

# Wireless World

## Information retrieval

### Editor:

H. W. BARNARD

### Technical Editor:

T. E. IVALL, M.I.E.R.E.

### Assistant Editors:

G. B. SHORTER, B.Sc.

W. E. ANDERTON, B.Sc.

### Drawing Office:

L. DARRAH.

### Production:

D. R. BRAY

### Advertisements:

G. BENTON ROWELL (*Manager*)

Phone 01-261 8339

G. J. STICHBURY

Phone 01-261 8037

A. PETERS (*Classified Advertisements*)

Phone 01-261 8508 or 01-928 4597

Into the editorial office of *Wireless World* flows a constant stream (sometimes almost a flood) of information; article manuscripts, circuit ideas, letters, application reports, new products, etc. In addition we receive some 300 different journals from about 30 countries. We would need a staff of linguists even if we were to attempt to read them all. However, as circuit diagrams are the *lingua franca* of electronic engineers, few of the journals are without interest. The problem which faces us, the majority of our readers and all designers and research workers is one of information retrieval.

Many readers, we know, have their own filing systems. Some who tear out particular articles, letters, circuit ideas, etc. for filing have suggested that all articles should start on a righthand page and finish on a left. It is, of course, gratifying to know that the journal is such a valuable reference source, but there would be production problems if the suggestion were adopted.

A study has been made of many hundreds of electronic circuits published in this and many other journals in recent years and an attempt made by four lecturers at the Paisley College of Technology to classify them. Their research convinced them that there was a need for a quick-reference source of information on basic circuits. As a result of their study they conceived of the idea of Circards which they offered to us for publication. An introductory article, outlining the idea, is published in this issue together with an article on the first set of 12 Circards, covering basic active filters, which is obtainable from the editorial office at £1 per set.

It is our intention to publish two more sets in November and December and on the demand for these to decide future plans for the publication of other sets of cards. The originators have produced a list of some 60 circuit types which could be included in Circards.

We hope this attempt to facilitate the ready retrieval of circuit information will meet a need we know exists among designers.

## Desk calculator

We regret the delay in the appearance of this issue which contains the constructional details for the Desk Calculator, and apologize to the many readers who have been anxiously awaiting information as to where they can apply for kits. The introductory article created considerable interest and we hope those who construct the calculator will find it comes up to their expectations.

# The Wireless World Desk Calculator

## Part 2: Construction and operation

by Roger Alexander\* and Brian Crank†

Most of the constructional articles in *Wireless World* leave room for the reader to exercise his own expertise and imagination. We would not normally give detailed instructions unless there was some aspect which was particularly critical from the electrical performance point of view. With this desk calculator the situation is somewhat different. A kit of parts, complete to the last detail, is available and the object of this articles is to explain how the kit should be assembled. Each and every part in the kit has only one correct place in the finished calculator, therefore this article must of necessity comprise a very detailed list of instructions.

At the end of the article operating instruc-

tions are included in the form of worked examples, including a few typical electronics calculations.

The kit for the *Wireless World* Desk Calculator can be obtained from Advance Electronics Ltd, Calculator Division, Raynham Road, Bishop's Stortford, Herts, price £39.25 plus 75p postage & packing. Send a crossed cheque, postal or money order for the full amount with your order. The kit is supplied packed in polystyrene mouldings with all the individual components neatly laid out in a polystyrene tray. An internal view of the calculator giving the positions of the majority of components is shown in Fig. 12 and the finished machine in Fig. 13.

### Points to watch

The two large expanded polystyrene mouldings and the cardboard box in which the kit

is packed should not be discarded as they are designed to protect the completed calculator during storage or in the post should there be any need to return the calculator for servicing.§

There are two very critical aspects of the construction, one of which must be understood by the constructor *before the kit is unpacked*. It will be noticed that the calculator integrated circuit (TMS1802NC) is

§The calculator kit is fully guaranteed against defective parts. If inspection reveals faulty components, they should be returned to Advance Electronics with the appropriate description and part numbers and they will be replaced under the guarantee. If the completed calculator should fail to function properly and attempts to find and cure the trouble prove ineffective, then the instrument may be returned to Advance for repair. A small service charge will be made where the defect is not covered by the terms of the guarantee included in each kit.

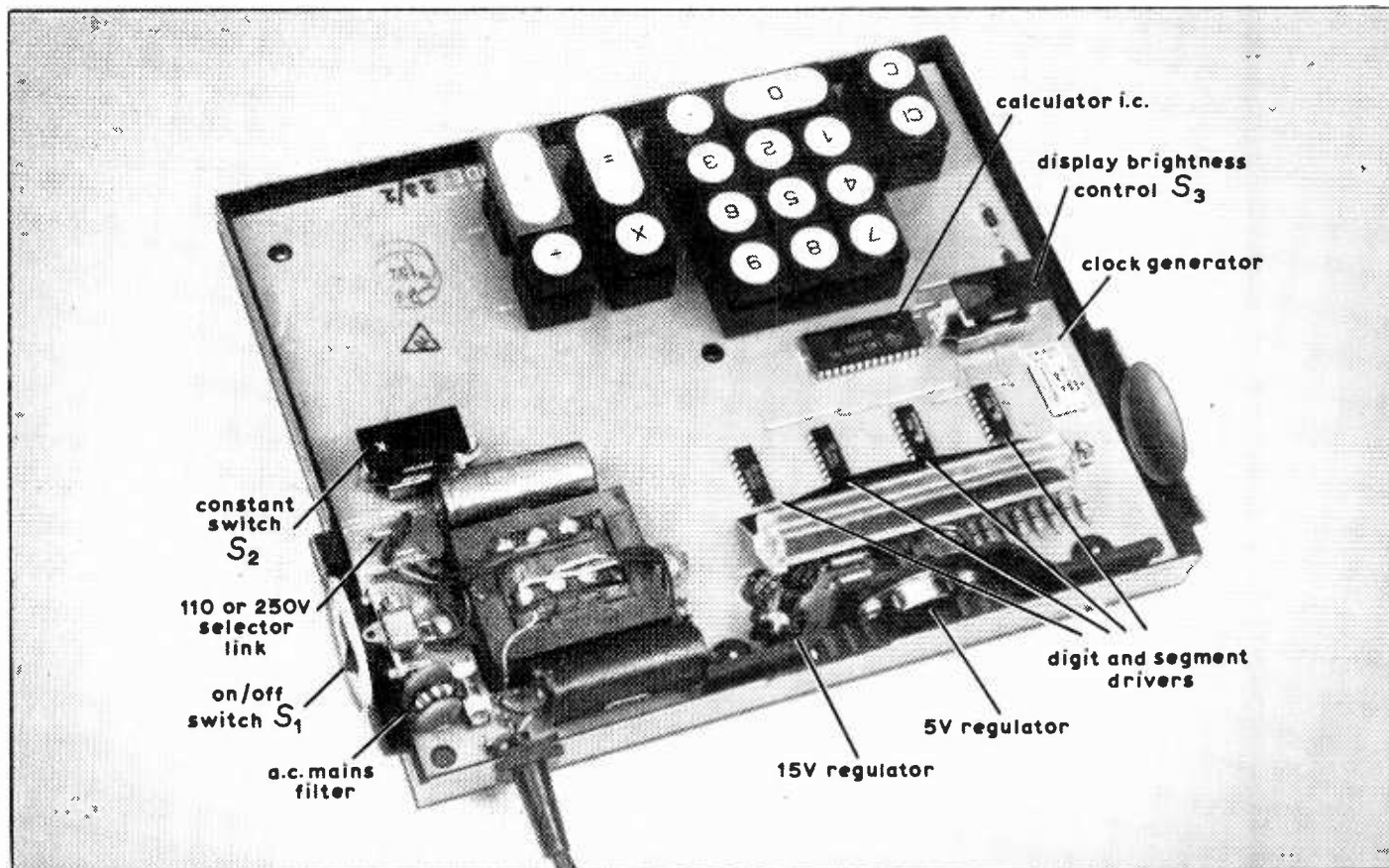


Fig. 12. Internal view of the calculator.

supplied with its leads embedded in what looks like ordinary black plastic foam material. The foam is in fact impregnated with a highly conductive material which short circuits all the leads during transport and handling. The reason for this is obvious when one considers the construction of the m.o.s. transistors in the i.c. The gate electrode of each m.o.s.f.e.t. is formed from a small metalized area insulated from the silicon chip by a very thin layer of silicon oxide. The impedance of the gates is extremely high and it is very easy to connect to the gate leadout wires a source of high voltage sufficient to puncture the oxide layer and destroy the i.c. Such voltage sources include static charges on nylon clothing or even bodily static charges. Anyone who has lived with a nylon carpet will know that such bodily static charges can be considerable, especially when one touches an earthed object or some object at a lower potential. Other sources of destructive high voltage can arise from capacitive coupling to the mains or, most important, unearthed soldering irons. Any attempt to solder the TMS1802NC calculator i.c. into the printed circuit board with an unearthed soldering iron will result in the instant destruction of the i.c. The TMS1802NC is by far the most expensive single item in the kit and to ensure it is not damaged the following precautions must be observed:

- Do not remove the black foam until the i.c. is to be soldered into the circuit board.
- Before removing the i.c. from the foam touch some earthed object to discharge any personal static charges.
- Grip the plastic package between the thumb and forefinger without touching the leadout wires.
- Only use a soldering iron of the highest quality which is connected to a *reliable* earth.

We apologize to readers with experience in handling m.o.s. l.s.i.c.s for labouring these points, but, as such devices may not be commonly used by some constructors, they will be the first to realize the importance of strictly adhering to the rules above.

The second critical point concerns the l.e.d. numerical displays. There are nine display packages which have to be mounted side-by-side on a small printed circuit board which plugs into the main mother board. Each package measures about 6.9 by 5.6 mm and has nine leadout wires. This means that 81 soldered joints have to be made in a space 55 x 13mm (2.2 x 0.52 inches). This requires a steady hand and a soldering iron with a bit diameter not greater than 1 or 2mm; if it has a chisel head so much the better. This should not present a problem as a larger bit can be turned down to the correct diameter in an electric drill and finally shaped with a file.

There are two other requirements for the soldering iron: it must have a fairly long bit if some of the wires are to be connected without melting the insulation on others and it must be of low wattage to prevent damage to the very narrow tracks on the circuit boards. About 15W is ideal.

If you are in any doubt at all about your soldering iron, buy a new one as it will cost

you less than £2.

All components, including the i.c.s, should be mounted as tightly to the board as possible if the proper performance is to be achieved. It is a good plan *not to* bend component leads over by 90° on the soldering side of the printed circuit board as this is not necessary for good connection and makes component removal very difficult during servicing or during the correction of mistakes.

Access to the individual components packed inside the two case halves is by removing the single screw at the centre of the base of the bottom half of the case.

In the detailed instructions which follow open parentheses ( ) have been placed before

each item for the constructor to tick as each task is completed as an *aide mémoire*.

### Assembly

#### Upper case half (Fig. 14)

( ) Remove the five strips of self-adhesive packing foam fitted inside the upper half of the case and discard.

( ) Place a piece of gauze over the slots on the inside at the rear of the case and fix in position by *lightly* touching it at about 50mm (2in) intervals with the tip of a soldering iron. The idea is to melt a small portion of the plastics case just below the gauze so that the gauze is held in position

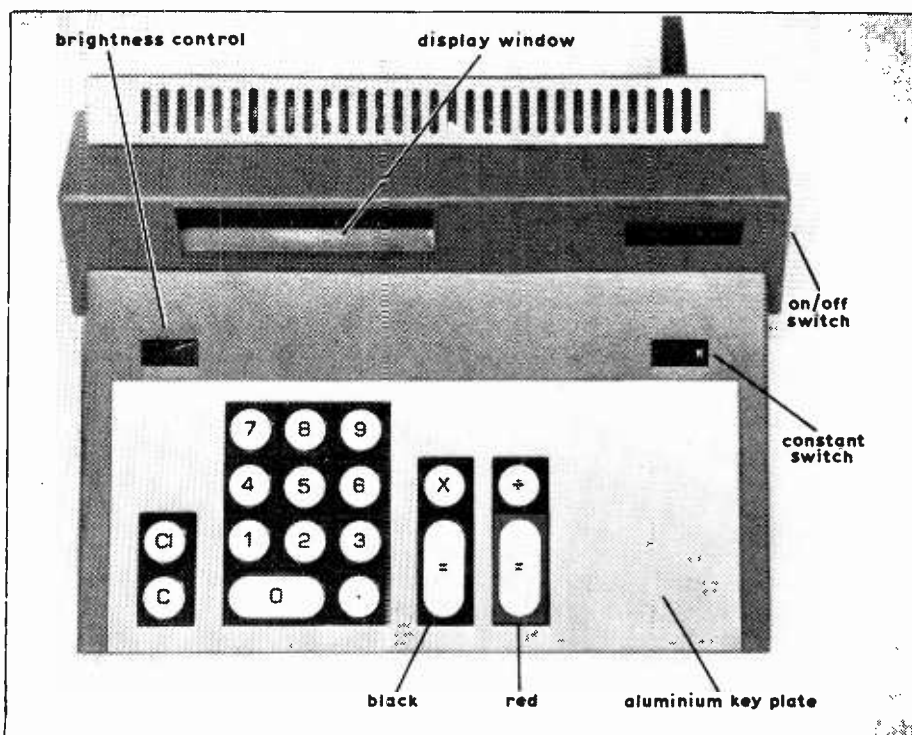


Fig. 13. The completed calculator showing the positions of the various keys and switches.

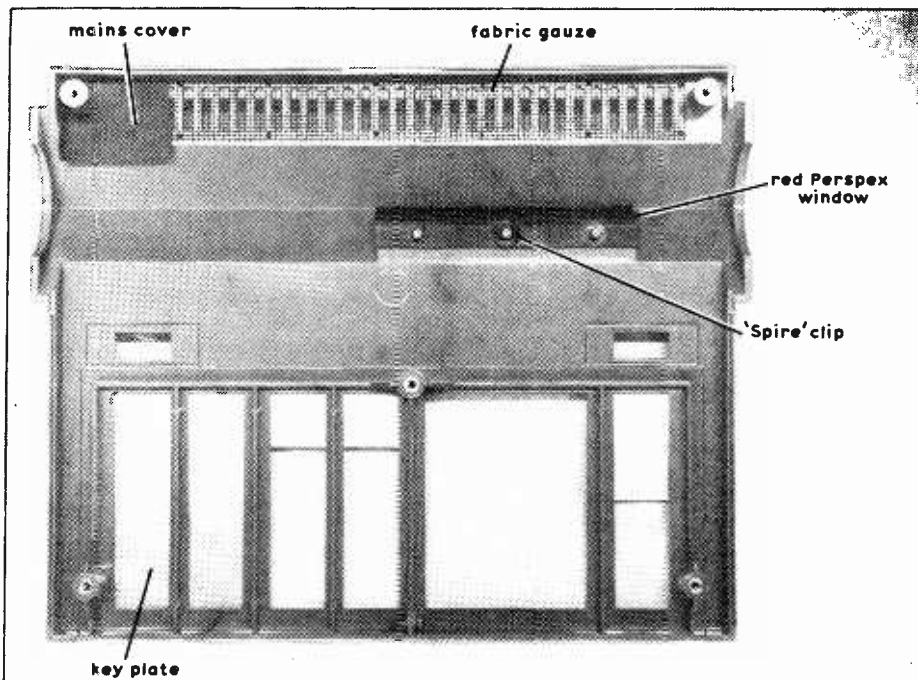


Fig. 14. Upper case half. The mains cover is not fitted until a late stage in the assembly procedure.

when the plastic sets. The emphasis is on the word lightly.

( ) Push the red Perspex window on to the three lugs and retain in position with a Spire clip on the centre lug. The concave side of the clip should face downwards.

( ) Remove the backing paper from the self-adhesive label 'Wireless World' and place in position in the indentation on the right-hand side of the case front (Fig. 13).

( ) Remove the backing paper from the large aluminium self-adhesive key plate and fit into position on the top of the case half. The best way to do this is to hold the plate at an angle of about 45° relative to the top of the case, locate the rear edge of the plate into the groove, and then bring the plate down into position. Press the plate down firmly to ensure good adhesion. *The plate has a thin protective layer of plastic; do not remove this until construction is completed.*

#### Lower case half (Fig. 15)

( ) Fix a piece of gauze over the slots on the inside of the case half in the same manner as before. This time remove a small piece of gauze from around the bulge in the case.

( ) Attach the self-adhesive serial number label to the indentation on the underside of the case half.

( ) Attach the self-adhesive lower plate (a piece of angle aluminium) to the case without removing the protective film.

( ) Push the two small rubber feet into the slots underneath the case with a small screwdriver.

#### 5V regulator and heat sink sub-assembly (Fig. 16)

( ) Referring to Fig. 16 fit the 5V regulator (L005) to the heat sink (it will fit only one way) and bolt into position using two 6.32, 9.5mm ( $\frac{3}{8}$  in) long screws, using a plain washer and nut on one side and a solder tag, wavy washer and nut on the other. With the heat sink in the position shown in Fig. 16 (mounting lugs downwards) the solder tag should be on the left hand screw.

( ) With the heat sink in the position described, solder a red wire to the top lead out, a black wire to the bottom lead out and a yellow wire to the solder tag. (Please observe the colour coding as the task of the engineers at Advance Electronics will be made easier should your calculator ever need servicing).

( ) Insulate each connection with one of the small sleeves supplied (do not use the large sleeve). Place the heat sink assembly on one side.

#### Mains switch sub-assembly (Fig. 17)

( ) Mount the switch to the bracket using two 8BA, 6mm ( $\frac{1}{4}$  in) long, screws using plain washers, shake proof washers and nuts. The photograph shows the exact method of assembly.

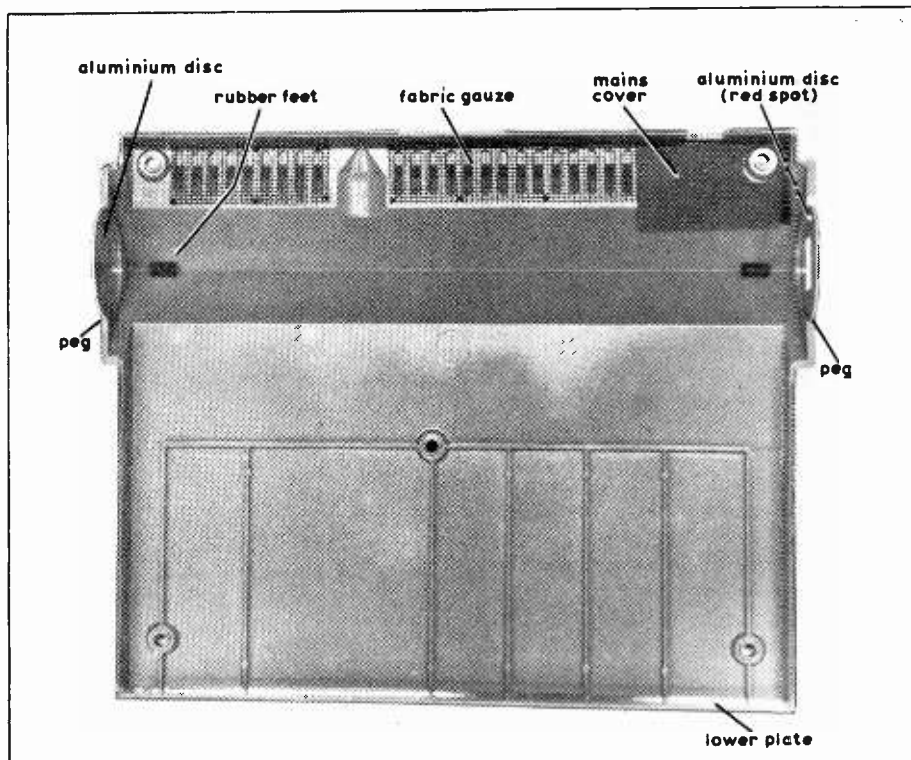
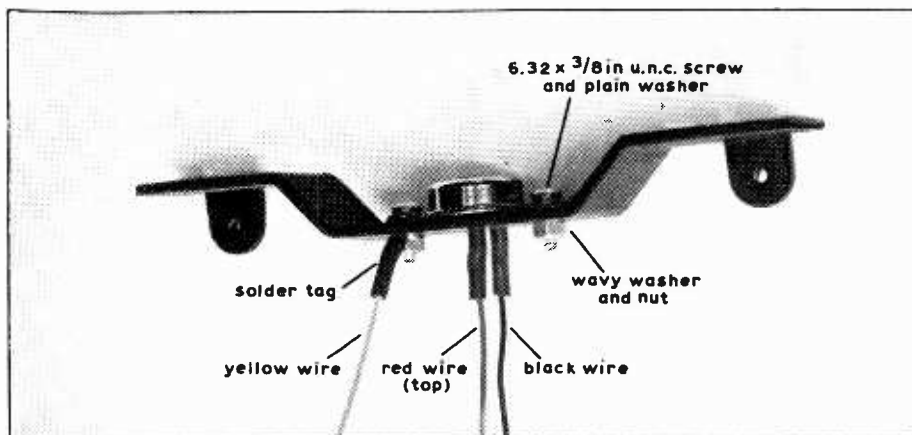


Fig. 15. Lower case half. Note the position of the cut-away in the gauze.



( ) Solder red wires to the terminals indicated in the photograph. Place the assembly on one side.

Fig. 16. The 5V regulator and heat sink sub-assembly.

#### Main circuit board (Fig. 18)

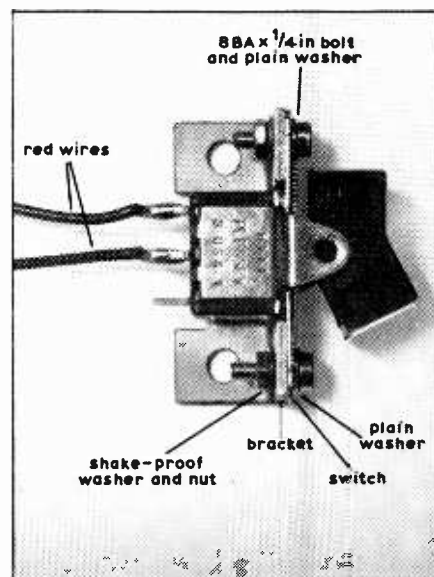
( ) Solder eight bare tinned copper wire links into position between holes connected by continuous white lines on the main circuit board (marked L on the photograph). *Do not solder links in the places marked '+ volts', '- volts' and '5 volts'.*

( ) Press fit the 21 miniature sockets into place and solder into position, making sure that the tops of the sockets are level with the top of the circuit board. Seventeen of the sockets (for the display sub-assembly) fit above the positions for the four d.i.l. i.c.s. The remaining four are situated in the holes marked 1, 2, 3, and 4.

It will be found that all electronic component positions are marked with their reference number on the board.

( ) Fit resistor  $R_1$ , 220 $\Omega$ , 0.5W.  
Fit resistors  $R_2$  to  $R_9$ , 47 $\Omega$ , 0.25W.

Fig. 17. Mains switch sub-assembly.



( ) Fit capacitors  $C_5$  and  $C_6$  ( $10\mu\text{F}$ ,  $16\text{V}$ ). The printed circuit board has white lines to show the components' positions; the bisecting line indicates the positive end. The black line round the capacitor is the *negative* connection. The positive connection is at the end nearest  $R_9$ .

( ) Fit diodes.  $D_1$  7.5V zener  
 $D_2, D_3$ , IN4001

The white band indicates the positive end.

( ) Fit bridge rectifiers  $MR_1$  and  $MR_2$  (type W005). The '+' mark on the rectifier's body must line up with the '+' mark on the circuit board. (Ensure that the bridges are pushed down flush with the board.)

( ) Fit the 15V regulator  $IC_1$  (TBA 625C). The pip on the TO-5 case must line up with the marking on the board. Make sure the bottom of the can is flat on the board.

( ) Press fit corrugated heat sink on to  $IC_1$ .

( ) Fit fuse holder into the two large holes to the left of the mounting position for  $C_1$  and  $C_2$ .

( ) Cut, strip and tin the four wires from the toroidal coil  $L_1$ . The red wires go to the holes marked 'R' and black wires to the holes marked 'B'. The coil is mounted so that it stands upright and is flush to the board.

( ) Fit capacitors  $C_1$  and  $C_2$  ( $1.8\text{nF}$  marked  $1800\text{p}$ ) either side of  $L_1$ . Together  $C_1$ ,  $C_2$  and  $L_1$  form a mains pulse interference suppressor.

( ) Fit the hybrid integrated circuit clock generator in the white package (9698 21280) so that pin 1 corresponds to the 1 marked on the board.

( ) Fit  $IC_3$  and  $IC_4$  (SN75491N) so that the 'horse shoe' indentation corresponds to the horse shoe marking on the board.

( ) Fit  $IC_5$  and  $IC_6$  (SN75492N). Each package has a horse shoe indentation which must be lined up with the board marking.

( ) Fit capacitors  $C_3$  ( $2,200\mu\text{F}$ ) and  $C_4$  ( $1,500\mu\text{F}$ ); the '+' marking on the components lining up with the '+' markings on the board.

( ) Fit the display brightness control switch  $S_3$  (three-position slide) in the following manner: Push a  $14\text{mm}$  ( $\frac{9}{16}\text{in}$ )  $4.40$  u.n.c. (unified coarse thread) screw through the circuit board from underneath and place a pillar, the switch and a wavy  $4.40$  washer on the screw in that order. Loosely secure with a nut. Repeat the procedure for the other switch mounting hole. Tighten up screws and then (*and only then*) solder the switch connections to the board.

( ) Fit  $S_2$  (two-position slide) to the board in the same manner as  $S_3$ .

( ) Remove the tops of all the key switches by giving them a slight pull.

*It will be noticed that the base of the key*

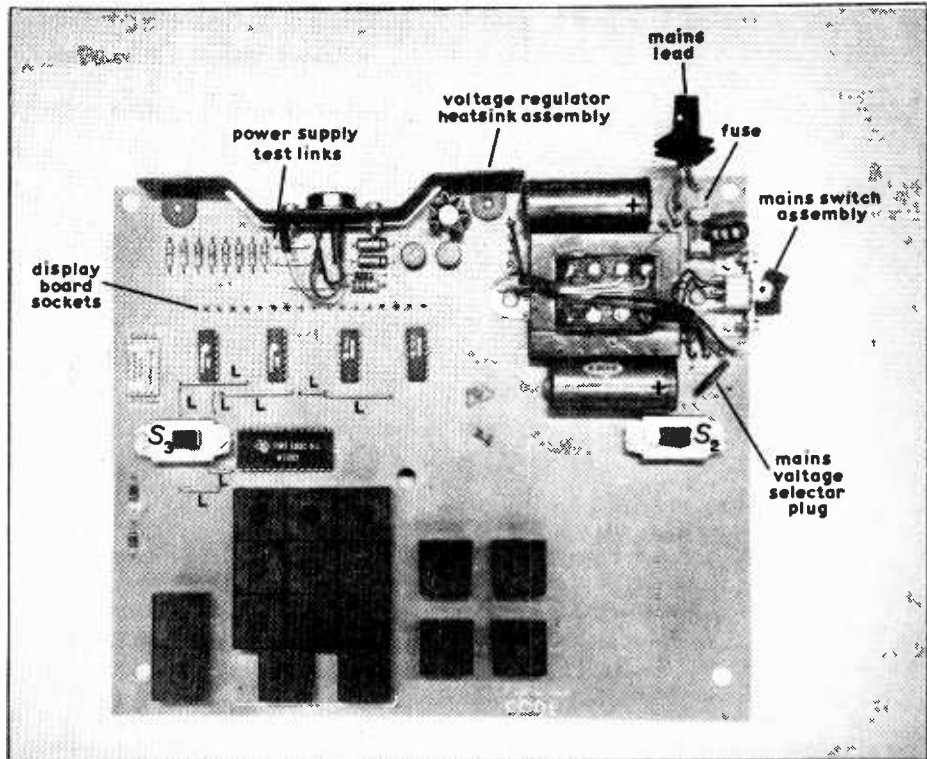


Fig. 18. Main printed circuit board showing the position of all components.

*switches is formed from two snap-together parts which contain the magnet and reed switch assembly. These two parts of the switch are matched and must not be interchanged.*

The shot-moulded key tops (with the numbers, letters etc.) are fully interchangeable.

( ) Fit all the key-switch bases to the board (they will only go in one way) and carefully align them both horizontally and vertically before soldering. Pieces of card and elastic bands may be of help here. Solder the switches in position.

If any switches have become misaligned melt the solder for that switch and 'juggle' it into position.

( ) Strip and tin the three wires from the 5V regulator and heat sink assembly and solder them to the circuit board pins as follows:

Red to pin B  
Black to pin E  
Yellow to pin C

( ) Identify the two 'Tapex' self tapping screws (when viewed from the thread end they have a very slightly triangular cross section). The screws are  $4.40$  u.n.c. and are  $6\text{mm}$  ( $\frac{1}{4}\text{in}$ ) long. Use these screws to secure the heat sink assembly to the main circuit board.

( ) Lay the mains transformer ( $T_1$ ) in the oblong cut-out in the printed circuit board with the white wire to the rear. Bolt the transformer in position using two  $6.32$  u.n.c.  $8\text{mm}$  ( $\frac{5}{16}\text{in}$ ) long screws,  $6.32$  wavy washers and nuts. The nuts and washers should be on the underside of the board.

( ) Cut the remaining large sleeve in two.

Place one half over the blue and yellow wires and the other half over the red, black, orange and brown wires. These sleeves are to keep the wires neatly in a bundle and are not for insulating purposes.

( ) Solder the transformer lead-out wires to the marked circuit board pins as follows (all the wires are tinned and are already cut to the correct length):

blue wires,	one to each pin BL
yellow wires,	one to each pin YW
red wire	to RD
black wire	to BLK
orange wire	to ORG
brown wire	to BRN
white wire	to W

( ) Bolt mains switch to board using two  $4.40$  u.n.c.,  $6\text{mm}$  ( $\frac{1}{4}\text{in}$ ) long, screws,  $4.40$  wavy washers and nuts. Refer to Fig. 18. The nuts and washers should be on the underside of the board.

( ) Solder the two red wires from the mains switch assembly to the two pins marked S1 (one wire to each pin!).

( ) Read the warning notes at the beginning of this article regarding the calculator i.c. TMS1802NC.

( ) Fit  $IC_7$  (TMS1802NC) to the printed circuit board after removing the conductive foam. If the i.c. has a horse shoe marking the device must be fitted so that this marking corresponds with the horse shoe marking on the board. That is, nearest to the switch  $S_3$ . The i.c. may, however, have a dot on the package indicating pin 1. If this is the case the package must be fitted with the end with the dot nearest to  $S_3$ .

If the pins on the i.c. do not line up with



the holes in the circuit board bend the pins by pressing them on a flat, insulating, surface. Remember not to touch the pins with the fingers.

( ) Solder the mains lead to the main circuit board pins as follows (the leads are tinned and have already been cut to the correct length):

green/yellow to pin E  
brown to pin L  
blue to pin N

This completes the main circuit board assembly.

#### Display printed circuit board assembly (Fig. 19)

The display board involves some fairly intricate soldering. The constructor must therefore have a suitable soldering iron and should preferably be working in a quiet environment to assist concentration.

The display printed circuit board is double sided and has plated through holes. It comes equipped with 17 mounted pins which have been accurately set at 45° and spaced to match the 17 sockets in the main circuit board. The alignment of these pins should not be disturbed.

( ) Solder the mounted pins to the printed circuit track on side A of the display board taking great care to prevent solder running down the pins. If this happens the solder will have to be removed before the display board will plug into the main circuit board.

( ) Insert one indicator into position LD9 on side B of the board ensuring that the type number on the package is facing in the direction indicated on the board. All the pins on the packages are accurately preformed and the package should be pushed down as far as the bends on the leads. Hold the digit in place while turning the board over. *Solder the middle pin only.* The middle pin has only a copper pad to solder to but as the hole is plated through solder will flow down into the hole and around the lead.

If necessary the solder connection should be re-heated whilst gently manipulating the indicator until the package reaches its final position. (Hard down against the bends in the leads and square).

( ) This procedure is repeated for the other eight digits (LD8 to LD1) ensuring that the indicators are inserted with the type number in the right direction and that only the middle pin on each package is soldered, making sure that all the packages finally sit at the same height. This can be achieved by very carefully melting the solder round the centre pin (taking care not to overheat) and manipulating each individual indicator. All the indicators should be true and square in all three planes.

( ) Cut all the indicator leads off so they stand about 1.5mm ( $\frac{1}{16}$ in) proud of side A of the board.

( ) Solder all the remaining connections, taking them a row at a time and taking care not to miss any. Soldering must be carried out only on side A of the board. The other holes in the board do not need soldering as they are plated through.

( ) Examine the display printed circuit board, with a magnifying glass if available, for conductors bridged with solder and missed connections.

#### Power supply test

**WARNING:** WHENEVER THE MACHINE IS CONNECTED TO THE MAINS CERTAIN COMPONENTS AND CERTAIN CONDUCTORS ON THE PRINTED CIRCUIT BOARD ARE AT MAINS VOLTAGE. CARELESS HANDLING COULD RESULT IN A FATAL ACCIDENT. TAKE CARE.

( ) Place the main circuit board assembly in the lower case half, locating the raised lugs in the holes in the circuit board.

( ) Fit red 'plug links' for the appropriate mains supply as indicated on the main

circuit board and insert a 50mA fuse in the fuse holder.

( ) Connect a suitable mains plug to the mains lead in the usual manner:

brown - live  
blue - neutral  
yellow/green - earth

( ) Plug the calculator into the mains socket and switch on the calculator.

( ) Measure the voltages present at the pins marked '5 volts', '+ volts' and '- volts' nearest to C<sub>5</sub> and C<sub>6</sub>. The results should be as follows (use the case of the TO-3, 5V regulator as common):

5 volt pin 5V ± 0.25V  
+ volt pin +7.5V ± 1V  
- volt pin -7.5 ± 1V

( ) Switch off and remove mains plug.

