.1	20	0.068
3	0.01	21	0.01
4	680p	22	0.47
5	330p	23	1.0 Mylar
6	0.15	24	80/25V
7	0.033	25	100/50V
8	0.001	26	6.8 Mylar
9	0.05	27	See text
10	100/12V	28	25/25V
11	50/50V	29	2/25V
12	0.1	30	0.01
13	0.05	31	2/25V
14	0.001	32	4700p
15	100/12V	33	100/25V
16	0.068	34	0.22
17	0.47	35	11 Mylar
18	0.068	36	100/25V

Inductors

1 V.h.f. choke: 10μH
2 Tape head 600Ω or similar

Switches

1 3 pole 9 way wafer
2 2 pole changeover toggle
3 2 pole 3 way wafer
4 1 pole make/break toggle
5 1 pole make/break toggle

Transformers

1 Mains 3V subminiature, RS Components Ltd
2 ILV-857, Mains 2 × 25V Gardners Transformers Ltd

Transistors

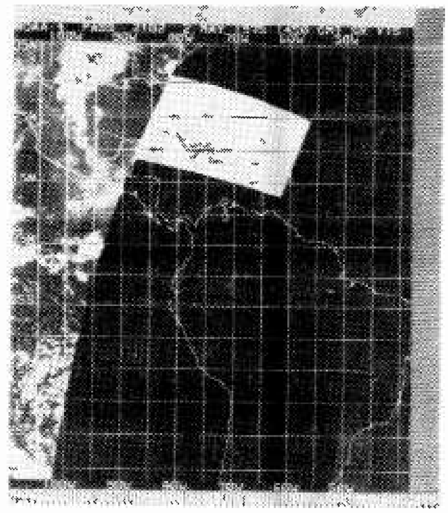
1	2N2333A	11	BFY51
2	2N3702	12	BFY51
3	2N3704	13	2N3704
4	2N3704	14	BFY51
5	2N3819	15	2N3055
6	BFY51	16	2N3055
7	BFY51	17	2N3704
8	BF258/BF259	18	2N3704
9	BU105	19	2N3704
10	2N3704		

Diodes

1	1N914	8	OA91/1N270
2	1N914	9	10V400mW zener
3	RS REC70 or similar	10	OA91/1N270
4	OA200	11	1N914
5	OA200	12	RS LED 3 or similar
6	OA200		
7	OA200	13	OA200
		14	5.1V400mW zener

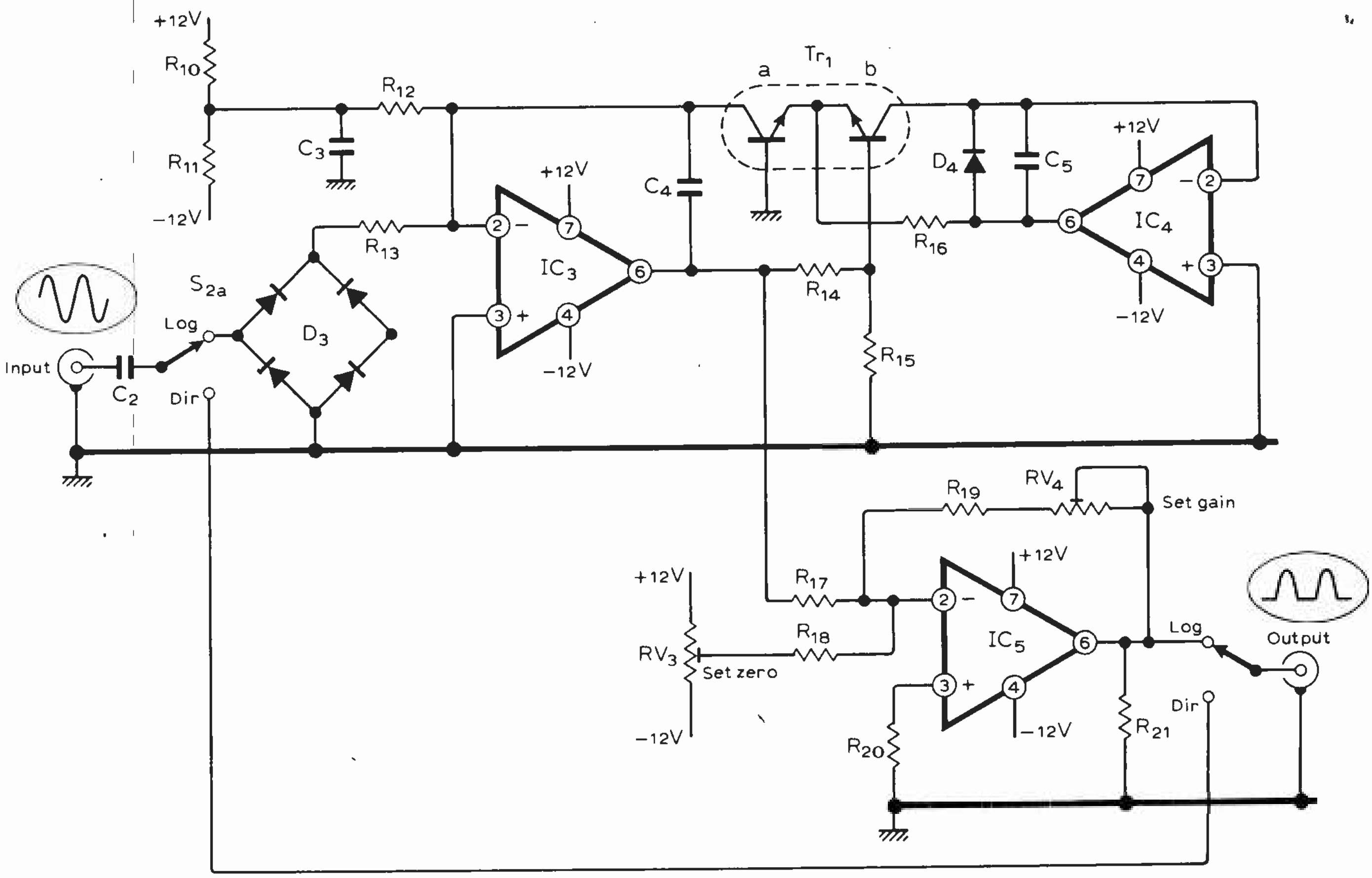
Expander feedback resistors

Switch position	Re_1	Re_2
1	82k	2.7k
2	82k	2.7k
3	56k	4.7k
4	47k	8.2k
5	33k	15k
6	33k	22k
7	27k	33k
8	27k	39k
9	27k	68k



ATS-3 picture. *Ground computer process chart of NOAA-4 scanning-radiometer visible data transmitted from the geosynchronous satellite ATS-3 when on station at 75 degrees west. Blank areas are where the computer has not received data in time for the scheduled broadcast from ATS-3 (black) or poor data was received (white). This print was obtained at 4 degrees elevation, slant range 41,000 kilometres (25,500 miles). Satellite has now drifted to 105 degrees west, out of sight from Great Britain.*

NOAA-4 picture. *Infra-red scanning radiometer picture from the NOAA-4 satellite, 19.25Z 21st November 1975 revolution 4647 south of north path. Typical 'milk bottle' distortion of unlinearized SR pictures can be seen here by the cloud alignment at the picture edges. Cold is white, warm is black. Norway, the Swedish lake, most of Great Britain and France can be seen. Note the white (cold) Alps and Pyrenees. The log detector and an unsteered omni antenna were used in reception.*



A static bias of +1.0V is derived from the potential divider R_{10}, R_{11} and summed with the video signal at the inverting input of the amplifier. Transistor Tr_{1a} is placed in the feedback line of IC_3. For small forward potentials, the base-emitter voltage characteristic of a transistor is the logarithm of the current, within certain constraints. One of these is temperature, so a second similar transistor, Tr_{1b}, feeds the logging transistor under similar thermal conditions, and maintains a temperature-corrected current into the logging transistor via operational amplifier IC_4. Diode D_4 prevents excessive drive to the transistors under transient conditions, and the potential divider R_{14}, R_{15} provides bias for Tr_{1b}. Although a dual transistor is shown on the circuit diagram, a pair of almost any n-p-n transistor type may be used. For the best temperature stability, the two transistors should be physically close and in the same thermal environment. For example, if two 2N3704 transistors are used they may conveniently be cemented together with epoxy. The accuracy of the logging process, which should have a dynamic range of 20dB or so using the circuit given, is set by the value of the bias voltage fed into IC_3. The small output voltage is amplified by operational amplifier IC_5, and the gain and zero level adjusted by preset pots RV_4 and RV_3 respectively. For linear video signal printing, the log amplifier is bypassed by switch S_2.

To be continued.

Fig. 5. Logarithmic amplifier.

References

1. Anderson W G, "Amateur Reception of Weather Satellite Picture Transmissions", *QST* Vol. 49 No. 11 Nov. 65 pp11-17.
2. McKnight C H, "Evolution of an Amateur Weather Satellite Picture Station", *QST* Vol. 52 No. 4 April 68 pp28-34.
3. Strong C L (ed), Ruperto E F, "The Amateur Scientist", *Sci American* Vol. 230 No. 1 Jan. 74 pp114-120.
4. Kennedy G R, "Weather Satellites Ground Station", *Wireless World* Nov. Dec. 74, Jan. 75.
5. Baylis P E, Brush R J H, "Contrast Expansion Processor", *Wireless World* Dec. 73 pp611-613.
6. Clayton G B, "Experiments with Operational Amplifiers – Part 7", *Wireless World* Jan. 73 pp33-35.
7. Kilvington J, "Circuit Ideas", *Wireless World* June 72 p275.
8. Benson F A, "Voltage Stabilisation", MacDonald, 65 pp18-23.
9. Brit. I. R.E., "Symposium on Cold Cathode Tubes", Cambridge, March 64.
10. White A D, "Cold Cathode Device", J.App.Phys. Vol. 30 No. 5 May 59.
11. Myers R F, "Factors Affecting the APT Picture Quality", Air Force Cambridge Laboratories AFCRL-68-0517, Instrumentation Papers No. 149, Office of Aerospace Research, United States Air Force, Oct. 68.
12. Nagle J J, "A Method of Converting the SMS/GOES WEFAX Frequency (1691 MHz) to the Existing APT/WEFAX Frequency (137MHz)", NOAA/NESS Office of System Engineering, Suitland, Maryland, April 74.
13. "Meteorological Fascimile Broadcasts", *WMO Publication* No. 9, Vol. D, Part F(2); World Meteorological Organisation, Palace des Nations, Geneva CH 1211, Switzerland.

Sixty Years Ago

Atomic clocks and digital data transmission were many years in the future in December, 1916. The simple operation of providing a time signal in the Panama Canal entailed transmission by cable from Washington to Key West, from where it was transmitted by wireless to Darien. The procedure at Darien, where the signal was transmitted by cable to port captains was as follows:

"The signal is sent from Key West in a series of dots. Five minutes before noon the wireless begins counting off the seconds by dots. After the twenty-eighth second there is a pause, the 29th dot being omitted; similarly there is a pause from the 54th to the 60th second. The count is resumed exactly on the minute. This procedure is kept up until 10 seconds before 12 o'clock, when there is a pause followed by a long dash at exactly 12 o'clock. The aerial transmission is recorded at Darien by a current too slight to permit ordinary relaying. Consequently an operator with a wireless receiver at his ears sends dots through an ordinary telegraph wire to the port captains. With practice he can strike the dots on his sending key in almost perfect synchronism with the dots received. The principal difficulty is in sending the final dash after a wait of 10 seconds. Here the tests show that the lag is between two-tenths and three-tenths of a second. By making allowance for this lag the chronometers in the Canal Zone can be adjusted to within about one-tenth of a second of the correct time.'

New Products

Switch modules

Spectradil is a range of single-throw laterally-operated dual-in-line module switches, available from Erg Components. The switches have arrow-shaped sliders, coloured in accordance with the international colour code, and are available in 2, 4, 6, 8 or 10-pole modules, from 5 to 25mm in length. Gold-plated spring-loaded wiping contacts are used, enabling the switches to be used for microvolt and low-power switching. Specifications claimed include a typical resistance of 10mΩ, with a repeatability of less than 1mΩ over several hundred operations, and a life of 10,000 operations at the full 10VA rating. Erg Industrial Corporation Limited, Luton Road, Dunstable, Bedfordshire, LU5 4LJ.

WW301 for further details

Packaged mixer

A low-cost double-balanced mixer, designed for r.f. signal processing applications, is packaged in a four-pin TO-5 can measuring only 0.3in high x 0.4in diameter. The M105 mixer, introduced by Merrimac Industries, is totally r.f. shielded and complies with MIL-STD-202, within an operating temperature range of −55 to +100°C, and the environmental specifications MIL-E-16400F Class 1 and MIL-E-5400L Class 2. The mean time-before-failure is rated at 650,000h for ground fixed equipment and 100,000h for airborne equipment (to MIL-HDBK-217B). Specifications include a frequency range from 1 to 500MHz, typical losses of 6dB from 1 to 200MHz and 7.5dB from 200 to 500MHz, minimum isolation 30 to 40dB at 1 to 50HMz and 18 to 25dB at 50 to 500MHz, a noise figure within ±1dB of the loss, and a maximum input power of 50mW. Merrimac Industries Inc., 41 Fairfield Place, West Caldwell, N.J. 07006, U.S.A.

WW302 for further details

Microwave sweep oscillator

The Model 554 is a compact sweep oscillator providing a power output of greater than 10mW c.w. over the frequency range 8.0 to 12.4GHz. Frequency limits of the sweep can be set to the nearest 10MHz by two digitally-calibrated and independent thumbwheel controls on the front panel. The sweep oscillator may be operated at fixed frequencies using the manual scan, or in slow single or fast automatic sweep modes, depending on the display used. An external voltage may be applied to the oscillator, via an external connector, to remotely control or phase lock the output frequency. The oscillator is YIG-tuned, features low noise (e.g. in the c.w. mode residual f.m. is typically 15kHz peak at 10kHz bandwidth, with filter) and provides an r.f. output of spectral purity. An isolator is fitted to avoid frequency pulling by output loading, and a low-pass filter is included to suppress harmonics. Flann Microwave Instruments Ltd, Dunmere Road, Bodmin, Cornwall, PL31 2QL.

WW303 for further details

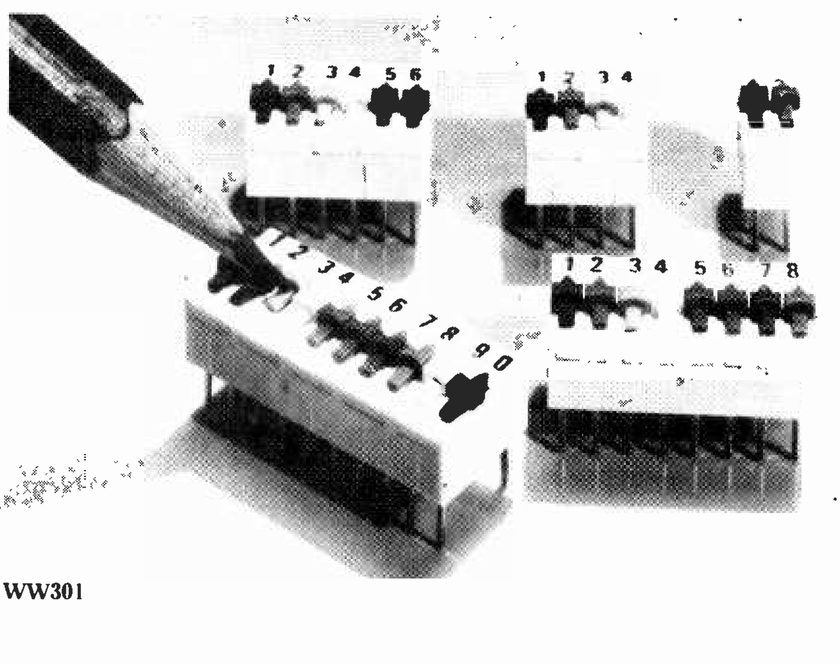
Toggle and rocker switches

Switches in the 7100 series, from Roxburgh Electronics, are designed for direct mounting to p.c.bs. The toggle and rocker switches have contact ratings of 0.4VA at 20V a.c. or d.c., maximum contact resistances of 10mΩ, minimum insulation resistances of 1000MΩ and dielectric strengths of 1000V r.m.s. Their contacts are made of gold on nickel-plated brass. Both single-pole double-throw and double-pole double-throw versions are available in these switches, which are designed to be vertically supported by means of separate brackets which extend parallel with the terminals. The terminals are also designed for direct soldering to the p.c.b. Five terminal lengths are available giving the switch a height ranging from 0.46in to 0.95in from the shoulder of the switch to the p.c.b. Roxburgh Electronics Limited, 22 Winchelsea Road, Rye, Sussex.

WW304 for further details

Op-amp power supply

A low-profile power supply module, designed for energizing operational amplifiers or other devices requiring a balanced dual rail supply, comprises a single printed circuit board assembly, carrying all the components, with a metal cover that also serves as the heatsink. The Weir op-amp power supply operates from an a.c. mains input in the voltage range 100 to 130 or 200 to 260V and delivers a balanced d.c. output which is adjustable over the range ±12 to ±15V by means of a preset control. Maximum load current is 250mA on each rail, with both load and line regulation better than 0.02%. For accurate load voltage stabilization, provision is made for external voltage sensing with sense-lead lengths up to 1



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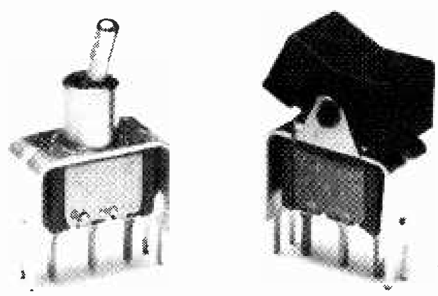

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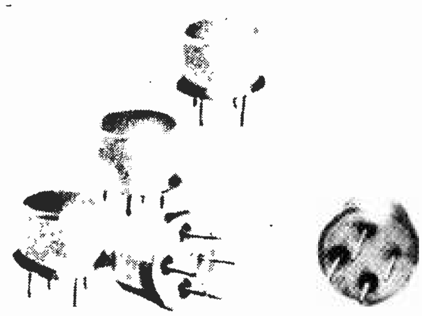


WW302

metre without the need for compensation. External control of the d.c. output, separate control of voltage and current using external resistors, and remote programming by external control voltages may also be facilitated. The unit measures 100 × 160 × 55mm. Weir Instrumentation Limited, Durban Road, Bognor Regis, Sussex.

WW 305 for further details

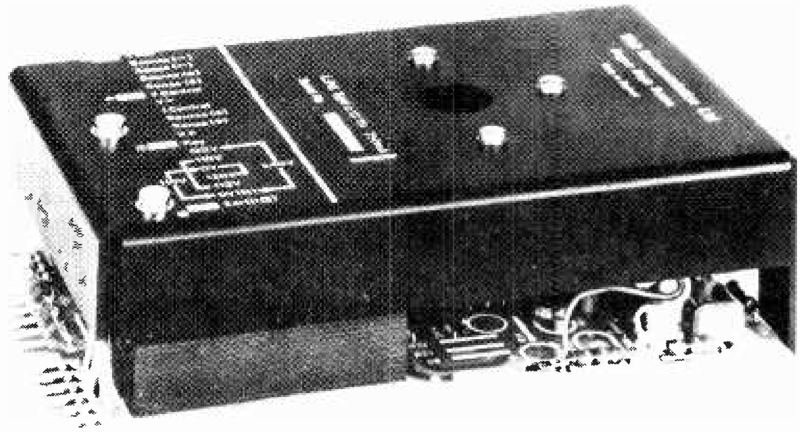
Low-cost oscilloscope

A dual-trace 10MHz oscilloscope, from Scopex Instruments Ltd, has an accuracy of ±3% on both time and voltage measurements and is priced at only £150. The model 4D10A, as it is called, is an improved version of the model 4D10 oscilloscope. This improved performance has been obtained by using stabilized power supplies throughout, enabling mains supply variations of ±10%, and by redesigning the attenuator to allow measurements up to 50V/cm. Other changes include the use of Glarecheq non-reflective filters with reverse side graticules, for low parallax error, and a re-designed trigger to include a mode allowing triggering from composite video waveforms at TV field rate. In addition, the use of aluminium panels instead of steel has given a weight reduction of 25%. Cost savings were made by bulk-buying precision components and by replacing many of the electrolytic capacitors by circuitry. Scopex Instruments Limited. Pixmore Industrial Estate, Pixmore Avenue, Letchworth, Herts. SG6 1JJ.

WW306 for further details

Resistance bridge

A precision a.c. resistance bridge, from J. J. Lloyd Instruments, has a calibration accuracy of 5 p.p.m. and a discrimination better than 0.1 p.p.m. for resistance values up to 444Ω. The instrument is especially useful for calibration and measurement with resistance thermometers, strain gauges and other in cases where very precise observation of relatively low resistance values is required. A multi-dial transformer ratio system compares the unknown resistor with a built-in standard, giving a stable direct read-out of resistance value, or deviation. A four-terminal pair network minimizes errors due to lead resistance without the need for a dummy load, and the use of relatively low frequency (320Hz), together with automatic feedback of the quadrature signal from the built-in detector, eliminates any need for manual balance of the non-resistive element, ensuring that precision measurement is achieved easily and quickly. Low power dissipation, both in the resistor under test and in the high-stability low-temperature-coefficient



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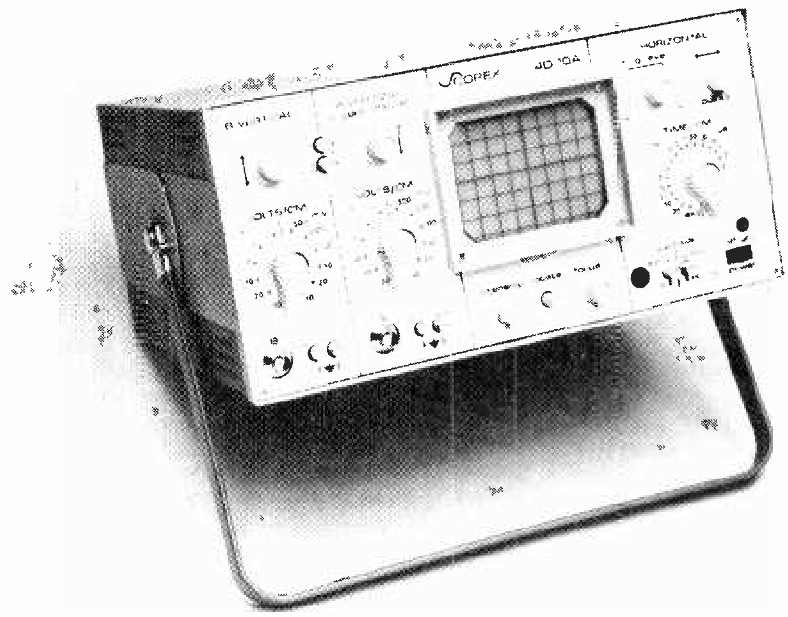

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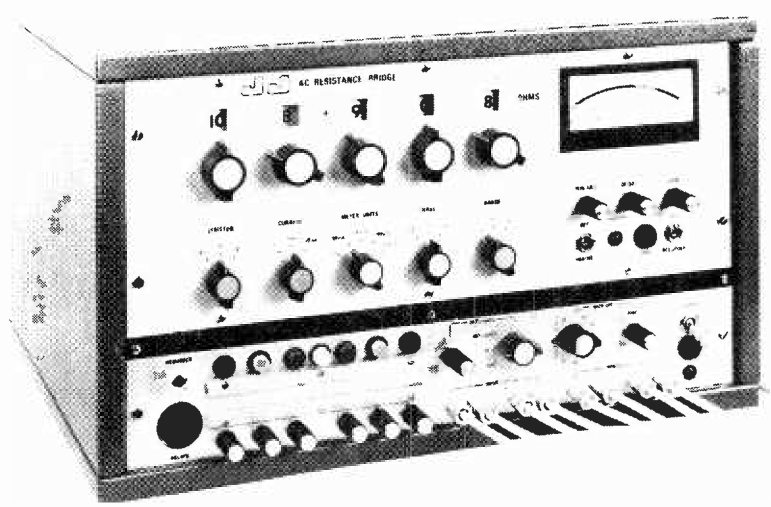


WW307

metal-film reference standard, minimizes the effect of self-heating. An off-limit indicator is available as an optional extra, which gives lamp indication of deviation in three pre-set bands above and below the nominal value, and which also increases the resolution by a further factor of ten. Reed relay outputs are provided to operate sorting systems or data recording equipment. Outputs are available both from the decade switches and the detector of the main instrument to facilitate external recording, either digitally or on a chart recorder. J. J. Lloyd Instruments Limited, Brook Avenue, Warsash, Southampton, SO3 6HP.
WW307 for further details