( ) If the voltage measurements were within the prescribed limits one can proceed with the construction. If they were not, locate and cure the trouble *before proceeding any further.*

( ) Solder in place three bare tinned copper wire links marked '5 volts', '+ volts' and '- volts'.

( ) Remove the printed circuit board from the lower case half and place it on a raised flat surface clearing the mains transformer protrusion.

( ) Push the key switch tops into position referring to Fig. 13.

( ) Place the constant slide switch top (S<sub>2</sub>) into position with the 'K' marking to the right.

( ) Place the display brightness switch top (S<sub>3</sub>) into position with the red section to the right.

( ) Plug the display printed circuit board into the 17 sockets in the main circuit board. A considerable amount of force is necessary so one must be very careful if nothing is to be broken.

(If it is necessary to remove the display board at any time carefully lever it upwards using a large screwdriver, taking care not to distort the pins).

( ) Place the main circuit board back into the lower case half as before.

#### Functional test

( ) Replace the mains plug, switch on, place K switch to right, and perform the tests detailed in Table 2.

If the calculator does not operate correctly examine all connections, referring to the circuit diagram (Fig. 20) and the calculator description given in the first article. If you are still unable to trace the fault complete the assembly procedure and, after carefully packing the calculator, return it to Advance Electronics for servicing.

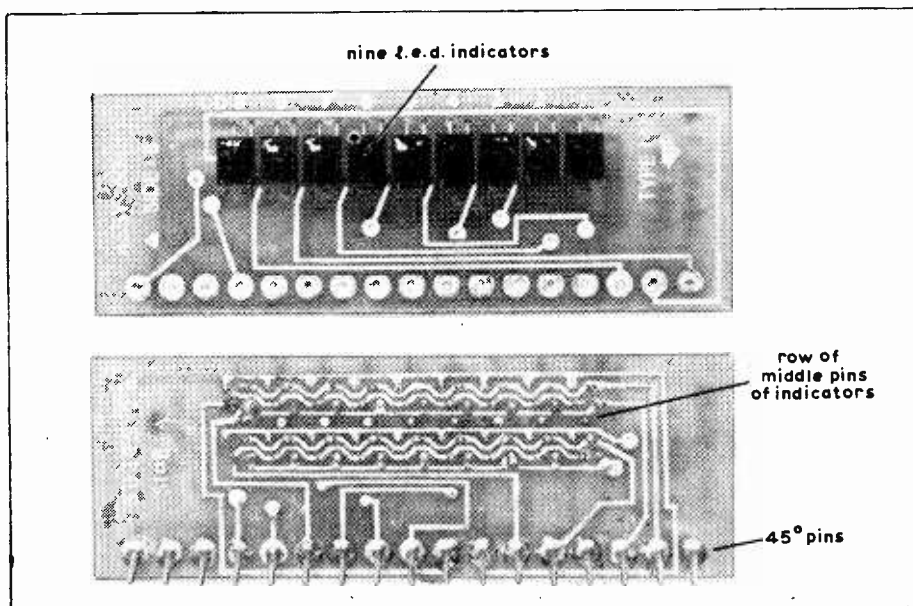


Fig. 19. Both sides of the indicator printed circuit board.

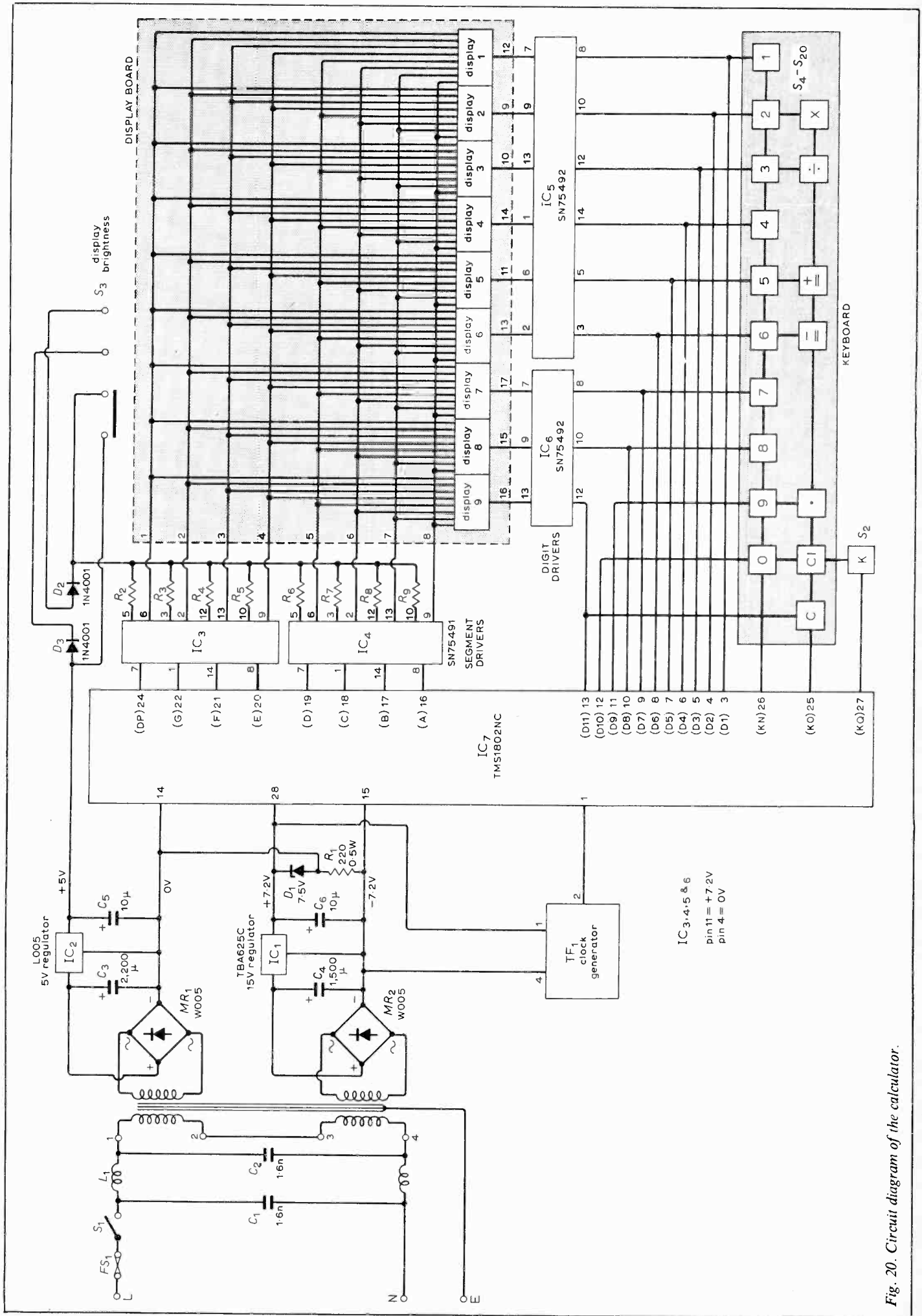


Fig. 20. Circuit diagram of the calculator.

Table 2

KEY OPERATION	DISPLAY READING
C	0.
1.2 3 4 5 6 7 9 0	[ 1.2345679
CI	0.
8 8 8 8 8 8 8 8	88888888.
X	88888888.
Black =	∟ 790 12344.
'K' switch to the far left (constant in)	
C	0.
.1 2 3 4 5 6 7	0. 1234567
X	0. 1234567
1	1
Black =	0. 1234567
÷	0. 1234567
.1 2 3 4 5 6 7	0. 1234567
Red =	-

- CI: Clears the last number entered (should an error have been made) and resets the display register to 0.
- K: Enables the calculator to store the command to multiply or divide by a number which does not vary for a series of calculations.

It will be remembered (Part 1) that the extreme left-hand indicator is used to indicate if the displayed number is negative or if some abnormal condition exists within the calculator. The symbols and their meanings are repeated in Table 3.

When an entry overflow is indicated calculations can continue but the symbol will remain illuminated until the machine is cleared.

Table 3

[	entry overflow
∟	answer overflow
-	negative number
6	entry overflow, answer overflow and negative number

**Final assembly**

( ) Cut the mains cover (a piece of black card with two holes punched in it) in the centre of the two fold lines and fit to the upper and lower case halves as shown in Figs. 14 and 15 after folding along the fold lines.

( ) Fit the circuit board into the lower case half ensuring that the lugs fit into the holes at the corners of the circuit board. It is best to align the left hand front hole first.

( ) Push the moulding on the mains lead firmly into the slot at the rear of the case.

( ) Fit the disc with the red dot into the groove at the right hand side of the case. The slot in the disc fits over the mains switch and the red dot should be towards the front of the case.

( ) Fit the second disc in its groove at the left hand side of the case (spun finish outwards) with the peg towards the front.

( ) Fit the display shield (a piece of black card with a slot cut in it) over the indicators so that it rests on the indicator leads.

( ) Slide the Perspex magnifier over the indicators, making sure that the printed circuit board and the display shield fit in the slots in the magnifier.

( ) Place the top half of the case in position ensuring that the end discs and the slide switch tops fit into their grooves and slots.

( ) Secure the two case halves together with five 6.32 u.n.c., 12mm (1/2 in) long screws fitted from underneath.

( ) Remove the thin protective film of plastic from both the aluminium key plate and the lower aluminium plate.

The calculator is now complete and if it has been carefully constructed should have a long and trouble free life. Note that a dust cover is provided to protect the machine when it is not being used.

**Operating the calculator**

Entering a number into the calculator is simply a matter of pressing the appropriate keys, as was seen during the test procedure. For instance, to enter 15.36 one presses key 1, then key 5, then the decimal point key followed by keys 3 and 6.

The operations which the various keys perform are set out below. Some of the explanations may not be clear at this stage but they will be clarified during the practical examples.

- x: Stores the command to multiply and executes a possible preceding instruction.
- ÷: Stores the command to divide and executes a possible preceding instruction.
- = (black): Performs addition. Enters the last number keyed into the calculator (which is indicated on the display) and performs a possible preceding instruction.
- = (red): Performs subtraction. Enters the last number keyed into the calculator (which is indicated on the display) as a negative number and performs a possible preceding instruction.
- C: Resets the whole calculator to 0.

If the symbol appears which indicates that the result of a calculation has exceeded the capacity of the machine the answer will be correct to the eight most significant digits and the decimal point must be shifted eight places to the right to obtain the correct answer.

Some worked examples follow and it is recommended that the reader tries these to familiarize himself with the machine.

During the examples a colon (:) will be used to indicate that keystrokes have to be made.

The instruction 5.1: means press key 5 followed by the decimal point key followed by the 1 key, in other words, enter 5.1. In the same manner the following instructions are to be interpreted as follows: x: press multiply key; ÷: press divide key; B=: press black equals key; R=: press red equals key; → K: slide constant switch to the right; ← K: constant switch to the left; and C: press clear key. The number which will appear on the display is printed in square brackets [4159659] whenever the indicated number is significant.

**General arithmetic examples**

**Example a.** 15.3 + 27.9  
C: 15.3: B=: 27.9: B=: [43.2]

**Example b.** 14.8 - 4.12  
C: 14.8: B=: 4.12: R=: [10.68]

**Example c.** 15 - 7 + 8  
C: 15: B=: 7: R=: 8: B=: [16]

**Example d.** 1.3923905 x 400  
C: 1.3923905: x: 400: B=: [556.9562]

**Example e.** -3 x 8  
C: 3: R=: x: 8: B=: [-24]



**Example f.**  $22 \div 7$   
C: 22:  $\div$ : 7: B=: [3.1428571]

**Example g.**  $5 \times (-7) \div (-3)$   
C: 5:  $\times$ : 7: R=:  $\div$ : 3: R=: [11.6666666]

**Example h.**  $\frac{4(5+7-3)}{2} - 3$

C: 5: B=: 7: B=: 3: R=:  $\times$ : 4:  $\div$ : 2:  
B=: 3: R=: [15]

**Example i.** Convert 17.1, 19.5, and 23 inches to millimetres. There are 25.4mm to the inch.

C:  $\leftarrow$  K: 25.4:  $\times$ :  
The machine has now stored the instruction multiply by 25.4 in its constant register. Proceed as follows:

17.1: B=: [434.34] mm  
19.5: B=: [495.3] mm  
23: B=: [584.2] mm

Notice that there was no need to enter the instruction to multiply or 25.4 between each calculation, nor was there need to clear the machine.

**Example j.** Convert \$17.26, \$15.33 and 77c to pounds assuming that the exchange rate is \$2.55 to the pound.

C:  $\leftarrow$  K: 17.26:  $\div$ : 2.55: B=: [6.7686274]  
which would be rounded off to £6.77. The machine has now stored the instruction to  $\div$  2.55. Proceed as follows

15.33: B=: [6.0117647] (£)  
.77: B=: [0.3019607] (£)

**Example k.**  $7^4 \times 3$   
C:  $\leftarrow$  K: 7:  $\times$ : 3: B=: B=: B=: B=: [7,203]

**Example l.**  $46 \div 3^3$   
C:  $\leftarrow$  K: 46:  $\div$ : 3: B=: B=: B=: [1.7037036]

**Example m.** Find  $3^2, 3^3, 3^4, 3^5, \dots, 3^n$   
C:  $\leftarrow$  K: 3:  $\times$ : B=: [9] =  $3^2$   
B=: [27] =  $3^3$   
B=: [81] =  $3^4$   
B=: [243] =  $3^5$  etc.

Make sure the constant switch is in the right hand position before the next example.

**Example n.** Find the reciprocal of 0.000081 (= 1/0.000081).

There are two ways of doing this.  
C: 1:  $\div$ : 0.000081: B=: [12345.679]

If 0.000081 is the result of an earlier calculation and is already held in the machine it is inconvenient to use the technique above to find the reciprocal as it would be necessary to clear the calculator and enter 1  $\div$  and the number.

The calculator holds 0.000081 as the result of a previous calculation (to simulate this enter 0.000081 followed by B=:). To find the reciprocal proceed as follows:

$\leftarrow$  K:  $\div$ : B=: [1] (indicated)  $\rightarrow$  K: B=: [12345.679]

To prove the result repeat the operation  $\leftarrow$  K:  $\div$ : B=:  $\rightarrow$  K: B=: [0.000081]

This technique can be used to great advantage as will be seen in later examples.

**Example o.** Find the square root of 35. The method uses the well known formula:

$$= \frac{1}{2} \left( \frac{x}{n} + n \right)$$

where  $n$  is an approximation and  $x$  is the number the square root of which is required. A mental approximation can be tried on the calculator and 5.9 seems reasonable

C: 5.9:  $\times$ : B=: [34.81] =  $(5.9^2)$

which is not far from 35.

To find  $\sqrt{35}$  proceed as follows:

C: 5.9: B=:  $\leftarrow$  K:  $\div$ : B=:  $\rightarrow$  K: 35: B=: 5.9: B=:  $\div$ : 2: B=: [5.9161015]

The result of this calculation (5.9161015) is used in place of 5.9 and the procedure is repeated. Because 5.9161015 is already in the machine the first three operations are omitted.

$\leftarrow$  K:  $\div$ : B=:  $\rightarrow$  K: 35: B=: 5.9161015: B=:  $\div$ : 2: B=: [5.9160795]

The procedure is repeated with the new approximation:

$\leftarrow$  K:  $\div$ : B=:  $\rightarrow$  K: 35: B=: 5.9160795: B=:  $\div$ : 2: B=: [5.9160795]

This is the same as the second approximation and the process is complete. To calculate the error, with the result still in the machine, all one need do is square 5.9160795:

$\times$ : B=: [34.999996]  
R=: 35: B=: [0.000004]

which represents the error.

In general the iteration process is continued until the square root is correct to the required number of decimal places.

### Some typical examples in electronics

**Example p.** Find the resistance  $R$  of a circuit consisting of  $3.9\text{k}\Omega$  in parallel with  $5.6\text{k}\Omega$  using the formula:

$$R = \frac{3.9 \times 5.6}{3.9 + 5.6} \times 10^3$$

This can be solved by calculating the denominator and using the constant register to store  $\div (3.9 + 5.6)$  while  $3.9 \times 5.6$  is being found:

C: 3.9: B=: 5.6: B=:  $\leftarrow$  K:  $\div$ : B=:  $\rightarrow$  K: 3.9:  $\times$ : 5.6: B=:  $\times$ : 1000: B=: [2298.9472] $\Omega$

**Example q.** A tuned circuit is required which will resonate at 10.7MHz; calculate suitable values of  $L$  and  $C$  using the formula:

$$10.7 = \frac{159}{\sqrt{LC}}$$

where  $L$  is in  $\mu\text{H}$  and  $C$  is in pF.

$$\sqrt{LC} = 159/10.7$$

C: 159:  $\div$ : 10.7: B=: [14.859813] (=  $\sqrt{LC}$ )

$$\therefore \frac{\sqrt{LC}}{LC} = \frac{14.859813}{(14.859813)^2}$$

(14.859813 is already in the calculator)

$$\times$$
: B=: [220.81404] (=  $LC$ )

If a value of  $8\mu\text{H}$  is chosen for  $L$ :

$$C = 220.81404/8$$

(220.81404 is already in the calculator)

$$\div$$
: 8: B=: [27.601755]

$\therefore C = 27\text{pF}$ ,  $L = 8\mu\text{H}$ .

As an exercise, to prove the calculation, proceed as follows: (we have already established 14.859813 as being  $\sqrt{LC}$ )

C: 27.601755:  $\times$ : 8:  $\div$ : 14.859813: B=:  $\leftarrow$  K:  $\div$ : B=:  $\rightarrow$  K: 159: B=: [10.7]

**Example r.** Assuming that the coil of the above example has a resistance of  $5\Omega$  calculate its dynamic resistance  $r_d$  using the formula:

$$r_d = (L/CR) \times 10^6$$

where  $L$  is in  $\mu\text{H}$ ,  $R$  is in ohms and  $C$  is in pF

$$r_d = [8/(27 \times 5)] \times 10^6$$

C: 27:  $\times$ : 5: B=:  $\leftarrow$  K:  $\div$ : B=:  $\rightarrow$  K: 8: B=:  $\times$ : 1000000: B=: [59,259.2]

$$r_d = 59,259.2\Omega$$

**Examples.** Find the  $Q$  of the coil in examples q and r using the formula:

$$Q = r_d / (2\pi f L)$$

$f$  in MHz,  $L$  in  $\mu\text{H}$

C: 2:  $\times$ : 3.1416:  $\times$ : 10.7:  $\times$ : 8: B=:  $\leftarrow$  K:  $\div$ : B=:  $\rightarrow$  K: 59259.2: B=: [110.17958]

$$Q = 110$$

**Example t.** The 3dB bandwidth of the tuned circuit (=  $f_0/Q$ ) can be calculated as follows:  
C: 10.7:  $\times$ : 1000:  $\div$ : 110: B=: [97.272727]

$$3\text{dB bandwidth} = 97\text{kHz}$$

There are of course many other ways in which the calculator can be used but by now the reader should be able to discover them for himself.

## V.H.F. Reception

*Wireless World* is collecting information for a survey on the reception of v.h.f./f.m. sound broadcasts and will be glad to hear of readers' experiences and opinions on this subject. The following topics would be of interest: design, performance and price of receivers; facilities on sets; dealers' experience in selling and installing sets; users' experience of buying sets and after-sales service; comparison of v.h.f./f.m. broadcast reception with that on medium and long waves; and interference effects from other stations (e.g. national vs. local), from man-made sources and natural sources.

# Domestic Receiver Survey

## A brief examination of the year's technological trends

The design of modern radio and television receivers has, to a large extent, settled into a well established configuration and much of the recent progress has been concentrated in improving performance and reliability and reducing manufacturing costs. In addition there is an increasing awareness that the receiver, television or radio, fulfils more than just the simple job of reproducing the original transmissions, it must also form an integral part of the modern home. This concept has been evident to a certain degree in cabinet design and styling from the very beginning, but now an even greater emphasis is being placed upon this and ergonomic aspects.

### Integrated circuits

The integrated circuit has been seen to be one of the most potentially significant factors in improving reliability and reducing manufacturing costs. Some of the earliest examples of linear amplifiers to be

used were developments from the simple operational amplifier, and first appeared as audio pre-amplifiers in low-cost, high-volume products. From this time there was a rapid evolution into low-power amplifiers delivering up to four or five watts to a 15-ohm loudspeaker, and thence into high-frequency applications such as the 6MHz intercarrier sound i.f. strip in a television receiver. Shortly after this, integrated circuit amplifiers capable of reaching 40MHz were introduced and found an application in the vision i.f. strips.

From this point on, the development of new integrated circuits for use in radio and television receivers was dictated by the set manufacturers, who soon saw the possibilities of these devices, and limited only by the ingenuity of the semiconductor manufacturers. In the past year some new TV receivers have been marketed containing anything from three to nine integ-

rated circuits, and a typical example of the applications being found for them is the simplified block schematic (Fig. 1) of the new G.E.C. single-standard colour receiver series C2110. Interestingly, the i.f. amplifier in this set uses discrete components, three transistors and the usual LC tuned circuits. The first integrated circuit immediately follows the i.f. strip and is a synchronous wave detector used to derive the signal to drive the luminance amplifier and the chrominance delay line. This i.c. is similar in its operation to the Motorola device described in last year's review of receivers,\* but the device used in this case is the Mullard TBA 270Q which appears to have an additional feature designed to generate an a.f.c. voltage which is fed back to the varicap tuner module. The method of producing this voltage is interesting since it employs

\*Television Receiver Review, October 1971, pp 470-472.

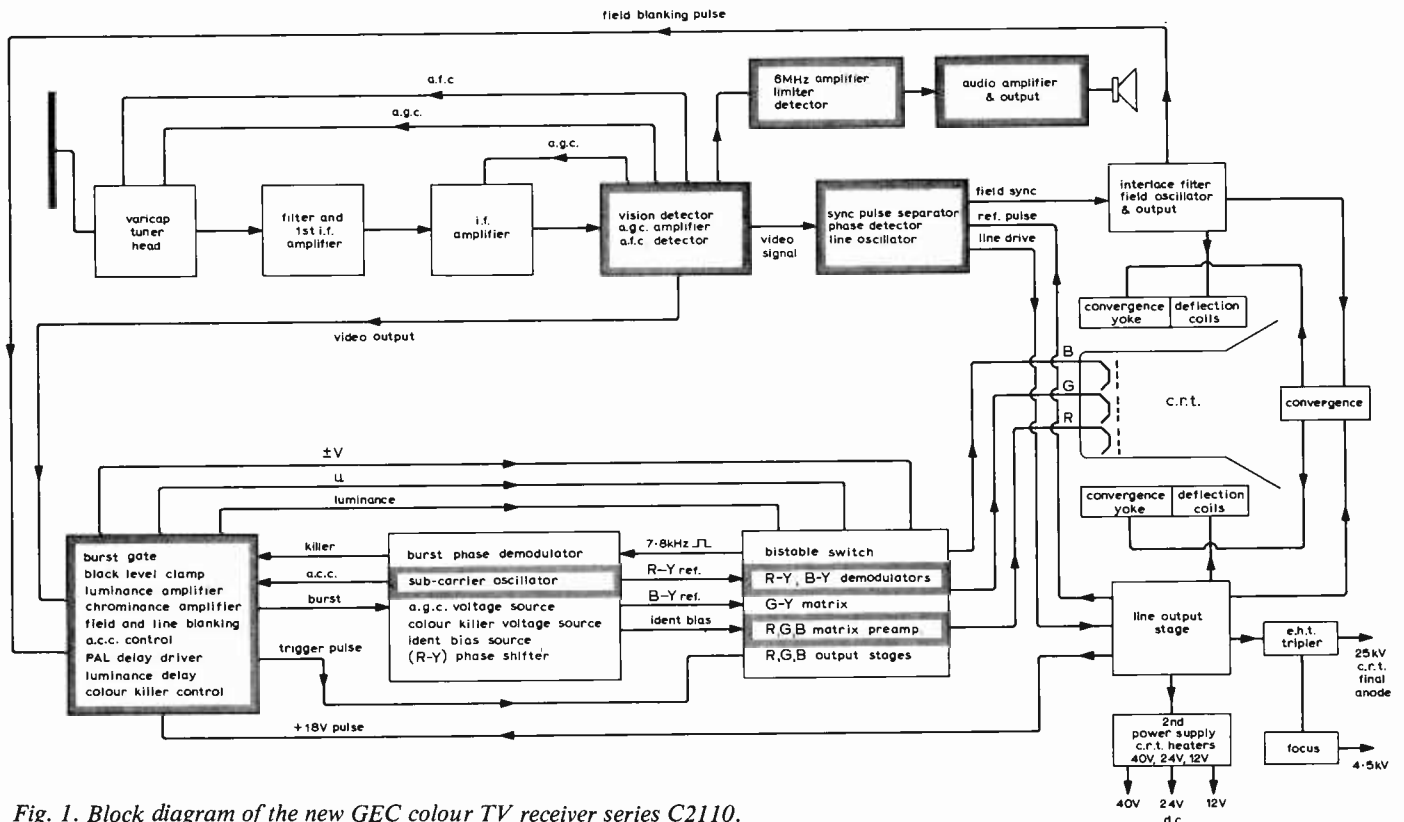


Fig. 1. Block diagram of the new GEC colour TV receiver series C2110.

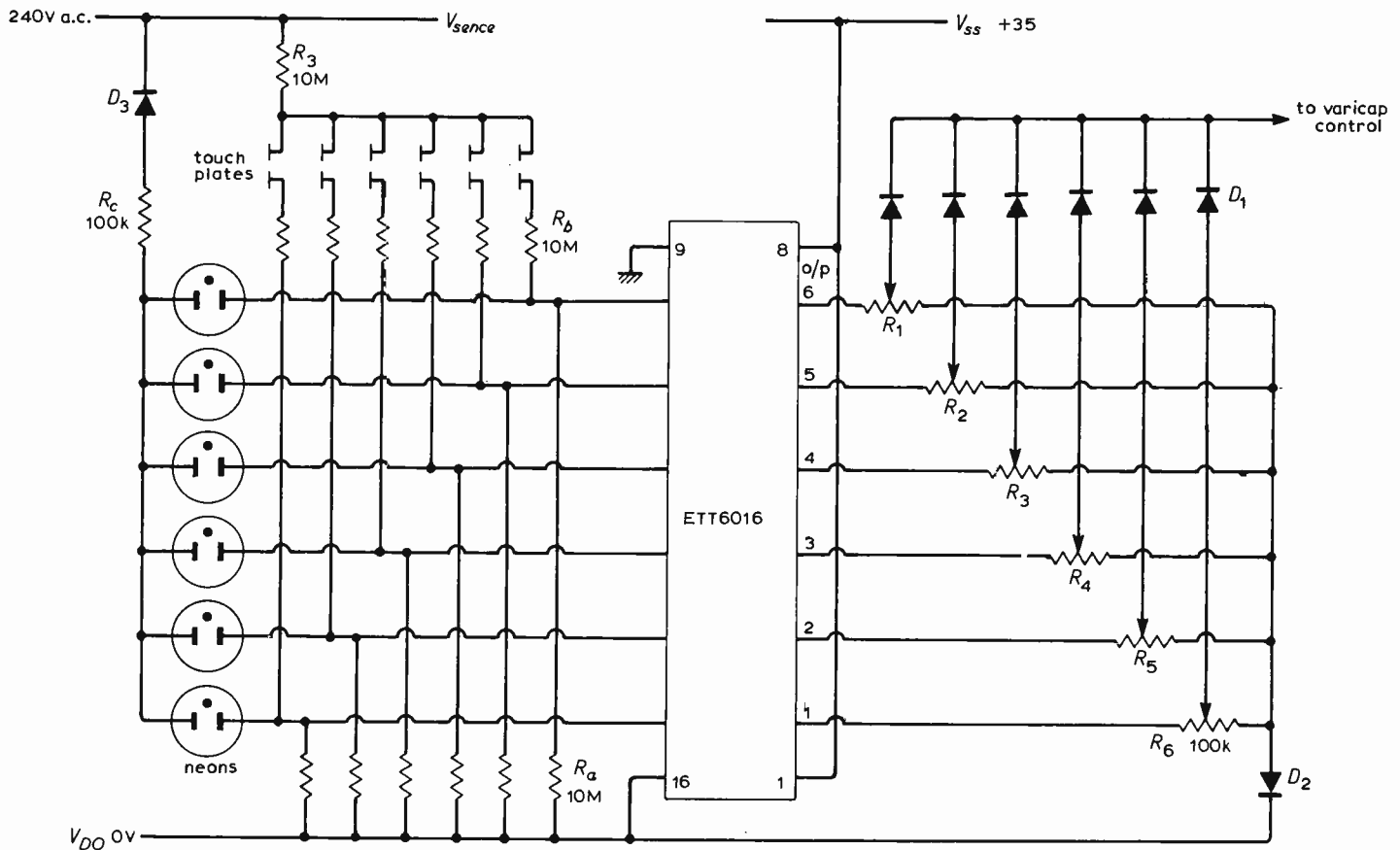


Fig. 2. Typical external circuitry for Emihus ETT6016 touch tuner

a second LC tuned element, capacitively coupled to the synchronous detector tuned circuit to form a quadrature circuit similar to the familiar Foster-Seeley discriminator. The voltage output of this is fed to a phase detector followed by a d.c. amplifier which provides a voltage to correct the bias of the varicap tuning diodes.

The 6MHz intercarrier signal is also derived in the TBA 270Q and is fed into yet another i.c. which performs the function of sound i.f. limiter and detector. To complete the line-up of integrated circuits in the sound section, a Texas Instruments SN76013 provides about 2 watts into the 20-ohm loudspeaker.

Chrominance information is fed to the luminance and chrominance signal processing panel where it connects to a TBA 560Q i.c. via the chroma input coil. Similarly luminance signals are fed to the same i.c. via the luminance delay lines. The TBA 560Q additionally provides d.c. contrast control, a black level clamp circuit, brightness control, flyback blanking and beam current limiting. The a.g.c. for this circuit is derived from the next panel which consists of a reference oscillator, the function being provided by a TBA 540 integrated circuit.

The output panel carries two more integrated circuits providing first a demodulation of the colour information followed by a pre-amplification of the colour difference outputs and R-G-B matrixing. A final i.c. operating as a line oscillator and sync separator completes the line-up used in this set.

**Jungle circuits**

Many new TV sets use similar arrangements of integrated circuits to a varying

degree and in the more complete examples of integration few functions are left for inclusion in this type of packaging. As a result there has been an emergence of a multi-purpose i.c. which collects together many of the odd, remaining circuits under a collective title of the "jungle circuit". Typical of the types in use now is the Motorola MC1345P which provides an a.g.c. keyer, amplifier and delay together with noise inversion and a sync separator. Similarly the TBA 550Q used in the new Philips 17in monochrome set, model 7320, fulfils the several functions of video pre-amp and detection, noise gate and detector, a.g.c. and sync separation.

In several instances it is obvious that full advantage has been taken of interaction between the set manufacturing division and the semiconductor design department when these two functions are within the purview of one company. This is evident in the products of RCA, Motorola and Philips, where jungle chips have been made to meet the specific requirements of their own set designs.

An interesting parallel development is taking place in the field of hybrid micro-circuits to perform similar functions, and a spokesman at the RCA semiconductor division predicted that these could become an important evolution ideally suited to producing packages designed for specific set manufacturers. Adopting this approach reduces the initial high design and development costs inherent in the monolithic i.c. and at the same time allows a degree of freedom for individual design ideas produced by the set manufacturers.

Integrating several circuit functions together is the next step, and some

evidence of this is seen in the combined sound i.f. and audio amplifiers recently designed by Sprague and National.

**Control functions**

A principal point of low reliability is the switched connections made in both TV and radio receivers and in recent years the increasing use of varicap tuning has helped in alleviating one constant source of trouble. However, with the limited capacitance ratio available, it has still proved necessary to switch the bias voltage to these devices, thus leaving a potential fault liability in the system. Philips, in introducing their touch tuning TV sets some two years ago, took a step in the right direction, one that has been reinforced recently by new integrated circuits being developed by both Siemens and Emihus.

The Emihus ETT 6016 is a p-type m.o.s. circuit (Fig. 2) incorporating a six-channel sensing device which can be operated from a two-pin sense plate. The input points are each connected to the drain of an f.e.t. and also a d.c. amplifier, and the source connected to a common supply rail of +33 volts. Resistors marked  $R_a$  connect each input to a zero voltage rail, thus providing an operating potential and setting the input impedance. Sense plates can be directly connected to each of these input points, the sensing potential being connected to the second plate. Since the value of this voltage affects the circuit sensitivity, and operation is possible with a.c. on the second plate, a convenient source is suggested as 50Hz mains applied to the sense plate via the 10MΩ protection resistors ( $R_b$ ).

On touching the two sense plates a

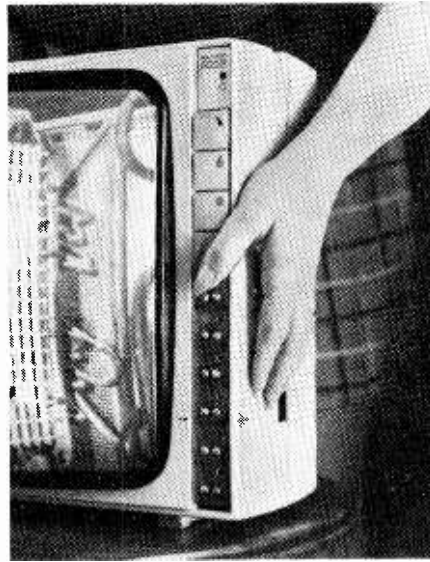
small  $1.5\mu\text{A}$  current flows, building up the 15 volts across  $R_a$  necessary to turn the device on. Since the output of each d.c. amplifier is connected via a latch to the gate of its associated f.e.t. the channel impedance drops to around 125 ohms and the potential on the input pin rises to +33 volts. Indicating neon tubes are also connected to the input pins and to 240V a.c. and so the tube associated with the "on" channel lights. A second m.o.s. switch driven from the same d.c. amplifier and latch connects a separate +33V rail to the varicap tuner to modify the bias and thus effect channel switching. Diode  $D_3$  is an isolation diode, as are the diodes  $D_1$ , and the additional diode  $D_2$  acts as temperature compensation.

Stepping from one channel to the next can be achieved by using the circuit shown in Fig. 3, where the application of a negative-going pulse to pin 9 of the ETT 6016 for 50 to  $100\mu\text{s}$  achieves the necessary aim. The CR network consisting of  $R_1$  and  $C_1$  removes spurious pulses due to contact bounce,  $R_2$  discharges  $C_1$  between steps and  $C_2$  determines pulse length.

At the time of going to press full details of the Siemens i.c. were not available, but it is known to provide similar functions.

### Remote control

Facilities for remote control do not seem to have caught on in the U.K. as they have in other parts of the world. However, since a large part of the TV market is supplied from Continental, East European and Far Eastern countries where such ideas are popular, it is not surprising to see a few models of this type appearing in the U.K. Earlier this year Grundig introduced two new colour TV sets, both of which utilized rather novel ideas for set control. Designated models 5010 and 6010, the concept starts with the electronic programme selection unit. Here a different technique is employed to that used by Emihus, and instead a central control unit consisting of logic elements forming an ascending step switch with seven positions each allotted to a preset station makes the basic unit. In the 5010, touch tuning is employed. The hum pick-up appearing as the elements are touched, is converted to a square wave by a limiting circuit and applied to an i.c. counter. When the count state in the i.c. agrees with an internal reference the pulsed channel switches on. Since this type of unit lends itself well to remote control, in the 6010 an additional portable cordless unit is provided for this function. Working on



*A modern colour receiver used as a test bed for the Emihus touch tuner and showing the twin sense plates for each channel.*

ultrasonic principles, the transmitter has seven contacts giving control of volume (one for up, and one down), programme selection by sequential stepping using a single contact, brightness using two more contacts, and colour contrast utilizing the final two contacts. In addition, where only a brief touch of the programme selection key gives programme change, a contact of longer than 2 seconds will switch the set into a "standby" or "on" mode dependent on its previous state. In the event of breakdown of the transmitter a set of manual controls is accessible behind a small panel on the front of the set. Using an ultrasonic signal of 35.5 — 45kHz in nine bands spaced 1.5kHz apart the transmitter will provide operation of set controls up to 10 metres away.

The remote control receiver at the set consists of a microphone followed by a four-transistor pre-amplifier driving a chain of seven LC tuned circuits. In the case of the programme selector a single diode and transistor is used to drive the clock input of the logic tuner control and step it from one programme selection to the next. During the actual changeover the sound channel of the set is muted to prevent annoying clicks. An additional pair of transistors with an RC chain form a discriminating element sensing the two-second on-standby command. The continuously variable controls are a little more complex and use two ultrasonic channels (for "up" and "down"). On receipt of an appropriate command, the

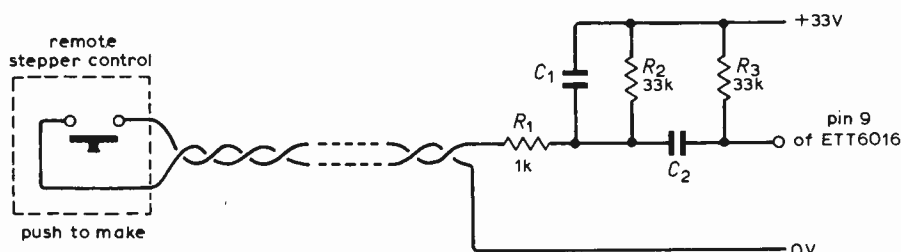
output voltage from the LC tuned circuit is rectified to provide positive d.c. for one direction of the control and negative d.c. for the other. The potential is applied to a memory module neon which itself has been pre-conditioned by the light from an adjacent, permanently on neon. The memory module neon then strikes and charges a capacitor connected to the gate of an m.o.s.f.e.t. The  $R_{DS}$  of the f.e.t. changes with its change of gate potential and thus provides a means of controlling volume, brightness, and colour contrast. An additional feature very necessary is that when the control signal stops, the f.e.t. gate should hold its charged state to avoid further changes of the function. This is achieved by the neons' extinguishing, their resistance going to an infinite value and thus preventing premature discharge of the capacitor.

Grundig claim that, after an initial adjustment of the transmitter tuned circuits for the oscillator at 35.5kHz (brightness) and 44.5kHz to within 50Hz, and with fresh batteries, the maximum drift of any channel frequency with battery ageing will be limited to 300Hz, well within the receiver unit tolerances.

### New tubes

Apart from the niceties of touch tuning or remote control, one of the Grundig sets, the 6010 contains an example of the new  $110^\circ$  degree tubes. It has been claimed that the principal reason for the development of these tubes is to produce a much slimmer set and in practice, of course, it does just this. About 4 inches can be the average reduction in set depth, which is not a great deal considering the difficulties involved. It is precisely this which has made the introduction of such tubes relatively slow. Typical problems involve a considerable increase in deflection current and much more complex dynamic convergence compensation. This perhaps explains why black and white sets such as the Philips 7320 have appeared ahead of colour versions from the same manufacturers. Claimed to be the largest of the  $110^\circ$  tube colour sets is the 26.5in Saba Telecommander from a long established German company which started marketing through U.K. distributors in May of this year. Similarly to the Grundig, this too has a cordless ultrasonic remote control unit.

The Sony Trinitron tube, already known to many of our readers through an article late last year,<sup>†</sup> showed a new approach to colour reproduction that was both inventive and produced some advantages. However it would seem that 1973 may well offer even more novel ideas in a similar vein since RCA have just published details<sup>‡</sup> of an unusual new colour tube design that will reduce neck length rather than accepting the much



*Fig. 3. Emihus remote control stepping system using a two wire link and a single switch.*

<sup>†</sup> The Trinitron Colour TV Tube, *Wireless World*, December 1971, pp.589-592.

<sup>‡</sup> New Color Picture Tube System for Portable TV Receivers, R. L. Barbin and R. H. Hughes, *I.E.E.E. Trans. on Broadcast and Television Receivers*, August 1972.

more difficult concept of widening the deflection angle to  $110^\circ$ . Like the Trinitron, the screen consists of a series of continuous vertical phosphor lines which are claimed to improve sharpness and brightness. The gun, however, is slightly different in that a closely spaced horizontal line-up is used for generating the three electron beams which are then operated on by a precision static toroid (p.s.t.) deflection yoke. It is suggested by RCA that using this arrangement produces convergence equal to, or better than, other commercial designs without the use of any dynamic convergence correction or circuitry. Adjustment of the convergence is achieved by moving the yoke either in a horizontal direction (at right angles to the tube axis) to increase the raster height and width produced by one of the outer beams, and reduce the raster of other outer beam, or in a vertical direction, which rotates one outer beam clockwise and the other outer beam anti-clockwise. Once the convergence is set, the p.s.t. is locked in place as a factory setting, no further adjustment ever becoming necessary. For this reason RCA plan to market tube and p.s.t. as a single unit, which is as easily replaced as the conventional monochrome tube.

The p.s.t. yoke itself is not without some interesting features since it consists of a wire coil accurately laid into the grooves of a plastic moulding, producing reliable and reproducible high levels of mechanical accuracy which are reflected in a very uniform tight tolerance of convergence variations.

Some slight corrections are necessary for purity and static convergence. In the case of the former the usual magnetized metal rings are adopted, but the static convergence correction is achieved in a way unique to the RCA system. Here individual barium ferrite magnets which have a permeability of near to one are moulded into four plastic rings and fitted to the p.s.t. Interaction with the yoke field can be avoided in such a manner since the permeability of free space in c.g.s. units is also unity, thus indicating that the presence of the magnetic materials in the vicinity of the yoke will have no effect on the shape of its field. Two of the rings have the magnets arranged to produce a four-pole field which will move the outer beams by equal amounts in opposite directions and the other two rings will move the outer beams by equal amounts in the same direction.

Several advantages claimed by RCA for this new tube include an improved performance and reliability with lower cost and simplified setting procedures. Tube sizes projected for future production are 19in, 17in, and 15in across diagonals

### Hi-fi television

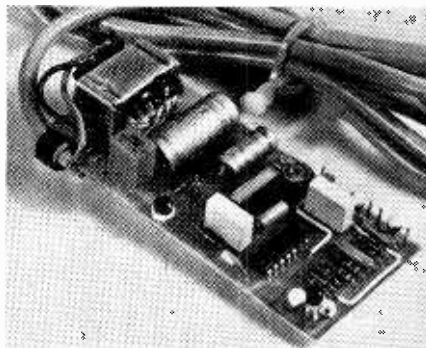
Before any readers jump to the wrong conclusions and think this section of the survey is concerned only with some new TV sets having very high quality sound sections (would that there were more!), this note more importantly deals with a

new piece of information recently received on the future production of luxury colour television receivers. These will originate from a new company, Information Technology Ltd, sometime in the New Year. It seems that this company is primarily in the market to design and produce high standard electronic units which would permit much greater freedom in cabinet design than is obtained by conventional chassis techniques. An important spin-off of such a concept is a greater flexibility in servicing techniques. The whole system comprises seven units: a receiver, decoder, timebases, c.r.t. with neck components, control panel and power pack. Several feet of interconnecting cable can be used between the units if necessary, requiring in the decoder a special output stage which provides low output impedance while keeping device dissipation to a minimum. With the exception of the video output stages all decoding is achieved in four i.cs.

The receiver section has varicap tuning and contains three i.cs (function unspecified) and two audio power transistors giving 5 watts power into a long-throw loudspeaker mounted in an acoustic chamber. A fully isolated power supply giving stabilized high and low voltage outputs together with an all-discrete-component timebase section completes the line-up. Isolation of the power supply makes the connection of tape recorders simple, a socket being provided for the purpose — a welcome facility also available on the new Dynatron 26in colour sets announced in April this year. In addition a socket is provided for video recorder input and output together with a headphone/hi-fi amplifier socket.

### Radio receivers

Much of this survey has been devoted to television receivers, this being due to the greater degree of change and technical innovation occurring in this area. In practice, much of the U.K. sales is occupied by portable radios imported from the continent, Eastern Europe, and the Far East with little competition offered by the few U.K. manufacturers. In general these have concentrated on high-quality products leaving the low and middle price ranges to the imported products. Typical of the new radios introduced here is the Hacker Super Sovereign RR75. This offers a choice of m.w., l.w., and f.m. with two s.w. bands for a price of £69.00.



*The TGE Ltd add-on stereo decoder unit, designed to adapt any f.m. mono radio receiver to stereo operation.*

Compare this single new product with the massive line-up of new portables announced by Sharp, giving variously three bands, four bands, five bands, six bands and another three-band set.

The expansion of stereo coverage announced by the B.B.C. and due this autumn will extend to Radio 2 and Radio 4, starting in the London area and spreading to the Midlands and other areas later. This in itself has motivated some new products including a portable combination of stereo radio and 8-track cartridge recorder housed in two separate loudspeaker cases from Electronic Music Company Imports Ltd. Another useful idea originates from TGE Ltd, who have designed and produced a p.c.b. stereo decoder module which will fit to existing mono v.h.f. sets and provide a stereo output. Since it incorporates a power supply, installation is simply effected to almost any set.

Trends in the larger mains receivers follow very similar patterns to the new TV receiver techniques and include varicap tuning, ceramic filters in the i.f., increasing use of integrated i.f. strips and i.c. phase lock loop stereo decoders. Many of these products are purely hi-fi units intended for highest quality reproduction such as the Beomaster 901 and the Sony 50551, but here in the U.K. the few radio manufacturers offering mains receivers are sticking largely to traditional or "unitized" designs such as the Dynatron Carnival series, a comprehensive collection of nine systems ranging in price from £87 to £145.50.

Typical of some imports which rely on gimmicks to provide a new look is the Trio Jumbo KR-6170, a tuner-amplifier which incorporates a rhythm composer giving twelve alternatives from march to jazz waltz (?) and throws in a reverb unit for good measure as well!

Siemens, through their distributors Interconti Electronics Ltd, are also marketing a new receiver. Designated the RK320, it is a mains/battery portable giving a choice of four bands and additional sockets for record player and tape recorder.

Details of products coming under the heading of hi-fi equipment, including a number of new tuners, and tuner amplifiers, will appear in our report on this year's Audio Fair.

### Summary

The conclusion to be drawn from this survey is that the past year has seen a consolidation of ideas by manufacturers, most of which aim at improved reliability from the use of integrated circuits and modular construction. What will be interesting is to see how TV manufacturers react to the problems of the burgeoning cable television business and how sound receiver manufacturers respond to the efforts of the B.B.C. in improving stereo coverage. A big question mark, of course, hangs over the public reaction to commercial radio and its impact on the trade, and perhaps this time next year *Wireless World* could be reporting on just this subject.



# About People

**James Redmond**, F.I.E.E., director of engineering, B.B.C., is the 1972/3 chairman of the Electronics Division of the I.E.E. Mr Redmond was a marine radio officer before joining the B.B.C. in 1937 and also during the war. His early days with the Corporation were spent in the Television Service at Alexandra Palace. Among his many extramural commitments Mr. Redmond is a member of the Technical Subcommittee of the Government's Television Advisory Committee.

**Melvyn W. Larkin**, Ph.D., B.Sc., M.I.E.E., previously technical operations manager of the East Kilbride factory of Motorola



*Dr Melvyn Larkin*

Semiconductors, has been appointed general manager of the plant. Dr Larkin, who is 38, received his Master's degree and later Ph.D. in electronic engineering at the Carnegie Institute of Technology in Pittsburgh in 1967, when his thesis was on m.o.s. phenomena. His B.Sc. in physics was obtained at Queen Mary College, London. Dr Larkin's previous appointments include being manager of Westinghouse Integrated Circuit New Product Development Department at their R & D Centre in Pittsburgh; and manager of the i.c. department of Texas Instruments Bedford.

A Fellowship has been established at Surrey University to commemorate Dr Alec Harley Reeves,

inventor of pulse code modulation, who died a year ago. The Fellowship will be jointly supported by Surrey University, Standard Telecommunication Laboratories Ltd, and Standard Telephones and Cables Ltd. The first Fellow to be appointed is **Professor George King**, B.Sc. (Eng.), A.C.G.I., F.I.E.E., F.Inst.P. who, until his appointment, was chief scientist of Standard Telecommunication Laboratories Ltd, Harlow, Essex, and visiting professor in telecommunications in the University of Surrey's department of electronic and electrical engineering. After wartime research in radar for the Admiralty. Professor King joined S.T.C. in 1946 as head of the microwave department, later becoming head of the materials division. In 1954 he was chief engineer of the transistor division, Standard Telephones and Cables Ltd and in 1958 returned to S.T.L. as director of research.

**Harold Molyneux**, who joined Siliconix in Santa Clara, at the beginning of the year, has been appointed managing director of Siliconix Ltd, the U.K. subsidiary. He succeeds **Richard Finch** who is returning to the parent company in Santa Clara, California. Mr Molyneux, who is 42, was unit manager of the discrete device section of Semiconductors Ltd.



*Harold Molyneux*

(Plessey) at Swindon prior to moving to the United States in 1966. The major part of his stay in America was spent with Philco-Ford in Lansdale, Pennsylvania — until Ford withdrew from the semiconductor business.

After two years as the product manager for General Instruments' Naples Microelectronics Division **Peter Rush**, M.A. (Cantab), has returned to the U.K. to become product marketing manager, m.o.s. standards, for General Instrument Microelectronics. Mr Rush, who is 28, graduated in electrical sciences, from Jesus College, Cambridge, and then joined Texas Instruments, Bedford. In 1967 he joined General Instrument's Technical Sales force and since 1969 has been in Naples.

**A. A. Dyson**, O.B.E., F.I.E.E., F.I.E.R.E., has announced his retirement as managing director of Erie Technological Products Ltd, the American-owned component manufacturers of Great Yarmouth, Norfolk. Mr Dyson, who is aged 64, joined the company in 1931 when it employed 12 people. It now employs nearly 5000 in its various establishments and has a turnover of £10M. Mr Dyson will continue as U.K. board chairman until December 31st, when he will become a consultant to the president of Erie Technological Products Inc. of Pennsylvania. When Erie, founded in America in 1925, started in a U.K. company in North London in December 1931 he became its first works manager. When a year later the U.K. company's Canadian founder resigned Mr Dyson took over as managing director. Mr Dyson is president of the Institution of Electronic and Radio Engineers and is a member of the National Electronics Council.

**Roger E. Regan**, 45, has been appointed sales manager for Honeywell Automatic Test Equipment in the U.K. A former Fleet Air Arm pilot, Mr Regan joined Honeywell in 1963 as a commissioning engineer. He was subsequently appointed on-site team leader for the development of automatic test equipment for the R.A.F. Lightning aircraft and spent five years at British Aircraft Corporation, Warton, before returning to Hemel Hempstead to head the Honeywell group working on software for Titan automatic test equipment.

It has been announced by the Science Research Council that **M. O. Robins**, of the Department of Trade and Industry, is to be director with responsibility for the

Astronomy, Space and Radio Division and Science Division; **Dr. H. H. Atkinson**, of the Rutherford Laboratory, (at present seconded to the Cabinet Office) becomes head of the Astronomy, Space and Radio Division; and **I. A. Learmouth** becomes head of the Nuclear Physics Division.

**Jerry H. Head**, who joined the Racal Electronics Group in 1958 to set up Racal Instruments Ltd, and subsequently held directorships in other Racal companies, has retired. He is retained by Racal Group Services Ltd as a consultant and is seeking opportunities to undertake consultative work for other organizations. Mr Head started his career in the electronics industry with the Ediswan Swan Co. in the 1920s. For ten years prior to joining Racal he was with Advance Electronics.

**John Turner** has been appointed to the board of Avid Electronics Ltd., of Ascot, Berks, specialists in audio-visual instructional aids, as sales director. Mr Turner, who is 39, was previously sales manager with the EMI military and computer peripherals equipment subsidiary, Recording Designs, at Camberley, Surrey. Prior to joining Recording Designs in 1969, he spent two years with Precision Instruments as U.K. sales manager responsible for the company's complete range of computer peripheral equipment. His previous appointment was as computer instrumentation sales engineer with the Ampex Corporation from 1961. He served his apprenticeship as an electronics engineer, specializing in magnetic tape recording, with EMI electronics at Hayes, Middlesex, which he joined in 1953.

## OBITUARY

**H. S. Arms**, M.A., D.Phil., D.Sc., technical director of Marconi Instruments Ltd, died, aged 60, on August 6th. Born in America he graduated at the University of Idaho, and was awarded a Rhodes Scholarship to Oxford where he took an honours degree in physics. Subsequently he was awarded a doctorate for research in low-temperature physics and also appointed to the academic staff at Oxford. He was later awarded an honorary doctorate of science by the University of Idaho. During the war Dr Arms undertook research into the uses of nuclear energy. He later returned to England to take up the post of head of Engineering Laboratories at Harwell. In 1953 Dr Arms joined the English Electric Company and later became chief engineer of the Atomic Power Project Group.

# Circards — a new information service on circuit design

by J. Carruthers, J. H. Evans, J. Kinsler & P. Williams\*

The system to be described is an attempt to break the lesser known of Finagle's Laws: — the information you have is not that which you want; — the information you want is not that which you need; — the information you need is not that which you can obtain; a very proper task as Finagle's Laws are the only ones known to man whose purpose is that they should be broken.

In more sober terms, it is fair to say that good ideas in circuit design are being developed all the time; that they are being published in this and other journals frequently; that professional engineers and enthusiasts alike are adopting and adapting them; that each user tries to bring order to this confusing flow of information aided by whatever resources he has access to in the way of filing and reference systems. Few have the time as users of this information to place it all in context, as they are too busy selecting as best they can whatever can help them in their immediate design problems.

Inevitably the choice is made from a limited selection, and rarely will a published circuit meet the precise demands of the moment — the supply voltage may be too low, or the bandwidth too small, or maybe the i.c. is just not available 'off the shelf'. When faced with such difficulties the choice may lie between modifying the circuit, searching for an alternative published circuit or designing something completely new. The experienced designer may use all three approaches in varying proportions, but for the system designer, young graduate and the harassed technician in a hurry, they all lack appeal.

### System requirements

For each user the real requirements seem to be the same.

- For a given circuit type, a clear statement of the nature of the circuit and the range of parameters commonly available.
- A selection of circuits representing a cross-section of the ways of performing the required function.
- Circuit diagrams giving component values where applicable for a typical set of operating conditions.
- A brief description of each circuit.
- Detailed suggestions of which com-

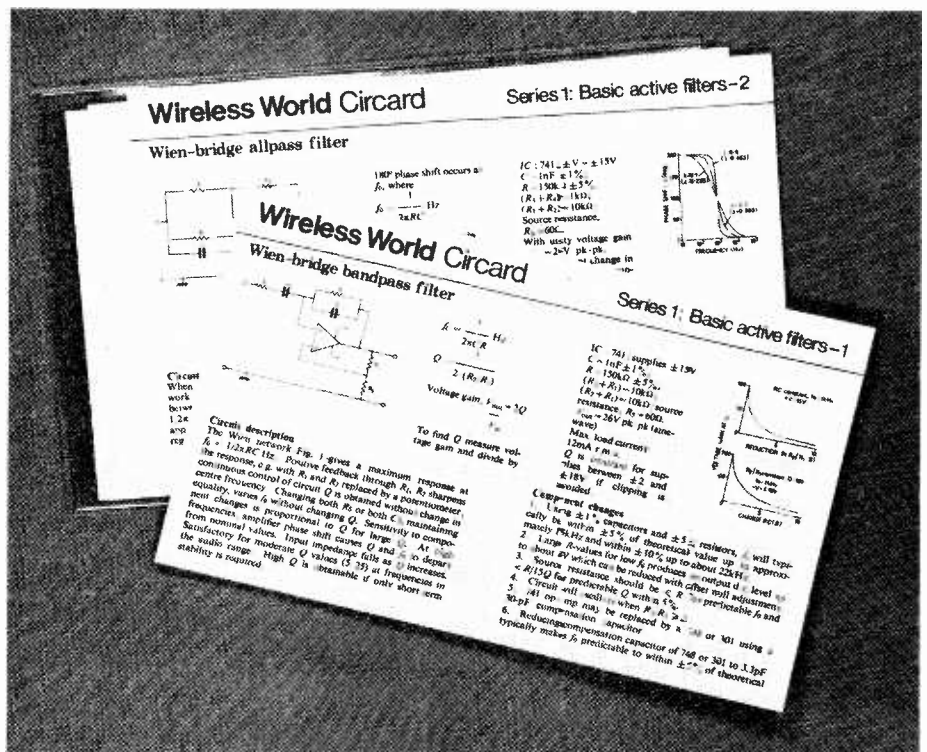
ponents may be varied and to what extent, so that the circuit can cover the widest range of requirements.

- Where possible, an indication of how the form of the circuit might be modified, or where components might be added, to extend its operation.
- An indication of where more information on the circuit might be obtained, either a standard reference if the circuit is well-known, or the article if recently published.
- References to related circuits.
- The format of the information should be such that it can be used by the engineer at his bench or desk, while capable of being filed for easy reference and retrieval.

Most sources of information contain not only too little about the problem at hand, but too much about extraneous problems. Having identified the section of the system with which he is concerned, the designer will be helped best by information on that section alone, presented succinctly, but with advice on how to mould it to his needs. The format which comes nearest to meeting

these demands seems to be that of the circuit card or Circard as it is called in this scheme.

A study was made of many hundreds of electronic circuits published in recent years, and an attempt made to classify them under suitable headings. A description such as 'amplifier' is so broad that even sub-divided a dozen times into specialist types, it leaves a wide range of published circuits under each sub-heading. By comparing these published designs, the techniques used were identified as far as possible, and particular versions were selected to form the basis for practical development. Under each heading a balance was aimed at between the classical circuits for which a vast number of modifications are known, the novel circuits exploiting lesser known devices or effects, and recently-developed circuits representing modern industrial practice. This selection procedure was carried out by a group of individuals with their own prides and prejudices, and readers may find that the precise balance differs from that which they would choose. It attempts however to



\*All with Paisley College of Technology.

provide a service that few individuals can provide for themselves without inordinate effort.

### Card format

The details of the card layout are clear from the photograph, and follow closely on the list of requirements postulated above. Generally the circuit description should help the user to assess the mode of operation of the circuit, but for fuller explanations references are given where the basic circuit is described or where the principles are detailed more fully.

The form of the circuit shown in the initial diagram on the card will have been thoroughly tested using the components specified in the accompanying lists. It is not claimed that these are the optimum components though it is hoped they will be typical. Where there is any evidence or any likelihood that a given component or parameter is critical (transistor current gain for example) additional samples of the device will have been substituted. Further information on the circuit behaviour, such as waveforms, frequency of operation, etc., will be specified and will be the measured values for the sample circuit.

A key section of the card is that on component changes. This covers variation in such parameters as supply voltage, load resistance and temperature as well as variations in component values and the use of alternative transistors, i.c.s etc. The difficulty here is that of steering a safe passage between the rocks of rigorous testing and the shifting sands of assumption without taking endless time over the journey. Thus the component changes suggested will have been tried separately but not in every conceivable combination. They will need to be used with common sense, with particular attention to maximum ratings. Obviously, using the maximum supply voltage simultaneously with the lowest resistance values would be a combination to be treated with caution. An indication of the corresponding range of circuit parameters is given, and these values will be deduced from the actual measurements on the sample circuit (supported by theoretical studies, as required).

To extend the circuit further, each card has a section on circuit modifications. This section includes suggestions on the addition of buffer stages, decoupling, diodes for protection or speed-up of pulse circuits, etc. Such suggestions can be only tentative and while there may be many variations possible with some circuits, others will permit little basic change. In all these cases the suggestions will have been verified in principle.

### System organisation

A major difficulty has been to decide what constitutes a circuit — one man's circuit is another man's system. There can be no sharp dividing line, and judgements will vary not only from person to person, but will depend on the general area of operation of the circuit. The guide lines adopted by the authors in devising the Circard system can be summarized as follows.

- An electronic circuit is the molecule — the smallest section of a system capable of

an independent existence. For example a standard multivibrator may best be viewed as a single entity while some triangular wave generators can be subdivided into recognizable circuits such as integrators and inverters.

- Exceptions improve the rule. If a function can be performed by what is recognizably a circuit on the above definition, but could be performed by an alternative method using a combination of two or more circuits, then the alternative has been considered on its merits.
- As a very rough guide, if a circuit contains more than three i.c.s or half-a-dozen transistors then it is worth reconsidering it to see if it can be divided into smaller independent circuits.

These are difficult judgements, and if the division is not taken far enough, it will not be easy to recognize the viable sub-sections and to see how they might be replaced by alternatives previously described.

A second difficulty which can never be completely resolved is that of circuit classification. How many distinct types of electronic circuit are there? At one extreme it is arguable that all can be classified as generators or processors, while at the other extreme there are circuits which are almost impossible to classify, requiring a classification to themselves. In the Circard scheme the initial classification has produced about 80 categories, many of which are distinguished by the range of frequencies over which they operate rather than the function they perform. The justification for this is that such a parameter is a major determining factor in the circuit topology, and not just

in the component values used.

Initially three sets of Circards will be published at monthly intervals and a descriptive article outlining the subject covered in the month's set of cards will be included in the appropriate issue. The demand for the cards will govern future plans for publication.

An introductory article on the first set of 12 Circards covering basic active filters is published below. The next two sets of cards will cover level-sensing circuits (November) and waveform generators (December).

Each set of cards is contained in a plastic case and costs £1. Particulars as to how to apply for the first and subsequent sets are given opposite.

A venture of this magnitude demands a clear overall view of the present status of electronic circuit design linked with a historical perspective and a vision that can pick out significant developments as they occur.

However hard a group tries to meet these criteria, the results will be subject to the distortion of the darkened glass, and limited knowledge as well as the colouring of individual interests and experience. It is the intention of this scheme and the hope of its authors, that those who use it will comment on the gaps in the information provided and improve the balance of that information.

The first priority must be to develop as many of the series as possible to provide the broadest possible foundation. It is hoped that a process of revision will then begin, so that Circards will continue to help users and designers of electronic circuits.

## Basic Active Filters

### An introduction to the first set of Circards

Like the doting parent reproached for a birthday present of an encyclopaedia with the response "It tells me more about things than I want to know", any writer on this topic has to exercise care.

The filters to be described belong to that broad class of circuits using active devices together with passive components, some of which are reactive, to produce a frequency-dependent transfer function. The possibilities range from single  $CR$  time-constants in the feedback path of an amplifier to complex multi-gyrator circuits. The former have applications in audio frequency work, while the latter are still the subject of continuing research. It is the in-between varieties that we shall consider, in particular second-order filters of various kinds.

These have numerous applications used separately but may in addition be combined to produce more complex filter functions. By second-order is meant that the transfer function is represented by an equation containing  $\omega^2$  as well as  $\omega$ . This is because of the presence of at least two reactive components — capacitors or inductors. The

latter are inconvenient and expensive below the radio-frequency range, and active-filters dispense with them by synthesizing the desired function using capacitors.

The common filter functions are

**Low-pass:** signals below a given cut-off frequency are passed at, or amplified to, a fixed level, falling by 3 dB at the cut-off frequency with a slope that reaches 12 dB per octave for a second-order filter — Fig. 1.

**High-pass:** the pass-band lies above the cut-off frequency, with 3 dB attenuation at the cut-off frequency, and with attenuation increasing at 12 dB/octave below this frequency — Fig. 2.

**Band-pass:** signals at both low and high frequencies are progressively attenuated with a maximum response at the centre frequency; the sharpness of the response is measured by the  $Q$  of the circuit with  $Q = f_0/2\Delta f$ , where  $f_0$  is the centre frequency and  $2\Delta f$  is the bandwidth for an attenuation of 3 dB relative to that at the centre frequency — Fig. 3.

**Band-stop or notch:** low and high frequencies are passed with a maximum attenuation (ideally zero transmission) at the centre or notch frequency — Fig. 4.

**All-pass:** the magnitude of the transfer function is constant but with a frequency-dependent phase-shift — Fig. 5.

The low- and high-pass filters are sometimes modified so that the output falls to a low but constant value at some other frequency — Figs. 6 and 7. The band-pass and band-stop filters may require extended frequency ranges within which the pass and stop functions are maintained. One possibility is the use of complex high-order filters. Alternatively a combination of one or more second-hand filters tuned to different frequencies can be used. A perfect null response is possible only at precise specified frequencies — Figs. 8 and 9.

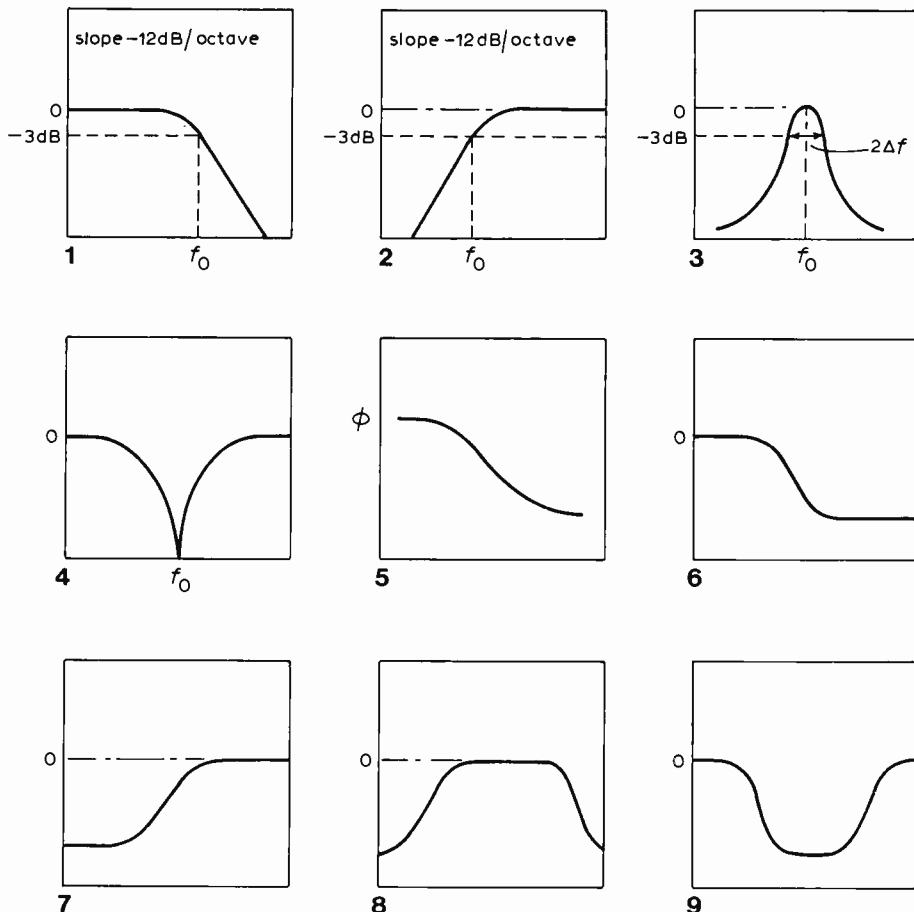
In determining which active circuit configuration most suits a particular filter function, the required  $Q$  is a major factor. High  $Q$  is often a requirement for band-pass and notch filters. It can be attained by two fundamentally different methods.

The first, requiring a single amplifier in the simplest cases, arranges for  $Q$  to depend on the difference between two nearly equal terms in the transfer function. The circuits using this technique are sometimes recognizable as a bridge circuit with the bridge almost at balance, combined negative and positive feedback with the latter almost equalling the former, or a negative-impedance converter in which an impedance in one part of a circuit appears elsewhere with a negative sign.