Meter calibrators

Two meter calibrators, the model 25A for r.f. milliwattmeters and the model 26A for r.f. millivoltmeters, have been introduced by Boonton Electronics. Both instruments provide accurate, stable 1MHz output signals with rotary switches selecting levels to conform to full-scale readings, and separate push buttons for selecting incremental steps within each range to check meter linearity. Output ranges of the instruments are −69 to +20dBm in 1dB steps, accurate to 0.05dB, for the model 25A and 60μV to 3V in 10% full-scale steps, accurate to 0.5%, for the model 26A. Euro Electronic Instruments Ltd, Shirley House, 27 Camden Road, London NW1 1YE.
WW308 for further details

Soldering bits

Stiron soldering bits are designed to give long trouble-free life in any iron taking interchangeable bits in $\frac{1}{8}$, $\frac{3}{16}$, $\frac{1}{4}$, $\frac{5}{16}$, $\frac{3}{8}$in and 14mm diameters. The design accommodates a variety of tip forms, and the iron-plating ensures low deformation throughout the working life. These bits, which are pre-tinned, are chromium plated (except where tinned) to prevent solder creepage. Screwdriver bits in the three larger diameters can be supplied tinned on one side only, to prevent damage to adjacent solder joints. Stiron bits were developed to the requirements of the Swedish Post Office and Ericson Telephones and are now available in the U.K. for use with many makes of iron. Tele-production Tools Limited, 28b Hamlet Court Road, Westcliff-on-Sea, Essex.
WW 309 for further details

Diagnostic servicing aid

Usijet is a small, light universal signal injector made in the form of a pen for clipping into the pocket. The circuit consists of two signal generators, one operating at audio frequency and the other at radio frequency. The impulse waveform derived from a blocking oscillator-type circuit, produces a signal with a wide range of harmonic frequencies up to 500MHz. This instrument may be used to trace breaks and component failures by injecting the signal at various points in circuits and may be applied to fault finding in a.f., i.f. and r.f. amplifier stages, l.w., m.w., s.w. and f.m. wavebands and TV v.h.f. and u.h.f. channels up to 500MHz. The fundamental frequencies are 1kHz and 500kHz, with an output voltage of 20V pk-pk, and the maximum permissible direct voltage at the probe tip is 500V. Usijet costs £7.50 + v.a.t., is powered by a 1.5V cell and has a current consumption of about 25mA. Precision Instrument Laboratories, Instrument House, 212 Ilderton Road, London SE15 1NT.
WW310 for further details

Receiver protection unit

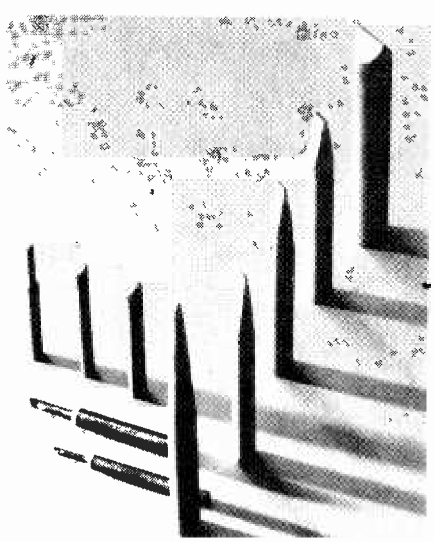
A range of receiver protection units, designed to protect the inputs of m.f. and h.f. radio receivers from the effects of r.f. voltages and currents induced in the antenna, has been developed by Callbuoy Marine Electronics. One of the principal needs for such a unit is in marine applications where radio energy from the vessel's own transmitter can induce high voltages and currents in the receiver antenna. The units, models RPU250, RPU500, RPU100/75 and RPU100/50, protect receiver inputs against 250V, 500V and 100V r.m.s. respectively. The two 100V models are low loss units matched to 75Ω or 50Ω feeders. All models operate over the frequency range 0 to 30MHz, with a minimum of insertion loss at normal signal levels, measure 200×55×50mm and weigh 1.1kg. Callbuoy Marine Electronics Limited, 6 Somerset Road, Cwmbran, Gwent NP4 1QX.
WW311 for further details

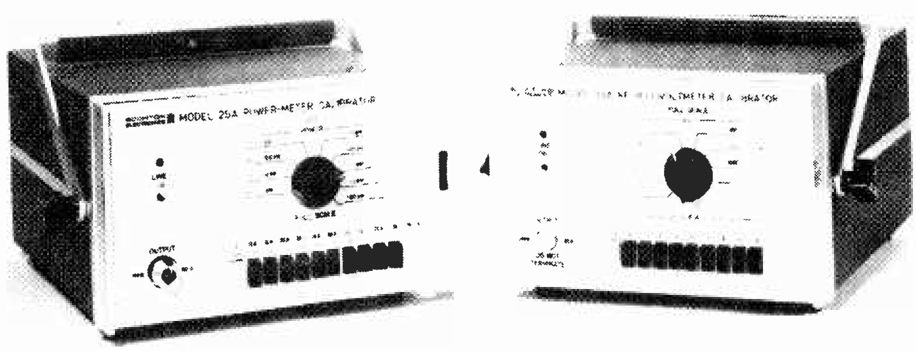
Switch seals

Amiseals are one-piece seals for toggle, push-button and rotary shaft switches. The seals are moulded to hexagonal nuts and are claimed to provide complete dust-proof and water-tight protection for switch actuators, and also seal the panel holes. The hexagonal nuts are available in a range of thread sizes to allow use on switches of various manufacturers. These seals are manufactured in the U.S.A. and meet the requirements of MIL specifications B5423. A. F. Bulgin & Co. Ltd, Barking, Essex.
WW312 for further details

High-brightness l.e.ds

A T1-packaged l.e.d. lamp, the RL-2000, has a typical luminous intensity in excess of 3.5mcd. The lamp is designed for panel mounting with either rear or front mounting clips and provides radiation with a wide viewing angle. It may be driven from existing i.c. circuitry, requiring no additional power supply, and offers the user the choice of





WW308

WW309

either extremely high intensity operation or low power consumption at lower brightness levels. A typical characteristic of the RL-2000 is a luminous intensity of 3.5mcd at 100mA and a peak inverse voltage of 3V. Litronix, 24 Sun Street, Hitchin, Herts SG5 1AH.

WW313 for further details

Scanning motors with mirrors

A range of scanning motors fitted with mirrors has been produced by Techmation Ltd for electronic, optical and medical applications such as raster generation and pattern generation, as in visual evoked response. These motors, in the S4 range, are based on the proven MFE miniature galvanometers and are tangent-corrected, exhibiting a linearity of up to 0.5% with 0.05% repeatability. The motors give mirror deflections of up to 30° pk-pk and work at frequencies up to 100Hz or more. Four motor sizes are available, each with a one-wavelength flatness mirror. Techmation Limited, 58 Edgware Way, Edgware, Middx HA8 8JP.

WW314 for further details

Electronic ice-point

An electronic ice-point, available from Ancom Limited, is built into a thermocouple connector and is powered from a self-contained battery. The Omega MCJ (miniature cold junction), which is compatible with any thermocouple quick-disconnect connector, is claimed to give 2500 hours continuous operation from one battery. The standard reference temperature setting is 0°C, with a compensation accuracy of ±0.5°C from 15°C to 30°C, and the output impedance is less than 200Ω. Internal balance adjustment is provided for high accuracy requirements. Ancom Limited, Devonshire Street, Cheltenham GL50 3LT.

WW315 for further details

Data-communications test set

On display at the Virginia Electronics Exhibition, held in the U.S. Trade Centre in October, was a test set from Dynatech Laboratories Incorporated. The TC-100 is a programmed test set for locating and defining faults in data communications systems. It is claimed to simulate and test all components in the data network including the communications circuits, modems, terminals and computer ports — both the hardware and software. Tech-lit Services Incorporated, 1519 Highwood Drive, Arlington V.A. 22207.

WW316 for further details

Tantalum chip capacitors

A high-reliability range of Tantalum chip capacitors, available from Waycom Limited, are manufactured to MIL-C-55365A standards and are intended for direct substrate mounting in high-quality thick and thin film assemblies. The BNS series covers the capacitance range 0.1 to 100μF, for working voltages up to 50V. The solder mounting terminals are claimed to be shock and vibration proof and the body has an insulating coating of inert polymer to avoid contaminating transistors or other sensitive components on the same substrate. Tolerances of ±20%, ±10% and ±5% are available, and the capacitors may be worked over the full military temperature range −55°C to +125°C. Waycom Limited, Wokingham Road, Bracknell, Berks.

WW317 for further details

Solid State Devices

Names of suppliers of devices in this section are given in abbreviation after each entry and in full at the end of the section.

H.f. transistor

The MRF905 n-p-n silicon high-frequency transistor, from Motorola, is designed for low-cost radiosonde service and microwave communications relay links. It is an oscillator transistor which is emitter ballasted and has the collector connected to its TO-46 metal can. Typical characteristics include low current density, a current-gain bandwidth product (f_t) of 2500MHz, and an output power, measured at 1.68GHz, of 500mW. The maximum collector-emitter voltage (V_{CEO}) is 20V, collector current is 150mA and power dissipation at 25°C is 2.5W.

WW318 **Motorola**

Low-noise f.e.ts

A family of gallium-arsenide Schottky barrier f.e.ts, designated as the model HFET-1000 series, is now available from Hewlett-Packard. The transistors offer a 14.5dBm linear 25mW power output at 10GHz. At this frequency the transistors have typical noise figures of 3.6dB with 6.9dB associated gain, and maximum available gains of 11.0dB. These chips, which are intended for use in low-noise amplifiers in the 2 to 12GHz range, have 1 by 500 micrometer gates.

WW319 **Hewlett-Packard**

High-voltage rectifiers

A low-cost high voltage rectifier range, the 1N5181-84 series, has been introduced by Semtech. Peak inverse voltages range from 4 to 10kV, the average rectified current is 100mA (at 55°C), the maximum forward voltage drop is 10V, and the maximum reverse current at 25°C is 1μA. The cylindrical rectifiers have axial leads and operate over a temperature range of −65 to +175°C.

WW320 **Bourns**

Microwave transistor

A range of low-cost high-power microwave transistors, from Microwave Semiconductor Corporation, operate in the frequency range 1.5 to 2.3GHz. The devices, designated as the Impac series, are input matched. Output powers range from 5 to 30W with an option of 24 or 28V. Applications for these transistors include satellite up and down links and missile telemetry. Prices range from £15 to £50.

WW321 **Tranchant**

Low-resistance switching transistors

Complementary p-n-p/n-p-n silicon epitaxial switching transistors with low inverted dynamic-saturation resistances (typically 4Ω) are available from Crystalonics. Other characteristics include typical collector/base and emitter/base leakage currents of 0.5nA, V_{CE} of 20V, V_{BE} of 30V, and an offset voltage of 0.7mV. Collector/base and emitter/base capacitances are 6pF and 5pF respectively. The transistors, which operate over a temperature range of −65 to +200°C, are packaged in a TO-46 can.

WW322 **GEE**

Suppliers

Bourns (Trimpot) Ltd, Hodford House, 17/27 High Street, Hounslow, Middlesex TW3 1TE.

G.E. Electronics (London) Ltd, 182/4 Campden Hill Road, Kensington, London W8 7AS.

Hewlett-Packard Limited, King Street Lane, Winnersh, Wokingham, Berkshire RG11 5AR.

Motorola Limited, Semiconductor Products Division, York House, Empire Way, Wembley, Middlesex HA9 0PR.

Tranchant Electronics (UK) Ltd, 100a High Street, Hampton, Middlesex TW12 2ST.

Real and Imaginary

by "Vector"

BAIRD ON TRIAL

ONE of the many strange phenomena of our time is the growth of nostalgia. Victorian bric-a-brac, not so long ago the object of derision, is now eagerly sought after. And the stuff needn't be so old at that. A nameplate of a steam locomotive scrapped only a couple of decades ago can now command upwards of £5,000 in the market place. Bits and pieces from axed branch lines change hands at fantastic prices. Tram tickets can be worth their weight in gold, while anyone who has in his loft a 1923 valved radio in mint condition is probably sleeping under a platinum mine.

The 'twenties phase has also hit the journal's correspondence columns with the John Logie Baird controversy — not, I'm thankful to note, that hardy annual as to whether or not he is indeed the Father of Television, but whether he was fooling the public. This has stirred up a rare old ding-dong, with many revered names cutting and thrusting in the best traditions of the late Mr Errol Flynn, including, I see, a former editor and an assistant editor of WW.

But, with the utmost respect to all participants in the story so far, it seems to me that to attempt to solve the question primarily by studying the business and technical aspects of Baird's 30-line activities is to create a cart-before-the-horse situation. Surely the initial approach should be to examine Baird's psychological makeup to see whether he was inherently capable of chicanery?

Ideally, I suppose, only unbiased witnesses who knew Baird intimately would be in a position to judge his integrity, but although there are many living who knew him well, hardly any, I imagine, could be completely objective. Failing that, one must turn to the literature, such as "John Baird," by Sydney Moseley, one of Baird's friends and business associates.

His account of Baird's pre-television days is illuminating. Baird, it seems, had a horror of poverty, yet no over-riding ambition towards riches. His early essay into diamond manufacture when he mounted terminals at the ends of a carbon rod, immersed it in a bucket of concrete and then connected the output of a power station (where he was an employee) across the terminals, isn't one to engender confidence in his technical abilities and judgement. Baird anticipated the sack by getting out of electrical engineering in a hurry and plunged into a series of one-man business ventures. The Baird Undersock, "Medicated, Soft, Absorbent. Keeps the feet warm in winter and cool in summer" was the first. These were ordinary socks, sprinkled with borax; Baird promoted their sale by means of "carefully prepared home-made testimonials" (his own words).

Next there was a disastrous excursion into jam-making in the West Indies, the climax of which came when he returned to England with kerosene tins full of mosquito-ridden jam which he was unable to sell until a sausage maker bought it to mix into his products. Other abortive ventures followed, including "Baird's Speedy Cleaner" a soap which Baird himself described as rubbish, but which sold well. Glass razor-blades and pneumatic soles for shoes were his first inventions — both abysmal failures.

We now move on to June 1923, by which time Baird had somehow latched on to Nipkow's apparatus and, with the aid of a selenium cell and valve amplifiers, had made it work to the point where it would transmit shadows. Still broke and needing more money for components, he inserted the advertisement in *The Times:*

"Seeing by Wireless — Inventor of apparatus wishes to hear from someone who will assist (not financially) in making working models . . ."

This, according to Sydney Moseley, was a "con." Eventually it brought a financial backer to the tune of £200. That soon vanished — not into Baird's pocket, but into equipment — and for some time afterwards he lived hand-to-mouth until investment by relatives eased matters a little.

The next incident, in terms of Baird's integrity, concerns the morning after the celebrated demonstration to members of the Royal Institution in January 1926, when Baird's premises in Frith Street were beseiged by pressmen. The press (says Moseley) were courteously received and "were told only what Baird and Hutchinson (another associate) chose to tell them".

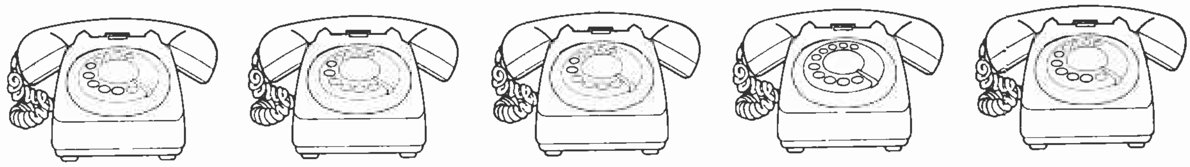
In 1927 a company was formed; thereafter Baird's personal finances were considerably easier and he had considerable sums at his disposal for research. But in one major respect his problems multiplied. He was no longer a lone inventor, responsible only to himself. He had shareholders – speculators who wanted a return on their investments as early as was possible. Baird had to whip up public interest to a point where a television service could be started. Only then could his company sell Televisors. Accordingly Baird plunged into an orgy of demonstrations while Moseley, an ex-Fleet Street journalist and completely non-technical, whipped up enthusiasm in the newspapers and banged the big drum. In record time Baird demonstrated colour television stereoscopy, and Noctovision as well as long-distance 30-line transmissions. All held considerable experimental interest. None of them had entertainment value.

Which brings us to the question before the meeting. Did Baird employ any degree of rigging in staging his demonstrations? Certainly the temptation must have been great. He had been first in the field with a moving picture containing a degree of light and shade, but only by a short head. By this time others were demonstrating; moreover, he had no master-patent to protect the overall system, so it was essential that he should be seen to be in the lead. At the same time, however, he must not give away too much technical detail to rivals.

When in 1930, the BBC rather reluctantly permitted Baird the use of two Brookman's Park transmitters — one for vision and one for sound — for limited experimental broadcasts, the Baird Televisor was launched in two forms; a complete model and a constructor's kit. I have a copy of the original brochure. It contains no salient technical information. No mention (naturally) is made of the "hunting" problem which still existed. It contains such phrases as "perfect reception is guaranteed", "see the world from your own fireside" and "The day is not far off when owners . . . will be able to witness a whole film performance . . ." (Six years, as it transpired – but not with the 30-line system!).

If it transpires that Baird did consciously fool the public (and he certainly seems to have had an amoral approach in his earlier life) it may well have been with the best of intentions. Most inventors have a blind spot concerning the deficiencies of their brain-children; Baird had a sublime belief in his system; he was convinced that in the end mechanical scanning would provide a 100% entertainment medium and so he might have argued that the employment of any means was justified in order to win through. And, before we dismiss him as an unqualified crank who stuck obstinately to mechanical scanning, let's not forget two things. One is that his early experiments triggered several large organizations into television research and their highly qualified engineers all followed the mechanical road for some years. The other is that in the famous trial against the Marconi-EMI system, Baird's 240-line Nipkow disc system was defeated not so much on picture quality as on being less flexible in operation.

I've sometimes wondered how Baird would have fared if he had lived in the days of NRDC. But that's another set of conjectures altogether!



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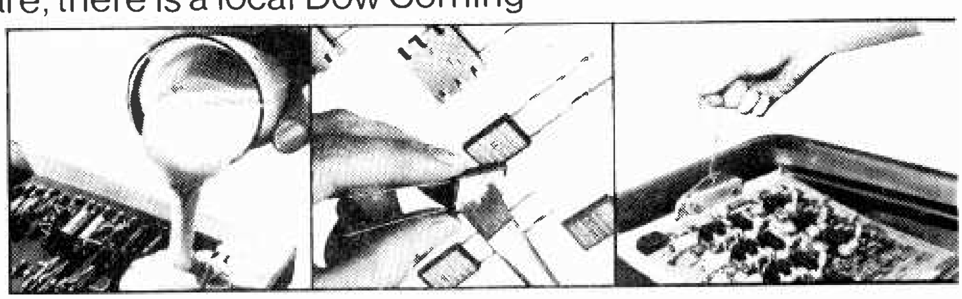


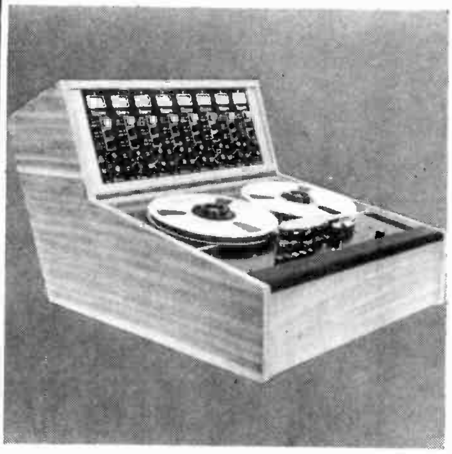
DOW CORNING

DOW CORNING

WW—086 FOR FURTHER DETAILS

itam

ITAM 805 (8TRACK) MASTER RECORDER



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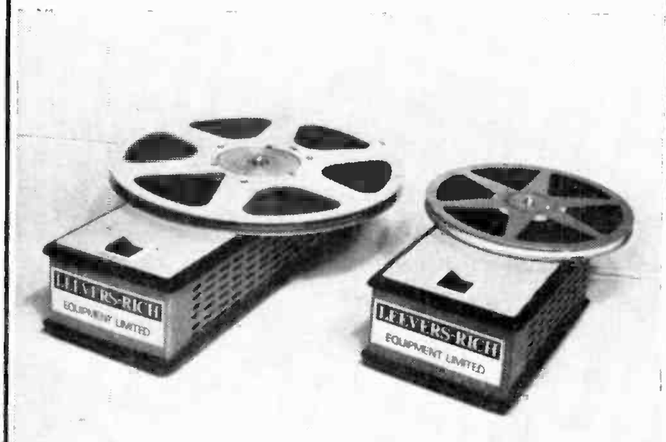
BULK ERASURE PROBLEMS?



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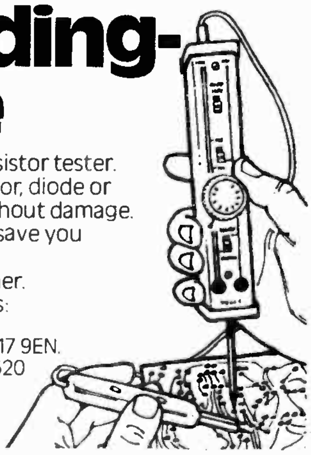
WW — 032 FOR FURTHER DETAILS

fault finding-no fiddle



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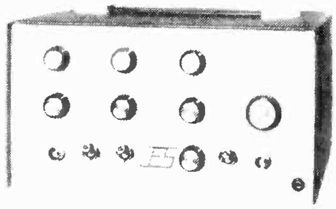
THORN Thorn Measurement Control and Automation Division

WW—044 FOR FURTHER DETAILS

JES AUDIO INSTRUMENTATION



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sine — square — RIAA

prices plus VAT

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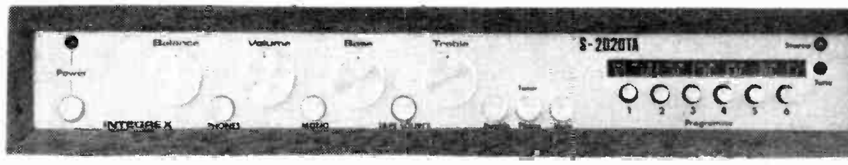
WW — 020 FOR FURTHER DETAILS

WW—043 FOR FURTHER DETAILS

INTEGREX

S-2020TA STEREO TUNER/AMPLIFIER KIT

SOLID MAHOGANY CABINET



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

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

PRICE: £53.95+VAT

NELSON-JONES STEREO FM TUNER KIT

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

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

Compare this spec. with tuners costing twice the price

Mono £29.15+VAT
With ICPL Decoder £33.42+VAT
With Portus-Haywood Decoder £35.95+VAT

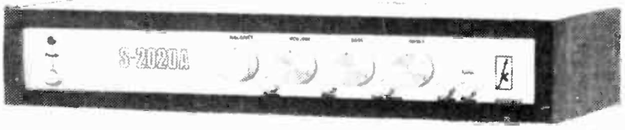
STEREO MODULE TUNER KIT

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

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

PRICE: Mono £26.85+VAT
Stereo £29.95+VAT

S-2020A AMPLIFIER KIT



Developed in our laboratories from the highly successful "TEXAN" design. PC mounting potentiometers, switches, sockets and fuses are used for ease of assembly and to minimize wiring

Power 'on/off' FET transient protection.

Typ Spec. 24+24W r.m.s. into 8-ohm load at less than 0.1% THD. Mag. PU input S/N 60dB. Radio input S/N 72dB. Headphone output. Tape In/Out facility (for noise reduction unit, etc.). Toroidal mains transformer.

PRICE: £31.95+VAT

ALL THE ABOVE KITS ARE SUPPLIED COMPLETE WITH ALL METALWORK, SOCKETS, FUSES, NUTS AND BOLTS, KNOBS, FRONT PANELS, SOLID MAHOGANY CABINETS AND COMPREHENSIVE INSTRUCTIONS

BASIC NELSON-JONES TUNER KIT **£14.28**+VAT
BASIC MODULE TUNER KIT (stereo) **£16.75**+VAT
PHASE-LOCKED IC DECODER KIT . . . **£4.47**+VAT
PUSH-BUTTON UNIT . . . . **£4.50**+VAT

PORTUS-HAYWOOD PHASE-LOCKED STEREO DECODER KIT . . . . **£8.00**+VAT

BI-PAK

High quality modules for stereo, mono and other audio equipment.

NEW

PUSH-BUTTON STEREO FM TUNER

OUR PRICE ONLY

£19.95

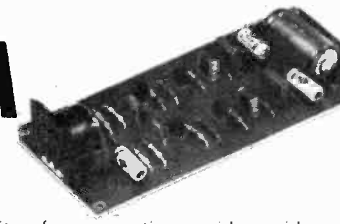
Fitted with Phase Lock-loop Decoder

The 450 Tuner provides instant program selection at the touch of a button ensuring accurate tuning of 4 pre-selected stations, any of which may be altered as often as you choose, by simply changing the settings of the pre-set controls.
Used with your existing audio equipment or with the BI-KITS **STEREO 30** or the **MK60** Kit etc. Alternatively the **PS12** can be used if no suitable supply is available, together with the Transformer **T538**.
The S450 is supplied fully built, tested and aligned. The unit is easily installed using the simple instructions supplied.

- ★ FET Input Stage
- ★ VARI-CAP diode tuning
- ★ Switched AFC
- ★ Multi turn pre-sets
- ★ LED Stereo Indicator

Typical Specification:
Sensitivity 3μ volts
Stereo separation 30db
Supply required 20-30v at 90 Ma max.

MPA 30



Enjoy the quality of a magnetic cartridge with your existing ceramic equipment using the new M.P.A. 30, a high quality pre-amplifier enabling magnetic cartridges to be used where facilities exist for the use of ceramic cartridges only.
It is provided with a standard DIN input socket for ease of connection.
Full instructions supplied.

£2.65

VAT ADD 12½%

POSTAGE & PACKING
Postage & Packing add 25p unless otherwise shown. Add extra for airmail. Min. £1.00

STEREO PRE-AMPLIFIER PA100

OUR PRICE £13.50

A top quality stereo pre-amplifier and tone control unit. The six push-button selector switch provides a choice of inputs together with two really effective filters for high and low frequencies, plus tape output.

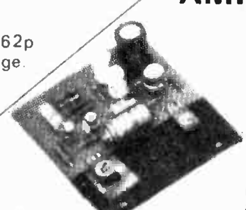
Frequency Response + 1dB 20Hz 20KHz. Sensitivity of inputs
1 Tape Input 100mV into 100K ohms
2 Radio Tuner 100mV into 100K ohms
3 Magnetic P.U. 3mV into 50K ohms
P.U. Input equalises to R1AA curve with 1dB from 20Hz to 20KHz.
Supply — 20-35V at 20mA.

Dimensions
299mm x 89mm x 35mm

MK. 60 AUDIO KIT: Comprising 2 x AL60's. 1 x SPM80. 1 x BTM80. 1 x PA100. 1 front panel and knobs. 1 Kit of parts to include on/off switch, neon indicator, stereo headphone sockets plus instruction booklet. **COMPLETE PRICE £27.55.** plus 62p postage.

TEAK 60 AUDIO KIT: Comprising Teak veneered cabinet size 16¾"x11½"x3¾", other parts include aluminium chassis, heatsink and front panel bracket plus back panel and appropriate sockets etc. **KIT PRICE £9.20** plus 62p postage.

AL-20-30 AUDIO AMPLIFIER MODULES



The AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power devices has resulted in a range of output powers from 5 to 10 watts R.M.S.
The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the home.

SPECIFICATION:
- **Harmonic Distortion Po=3 watts f=1KHz 02.5%**
- **Load Impedance 8-16ohm**
- **Size: 75mm x 63mm x 25mm**
- **Frequency response ±3dB Po=2 watts 50Hz-25Hz**
- **Sensitivity for Rated O/P — Vs=25v. RL=8ohm f=1KHz 75mV. RMS**

AL20 5w R.M.S. £2.65 AL30 10w R.M.S. £2.95

STEREO 30

COMPLETE AUDIO

7+7 WATTS R.M.S.

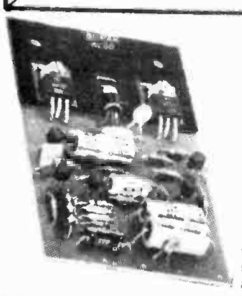
P & P 45p

£15.75

The Stereo 30 comprises a complete stereo pre-amplifier, power amplifiers and power supply. This, with only the addition of a transformer or overwind will produce a high quality audio unit suitable for use with a wide range of inputs i.e. high quality ceramic pick-up, stereo tuner, stereo tape deck etc. Simple to install, capable of producing really first class results, this unit is supplied with full instructions, black front panel knobs, main switch, fuse and fuse holder and universal mounting brackets enabling it to be installed in a record plinth, cabinets of your own construction or the cabinet available. Ideal for the beginner or the advanced constructor who requires Hi-Fi performance with a minimum of installation difficulty (can be installed in 30 mins).

TRANSFORMER £2.45 plus 62p p &p
TEAK CASE £3.65 plus 62p p & p.

AL 60 25 Watts (RMS)



★ **Max Heat Sink temp 90C.** ★ **Frequency response 20Hz to 100KHz** ★ **Distortion better than 0.1 at 1KHz** ★ **Supply voltage 15-50v** ★ **Thermal Feedback** ★ **Latest Design Improvements** ★ **Load — 3,4,8, or 16 ohms** ★ **Signal to noise ratio 80db** ★ **Overall size 63mm. 105mm. 13mm.**

Especially designed to a strict specification. Only the finest components have been used and the latest solid-state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast.

£3.95

NEW PA12

NEW PA12 Stereo Pre-Amplifier completely redesigned for use with AL 20/30 Amplifier Modules. Features include on/off volume. Balance, Bass and Treble controls. Complete with tape output.

Frequency Response 20Hz-20KHz (—3dB). Bass and Treble range 12dB. Input Impedence 1 meg ohm. Input Sensitivity 300mV. Supply requirements 24V.5mA. Size 152mm x 84mm x 33mm.

£6.50

PS12

Power supply for **AL20/30, PA12, SA450** etc.

Input voltage 15-20v A.C. Output voltage 22-30v D.C. Output current 800 mA Max. Size 60mm x 43mm x 26mm.
Transformer T538 £2.30

OUR PRICE £1.20

Stabilised Power Supply Type SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watts (R.M.S.) per channel simultaneously. With the addition of the Mains Transformer **BMT80**, the unit will provide outputs of up to 1.5A at 35V. Size: 63mm. 105mm. 30mm.
Incorporating short circuit protection.
Transformer BMT80
£2.60 + 62p postage

£3.00

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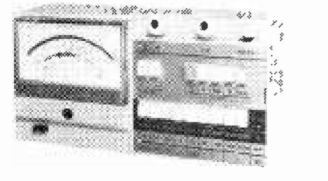
MULTIMETER F4313 *(Made in USSR)*



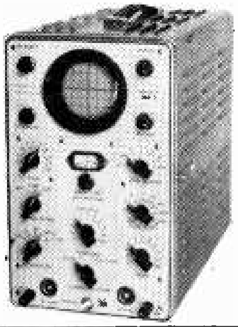
SENSITIVITY:
1200V DC range: 10,000 Ω/V
Other DC ranges: 20,000 Ω/V
1200 AC range: 6,000 Ω/V
600V AC range: 15,000 Ω/V
300V AC range: 15,000 Ω/V
Other AC ranges: 20,000 Ω/V

AC/DC current ranges: 60-120-600 μA-3-12-300mA-1.2-6A
AC/DC voltage ranges: 60-300mV-1.2-6-30-120-300-600-1200V
Resistance ranges: 300Ω-10-100-1000K
Accuracy: 1.5% DC; 2.5% AC (of full scale deflection)

Mirror scale and knife edge pointer. Taut suspension of movement. Transistor amplifier is used for all AC ranges thus achieving a common linear scale for both AC and DC ranges.

Meter is fully protected for a transistorised cut-out relay circuit. Range selection is achieved by clearly marked piano keys. Power source 5 1.5V dry cells. Dimensions: 95 x 225 x 120mm.

PRICE £37.50 plus VAT
Packaging and postage £1.10



OSCILLOSCOPE CI-5
Made in USSR

Extremely simple and easy to use single beam oscilloscope. Well proved design based on standard octal valves makes servicing and maintenance straightforward and inexpensive. Because of its bandwidth of 10 MHz the instrument is suitable for general electronic applications and educational purposes where a sophisticated instrument would be both too expensive and delicate. 3-in. tube giving a 50 x 50mm clear display. Amplitude and time base calibrations. Sensitivity 30mm/v max. Triggered and free-running time base, suitable for displaying pulses from 0.1 μ sec. to 3 m sec. A.C. mains operation.

Price £55.00 ex. works
Packing and carriage (U.K. only £2.50)

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VALVES

0A2	0.45	6SN7GT	0.55					KT66	3.40	PL508	0.90
0A3	0.55	12AT7	0.45					KT88	3.65	PL509	1.30
0B2	0.45	12AU7	0.38					PC86	0.65	PL802	1.40
0C3	0.45	12AX7	0.38					PC88	0.65	PY31	0.50
0D3	0.45	12B4A	0.80					PC900	0.55	PY33	0.63
5R4GY	1.00	12BA6	0.60					PCC84	0.45	PY81	0.45
5U4G	0.55	12BE6	0.60					PCC85	0.45	PY82	0.45
5Z4G	0.55	12BH7	0.60					PCC88	0.65	PY88	0.50
5Y3GT	0.65	12X4	0.50					PCC89	0.55	PY500A	1.10
6AB4	0.50	19AQ5	0.75					PCC189	0.65	PY800	0.50
6AJ5	0.65	30A5	0.70	ECC83	0.38	EF86	0.40	PCF80	0.40	TT21	5.90
6AK5	0.45	35A3	0.70	ECC84	0.35	EF183	0.35	PCF82	0.40	TT22	5.90
6AL5	0.30	35A5	0.80	ECC85	0.45	EF184	0.40	PCF86	0.65	WABC80	0.50
6AQ5	0.50	35B5	0.70	ECC86	1.25	EFL200	0.75	PCF200	0.80	UAF42	0.70
6AT6	0.60	35C5	0.70	ECC88	0.60	EL34	0.70	PCF201	0.85	UBC41	0.50
6AV6	0.50	35A5	0.80	ECC89	0.60	EL36	0.60	PCF801	0.55	UBC81	0.50
6AWBA	0.75	35WA	0.60	ECC189	0.80	EL41	0.80	PCF802	0.55	UBF80	0.50
6AU6	0.40	50AS	1.00	ECF80	0.45	EL81	0.60	PCH200	0.75	UBF89	0.50
6BA6	0.38	50B5	0.85	ECF82	0.45	EL82	0.60	PCL81	0.55	UCC84	0.75
6BE6	0.45	50C5	0.70	ECF86	0.75	EI83	0.60	PCL82	0.40	UCC85	0.50
6BH6	0.75	5763	1.50	ECF801	0.75	EL84	0.35	PCL83	0.70	UCF80	0.75
6BJ6	0.75	EABC80	0.40	ECF802	0.75	EL90	0.50	PCL84	0.50	UCH42	0.80
6BN6	0.80	EAC91	0.55	ECH42	0.85	EL95	0.70	PCL85	0.60	UCH81	0.50
6BN8	0.65	EAF42	0.70	ECH81	0.50	EL500	0.80	PCL86	0.60	UCL82	0.40
6BZ6	0.55	EAF801	0.65	ECH83	0.50	EM80	0.55	PCL200	0.75	UCL83	0.70
6BZ7	0.70	EBC41	0.75	ECH84	0.50	EM81	0.60	PD500	1.70	UF41	0.75
6CA	0.40	EBC81	0.50	ECL80	0.40	EM84	0.40	PFL200	0.70	UF42	0.75
6CB6	0.50	EBF80	0.50	ECL81	0.75	EY51	0.45	PL35	0.40	UF80	0.40
6EA8	0.75	EBF83	0.50	ECL82	0.42	EY51	0.45	PL36	0.60	UF85	0.50
6GK5	0.70	EBF89	0.40	ECL83	0.75	EY87	0.50	PL38	0.65	UF89	0.50
GK6	0.65	EC86	0.75	ECL84	0.60	EY88	0.50	PL81	0.55	UL41	0.70
6J4	0.75	EC88	0.75	ECL85	0.65	EZ40	0.60	PL82	0.50	UL84	0.50
6J5GT	0.55	EC91	2.60	ECL86	0.55	EZ41	0.75	PL83	0.50	UY41	0.55
6J6	0.35	ECC40	0.80	ECLL800	4.50	EZ80	0.30	PL84	0.50	UY42	0.55
6L6GT	0.60	ECC81	0.45	EF80	0.35	EZ81	0.35	PL95	0.70	UY82	0.60
6SL7GT	0.55	ECC82	0.38	EF85	0.45	GZ34	0.75	PL504	0.90	UY85	0.50

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BCY70/2	18p★
BD131	39p
BD132	39p
BFY501	15p★
MJ2955	95p★
MJE2955	95p★
MJE3055	65p★
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TIP42C	£1.50★
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7420	23p★	4012	19p★
7430	22p★	4013	50p★
7440	16p★	4015	94p★
7441	75p★	4016	50p★
7442	65p★	4017	94p★
7447	79p★	4023	19p★
7470	29p★	4024	72p★
7472	25p★	4025	19p★
7474	31p★	4028	87p★
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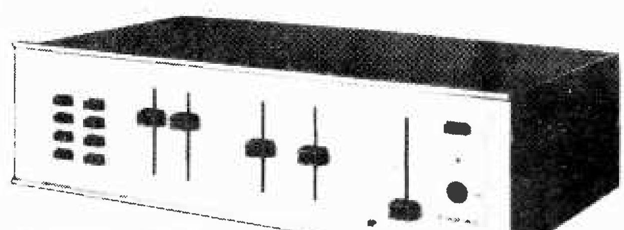
Resistors **2p ea.** POTS AB **20p**
Electrolytics **7p.** Presets **6p**
Heat Sinks TO5 & 18 **7p★** TO3 **16p★**

RADFORD HD250

High Definition Stereo Amplifier



A new standard for sound reproduction in the home! We believe that no other amplifier in the world can match the overall specification of the HD250.

Rated power output: 50 watts av. continuous per channel into any impedance from 4 to 8 ohms, both channels driven.

Maximum power output: 90 watts av. per channel into 5 ohms.

Distortion, preamplifier: Virtually zero (cannot be identified or measured as it is below inherent circuit noise.)

Distortion, power amplifier: Typically 0.006% at 25 watts, less than 0.02% at rated output (Typically 0.01% at 1 Khz)

Hum and noise: Disc,—83dBV measured flat with noise band width 23 Khz (ref 5mV); —88dBV "A" weighted (ref. 5mv)

Line —85 dBV measured flat (ref 100v)
—88d BV "A" weighted (ref 100v)

Hear the **HD250** at

SWIFT OF WILMSLOW

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(Tel: 26213)

Mail Order and Personal Export enquiries: Wilmslow Audio, Swan Works, Bank Square, Wilmslow (Tel. 29599)

Now available ZD100 power amplifier and ZD22 pre-amplifier

WW—054 FOR FURTHER DETAILS

VALVES

A1065	1.25	EF37A	1.10	GZ37	1.00
AR8	0.60	EF40	0.70	KT66	3.00
ARP3	0.60	EF41	0.75	KT88	4.50
ATP4	0.50	EF80	0.35	MH4	1.00
B12H	3.00	EF83	1.25	ML6	0.75
OAF96	0.60	EF85	0.40	OA2	0.45
DF96	0.60	EF86	0.40	OB2	0.45
DK96	0.75	EF89	0.35	PABC80	0.40
DL92	0.50	EF91	0.60	PC86	0.65
DL96	0.70	EF92	0.50	PC88	0.65
DY86/87	0.45	EF95	0.45	PC900	0.55
OY802	0.45	EF183	0.40	PCC84	0.45
E88CC/01	1.30	EF184	0.40	PCC89	0.60
E180CC	1.00	EFL200	0.75	PCC189	0.65
E182CC	3.00	EL34	0.70	PCF80	0.40
EA50	0.40	EL35	0.70	PCF82	0.40
EABC80	0.40	EL37	2.20	PCF84	0.65
EAF42	0.70	EL41	0.80	PCF86	0.65
EB91	0.30	EL81	0.60	PCF200	0.90
EBC33	1.00	EL84	0.35	PCF201	0.90
EBC41	0.75	EL85	0.60	PCF801	0.55
EBF80	0.40	EL86	0.50	PCF802	0.55
EBF83	0.45	EL90	0.50	PCF806	0.90
EBF89	0.40	EL91	1.00	PCH200	0.80
EC52	0.40	EL95	0.70	PCL81	0.60
ECC81	0.45	EL504	0.80	PCL82	0.40
ECC82	0.35	EL821	1.60	PCL83	0.70
ECC83	0.35	EM31	0.70	PCL84	0.50
ECC84	0.35	EM80	0.55	PCL86	0.60
ECC85	0.45	EM81	0.60	PCL805/85	
ECC86	1.25	EM84	0.40		0.60
ECC88	0.55	EM87	1.00	PFL200	0.70
ECC189	0.30	EY51	0.45	PL36	0.60
ECF80	0.45	EY81	0.45	PL81	0.55
ECF82	0.45	EY86/87	0.45	PL82	0.50
ECF801	0.75	EY88	0.50	PL83	0.50
ECH42	0.85	EZ40	0.70	PL84	0.50
ECH81	0.40	EZ41	0.75	PL504	0.85
ECH84	0.60	EZ80	0.30	PL508	0.95
ECL80	0.60	EZ81	0.35	PL509	1.35
ECL82	0.40	GT1C	5.00	PL802	1.85
ECL83	0.75	GY501	0.80	PY33	0.60
ECL86	0.60	GZ32	0.65		
EF36	0.65	GZ34	0.80		

A lot of these valves are imported and prices vary for each delivery, so we reserve the right to change prices for new stock when unavoidable

PLUMBICON TUBES TYPE XO 1071 Mullard £150.00

PY80	0.60	U27	1.00	UF85	0.50	IR5	0.50	5Y3GT	0.60	6AT6	0.60
PY/81/800	0.50	U191	0.75	UF89	0.50	IS4	0.35	5Z3	1.20	6AU6	0.40
PY82	0.45	U801	0.80	UL41	0.70	IS5	0.35	5Z4G	0.60	6AV6	0.50
PY83	0.50	UABC80	0.45	UL84	0.50	IT4	0.35	5Z4GT	0.65	6AX4GT	0.75
PY88	0.50	UAF42	0.70	UY41	0.50	IX2B	0.75	6AB7	0.60	6AX5GT	1.00
PY500	1.10	UBC41	0.60	UY85	0.50	2D21	0.50	6AC7	0.60	6B7	0.70
PY801	0.55	UBF80	0.50	VR105/30	0.45	2K25	9.00	6AH6	0.70	6BA6	0.40
QQV03-10	1.70	UBF89	0.50	VR150/30	0.45	3A4	0.60	6AK5	0.45	6BE6	0.40
QQV06-40A	14.00	UBL1	1.00	X61M	1.50	3D6	0.40	6AK8	0.40	6BG6G	1.00
QV03-12	1.70	UBL21	0.75	X66	0.75	3E29	5.50	6AL5	0.30	6BJ6	0.75
SC1/400	3.60	UCC85	0.50	Z759	4.50	3S4	0.50	6AL5W	0.60	6BQ7A	0.60
SC1/600	5.50	UCF80	0.80	Z800U	3.00	3V4	0.85	6AM5	1.00	6BR7	1.30
SP61	0.80	UCH42	0.80	Z801U	3.00	5B/254M	5.00	6AM6	0.60	6BW6	1.10
TT21	6.00	UCH81	0.50	Z900T	1.50	5B/255M	5.00	6AN8	0.70		
U25	1.00	UCL82	0.45	1A3	0.55	5B/258M	5.50	6AQ5	0.55		
U26	0.80	UCL83	0.70	IL4	0.30	5R4GY	1.00	6AQ5W	0.70		
		UF41	0.70			5U4G	0.55	6AS6	0.80		
		UF80	0.40			5V4G	0.65	6AS7G	1.00		

VIDECON TUBE TYPE P 863 B English Electric £20.00

TRANSISTORS 12½% Please add VAT 12½% for valves, etc.

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AAZ12-BAV10	AF186	BCY72	GET116	OC35	OC204	2N3638A
AC113	AF239	BF115	GEX66	OC36	OC206	2N3730
AC126	AFZ12	BF167	NKT222	OC42	ZR11	2N3819
AC127	ASY26	BF173	NKT304	OC44	ZR21	2N4038
AC128	ASY27	BF185	NKT404	OC45	ZR22	2N4058
AC176	ASY28	BFY51	OA5	OC70	2N456A	2N4061
ACY17	BC107	BFY52	OA47	OC73	2N525	2N4172
ACY18	BC108	BSY27	OP70	OC75	2N696	2N5295
ACY19	BC109	BSY38	OA71	OC78	2N708	3N126
ACY20	BC113	BSY95A	OA73	OC78D	2N918	3N128
ACY39	BC116	BY100	OA79	OC81	2N1305	3N154
ACY40	BC118	BYZ16	OA91	OC82	2N1307	3N159
AD149	BC136	CRS1/20	OA200	OC82DM	2N1309	SX754
AD161	BC137	CRS1/30	OA202	OC83	2N2062	2S303
A0162	BC148A	CRS3/10	OAZ200	OC83B	2N2411	T12082
ADZ11	BC172	CRS3/20	OC22	OC139	2N2989	40235
ADZ12	BC172A	CRS3/30	OC25	OC140	2N3053	40250
AF114	BC212A	CRS3/40	OC26	OC170	2N3054	40251
AF115	8CY31	CRS25/025	OC28	OC172	2N3055	IN23A
AF116	BCY33	GET115	OC29	OC200	2N3391	IN25
AF117						IN38A
AF118						IN43
AF124						IN70
AF125						IN677
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AF139						
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6SQ7	0.60
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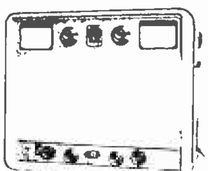

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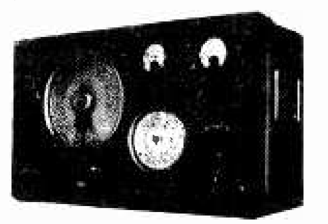

TF 801D/1/S SIGNAL GENERATOR. Range 10-485MHz in 5 ranges R F output 0.1uV-1V Source C M Dial calibrated in volts, decibels and power relative to thermal noise Piston type attenuator 50Ω output impedance Internal modulation at 1KHz at up to 90% depth also external sine and pulse modulation Built in 5MHz crystal calibrator Separate RF and mod meters P O A

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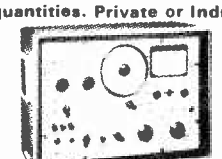

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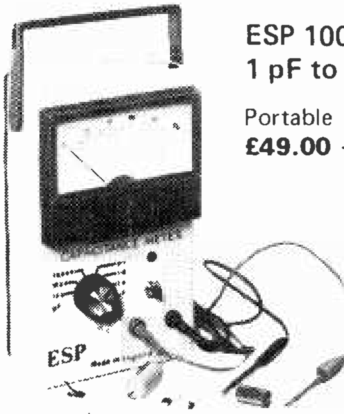

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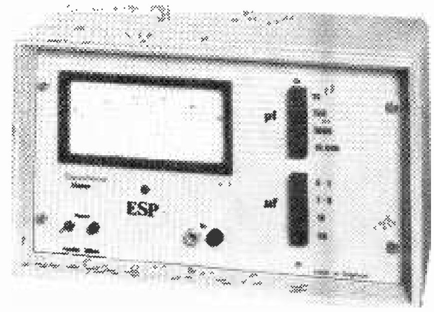

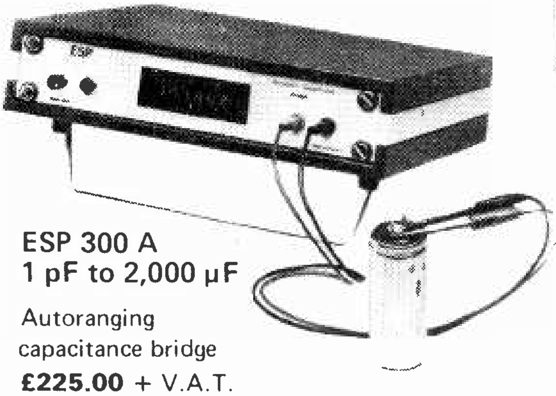

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SOLARTRON VARIABLE POWER UNIT S.R.S. 1535: 0-500 volts at 100 mA and 6.3 volts C.T. 3 amps d.c. 110/250 volts a.c. input. **£18.50.** Carr. £1.50.
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ADVANCE A.F. SIGNAL GENERATORS H1: Sinesoidal or square wave output. 15-50kHz. Adjustable level between 200 uv and 20v. Overall distortion less than 1%. Output adjustable 1.4mV-140v. Waveform ratio 50:50 up to 25kHz. Standard a.c. mains input Secondhand condition. **£25.00.** Carr. £2.00.
POWER UNIT: 110/230v. a.c. input, 28v. d.c. @ 40 amps output. **£30.00.** Carr. £3.00.
SMOOTHING UNIT: (for the above Power unit) **£10.00.** Carr. £2.00.
CLASS 'D' WAVEMETER NO. 1: Crystal controlled heterodyne frequency meter covering 2-8 MHz. Power supply 6V d.c. Good secondhand condition. **£8.50.** Carr. £1.50.