Any given circuit may be recognizable under more than one of the above headings which might be considered as different manifestations of the same underlying process. While high  $Q$  is possible, it becomes over sensitive to component and environmental changes, as it depends on the near-cancellation of comparable terms. The fractional change in  $Q$  caused by a change in some component is broadly proportional to the nominal  $Q$  aimed for, e.g. a circuit with  $Q = 20$  as the design value might have a practical value of  $Q = 25$  for a 1 or 2% change in a particular resistor.

The corresponding practical values for nominal  $Q$  values of 10 and so might be 11 and 75 respectively. The centre frequency is also dependent on component values but active circuits are comparable to passive networks in this respect. The exception is at high frequencies when the amplifier limitations may be all too apparent. This is shown by the increasing departures at the observed centre-frequency from the nominal value, coinciding often with a fall in the achievable value of  $Q$ .

The second high- $Q$  approach uses multiple active devices. One type, well-known in analogue computing, uses two integrators in a closed loop such that the open-loop gain of the system at the centre frequency, and hence  $Q$ , is controlled by a single resistor. The same pattern of passive components reappears in filters based on the gyrator, a device which has an impedance at one port related to that presented to a second port in such a way that a capacitance



In these graphs illustrating low-pass, high-pass, band-pass, band-stop and all-pass active filters, transfer function magnitude is plotted as the ordinate with frequency as the abscissa, except in 5 where the ordinate is phase angle.

is "gyrated" into an inductance, a parallel tuned circuit into a series tuned circuit, etc. Gyrators may be constructed from various configurations of amplifiers, with the usual limitations on frequency response, for example.

In neither approach is the  $Q$  excessively sensitive to component variations. Broadly the sensitivity is comparable to that obtaining with passive circuits, i.e. a 1% change in any component will not normally change the  $Q$  by more than 1% even at high values of  $Q$ . With multiple amplifier filters, there is more than one output available, and some circuits have band-pass, low-pass and high-pass functions available simultaneously. The falling cost of operational amplifiers makes such solutions attractive, particularly for larger systems where the flexibility is a considerable advantage. A problem can be the phase-shift in multiple amplifiers, which can result in oscillation when high  $Q$  is

attempted at frequencies near the upper frequency limit of the amplifier.

For simple low-pass and high-pass applications the single-amplifier methods are suitable, and as an example scratch and rumble filters may use twin-gang potentiometers for widely variable cut-off frequencies. Using special i.c. amplifiers with very high input resistance the cut-off frequency can be readily extended below 1 Hz if required, while the upper limit approaches 1 MHz.

A completely different approach which is certain to become dominant in many fields is that of the  $n$ -path filter. There will presumably be as many variants as there are at present with the analogue approach, but the basic technique appearing in some recently published circuits is as follows.

In place of a single filter a number, say  $n$ , of identical units are switched into the circuit in succession. These may be, for example, low-pass filters, passive or active, or simply the capacitors of a set of  $CR$  circuits using a common  $R$ . Switching frequency is set to  $n$  times the fundamental frequency to which the filter is to be tuned.

The filter has responses at harmonics of the fundamental frequency and may have a very high  $Q$  at each, but simple low-cost filters of the type described earlier can be used to attenuate these responses.

A vital point is that the filter centre-frequency is controlled by the clock-rate driving the switches, and therefore readily variable over a wide range, as is bandwidth.

**Circards**

Applications for Circards should be sent to "Circards", *Wireless World*, Dorset House, Stamford Street, London SE1 9LU, enclosing remittance (£1 per set including postage). Early application for the first set is advisable as print order is limited.

# News of the Month

## Noise abatement

A recent exhibition at the London Design Centre on environmental noise and its effects, showed the difficulty of establishing the criteria for measuring noise for relating loudness with either physiological irritation or ear damage. This is important information in a work environment where a certain amount of background noise is a necessary stimulus, and more than this optimum level causes a reduction in working efficiency.

Sound level meters have an approximate logarithmic weighting to compensate for the non-linear sensitivity of the ear (A, B or C rating) and usually measure the level of sound in dBA units. Short term exposure to noise levels up to 140dBA can be withstood by the human ear (the threshold of pain is at approximately 120dB) but the safe noise limits, with long periods of exposure — recommended by a Department of the Environment Code of Practice for reducing the exposure of employed persons to noise — are surprisingly low figures of 90dBA for 8 hours per day and continuous 105dBA for 15 minutes. Typical noise levels in industrial situations are: diesel electric generator 96dBA, heavy lorry 105dBA and steel works 114dBA.

The factors relating noise and annoyance have not been firmly established but certain common adverse conditions are clear. For instance various aspects of annoyance are connected simply with the loudness of a noise. Also, a great number of psychoacoustical experiments show that high-frequency noise is more annoying than low-pitched noise; the high to low frequencies here range from around 1500 to 10,000Hz. Furthermore, if the noise is intermittent (for example the fly-over of aircraft at various time intervals), irregular or rhythmic, it may also be considerably more annoying than a steady noise of the same physical intensity. Based on considerations such as these a measure of annoyance or "noise pollution" can be made.

The two main sources of irritation, which affect all people who live in or near large towns or cities, are traffic and aeroplane noise. Britain was the first country to legislate against traffic noise and the Transport and Road Research Laboratory has a five year plan for the production of

a "quiet" lorry. If successful it will enable heavy goods vehicles, with a maximum noise level of 80dBA (quieter than the average family car), to be produced by 1980. This development coupled with the vastly reduced aeroplane engine noise level inherent in the Rolls Royce RB211 demonstrates the need for controlling noise levels and the degree of success to which this can be achieved. The main problem is to help people recognize the conditions which can cause early deterioration in sensitivity or even permanent physical damage of the ear.

## Digital Braille production

The Electrical Research Association's Control and Automation Division has recently been commissioned by the Royal National Institute for the Blind to upgrade and modernize its automatic Braille production process. Three new digital control systems will be used to operate transcription machinery that prepares zinc plates for use as printing masters in the R.N.I.B.'s Braille production process. Data is supplied to the control system during plate preparation on punched cards generated by an IBM 1130; this machine uses established software to perform the conversion from English text to Grade II Braille format.

Braille production in the U.K., amounting to some 100,000 books and half a million periodicals every year, will be dependent upon the continuous and efficient operation of the automatic equipment.

## Displacement detector for TV masts

An electronic system so sensitive that it can detect changes of as little as one part in 200,000 (equivalent to one cm in two km) is being used by the Independent Broadcasting Authority on three of its TV masts, including Emley Moor, Yorkshire, the third highest concrete tower of its type in the world (330m). The other masts incorporating the system are the 300m steel masts at Winterhill, near Bolton, and the similar 340m mast at Belmont, near Lough.

The displacement detector is part of an

instrumentation scheme to provide long-term analysis of the effects of wind on the masts, and is based on an electronic spirit level, the Electrolevel — a 10cm long instrument produced by the Electronics Division of Irvin Great Britain Ltd of Letchworth, Hertfordshire (see Farnborough report in this issue).

The Electrolevel is used in this application as an accelerometer. The instrument design allows very low frequencies to be accurately measured. The readings at Bolton and Belmont are recorded on magnetic tapes and at Emley Moor an ultra violet recorder is being used. The Electrical Research Association has been involved in the processing of some of the results of this instrumentation system.

Because of its sensitivity and accuracy the Electrolevel is being used for a variety of applications — including British Rail's Advanced Passenger Train (A.P.T.) for sensing centrifugal forces, checking subsidence of building foundations, detection of landslip "creep" and as part of ships' helicopter and equipment.

## Atomic clocks checked by satellite

The Royal Greenwich Observatory at Herstmonceux, Sussex is engaged in an experiment to compare time standards with the United States Naval Observatory in Washington D.C., using for the first time a clock carried between the two sites by satellite.

The U.S. time navigation satellite Timation II, launched in September 1969, is in orbit 500 nautical miles above the surface of the earth and is transmitting signals at a frequency close to 400MHz. These signals are received first by the station in Washington and about 15 minutes later, when the satellite is at its nearest point, at the Greenwich Observatory. By plotting the location of the satellite and computing the time required for the signal to travel from the satellite to the U.S. Naval Observatory in Washington, observers ascertain the time at the satellite clock as compared with the Naval Observatory standard. When the satellite is near the Royal Greenwich Observatory, the same computations are made and the satellite time, corrected for clock drift, is computed according to the time standard at the R.G.O. The difference in the satellite times at Washington and Herstmonceux is a measure of the difference in the time standard at the two sites.

The time standards at the two sites, provided by similar caesium beam atomic clocks, are at present compared by using portable clocks carried in aircraft and by the Loran-C navigation system operated by the U.S. Coast Guard. The portable clocks give very good time comparisons but involve an expensive logistics problem. The Loran-C net involves very little logistics but does involve difficulties due to propagation properties of land, sea and the ionosphere. The satellite method provides a very high speed, portable clock



and will enable a check to be made on the other two methods. Clocks which are accurate to within one half microsecond will facilitate accurate distance measurement and navigation. In one half microsecond light travels 500ft, so, if man can measure his position to the same order, accurate clocks will enable aircraft to be kept separated in space and are proposed for use in aircraft collision avoidance systems.

## Digital data by telephone

A new service for sending computer data over the public telephone network for the cost of a telephone call has been introduced by the Post Office. Known as Datal 2400 Dial-up, the service will enable computer users to send data in binary form at 2,400 bits per second. Customers will be able to use types of data terminal equipment — including visual display units, remote batch terminals and front-end processors — which were previously restricted to use over special private circuits or at lower operating speeds over the switched telephone network.

As with existing Datal 200 and 500, users of the new service will have a modem (modulator/demodulator) associated with their telephone to convert the digital data to a form suitable for telephone lines. They will set up calls by dialling in the usual way and then switching over to data transmission. The modified modem will provide synchronous transmission of serial, binary data, at 2,400 bits per second in one direction at a time. Transmission at 2,400 bits per second is possible on a large proportion of the public network.

Charge for the Dial-up service is made up of a connection charge of £50 and a modem annual rental of £280. The cost of transmission will be the same as for a speech call over the same distance for the same time.

## Anti-collision device for cars

Five apprentices at British Aircraft Corporation's Guided Weapons Division at Bristol have built a device which could be fitted to an ordinary family saloon car or to lorries to prevent the serious nose-to-tail collisions which often occur under bad visibility conditions on motorways.

Using a radar signal to detect obstructions ahead, the automatic device can close the throttle, if this is sufficient to avoid collision, or it can apply gentle or hard braking as necessary. An old family saloon has been equipped with two radar horns carried on a roof rack, but a developed production version of the device would use a microwave strip, which could be hidden, for instance, in the front bumper. The cost of fitting the developed device would add an estimated £60-70 to the cost of a new car. The apprentices who undertook the project as part of a special pre-university course were given 13 weeks to design, build and test the device and



*The car in which the prototype anti-collision device, developed by apprentices at B.A.C., has been fitted. The radar transmitting and receiving aerials are seen attached to the roof rack.*

were allowed to spend no more than £100 on materials.

The device works by measuring three parameters — the distance from the obstruction and the closing (or opening) speed, which are measured by the radar transmitting and receiving aerials, and the car's own speed which is measured electro-mechanically from the propshaft. These measurements are continuously fed into a programmed computer and, according to the signals received, the computer can: (a) decide that there is no danger and take no action; (b) decide that closure of the throttle will supply sufficient deceleration; (c) activate gentle braking; or (d) activate emergency braking. Throttle closure is carried out via a small electric motor operating a modified linkage system, which overrides the normal accelerator pedal. The computer demands for braking, however, are fed via relays to a solenoid operating a lever, which puts pressure into a servo-assisted hydraulic system. A special valve is provided to isolate the automatic braking system from the manual system while still allowing the normal footbrake to be used if necessary.

The whole system works off the car's standard battery, is independent in that it needs no reflector or transmitter in other vehicles, and can function in all weathers. It incorporates a simple "on-off" switch so that drivers can select it at will and warning lights that report any malfunctioning of the system.

## Vintage wireless society

A new organization, to be known as the Wireless Preservation Society, has been formed for the preservation and restoration of vintage wireless equipment for cultural, educational and historical purposes.

A wireless museum has been established in a Lincolnshire farm, where dozens of old receivers are in the process of being restored by local radio amateurs. Several crystal sets with cat's whiskers, and valve receivers equipped with bright emitters (those with pips on top!) have been brought back into operation in conjunction with wood-and-metal

flared horn loudspeakers.

The honorary secretary of the new society is Mr. D. Byrne, G3KPO, (area representative of the R.S.G.B.), of Homa House, Quadring Watergate, Spalding, who would like to know of anyone who has any old wireless apparatus, and especially radio books, magazines or catalogues dating back to the twenties or thirties. These latter are especially valuable as an aid to dating the many sets and components already given to the museum. Viewing is free of charge, but prior arrangement should be made, in order to avoid disappointment, by ringing Mr. Byrne at 077-584-485.

## Visible satellite laser communication

NASA has selected I. T. & T. Gilfillan, a division of I. T. & T. Corp., Van Nuys, California, to develop a visible laser communication experiment for flight on the Applications Technology Satellite (ATS-G) in 1975. The laser experiment is being tested because the very high frequency light waves emitted by lasers can carry far more information than radio waves. For example, a single laser channel could carry the equivalent of 20 normal television channels. The laser beams are so narrow that even after travelling a distance of 35,000km through space, they illuminate a spot on the Earth only about 300m in diameter. Thus many different systems can work on the same frequency at the same time without interference, by simply pointing the beams in slightly different directions.

The system on the ATS-G satellite will use a red beam of light generated by a laser containing helium and neon gas. The link from ground to spacecraft will use a blue-green beam from a laser containing argon gas. The telescope or aerial in the spacecraft will be only 13cm in diameter and therefore, is much lighter and easier to design into the spacecraft than conventional communication systems. Output power of the satellite laser is only 5 milliwatts. A mobile ground station will be alternately operated from the Mt. Hopkins facility of the

Smithsonian Astrophysics Observatory in Arizona and the NASA Network Station at Barstow, California.

Specific aims of the experiment are to: (a) determine the effects of the Earth's atmosphere on laser beams in a vertical path between a spacecraft and the Earth in two directions; (b) prove the feasibility of using widened laser beams for finding a desired laser communication station and then narrowing the beams to lock-on for tracking and communicating; (c) establish a two-way optical communication link between a spacecraft and the earth with a capacity of 30 million bits of information every second; (d) gain experience with a laser communication system in space to furnish the basis for design of future operational systems; and (e) provide for a possible extension of the experiment to communicate between ATS-G at synchronous altitude and a satellite in a much lower Earth orbit such as the space shuttle.

### B.B.C. 50-the technical story

Thirty three talks will be given during the two-month run of the exhibition, "B.B.C. 50-The Technical Story", at Mullard House, London, from November 3rd until December 21st. Most of the talks, by B.B.C., Mullard and other specialists, will be repeated to give a total of 63 presentations.

Purely technical talks include: Audio Recording Developments, Satellite TV Broadcasting, Development of Modules for Radio Telephones, Component Development for Post Office Equipment and Digital Techniques in Broadcasting. Talks of more general interest will include: The B.B.C.'s Sound Archives, Television Special Effects, Running a Local Radio Station, Organizing TV Sports Coverage and Television News. A programme of B.B.C./Mullard/Post Office films will be presented, as will the talks, in the Mullard House Theatre.

A detailed programme of talks and films, together with a time-table, will be available from October 23rd. Tickets for particular talks and films on specific days can then be applied for. All requests regarding programmes and tickets should be made to Mrs. Doreen Smith, Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.

### Increased colour television production

Colour television production in the U.K. during June totalled 116,050 receivers, giving a half-year total of 673,000, compared with a figure of 362,000 for the first 6 months of 1971. Production of monochrome sets in June was 156,000 giving a 6-month total of 839,000 — a drop in production of 2,000 sets compared with the same period in 1971. These are estimates of U.K. produced television receivers compiled by the British Radio Equipment Manufacturers' Association.

## Video long-playing records

Colour television programmes of 30 to 45 minutes duration can be recorded on one side of a new kind of disc, resembling a gramophone record of normal l.p. size, developed by Philips in Holland. For playback of these video records a player has been developed, based on an optical pick-up principle, for connecting directly to a television set. The system is flexible in use, providing stills, slow-motion or reverse-motion pictures from the recorded scenes.

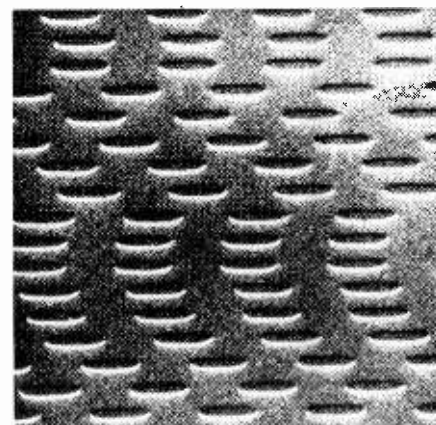
Information is stored on the disc along a spiral track. The disc rotates at a speed of 25 revolutions per second, and each 360° (revolution) of the spiral track contains the information needed to reproduce one complete television picture (two fields). The track consists of a series of microscopically small oblong pits, and the photograph shows horizontally a number of adjacent parts of this track. All pits are of equal depth and width, and it is their variation in length, and distance from one another, that contains all the information required. For example the luminance information is carried by the varying distance between corresponding points in successive pits and the chrominance information by the varying length of the pits (Fig. 1). When the pits are transformed by playback from a spatial pattern into a temporal sequence the resulting electrical signal is a train of pulses constituting a carrier. Luminance information is therefore conveyed by frequency modulation of this pulse carrier and chrominance information by pulse duration modulation.

In the player an extremely small, high-intensity spot of light produced by a helium-neon laser is used for information pick-up. This spot is automatically centred on the track by an opto-electronic control system, allowing an extremely small track pitch. Light reflected by the record, and modulated by the moving pits, impinges on a photo-diode; and this delivers an electrical signal which, after processing, provides a signal to be fed to a television set. Since information is picked up without mechanical contact, neither the record nor the pick-up system wears out.

In manufacture of the discs a compound similar to gramophone record material is pressed between moulds. After pressing, the records are coated with a thin, reflecting metallic layer. "Cutting" the master record takes as long as the duration of the programme, so the output from normal TV cameras, video tape recorders or cine

cameras is compatible with the production process.

Philips estimate that the player will cost about the same as a 26-inch colour television set.



Surface of video record, photographed through a scanning electron microscope. The track of pits runs from side to side of the picture.

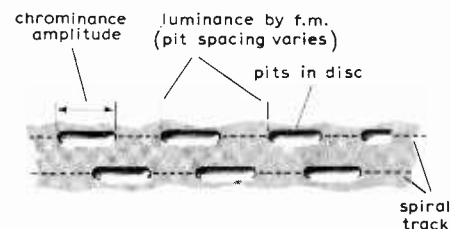
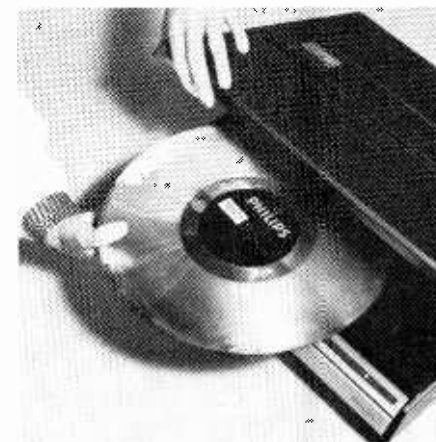


Fig. 1. Illustrating how the pits constitute a carrier, conveying luminance and chrominance information.



A video record being put into the player.

# Circuit Ideas

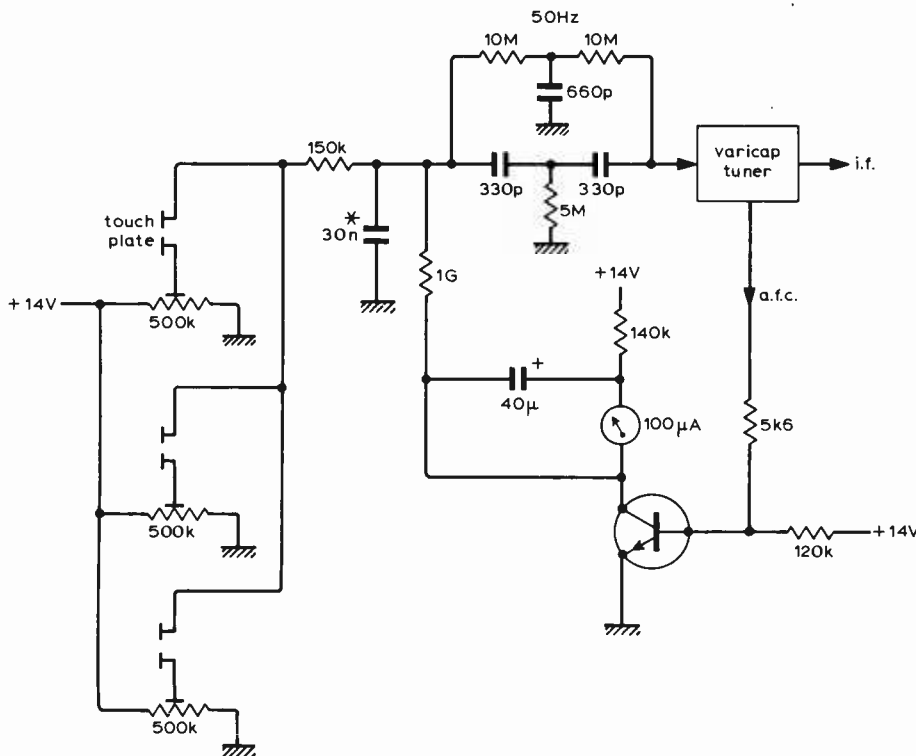
## Touch controlled tuner

The control voltage in a varicap tuner must be stored in a memory – in this design an analogue memory is chosen. A feedback a.f.c. signal prevents the control voltage dropping due to leakage current of the tuner. Changing the control voltage by a current through the fingertips over-rides the a.f.c. loop because the skin resistance (max.  $10M\Omega$ ) is much lower than the feedback resistance ( $1G\Omega$ ).

Delay time in the tuning process depends on the skin resistance and measured values are 7s ( $10M\Omega$ ), 3s ( $3.3M\Omega$ ) and 1s ( $1M\Omega$ ) for a frequency changing from 88 to 100MHz. Decreasing the memory capaci-

tance (starred) to reduce delay time is difficult as static charges may be fed into the system while removing the fingertip from the "hot" contact. Due to the high impedances in this system care must be taken in choosing the isolating materials for the touch controls. In this design PVC has been used with success. A twin-T filter is used to prevent 50-Hz modulation. Control voltage ranges from 2V at 88MHz to 9V at 100MHz.

J. W. Richter  
Eindhoven,  
Netherlands.



affect the accuracy of the meter, apply a voltage to the circuit to give f.s.d., remove the transistor emitter, and diode cathodes. Needle position should not alter.

- Decide maximum voltage drop that can be tolerated across  $R_1$  ( $I_{FSD} \times R_1$ ), and hence choose a value of  $R_1$ .

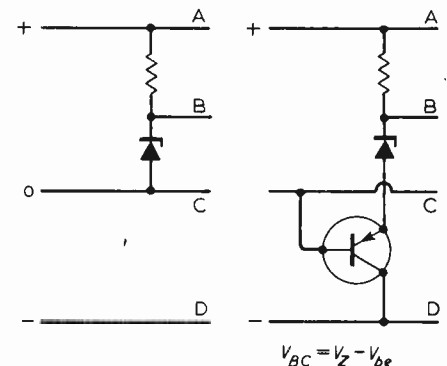
- Effective resistance of the movement will be  $R_C + R_1$ , which must be used in calculating shunts or multipliers for use with the meter.

- Maximum forward and reverse voltage that the circuit will tolerate will then be  $R_1 \times 200mA$ . If the reverse voltage will never exceed 5V, base diode can be omitted.

On an overload, which would normally result in a little "clink" as the needle entwines the stop, the needle runs off the scale in either direction in a controlled way, and gently presses itself against the stop. C. Shenton,  
Weston-super-Mare,  
Somerset.

## Zero current zener reference

Left-most circuit illustrates a commonly used circuit feature where a zener diode establishes a potential at B with reference to a centre rail C. In certain circuitry it is essential that the zener current be prevented from passing into any load connected be-



tween the centre rail, C, and the common rail, D. The circuit arrangement on the right illustrates a means of ensuring that the zener current is bypassed to the common rail D.

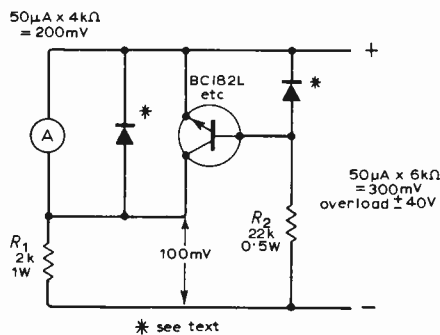
A typical application is where the potential CD is a voltage-regulated supply used to feed a low current into a capacitive load and where the source voltage CD is liable, even if only under transient conditions, to be open-circuited such that the zener current if not by-passed could affect an over-voltage condition at CD.

J. Double  
Bangor.

## Meter protection circuit

Design of the protection circuit shown is as follows (though values shown should suit most movements).

- Establish  $V_F$  for the basic meter movement ( $R_C \times I_{FSD}$ ). If  $< 350mV$  circuit can be used as it stands. If  $350mV < V_F < 700mV$  two diodes must be used in series in both positions, and if  $700mV < V_F < 1V$  three diodes should be used. As a check to ensure the circuit does not



# Letters to the Editor

*The Editor does not necessarily endorse opinions expressed by his correspondents*

## Noise — white, pink, red

For a long time, the term white noise has been clearly understood to refer to a random amplitude signal, having equal integrated energy per cycle bandwidth. A progressive "reddening" of white noise by increase of its integrated energy with decrease of frequency at the rate of 3.01dB/octave was later defined as "pink noise", having equal integrated energy per octave bandwidth. Incidentally, I understand that this description was first coined by Mr H. D. Harwood, of the B.B.C. Research Dept. in the early 1950s.

I note that the term "red noise" is now being used to describe white noise reddened at the rate of 6.02dB/octave, but I feel that such terminology may ultimately lead to confusion, since the description could equally apply to a narrow bandwidth signal. Since various types of random functions are now used to test loudspeakers — the visible colour spectrum range from red to violet of about one octave being presumably expanded linearly to describe the 10 octaves of audio — I suggest that it is timely to clarify just what such terms are meant to imply. For example, feeding white noise signals to certain so called "monitor" loudspeakers, I would describe the acoustic output as being muddy brown with some bluish lines, but would other readers interpret such a statement with any accuracy?

R. N. Baldock,  
Harrow,  
Middlesex.

## S.S.B. on medium waves?

In his article, "S.S.B. on Medium Waves?" in your August issue, Mr Wareham clearly invites criticism and controversy of the wide range of subjects and the opinions expressed. He asks: "Can we get more broadcasting channels into the available frequency band?" and in his conclusion seems to say: "One day, perhaps". I believe the answer should and must be: "Yes, here and now", for means are available to achieve an orderly change to an s.s.b. system without listener resistance and without the capital wastage contemplated by Mr Wareham.

How can we introduce an s.s.b. service into a frequency band already fully occupied? We can simply reduce the spectrum required for the existing service by adapting the d.s.b. transmitters to compatible single sideband (c.s.s.b.) operation. Domestic m.f. receivers would thus continue to be used for their economic life, while into the spaces made available in the m.f. band, s.s.b. transmissions could be inserted to carry the programmes, justifying the production of new s.s.b. receivers. Obviously such a proposal involves compromises. For example, the frequency response of the transmitters will be restricted initially to the present 5kHz, so that the full advantages of s.s.b. cannot be realized until the m.f. band is cleared of other types of transmission; international agreements will have to be worked out to keep interference to a minimum; and so on. As representative of Kahn Research Laboratories, developer of c.s.s.b., I feel that the use of c.s.s.b. offers the only way to solve the m.f. problem with existing hardware while providing an improved broadcasting service to prepare the public for full s.s.b. transmission in the future.

The existence and virtues of c.s.s.b. have been largely overlooked until now, despite its tangible benefits which include increased signal strength, improved signal/noise ratio and reduced adjacent-channel interference under present allocation policies, and improved audio fidelity with existing broadcast receivers. C.s.s.b. has also suffered unjustified criticism in Europe resulting from spurious tests conducted under unrealistic conditions using receivers unrepresentative of normal commercial practice, without the participation of the listening public. Yet, it is interesting to note that in extensive tests in the United States, of genuine listeners polled at random, 78% reported improved reception with c.s.s.b., 19.5% reported no change, while only 4.5% reported worse reception. In tests over the famous KDKA station, no adverse reports were received over a five month trial period. The introduction of the Kahn a.m. stereo system (which is effectively a form of c.s.s.b.) in Southern California a month before it was publicly announced, generated no comment that the signal had changed in any way;

extensive tests with this system are now being carried out in New York City.

Mr Wareham states that harmonic distortion is incurred in practical broadcast systems and he will doubtless agree that the harmonic distortion with a practical c.s.s.b. transmitter is no higher than with currently operational d.s.b. transmitters — some 3%. Receiver distortion averaged over a range of typical domestic receivers shows a difference between c.s.s.b. and d.s.b. of no more than 1%. Again, he suggests that c.s.s.b. may be more prone to interference than s.s.b. because of the distribution of sideband energy. Because of the stochastic nature of programme material, the higher modulating frequencies are at a much lower level than are the low frequencies; hence the second order sideband is emitted at low modulating frequencies only, while at higher modulating frequencies the emitted wave is essentially an s.s.b. wave that occupies the expected spectrum. These points are made clear by the inventor of c.s.s.b., Leonard Kahn, in his article in *Proc I.R.E.* for October 1961 cited by Mr Wareham. Mr Wareham also mentions that maladjustment may cause out-of-channel emission with c.s.s.b.; it is impossible to imagine any other system of which the same is not true.

Finally, I would like to stress the necessity of relating theoretical systems to practical realities imposed by existing facilities and commitments. So long as dogma and vested interests control broadcasting in Europe, no progress will be made.

G. M. Ward,  
Crewkerne,  
Somerset.

### *The author replies:*

While I appreciate Mr Ward's concern to get Kahn c.s.s.b. into operation in Europe I do not think that it is likely that c.s.s.b. — Kahn's system, or anybody else's — will have much relevance to the problem in the immediate future. It is not in transmitter design that the problems lie, but in receiver design and, even more so, in the short term, in politics.

Pure altruism has never been a major driving force in international affairs. With this in mind, consider these cases:

Case 1. You are a European broadcasting authority which by great good fortune is rejoicing in the luxury of a reasonably clear channel. If you voluntarily adopt some form of c.s.s.b. you will create a tempting vacant space 4.5kHz wide, right next to your own c.s.s.b. channel. Even if this space were allotted to you by international agreement you would find it hard to use, since to transmit another c.s.s.b. programme in it would interfere with the original one, receiver selectivity being what it is. More likely somebody else would grab it. In these circumstances, are you going to change to c.s.s.b.?

Case 2. You are transmitting on an agreed frequency at an agreed power. Along comes an unfriendly rival who transmits on exactly your frequency at ten times the power. After dark your broadcasts

experience heavy interference and your service area shrinks drastically. If you now adopt c.s.s.b., those of your listeners who have superbly selective receivers and are capable of tuning them correctly may be able to reduce the level of the interference by 3dB; the majority will do much worse than this. Is c.s.s.b. really worth the trouble and expense?

Case 3. You are the aggressor, broadcasting on the wrong frequency and with enormous power. Somebody comes along and tells you that you may create less interference by adopting c.s.s.b. Do you really care? (If Mr Ward thinks you do, he might try to sell his system to, say, Albania.)

These are the practical realities in Europe, and they will not change overnight. One could, of course, conceive a situation in which the vested interests Mr Ward complains about lose even the partial control over broadcasting which they now have. In the ensuing chaos c.s.s.b. might have a place.

There is, however, an alternative to chaos. This is the rational planning of transmissions over a wide area. In a careful study referred to in my article (Ref. 2) Eden shows that, given specified transmitter powers, geographical spacings, channel separation, and receiver selectivity it is possible to carry out a mathematical optimization process for l.f./m.f. broadcasting, on a world basis. It seems reasonable to suppose that there are benefits to be reaped even though such planning were done, not on a global scale, but on a European one.

That some form of s.s.b. transmission, including Kahn's and other types of c.s.s.b., could play a part in such a plan is obvious. The political problems are, of course, formidable, but, as I tried to show in my article, there is also a formidable technical problem — the design of cheap receivers for the closer channel spacings required. These receivers will be needed whatever modulation system is adopted — s.s.b., s.s.b. + c, c.s.s.b. or vestigial sideband. At present, despite some heroic efforts of enthusiasts, they do not exist. It is up to us, the engineers, to find out whether they can be created.

To my mind it is significant that s.s.b. broadcasting has not been generally adopted in one of the few parts of the world where the need is great and the political difficulties small, namely the United States; there is one authority, backed by law, for frequency allocations, and the neighbours are friendly.

G. Wareham

## Doppler effect

In reply to the *cri de coeur* by Cathode Ray in his reply to Mr Unwin's letter in the August issue. Doppler distortion was first measured nearly thirty years ago. Beers and Belar, in their well-known article entitled "Frequency modulation distortion in loudspeakers", *Proc. I.R.E.*, Vol. 31 No. 4 April 1943, p. 132, give curves demonstrating this effect. Unfortunately, the measurement is

complicated by the fact that intermodulation products due to non-linearity distortion have the same frequency, at any rate for low degrees of distortion. Beers and Belar therefore first measured the non-linearity of the loudspeakers with a pure tone and from this calculated the corresponding intermodulation products. They then measured the level of the sidebands when a fixed low-frequency and a variable high-frequency tone were applied to the loudspeaker. They showed that in the higher frequency range this was considerably above the level which could be attributed to non-linearity distortion and that the level continued to rise with increasing frequency as would be expected of Doppler distortion, but not of that due to non-linearity.