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PRECISION PHASE DETECTOR TYPE 205: Freq. 0.1-15MHz in 5 ranges. Variable time delay microseconds 0-0.1c, 115V input. **£55** each. Carr. £1.
RING TOROIDAL DUST CORES: Size 2½" outside 1¾ inside 5/16" thick. Box of two **£1.00.** Post 30p.
MUIRHEAD PHASEMETER TYPE D729: A.M. **£95.00.** Carr. £3.00.
CT.420 SIGNAL GENERATOR: 200-8000c/s Variable tuning. Two fixed frequencies 9000 and 10,000. Internal calibrator 100 & 500 c/s. **£75** each carr. £2.
NOISE GENERATOR TF-1106: Frequency 1 to 200 Mc/s Direct noise factor calibration. Output impedance 70 ohms **£65** each. Carr. £1.50.
MW-59 UNIVERSAL KLYSTRON POWER SUPPLY: £85. Carr. £3.
TF-1278/1 TRAVELLING TUBE WAVE AMPLIFIER: £125. Carr. £2.
BPL A.C. MILLIVOLTMETER TYPE VM.348-D Mk. 3: 2 millivolts-2 volts, 6 ranges. **£30.** Carr. £1.
CAWKELL REMSCOPE TYPE 741 : Memory scope, 'as new' cond. **£150.00.**
MANSON SYNTHESISER O115-URC: 2-30 mc/s. **£175.00.**
FIREPROOF TELEPHONES: £25.00 each, carr. £1.50.
BACKWARD WAVE OSCILLATOR TYPE SE-125: 6.3 heater, 105V Anode, 7.9mA. Mnfr. Watkins & Johnson. **£85** each. Carr. £1.
X-BAND MODULATOR CALIBRATOR TYPE MC-4420-X: Mnfr. James Scott. **£125** each.Carr. £1.
ROTARY INVERTERS: TYPE PE.218E — input 24-28V d.c., 80 Amps. 4,800 rpm. Output 115V a.c. 13 Amp 400 c/s. 1Ph. P.F.9. **£20.00** each. Carr. £2.50.
FREQUENCY METER BC-221: 125-20,000 Kc/s complete with original calibration charts. Checked out, working order. **£21.00 + £1.50** carr.
RECTIFIER UNIT: 200-250v a.c. input, **24v** d.c. @ 26 amps output continuous rating. **£35.00** each. Carr. £5.00.
EVERSHED SAFETY OHM. METER: Max 10Ma. Test pressure 30v. Complete in leather case. **£25.00** each, post £1.00.
AUTOMATIC VOLTAGE STABILIZERS: Input 207-242v a.c. Output 230v a.c. at 2.80 amps. **£17.50,** carriage £1.50.
AVO TRANSISTOR ANALYSER CT.446: £35.00. Carr. £2.00.
HEWLETT PACKARD PULSE GENERATOR Type 215A; 1kHz-1mHz Pulse width 0-110 Nsecs. Attenuator 0-12db. **£75.00.** Carr. £2.00.
ADVANCE TCD.40 FREQUENCY DIVIDER: 0-40mHz. **£10.00** each. Post £1.00.
MARCONI FREQUENCY METER 1026/4: 2000-4000mHz 'as new' condition. **£30.00,** or secondhand **£22.50.**
1026/2: 0-100 mHz **£30.00** 'as new', or s/hand **£22.50.** Carriage for all types £2.00.
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VALVES

AZ31	1.00	ECH84	0.50	HLD41DD	0.70	PL504	0.85	VR150/30	0.45	6SL7GT	0.55	35Z4GT	0.70
AZ41	0.70	ECL80	0.60	HN309	1.50	PL508	0.90	YR3	1.25	6SN7GT	0.55	50C5	0.70
CBL31	1.40	ECL82	0.42	KT61	3.40	PL509	1.55	1R5	0.50	6U4GT	0.75	50CD6G	1.20
CL33	1.50	ECL86	0.55	KT66	3.40	PL801	1.00	1S5	0.40	6U5G	1.50	80	0.75
CY31	1.00	ECLL800	3.50	KT81 (7C5)	2.00	PL802	2.00	1T4	0.40	6V6GT	0.60	807	1.00
DAF91	0.40	EF37A	1.50	KT88	4.00	PY32	0.63	3S4	0.50	6X4	0.45	6080	3.80
DAF96	0.60	EF39	1.25	KTW61	1.50	PY33	0.63	3V4	0.85	6X5GT/G	0.55	6146	3.80
DCC90	1.35	EF41	0.75	KTW62	1.50	PY81/800	0.50	5R4GY	1.20	7B6	0.80	6146A	3.80
DF91	0.40	EF55	1.50	N78	7.50	PY82	0.45	5U4G	1.25	7B7	0.80	6146B	4.20
DF96	0.60	EF80	0.35	OA2	0.45	PY83	0.50	5V4G	0.65	7C5	2.00	**TUBES**	
DK91	0.50	EF85	0.45	OB2	0.45	PY500	1.10	5Y3GT	0.65	7C6	1.00	2BP1	4.00
DK92	1.00	EF86	0.50	OZ4	0.55	PY801	0.55	5Z4G	0.95	7H7	0.80	3BP1	4.50
DK96	0.75	EF89	0.35	PC86	0.65	SP41	3.00	6/30L2	0.90	7R7	1.30	3DP1A	4.00
DL92	0.50	EF91	0.40	PC88	0.65	SP61	0.85	6AL5	0.30	7S7	2.25	3EG1	8.00
DL94	0.85	EF92	0.50	PC900	0.55	T41	1.50	6AQ5	0.50	7Y4	0.80	3FP7	2.00
DL96	0.55	EF98	0.80	PCC84	0.45	U25	1.00	6AS7G	1.00	12AC6	0.80	3GP1	5.00
DM70	0.70	EF183	0.40	PCC89	0.55	U26	0.85	6AT6	0.60	12AD6	0.80	5BP1	8.00
DY86/7	0.45	EF184	0.40	PCC189	0.65	U191	0.75	6AU6	0.40	12AE6	0.75	5CP1	5.00
DY802	0.47	EH90	0.60	PCF80	0.40	U404	0.75	6AV5	0.50	12AT6	0.45	88D	15.00
EABC80	0.38	EL33	3.00	PCF86	0.65	U801	1.18	6BA6	0.38	12AT7	0.45	CV429	27.50
EAF42	0.70	EL34	0.70	PCF801	0.60	UABC80	0.40	6BE6	0.45	12AU6	0.50	DG7-5	18.00
EAF801	0.75	EL37	3.40	PCF802	0.55	UAF42	0.75	6BH6	0.75	12AU7	0.38	VCR138	10.00
EBC33	1.00	EL41	0.90	PCF805	0.90	UBC41	0.60	6BJ6	0.75	12AX7	0.38	VCR139A	8.00
EBC41	0.75	EL42	1.65	PCF806	0.80	UBF80	0.50	6BQ7A	0.55	12BA6	0.50		
EBC81	0.40	EL84	0.35	PCF808	1.00	UBF89	0.50	6BR7	3.00	12BE6	0.60		
EBF80	0.40	EL91	2.00	PCL82	0.45	UCC85	0.50	6BW6	1.00	12BH7	0.60		
EBF83	0.40	EL95	0.60	PCL83	0.70	UCH42	0.80	6BW7	1.00	30C15	1.00		
EBF89	0.32	EL360	1.75	PCL84	0.50	UCH81	0.50	6C4	0.40	30C17	1.00		
EBL31	2.00	EM80	0.55	PCL85	0.60	UCL82	0.40	6DC6G	1.60	30C18	0.90		
ECC40	1.00	EM81	0.60	PCL86	0.50	UCL83	0.70	6CH6	2.20	30F5	1.00		
ECC81	0.45	EY51	0.45	PD500	1.50	UF41	0.75	6E5GT	1.50	30FL1	1.00		
ECC82	0.38	EY86	0.50	PEN45DD	0.75	UF89	0.50	6F23	0.90	30FL14	1.00		
ECC83	0.38	EZ40	0.60	PFL200	0.70	UL41	0.85	6J5G	0.45	30L15	0.95		
ECC85	0.45	EZ41	0.75	PL36	0.63	UL84	0.50	6J5GT	0.55	30L17	0.95		
ECC88	0.50	EZ80	0.30	PL38	1.25	UY41	0.55	6J7GT	0.45	30P12	1.00		
ECF80	0.45	EZ81	0.31	PL81	0.55	UY85	0.45	6K6GT	0.80	30P19	0.95		
ECF82	0.45	EZ90	0.45	PL82	0.50	VP4B	1.25	6K7GT	0.35	30PL1	0.95		
ECH35	1.50	GY501	0.90	PL83	0.50	VR75/30	0.55	6K8GT	0.50	30PL13	1.10		
ECH42	0.85	GZ30	0.65	PL84	0.50	VR105/30	0.40	6P25	3.00	30PL14	1.10		
ECH81	0.35	GZ32	0.65	PL500	0.85			6Q7GT	0.43	35L6GT	0.80		
ECH83	0.50	GZ34	0.75					6SG7	0.50	35W4	0.60		
		H63	0.90					6SJ7GT	0.30	35Z3	0.80		

TRANSISTORS & ICs

AA119	0.07	BF180	0.30	OC44	0.45	2N706A	0.12	40360	0.40	SN7483	1.10
AAZ13	0.10	BF181	0.30	OC45	0.45	2N1131	0.23	40361	0.45	SN7484	1.00
AAZ15	0.12	BF194	0.10	OC71	0.25	2N1132	0.25	40362	0.40	SN7486	0.47
AC107	0.75	BF195	0.10	OC72	0.45	2N1302	0.30	40430	0.85	SN7490	0.55
AC126	0.25	BF197	0.12	OC76	0.45	2N1303	0.40	SN7400	0.16	SN7491AN	1.00
AC127	0.25	BF200	0.32	OC77	0.75	2N1304	0.45	SN7401	0.16	SN7492	0.70
AC128	0.22	BFS61	0.25	OC81	0.50	2N1305	0.45	SN7402	0.16	SN7493	0.70
AC176	0.25	BFS98	0.25	OC81D	0.28	2N1306	0.50	SN7403	0.16	SN7494	0.80
AC187	0.25	BFW10	0.61	OC81Z	1.00	2N1307	0.50	SN7404	0.26	SN7495	0.80
AC188	0.25	BFX29	0.28	OC83	0.55	2N1308	0.50	SN7405	0.22	SN7496	0.95
ACY21	0.55	BFX88	0.25	OC140	1.50	2N1309	0.50	SN7406	0.42	SN7497	3.87
ACY39	1.00	BFY50	0.21	OC170	0.50	2N1613	0.21	SN7407	0.42	SN74100	1.89
AD140	0.65	BFY51	0.21	OC171	0.50	2N1614	0.45	SN7408	0.28	SN74107	0.45
AD149	0.65	BFY52	0.23	OC200	1.00	2N2147	1.20	SN7409	0.28	SN74110	0.58
AD161	0.45	BR100	0.40	OC201	1.75	2N2160	0.75	SN7410	0.16	SN74111	0.86
AD162	0.45	BY100	0.45	OC202	1.50	2N2369A	0.25	SN7411	0.25	SN74118	0.90
AF115	0.25	BY126	0.12	OC203	1.50	2N2646	0.50	SN7412	0.30	SN74119	1.68
AF116	0.25	BY127	0.12	OCP71	1.25	2N2904	0.25	SN7413	0.36	SN74121	0.50
AF117	0.25	BFX61 series	0.20	ORP12	0.60	2N2904A	0.25	SN7416	0.36	SN74122	0.70
AF186	1.80	BZY88 series	0.12	ORP60	0.65	2N2905	0.30	SN7417	0.36	SN74123	1.00
AF239	0.45	CRS1-05	0.45	TIC44	0.30	2N2905A	0.25	SN7420	0.16	SN74141	0.90
ASY27	0.45	CRS1-40	0.60	TIC226D	1.40	2N2906	0.22	SN7422	0.25	SN74145	1.26
ASY28	0.25	CRS3-05	0.45	TIL209	0.22	2N2926	0.15	SN7423	0.37	SN74150	1.75
BA102	0.25	CRS3-40	0.75	ZTX107	0.10	2N3053	0.20	SN7425	0.37	SN74151	1.00
BA115	0.15	MJE340	0.42	ZTX108	0.10	2N3055	0.60	SN7427	0.37	SN74154	2.00
BC107	0.14	MJE370	0.65	ZTX300	0.12	2N3525	0.90	SN7428	0.40	SN74155	1.00
BC108	0.14	MJE520	0.60	ZTX301	0.13	2N3614	1.00	SN7430	0.16	SN74156	1.00
BC109	0.15	MJE2955	1.25	ZTX302	0.17	2N3615	1.10	SN7432	0.37	SN74157	0.95
BC113	0.15	MJE3055	0.75	ZTX304	0.22	2N3702	0.13	SN7433	0.37	SN74170	2.52
BC117	0.22	MPF102	0.40	ZTX500	0.12	2N3703	0.13	SN7437	0.37	SN74174	1.57
BC143	0.30	MPF103	0.40	ZTX501	0.13	2N3704	0.15	SN7438	0.37	SN74175	1.10
BC147	0.10	MPF104	0.40	ZTX503	0.16	2N3705	0.13	SN7440	0.22	SN74176	1.26
BC148	0.08	MPF105	0.40	ZTX531	0.25	2N3706	0.13	SN7441AN	0.79	SN74190	2.00
BC169C	0.15	NE555	0.42	ZTX550	0.18	2N3707	0.13	SN7442	0.79	SN74191	2.00
BC182	0.12	NKT404	1.25	IN914	0.06	2N3708	0.09	SN7450	0.16	SN74192	2.00
BC182L	0.12	OA5	0.75	IN4001	0.07	2N3709	0.12	SN7451	0.16	SN74193	2.00
BC184L	0.13	OA10	0.55	IN4002	0.07	2N3710	0.13	SN7453	0.16	SN74194	1.30
BCY32	1.00	OA79	0.12	IN4003	0.08	2N3711	0.13	SN7454	0.16	SN74195	1.10
BCY33	0.70	OA81	0.15	IN4004	0.08	2N3819	0.37	SN7460	0.16	SN74196	1.20
BCY34	0.75	OA91	0.07	IN4005	0.09	2N3820	0.55	SN7470	0.35	SN74197	1.20
BCY70	0.18	OA200	0.10	IN4006	0.10	2N3823	0.60	SN7472	0.38	SN74198	2.77
BCY71	0.22	OA202	0.10	IN4007	0.11	2N3903	0.15	SN7473	0.41	SN74199	2.52
BCY72	0.12	OC16	1.25	IN4009	0.08	2N3904	0.15	SN7474	0.42		
BCZ11	1.25	OC20	2.00	IN4148	0.06	2N3905	0.17	SN7475	0.59		
BD121	1.55	OC23	2.25	IS921	0.08	2N3906	0.17	SN7476	0.45		
BD124	0.75	OC25	0.65	IS2033	0.20	2N4058	0.16	SN7480	0.60		
BD131	0.40	OC28	0.75	IS2051A	0.20	2N4059	0.12	SN7482	0.87		
BD132	0.45	OC35	0.75	IS2100A	0.20	2N4060	0.13				
BF115	0.20	OC36	0.75	IS3010	0.25	2N4061	0.13				
BF167	0.20	OC42	0.50	2N696	0.20	2N4062	0.14				
BF173	0.25			2N697	0.17	2N4289	0.30				
BF179	0.30			2N706	0.12	3N141	0.80				

DIL SOCKETS 8 pin 12p, 14 pin 15p, 16 pin 17p

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1B3GT, 1B24, 1B35A, 1B63A, 1N21, 1N21B, 1N23B, 1N23CR, 1X2A, 1X2B, 2A3, 2AS15, 2C26A, 2C34, 2C39A, 2C43, 2D21, 2D21W, 2E26, 2J31, 2J33, 2J50, 2J54, 2J56A, 2K25, 2K26, 2K28, 2K45, 2X2A, 3A/107A, 3A/108A, 3A/108B, 3A/109B, 3A/110A, 3A/110B, 3A/146J, 3A/167M, 3A5, 3B/240M, 3B/241M, 3B24, 3B28, 3B29, 3C22, 3C23, 3C24/24G, 3C45, 3CX100A5, 3E29, 3J/121E, 3J/160E, 3J/170E, 3Q/150E, 3Q/195E, 3S4, 3V/340B, 3V/390A, 3V/390B, 4-125A, 4-250A, 4-400A, 4B32, 4C35, 4CX250B, 4E27, 4J50, 4J52, 4J52A, 4J53, 4X150A, 4X150D, 4X250B, 5B/251M, 5B/252M, 5B/254M

5B/255M, 5B/256M, 5B/257M, 5C22, 5D21, 5R4GY, 5U4GB, 5Z3, 5Z4G, 6AF4A, 6AK5, 6AM5, 6AM6, 6AN5, 6AN8, 6AR5, 6AS6, 6AU4GTA, 6AU5GT, 6AU6, 6AV5GTA, 6AW8A, 6AX5GT, 6B4G, 6BA8A, 6BK4, 6BK7A, 6BL7GTA, 6BN6, 6BR7, 6BS7, 6BX7GT, 6BZ6, 6CB6, 6CH6, 6CL6, 6CW4, 6DK6, 6DQ6B, 6EA8, 6F33, 6H6(metal), 6K7GT, 6U8A, 6V6GT, 11E3, 11E13, 12AY7, 12B4A, 12BY7A, 12E1, 12E14, 13E1, 28D7, 29C1, 53KU, 75B1, 75C1, 83A1, 85A1, 85A2, 90AG, 90AV, 90C1, 90CG, 90CV, 95A1, 100TH, 150B2, 150B3, 150C1, 150C2, 150C3, 150C4, 250TH, 328, 329

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CV3986, CV3988, CV3991, CV3998, CV4001, CV4002, CV4003, CV4004, CV4005, CV4006, CV4007, CV4008, CV4009, CV4010, CV4011, CV4012, CV4013, CV4014, CV4015, CV4016, CV4017, CV4018, CV4019, CV4020, CV4022, CV4023, CV4024, CV4025, CV4028, CV4033, CV4035, CV4038, CV4039, CV4040, CV4056, CV4059, CV4060, CV4062, CV4063, CV4064, CV4079, CV4501, CV4502, CV4503, CV4504, CV4507, CV4508, CV5060, CV6004, CV6008, CV6045, DA30, DA41, DA42, DA100, DET22, E55L, E80CC, E80FC, E80F, E80L, E80T, E81CC, E81L, E82CC, E83CC, E83F, E88CC, E90CC, E90L, E91H, E92CC, E180CC, EA50, EA52, EA76, ECC35, ECF804, EF50

EF54, EF55, EF804, EFP60, EL91, EN30, EN31, EN32, EN91, ESU74, ESU76, ESU77, F6057, F6060, F6061, F6063, FX219, FX225, FX227, G1/371K, G120/1B, G150/2B, G180/2M, G240/2D, G400/1K, GN4, GT1C, GTR120W, GTR150MS, GU18, GU20/21, GU50, GXU1, KT66, KT67, KT88, M8079, M8080, M8081, M8082, M8083, M8091, M8096, M8097, M8098, M8100, M8136, M8137, M8140, M8141, M8142, M8144, M8149, M8157, M8161, M8162, M8163, M8167, M8179, M8190, M8196, M8204, M8212, M8214, M8223, M8224, M8225, M8232, M8237, M8245, ME1400, ME1401, OA2, OA3, OA4G, OB2, OB3

OD3, OG3, OZ4, OZ4A, PT15, QA2400, QA2403, QA2404, QA2406, QA2407, QB3/300, QB3-5-750, QB4-1100, QF41, QF45, QQV02 6, QQV03 10, QQV03 20, QQV03 20A, QQV04 15, QQV06 40, QQV06 40A, QS70/20, QS75/20, QS75/40, QS75/60, QS83/3, QS92/10, QS95/10, QS105/45, QS150/40, QS150/45, QS150/80, QS1200, QS1202, QS1203, QS1205, QU37, QV03-12, QV04-7, QV05-25, QV06 20, QY3 125A, QY4 250A, QY4 400A, R10, R17, R18, S11E12, S130, S130P, STV280/40, STV280/80, SU41, SU42, TD03-10, TT15, TT21, TTR31MR, TZ40, U17, U19, U27, VLS631, Z300T, Z759, Z803U

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VALVES & PLASTIC TRANSISTORS 12½%
INTEGRATED CIRCUITS 8% AND METAL CAN TRANSISTORS 8%

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OSCILLOSCOPE TUBES
TYPE VCR 139A, CV 1526
Price £8.00 P&P 50p add VAT 8%
SPECIAL OFFER

Terms of Business: Mon. to Fri. Open for callers 9 a.m. to 5 p.m. Closed Sat. Express postage 15p for 1st valve; 2p each additional valve. Express postage: 15p per order for transistors. Prices on application for any type not listed. Obsolete valves a speciality. Prices correct when going to press. This applies to the U.K.

THE OPEN DOOR TO QUALITY

This catalogue — Electrovalue Catalogue No. 8 (Issue 2, up-dated) offers items from advanced opto-electronic components to humble (but essential) washers. Many things listed are very difficult to obtain elsewhere. The company's own computer is programmed to expedite delivery and maintain customer satisfaction. Attractive discounts are allowed on many purchases; Access and Barclaycard orders are accepted.

144 pages
40p
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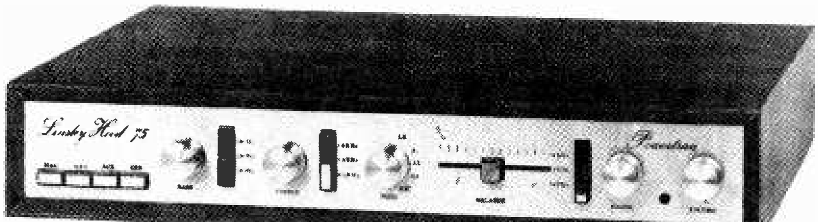
POWERTRAN ELECTRONICS
INCORPORATING
AMBIENTACOUSTICS

HI-FI NEWS 75W/CHANNEL AMPLIFIER



By J. L. Linsley Hood

In Hi-Fi News there was published by Mr. Linsley-Hood a series of four articles (November, 1972-February, 1973) and a subsequent follow-up article (April, 1974) on a design for an amplifier of exceptional performance which has as its principal feature an ability to supply from a direct coupled fully protected output stage, power in excess of 75 watts whilst maintaining distortion at less than 0.01% even at very low power levels. The power amplifier is complemented by a pre-amplifier based on a discrete component operational amplifier referred to as the Liniac which is employed in the two most critical points of the system, namely the equalization stage and tone control stage, positions where most conventional designs run out of gain at the extremes of the frequency spectrum. Unusual features of the design are the variable transition frequencies of the tone controls and the variable slope of the scratch filter. There is a choice of four inputs, two equalized and two linear, each having independently adjustable signal level. The attractive slimline unit pictured has been made practical by highly compact PCBs and a specially designed Toroidal transformer.

Pack	Price
1. Fibreglass printed-circuit board for power amp	£1.15
2. Set of resistors, capacitors, pre-sets for power amp	£2.15
3. Set of semiconductors for power amp	£6.50
4. Pair of 2 drilled, finned heat sinks	£1.10
5. Fibreglass printed-circuit board for pre-amp	£1.75
6. Set of low noise resistors, capacitors, pre-sets for pre-amp	£3.40
7. Set of low noise, high gain semiconductors for pre-amp	£2.40
8. Set of potentiometers (including mains switch)	£3.15
9. Set of 4 push-button switches, rotary mode switch	£4.50
10. Toroidal transformer complete with magnetic screen/housing primary 0 117-234 V; secondaries: 33-0-33 V, 25-0-25 V	£10.95
11. Fibreglass printed-circuit board for power supply	£0.85
12. Set of resistors, capacitors, secondary fuses, semi-conductors for power supply	£4.60
13. Set of miscellaneous parts including DIN skts, mains input skt, fuse holder, inter-connecting cable, control knobs	£5.35
14. Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc.	£7.30
15. Handbook	£0.30
16. Teak cabinet 18.3" x 12.7" x 3.1"	£9.85

2 each of packs 1-7 inclusive are required for complete stereo system. Total cost of individually purchased packs £83.75

FREE TEAK CASE WITH FULL KITS

KIT PRICE ONLY **£73.90**

WIRELESS WORLD FM TUNER

Designed in response to demand for a tuner to complement the world-wide acclaimed Linsley Hood 75W Amplifier, this kit provides the perfect match. The Wireless World published original circuit has been developed further for inclusion into this outstanding slimline unit and features a pre-aligned front end module, excellent a.m. rejection and temperature compensated varicap tuning, which may be controlled either continuously or by push button pre-selection. Frequencies are indicated by a frequency meter and sliding LED indicators, attached to each channel selector pre-set. The PLL stereo decoder incorporates active filters for "birdy" suppression and power is supplied via a toroidal transformer and integrated regulator. For long term stability metal oxide resistors are used throughout

Pack	Price
1. Fibreglass printed board for front end IF strip, demodulator, AFC and mute circuits	£2.15
2. Set of metal oxide resistors, thermistor, capacitors, cermet preset for mounting on pack 1	£4.30
3. Set of transistors, diodes, LED, integrated circuits for mounting on pack 1	£5.25
4. Pre-aligned front end module, coil assembly, three section ceramic filter	£8.50
5. Fibreglass printed circuit board for stereo decoder	£1.10
6. Set of metal oxide resistors, capacitors, cermet preset for decoder	£2.60
7. Set of transistors LED, integrated circuit for decoder	£2.90
8. Set of components for channel selector switch module including fibreglass printed circuit board, push-button switches, knobs, LEDs, preset adjusters etc.	£8.80
9. Function switch, 10 turn tuning potentiometer, knobs	£5.30
10. Frequency meter, meter drive components, fibreglass printed circuit board	£9.45
11. Toroidal transformer with electrostatic screen. Primary: 0—117V—234V	£4.45
12. Set of capacitors, rectifiers, voltage regulator for power supply	£2.95
13. Set of miscellaneous parts, including sockets, fuse holder, fuses, inter-connecting wire, etc.	£1.50
14. Set of metal work parts including silk screen printed facia panel, acrylic silk screen printed tuning indicator panel insert, internal screen, fixing parts, etc.	£7.50
15. Construction notes (free with complete kit)	£0.25
16. Teak cabinet 18.3" x 12.7" x 3.1"	£9.85

One each of packs 1-16 inclusive are required for complete stereo FM tuner. Total cost of individually purchased packs £76.85

FREE TEAK CASE WITH FULL KITS

KIT PRICE only **£66.75**

NEW KIT!
LINSLEY-HOOD CASSETTE DECK

Published in Wireless World (May, June, August 1976) by Mr. Linsley-Hood, this design, although straightforward and relatively low cost nevertheless provides a very high standard of performance. To permit circuit optimization separate record and replay amplifiers are used, the latter using a discrete component front-end designed such that the noise level is below that of the tape background. Push button switches are used to provide a choice of equalization time constants, a choice of bias levels and also an option of using an additional pre-amplifier for microphone use. The mechanism used is the Goldring-Lenco CRV, a unit distinguished in its robustness and ease of operation. Speed control and automatic cassette ejection are both implemented by electronic circuitry. This unit which is powered by a toroidal transformer and uses metal oxide resistors throughout offers an excellent match for the Wireless World Tuner and the Linsley-Hood 75 Watt Amplifier.

Pack	Price
1. Stereo PCB (accommodates 2 rep. amps, 2 rec. amps, 2 meter amps, bias/erase osc, relay)	£3.35
2. Stereo set of capitors, M.O. resistors, potentiometers for above	£9.80
3. Stereo set of semiconductors for above	£8.90
4. Miniature relay with socket	£2.45
5. PCB, all components for solenoid, speed control circuits	£3.20
6. Goldring Lenco mechanism as specified	£19.10
7. Function switch, knobs	£1.60
8. Dual VU meter with illuminating lamp	£7.20
9. Toroidal transformer with E.S. screen prim. 0-117V, 234V, Sec. 15V	£4.45
10. Set of capacitors, rectifiers, I.C. voltage regulator for power supply (Powertran design)	£2.80
11. Set of miscellaneous parts, including sockets, fuse holder, fuses, interconnecting wire, etc.	£2.50
12. Set of metalwork including silk screened facia panel, internal screen, fixing parts, etc.	£7.10
13. Construction notes	£0.25
14. Teak cabinet 18.3" x 12.7" x 3.1"	£9.85

One each of packs 1-14 inclusive are required for compete stereo cassette deck. Total cost of individually purchased packs £82.55

PRICE STABILITY

Order with confidence! Irrespective of any price changes we will honour all prices in this advertisement for two months from issue date provided that this advertisement is quoted with your order. E&OE VAT rate changes excluded. All components are brand new first grade full specification devices. All resistors (except where stated) are low noise carbon film types. All printed circuit boards are fibre-glass, drilled, roller tinned and supplied with circuit diagrams and construction layouts.

SPECIAL PRICE FOR COMPLETE SETS £78.50

Further details of above given in our FREE LIST

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SIEMENS PLESSEY. etc.
MINIATURE RELAYS

1	2	3	4	1	2	3	4
52	4–8	2c/o	85p*	700	12–24	2 c/o	85p
58	5–9	6c/o	95p*	700	16–24	4 c/o	95p*
185	8–12	6M	85p*	1250	18–36	2 c/o	85p*
230	9–18	2c/oHD	95p*	2500	36–45	6 M	85p*
430	9–24	2c/o	85p*	2500	31–43	2 c/oHD	
430	12–24	2c/o HD	85p				85p*
430	15–24	4c/o	95p*	15k	85–110	6 M	85p
600	10–20	6M	95p*	5800	33–72	2 c/o	85p*
600	10–24	2/o	85p				
600	14–24	4c/o	95p				

(1) Coil ohms; (2) Working d.c. volts; (3) Contacts; (4) Price HD = Heavy Duty. All Post Paid. (*Including Base)

OPEN TYPE RELAYS

6 VOLT D.C. 1 make con. **45p.** Post 15p

9 VOLT D.C. RELAY
3 c/o 5 amp contacts. 70 ohm coil **85p.** Post 15p

9/12 VOLT D.C. RELAY
3 c/o 5 amp contacts, available as single hole fixing or P.C. fixing, state type required **85p.** Post 15p

24 VOLT D.C. 2 HD c/o 700 ohm coil **85p.** Post 15p. 4 c/o 300 ohm coil **95p.** Post 15p

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24V D.C. 3 c/o **85p.** Post 20p. Base 15p

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240V. A.C. heavy duty 3 c/o contacts. Price **85p.** Post 20p Octal base 15p extra.

220/240 VOLT A.C. RELAY
3 c/o 5 amp cont. Sealed M.f.g. ISKRA **£1.35.** Post 20p Base 15p extra.

ARROW 230/240V AC
2 c/o 15 amp contacts. Amp connectors **£1.10.** Post 20p.

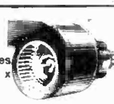
CLARE-ELLIOTT Type RP 7641 G8
Miniature relay 675 ohm coil. 24 volt D.C. 2 c/o **80p** P.P.

MANY OTHERS FROM STOCK. PHONE FOR DETAILS

LATCHING RELAY

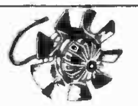
Twin latching relay, flip-flop, 2 c/o each relay. Mains contacts. 115 volts A.C. or 50 volt D.C. operation or 240 volts A.C. with 2.5K resistor **85p.** Post 20p.

PRECISION CENTRIFUGAL BLOWERS (230/240v AC)



Mfg. by Smiths Industries. Miniature model Series SF/200. Size 95mm x 82mm. Aperture 38mm x 31mm. 12 c.f.m. **£2.75.** Post 50p
Other types available, phone for details

BLOWER UNIT



200/240V a.c. precision. German built. Dynamically balanced, quiet, con. rated, reversible. Consumption 60mA. Size 120mm dia x 60mm deep. Price **£3.50.** Post 50p

Mfg. by Sracmo 115/230v A.C. 2800/3400 r.p.m. fan type aperture 3" x 2½" VBL4 25/c. Mfg. Airlow Control Installations Ltd. Price **£12.00.** Post £4.00

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12v 11 way 4 bank (3 non-bridging 1 homing) **£2.50.** P.P. 35p

230 VOLT FAN ASSEMBLY

Continuously rated, removable aluminium blades. Price **£1.25.** Post 50p.
VAT 12½%

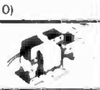
UNISELECTOR

switches 4 bank, 25 way 75 ohm coil, 36-48v D.C. operation. Ex. **new** equipment. **£4.25,** p. & p. 75p. Total price inc. VAT, **£5.40.**

MINIATURE ROLLER

M switch OMRON type V15 FL 22-1C. 10 for **£2.00** post 50p (Min. order 10)
Sub-miniature Burgess type V 4T.I. 10 for **£2.50.** 50 for **£10.00,** post paid.
LEVER OPERATED 20 amp c/o m/s Mfg. by Unimax USA. 10 for **£4.00** plus 50p p.p. (min. order 10)

230-250 VOLT A.C. SOLENOID



Similar in appearance to illustration. Approximately 1½lb. pull. Size of feet 1⅜" 1 3/16". Price **£1.00.** Post 25p.

SOLENOID HEAVY DUTY MODEL

230/250v A.C. Apprx. 10lb. pull, 4" long x 2⅜" wide x 3" high. **£2.50.** Post 50p

24 VOLT D.C. SOLENOIDS

UNIT containing: 1 heavy duty solenoid approx. 25 lb. pull at 1 in. travel, 2 solenoids of approx. 1 lb. pull at ½ in. travel. 6 solenoids of approx. 4 oz. pull at ½ in. travel. Plus 1 24V D.C. 1 heavy duty 1 make relay. Price **£3.00.** Post £1.00. **ABSOLUTE BARGAIN**

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PRICE **£2.75.** Post 50p. NEW original packing.

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Carriage extra

INPUT 230 v. A.C. 50/60
OUTPUT VARIABLE 0/260v. A.C.
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200W (1 Amp) fitted A/C volt meter **£11.50**
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0.10, 17, 18 volt @ 10 amp **£10.45** Post £1.00
0.6, 12 volt @ 20 amp **£13.00** Post £1.00
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0.4, 6, 24, 32 volt @ 12 amp **£12.35** Post £1.00
0.6, 12, 17, 18, 20 volt @ 20 amp **£14.15** post £1.00
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At 75 watt **£3.60** Post 40p. 150 watt **£5.15** Post 50p. 300 watt **£6.20** Post 60p. 500 watt **£11.00** Post 75p. 1000 watt **£16.20** Post 90p.

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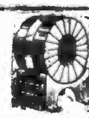

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These multi-purpose Auto Transformers with large centre aperture, can be used as a Double wound current Transformer. Auto Transformer. H.T. or L.T. Transformer, by simply hand winding the required number of turns through the centre opening.
E.g. Using the RT 100 V.A. Model the output could be wound to give 8V @ 12½ Amp., 4V @ 25 Amp. or 2V @ 50 Amp., etc. Price
RT 100VA 3.18 turns per volt. **£5.00.** Post 75p
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Latest type Xenon white light tube. Solid state timing and triggering circuit. 230/240 volt A.C. operation. Speed adjustable 1-20 f.p.s. Designed for large rooms, halls, etc. Light output greater than many (so called 4 Joule) strobes. Price **£15.40.** Post 75p. Specially designed case and reflector **£8.25.** Super high light approx. 4 times more output. S.a.e. for leaflet.
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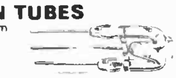

Range of Xenon tubes available from stock. S.A.E. for full details.

ULTRA VIOLET BLACK LIGHT FLUORESCENT TUBES

4ft. 40 watt £6.00 (callers only). **2ft. 20 watt £4.60.** Post 60p. (For use in stan bi-pin fittings). MINI **12in. 8 watt £1.75.** Post 25p. **9in. 6 watt £1.40.** 6in. 4 watt **£1.40.** Post 25p. Complete ballast unit and holders for either 9" or 12" tube **£2.50.** Post 30p (9" x 12" measures approx.)

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400W Mercury Vapour Ultra Violet Lamp. Powerful source of UV. P.F. ballast unit is essential with this lamp. Price of bulb and matched ballast unit. **£28.** Post £2. Spare bulb only **£10.** Post 80p.

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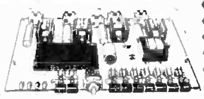

A new conception in light control. Four channels each capable of handling 750 watts of spotlights, floodlights or dozens of small mains lamps. Seven programs all speed controlled plus flash modulation, effectively giving 14 different displays. Makes sound-to-light obsolete. Completely electrically and mechanically noise free.
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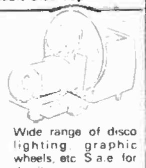

200/240V a.c. 50Hz 150W lamp, complete with oil filled colour wheel and motor plate. Takes intachange accessories and full range of lenses. £29.95. Post £1.35 (Total inc. VAT & Post **£33.70**).

Wide range of disco lighting, graphic wheels, etc. S.a.e. for details.

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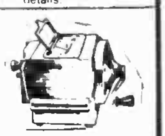

Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L. 8 in., W. 4 in. H. 6 in., weight 6 lb.
500 VOLTS 500 megohms **£40.00** Post 80p
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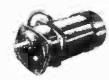
100 R.P.M. 115 lbs. ins.!!

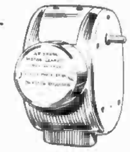


115 lb. ins. 110 volt, 50Hz, 2.8 amp, single phase, split capacitor motor. Immense power. Continuously rated. Totally enclosed. Fan cooled. In-line gearbox. Length 250mm. Dia. 135mm. Spindle Dia. 15.5mm. Length 145mm. ex-equipment tested **£12.00.** Post £1.50. Suitable transformer 230/240 volt **£8.00.** Post 75p.

15 R.P.M.

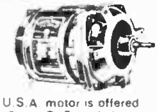
Type S048 15 r.p.m. 80 lb. ins. Input 100/120 volt A.C. Length incl. gearbox 270mm. Height 135mm. Width 150mm. Shaft drive 16mm. Weight 8.5 Kilos. BRAND NEW. Price **£10.00,** carr. £1.00. Suitable transformer for use on 220/240 volt A.C. **£3.85.** Post 50p

DRAYTON MOTOR



Type RQR 230/250v 50c. Continuously rated 1 RPM. 90lb. in. Reversible motor is fitted with limit switch for 160° angular reversible rotation if required. Twin spindle size 100mm by 140mm by 125mm. Shaft 50mm by 8mm. Weight 2 kilos. **New** Price **£16.50** p&p £1.00

BODINE TYPE N.C.I. GEARED MOTOR



(Type 1) 71 r.p.m. torque 10 lb. in. **Reversible** 1/70th h.p. cycle 38 amp. This U.S.A. motor is offered in as new condition. Input voltage of motor 115v. **A.C.** Supplied complete with transformer for **230/240v A.C. input.**
Price, type **£6.25.** Post 75p or less transformer **£3.75.** Post 65p
(Type 3) 71 r.p.m. 230 Volt A.C.
Continuously rated. Non reversible. £6.50 Post 75p

6/9 VOT D.C. GOVERNED 40mm x 40mm. Spindle 10mm. Dia. 2mm **£1.00.** Post Paid. Two for **£1.65.** Post Paid

24 R.P.M. 230 volt A.C. Continuously rated. Mfg. Mycalex Ex-equip. Fully tested **£3.85.** Post 75p

1 R.P.M. 230/240 VOLT A.C. SYNCHRONOUS!! Ex-equipment. Thoroughly tested and guaranteed **ONLY £1.50.** Post 20p

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General Electric 230v A.C. 1,600 r.p.m. 0.25 amp. Complete with anti-vibration mounting bracket and capacitor. O/A size 110mm x 95mm. Spindle 5/16" dia. 20mm long. Ex-equipment tested **£3.00.** Post 50p.

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90mm Diameter

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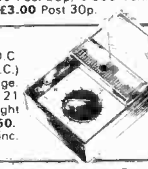

MULTI RANGE METER. A.C. volts 2.5-500 D.C. volts 2.5-500 (Sensitivity 2000Ω/V D.C. & A.C.) D.C. current 0/1/10/100 mA. Ohms range. Sturdy compact moving coil instrument with 21 ranges, dimensions 120 x 80 x 44mm. Weight 0.32 kg. SERVICE TRADING 00. Price **£5.50.** Incl. leads and battery. Post 50p (Total price inc. VAT & Post **£5.94**).

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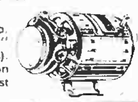

Carbon vane, oil-less 100/115V A.C. 1/12 h.p. motor 50/60 cycle. 2875/3450 r.p.m. 20" vacuum 1.25 c.f.m. 10 p.s.i. (approx. figures). New unused surplus stock with elect connection data. Fraction of maker's price. **£12.00.** Post £1.00. Suitable transformer **£3.50.** Post 50p.

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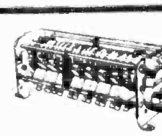
Black Silver Skirted knob calibrated in Nos. 1-9, 1½ in. dia brass bush. Ideal for above Rheostats, **22p ea.**

PROGRAMME TIMERS



230 Volt AC Operation. 15 or 20 r.p.m. Each cam operates a c/o micro switch. Ideal for lighting effects, displays, etc. Ex equip. tested. Similiar to illustration.
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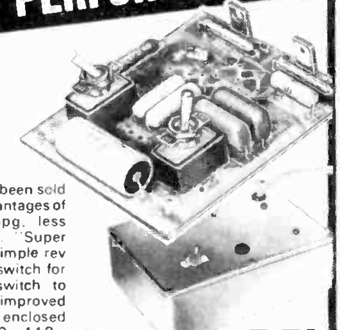

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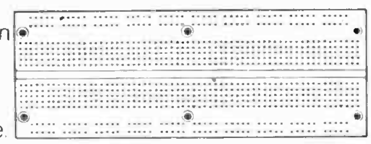

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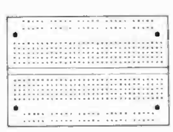

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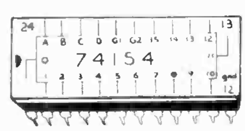

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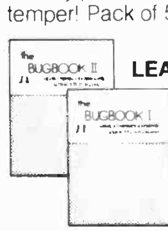

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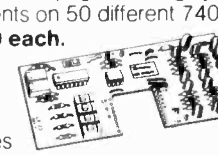

LR25. A useful control package for digital circuits on SK10/SK50 sockets. Generates pulses. Monitors outputs. 8 LED indicators. 4 logic switches. 2 pulsers. Variable frequency clock. **£41.75.**

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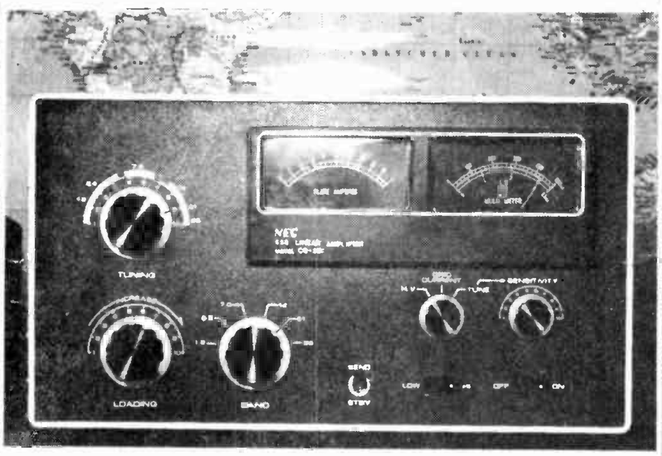
NEC CQ 301



allband HF, 3KW, linear amplifier, 160/80/40/20/15/11/10 meter, for modern amateur communication. Two EIMAC 3-500 Z triodes, in zero bias grounded grid application guarantee long trouble free communication. The NEC CQ 301 can be driven by our CQ 110E or other exciters capable of about 50-100 watts of drive. AC power supply 100-235 volts is built in of course.
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152	250	**11.87**	1.53
153	350	**14.34**	1.53
154	500	**16.48**	1.79
155	750	**25.23**	BRS
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*115 or 240 sec only

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Primary 220-240 Volts

Ref	Amps 12v	Amps 24v	£	P&P
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213	1.0	0.5	**2.14**	.65
71	2	1	**2.77**	.65
18	4	2	**3.42**	.80
70	6	3	**5.09**	.80
108	8	4	**5.85**	.95
72	10	5	**6,33**	.95
116	12	6	**6.67**	1.10
17	16	8	**8.60**	1.10
115	20	10	**12.55**	1.73
187	30	15	**16.33**	1.73
226	60	30	**20.32**	BRS

50 VOLT RANGE
Primary 240V
SEC. TAPS 0-19-25-33-40-50V

Ref.	Amps	£	P&P
102	0.5	**3.12**	.65
103	1.0	**4.08**	.80
104	2.0	**5.69**	.95
105	3.0	**7.02**	1.10
106	4.0	**9.18**	1.25
107	6.0	**14.62**	1.37
118	8.0	**15.56**	1.73
119	10.0	**20.41**	BRS

30 VOLT RANGE
Primary 240V
SEC. TAPS 0-12-15-20-25-30V

Ref.	Amps	£	P&P
112	0.5	**2.27**	.65
79	1.0	**2.90**	.80
3	2.0	**4.34**	.80
20	3.0	**5.41**	.95
21	4.0	**6.39**	.95
51	5.0	**7.74**	1.10
117	6.0	**8.65**	1.25
88	8.0	**11.73**	1.37
89	10.0	**11.91**	1.53

60 VOLT RANGE
Primary 240V
SEC TAPS 0-24-30-40-48-60V

Ref.	Amps	£	P&P
124	0.5	**2.85**	.80
126	1.0	**4.23**	.80
127	2.0	**6.13**	.95
125	3.0	**9.09**	1.10
123	4.0	**10.57**	1.53
40	5.0	**11.78**	1.37
120	6.0	**13.88**	1.53
121	8.0	**18.11**	BRS
122	10.0	**22.31**	BRS
189	12.0	**23.30**	BRS

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Ref.	VA Watts	AUTO TAPS	£	P&P
113	20	0-115-210-240V	**2.01**	.59
64	75	0-115-210-240V	**3.51**	.80
4	150	0-115-210-220-240V	**4.98**	.80
66	300	.. ..	**7.03**	.95
67	500	.. ..	**10.76**	1.37
84	1000	.. ..	**16.51**	1.73
93	1500	.. ..	**21.87**	BRS
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1000	250	**30.26**	BRS
2000	252	**50.74**	BRS

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Ref.	mA	Volts	£	P&P
238	200	3-0-3	**1.86**	.46
212	1A, 1A	0-6, 0-6	**2.22**	.58
13	100	9-0-9	**1.79**	.32
235	330, 330	0-9, 0-9	**1.89**	.32
207	500, 500	0-8-9, 0-8-9	**2.32**	.65
208	1A, 1A	0-8-9, 0-8-9	**3.53**	.65
236	200, 200	0-15, 0-15	**1.79**	.32
214	300, 300	0-20, 0-20	**2.33**	.65
221	700 (DC)	20-12-0-12-20	**2.74**	.65
206	1A, 1A	0-15-20, 0-15-20	**4.17**	.80
203	500, 500	0-15-27, 0-15-27	**3.62**	.80
204	1A, 1A	0-15-27, 0-15-27	**4.76**	.80
S112	500	0-12-15-20-24-30	**2.27**	.65

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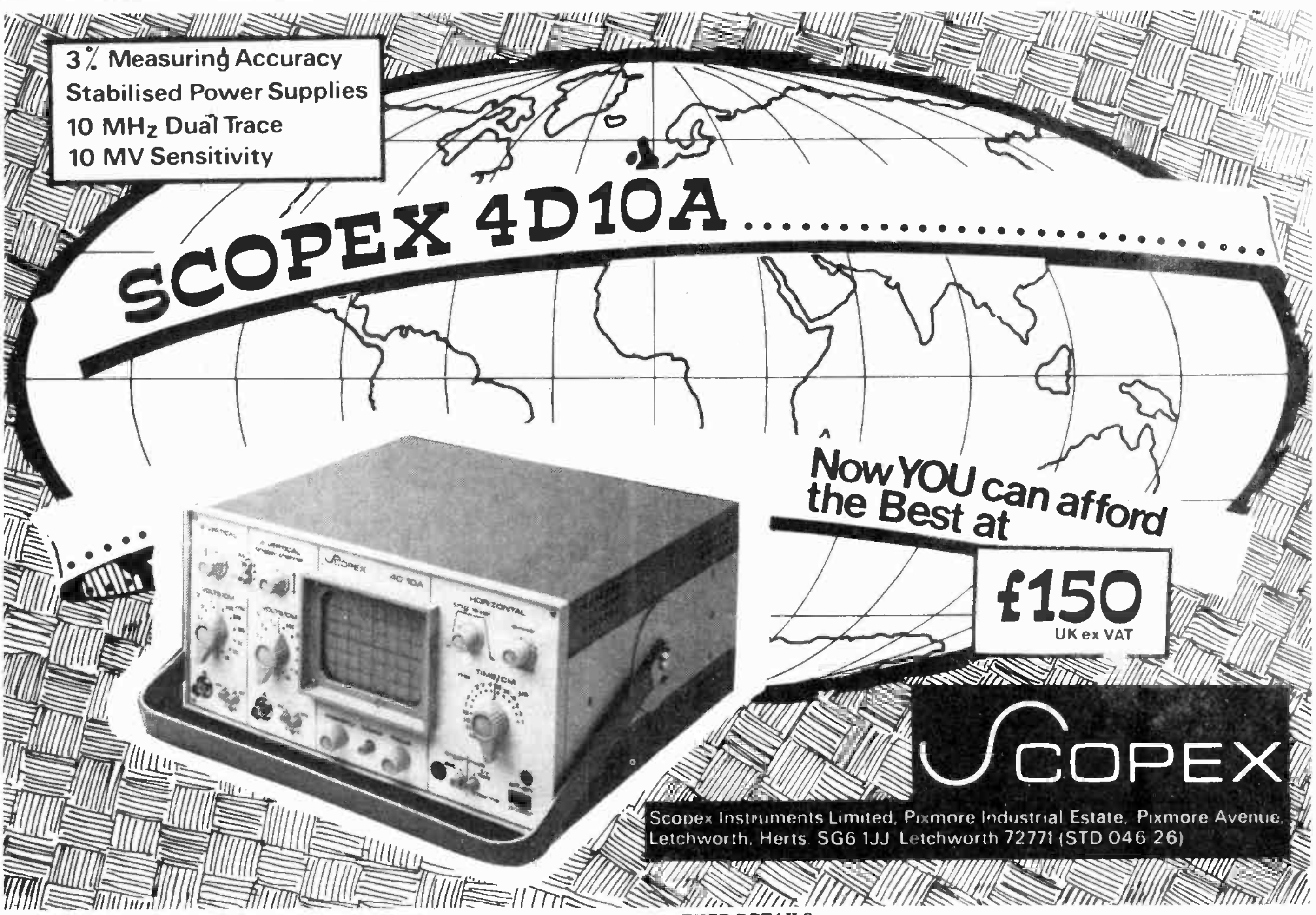