Calculations of the Doppler distortion in three of the latest types of B.B.C. monitoring loudspeaker at their maximum rated power were described in my lecture to the A.E.S. in January, and it was shown that in no case was Doppler distortion audible.

If I might take this opportunity of commenting on the subsequent letter by Mr Foggitt in the September issue, I have a feeling that he does not quite understand the problem. The Doppler effect in the case he quotes in his first paragraph is a function of the velocity of the cone at the lower frequency, not of the sound pressure, even though these are related. In the example Cathode Ray quotes, the amplitude, and therefore velocity, of the microphone diaphragm is minute for any sound pressures we are likely to meet. If for convenience we take a capacitor microphone, as the amplitude is independent of frequency, then for a sound pressure of  $1N/m^2$  the amplitude of vibration of the diaphragm will be of the order of 0.000,000,1 in, with a correspondingly small velocity. Although it must be admitted, therefore, that some Doppler distortion is produced, the effect is so minute as to be undetectable and consequently that from the loudspeaker would show up at its full value. The same argument disposes of the suggestion in his second paragraph that in programmes Doppler distortion is cancelled out.

The fact that the use of multiple units in a loudspeaker reduces the level of this form of distortion from the objective aspect should, however, be clear; but even assuming that conditions are so extreme that Doppler distortion is audible from the single unit system, it does not necessarily follow that the lower amount of distortion associated with a two-frequency-band system is any less audible, as the effect of bandwidth on the *audibility* of this form of distortion has never been examined to my knowledge. It is clear that when reproducing normal programmes the distortion will occur less frequently when the bandwidth of the bass unit is reduced, but it does not necessarily follow that when it does occur it will be any less audible.

H. D. Harwood,  
B.B.C. Research Dept.,  
Surrey.

## Theory of relativity

In the August issue Cathode Ray mentioned an experiment to test Einstein's Theory of Relativity. This test involved the flying of precise atomic clocks around the Earth to compare their time with clocks stationary on the Earth and has in fact recently been carried out by Prof. J. Hafele, of Washington University, and R. Keating, of the U.S. Naval Observatory.

Four Hewlett-Packard caesium standard clocks were flown around the Earth in an easterly direction and their time compared with identical earthbound clocks. The experiment was then repeated with the clocks moving westward. On the easterly trip the flying clocks should lose 40ns relative to their earthbound companions and on the westerly trip should gain 275ns. These time differences can easily be measured with the caesium standard which utilizes a precise energy jump in caesium of  $h\nu$ , where  $h$  is Planck's constant and  $\nu$  is 9,192,631,770Hz. This energy transition can be initiated by r.f. radiation, i.e., what we have got is a super  $Q$  tuned circuit. The second has actually been defined as that interval of time during which 9,192,631,770 oscillations of the free caesium atoms occur.

The data obtained by the experiment is complicated by the Earth's gravitational field but preliminary results indicate agreement with Einstein's Theory as 50ns was lost going east and 160ns gained on the westerly trip, i.e., all this business of twins aging differently seems to be true.

Incidentally there is another experiment planned where the clocks would be taken to the moon and back in an Apollo spacecraft. This would provide more accurate data to test the theory.

L. Gray,  
Linlithgow,  
W. Lothian.

## Transmission-line speakers

Dr Bailey's transmission-line speaker design in the May issue of *Wireless World* was very interesting. Just before reading it I had been studying his previous design in the October 1965 issue and wondering whether it would be possible to reduce the chance of standing waves inside the enclosure by using angled panels to give triangular cross sections, when, lo and behold, Dr Bailey had done it for me. I was all set to build the new enclosure when I happened to notice the comparison between the published frequency response curves for the new design, the 1965 design, and the KEF Concord totally-enclosed design. For frequencies below 1000Hz the original design response is flat within +0.5-2.0dB down to 25Hz (excellent), the new improved design is flat within +2.0-11.0dB over the same range (not so good). More interesting is the comparison between the new design and KEF's totally-enclosed cabinet as published in their enclosure design leaflet.



The two curves are virtually identical being within 2.0dB of each other over nearly all the range from 1kHz to 20 Hz. One would expect the new transmission-line response to be similar to the original, and yet it is much more like the KEF cabinet which is one-third the volume and based on a different principle.

Sound reproduction is still more art than science, and I feel Dr Bailey's comments on this apparent contradiction would be illuminating and also helpful to people like me.

P. A. Sheppard,  
Chandlers Ford,  
Hants.

#### *The author replies:*

The original transmission-line cabinet was tested under free-field conditions but with the presence of a floor and a reflecting wall. This will give at least 6dB of boost compared with the truly anechoic response curves which were published for the second design. This boost at the low frequencies is due to the prevention of diffraction which otherwise occurs due to the absence of floor, walls or ceiling. In other words, the anechoic response is only a guide to performance, and a loudspeaker that gives a truly flat response under anechoic conditions will sound very bass heavy when used in a normal room.

Frequency response curves are only a guide to performance, and certainly one cannot tell from an examination of response curves alone the respected merits of different loudspeaker systems. In a system using several drive units it is possible to obtain widely differing response curves merely by changing the microphone position being used to measure the loudspeaker characteristics. It is by no means unusual to find a response curve that is sensibly flat on the axis of the tweeter turn into a curve with dips of 10dB or more when measuring the axis of the mid-range or bass unit. In addition, no anechoic chamber is perfect and one can obtain considerable variations in response curves when using the same test object in different anechoic chambers. There is at least one known instance of a speaker being deliberately angled to a very peculiar position in an "anechoic" chamber, because that was the position where a flat response curve was obtained. We are still in a position of not being able to evaluate loudspeakers adequately using axial response curves, and until superior measurement techniques have been evolved, by far the best test is that of careful listening and switching between the various units being evaluated.

I have not tested the KEF Concord that Mr Sheppard mentions, but I feel that the foregoing may partly answer his queries. In addition there are such aspects as power handling capacity and frequency doubling to be taken into account, so I would hesitate to make a definite pronouncement except that in general, large cabinets perform better than small ones.

A. R. Bailey

## Linking schools with industry

The National Electronics Council, supported by the I.E.R.E., I.E.E. and the Institute of Physics, is sponsoring the introduction of a link scheme for the electronics industry in order that pupils can be given a better opportunity to appreciate the applications of electronics which will inevitably influence their lives when they have left school. The object of the scheme is to encourage closer co-operation between schools and local electronics companies by establishing a "link"; that is, a personal liaison between individuals in a company and a teacher at a neighbouring school.

One of the main benefits that can result from such a link is the ease with which a teacher can obtain up-to-date technical information and advice on the application of electronic devices and techniques. In the most advanced form of link the individual from industry pays frequent visits (at least once a month during term time) to the school in order to act as a technical adviser/supervisor to one or more groups of pupils undertaking a project or investigation involving the use of electronics. Often this takes the form of an extra-curricular activity, although now that the benefit to be gained from project work has been appreciated, more of this type of activity is being introduced into the formal course work.

Many schools have indicated an interest in this scheme and in order to encourage the establishment of new links, I have been appointed national co-ordinator. In response to a request from a school teacher I am contacting local electronics companies in an attempt to discover enthusiastic individuals who are willing to participate in establishing a link. If any of your readers are interested in offering some assistance to a local school, I would ask them to please write to me at the following address:

P. D. Noakes,  
Department of Electrical Engineering  
Science,  
University of Essex,  
Wivenhoe Park,  
Colchester, Essex, CO4 3SQ.

## Tree effects in TV reception

Where reception of short radio waves is over sea, interference (in the optical sense) is likely to occur between the waves received along the direct path and those reflected from the surface of the sea. Tides make the height of that surface vary throughout the day, varying the difference between the distances along the two paths. When the difference equals any odd number of half-wavelengths the sets of waves arrive in opposite phase, causing some degree of cancellation of signals of the particular frequency corresponding to that wavelength. To take advantage of the absence of obstructive terrain, some broadcasting stations have deliberately

been sited to serve areas across sea. This is all very well provided that at no state of the tide does cancellation occur. In practice there are places where it does occur. Because television channel bandwidths are so great, cancellation is selective within them, causing rather complex visual effects, especially with colour. All this has been well known for some time, and recently a detailed B.B.C. report on the phenomenon was published\*. Since it was written, further experimental results have emerged which do not appear to be adequately explained by the simple 'obvious' two-paths theory outlined above.

Having recently moved from within view of the Crystal Palace aerial to a site served by the Heathfield, Sussex, transmitters over a mostly unobstructed 12-mile path, but just on the wrong side of the top of a hill plentifully adorned by trees, I have been made aware for the first time that there are overland propagation effects not unlike the tidal ones.

Although I have not yet made careful systematic observations, enough has been seen to raise some interesting questions. I feel sure that effects of this kind must be widespread — more so than tidal ones — and of considerable practical and theoretical interest. Yet, as far as I know, they have not been adequately treated, if at all, in the literature. If the 10-page B.B.C. paper on the tide effect is incomplete (as I am told) it is perhaps too much to hope that the presumably far more complex problem of what, to be accepted as scientific would no doubt have to be called arboreal interference or foliage multipath reception, could be explained simply and clearly and yet correctly by some benefactor with enough data and perception. Yet I do hope that some discussion of the subject will appear in your pages.

To start it off I will summarize what I have observed here. While the trees were still bare, satisfactory colour reception was obtained, using a 16-element array and broadband mast-top amplifier, on all three channels: BBC-1, 694-702 MHz; BBC-2, 718-726 MHz; and IBA, 814-822 MHz (horizontal polarization). This in spite of being just below the top of a hill on the line from Heathfield. As the trees on top of the hill came into leaf some fall in signal strength occurred, understandably. May and June 1972, as many will remember, were notorious for persistent windiness. Coinciding with this, colour saturation varied from nil (black and white) to excessive, with cyclic periods of the order of a few seconds, agreeing with tree foliage displacements. During gales sometimes both picture and sound were violently disrupted. At times there was severe breakthrough of sound on vision or pulse hum on sound. On other occasions, during very light breeze, there were slight variations of colour saturation or of visual noise. Sometimes several sharply defined "ghosts" could be seen, corresponding to path differences of up to about 800m. At other times, in apparently similar conditions, they were imperceptible.

All the effects described have been confined almost entirely to the middle-frequency channel (BBC-2). On the other two they are rare and slight.

Local tests by the B.B.C. established that multipath reception was indeed taking place, maximum signal strength not being obtained on the direct bearing of Heathfield, screened as it is by a row of tall trees on the hilltop, but at angles of the order of 10 degrees each side, where there are gaps. Signal strength was varying in the moderate wind by up to 6dB, and was markedly and surprisingly lowest on BBC-2.

Varying colour saturation can be explained by selective signal cancellation around the frequency of the subcarrier; varying noise similarly at luminance frequencies. There seems to be no doubt about correlation between these effects and wind.

But some features of the observed results present problems.

If the effects are indeed due to tree movements in the wind, how can they be so frequency-selective when the leaves provide no smooth plane surfaces but are extremely random? Remember  $\lambda/2$  is of the order of only 20 cm. This could perhaps be explained if the reflectors were smooth rigid surfaces, reflecting the waves at two or more angles, reception at these angles being attenuated by intervening trees to an extent varied by the wind. As it happens there are one or two large houses on each side of the direct line from Heathfield, among the trees on the considerable area of the hilltop and Heathfield-facing slope. But they cannot be nearer than 100m, and one can easily calculate that the path differences would almost certainly be a good many half-wavelengths. That being so, one is at a loss to explain the virtual absence of effects on the other two channels. Nor is it easy to explain the widely varying incidence of ghosts, which does not correlate with the signal cancellation effects. They could be created by substantially increased attenuation along more direct paths, but what would maintain such attenuation steadily for hours?

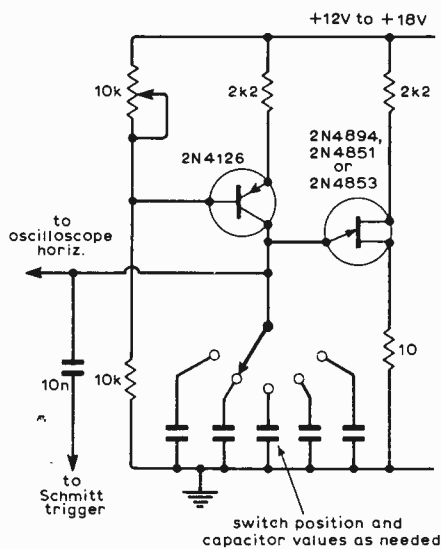
Observations elsewhere, if readers would contribute them, might help to shed light on the mechanism of effects of this kind. (They might of course add further apparent anomalies!)

M. G. Scroggie,  
Bexhill,  
Sussex.

\*\*Television Reception over Sea Paths: the Effect of the Tide', P. A. Laven, D. W. Taplin and C. P. Bell, *BBC Engineering*, May 1972, pp.4-13.

## Trace quadrupler

I enjoyed reading D. Bollen's article on a trace quadrupler for d.c. 'scopes, in the May issue of *Wireless World*. I recently built a similar unit that used m.o.s. f.e.t. switches rather than the diode bridge. Mr Bollen shows the X plate used as the source for the trigger when the unit is in



Mr Titus u.j.t. oscillator for an oscilloscope trace quadrupler.

the alternate mode. Since many experimenters may not want to add an extra terminal to their 'scopes, or are reluctant to add anything to it I would suggest an alternative method.

A constant current, unijunction transistor oscillator will produce a very linear sawtooth wave which may be used to trigger the Schmitt trigger. This sawtooth wave also supplies the horizontal sweep voltage for the 'scope when it is applied to the horizontal terminal. In this way it provides the trigger and the sweep. The frequency is varied through the use of a switched set of capacitors and a variable resistor.

J. A. Titus,  
Blacksburg,  
Virginia, U.S.A.

### The author replies:

The trouble with 'scopes is that they come in all shapes and functions. Mr Titus' 'scope obviously has no external X plate connection, but is endowed with an X amplifier input, in which case the idea of a separate sweep oscillator is certainly worth considering. Being of a lazy disposition, I would rather add a few components to the 'scope than build a sweep oscillator, on the principle that the more terminals there are the greater flexibility there is.

Assuming that an external sweep oscillator is either desirable or unavoidable, my main objection to the u.j.t. circuit is that it will operate only up to 100kHz or so, with a sluggish flyback. Even cheap 'scopes can usually muster a timebase rate of 500kHz, and the trace quadrupler will respond to 2MHz, so it does seem to be rather a waste of top-end performance. An emitter follower should

be added to the u.j.t. oscillator output to prevent loading of the timing capacitor by the low impedance input Schmitt in the quadrupler.

D. Bollen.

## Pre-amplifier using op-amps

In your July issue, I read with a great interest the description, by Mr Daniel Meyer, of a low-distortion pre-amplifier using operational amplifiers. I agree with the advantages of such a circuit regarding low distortion and the fact that input and output are at the potential of the Earth. But one of the disadvantages of using a great amount of feedback is to provide phase shifts which may become important. In the case of the R.I.A.A. network, for instance, this phase shift is strongly dependent on the frequency and the result is that the amplifier oscillates during about one second when switched on. This seems to be due to the charge of  $C_f$  ( $33\mu$  F). The frequency of this oscillation is slipping (2 to 10 kHz, approximately). This does not occur when using a linear feedback network like the microphone one. This causes a brief but strong and very disagreeable kind of whistle.

I did not succeed by any means to correct it. I must confess that I used BC409 and BC309 transistors instead of the ones recommended by Mr Meyer which are quite impossible to find in France. But BC409 and BC309 are of low-noise type and seem perfectly good for this circuit. Can you help me to correct this trouble?

The  $0.1\mu$  F capacitor in the input causes an attenuation at low frequencies (its impedance is about  $30k\Omega$  at 50 Hz!) and should be replaced by a  $1\mu$  F. This explains the value of  $750k\Omega$  used in the R.I.A.A. network which will normally cause an excessive bass boost. With  $1\mu$  F in the input, this value may be set at  $510k\Omega$  and give a result very close of the R.I.A.A. curve.

M. Dreyfus,  
Enghien,  
France.

### The author replies:

The transient, or oscillation, in the pre-amp circuit that occurs upon start up can be eliminated, or at least greatly reduced, by adding a  $47k\Omega$  resistor in parallel with  $C_f$ . As you note, this is noticed primarily in the "Phono" compensation network. The reason being that the capacitor is charging through a much larger resistor with this network ( $750k\Omega$  in this case) and more time is required for it to reach its normal operating point. The added resistor may cause an increase in the offset of the circuits output from ground, but our experience indicates that it will never be enough to cause any changes in the circuit's characteristics.

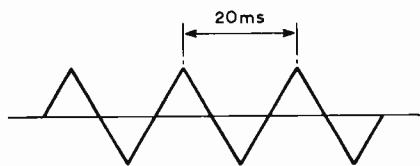
As noted in the article, I favour the complete elimination of the input

capacitor, but it can be useful in helping to control subsonic noise that is present in some systems. The value of  $0.1\mu\text{F}$  specified will indeed cause the response to fall off below 30 Hz and the size should be increased if the builder wishes a more extended bass response. The size of this capacitor, or its use at all, is a matter to be determined by the builder after consideration of the total system response.

Daniel Meyer.

## Op-amp transfer characteristic

The results of Mr Hart's experiments ("Letters", August, p.387) are totally predictable. In his Fig. 2, which is easier to work with, the time taken to traverse the characteristic is rather under 20ms. The remainder of the sweep is to our purpose nothing. We could, therefore, use an input of the form shown below, and get the same sort of excitation. Without troubling our tiny minds about the Fourier analysis, this is a 50Hz input. The open loop gain of the 741 is about 14dB down at 50Hz.



In Mr Hart's Fig. 3 the traverse seems to take about 50ms. This plants the signal just on the knee of the frequency characteristic. Thus even this trace is too fast. However, only something like 0.2V of the 2-V sweep is really being used. The display would be much clearer if the input level were reduced and only the active part of the characteristic were displayed. There would also, I feel, be educational advantages in using a sinusoidal drive, so that both the change of gain and the associated phase shift were made visible.

Thomas Roddam.

## Electric heater control

Several points in the article "Electric Heater Control" by R. M. Marston, (June *Wireless World*), need, I think, some comments.

The circuit in Mr Marston's Fig. 1 using a thermostat to obtain simple on-off zero crossing control seems to possess certain qualities amongst which is economy of components. However, when a more proportional approach to temperature control is attempted with the addition of the circuit in Fig. 2, reliance is made on triac parameters which are not closely controlled. The parameter is gate current sensitivity and the changeover from full conduction to half-wave conduction relies on one quadrant being markedly more sensitive than the other quadrant used for gate firing. Normally this would be the case, although it would be dangerous to rely on "typical" data, and it is quite possible for a similar gate sensi-

tivity to be experienced in both quadrants. In addition to this the triac gate sensitivity is a close function of device temperature and even if the correct circuit operation occurred at  $25^\circ\text{C}$  then this would not normally be the case at higher temperatures. Gate current required to trigger the device at high temperatures could be a small fraction of that specified at room temperature.

With reference to the "integral cycle heat controller" it should be pointed out that the circuit shown is not in fact capable of *integral* cycle control. Integral cycling by definition means that the triac conducts for whole integral cycles, e.g. starting on a positive half-cycle and finishing on a negative half a cycle. Mr Marston's circuit allows quite variable starting and finishing sense, albeit the trigger points occur at the a.c. zero crossing point. This form of zero crossing control would therefore give rise to odd half cycles occurring in a given time period resulting in a d.c. component in the a.c. line. Should the load be fed from an isolating transformer then it becomes possible to cause saturation in the core under some circumstances.

M. J. Shilling,  
RCA Ltd.  
Sunbury-on-Thames,  
Middx.

The author replies:

All triacs exhibit sensitivity differences between the positive and negative quadrants. Such variations are an inevitable result of the manufacturing technique, and are recognized as such in all application notes produced by triac manufacturers (including RCA). It is clearly impossible to produce a triac having *identical* sensitivities in opposing operating modes. Since these differences exist, it follows that the Fig. 2 circuit must inevitably give tri-mode operation, as described in the article, irrespective of the actual magnitudes of quadrant sensitivity, providing that these sensitivities are not outside of the manufacturers' published production limits.

As is pointed out in the text of the article, the overall temperature-regulation performance of the Fig. 2 control system is limited primarily by the thermal time-constant of the room and the electric heater, and not by the electronic control circuitry. These time-constants swamp any variations in triggering caused by variations in triac gate sensitivity, since the design is capable of shifting the gate current from zero to approximately 120mA with a *thermistor* temperature change of less than  $0.2^\circ\text{F}$ .

Concerning the use of the term "integral cycle". It is clearly stated in the article that the integral cycle system described uses a technique in which power is applied to the heater for an integral number of *half-cycles* in a given period.

The comment concerning the possibility of my integral cycle control system causing a d.c. component in the a.c. line, and this d.c. consequently causing core saturation of an isolating transformer, etc., is a valid one.

R. M. Marston.

## Sixty Years Ago

"Unsolved Problems of Wireless Telegraphy" was the heading to a 20-page report in the October 1912 issue of *The Marconigraph* (the title by which *Wireless World* was known for the first two years). The report covered the annual meeting of the British Association at Dundee at which Professor J. A. Fleming opened the discussion on "wireless telegraphy and its outstanding problems". Professor Fleming "went directly to the root of the matter, and raised questions which have perplexed physicists and engineers for years. The points discussed were: The 'bending' of the waves to follow the contour of the earth, and the so-called 'daylight effect', which makes it possible in certain circumstances to transmit signals for a very much greater distance by night than by day, using the same power". The reporter stated that "from many points of view this discussion was one of the most important features of the meeting. Contrary to the usual custom, practical achievements were almost disregarded, and there was a total absence of those sensational announcements which have tended to become characteristic of public discussion on wireless telegraphy".

### Deferred

We regret it has been necessary to hold over the publication of the second part of Pat Hawker's article on *synchronous detection* and the sixth in the series of *experiments with op-amps* until the next issue.

### Corrections

David Bowman, author of the series of articles on the 10-80 metre amateur transceiver, has notified us of the following amendments and corrections. Part 2 (July):  $L_2$  consists of 50 turns of 34 s.w.g. close wound.  $L_{13}$  secondary consists of 32 turns, i.e. 16 + 16 bifilar wound. The following components  $C_{20}$ ,  $C_{21}$ ,  $C_1$ , and  $R_1$  were shown incorrectly wired on the printed circuit (Fig. 8) but were correct in the circuit, Fig. 7. Part 3 (Aug): Type numbers for  $V_3$ : 6.3-V heater 6146 or 6146B, 12.6-V heater QV06-20B.  $RL_{1a}$  was drawn in the wrong sense in Fig. 13. Part 4 (September): Vertical scales of Fig. 17 are 10dB per division.

In the circuit of the Portable Distortion Monitor by J. L. Linsley Hood (July) a  $0.1\mu\text{F}$  capacitor should be inserted between the emitter of  $T_7$  and  $R_{17}$  (Fig. 2).

# Electronics at Farnborough-Europe 72

## A cross-section of the equipment on view at the air show

The 28th air show presented by the Society of British Aerospace Companies, and the 20th at the Royal Air Force Establishment, Farnborough, was the first combined British-European occasion at which daily flying appearances by Concorde spearheaded the examples of collaborative design and construction programmes. This example has been followed by other co-operative projects — the Jaguar Strike Trainer, the A-300B Airbus and the Panavia MRCA helicopters and guided weapons — and future programmes promise a share for Britain in the production of at least 3,500 aircraft and helicopters and over 10,000 engines in the 1980s. Future prosperity was also reflected in the exhibits on the stands of over 225 firms who took part in the static displays and equipment demonstrations. Involvement with Europe has not meant that British manufacturers are now sitting back on their heels but, on the contrary, are making rapid advances throughout the fields of automation, communication and safety.

### Noise analysers

A new range, the ARN80 series, of automatic analogue random noise equalizers/analysers was displayed by Derritron Electronics. Replacing the ARN1, 2 and 3 series this new generation incorporates active filters and, depending on the resolution required, the broadband of random noise may be equalized and analysed by banks of 40, 80, 120 or 160 filters. The standard unit, the ARN80, consists of a control unit and two 40-channel spectral level units. To this may be added one or two further spectral units. Also incorporated is a three-colour display and facilities are provided for the operation, without modification, of an X-Y plotter. An operational frequency range of 1-10,000Hz is possible, using filters with  $Q$  factors between 1 and 100. As the filter centre frequency and bandwidth are established during manufacture, these may be designed to meet individual customer requirements. Each channel of the system has three display modes, one a histogram waveform, the second the equalization function. Both of these modes are depicted on the three-colour display unit. The display system also indicates the channel number and synthesized centre frequency in Hz, identification being achieved by a channel marker, which corresponds to a voltmeter reading. The third mode indicates directly on the meter the spectral density of the energy level in each channel.

### Radar and safety

The central theme of the Cossor Electronics display was new systems and equipment designed to increase air safety by reducing the ground controller's burden. A contribution to air safety is promised by an accurate and flexible secondary surveillance radar system, which can handle up to 150 aircraft, by expanding the terminal system on a modular basis. Designated SSR990, it provides ground controllers with accurate and vital air traffic data. This data is presented on a new type of radar display developed by Cossor, the CSD2000 (see photograph). This offers easy legibility in all lighting conditions so that the semi-darkened rooms of air traffic control centres can be brighter and thus more efficient. In addition, the display has fast-writing characteristics, which permit comprehensive aircraft labels of 20 characters or more to be specified, so minimizing the need for routine cross-reference with flight progress boards — an important consideration as traffic loads increase. In conjunction with the Royal Radar Establishment, Cossor have made another step towards air safety with the development of a new secondary surveillance radar technique, labelled ADSEL (Selectively Addressable Secondary Surveillance Radar). ADSEL establishes an aircraft's height, code

*An air traffic control radar display, designated CSD2000, has been developed by Cossor electronics to help ease increasing pressure on air traffic controllers.*

range and bearing from a single reply where, in conventional systems, only range and code or height are obtainable. From a number of replies, ADSEL can predict an aircraft's track and could — if used with a data link facility — issue conflict avoidance instructions automatically, where necessary.

In the Space, Missiles and Radar Exhibition on the plateau outside the main exhibition hall, Plessey Radar featured a wide range of navaid equipment and air traffic control systems. The ACR430 airfield control radar was shown in operation. This X-band (3cm) radar which has a two-beam aerial system, is designed to fulfil a number of operational roles, which include accurate surveillance radar approaches and approach sequencing in addition to surveillance of local area traffic, airfield circuit, departing traffic and parallel approaches. Graphics on the Plessey stand emphasized the role of the 23cm AR5 long-range radar, which has a 200 nautical-mile range and includes such refinements as a digital moving target indication (DMTI) system. The AR5 is suitable for operation in all a.t.c. environments, and is designed for system integration with secondary surveillance radar, computer controlled data handling and automatic plot extraction. An interesting development made by Plessey Materials is a microwave absorbent material which finds application in



locations where the presence of stray high-frequency radiations are of potential nuisance value or a source of possible danger. Plessey Materials had lined with this material the walls of a small room which, in the radiation sense, was anechoic.

### Display generator

The airborne display generator (Mk. II) demonstrated by Ferranti is designed to interface with a variety of digital data sources and a suitable c.r.t. display. Two displays can be driven simultaneously with each display showing a different format. Printed circuit cards may be removed or added to provide facilities for individual customer requirements. Positioning and symbol generation is performed using entirely digital techniques, and the common digital output is converted into a corresponding analogue waveform by the output circuitry. This eliminates sources of drifting which occur when each symbol has a separately generated analogue waveform. Standard features include cursive generation, individual symbols may be "picked-out" by making them extra bright, output of  $\pm 3V$  maximum into  $75 \Omega$  with two separate channels provided, normal "refresh" rate of 50Hz (variable).

An r.a.m. semi-conductor store is provided if the digital interface being used is unable to provide all the data required at the refresh rate of the display. Rotation, picture horizontal and vertical movement, lines, circles and alphanumerics are each independent sub-units which can be removed if not required.

### Electronic "spirit level"

An instrument capable of registering angular changes equivalent to one inch in three miles, and with a wide range of applications in the aerospace industry, is now being produced by the Electronics Division of Irvin Great Britain Limited. This instrument, the Electrolevel, can be used in all weather conditions at any altitude and even to depths below 500ft under water. A typical assembly is not more than eight inches long, six inches wide and four inches high, and weighs less

than 10lb. It is manufactured and sold under exclusive commercial world-wide licence from the British Aircraft Corporation. The Electrolevel can be used as a landing aid for helicopters on sea platforms and floating rigs, providing an indication to the pilot of platform movement, particularly vital on landing, take-off and manoeuvring. Servicing of large aircraft undercarriages is carried out with the aircraft lifted off the ground usually by means of three jacks, each individually controlled. Co-ordination of this time-consuming operation is critical, because of the many stresses involved, and is carried out by means of an altitude indicator. Two Electrolevels can help bring the information to two meters and enable the jacks to be operated much more quickly. The same system can also be used for lining up navigational equipment. The equipment comprises a double Electrolevel head and associated electronics in a compact case with connecting cable and remote meters, the basic cost being approximately £300. Other applications include runway construction, horizon location on radar equipment and in seismology. The Electrolevel's head can be linked, by cable up to a mile in length, to a battery power supply and to the indicator.

### Solid-state display

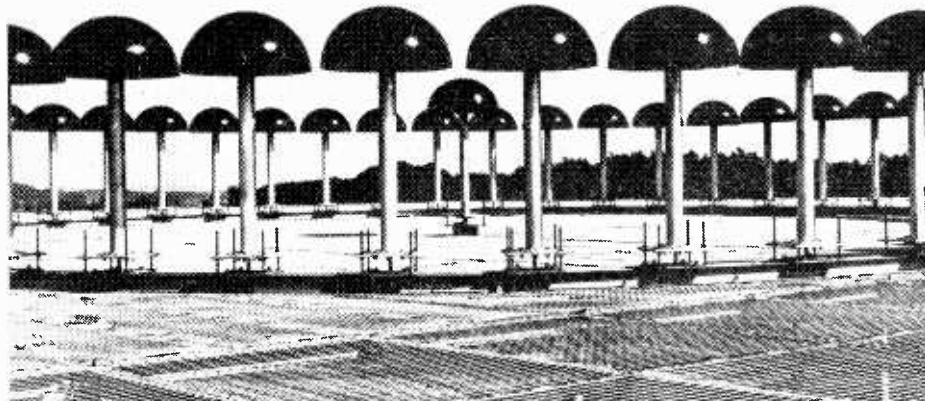
A new form of solid state radar display, which eliminates the conventional cathode-ray tube, was demonstrated in the GEC-Marconi pavilion. Based on the use of a matrix of light-emitting diodes, the display is less than one inch thick and provides a bright display which can be seen without difficulty in the high ambient light levels of an airfield control tower. Display luminance can be as high as  $3,500 \text{ cd/m}^2$ . The prototype system was demonstrated in Distance-From-Threshold Indicator (DFTI) — a small radar display used in the control tower to provide air traffic controllers with a radar picture of either the approach or the take-off path, as an aid to safe and rapid clearances. The complete display is only a fraction of the size of the equivalent cathode-ray tube equipment, and it requires less than a twentieth of the power supply. This cuts

down the heat dissipation of the complete system, and thus reduces the demand on air conditioning and cooling equipment. The i.e.d. device is inherently very rugged and reliable, and even if one should fail, only a minute portion of the complete display would be lost and it could be quickly and easily replaced. Under normal operation, an aircraft track would have at least two diodes lit at any one time to give a directional "tail" as it moves across the screen.

Head-up display has already proved to be by far the most effective instrument and weapon aiming display currently available for military combat flying. It allows the pilot to see his instrument and aiming information apparently superimposed upon the view of the outside world through the windscreen, so that he gains maximum benefit from the simultaneous and co-ordinated view of instruments and the outside world. An extension to the capability of head-up display is the Marconi-Elliott Avionics 24-hour head-up display, which has been successfully flight tested in U.S. Navy and Air Force A-7 Corsair attack aircraft. The Marconi-Elliott Avionics digital head-up display is already standard equipment in these aircraft and conversion to 24-hour capability requires only the addition of an electronic scan converter unit. This combines the TV raster scan of the picture from the night sensor with the stroke written symbols generated by the head-up display computer. The display demonstrated consisted of the 24-hour h.u. display associated with a working low-light television camera viewing a model scene in a darkened cubicle. This display can operate with a wide selection of sensors. As well as passive and active low-light television cameras, it has flown with forward-looking infra-red scanners. An additional feature is the ability to display various types of radar information on the head-up display, which can greatly reduce pilot workload in both single- and two-seat aircraft. With any of these sensors, the full complement of instrument, flight director and aiming symbols remains available for both day and night operation.

### Airborne reconnaissance

"Linescan" is an infra-red reconnaissance equipment developed by Hawker Siddeley Dynamics. Infra-red reconnaissance is a new source of combat intelligence and by examination of terrain through the infra-red waveband, the sensor derives information not obtainable by optical cameras or radar mapping. All bodies radiate thermal energy in the infra-red waveband as a function of their absolute temperature and emissivity. Terrain is scanned by a sensitive detector and a comprehensive thermal picture built up. Sharp high-quality prints are obtained from standard 70mm reconnaissance film using normal developing and printing methods. Night operation is possible without artificial illumination and as the system is totally passive, the security of the reconnaissance aircraft is enhanced.



Some of the 51 aerial elements mounted on a 13.5m counterpoise at the Biggin Hill station on which the Civilian Aircraft Authority carried out evaluation of the Doppler v.h.f. omni-range (DVOR) beacon. The installation and integration work and the provision of the counterpoise aerial was a Plessey Radar responsibility.



# Noise Silencer for A.M. Receivers

by T. A. Tong, B.Sc., Ph.D.