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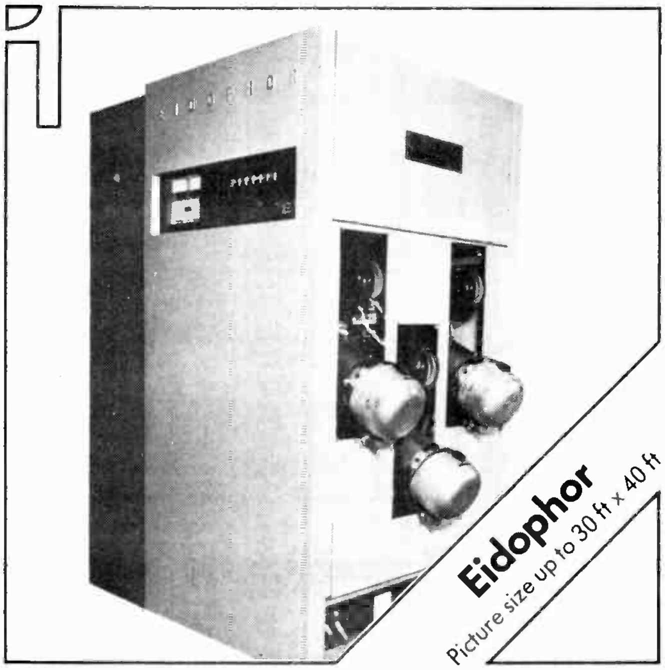
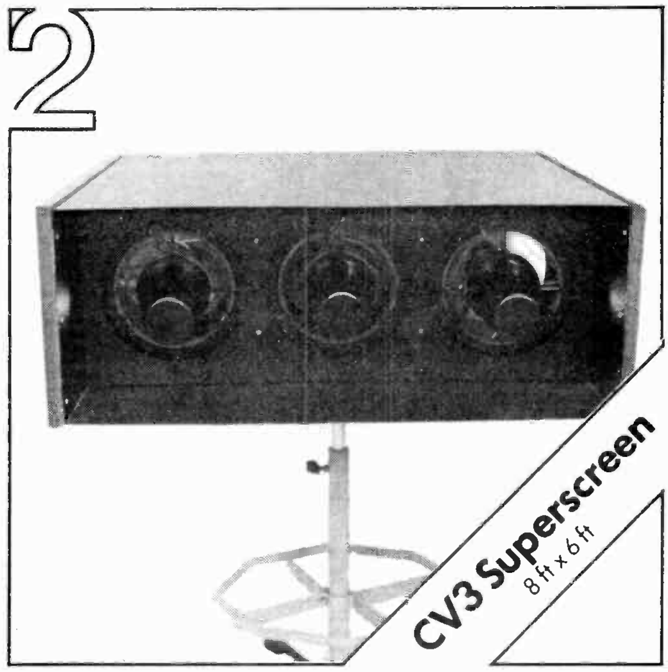
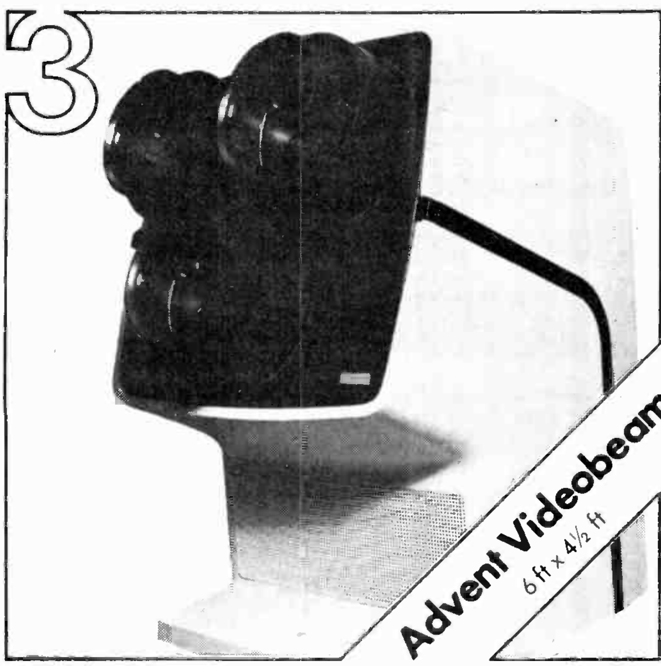
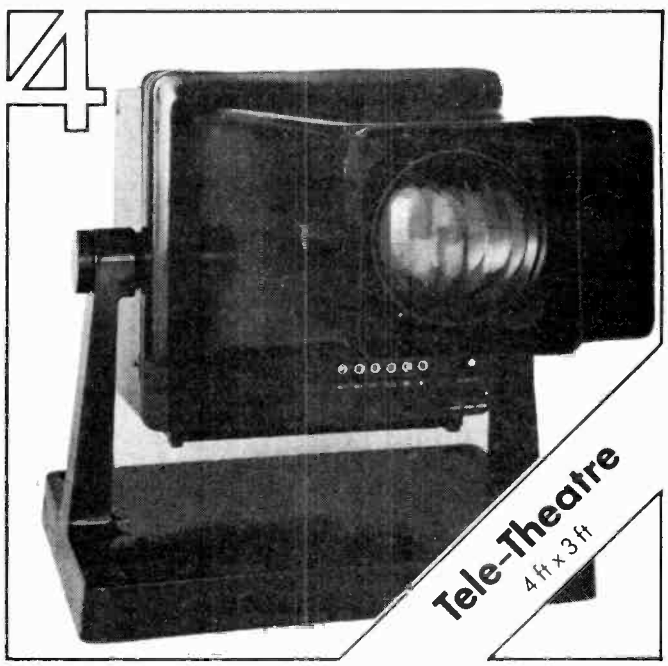








For further information and demonstrations write to or telephone:
Speywood Communications Ltd, 26 Northfield Industrial Estate,
Beresford Avenue, Wembley, Middlesex. Telephone 01-903 3381.
Telex 377138.

WW—105 FOR FURTHER DETAILS

RETURN OF POST MAIL ORDER SERVICE

BSR HI-FI AUTOCHANGER

STEREO AND MONO

Plays 12", 10" or 7" records. Auto or Manual. A high quality unit backed by BSR reliability with 12 months' guarantee. A.C. 200/250V. Size 13½-11¼in. 3 speeds. Above motor board 3¾in. Below motor board 2½in. with STEREO and MONO CARTRIDGE **£11.95** Post 75p

B.S.R. SINGLE PLAYER similar to above with stereo cartridge and cueing device, large turntable. **£15.50.**

PORTABLE PLAYER CABINET

Modern design. Rexine covered. Vynair front grille. Chrome fittings Size 17 x 15 x 8in. approx **£4.50** Post 50p

Motor board cut for BSR or Garrard deck

HEAVY METAL PLINTHS £5.95

With P.V.C. Cover. Cut out for most B.S.R. or Garrard decks. Silver grey finish. Post 75p.
Model "A" Size 12½ x 14¾ x 7½in.
Model "B" Size 16 x 13¾ x 7in. **£6.95.**
Extra large plinth & cover, wood base. Size 20"×17½"×9" **£19.50.** Callers only

COMPLETE STEREO SYSTEM

Two full size loudspeakers 13¾ x 10 x 3¾in. Player unit clips to loudspeakers making it extremely compact, overall size only 13¾ x 10 x 8½in, 3 watts per channel, plays all records 33 r.p.m., 45 r.p.m. Separate volume and tone controls. Attractive teak finish. 240V a.c. mains. **£22.50** £1 carriage

SPECIAL OFFER!
SMITH'S CLOCKWORK 15 AMP TIME SWITCH
0—60 MINUTES £2.95 Post 35p

Single pole two-way. Surface mounting with fixing screws. Will replace existing wall switch to give light for return home, garage, automatic anti-burglar lights, etc Variable knob. Turn on or off at full or intermediate settings. Brand new and fully guaranteed.

TEAKWOOD LOUDSPEAKER GRILLES will easily fit to baffle board. Size 10½ x 7⅞in—**45p.**

R.C.S. "MINOR" 10 watt AMPLIFIER KIT

This kit is suitable for record players, guitars, tape playback, electronic instruments or small P.A. systems. Two versions available Mono, **£11.25;** Stereo, **£18.** Post 45p. Specification 10W per channel; input 100mV; size 9½ x 3 x 2in. approx. S.A.E. details. Full instructions supplied AC mains powered.

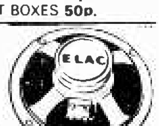
VOLUME CONTROLS

5kΩ to 2MΩ LOG or LIN L/S **25p.** D P **40p.** STEREO L/S **65p.** D P **85p.** Edge 5K S P Transistor **30p.**

80 Ohm Coax 8p yd.

STANDARD TYPE VHF FRINGE LOW LOSS **15p yd.** Ideal 625 and colour
PLUGS **10p.** SOCKETS **10p.**
LINE SOCKETS **18p.**
OUTLET BOXES **50p.**

ELAC HI-FI SPEAKER 8in. TWIN CONE



Dual cone plasticised roll surround Large ceramic magnet. 50-16,000 c/s Bass resonance 55 c/s. 8 ohm impedance 10 watts. music power **£3.95** Post 35p

E.M.I. 13½ x 8in. SPEAKER SALE!

With tweeter and crossover. 10 watt State 3 or 8 ohm. As illustrated. **£5.25** Post 35p

Ditto 15 watts. 8 or 15 ohm. **£7.95** Post 45p

With tweeter and cross-over 20 watt Bass res 25 c p.s. Flux = 11,000 gauss. 8 or 15 ohm. 20 to 20,000 c.p.s **£8.95** Post 45p

Bookshelf Cabinet **£7.50**
Teak finish, for EMI 13 x 8 speakers Post 75p

THE "INSTANT" BULK TAPE ERASER AND HEAD DEMAGNETISER. Suitable for cassettes, and all sizes of tape reels A C mains 200/250V Leaflet S A E Will also demagnetise small tools **£3.95** Post 30p

BLANK ALUMINIUM CHASSIS. 6 x 4—**70p;** 8 x 6—**90p;** 10 x 7—**£1.15;** 12 x 8—**£1.35;** 14 x 9—**£1.50;** 16 x 6—**£1.45;** 16 x 10—**£1.70.** **ANGLE ALI.** 6 x ¾ x ¾ in—**15p.** **ALUMINIUM PANELS.** 6 x 4—**17p;** 8 x 6—**24p;** 14 x 3—**25p;** 10 x 7—**35p;** 12 x 8—**43p;** 12 x 5—**30p;** 16 x 6—**43p;** 14 x 9—**52p;** 12 x 12—**68p;** 16 x 10—**75p.**
MANY ALI BOXES IN STOCK

ELAC 9 x 5in HI-FI SPEAKER TYPE 59RM **£3.45** Post 35p
This famous unit now available. 10 watts. 8 ohm.

RCS LOW VOLTAGE STABILISED POWER PACK KITS **£2.95**

All parts and instructions with Zener diode, printed circuit rectifiers and double wound mains transformer. Input 200/240V a.c. Output voltages available, 6 or 7.5 or 9 or 12V d.c. up to 100mA or less. Size 3 x 2½ x 1½in. Please state voltage required Post 45p

RCS POWER PACK KIT **£3.35**
12 VOLT, 750mA. Complete with printed circuit board and assembly instructions. Post 30p
12 VOLT 300mA KIT. **£3.15.** 9 VOLT 1 AMP KIT, **£3.35.**

R.C.S. GENERAL PURPOSE TRANSISTOR PRE-AMPLIFIER — BRITISH MADE

Ideal for Mike, Tape, P.U., Guitar, etc Can be used with Battery 9-12V or H.T. line 200-300V d.c. operation Size. 1¾ x 1¼ x ¾in. Response 25 c/s to 25 kc/s. 26 dB gain For use with valve or transistor equipment **£1.45**
Full instructions supplied. Details S.A.E. Post 30p

ELECTRO MAGNETIC PENDULUM MECHANISM

1.5V d.c. operation over 300 hours continuous on SP2 battery, fully adjustable swing and speed. Ideal displays, teaching electro magnetism or for metronome, strobe, etc. **95p** Post 30p

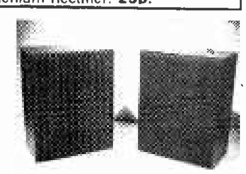
MAINS TRANSFORMERS

ALL POST 50p

250-0-250V 70mA, 6.5V, 2A	**£3.45**
250-0-250 80mA, 6.3V 3.5A, 6.3V 1A or 5V 2A	**£4.60**
350-0-350 80mA, 6.3V 3.5A, 6.3V 1A or 5V 2A	**£5.80**
300-0-300V 120mA, 6.3V 4A C.T.; 6.3V 2A	**£7.00**
MIDGET 220V 45mA, 6.3V 2A	**£1.75**
HEATED TRANS. 6.3V ½ amp **£1;** 3 amp	**£1.40**

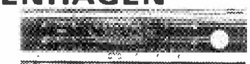
GENERAL PURPOSE LOW VOLTAGE. Tapped outputs at 2 amp. 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V **£4.60.** 1 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£4.60.** 2 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£7.00.** 3 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£8.70.** 5 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£11.25.** 6.06V 500mA **£1,** 9V 1 amp. **£1,** 12V 300mA, **£1,** 12V 500mA, **£1,** 12V 750mA, **£1,** 10V, 30V, 40V, 2 amp., **£2.75,** 20V, 3 amp., **£2.45,** 40V, 2 amp., **£2.95,** 30V 5A and 34V 2ACT **£3.45,** 16V, ½ amp, **£1,** 16V, 2 amp., **£2.20,** 0, 5, 8, 10, 16V, ½ amp **£1.95,** 20V ½ amp., **£1.75,** 20V, 1 amp., **£2.20,** 20V 3 amp., **£2.50,** 20-0-20V 1 amp., **£2.95,** 30V 1½ amp. **£2.75,** 20v, 40v, 60v or 20-0-20v, 1A, **£3.50.**
AUTO TRANSFORMERS, 115V to 230V or 230V to 115V 150W **£5;** 250W **£6;** 400W **£7;** 500W **£8.**
FULL WAVE BRIDGE CHARGER RECTIFIERS:
6 or 12V outputs, 1½ amp **40p;** 2 amp **55p;** 4 amp **85p.**
CHARGER TRANSFORMERS: 1½ amp **£2.75;** 4 amp. **£4.60.**
12V, 1½A HALF WAVE Selenium Rectifier, **25p.**

R.C.S. ROSEWOOD SPEAKERS



Size 12½in. x 9¾in. x 5½in. Response 50 to 14,000 cps 8 watts rms. 3, or 8, or 16 ohms.
£12 pair Post 75p.

KUBA - KOPENHAGEN STEREO



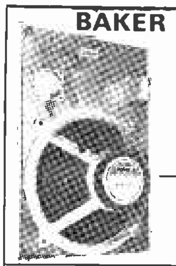
TUNER-AMPLIFIER CHASSIS AM-FM 5+5 WATT

This Continental 4-band radiogram chassis uses first class quality components throughout. Features: Large facia panel with 7 push buttons for medium, long, short, VHF-FM, AFC, phono, mains on-off, 4-rotary controls, tuning, volume, tone, balance. Facia size 17 × 4½ inches. Chassis size 17 × 4½ × 5½ inches. DIN-connector sockets for tape record/playback, loudspeakers, phono pick-up, external FM-AM aerials. Automatic stereo beacon light. Built-in ferrite rod aerial for medium/longwave. A.C. 240V. mains. Circuit supplied. **£38.50** Post £1 50

LOW VOLTAGE ELECTROLYTICS
1, 2, 4, 5, 8, 16, 25, 30, 50, 100, 200mF 15V **10p.**
500mF 12V **15p;** 25V **20p;** 50V **30p.**
1000mF 12V **17p;** 25V **35p;** 50V **47p;** 100V **70p.**
2000mF 6V **25p;** 25V **42p;** 50V **57p.**
2500mF 50V **62p;** 3000mF 25V **47p;** 50V **65p.**
5000mF 6V **25p;** 12V **42p;** 25V **75p;** 35V **85p;** 50V **95p.**

SHORT WAVE 100pF air spaced gangable tuner. **95p.**
TRIMMERS 10pF, 30pF, 50pF, **5p.** 100pF, 150pF, **15p.**
CERAMIC, 1pF to 0.01mF, **5p.** Silver Mica 2 to 5000pF, **5p.**
PAPER 350V-0 1 **7p;** 0 5 **13p;** 1mF 150V **15p;** 2mF 150V **15p;** 500V-0.001 to 0 05 **5p;** 0.1 **10p;** 0.25 **13p;** 0 47 **25p.**
MICRO SWITCH SINGLE POLE CHANGEOVER 20p.
SUB-MIN MICRO SWITCH. 25p. Single pole change over
TWIN GANG, 385 + 385pF **50p;** 500pF standard **75p;** 365 + 365 + 25 + 25pF Slow motion drive **65p.**
120pF **TWIN GANG, 50p;** 365pF **TWIN GANG, 50p.**
NEON PANEL INDICATORS 250V. Amber or red **30p.**
RESISTORS. ¼W, ½W, 1W, 20% **2p;** 2W, **10p;** 10Ω to 10M
HIGH STABILITY. ½W 2% 10 ohms to 6 meg., **12p.**
Ditto 5%. Preferred values 10 ohms to 10 meg., **5p.**
WIRE-WOUND RESISTORS 5 watt, 10 watt, 15watt, 10 ohms to 100K **12p** each.
TAPE OSCILLATOR COIL. Valve type, **35p.**
BRIDGE RECTIFIER 200V PIV ½ amp **50p.**
TOGGLE SWITCHES S.P **20p.** D.P S.T **25p.** D P.D T. **30p.**
MANY OTHER TOGGLES IN STOCK.
PICK-UP CARTRIDGES ACOS GP91 **£1.50.**
SONOTONE stereo **£2.00.**

BAKER MAJOR 12" £10.35



30-14,500 c/s, 12in. double cone, woofer and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwells. Bass resonance 40 c/s. Rated 25W. NOTE. 3 or 8 or 15 ohms must be stated.

Module kit, 30-17,000 c/s with tweeter, crossover, baffle and instructions. **£13** Post 60p each
Please state 3 or 8 or 15 ohms.

BAKER "BIG-SOUND" SPEAKERS. Post 50p each.

'Group 25'	'Group 35'	'Group 50/15'
12in 30W **£8.95**	12in. 40W **£10.50**	15in 75W **£19.50**
3 or 8 or 15 ohm	3 or 8 or 15 ohm	8 or 15 ohm

BAKER LOUDSPEAKER, 12 INCH. 60 WATT.
GROUP 50/12, 8 OR 15 OHM HIGH POWER
FULL RANGE PROFESSIONAL QUALITY
30-16,000 CPS
MASSIVE CERAMIC MAGNET
WITH ALUMINIUM PRESENCE
CENTRE DOME **£14.50** Post 80p

TEAK VENEERED HI-FI SPEAKERS AND CABINETS
For 12in. or 10in speaker 20x13x12in. **£12.50** Post 95p
For 13 x 8in. or 8in. speaker ... **£6.95** Post 75p
For 8x5in speaker 12x8x6in ... **£4.95** Post 50p

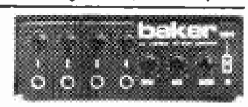
R.C.S. 100 watt VALVE AMPLIFIER CHASSIS

Four inputs. Four way mixing, master volume, treble and bass controls. Suits all speakers This professional quality amplifier chassis is suitable for all groups, disco, P.A., where high quality power is required. 5 speaker outputs A/C mains operated. Slave output socket. Produced by demand for a quality valve amplifier 100V line output to order Send for leaflet. Suitable carrying cab **£14.** Price **£85** carr £2 50

SPEAKER COVERING MATERIALS. Samples Large S.A.E
LOUDSPEAKER CABINET WADDING 18in wide **20p** ft.
Horn Tweeters 2-16kc/s, 10W 8 ohm or 15 ohm **£3.60**
De Luxe Horn Tweeters 3-18kc/s, 30W, 8 ohm, **£7.50.**
CROSSOVERS. TWO-WAY 3000 c/s 3 or 8 or 15 ohm **£1.90.** 3-way 950 cps/3000 cps, **£2.20.**
LOUDSPEAKERS P.M. 3 OHMS. 7x4in **£1.50;** 6½in, **£1.80;** 8x5in., **£1.90;** 8in., **£1.95.**
SPECIAL OFFER: 80 ohm 2¼in, 2¾in., 35 ohm, 3in, 25 ohm, 2½in dia, 3in dia, 5x3in, 8 ohm, 2½in, 3in, 3½in., 5in, 15 ohm, 3½in dia, 6x4in., 7x4in., 5x3in, 3 ohm., 2½in, 2⅝in, 3½in., 5in dia **£1.25 each.**
PHILIPS LOUDSPEAKER, 8in, 4 ohms, 4 watts, **£1.95**
RICHARD ALLAN TWIN CONE LOUDSPEAKERS
8in diameter 4W **£2.50.** 10in diameter 5W **£2.95;** 12in diameter 6W **£3.50.** 3/8/15 ohms, please state
VALVE OUTPUT TRANS. 40p; MIKE TRANS. 50:1, **40p.**
Mike trans. mu metal 100 1 **£1.25.**

Tweeter Volume Control 15 ohms 10W with one inch long threaded bush for wood panel mounting ¼in. spindle. **65p.**

BAKER 150 WATT PROFESSIONAL MIXER AMPLIFIER



All purpose transistorised Ideal for Groups, Disco and P A 4 inputs speech and music 4 way mixing Output 4 8/15 ohms a c Mains. Separate treble and bass controls Master volume control Guaranteed Details S A E **£68** £1 50 carr
NEW MODEL MAJOR—50 watt, 4 input, 2 vol Treble and bass Ideal disco amplifier **£49** Carr £1

100 WATT DISCO AMPLIFIER CHASSIS
volume, treble, bass controls. 500 M.V. or 1 volt input. Four loudspeaker outputs 4 to 16 ohm. All transistor. **£52**

BARGAIN 4 CHANNEL TRANSISTOR MONO MIXER
Add musical highlights and sound effects to recordings Will mix Microphone, records, tape and tuner with separate controls into single output. 9V **£5.20**
TWO STEREO CHANNEL VERSION **£6.85**
BARGAIN 3 WATT AMPLIFIER. 4 Transistor Push-Pull Ready Built, with volume, Treble and bass controls 18 volt d.c. Mains Power Pack **£3.45** **£3.95**

BALANCED TWIN RIBBON FEEDER 300 ohms. 5p yd.
JACK SOCKET Std. open-circuit 20p, closed circuit 25p;
Chrome Lead-Socket 45p. Mono or Stereo.
Phono Plugs 8p. Phono Socket 8p.
JACK PLUGS Std. Chrome 30p; Plastic 25p; 3.5mm 15p.
STEREO JACK PLUG 30p. SOCKET 25p.
DIN SOCKETS Chassis 3-pin 10p. 5-pin 10p.
DIN SOCKETS FREE 3-pin 25p; 5-pin 25p. DIN PLUGS 3-pin 25p; 5-pin 25p. VALVE HOLDERS, 10p; CANS 10p.

R.C.S. SOUND TO LIGHT KIT
Kit of parts to build a 3 channel sound to light unit 1,000 watts per channel **£12.50.** Post 35p
Easy to build Full instructions supplied. Cabinet **£3.**

E.M.I. TAPE MOTORS. 240V a c 1,200 r p m 4 pole Spindle 0 187x0 75in Size 3¼ x 2½ x 2¼in **£2.** Post 50p
Collaro gram motor 120V **75p.**
E M I gram motor 240V **£1.25.**

RADIO COMPONENT SPECIALISTS

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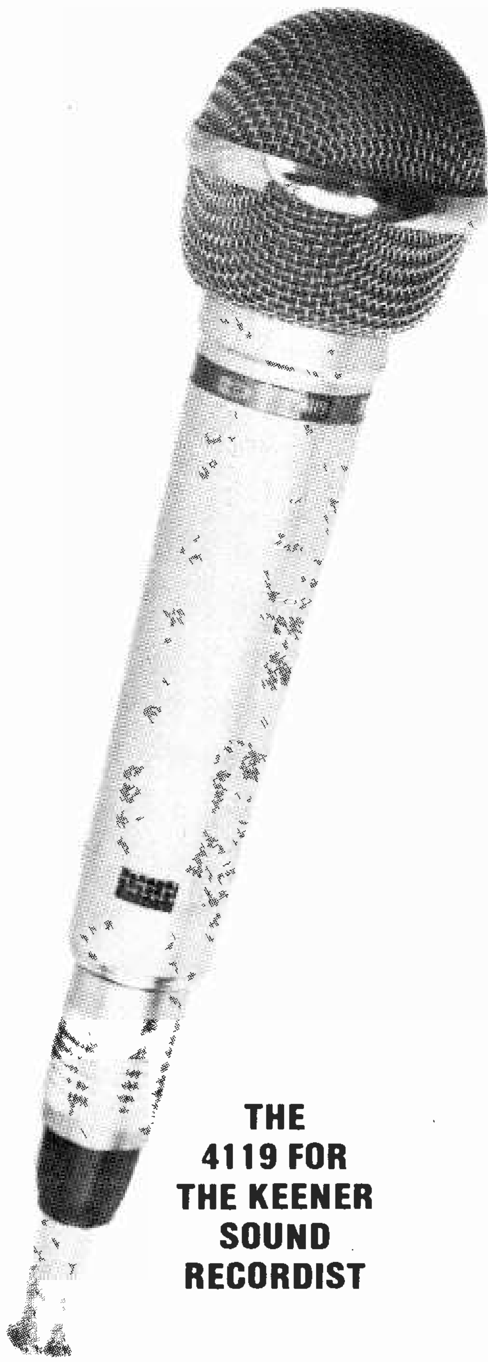
Open 9-6. Wed. 9-1. Sat. 9-5 (Closed for lunch 1.15-2.30)

Radio Books and Components Lists 10p. (Minimum posting charge 30p.) All prices include VAT. (We accept Access or Barclaycard. Phone your order.) **Tel. 01-684 1665**

DID YOU KNOW ?

That the British rifle team won 5 gold, 5 silver and 16 bronze medals at this year's International Matches. Probably not! The media has a habit of overlooking our achievements. Therefore, it is unlikely you will know that a member of the team, Mr. D. A. Hodson, a keen amateur sound recordist, loaned his Coles 4119 twin ribbon microphone to a member of the Canadian Broadcasting Corporation who was televising the events. He was very pleased with its performance.

We at Coles are pleased with performances and would like you to try the 4119 for yourself.



THE
4119 FOR
THE KEENER
SOUND
RECORDIST

DETAILS AVAILABLE FROM:

COLES ELECTROACOUSTICS
PINDAR ROAD
HODDESDON, HERTS.

TEL. HODDESDON 66685

AND

HAMPSTEAD HI-FI
HIGH STREET, HAMPSTEAD
LONDON, NW3

TEL. 01-435 6377

Our thanks to the Adjutant, C. S. O'Brien, and Mr. D. A. Hodson for the use of the above information

WW — 091 FOR FURTHER DETAILS

SIGNAL SOURCES

ADVANCE
V H F Square wave Generator SG21 10 KHz-100MHz. Max. o/p 2V **£35**
H1B AUDIO SIGNAL GENERATOR 15Hz-50KHz. Sine and Square Wave **£45.00**
H1 Audio Signal Generator, earlier version of H1B above **£35.00**
E2 R.F. Signal Generator 10KHz-100MHz **£76.00**
AIRMEC
Signal Generator Type 701 30 KHz-30 MHz (2 only) **£75.00**
GENERAL RADIO
Unit Oscillator 1209C. Freq. 250-920MHz. Accuracy 1% Drift 0.2%. O/pin to 50ohms = 150mW supplied with Power Supply Type 1201—CQ **£145**
Unit Oscillator 1218A. 900-2000MHz. Power output of 200mW across band **£140**
HEWLETT PACKARD
10515A Frequency Doubler. Extends the useable frequency range of signal generators. Operating on input frequencies 0.5MHz to 500MHz it provides a doubled output in the range of 1MHz to 1GHz. The frequency response of this 50ohm device is very flat (< ± 2dB typically) over the entire frequency range and undesired harmonics are well suppressed. Brand new **£75.00**
209A Audio Generator, 4Hz to 2MHz (6 ranges), 0 1% distortion. Sine wave and Square wave, 600 ohm impedance **£175.00**
211A Square Wave Generator 1Hz-1MHz **£75.00**
F.M./A.M. Signal Generator 202H. F.M. A.M. C.W. & pulse coverage 54 to 216 MHz R.F. o/p 0.1µV-0.2V 50ohms Impedance **£450**
Audio Signal Generator 206A 20Hz-20KHz ± 2% accuracy Distortion ∠ 1% **£90**
LEVELL
TG150D R.C. Oscillator 1.5Hz to 150KHz, Sine and Square Wave **£30.00**
MARCONI INSTS.
TF937 FM/A.M. Signal Generator 85KHz-30MHz **£200.00**
TF1060 U.H.F. Signal Generator 450-1250MHz, Sine wave and pulse a.m **£350.00**
TF144H/S A.M. Signal Generator 10KHz-72MHz **£295.00**
TF2005R Two Tone Source. The instrument comprises two identical low-distortion a.f. oscillators and a monitored attenuator unit, to form a compact test set for the measurement of inter-modulation distortion using the methods recommended by S.M.P.T.E. and C.C.I.F. Frequency range 20Hz to 20KHz in six bands (each oscillator can be adjusted and used independently). Harmonic distortion. Less than 0 05% between 63Hz and 6KHz when using unbalanced output. Generally less than 0 1% under other conditions. Intermodulation. Below -80dB with respect to the wanted signal. Amplitude. Reference Level. Up to +10dBm from each oscillator. Output attenuator 111dB in 0 1dB steps. Output impedance 600Ω unbalanced, or 600Ω 150Ω or 75Ω balanced and centre-tapped **£485.00**
AM/FM SIGNAL GENERATDR TF1066 10-470MHz. R.F. Output 0 2µV—200mV Z = 50 Ohms **£200.00**
S.H.F. Signal Generator 618C. 2.8-7.6GHz ± 1% 50ohms **£550**
F.M./A.M. Signal Generator TF 995A/3S. Ministry type No CT402 1.5MHz-220MHz. R.F. o/p 2µV-200mV Internal & External Mod Facilities. V. good condition **£385**
F.M./A.M. Signal Generator TF 995A/5 1 5-220MHz in 5 bands. 0.1µV-200mV F.M. up to ± 120KHz from 50Hz-15KHz. A.M. up to 50% from 100Hz-10KHz o/p (1) 2µV-200mV (2) with terminating unit 1µV-100mV Int mod freqs. 400Hz, 1KHz & 1 5KHz. Distortion (1) on internal F.M. ± 25Hz. (2) on internal A.M. 6% at 30% mod. **£300 to £450**
A.M. Signal Generator TF801D/1 Freq. range 10-470MHz. R.F. output 0.1µ-1V Piston attenuator 50ohms Impedance. Modulation Int A.M. 1KHz Ext. A.M. 30Hz-20KHz. Low spurious F.M. & drift V.S.W.R. 1.2 or less **£400-£800**
A.M. Signal Generator TF801D/1S Military Version 10-485MHz **£450-£800**
R.C. Oscillator TF1370A 10Hz-10MHz. Square Wave up to 100KHz High Outputs up to 31 6V **£285**
Phase/A.M. Signal Generator TF 2003 0 4-12MHz **£150**
AM Signal Generator TF 801B/3S 12.485MHz 0 1µV-1V **£195**
R.C. Oscillator TF1101 Frequency range 20HZ-200KHz. Output. Direct into 600Ω0-20V variable Attenuator 0-6dB in 10dB steps. Impedance 600Ω. Distortion. Via 1KHz Filter less than 0 1%. Direct or via Attenuator. Less than 0.5%. 50Hz-20KHz. Less than 1% 20Hz-200KHz **£120-£150**
FM/AM Signal Generator TF937/1 CT320. 35KHz-18 3MHz. As seen condition **£80**
Signal Generator TF144H/4. Late models in su condition **£500 to £650**
U.H.F. F.M. Signal Generator TF 2012 400-520MHz. Low Noise & freq. drift. For narrow band f.m. receiver measurements. Price new ca £1,300 — OUR PRICE **£680**
MUIRHEAD L.F. Decade Oscillator D880A. 2 phase 0 01HZ-11 2KHz **£295**
Decade Oscillator D890D 1Hz-11 2KHz **£260**
NEUWIRTH (WEST GERMANY)
VHF Signal Generator MS4/U Freq. Range 9.6MHz to 230MHz. Turret Osc. for each band. Accuracy 1-2% o/p 30mV-1µV Freq. Dev 1KHz-100KHz. Amp. Mod 0-100% **£175.00**
SANDERS
CT478 Microwave Signal Generator 1 5GHz-4.5GHz **£285.00**
RADIOMETER
Stereo signal generator SMG1C. Full spec. on request. Superb condition **£350**
RHODE & SCHWARTZ
S.H.F. generator SMCB-BN 41042 1700-5000MHz. **P.O.A.**
WAYNE KERR
Video Oscillator 0 222 7KHz-8MHz in 6 ranges **£75**
WANDEL & GOLTERMAN
U.H.F. Power Oscillator LMS-68 c/w plug in Oscillators
Type LO-4 4- 41MHz
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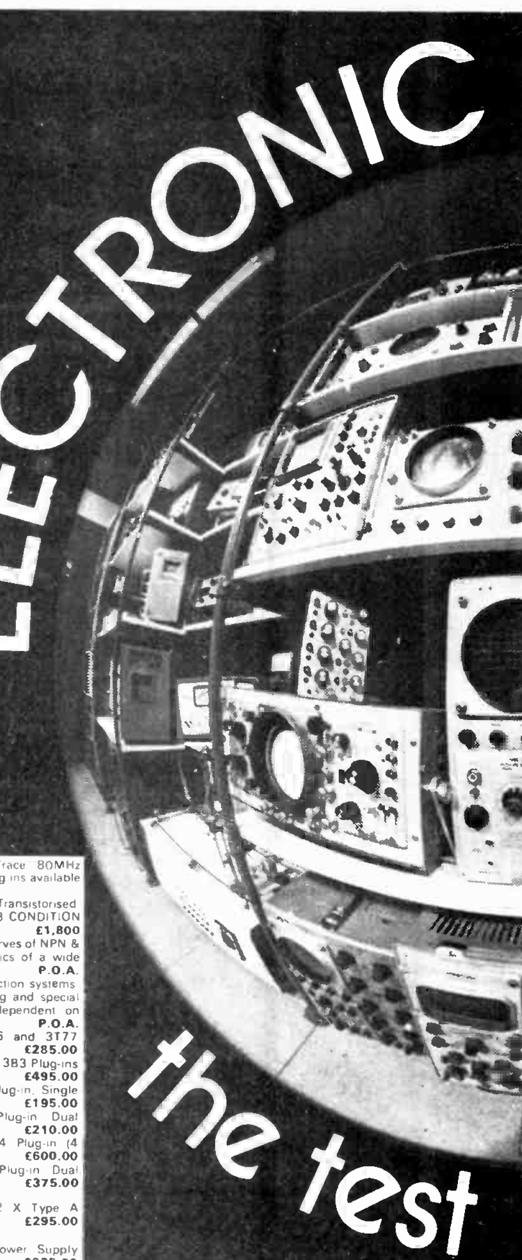

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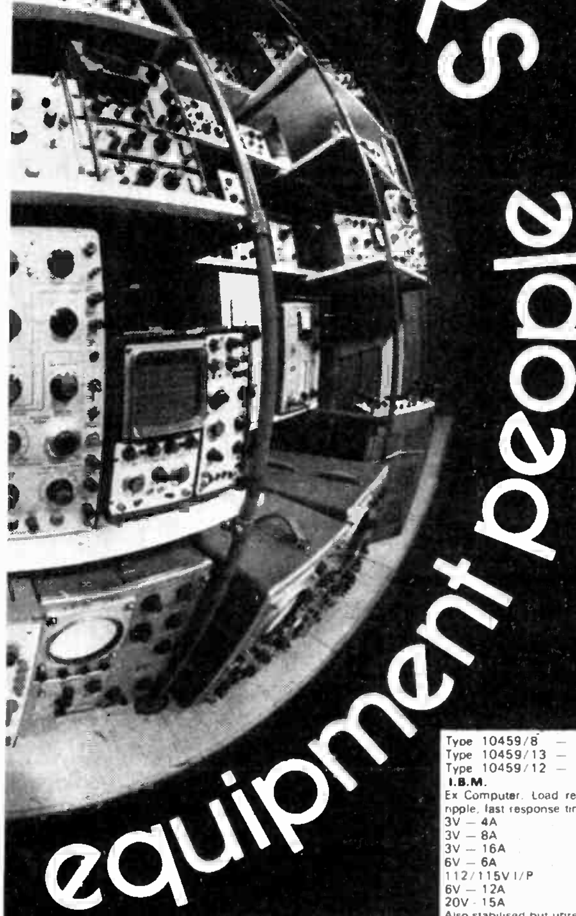

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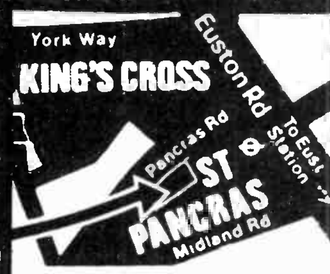

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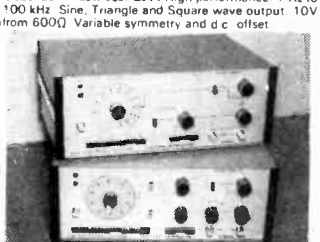

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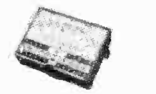

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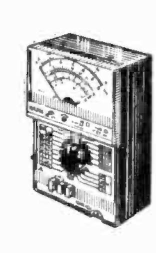

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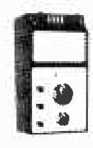
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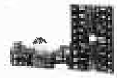
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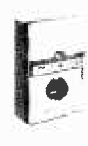
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Baker Deluxe, 8 or 15 ohm	£13.38
Baker Major, 3, 8 or 15 ohm	£10.69
Baker Regent, 8 or 15 ohm	£9.00
Baker Superb, 8 or 15 ohm	£16.31
Celestion HF1300 8 or 15 ohm	£6.98
Celestion MH 1000 horn, 8 or 15 ohm	£13.50
Coles 400 1 G super tweeter	£5.90
Coles 400 1 K super tweeter	£5.90
Decca London and X over	£36.90
Decca DK30 and X over	£24.70
EMI 5" Mid range	£3.15
EMI 6½" d/cone roll surr. 8 ohm	£3.93
EMI 8 x 5, 10 watt, d/c, roll/s 8 ohm	£3.75
EMI 14" x 9" Bass 8 ohm	£11.92
Elac 59RM 109 15 ohm, 59RM 114 8 ohm	£3.38
Elac 6½" d/c roll/s 8 ohm	£3.95
Fane Pop 15 watt 12"	£5.50
Fane Pop 33T 33 watt 12"	£9.75
Fane Pop 50 watt, 12"	£12.50
Fane Pop 55, 12" 60 watt	£16.75
Fane Pop 60 watt, 15"	£19.95
Fane Pop 70 watt 15"	£21.75
Fane Pop 100 watt, 18"	£33.95
Fane Crescendo 12A or B, 8 or 15 ohm	£42.95
Fane Crescendo 15, 8 or 15 ohm	£54.95
Fane Crescendo 18, 8 or 15 ohm	£75.95
Fane 807T 8" d/c, rolls/s, 8 or 15 ohm	£5.18
Fane 801T 8" d/c roll/s 8 ohm	£8.96
Goodmans 8P 8 or 15 ohm	£6.50
Goodmans 10P 8 or 15 ohm	£6.95
Goodmans 12P 8 or 15 ohm	£16.50
Goodmans 12P-D 8 or 15 ohm	£18.75
Goodmans 12P-G 8 or 15 ohm	£17.75
Goodmans Audiom 200 8 ohm	£14.95
Goodmans Axent 100 8 ohm	£8.50
Goodmans Axiom 402 8 or 15 ohm	£22.00
Goodmans Twinaxiom 8" 8 or 15 ohm	£10.60
Goodmans Twinaxiom 10" 8 or 15 ohm	£10.95
Kef T27	£5.18
Kef T15	£10.75
Kef B110	£6.75
Kef B200	£7.85
Kef B139	£16.50
Kef DN8	£2.08
Kef DN12	£5.39
Kef DN13	£4.05
Richard Allan HP8B 8" 45 watt	£12.50
Richard Allan CG8T 8" d/c roll/s	£7.95
Baker Major Module, each	£13.28
Goodmans Mezzo Twinkit, pair	£51.95
Goodmans DIN 20, 4 ohm, each	£15.75
Helme XLK35, pair	£26.75
Helme XLK40, pair	£38.50
Helme XLK30, pair	£21.95
Kefkit 1, pair	£51.00
Kefkit III, each	£46.00
Richard Allan Twinkit, each	£13.95
Richard Allan Triple 8, each	£20.75
Richard Allan Triple 12, each	£25.95
Richard Allan Super Triple, each	£29.50
Richard Allan RA8 kit, pair	£37.80
Richard Allan RA82 kit, pair	£59.40
Wharfedale Linton 2 kit (pair)	£21.50
Wharfedale Glendale 3 XP kit, pair	£47.70
Wharfedale Dovedale 3 kit, pair	£59.40

All Radford, Gauss, Castle, Jordan Watts, Eagle, Lowther, Peerless Tannoy units in stock
Prices correct at 1/11/76

ALL PRICES INCLUDE VAT
Cabinets wadding, Vynair, Crossovers etc.
Send stamp for free 38 page booklet "Choosing a Speaker"
FREE with all orders over £10 — Hi-Fi Loudspeaker Enclosures Book
All units are guaranteed new and perfect
Prompt despatch
Carriage Speakers up to 12" 60p; 12" £1; 15" £1 75; 18" £2.50. Kits £1 each (£2 per pair). Tweeters & Crossovers 33p each

WILMSLOW AUDIO
Dept. WW

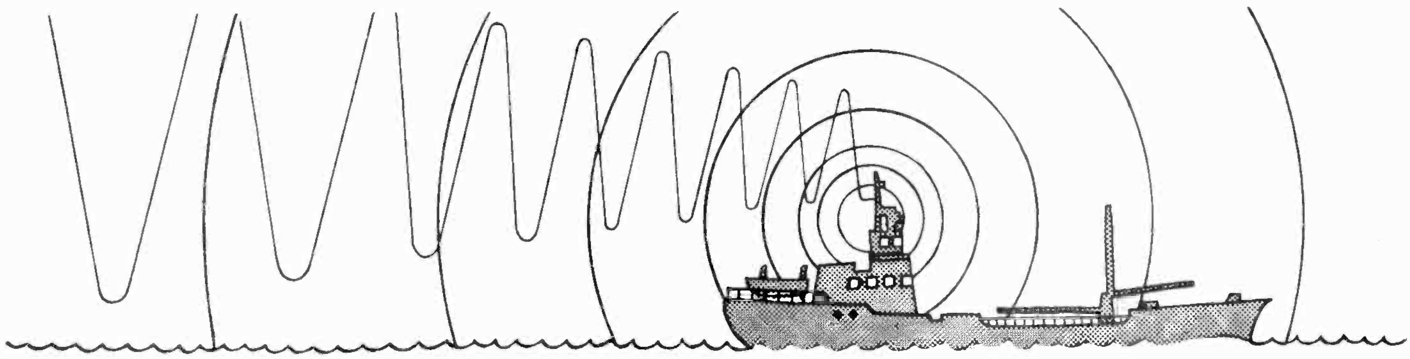
Loudspeakers & Export Dept: Swan Works, Bank Square, Wilmslow, Cheshire SK9 1HF. Discount Hi-Fi, PA etc: 10 Swan Street, Wilmslow. Radio, Hi-Fi, TV: Swift of Wilmslow, 5 Swan Street, Wilmslow. Tel. (Loudspeakers) Wilmslow 29599, (Hi-Fi, etc.) Wilmslow 26213.
Access and Barclaycard orders accepted by phone.

WW—029 FOR FURTHER DETAILS

Appointments

Advertisements accepted up to 12 noon Monday, November 29, for the January issue, subject to space being available.

DISPLAYED APPOINTMENTS VACANT: £6.50 per single col. centimetre (min. 3cm).
LINE advertisements (run on): £1 per line, minimum three lines.
BOX NUMBERS: 45p extra. (Replies should be addressed to the Box Number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London SE1 9LU.)
PHONE: Owen Bailey on 01-261 8508
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.



Radio Officers–now you can enjoy the comforts of home.

Working for the Post Office Maritime Services really makes sense. You still do the work that interests you, but with all the advantages of a shore-based job: more time to enjoy home life, job security and good money. To qualify, you need a United Kingdom Maritime Radiocommunication Operator's General Certificate or First Class Certificate of competence in Radiotelegraphy, or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic.

Starting salaries, at 25 or over, are £2905 rising to £3704 after three years service. Between 19 and 24, the starting salary varies from £2234 to £2627 according to age. In addition, a supplement of £312 p.a. is payable. You'll also receive an allowance for shift duties which at the maximum of the scale averages £900 a year and there are opportunities to earn overtime. There's a good pension scheme, sick pay benefits and prospects of promotion to senior management.

Right now we have a few vacancies at some of our coastal radio stations, so if you're 19 or over, preferably with sea-going experience, write to:
ETE Maritime Radio Services Division (L690),
ET 17.1.1.2., Room 643, Union House,
St. Martins-le-Grand, London EC1A 1AR.

Post Office Telecommunications

DESIGN ENGINEER

Thorn Consumer Electronics Limited, the leading manufacturer of television, radio and audio equipment in the U.K. wish to appoint an experienced Design Engineer for their research and engineering centre at Enfield.

He/she will be of degree or equivalent standard, preferably under 35 years of age with at least 2 years background of television design and some digital design capability.

He/she will join a team investigating new ideas and systems and be required to work on his/her own initiative liaising with internal development departments and outside suppliers.

Applications in writing giving details of age, experience and qualifications to:

The Personnel Manager (DE/WW)
Thorn Consumer Electronics Ltd.
Great Cambridge Road, Enfield, Middlesex EN1 1UL

THORN

(6520)

UNIVERSITY COLLEGE OF NORTH WALES BANGOR
SCHOOL OF PHYSICAL AND MOLECULAR SCIENCES

ELECTRONICS TECHNICIAN GRADE 5

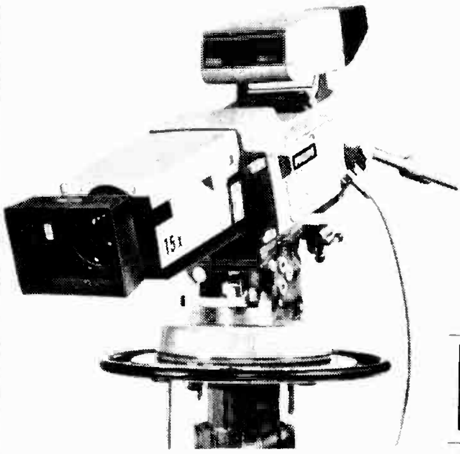
Applications are invited for the post of Electronics Technician Grade 5 in the above mentioned School.
The successful applicant would be concerned with the development, construction and maintenance of specialised electronic equipment for a wide range of research work and teaching in the School.
Applicants should have had several years' relevant practical experience coupled with theoretical knowledge preferably to H.N.C. standard or equivalent.
Salary at an appropriate point on scale: £2,889-£3,367 per annum.
Pension Scheme.
Applications (two copies), giving details of age, education and experience, together with the names and addresses of two referees, should be submitted to the Assistant Registrar (Personnel), University College of North Wales, Bangor, Gwynedd LL57 2DG, to reach him not later than 31st December, 1976.

(6572)

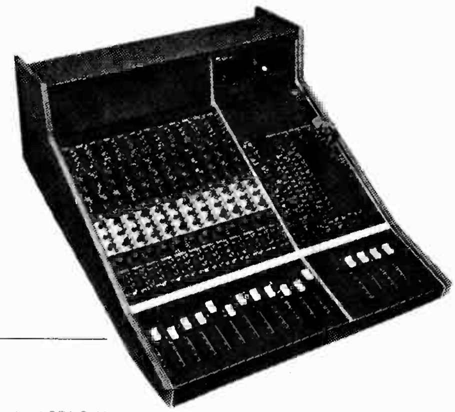
Development Engineers Video and Audio – Cambridge

Pye TVT Ltd. is a highly successful company in the international field of broadcast engineering.
We are urgently seeking Electronic Development Engineers to join a team in our studio engineering laboratory working on the development and design of equipment and systems in the video and audio engineering areas.