**The circuit samples the signal at the output of the mixer in an a.m. receiver and, when a noise pulse is detected, interrupts the receiver's signal chain between mixer and i.f. amplifier for the duration of the noise pulse. The circuit has the advantage of eliminating the noise spikes before the receiver's main selective part so that the pulses are not stretched by the narrow bandwidth of the i.f. amplifier.**

Some form of noise limiter is essential in radio equipment designed for use in or near road vehicles. In its most common form a noise limiter operates on the output from the final detector in a receiver and is arranged to clip this output whenever it rises above a level which corresponds to say 80% depth of modulation in the case of amplitude modulation. One of the original limiters of this type used a series diode as the clipping element. An improved variant of this system was described by Nicholson<sup>1</sup>, while modifications to the conventional shunt-diode noise limiter and a system using a series f.e.t. audio gate have been described by the author<sup>2,3</sup>. The common factor in all these designs is that they operate on the signal after it has passed through the selective portion of the receiver. In a highly selective receiver this is a serious limitation because of the stretching effect of the narrow bandwidth on the initially very narrow noise impulses. An impulse lasting for less than a microsecond can easily become as long as several milliseconds after passing through a selective receiver.

In order to overcome this disadvantage, noise "silencers" have been developed<sup>4</sup> in which a gate in series with

the main signal path to the selective part of the receiver is closed for the duration of any noise impulse. In this way there is little or no pulse stretching and the receiver is merely muted for an insignificant period. Subjectively the result can be almost complete elimination of the effects of impulse interference. In some noise silencer designs a separate wideband receiver is used to generate the gating pulses, while in others the main pre-selectivity receiver path is used.

An obstacle to the use of noise silencers, as opposed to noise limiters, has been that a duplicate i.f. amplifier chain is required; for example a recent design<sup>5</sup> uses three valves and several transistors (plus associated components) in order to generate the blanking pulses. Now that complete i.f. strips can be enclosed in TO-5 cans the outlook for noise silencer systems is much brighter and a design is presented which was developed for use in a pocket-size v.h.f., a.m., transceiver. Unlike most previous designs the threshold level is set automatically by the incoming signal and therefore no extra controls need be added to a receiver in which the device is incorporated.

A block diagram of the circuit is shown in Fig. 1. The wideband amplifier and

detector are contained in the LM372 integrated circuit (National Semiconductor) which has its own a.g.c. loop with a quoted range of typically 69dB; this enables the system to accommodate a wide range of input levels. Output from the active detector in the LM372 is a voltage which goes positive with increasing input from a no-signal level of 1.6V. The function of the pulse amplifier is to produce negative-going gating pulses with duration slightly greater than the noise impulse, but only from impulses whose amplitudes exceed a level equal to twice the incoming carrier level (for amplitudes corresponding to 100% modulation of the carrier). The rise time of the blanking pulses must be very short (several microseconds) but fall times are relatively unimportant. The noise gate itself is a critical item since any switching transients will obviously nullify the effect of the noise silencer. A balanced gate using a pair of field effect transistors has been found to perform very well here. An unbalanced f.e.t. gate with a trimming adjustment to cancel out capacitively transferred gating pulses has previously been used by Martin<sup>5</sup>.

Fig. 2 shows the complete circuit diagram of the unit while Fig. 3 shows the circuitry contained in the LM372. In order to fully inhibit transmission through the noise gate the two f.e.t.s ( $Tr_{4,5}$ ) require a gate-to-source voltage which is negative and greater than the pinch-off voltage ( $-1$  to  $-6V$  for the f.e.t.s specified). Since the rest of the circuit operates with a positive supply line, direct coupling is inconvenient and therefore diode-clamped capacitive coupling is used. It is the negative-going edge of the gating pulse which must have the best transition time and therefore the final stage of the pulse amplifier is arranged to give active pull-down of its output by using an n-p-n transistor ( $Tr_3$ ). This means that the differential pair ( $Tr_1, Tr_2$ ) must consist of p-n-p devices which precludes the use of one of the many long-tailed pair integrated circuits.

One input (A) to the differential amplifier is a voltage proportional to the average carrier level and is in fact the detector output smoothed by a capacitor. The other (B) is the detector output divided by two so that modulation peaks cannot produce a gating signal. Thus, whenever B goes momentarily more positive than A, a negative pulse appears at the gates of  $Tr_4$  and  $Tr_5$  and the receiver signal path is interrupted. Because of the no-signal quiescent voltage at the detector output the potential divider,  $R_1$  and  $R_2$ , is returned to the d.c. feedback point in the LM372, which is at 1.3V. The potential at point B is slightly lower than 1.6V due to the current taken by the a.g.c. stage in the i.c., but despite reasonable differential offset voltages in  $Tr_1$  and  $Tr_2$ , the latter will normally be fully non-conducting in the absence of noise impulses and further control of the clipping level may be had by altering the value of  $R_4$ . The smaller its resistance, the bigger the noise pulse has to be to turn on  $Tr_3$ . Because of the relatively large

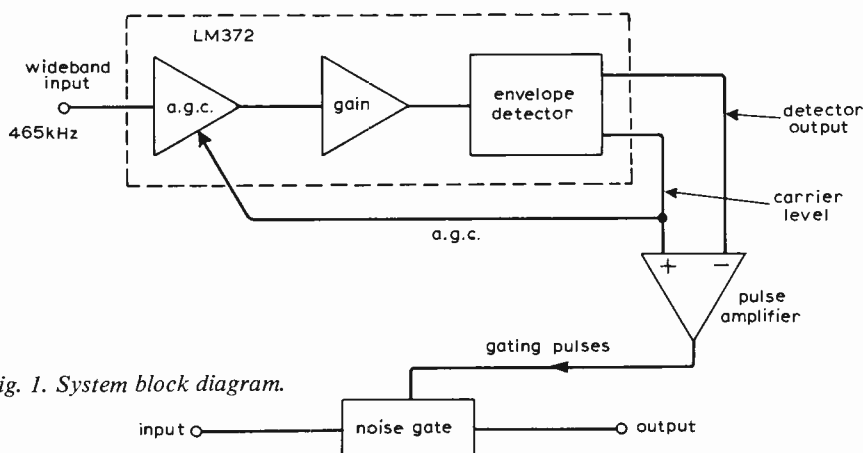


Fig. 1. System block diagram.

amplitude of noise pulses, really accurate tracking of carrier level is not necessary. An impulse which is only, say, twice as large as a modulated carrier at the aerial input is almost undetectable by ear when stretched, and therefore reduced in amplitude, by the main receiver selectivity.

The balanced r.f. gate is very effective

and does not require selected f.e.t.s. There is no reason why other types should not be suitable. The E300, made by Siliconix Ltd, is a relatively low-cost, low-capacitance type intended for use in v.h.f. amplifiers. Similarly the transformers are not critical and should merely be designed to match the impedance values in the particular

receiver. Probably untuned ferrite transformers would be equally suitable but were not tried.

The operating frequency range of the LM372 is from 50kHz to 2MHz. If operation at frequencies higher than this is desired, the LM373, which has a similar active detector and a frequency range from audio to 15MHz, could be used. The penalty is an increased current consumption from 2mA for the LM372 to 15mA for the LM373. The supply can be from 6 to 15V with the circuit given.

If the circuit is to be used with modes of transmission other than a.m., the reference level at point A could be derived from a manually operated potentiometer. It is important to note that the LM372 requires only a "whiff" of input to operate properly. It should not be overloaded and the input should be taken from a point in the receiver close to the mixer. Ten millivolts of signal represent a reasonable upper limit for the input at pin 2. If more than about 50mV is applied, the a.g.c. range of the unit will be exceeded and the gate may partially cut-off on modulation peaks. The noise gate should be inserted at the main receiver mixer output, where signal amplitudes are reasonably low, and before the selectivity-determining components.

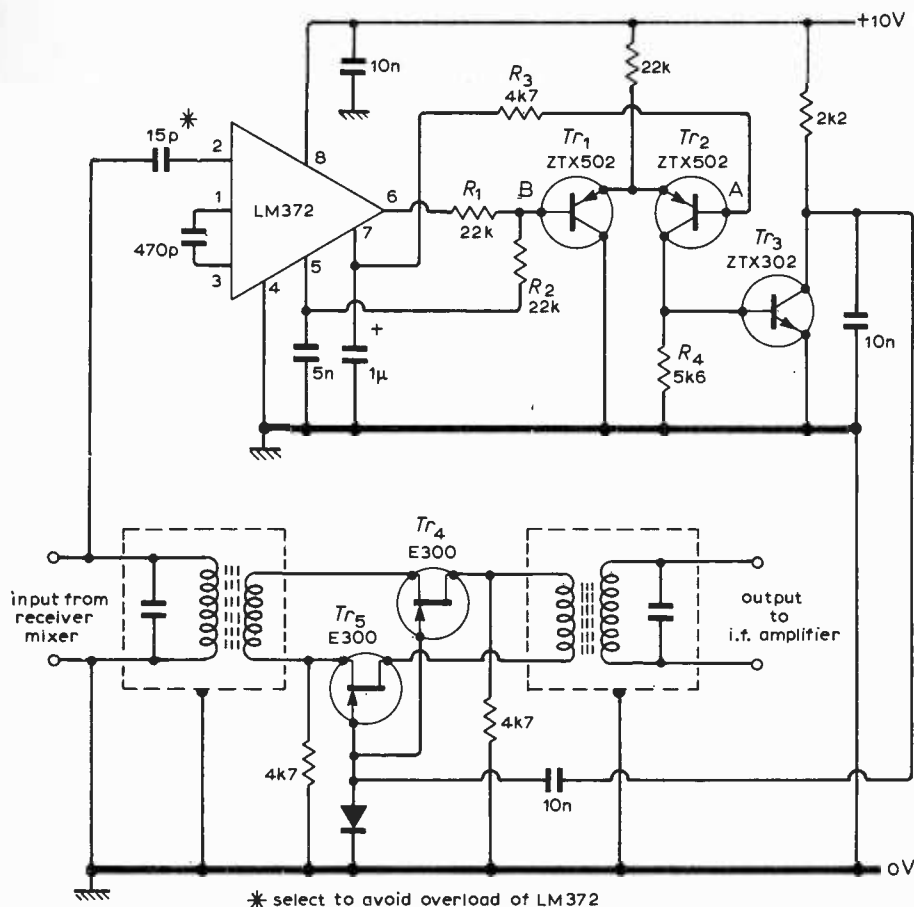


Fig. 2. Circuit diagram. For frequencies above 2MHz use an LM373 instead of the LM372.

References

1. Nicholson, M. G., *Wireless Engineer*, July 1947, p.197.
2. Tong, D. A., *Wireless World*, Jan, 1969, p.15.
3. Tong, D. A., *Radio Communication*, Dec. 1971, p.834.
4. Lamb, J. J., *QST*, Feb. 1936.
5. Martin, P. G., *Radio Communication*, Vol.47, p. 168, 306. (See also *Wireless World*, Sept. 1972, p.447)

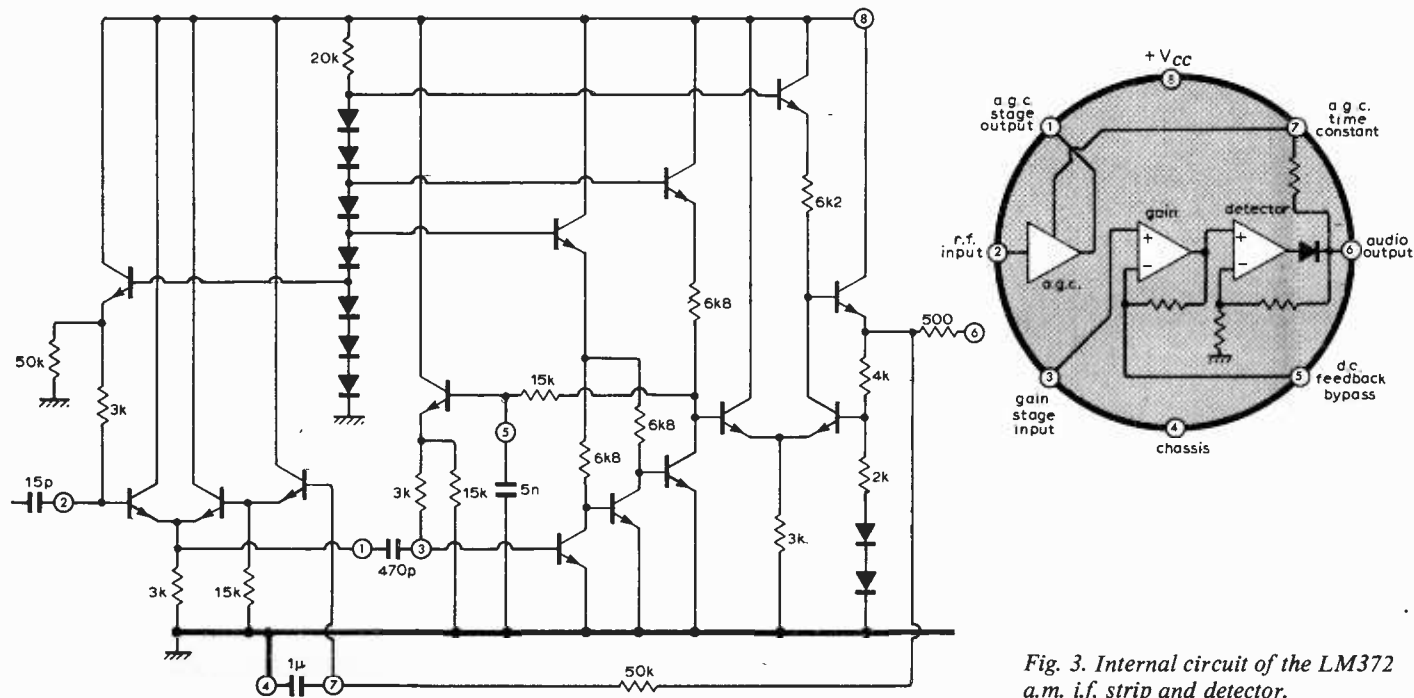


Fig. 3. Internal circuit of the LM372 a.m. i.f. strip and detector.

# Non-linear Function Generator

## A system with a wide dynamic range for implementing single valued quadratic and cubic polynomials

by H. McPherson

How to generate a non-linear function is a problem which is frequently encountered in many fields of electronic circuit design. In cases where only a rough approximation to a simple curve is required, it may be possible to utilize a single non-linear circuit element such as an f.e.t. operated in the region before pinch-off. For greater accuracy, a common method is to build up the curve from straight line segments using a diode-resistor network. Where the input is a ramp function, the use of integration with respect to time may provide a solution. The majority of methods, however, tend to suffer from poor dynamic range, and are usually applicable only over a limited portion of the required function. For example, four quadrant operation and the presence of turning points in the curve may cause difficulties. This article describes how the logarithmic relationship between base-emitter voltage and collector current in each of a matched pair of diode connected transistors may be exploited to implement any single valued quadratic and certain cubic polynomials. Four quadrant operation is possible, and accuracy is maintained over an input amplitude range of several decades.

### Applications

Obvious applications arise in all systems involving analogue computation. To quote an example in the field of weapon aiming computation, ballistics functions invariably include  $\frac{1}{2}gt^2$  gravity drop and  $\frac{1}{2}pv^2$  drag terms. Non-linear functions also occur frequently in radar systems. Since the radar equation involves the fourth power of range, two square law units could provide a swept gain law for i.f. receivers. The system may also be used to correct for undesired circuit non-linearities. Linearization of the characteristics of transducers and instruments, such as strain gauges, photo- and

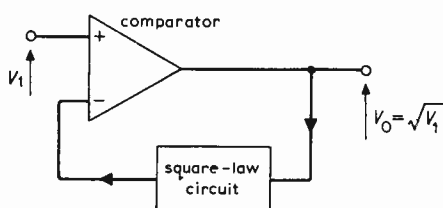


Fig. 1. Block diagram for calculating square roots using a square law circuit.

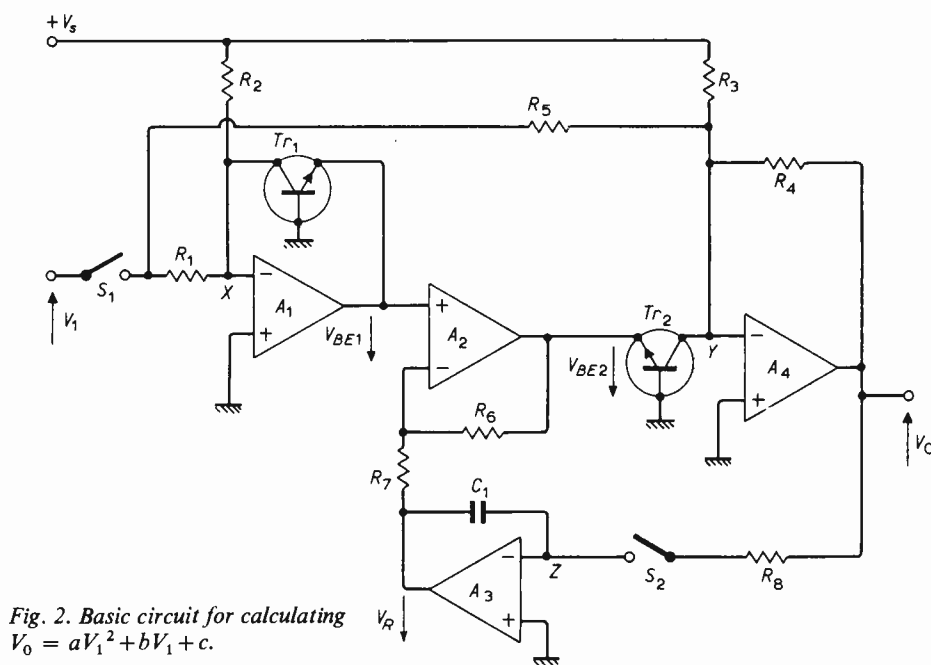


Fig. 2. Basic circuit for calculating  $V_0 = aV_1^2 + bV_1 + c$ .

thermo-electric devices, and barometric instruments, are but a few examples of this extensive area of application. With the circuit shown in Fig. 1, it is possible to use a square law device to calculate square roots. This, together with two other square law devices, offers a solution to the problem of finding the resultant of two orthogonal vectors. Finally, the unit may have applications in educational establishments as a teaching aid in the theory of quadratic equations.

### Theory

Generation of the quadratic polynomial

$$V_0 = aV_1^2 + bV_1 + c$$

reduces to the problem of squaring the input voltage,  $V_1$ . Employing the logarithmic base-emitter voltage vs. collector current characteristic exhibited by a transistor, with its collector-base voltage held to zero, it is possible to produce a voltage proportional to  $\log_e V_1$ . By doubling this voltage and antilogging with a similar transistor, the resulting term in  $V_1^2$  may be summed with linear and constant terms to give the required expression. For the transistors to be biased in the region for a good logarithmic response, however, offsets must be included

during both the logging and antilogging processes. The following analysis shows the effect of these offsets on the coefficients in the polynomial.

Referring to Fig. 2,  $Tr_1$  represents the logging transistor and  $Tr_2$  the antilogging device. Since points X and Y are virtual earths, the collector-base voltages of both  $Tr_1$  and  $Tr_2$  are zero. For an n-p-n transistor connected in this way, the Ebers-Moll equation relating collector current,  $I_C$ , to base-emitter voltage,  $V_{BE}$ , becomes

$$I_C = \alpha_F \cdot I_{ES} (e^{qV_{BE}/kT} \cdot (V_{BE} - V_{GO}) - 1)$$

where  $\alpha_F$  is the forward circuit current gain in the common base mode and  $I_{ES}$  is the emitter saturation current with the collector and base shorted. Voltage  $V_{GO}$  is the energy gap extrapolated to 0°K, and equals 1.205V for silicon transistors. If  $V_{BE}$  is greater than about 100mV, the exponential term predominates, and we may write

$$I_C = \alpha_F \cdot I_{ES} \cdot e^{qV_{BE}/kT} \cdot (V_{BE} - V_{GO})$$

or  $\log_e I_C = A + BV_{BE}$

where  $A = \log_e \alpha_F \cdot I_{ES} - \frac{qV_{GO}}{kT}$

$$B = q/kT$$

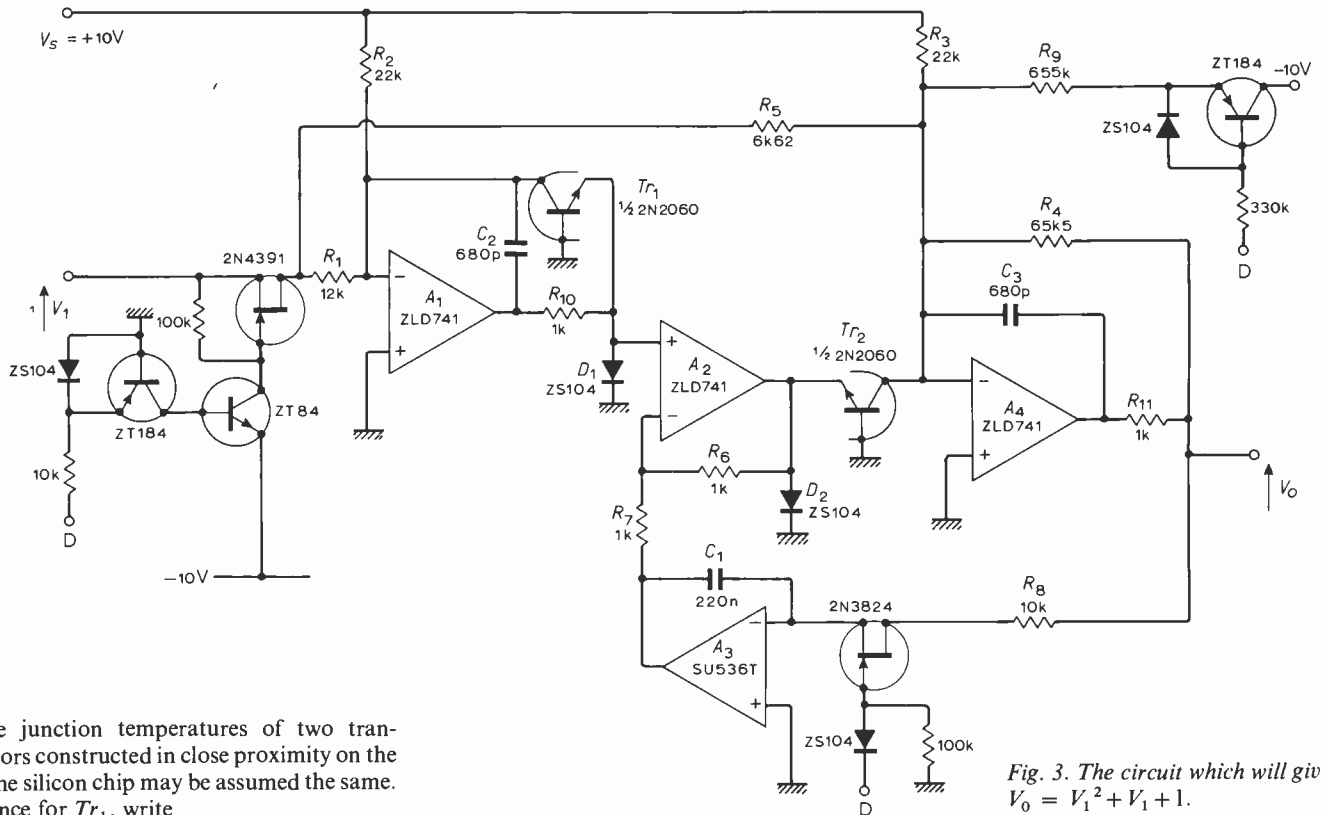


Fig. 3. The circuit which will give  $V_0 = V_1^2 + V_1 + 1$ .

The junction temperatures of two transistors constructed in close proximity on the same silicon chip may be assumed the same. Hence for  $Tr_1$ , write

$$\log_e I_{C1} = A_1 + BV_{BE1} \quad (1)$$

and for  $Tr_2$

$$\log_e I_{C2} = A_2 + BV_{BE2} \quad (2)$$

Thus with switches  $S_1$  closed and  $S_2$  open, a summation of currents at virtual earths X and Y gives

$$\log_e (V_s/R_2 + V_1/R_1) = A_1 + BV_{BE1} \quad (3)$$

$$\log_e (V_1/R_5 + V_s/R_3 + V_0/R_4) = A_2 + BV_{BE2} \quad (4)$$

Also, if  $R_6 = R_7$ ,

$$V_{BE2} = 2V_{BE1} - V_R \quad (5)$$

Substitution of equations (3) and (4) in (5) yields

$$\log_e (V_1/R_5 + V_s/R_3 + V_0/R_4) = A_2 - 2A_1 + 2\log_e (V_s/R_2 + V_1/R_1) - B \cdot V_R \quad (6)$$

Prior to each computation, or computing cycle, if  $V_1$  varies continuously with time, the circuit is set up by allowing  $V_R$  to assume a value such that when  $V_1 = 0$ ,  $V_0 = 0$ . This is done by opening  $S_1$ , giving  $V_1 = 0$ , and closing  $S_2$ . Since point Z must then become a virtual earth, a voltage  $V_R$  is stored on capacitor  $C_1$  such that  $V_0 = 0$ . Hence from equation (6), when  $V_1 = V_0 = 0$

$$B \cdot V_R = A_2 - 2A_1 + 2\log_e V_s/R_2 - \log_e V_s/R_3 \quad (7)$$

On replacing  $B \cdot V_R$  in equation (6) with the above expression (7), constants  $A_1$  and  $A_2$  vanish, giving

$$V_0 = \frac{R_2^2 \cdot R_4}{R_1^2 \cdot R_3} \cdot \frac{1}{V_s} V_1^2 + \left( \frac{2R_2 R_4}{R_1 R_3} - \frac{R_4}{R_5} \right) V_1 \quad (8)$$

The addition of a constant to this expression may be done in either of two ways. The loop may be set up such that when  $V_1 = 0$ ,  $V_0 = V_c$ . This will introduce a constant  $V_c$  into equation (8), but will complicate the

coefficient of  $V_1^2$  and  $V_1$  by the addition of terms

$$\frac{V_0 R_2^2}{V_s^2 R_1^2} \text{ and } \frac{2R_2 \cdot V_0}{R_1 V_s} \text{ respectively.}$$

To preserve accuracy, a better solution is the addition of a constant current into  $A_4$  virtual earth during the computing cycle.

**Extension to cubics**

In general,

$$V_{BE2} = (1 + R_6/R_7)V_{BE1} - R_6/R_7 V_R$$

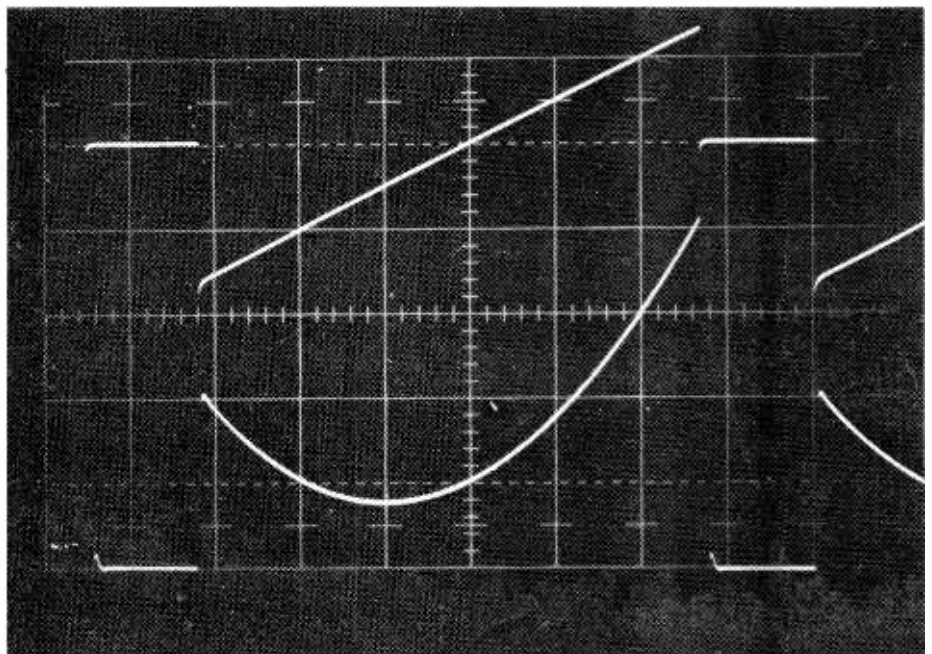
If  $R_6 = 2R_7$ , it can be shown that

$$V_0 = \frac{R_2^3 R_4}{R_1^3 R_3} \cdot \frac{1}{V_s^2} V_1^3 + 3 \frac{R_2^2 R_4}{R_1^2 R_3} \cdot \frac{1}{V_s} V_1^2 + 3 \left( \frac{R_2 R_4}{R_1 R_3} - \frac{R_4}{R_5} \right) V_1$$

Thus a cubic polynomial with independent coefficients is possible, although the choice of voltage  $V_s$  is no longer arbitrary, and the coefficients of  $V_1^3$  and  $V_1^2$  must be of the same sign.

**Design**

The design procedure is best illustrated by means of a practical example. e.g. Given



Oscilloscope trace obtained from the circuit in Fig. 3 for evaluating  $V_0 = V_1^2 + V_1 + 1$ . The upper trace shows  $V_1$ , the lower trace  $V_0$ . Vertical scale is 1V/cm.

stabilized power supplies of  $\pm 10V$ , and an input voltage range of  $\pm 1V$ , design a circuit to synthesize the quadratic:

$$V_0 = V_1^2 + V_1 + 1$$

A suitable choice of transistor for  $Tr_1$  and  $Tr_2$  is the 2N2060, a silicon n-p-n planar double transistor. Such a device will exhibit a logarithmic transfer characteristic over a collector current range of approximately 10nA to 5mA. Resistor values  $R_2$  and  $R_3$  are dictated by the required collector currents when  $V_1 = 0$ . To avoid problems of noise and the need for high input resistance amplifiers, let  $I_{C1}$  and  $I_{C2}$  be chosen near the upper end of the scale, say 0.5mA

$$\text{Then } R_2 = R_3 = V_s / I_C = \frac{10V}{0.5mA} \approx 22k\Omega$$

taking the nearest standard value. Since changes in collector current will be greatest in  $Tr_2$ , define the limits of the change  $\Delta I_{C2}$  in  $I_{C2}$  say  $\pm 0.25mA$ . Now in Fig. 2,  $I_{C2}$  is independent of the currents flowing through  $R_5$  and  $R_9$ , which serve only to modify  $A_4$  output by the introduction of a linear and constant term. Were these resistors absent,  $V_0$  would become

$$V_0 = \frac{R_2^2 \cdot R_4}{R_1^2 \cdot R_3 \cdot V_s} V_1^2 + \frac{2R_2 \cdot R_4}{R_1 \cdot R_3} V_1$$

from equation (8). The value of  $|V_0'|$  thus reaches  $|V_0'|_{max}$  when  $V_1 = +1V$ , giving

$$\begin{aligned} \Delta I_{C2_{max}} &= \frac{|V_0'|_{max}}{R_4} \\ &= \frac{R_2^2}{R_1^2} \cdot \frac{1}{R_3 \cdot V_s} + \frac{2R_2}{R_1 \cdot R_3} \\ \therefore 0.25mA &= \frac{(22k)^2}{R_1^2} \cdot \frac{1}{(22k) \times 10V} + \frac{2}{R_1} \end{aligned}$$

On solving,  $R_1 = 12k\Omega$  taking the next highest value. Now evaluate  $R_4$  from

$$a = 1 = \frac{R_2^2 \cdot R_4 \cdot 1}{R_1^2 \cdot R_3 \cdot V_s}$$

$$\therefore R_4 = 65.5k\Omega$$

Next, find  $R_5$  from

$$b = 1 = \frac{2R_2 R_4}{R_1 R_3} - \frac{R_4}{R_5}$$

$$\therefore R_5 = 6.62k\Omega$$

Finally, find  $R_9$  from

$$c = 1 = \frac{R_4}{R_9} \cdot V_s$$

$$\therefore R_9 = 655k\Omega$$

The complete circuit is shown in Fig. 3. Note the inclusion of diodes  $D_1$  and  $D_2$  to prevent the maximum reverse base-emitter voltages of  $Tr_1$  and  $Tr_2$  from being exceeded. As  $Tr_1$  and  $Tr_2$  introduce gain and phase shift,  $R_{10}$ ,  $R_{11}$ ,  $C_2$  and  $C_3$  are necessary to ensure stability and ideally, amplifiers  $A_1$ ,  $A_3$ , and  $A_4$  should have zero offset voltage. A 10ms ramp waveform, at the input, preceded by a 2ms setting up period gave the parabola shown in the photograph. In cases where the input is a d.c. voltage,  $A_4$  output must be followed by a sample and hold circuit.

# The Analogue Recursive Computer

## Analogue computation under digital programme control

by R. J. Lamden\*, M.Sc., M.I.E.E.

Most control engineers will have found themselves needing a controller with the flexibility of a digital computer, but where the size of the job has not really justified the expense and complication involved. Even though the cost of digital computers is falling all the time, and indeed the "computer on a chip" is now becoming available, this is only part of the story, since a good deal of circuitry is usually needed to translate between the computer digital format and analogue inputs and outputs. In many cases engineers will have opted for an analogue solution, and have then wondered uneasily whether the saving in cost on the computer and interfaces justifies the design and modification costs of the special-to-purpose analogue computer which is evolved.

computer, by time sharing, so only a few operational amplifiers and one analogue multiplier-divider are required. The analogue time-sharing gives simple input-output interfaces while maintaining all the flexibility of a programmable device.

A key component is a field effect switch, which is used for data selection and storage. In the on state capacitor data stores are charged to analogue voltages, while in the off state leakage is so small that stored quantities can be recovered with very little error. Of course the lost charge must be restored at some point in each execution of the programme, and this accounts for the word recursive in the name of this computer. The absolute accuracy is  $\pm 0.1\%$  for each operation although this may be improved, while a time of twenty microseconds has been allowed for each operation. Addition, subtraction, multiplication, division, logical branch, and maximization are among the functions available. Monolithic operational amplifiers with settling times of about one microsecond and slew rates of hundreds of volts per microsecond are now becoming available, so that the speed could be increased if required.

This computer was developed by Ultra Electronics for the control of aircraft gas turbines, but it now seems that its flexibility, small size and weight, and the reliability given by the relatively small number of components used, makes it suitable for much wider application. It has already been used in place of a conventional analogue computer for the real time simulation of complex non-linear systems. In this application the use of a digital programme gives a very considerable reduction both in set-up time and in programming errors. Programming can be simplified by the use of a hard-wired compiler, which translates symbolic language resembling Fortran into machine code.

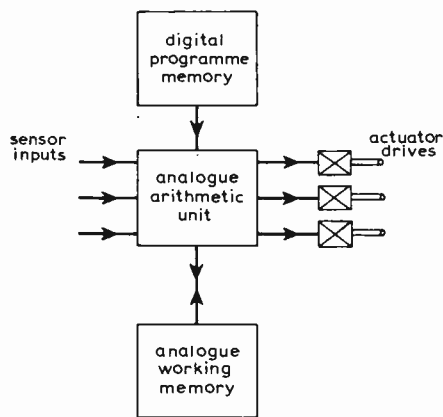


Fig. 1. Block diagram of the analogue recursive computer. The analogue store employs f.e.t.s and capacitors.

A novel device, shown in Fig. 1, offers a solution to this dilemma. The basic concept is to use a digital programme, which is executed in the usual way, instruction by instruction, to control an arithmetic unit working entirely with analogue quantities. One set of arithmetic elements is used just as in a digital

\*Control System Consultants, formerly with Ultra Electronics Ltd.

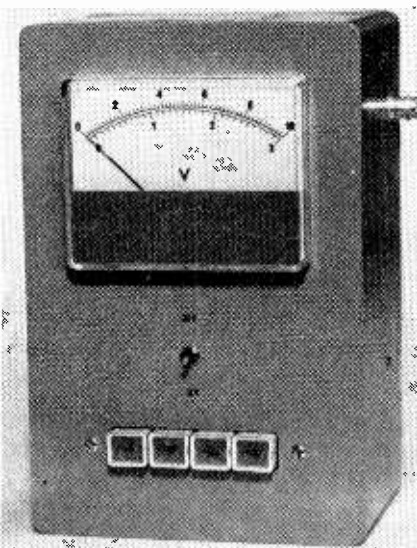
# Linear Decibel Meter

## A simple design capable of measuring signals down to $-80\text{dB}$

by J. H. Smith\*, M.I.E.R.E.

People concerned with communications over telephone circuits frequently need to measure signal levels (in decibels). For example, the British Post Office regulates strictly the levels of signals transmitted to and from newspaper wire rooms. Today, telephone circuits carry such traffic as telephoto (picture transmission), facsimile, remote copying, and data transmission in addition to speech. All of these signals have to be regulated to avoid excessive cross talk and noise. Current regulations call for a maximum signal level of  $-7\text{dB}$  and transmitting equipment must be set to this level. The meter to be described is at present in use by technicians concerned with telephone circuits, who use it for checking the attenuation and bandwidth of lines, to monitor transmissions and to set the dynamic range of transmitters. Incorporating a linear dB scale and push buttons for extending the range of the instrument from  $+10$  to  $-80\text{dB}$ , the instrument's bandwidth is the nominal d.c. to  $3.5\text{kHz}$  of Post Office telephone lines. At the end of the article further

\*I.P.C. Research and Development Department.



The prototype instrument with a meter scale from 0 to  $+10\text{db}$ . The push buttons underneath the meter introduce amplifiers preceding the indicator circuit.

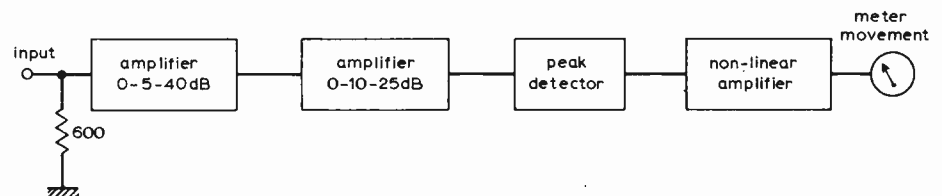


Fig. 1. Block diagram of the basic system.

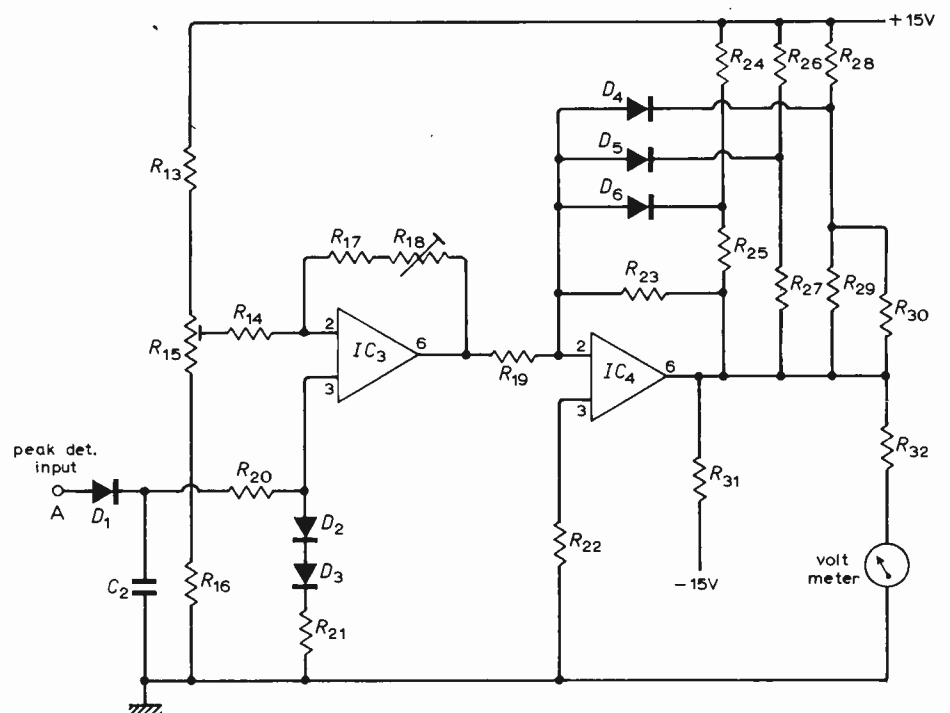


Fig. 2. Circuit of the indicator amplifier.

developments are suggested to extend the capabilities of the meter.

A photograph of the prototype is shown. To operate the instrument one simply connects it to the line carrying the unknown signal and pushes the  $-dB$  buttons until the meter shows a reading. The sum of the values of the buttons, depressed minus the meter reading gives the actual dB level. The push buttons shown are set to give  $-5\text{dB}$ ,  $-10\text{dB}$ ,  $-25\text{dB}$  and  $-40\text{dB}$ .

A block diagram of the instrument is shown in Fig. 1. The input signal passes to a load resistor of  $600\Omega$ , so that it matches the impedance of telephone equipment: a switched amplifier, which can be set to 0, 5, 40, or  $45\text{dB}$  gain with the aid of  $-5$  and

$-40\text{dB}$  push buttons, amplifies the input. The amplified signal passes to a second amplifier which may be switched to 0, 10, 25, or  $35\text{dB}$  with the aid of  $-10$  and  $-25\text{dB}$  push buttons. The accuracy of the instrument depends upon the accuracy and stability of these amplifiers. The output signal from the second amplifier passes to a peak detector which converts the a.c. signal to a d.c. level. This d.c. signal passes to a non-linear amplifier which drives an indicating meter. Almost any meter can be used provided that the integrated circuit will drive it.

### Indicating circuit design

Fig. 2 shows the non-linear indicating amplifier circuit. The peak detector and its



associated amplifier comprises the first stage  $IC_3$ , the peak signal being a charge on  $C_2$ . Zero dB gives a peak voltage of  $E_{pk} = \sqrt{2} \times \sqrt{600 \times 10^{-3}}$  or 1.1V approximately. This peak signal passes to the non-inverting input of  $IC_3$  and is backed off by a d.c. potential fed to the inverting input. The output of  $IC_3$  is zero for a zero dB signal input. Note that zero dB is a specific signal input and not the absence of a signal. Diode  $D_1$  is the charging diode of the peak detector, while diodes  $D_2$  and  $D_3$  merely provide stability at higher temperatures. The following formula relates the peak level of a 10dB signal  $E_{10}$  to zero dB:

$$20 \log (E_{10}/E_{pk}) = 10$$

$$\therefore E_{10}/E_{pk} = 3.16$$

Hence the peak signal for a 10dB input is  $3.16 \times 1.1V$  or 3.48V approximately. This voltage is partially backed off by the d.c. voltage applied to the inverting input of  $IC_3$ , therefore a 10dB signal is equivalent to presenting 2.38V to the amplifier. The amplifier gain is set to 4.2, so that a 10dB signal gives +10V output. Thus  $IC_3$  gives 0 volts for zero dB and +10V for +10dB. The amplifier design is started by plotting a table of transfer functions.

Fig. 3 shows a plot of  $IC_3$  output (this is  $IC_4$  input) against the output required from  $IC_4$ . This curve is obtained from the transfer functions tabulated in Table 1. Fig. 3 shows

Table 1

Signal (dB)	Ratio (antilog dB/20)	Peak voltage (V)	$IC_3$ output* (V)	Required $IC_4$ output (V)
0	1	1.1	0	0
1	1.12	1.23	0.546	1
2	1.26	1.382	1.184	2
3	1.416	1.555	1.91	3
4	1.582	1.74	2.69	4
5	1.78	1.958	3.6	5
6	2.0	2.2	4.61	6
7	2.24	2.46	5.71	7
8	2.51	2.76	6.97	8
9	2.81	3.1	8.4	9
10	3.16	3.48	10	10

\*(Peak signal - 1.1)  $\times$  4.2.

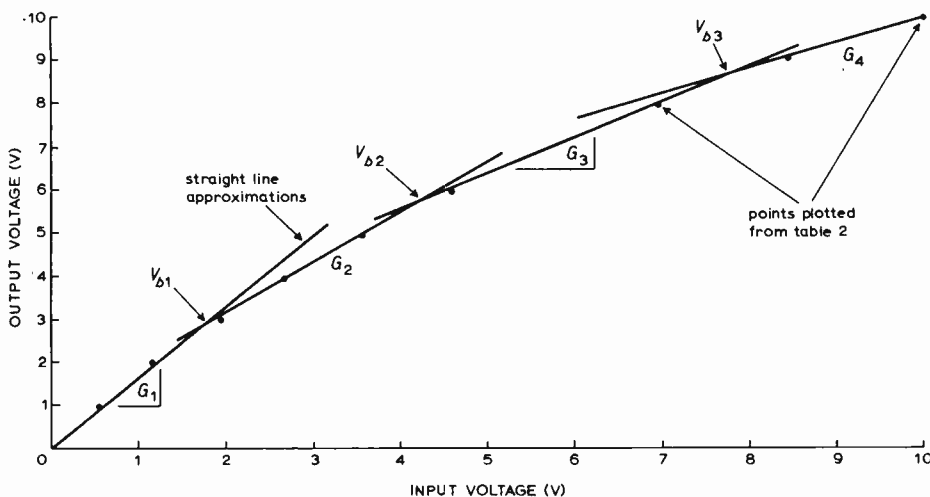


Fig. 3. The approximate non-linear amplifier characteristic of  $IC_4$ .

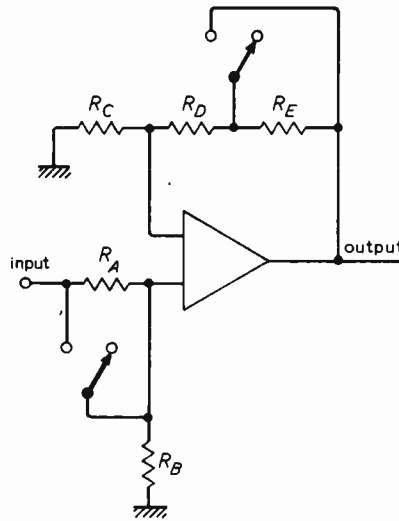


Fig. 4. Basic switched gain amplifier.

also that a series of straight lines approximates the required curve.

Table 2 lists the following information corresponding to four values of the gain ( $G$ ) of each straight line approximation:

- $G$  slope of each line.
- $V_b$  break points determined by the intersection of each straight line.
- $V'_b$  break points minus the diode forward potential. (0.5V is allowed in this example).
- $R_f$  feedback resistor required to give the slopes  $G$ .
- $R'_f$  actual resistor needed to give  $R_f$ . ( $R_f$  is the parallel combination of all the previous feedback resistors).
- $R_b$  bias resistor necessary to give the break points

$$R_b = (15/V'_b) \times R'_f$$

$R_d$  Balancing resistor, the series parallel combination of  $R_{24}$  to  $R_{30}$ .

As  $R'_f$  and  $R_b$  have to be standard values, one can obtain a more accurate approximation by determining the break point using standard resistor values and plotting a straight line approximation from the actual point obtained. This dB meter required an overall accuracy of  $\pm 1$ dB and the approximations using standard resistor

Table 2

$G$	1.65	1.16	0.73	0.58
$V_b$	—	3.0V	5.85V	8.75V
$V'_b$	—	2.5V	5.35V	8.25V
$R_f$	16.5k	11.6k	7.3k	5.8k
$R'_f$	—	39k	20k	28k
$R_b$	—	240k	56k	51k
$R_d$	—	—	—	33k

values are well within this limit. Resistors  $R_b$  have no appreciable effect upon the gain because they are connected through the diodes to the inverting input of  $IC_4$ . This input is the 'virtual earth' of the operational amplifier.

### Amplifier circuits design

Fig. 1 shows how switched gain amplifiers drive the indicator unit, while Fig. 4 illustrates how a basic operational amplifier can produce additive dB gains by switching various resistors. Note that additive dB signals are multiplicative gains. The following expressions give the gain,  $G$ , of the amplifier shown in Fig. 4.

$$G_1 = \frac{R_B}{R_A + R_B} \times \frac{R_C + R_D + R_E}{R_C}$$

If  $R_A$  is shorted, the gain becomes

$$G_2 = (R_C + R_D + R_E)/R_C$$

If  $R_E$  is also shorted, the gain becomes

$$G_3 = (R_C + R_D)/R_C$$

If  $R_E$  is shorted, but not  $R_A$ , the gain becomes

$$G_4 = \frac{R_B}{R_A + R_B} \times \frac{R_C + R_D}{R_C}$$

The relationship between these various gains may be seen clearly from the numerical example:

$$R_A = 33.6k\Omega$$

$$R_B = 2.0k\Omega$$

$$R_C = 2.0k\Omega$$

$$R_D = 33.6k\Omega$$

$$R_E = 77k\Omega$$

$$G_1 = \frac{2}{33.6+2} \times \frac{2+33.6+77}{2} = 3.16 \approx 10dB$$

$$G_2 = \frac{2+33.6+77}{2} = 56.3 \approx 35dB$$

$$G_3 = \frac{2+33.6}{2} = 17.8 \approx 25dB$$

$$G_4 = \frac{2}{33.6+2} \times \frac{2+33.6}{2} = 1 \approx 0dB$$

The following formula gives the gain in dB: dB gain =  $20 \log G$ . Gain  $G_4$  will be 0dB provided that  $R_A = R_D$  and  $R_B = R_C$ . Gain  $G_2$  is the product of  $G_1 \times G_3$ . The only gains which need calculating are  $G_1$  and  $G_3$  provided  $R_A = R_D$  and  $R_B = R_C$ . These gains are those needed from each individual push button of which there are four:

$$5dB \approx 1.78$$

$$10dB \approx 3.16$$

$$25dB \approx 17.8$$

$$40dB \approx 100$$

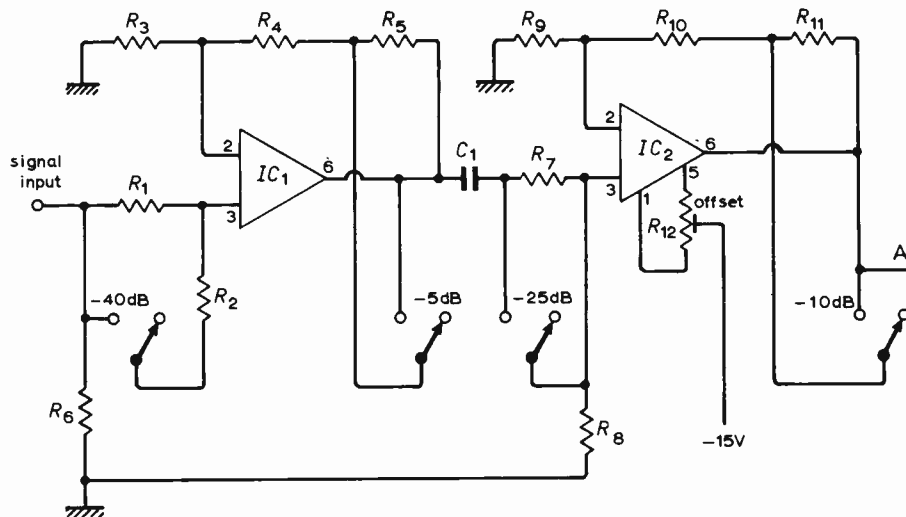


Fig. 5. Complete circuit of the cascaded switched gain amplifiers.

As I have already discussed the 10 and 25dB amplifier, it only requires a further stage of amplification to provide the 5 and 40dB circuits.

### Construction

Because of the limited bandwidth of the integrated circuits used in this design, the construction and layout of the instrument is not very critical. However, as the amplifier gain is 80dB the input and output circuits must not be too close to each other. The positive and negative 15V supplies must not vary to any appreciable extent, otherwise the accuracy and stability will be impaired.

To set up the instrument one has to set three trim potentiometers. First one sets trimmer  $R_{12}$  to give 0V d.c. out of  $IC_2$ , when no input signal is present. Then one applies a zero dB signal from a 1kHz generator and sets  $R_{15}$  to give a zero indication on the meter. Next, one presses the -10dB button and adjusts  $R_{18}$  to give a full scale reading and then releases the -10dB button. Finally one presses the -5dB button and adjusts  $R_{15}$  and  $R_{18}$ , as necessary, to make the meter reading +5dB (half scale), in order that the instrument gives its most accurate readings from the centre of the scale.

### Further development

We could make the dB meter cover much wider bandwidths if we replaced the SN72741 integrated circuits with a higher frequency type. Such a modification would require much more careful layout and screening to avoid the possibility of feedback and oscillation.

We can achieve greater accuracy by using a larger number of straight line approximations in the non-linear amplifier, and by using close tolerance resistors in the two switched amplifiers. By fitting an attenuator on the input and adding it to the positive meter reading, we can extend the range so that the unit will read positive dB levels, e.g. if we fitted a 50dB attenuator to the input then the dB level of the signal would be: meter reading +50dB minus sum of decibels marked on buttons depressed. However, we would have to ensure that the load impedance was 600Ω.

As dB readings always represent a ratio, the meter is accurate only for a zero level defined as 1mW in 600Ω. We could use other references providing we fitted the appropriate amplifiers or attenuators, e.g. if 1mW in 75Ω is required we have:

$$V_{pk}(600 \text{ ohms}) = \sqrt{600 \cdot 10^{-3}} \times \sqrt{2}$$

$$V_{pk}(75 \text{ ohms}) = \sqrt{75 \cdot 10^{-3}} \times \sqrt{2}$$

The factor  $\sqrt{2}$  is necessary to change r.m.s. into peak volts.

$$V_{pk}(600)/V_{pk}(75) = 2\sqrt{2}$$

Therefore, 2.828 represents the additional gain necessary to change the instrument to a 75Ω dB meter.

The author wishes to thank two of his colleagues in I.P.C. Research & Development, K. W. Barlow and J. Trueman, for suggesting this instrument and, respectively, for constructing and testing the prototype.

### Components list

#### Resistors

$R_1$  to  $R_{11}$  have been selected for close tolerance.

1 - 198k	17 - 33k
2 - 2k	18 - 25k trimmer
3 - 2k	19 - 10k
4 - 198k	20 - 10k
5 - 156.2k	21 - 47k
6 - 600Ω	22 - 6.2k
7 - 33.56k	23 - 16.51k
8 - 2k	24 - 240k
9 - 2k	25 - 39k
10 - 33.56k	26 - 56k
11 - 77k	27 - 20k
12 - 10k trimmer	28 - 51k
13 - 11k	29 - 30k
14 - 10k	30 - 470k
15 - 500k trimmer	31 - 33k
16 - 240Ω	32 - 98.8k

Some values are made up with series standard resistors.

#### Capacitors

1 - 3.3μ	2 - 15μ
----------	---------

#### Diodes

1, 2, 3, 4, 5, 6 - OA202
--------------------------

#### Integrated circuits

1, 2, 3, 4 - SN72741
----------------------

## Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

- Oct. 16-20 Tilbury Dock  
**Japan Industry Floating Fair**  
 (Forman House Public Relations, 39 Charing Cross Rd, London WC2H OAS)
- Oct. 23-28 Olympia  
**Audio Festival and Fair**  
 (International Audio Festival and Fair Ltd, 42 Manchester St, London W1)
- Oct. 24-27 Middlesex Hospital Medical School  
**Computers — Systems and Technology Conference**  
 (I.E.R.E., 8-9 Bedford Sq., London WC1B 3RG)
- BRIGHTON**  
 Oct. 17-19 Metropole Convention Centre  
**Inter/Nepcon**  
 (Kiver Communications, 149 Ewell Rd, Surbiton, Surrey)
- SOUTHAMPTON**  
 Oct. 3-5 The Skyway Hotel  
**Electronic Instruments Exhibition**  
 (Industrial Exhibitions Ltd, 1-19 New Oxford St, London WC1A 1PB)
- OVERSEAS**
- Oct. 1-5 Bal Harbour, Fla.  
**Engineering in Medicine and Biology Conference**  
 (A.C.E.M.B., Six Beacon St, Boston, Massachusetts 02108)
- Oct. 3-5 Tokyo  
**USA-Japan Computer Conference**  
 (Robert B. Steel, Informatics Inc., 21050 Vanowen St, Canoga Park, California 91303)
- Oct. 3-6 Wiesbaden  
**Trends in Physics**  
 (European Physical Society, D-6000 Frankfurt (Main) 1, Robert-Mayer Strasse 2-4)
- Oct. 8-12 Genoa  
**International Meeting of Communications and Transports**  
 (Istituto Internazionale delle Comunicazioni, via Pertinace, villa Piaggio, 16125 Genova)
- Oct. 10-14 Ljubljana  
**Elektronika '72**  
 (Gospodarsko Razstavisce, Ljubljana, Titova No. 50)
- Oct. 11 & 12 New York  
**Conference on Display Devices**  
 (I.E.E.E., 345 E. 47th St, New York, N.Y. 10017)
- Oct. 11-15 Vienna  
**Hi-Fi-Stereo '72**  
 (Osterreichisches Bauzentrum, Palais Liechtenstein, 1090 Wien 9)
- Oct. 22-27 Los Angeles  
**Conference and Equipment Exhibit**  
 (Society of Motion Picture and Television engineers, 9 E. 41st St, New York, N.Y. 10017)
- Oct. 24-26 Washington  
**Interdisciplinary Conference on Computer Communications**  
 (I.E.E.E. Computer Society, 345 E. 47th St, New York, N.Y. 10017)
- Oct. 26-29 Cologne  
**Tonmeister-tagung**  
 (Verband Deutscher Tonmeister und Toningenieur e.V., 2 Hamburg 70, Tonndorfer Hauptstrasse 90)

# British Isles V.H.F. Beacon System

## An aid to propagation studies

by Jack Hum, G5UM

The British Isles metre-wavelength beacon chain for amateur radio propagation studies had its genesis in the International Geophysical Year of 1957 and was the result of some proposals, for participation by radio amateurs in the I.G.Y., made by Dr R. L. Smith-Rose, director of radio research at the Department of Industrial and Scientific Research. A special I.G.Y. co-ordinating group was established by the Radio Society of Great Britain under the aegis of D. W. Furby, G3EOH, and G. M. C. Stone, G3FZL. This group, incidentally, could well be regarded as the precursor of the present day scientific studies committee of the R.S.G.B. Mr Stone remains its chairman.

A wide ranging programme of I.G.Y. studies to be made by radio amateurs in 1957 included establishing a v.h.f. beacon station that would transmit its callsign GB3IGY continuously and automatically on a frequency of 145.5MHz (then still called Mc/s). A special dispensation by the Post Office licensing authority permitted an input of up to 500W to be used (the normal top limit for British amateur transmitters was 150W). When K. E. S. Ellis, G5KW, offered to install this beacon station on his site in the Kent hills near Sevenoaks, the project showed every promise of success.

The 24-element directional aerial system at GB3IGY with its gain of 18dB beaming northwards laid down a signal over the greater part of England at ranges hitherto regarded by amateur radio v.h.f. operators as quite exceptional. The value of the Kent beacon, both as an indicator of propagation conditions in the 144-146MHz band and as a reliable reference source for amateur operators to use for equipment alignment, created a demand for a similar service to be provided in other parts of the U.K.

When GB3IGY closed down in March of 1959 an approach was made by the R.S.G.B. to the B.B.C. for permission to install a similar beacon on a Corporation site. This permission was readily granted and by the middle of 1960 a specification of what was to become GB3VHF had been laid down. By the end of the year the new beacon was radiating 50W on 144.5MHz from an aerial positioned 200ft above ground on one of the masts at the B.B.C. f.m. radio station at Wrotham in

Kent, giving an effective height of almost 1,000ft a.s.l.

The transmitter was intended to be used "... initially for v.h.f. propagation measurements in support of the United Kingdom programme in preparation for the tenth plenary meeting of the C.C.I.R. which is to be held in 1963. This work is being carried out for the U.K. Study Group 5, the body which is concerned with v.h.f./u.h.f. propagation. The second purpose of the transmitter is to provide a reliable service to v.h.f. amateurs as a

frequency marker, a signal for receiver adjustments and also as an indication of propagation conditions to operators outside the immediate vicinity".<sup>1</sup> Thus the scientific basis which is the *raison d'être* of an amateur radio beacon system, as established by GB3IGY, was reinforced when GB3VHF came into commission.

An unexpected side effect of the introduction of the Wrotham beacon was a noticeable increase of activity in the amateur 2m band. Today, when the 144-146MHz area enjoys heavy

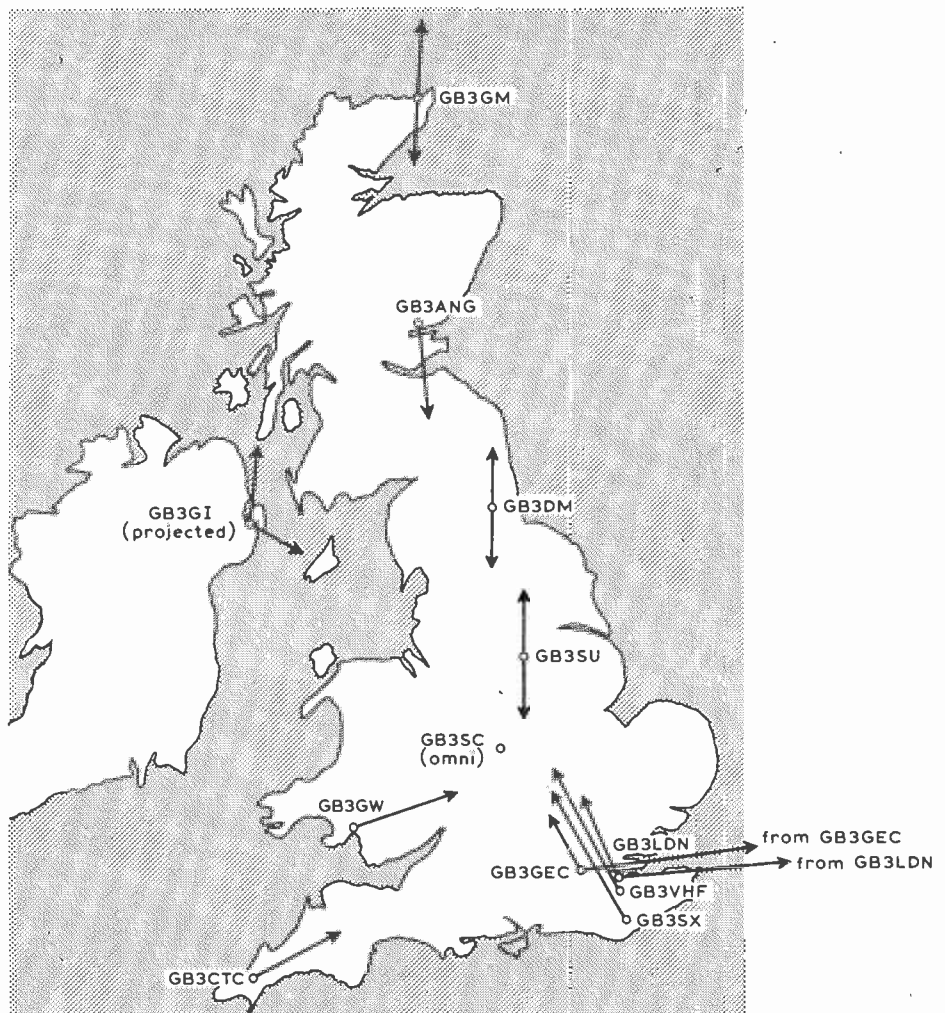


Fig. 1. All the beacons shown operate continuously (GB3LER in Lerwick operates 0000-0600 G.M.T.) and callsigns are sent automatically in Morse code

occupancy, largely as the result of the advent in the last four years of class B "v.h.f. only" operators, it is difficult to recall that in the early nineteen sixties this band was sparsely populated. A fixed frequency marker transmission like that from GB3VHF came to assume beacon characteristics in the sense that here was a welcome signal penetrating an apparently deserted spectrum consisting mainly of receiver noise. It has always been axiomatic among v.h.f. operators that activity begets activity; GB3VHF was indeed a "true begetter", and its successors in other parts of the country have proved the point.

Where these successors should be established was not difficult to decide. They would be needed on additional bands, particularly in the 420-440MHz sector ("seventy centimetres"), and situated in additional geographical regions remote from Wrotham to extend the national coverage on 2m. On 9th April 1962, an automatic transmitter, GB3CTC, "Cornwall Technical College", came into service at Redruth on 144.1MHz with a north easterly directed radiation pattern. And in the same year, four months earlier, GB3GEC commenced operating on 431.5MHz with an effective radiated power of 5kW directed towards Holland, and again intended to support the work of C.C.I.R. Study Group 5. This first British 70cm beacon, sited at the M-O Valve Works in West London, provided a wealth of information on mutual interference patterns between remote u.h.f. transmitters (such as those which later were to carry television services into the "ultra highs"), as well as much data on propagation over mixed land/sea paths.

Later, the aerials at GB3GEC were reorientated to give a service to U.K. amateurs north westwards from London, as well as to the Low Countries. Its frequency was changed to 433.5MHz in accordance with a plan to group amateur radio beacon stations near the upper limit of the v.h.f. and u.h.f. allocations. This policy dictated the frequency to be allotted to the second 70cm beacon station, and a channel at 433.5MHz, lying at the edge of the 432-433.5MHz communication section of the 70cm band, was reserved for GB3SC, which came "on air" a few years

### V.h.f./u.h.f. beacon stations

<b>6 metres</b>		
GB3LER	Lerwick	50.1MHz
<b>4 metres</b>		
GB3GM	Thurso	70.305MHz
GB3SU	Sheffield	70.695MHz
GB3SX	Crowborough	70.699MHz
<b>2 metres</b>		
GB3CTC	Redruth	144.13MHz
GB3GW	Swansea	144.25MHz
GB3VHF	Wrotham	144.50MHz
GB3ANG	Dundee	145.95MHz
GB3DM	Durham	145.975MHz
GB3GI	Tullywest	145.990MHz
GB3GM	Thurso	145.995MHz
<b>70 centimetres</b>		
GB3GEC	W. London	433.45MHz
GB3DM	Durham	433.475MHz
GB3SC	S. Coldfield	433.5MHz
<b>23 centimetres</b>		
GB3LDN	S.E. London	1297.95MHz

later. A transmitter was installed at the B.B.C. Sutton Coldfield site for use by Midland observers, and admirably complemented GB3GEC in the south.

Another aspect of scientific study of interest to metre-wave workers is the effect of auroral manifestations on propagation. To observe these over a period of time it helps to have a v.h.f. beacon station in a northerly latitude, where aurorae originate. In 1964 an opportunity to establish one occurred when R. G. Flavell, G3LTP, was posted from the Radio Research Station at Slough to The Observatory at Lerwick in the Shetlands. Here, two beacon transmitters, GB3LER, were set up on 29.005MHz and 145.995MHz specifically to reflect signals from the auroral curtain, thus also providing much information on the subject of communication on v.h.f. at extreme range. This work was a useful contribution to the I.Q.S.Y. (the International Quiet Sun Year), falling within a period of sunspot minima in contrast to the I.G.Y. which was arranged to coincide with sunspot maxima occurring seven years earlier.

More recently, arrangements have been made to reactivate GB3LER in the

50MHz ("six metre") band to study night-time transatlantic propagation in this frequency area. Operation will be between midnight and 0600G.M.T. and outside U.K. television hours. The 50MHz band is available to transmitting amateurs in certain regions of the world, notably North America, but not to those in Europe, where it is occupied by television.