We would like to meet ambitious men and women, aged 25-35, who are capable of handling responsibility and hold an appropriate degree or equivalent qualification. Several years' experience in the design of video, digital or switching-type equipment, or the design of professional audio equipment, is highly desirable.



Successful candidates will be offered an attractive salary and excellent security. Company benefits include good catering facilities, staff shop, pension fund and an active sports and social club. Generous assistance with relocation expenses to this pleasant part of East Anglia is given in approved cases.
Apply to: Mr. David Barnicoat,



Pye TVT Limited
PO Box 41 Coldhams Lane Cambridge England CB1 3JU
Tel. Cambridge (0223) 45115 Telex 81103

A member of the Pye of Cambridge Group

Operational Engineer for CCTV Studio

The CCTV studio of a major advertising agency requires an engineer experienced in the operation and maintenance of colour cameras, video recorders, monitors and associated control equipment. The studio, which has been in monochrome operation for seven years, is in the process of changing over to colour operation and the person appointed will be required to liaise between the studio manager and suppliers in the selection of equipment and will supervise its installation.

In normal operation, the post involves taking charge of the CCTV control room and ensuring the uninterrupted and efficient use of its equipment.

Applicants should be familiar with non-broadcast colour equipment of the type widely installed in advertising agencies and industrial staff training units.

Salary is open to negotiation and will be dependent on experience and qualification.

The company operates profit sharing and pension schemes.

Applicants should write, giving details of age, education, qualifications, relevant experience and present post to
Mr. P. Sowerby
Ogilvy Benson & Mather Ltd.,
CCTV Studio,
7 Exchange Court, London WC2

OB &M

(6502)

RADIO TECHNICIANS

Government Communications Headquarters has vacancies for Radio Technicians. Applicants should be 19 or over.

Standards required call for a sound knowledge of the principles of electricity and radio, together with 2 years experience of using and maintaining radio and electronic test gear.

Duties cover highly skilled Telecommunications/electronic work, indluding the construction, installation, maintenance and testing of radio and radar telecommunications equipment and advanced computer an analytic machinery.

Qualifications: Candidates must hold either the City and Guilds Telecommunications Part I (Intermediate) Certificate or equivalent HM Forces qualification.

Salary scale from £2,230 at 19 to £2,905 at 25 (highest pay on entry), rising to £3,385 with opportunity for advancement to higher grades up to £3,780 with a few posts carrying still higher salaries. Pay supplement of £313.20 per annum.

Annual Leave allowance is 4 weeks rising to 6 weeks after 27 years' service.

Opportunities for service overseas.

Candidates must be UK residents.

Further particulars and Application forms available from:

Recruitment Officer
Government Communications Headquarters
Oakley, Priors Road
CHELTENHAM, Glos GL52 5AJ
Tel. Cheltenham 21491 Ext. 2270
(STD 0242-21401)

(6507)

Revitalised economy — superb location!

Together with most other countries, Zambia has recently been affected by the worldwide economic recession. Now our economy is surging forward strongly again, revitalised partly by significant advances in the country's agricultural industry and rising copper prices on world markets. Come here on a 3-year contract and your skills will be welcomed – and broadened. You'll enjoy the warm, pleasant climate in this totally land-locked country, larger than France, Belgium, the Netherlands and Switzerland combined. You'll enjoy the scenery too; although mainly a broad plateau, Zambia also features spectacular mountains, a certain amount of dense forest, imposing rivers, vast lakes and extensive game reserves. Its many large cities and towns contain all the normal modern facilities and are linked by excellent roads and rail services.

Post & Telecommunications Corporation

Chief Engineers

K6756-K7200 (c.£5067-£5400).
Supplement £4902 (married), £2784 (single)

Requirements:

Electrical or Telecommunications Degree plus senior management experience.

Responsibilities:

Either: planning switching and external plant networks; or planning budgets and methods including long-term income/expenditure forecasts, staffing and training requirements and long/medium/short-term national planning; some training is involved and you will report to the Assistant Director, Planning.

Principal Engineers

K6324-K6756 (c.£4755-£5067).
Supplement £4704 (married), £2586 (single)

Requirements:

Electrical, Electronic or Telecommunications Engineering degree; senior management experience.

Responsibilities:

Either: (a) controlling switching planning groups, including major projects management, requiring crossbar/electronic switching systems experience; or (b) controlling, advising on planning, budgets methods, staff; co-ordinating long/medium/short-term plans and preparing capital estimates; some staff training. You will report to the Chief Engineer.

Senior Engineer

K5700-K6108 (c.£4275-£5281).
Supplement £4524 (married), £2406 (single)

Requirements:

C & G Final or equivalent; initiative and responsible managerial experience of at least 3 years.

Responsibilities:

(a) For external plant – preparing development scheme and contract specifications; familiarity with latest overhead and underground system methods is essential.
(b) For switching – implementing plans, preparing for and evaluating tenders; crossbar systems experience is essential.
(c) For planning, budgets, methods – preparing plans and engineering instructions, studying/reporting on new techniques, recommending new methods in radio/transmission, switching and external plant.
(d) Planning, budgets and methods – preparing/maintaining an annual works programme, preparing time/resource diagrams, monitoring project progress.

Engineers

K5316-K5700 (c.£3987-£4275).
Supplement £4296 (married), £2232 (single)

Requirements:

C & G Final or equivalent plus initiative.

Responsibilities:

Either for: (a) telegraph and subscribers' apparatus including specifications/tender evaluation/type approval;
(b) power and accommodation – liaising with field staff/contractors in such areas as power plant maintenance;
(c) Liaison with engineering, sales, traffic sections, special investigations, co-ordination of such staff as aerial riggers and diesel mechanics. In all cases staff training is probably involved.

Technician I posts

K4416-K5136 (c.£3312-£3852).
Supplement £4134 (married), £2070 (single)

Requirements:

C & G Intermediate or equivalent plus appropriate experience.

Responsibilities:

Either: (a) External (underground/overhead) plant; (b) switching; (c) radio and transmission; (d) power and air-conditioning; (e) stores liaison; (f) power/accommodation maintenance; (g) diesel maintenance; (h) shift leader – earth station (non-automatic satellite ground station and its links); (i) day-to-day maintenance of a small rural area; (j) switching construction supervision; (k) transmission construction supervision. In all cases staff training may be necessary.

Technician II posts

K3756-K4416 (c.£2817-£3312).
Supplement £3846 (married), £1830 (single)

Requirements:

C & G Intermediate or equivalent plus appropriate experience.

Responsibilities:

Either: (a) external plant – including line surveys, and estimate preparation; (b) external works supervision – cable/duct installation by contractors, underground/overhead work by Government staff. In both cases staff training will be included in duties

Technician III posts

K2388-K4410 (£1791-£3308).
Supplement £3804 (married), £1788 (single)

Requirements:

C & G Intermediate, initiative, 4 years' experience after training.

Responsibilities:

Either: (a) Microwave maintenance; (b) strowger maintenance; (c) Pentaconta maintenance (BXB 1121); (d) LM Ericsson maintenance (ARK, ARF, and/or ARM); (e) Multiplex maintenance; (f) PABX maintenance.

Strong financial attractions

As well as the salary quoted, you will enjoy TAX-FREE supplements, a TAX-FREE terminal gratuity, low-cost accommodation, low taxation and free passages. Together, these add up to exceptional real earnings. Starting salaries relate to qualifications/experience, while gratuities total 25% of basic salary. Salary-related supplements are reviewed annually and paid by the British Government to designated British nationals (annual maximum is shown), while appointment grants, education allowances, car loans, medical aid assistance and free holiday visits for children educated in Britain are also provided for those receiving supplements. N.B. Sterling equivalents given are approximations only due to constant exchange rate fluctuations.

For further information please send full personal/professional details (without obligation and in total confidence), indicating which position interests you, to: Recruiting Officer (Room 33), Zambia High Commission, 7-11 Cavendish Place, London W1.

(6538)

ZAMBIA

ELECTRONIC DESIGN/ DEVELOPMENT ENGINEERS

FERRANTI OFFERS YOU FREEDOM

..... freedom to create. Over the years leading design and development engineers have been attracted to Ferranti by our reputation for truly innovative engineering and together they have formed specialised teams involved on a variety of sophisticated projects related to the Tornado, Sea Harrier, Jaguar, Nimrod 2 and other front line aircraft.

We now require additional engineers to join these teams engaged on the creative work of designing and developing airborne radar, laser and inertial navigation systems and their associated test equipment.

Engineers are required in the following technical fields:-

Digital and analogue electronic circuitry design.

Design and application of small digital computers.

Microwave and laser techniques.

Advanced instrument design including gyroscopes of inertial quality.

Design of small mechanical structures and analysis of stress.

In addition to the above we have vacancies for production engineers with either electrical or mechanical backgrounds in these fields.

Applicants should have some design/development experience to offer in avionics and a desire to expand their experience to project leader level.

Edinburgh, with its outstanding facilities for education, housing, sport and entertainment, is one of the ideal cities in Europe in which to live, work and bring up a family. And to make moving here easier, we pay realistic relocation expenses. Salaries are negotiableand the Company operates a contributory pension and life assurance scheme.

Apply in writing, with full details of experience and qualifications, to **Staff Appointments Officer, Ferranti Limited, Ferry Road, EDINBURGH, EH5 2XS.**

FERRANTI

DATEK SYSTEMS LTD.

A leading Company in the Phototypesetting Industry requires a:

SENIOR TEST ENGINEER

The position requires a man with several years' experience of digital systems with the ability to faultfind 74 series T.T.L. to chip level. A background in the data prep. or V.D.U. market would be most appropriate and an academic level of at least H.N.C. would be expected.

The job involves some field service support and a driving licence is essential. Salary £4,000 p.a.

JUNIOR TEST ENGINEER

This position requires a young engineer with a degree or Dip.Tech. in Electrical Engineering with an electronics bias.

Some experience in T.T.L. logic or microprocessors would be useful. Salary about £2,750 p.a.

The company offers 4 weeks' holiday and a sickness and pension scheme.

Phone or write for application form to:

Miss L. Bux
DATEK SYSTEMS LTD.
849 Harrow Road, Wembley, Middx.
Tel. 01-904 0061

(6533)

ELECTROSONIC

WE ARE MARKET LEADERS IN THE FIELD OF MULTIVISION, AUDIO AND LIGHTING CONTROL SYSTEMS. DUE TO CONTINUED EXPANSION WE REQUIRE THREE POSITIVE THINKING SALES EXECUTIVES TO JOIN THE U.K. TEAM BASED AT OUR MODERN OFFICE IN S.E. LONDON.

A.V. SYSTEMS SALES ENGINEER

With a Commercial, Technical and Operational Understanding of Slide-Sound Audio Visual Systems and their Markets.

AUDIO SYSTEMS SALES ENGINEER

With a wide knowledge of Professional Audio Products. Experience in Contract Negotiations, Technical Spacifications and Operational Requirements for Theaters, Conference and P/A Audio Systems.

LIGHTING SYSTEMS SALES ENGINEER

Experienced in Contract Negotiations, Technical Specifications and Operational Requirements for Industrial, Commercial and Entertainment Lighting Control Systems.

Applicants should be 25 to 40 years old with strong technical background and at least five years' commercial experience in systems engineering. Capable of negotiating major contracts with architects, consultants and government. Basic salaries negotiable up to £5,000 p.a. Company car, applications with career and salary details to: **S. F. GIDDINGS, SYSTEMS MARKETING MANAGER, ELECTRO-SONIC LIMITED, 815 WOOLWICH ROAD, LONDON SE7 8LT.**

(6547)

mi

Careers in Professional Electronics

Your experience could open the door to a range of interesting and rewarding opportunities in the Design, Production or Service departments of a Company whose products complement the most advanced modern electronic techniques.

For more information apply in confidence to :– John Prodger,

MARCONI INSTRUMENTS LIMITED
Longacres, St. Albans, Herts. Tel : St. Albans 59292
A GEC–Marconi Electronics Company

6544

ELECTRONIC ENGINEERS

(Lighting Control Systems)

The Theatre Lighting Division of Thorn Lighting Limited design, manufacture and install one of the world's finest ranges of control systems for TV and theatre lighting. Installations cover every continent, with 80% of our equipment being exported.

Systems currently in production employ core store, 'floppy disc' and MOS memories, and microprocessor based peripherals: modern techniques are also employed in our extensive range of power dimmers.

There are vacancies at several levels for experienced electronic engineers in our DESIGN, SALES, PROJECTS and TEST departments. Applicants having an interest in TV or theatre lighting will be especially welcome.

Our approach is very flexible – if the above interests you please write to or telephone Peter Balchin, Engineering Manager, for an application form and further details at Thorn Lighting Limited, Theatre Lighting Division, Angel Road Works, 402 Angel Road, Edmonton, London N18 3AJ. Telephone: 01-807 9011.

(6521)

THORN LIGHTING A member of the Thorn Group

ELECTROSONIC S.E. LONDON

Electrosonic Ltd., a leading company in the rapidly expanding fields of audio, audio visual and lighting control systems, require a printed Circuit Designer and Test Engineers.

PRINTED CIRCUIT DESIGNER

Salary @ c £3,800

An experienced and creative engineer is required to design and lay out printed circuit boards from logic and circuit diagrams. The work will entail the preparation of artwork, component reference masters and other essential P.C.B. documentation. The ability to produce fast and accurate results is essential. This will be a new appointment.

TEST ENGINEERS

Starting salary c £2,900

Vacancies exist for Electronic Engineers having a minimum of two years' experience of control and/or audio systems. An academic training to ONC/HNC level or equivalent qualification is desirable. On the job training will be given and opportunities for advancement are available.

The company offers an attractive working environment and excellent conditions of employment.

Applications to Mr. R. D. Naisbitt, Personnel Director, Electrosonic Ltd., 815 Woolwich Road, London, SE7 8LT. Telephone: 01-855 1101.

(6597)

SERVICE AND TEST ENGINEERS

At Stanmore we are involved in the provision of spares and the repair, maintenance and overhaul of a wide range of British and American airborne electronics equipment.

It's skilled work calling for the highest standards of craftsmanship and with the continuing growth of our servicing programme we are now looking for additional personnel to join our teams of Service and Test Engineers working both in the aircraft and in our extensively equipped workshops.

You should have a good knowledge of radio and electronics theory, ranging from audio to microwave, and at least two years' experience in servicing and maintaining complex electronic equipment, including fault diagnosis using sophisticated test gear. A recognised qualification would also be desirable but sound practical experience is more important.

FOR AIRBORNE ELECTRONICS EQUIPMENT

A good salary will be offered together with an attractive range of benefits. Working conditions are excellent and the establishment is conveniently situated in pleasant surroundings within easy reach of the A1 and M1.

Write with details of experience to Mrs. E. Wagg, Marconi-Elliott Avionic Systems Limited, 22-26 Dalston Gardens, Stanmore, Middlesex HA7 1BZ. Tel: 01-204 3322.

MARCONI ELLIOTT AVIONICS

A GEC-Marconi Electronics Company

THE UNIVERSITY OF LIVERPOOL

Institute of Child Health
Alder Hey Children's Hospital

TECHNICIAN

To assist with research. Work will include assistance with the design and development of medical electronic instruments and operation of the Institute's digital computer. Applicants must possess ONC or equivalent as a minimum qualification and be experienced in fault diagnosis and use of digital and analogue integrated circuits. Knowledge of programming an advantage. Salary within range up to £2,940 per annum (under review) according to qualifications and experience.

Application forms may be obtained from the Registrar, The University, P.O. Box 147, Liverpool L69 3BX. Quote Ref: RV/905/WW.

(6536)

CA CAPITAL APPOINTMENTS LTD.

JOB HUNTING?

We have more vacancies for DESIGN, DEV., TEST AND FIELD SERVICE ENG. than ever before. All areas and applications. Salaries to **£5,000**

6566

34 Percy Street, London, W1
01-636 9659 (day) or 550 0836 (evg.)

Home Office, London
RADIO PROPAGATION RESEARCH
up to £6700

This post, in the Propagation Section of the Directorate of Radio Technology, is concerned with the study of the latest worldwide researches in the field of radio propagation and the quantification of the effects so that they can be applied in practice. The work includes: liaising with research establishments; stimulating propagation research activities in areas of interest to the Directorate; and participating in the work of the International Radio Consultative Committee's study groups relating to the propagation of radio valves in ionized and non-ionized media.

Candidates must have a degree, or equivalent qualification, in Electrical Engineering or Physics, and should be Chartered Engineers. They should have specialised in radio wave propagation for about five years, and preferably have some research experience.

Starting salary betwen £5490 and £6700 depending on qualifications and experience. Prospects of promotion. Non-contributory pension scheme.

For further details and an application form (to be returned by 13th December, 1976) write to Civil Service Commission, Alencon Link, Basingstoke, Hants RG21 1JB, or telephone Basingstoke (0256) 68551 (answering service operates outside office hours). Please quote T(21)85.

(6540)

ALADDIN INDUSTRIES LTD.

require an

ASSISTANT DEVELOPMENT ENGINEER

to assist in the development and preparation of sample chokes and transformers. As such, he or she will be involved in the development of test equipment, testing ferrite components and providing an advisory service to production and inspection departments. Candidates, aged 20 to 24 years, should ideally have progressed to the final year of City and Guilds in Radio and TV Electronics Technicians Course or be studying for an HNC in Electrical Engineering, 2-3 years' experience of working in the electrical/electronic industry is essential.

Salary will be commensurate with age and experience up to £2,200 per annum and benefits include four weeks' annual holiday and contributory pension scheme.

For further details, telephone or write to

Mrs. L. Cooper, Personnel Department
Aladdin Industries Ltd.
Aladdin Building
Western Avenue
Greenford, Middlesex
Telephone: 578 2300

(6535)

Senior Test & Commissioning Engineers for Television Broadcast Equipment c. £5,000

Our new range of Telecine products are selling in ever-increasing numbers to customers worldwide. If you have experience of testing or servicing similar products and would like to join a growing Company exporting 90% of its equipment we would like to hear from you.

We have vacancies for:

U.K. based (Ware) Service and Installation Engineers to install and service equipment in the UK, USA, Europe and Asia.

Factory Final Test Engineers responsible for ensuring that our equipment meets the extremely high specifications we have set, and to conduct Customer Acceptance Trials.

For the right applicants we will pay a salary of up to £5,000, in addition some vacancies include a Company car. Relocation expenses will be paid by the Company for the more senior positions.

Please telephone or write to

The Personnel Department
Rank Cintel
Watton Road
WARE, Herts SG12 0AE
Telephone: Ware 3939

1975 THE QUEEN'S AWARD TO INDUSTRY

RANK CINTEL

Brighton Polytechnic
Learning Resources

MAINTENANCE ENGINEER CCTV and A/V

£3,678 to £4,407

to work in an expanding TV and AV service. High maintenance skills required with a wide range of A/V equipment from 16mm projectors to advanced Colour TV studio. This challenging job will need organising skills, and will be part of a technical team working in a newly built centre in a pleasant area.

VTR ENGINEER

£3,678 to £4,407

Qualified in electronics, with a background in broadcasting, large CC TV studio or other connections with television, preferably colour, to work in educational establishments breaking new ground in CC TV. Will have proven ability to maintain studio Helical VTR's but the interest and willingness to maintain a quantity of open reel portable and editing VTR's and VCR's.

Details and application forms from Personnel Officer, Brighton Polytechnic, Moulsecoomb, Brighton BN2 4GJ. Tel: 0273 67304.

Closing date 15th December (6591)

ONE ZAMBIA ONE NATION

Radio Engineers

K2388-K3756 (c. £1791–£2817)
Supplement £4122 (married), £2058 (single)

Together with most other countries, Zambia has recently been affected by the worldwide economic recession. Now our economy is surging forward strongly again, revitalised partly by significant advances in the country's agricultural industry and rising copper prices on world markets. Come here on a 3-year contract and your skills will be welcomed – and broadened. You'll enjoy the warm, pleasant climate in this totally land-locked country, larger than France, Belgium, the Netherlands and Switzerland combined. You'll enjoy the scenery too; although mainly a broad plateau, Zambia also features spectacular mountains, a certain amount of dense forest, imposing rivers, vast lakes and extensive game reserves. Its many large cities and towns contain all the normal modern facilities and are linked by excellent roads and rail services.

Requirements:

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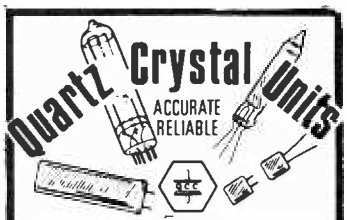

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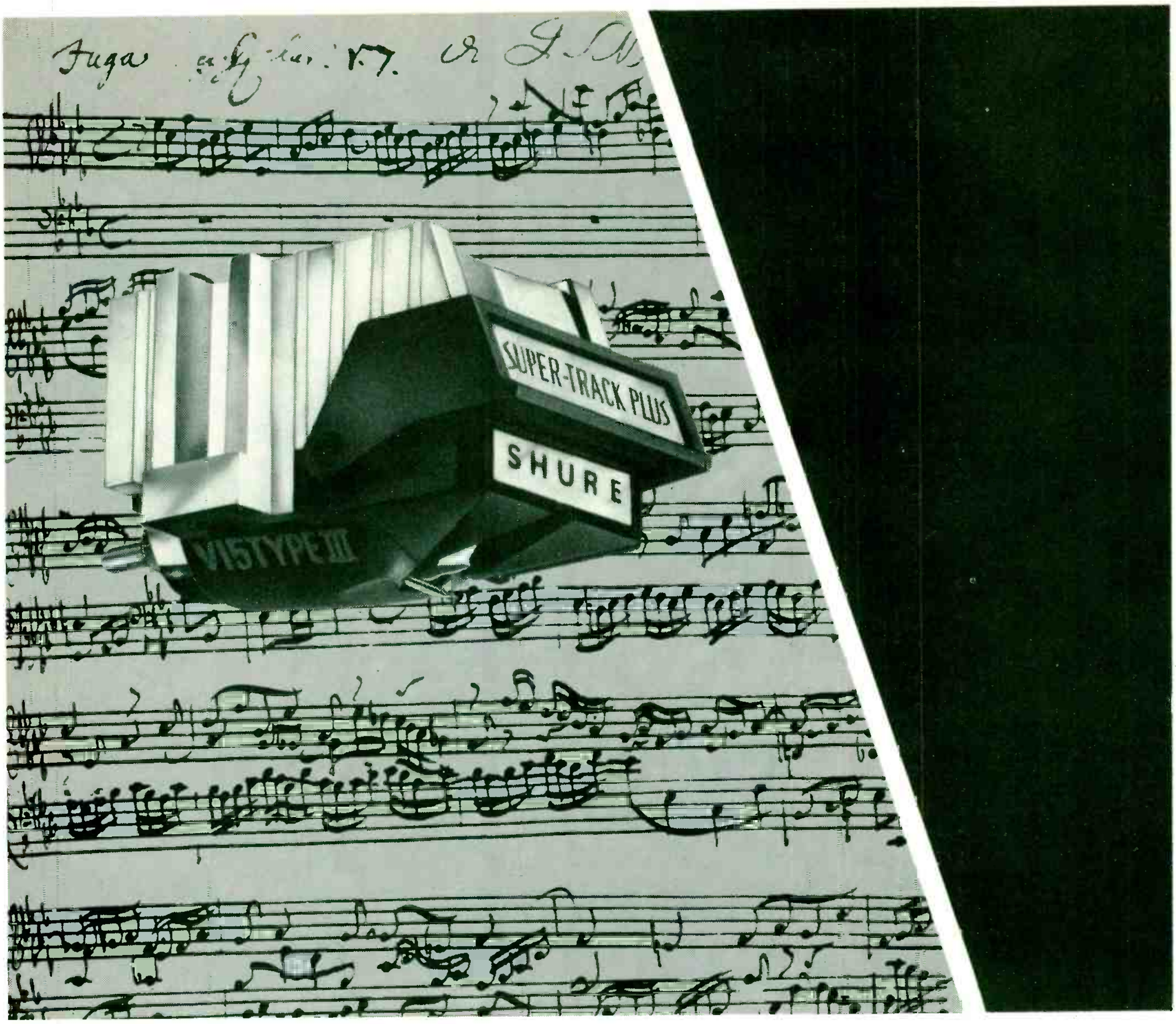

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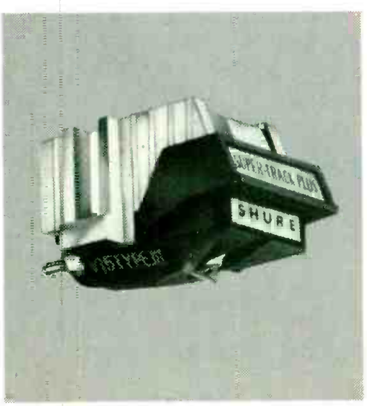

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