It is the 144-146MHz ("two metre") band which carries, in Europe, the greater part of amateur v.h.f. activity, and it is here that the British Isles beacon chain has been developed over the last seven years to provide the coverage shown in Fig. 1. In most urban areas, where the bulk of the v.h.f. amateur population is concentrated, it is unusual for more than one beacon transmitter to be within range, except at elevated receiving locations. Indeed, in some built up areas no beacon at all is audible except under "lift" conditions of anomalous propagation. Distant marker signals as indicators of such conditions are of great value to amateur and professional observers alike.

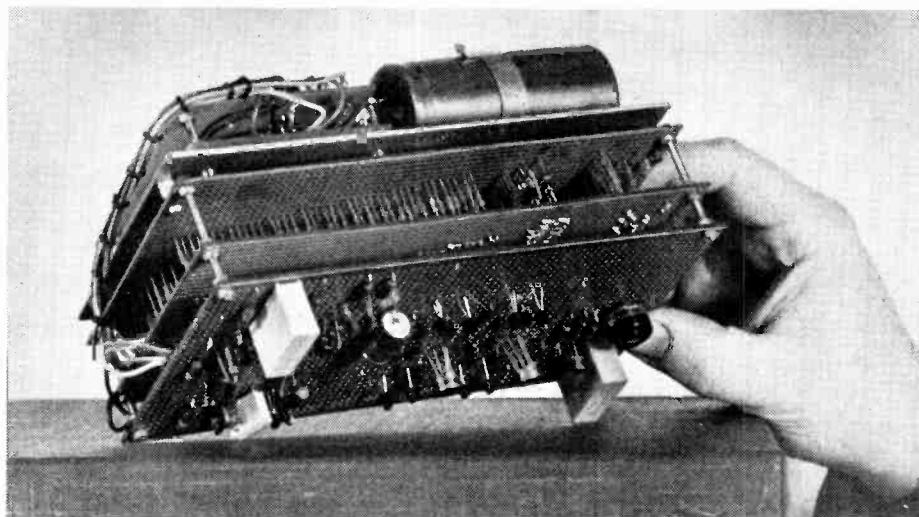
Lower system gain and greater path loss at 432MHz reduce the range of the beacons in this band, and it has long been clear to the v.h.f. committee of the R.S.G.B., who are responsible for the management of the U.K. beacon chain, that to have more of them in this part of the spectrum would not only provide a 70cm signal source to the increasing number of people operating on "seventy" but in the context of "activity begetting activity" would tend to encourage still greater occupancy of this important amateur allocation. The same reasoning applies to the 70MHz ("four metre") and 1296MHz ("twenty three centimetre") bands. For some years GB3SU on 70.695MHz, radiating a 24-hour service from a Sheffield University site, intended to provide no more than Thames-to-Tyne coverage, has produced results little short of phenomenal by being heard as far away as Malta and Gibraltar under sporadic-E conditions. Spurred by the potential of 70MHz to produce ranges in excess of 1,000 miles, and this with a 50W power restriction, amateur groups in places as widely separated as Gibraltar and Iceland have established automatic beacons of their own, beamed on the U.K. The emergence of ZB2VHF or TF3VHF from the receiver noise alerts British operators to the fact that "four" is ripe for long distance communication.

Another 4m beacon, GB3SX, installed on the Sussex Downs site of A. Taylor, G3DME, radiates a powerful signal northwards that could be a useful aurora indicator. Much nearer to the auroral belt is GB3GM at Thurso, with 70MHz as well as 145MHz aeriels beamed northwards for precisely this purpose.

At the other end of the spectrum the new 23cm beacon at Shooters Hill in S.E. London, the first of its kind, will present even greater challenges in respect of system gain and path loss than the 432MHz devices already referred to. As operating experience is gained with GB3LDN, evidence of extended ranges in



*The electronic keying unit employed at GB3VHF, Wrotham, Kent, and designed by G. E. Goodwin, has only one moving part — the keying relay.*



An interior view of the GB3VHF keyer. From top to bottom, the aluminium plate carrying smoothing capacitor, mains transformer and series stabilizing transistor, and to the left the p.c.b.s containing the power supplies, audio and relay circuits. Below these are the two Veroboards with the matrix and decoder diodes, and between them the decoder emitter followers. The bottom board carries timer, reset, pulse generator, and counter i.c.s. (Illustrations by courtesy of Radio Communication.)

this microwave region may be uncovered, and it is for this reason that one of the aeri-als at Shooters Hill is to be directed on to Holland. The other is intended to serve a large group of 1296MHz experimenters out to the north west.

Extensions of the beacon service into frequency regions even higher than 1296MHz are being considered, e.g., the 10GHz band, to meet the need for an external signal source for the growing number of people using the microwave bands. Developments of this kind, following those of the past 15 years since GB3IGY, suggest that the U.K. beacon chain is the most comprehensive in the world at the present time; and although no claim is made that it was the first of its kind (the Danes, for instance, put on the air a very successful 2m beacon, OZ7IGY, during the International Geophysical Year), national amateur radio societies in many countries now have or are planning systems of their own based on the British precedent. This is a good thing for the metre-wave movement as a whole, as many additional signal sources are made available to assist v.h.f./u.h.f. propagation studies.

Finally, what of the equipment, administration and maintenance problems of the British Isles beacon chain? Of the transmitters in use some are modified ex-commercial base stations and others locally constructed. All of them are provided with means to send their call signs automatically in the Morse code, either by simple carrier-break c.w. or by f.s.k., with the carrier on throughout the keying cycle. The original GB3VHF sender was a Plessey PT15C delivering 50W to a 5-element Yagi donated by J. Beam Engineering. Beacon transmitters more recently established employ solid state circuitry throughout and automatic keying by digital processes embodying i.c. techniques.<sup>2</sup> In general, the provisioning side of the beacon chain conforms

with the traditional amateur radio philosophy of maximum results for minimum expenditure, the latter perhaps being no more than the cost of the licence from the M.P.T. (cost effectiveness plus!).

Administratively, each beacon station licensed by the M.P.T. is allocated a special "GB prefix" callsign, of a self evident character, such as GB3DM (Durham) and GB3ANG (Angus). It might be added that each transmitter's automatic keyer is set at a speed sufficiently slow to be readable by listeners with little knowledge of the Morse code.

Operational responsibility for the beacon chain is vested in the v.h.f. committee of the Radio Society of Great Britain. And the serviceability of the transmitters, on-air for 24-hours a day, is assured by volunteer "beacon keepers", radio amateurs living nearby. The fact that beacon reliability has been outstandingly high does not preclude the possibility that beacon keepers may be called out at any time to restore service when a rare failure occurs — and when it does the snow is generally three feet deep!

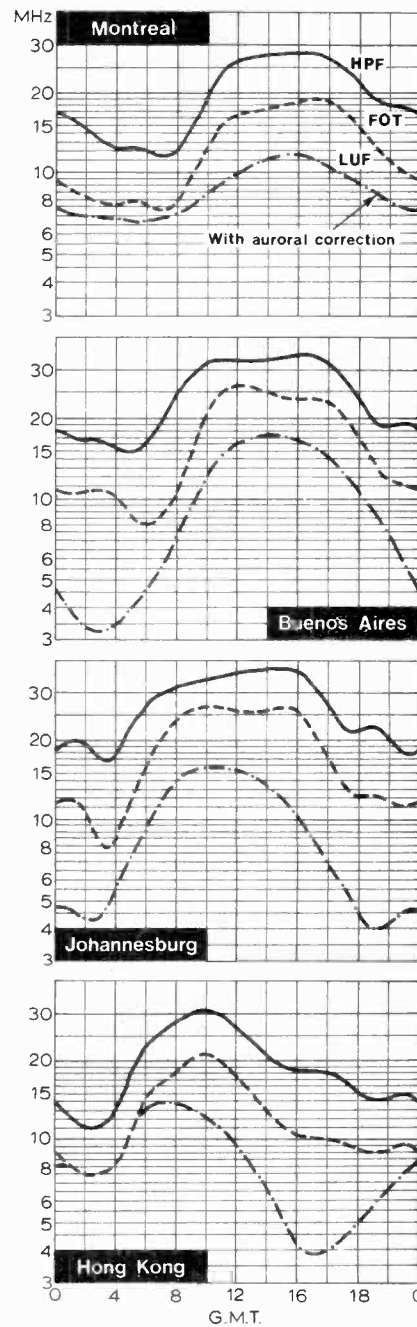
**References**

1. "Beacon Station GB3VHF" by F. G. Lambeth, *RSGB Bulletin*, August 1960.
2. "A keyer for GB3VHF" by G. E. Goodwin, *Radio Communication*, June 1970.

# H.F. Predictions— October

Seasonal changes are evident as an increase in daylight MUFs on all routes. Northern hemisphere routes will continue this trend over the next two months but MUFs on southern hemisphere routes will decrease slowly.

As predicted there was a peak of ionospheric disturbances during the first two weeks of August. Large sunspots and solar flares produced major daylight fadeouts on the 4th, 7th and 11th; the flare on the 7th being the largest for ten years. Magnetic activity was high, with a severe storm on the 4th, 5th and 6th.



# World of Amateur Radio

## The "wrong" frequencies?

Recently, an old-timer put forward the surprising view that amateurs should avoid using frequencies not suited to the distance involved; in other words they should be guided by professionally accepted frequency/distance principles in their use of the amateur bands. To the non-amateur this may seem commonsense, but to some of us it is near heresy. The whole history of radio would have been changed if amateurs had always accepted such views! One of the most interesting features of the hobby has always been the determination to show that longer distances can be achieved on a given frequency than is believed by the necessarily cautious professional communicator. It was this outlook that led to the opening of h.f. for world-wide communication and to the exploitation of tropospheric and other "abnormal" openings on v.h.f. and u.h.f. And it is this outlook that has encouraged in recent years a reappraisal of the long-distance potentialities of 1.8 and 3.5 MHz.

Consider, for example, recent work by Norman O'Brien, G3LP and G6ADO/T, of Cheltenham. On August 29, 1971 he began a regular schedule with the New Zealand station ZL4IE on 3.5 MHz. How many professionals would recommend this frequency for this purpose? Yet up to July 31 this year, two-way contact was made on 313 days; on only 2 days were no contacts made due to conditions; on 2 days due to power cuts; and on 21 days due to holidays at one end or the other. Norman O'Brien uses 100 to 150 watts input, and a G5RV multi-band dipole aerial carefully matched to either LG300 or SB400 transmitter and SB300 receiver.

The key to these outstanding results seems to be the relation of time of contact with local dawn: varying seasonally from 04.20 in June to 08.30 in December. Many contacts were aided by the interesting chordal hop mode. Norman O'Brien notes "propagation appears to be by one reflection over the southern part of the North Atlantic when the signal comes down into Brazil but reflects there on the upper side of the E layer to make a second F layer reflection over the Pacific, and right down into New Zealand. When the E layer is not heavily ionized over Brazil the signals go through the layer and it is possible to work

Brazilian stations at the same time as New Zealand."

On 1.8 MHz, organized tests have shown that it is possible to work all over the world. From 1.8 MHz enthusiast Stewart Perry, W1BB, comes details of a "fence" aerial (Beverage-type) being used by Australian listener George Allen who (as noted in the November 1971 issue) has done much useful work in correlating Europe/West Australia openings with dawn periods. He is currently using a 350-ft wire, strung along a wooden fence and only 5 ft high, with excellent results. Another type of directional receiving aerial that is once again proving useful for m.f. and 1.8 MHz long-distance reception is the simple loop or frame aerial, comprising about 7 turns on a framework with 1-m sides, tuned by 500 pF variable capacitor and coupled with single-turn to low-impedance (dipole) socket of the receiver. Such aeri-als can null out European interference while searching for DX signals.

## Anniversaries

Fifty years ago, under the auspices of the Wireless Society of London and its many affiliated societies, the first "All-British Wireless Exhibition and Convention" (forerunner to the long series of Radiolympia shows) was held at the Horticultural Hall, London — at a time when there was much debate and controversy over the terms of the early British broadcast receiving licences. At the time these still required full details of the receiver to be disclosed and stipulated "no reaction during broadcast hours".

The Bristol Group of the R.S.G.B. has announced that as part of the 600th anniversary celebrations of the Royal Charter of the City and County of Bristol, they will operate an exhibition station (GB2GB) during August 1973 on the s.s. *Great Britain*, which is being restored in dry dock.

## National Field Day

Although the number of groups and societies submitting entries to this year's National Field Day dropped just below 100, the event is still highly competitive and keenly contested. This year the N.F.D. Trophy (two-station entry) goes to the

combined entry of the Surrey Radio Contact Club and Croydon R.S.G.B. group, with Oxford the runners-up. The Bristol Trophy for the popular single-station entrants was won by the Racial Amateur Radio Club (G3RAC). Individual band winners were: Sutton and Cheam (1.8); Aquila (3.5); Salisbury (7); Oxford (14); Moray Firth (21); and S.R.C.C./Croydon (28 MHz). Home-built and kit-built equipment figured prominently in the leading stations. Commercial beam aeri-als (permitted this year) did not do particularly well. To gain the top award the Surrey club erected virtually an "aerial farm" including half-wave end-fed on 1.8 MHz; full-wave on 3.5 MHz; full-wave loop and inverted-V on 7 MHz; eight-element all-driven array directed to United States, quad and 265-ft long-wire on 14 MHz; and quads for 21 and 28 MHz.

## In brief

Efforts are to be made by a Washington group of amateurs to achieve 28 MHz moonbounce contacts on W7RM which will use a 40-element rotatable/tiltable aerial array. With this ambitious set-up it is believed that contacts will be possible with European stations equipped with the equivalent of 4 or 5 element arrays, power about 1 kW, and 200 Hz receiver bandwidth . . . The R.S.G.B. intruder watch detected over 120 intruders operating in exclusive amateur bands in the first half of this year. Most persistent are still the 7-MHz broadcasting stations but in addition a larger number of third and fourth harmonics of broadcasting stations using authorized frequencies have been logged in the 28-MHz band. As a result the Ministry of Post & Telecommunications made ten requests with a view to administrations preventing the offending emissions . . . The Scottish V.H.F. Convention, with the theme "U.H.F. and upwards" will be on Sunday, October 1 at Shawlands Hotel, Glasgow. Speakers will include Geoff Stone, G3FZL, and Harry Mackie, GM3FYB. Details from Arthur O'Lone, GM3EXX, West of Scotland Amateur Radio Society, 8 Kirklee Terrace, Glasgow, G12 0TH (041-334 2526) . . . Barking Radio and Electronics Society, following its recent successful special station operation at the Dagenham Town Show (GB2DTS) is to hold the 2nd G3XBF Constructors Award competition at Westbury Recreation Centre, Ripple Road, Barking on November 9 (details A. P. Foss, G8EAY, 73 Coolgardie Avenue, Chigwell, Tel: 01-500 6034) . . . The Canadian Amateur Radio Federation has received a federal charter and is now acting as a recognized liaison and advisory agency between Canadian amateur societies and the Canadian Dept of Communications . . . Italy has introduced a Technician licence and the position of amateurs in Italy is being improved . . . A Swiss beacon station on 145.985 MHz at Chasseral at a height of 1551 m is continuously operating with signals beamed north.

Pat Hawker, G3VA



# Simple Amplifier for Muscle Voltages

## A low-frequency amplifier for use in examining the electrical activity of voluntary muscles

by R. E. George\*

When a muscle contracts, electrical activity is produced throughout the muscle and this increases with the force exerted. Two small metal electrodes placed on the skin over the muscle will detect this activity. With small contractions the amplitude of the electro-myogram is only a few microvolts. At strong contractions it rises to several millivolts with a spectrum spanning 20Hz to 5kHz, and in the larger muscles rises to a maximum in the region 40 to 70Hz. An amplifier for muscle potentials, in common with biological amplifiers, must have a high absolute sensitivity, a high rejection to common-mode interference, and an input impedance substantially greater than the source impedance. A transformer at the amplifier input can satisfy these three requirements. The input terminals in this case are isolated from the apparatus, so there is no need for the amplifying devices to be arranged in a balanced configuration and provided the capacitance between the primary and all other parts of the transformer is small, mains interference and common-mode signals can be rejected without balancing out stray capacitances. The advantages of negative feedback are obtained simply by connection through the secondary winding. A balanced input using planar junction or field-effect transistors can be designed to fulfil a much more exacting specification than the transformer input. However, the transformer type of input was chosen by the author for its inherent simplicity.

### Noise

Early designs of transistor amplifier for electromyography were based on alloyed-junction types of transistor such as the OC70<sup>2,3</sup> whose optimum conditions as a low-noise, low-frequency amplifier in common emitter configuration were obtained at a working point of 80μA collector current, and 0.5V between emitter and collector. The ratio of the voltage to the current generator gave somewhat more than 1kΩ for the equivalent noise resistance. The correlation between the

generators was ignored since only an approximate figure was needed. It was fortunate that this value was lower than the usual values of biological source impedance obtained with surface electrodes, for the transformer could be specified with a voltage step-down ratio, permitting easier design when large values of primary inductance have to be considered. The turns ratio is determined by matching the source to the equivalent noise resistance, in the same way that a generator is matched for maximum power loading. The input impedance of the OC70 under the conditions specified was about 10kΩ. Thus, optimum noise conditions and slight loading of the source impedance, even without negative feedback, could be attained. The OC70 was succeeded by the higher frequency types such as the OC44 and GET880. These were run at a collector current of 60μA.

Eight years after the introduction of the alloyed junction transistor, the silicon planar with its superior characteristics, typified in the 2N929, became available. Its use as an amplifier of microvolt level biological signals was reported by Molyneux and Osselton<sup>4</sup>. The leakage current was less than 1% of that of the alloyed type and it had an inherently higher current gain, which was maintained down to collector currents of only a few microamps. These properties are desirable in a transistor for low-noise amplification<sup>5,6</sup>. At low currents, moderately high values of input impedance are obtained.

A simple model for transistor noise<sup>7</sup>, based on the shot effect of current due to electron flow, shows that with random partition of emitter current, the collector and base current generators have zero correlation. The collector current,  $I_c$ , a function of mutual conductance,  $g_m$ , is transformed to the input as a voltage noise generator, while the base current,  $I_b$ , is the current noise generator. The optimum source resistance is given as

$$R_s = 1/g_m \sqrt{I_c I_b}$$

The noise performance of planar transistors can be calculated in terms of collector current, current gain and fundamental constants. Excess semiconductor and thermal noise do not contribute materially to the total noise. Walker<sup>8</sup> refers to p-n-p types which, having a lower effective base resistance, offer a marginally

better noise performance than n-p-n types.

The author's choice of the 2N930, currently available at a very low price, was made partly for economic considerations and also because the results were adequate. As with the early designs, a step-down transformer can be used for noise matching with the 2N930 (Fig. 1). At a collector current of 125μA, the current gain is well in excess of 100, and  $R_s$  (optimum) is somewhat greater than 2kΩ. The transformer primary winding, having a resistance of 16kΩ, contributes materially to the amplifier noise which, measured for a source resistance of 25kΩ and passband 4Hz to 7kHz, was 3.9μV r.m.s.

### Circuit

The low-frequency cut-off of the amplifier will depend on the relation between the transformer primary reactance and the source impedance, which is made up of electrode-to-skin plus tissue impedance. For demonstration of the electromyogram, adequate results are obtainable with an inductance of only 30H, but for the measurement of activity and the recording of the lower frequencies in the e.m.g., at least ten times this value is required. With the transformer used (Parmeko type DMSC 2443), even if the source impedance is as high as 50kΩ, the amplifier will respond to the potential (electrocardiogram) produced by the heart at each beat, although the lowest frequency components will suffer some attenuation. The e.c.g. is most conveniently detected between the wrists. The amplifier low-frequency turnover can be extended to below 2Hz by increasing the feedback path capacitor to 1,000μF.

Transistor  $Tr_1$  collector voltage is determined by a potential divider network to the inverting input of the "709" high-gain d.c. amplifier and maintained by overall d.c. negative feedback. The bias current is applied through  $R_B$ . The base-to-emitter voltage drop is opposed by the forward voltage of the diode and does not appear at the amplifier output. The gain of the transistor is about 400, giving a loop gain of about 65. Capacitors  $C_1$  and  $C_2$  each produce a phase-lag giving rise to a pair of complex poles in the transfer function of the amplifier. Their position is set by adjustment to  $R_F$  (around 800kΩ),

\* Physics Department, Guys Hospital Medical School.

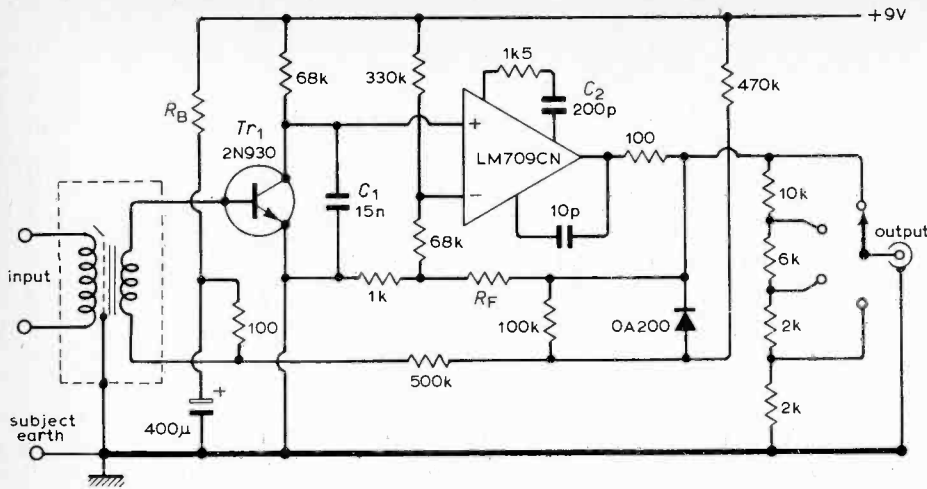


Fig. 1. The circuit of the muscle voltage amplifier.

Transformer type	Primary inductance	Primary resistance	Turns ratio	Secondary resistance	Primary-to-screen plus secondary capacitance
MSC 171	30H	1k $\Omega$	2.5:1	500 $\Omega$	43pF (approx.)
DMSC 2443	2.000H	16k $\Omega$	5:1	500 $\Omega$	280pF (approx.)

the local feedback resistor, to give a well defined 12dB/octave falling characteristic above the turnover frequency.

The amplifier output can handle a peak-to-peak excursion of 9V, and, with an overall voltage gain of 1,000, is unlikely to overload on the surface electromyogram during a strong muscular contraction.

The design is economical in battery loading. It consumes 1.75 and 1.65mA

from the 9V positive and negative supplies, respectively. The two transformers (see table), originally designed by Fortiphone Ltd., are obtainable from Parmeko Ltd., Barking. The second type was produced to a specification by Mr. T. K. Cowell of St. Thomas' Hospital, London.

### Electrodes

Metal electrodes made from 13mm dia-

meter discs of thin silver sheet, preferably with a concave contour on the contact side, will give good results. A suitable form of electrode connection is a lightweight, insulated coaxially screened flex, the pair being lightly twisted together to minimize microphonic effects arising from lead movement. The screens should be connected to the amplifier earth and a third earth electrode may be necessary if mains hum interference is a nuisance. The skin needs only the simplest preparation; a few gentle scrapes with a fine abrasive paper will remove the top non-conducting layer. A small cottonwool pad soaked in common salt solution, or a blob of a proprietary gel\* should be placed in the concavity. The electrodes may be held down with an adhesive tape.

\*Obtainable from Smith and Nephew Ltd.

### References

1. Knowles, J. B. and Stevens, B. L., "Transistorised Biological Amplifiers", *World of Medical Electronics*, 1966 Vol.4, pp.189-191.
2. George, R. E., "A Transistor Pre-Amplifier for Electromyography", *Proc. Electrophysiol. Technol. Assn.*, 1956 Vol.7, pp.6 & 7.
3. George, R. E., "A Transistor Electromyograph Amplifier", *Ann. Physiological Medicine*, 1956 No.3, pp.66 & 67.
4. Molyneux, L. and Osselton, J. W., "A Simple Low-Noise, Low-Frequency Transistor Amplifier", *Nature*, 1962 Vol.194, p.76.
5. Faulkner, E. A., "The Design of Low-Noise Audio-Frequency Amplifiers", *Radio & Electronic Engineering*, 1968 Vol.36, pp.17-30.
6. Baxandall, P. J., "Noise in Transistor Circuits", *Wireless World*, 1968 Vol.74, pp.388-392, 454-459.
7. Robinson, F. N. H., "Noise in Transistors", *Wireless World*, 1970 Vol.76, pp.339 & 340.
8. Walker, H. P., "Low-noise Audio Amplifiers", *Wireless World*, 1972 Vol.78, pp.233-237.

## Announcements

Two courses to be held at **Hendon College of Technology**, on Tuesdays commencing 10th October, are: Electronics for non-electrical engineers at 19.00 and Computer Programming (FORTRAN) at 18.30. Further details are available from the Department of Electrical Engineering, Hendon College of Technology, The Burroughs, Hendon, London NW4 4BT.

"Post Office Datel Services" is the title of a new Post Office film demonstrating the systems which carry data by telephone and telex between computer users and the computers that they use.

Dubilier Ltd has acquired two companies and created a new operating company, **Dubilier Electronics Ltd**. The two companies acquired are Greenpar Engineering Ltd, makers of standard coaxial connectors and Kenneth E. Beswick Ltd, who have been manufacturing fuses and fuse holders since 1923.

Unitech, Phoenix House, Station Hill, Reading, Berks, has acquired from A.P.T. Electronic Industries Ltd (a member of the Bonochord Group) **APT Electronics Ltd**, whose activities include the

manufacture of power supplies and the Lektrokit range of products.

An agreement has been made between **Data Technology Inc.**, of the U.S.A., and B. Hepworth & Co. Ltd, Bank Buildings, Kidderminster. DY10 1BG, whereby B. Hepworth become sole U.K. agents for the American company's products which include optical shaft encoders.

British Aircraft Corporation's Electronic and Space Systems Group, Brooklands Road, Weybridge, Surrey, are to take over all the activities previously carried out by the Avionics Division of STC, New Southgate, London, in respect of **h.f. notch aerial tuning units** for military applications.

Plessey Avionics & Communications, which has developed the PRC320 h.f. transceiver and the frequency synthesizers for the British Army **Clansman** net radio system, has received production orders from the Ministry of Defence for both complete PRC320 equipments and synthesizers, valued in excess of £4M.

Marine Products Division of Circle Marketing, Kelvin House, Totteridge Avenue, High Wycombe, Bucks, has been appointed sole distributor in the U.K. by **Sonar Radio Corporation**, of the U.S.A., for their range of electronic marine equipment, which includes radio-telephones, direction finders, depth indicators and aeriels.

Semikron G.m.b.H., of West Germany, manufacturers of power semiconductors, announce

the formation of a U.K. associate company, **Semikron (U.K.) Ltd**, Brewhouse Lane, Hertford Tel: Hertford 4677.

A contract for the project definition phase, for the guidance system in a proposed new British Naval "Sea Skimmer" **anti-ship missile**, has been placed with Marconi Space and Defence Systems Ltd.

Information Magnetics Corporation, of California, has reached an agreement in principle to merge its interests with those of Gresham Recording Heads Ltd. The new business will operate under the name of **Gresham-Infomag Ltd**, from the present Gresham factory at Weybridge, Surrey.

A new company, **Pambry Electronics Ltd**, One Chimney, Blackpond Lane, Farnham Royal, Bucks, SL2 3EA, has been formed by B. R. Bicknell, formerly of Amplivox. The company has been appointed agents for Nexus International Sales Corporation, of Connecticut, U.S.A., and Conway Electronic Enterprises Ltd. of Ontario, Canada.

Rastra Electronics Ltd, 275 King Street, Hammersmith, London W6, have been appointed U.K. representatives of **Halex Inc.**, manufacturers of hybrid and thin film resistor networks.

**Electronorgtechnika carbon film resistors**, stocked by Z & I Aero Services Ltd, 44a Westbourne Grove, London W2 5SF, are now priced at £30 per 1000 for  $\frac{1}{4}$ ,  $\frac{1}{2}$  and  $\frac{3}{4}$ W ratings. These are price reductions of 23%, 25% and 30% respectively.

# New Products

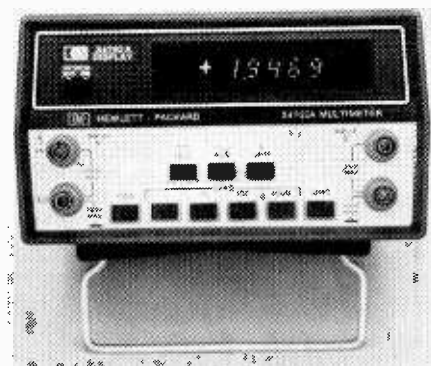
## Silvered mica capacitors

A new series of mica capacitors is now available from ITT Components Group Europe. Made of ruby mica, the Z series capacitors are silvered, resin-dipped and wax impregnated to provide good moisture protection. Available in six case sizes, the Z series provides capacitances in the range 1 to 3300pF at tolerances of  $\pm 0.5\text{pF}$ ,  $\pm 2\%$ ,  $\pm 5\%$ ,  $\pm 10\%$ , or  $\pm 20\%$  depending on value. The rated voltage is 50V or 500V d.c. and the operating temperature range is  $-25^\circ$  to  $+85^\circ\text{C}$ . Insulation resistance of Z series capacitors is at least  $5 \times 10^4 \Omega$  at  $20^\circ\text{C}$  and at least  $3 \times 10^3 \text{M}\Omega$  at  $85^\circ\text{C}$ . These capacitors are said to be particularly suitable for use in i.f. strips tuners and high-frequency circuits. ITT Components Group Europe, Capacitor Product Division, Brixham Road, Paignton, Devon.

**WW313 for further details**

## Digital measuring system

New from Hewlett-Packard is the model 3470 measurement system. It consists of a 4-digit solid-state display module, Model 3474OA, and a variety of plug-in units. The multimeter, model 34702A, shown combined with the display module, is a digital instrument with four full digits plus 100% overranging. It has four ranges of both a.c. and d.c. from 1V to 1000V full scale, and 6 ranges of resistance measurement from  $100\Omega$  to  $10\text{M}\Omega$ . D.c. accuracy is  $\pm (0.03\%$  of reading  $+0.01\%$  of range) on all ranges. The a.c. measurement frequency range is 45Hz to 100kHz, with accuracies of



$\pm (0.25\%$  of reading  $+0.05\%$  of range) from 45Hz to 20kHz. From 20 to 100kHz, accuracy is  $\pm (0.75\%$  of reading  $+0.05\%$  of range).

Also available is a d.c. voltmeter module, model 34701. Either the d.c. voltmeter or multimeter module is plugged into the bottom of the display module to make up a complete instrument. Also available are two centre section modules, model 3472OA battery module and the model 34721BCD module. Either of these are added between the top and bottom sections resulting in a three module instrument. Thus, the system can be converted for portable operation with up to 6 hours of continuous operation on rechargeable batteries. Having a b.c.d. option, a non-isolated output can be used to drive printers and other devices. An accessory test card can be plugged into the display section to make a comprehensive series of tests.

Hewlett-Packard Ltd, 224 Bath Road, Slough, Bucks.

**WW312 for further details.**

## Dual output power supplies

Guest International Ltd, have now added a range of miniature power supplies to the products from their Industrial Components Division. The "l.c.d." (least common denominator) series of encapsulated, regulated dual- and single-output power supplies was designed and manufactured by Semiconductor Circuits Inc. to provide all the basic requirements essential to most i.c. and operational amplifier applications.

Thirteen dual output models provide  $\pm 6\text{V}$ ,  $\pm 12\text{V}$ ,  $\pm 15\text{V}$  and  $\pm 18\text{V}$  at 35mA;  $\pm 6\text{V}$ ,  $\pm 12\text{V}$ ,  $\pm 15\text{V}$ ,  $\pm 18\text{V}$  and  $\pm 24\text{V}$  at 50mA;  $\pm 12\text{V}$  and  $\pm 15\text{V}$  at 100mA; and  $\pm 12\text{V}$  and  $\pm 15\text{V}$  at 200mA. Two single output models provide 5V at 500mA or 1A. All units operate from a.c. source of 204 to 252 volts, 50 to 440Hz. Line and load regulation is 0.2% max. Ripple and noise are less than 1V r.m.s. Temperature stability is 0.02% per degree Centigrade, typical. All units are short-circuit protected (current limiting) and will not derate over the entire operating temperature range  $-25^\circ$  to  $+71^\circ\text{C}$ . Measuring only  $2.5 \times 3.5 \times 0.875\text{in}$  these supplies offer a low profile which conserves card rack space. They may

be mounted directly to printed circuit boards or to mating sockets, available from Guest International. Unit prices start at £9.50 at ten off.

Industrial Components Division, Guest International Ltd, Nicholas House, Brigstock Road, Thornton Heath, Surrey, CR4 7JA.

**WW308 for further details.**

## High-frequency wattmeter

A solid-state wattmeter manufactured by Wave Energy Systems Inc., of New York, and measuring h.f. power up to 29kW over a frequency range of 5 to 100kHz is being marketed in the U.K. by Tinsley Ultrasonics. Intended primarily for the measurement of power delivered to ultrasonic trans-



ducers, this design permits generator output to be determined irrespective of current and voltage waveforms and their relative phase angle. The use of integrated circuits eliminates the complications inherent with thermo-junction instruments. Tinsley Ultrasonics Div., Werndee Hall, South Norwood, London SE25.

**WW307 for further details**

## Ultrasonic data tablet

Sintrom Electronics Ltd have just released information on the Science Accessories Co. Graf/Pen ultrasonic data tablet for which they are agents. Material drawn, written or marked on the tablet with the stylus yields a permanent copy and is simultaneously digitized by hypersonic ranging, a new encoding principle, at rates up to 200 co-ordinate pairs per second and a resolution of  $2000 \times 2000$  line pairs. The sensing rate is variable to match the user's speed and for efficient use of communications circuits and computer capacity. Output data, at t.t.l. levels, are available in binary or b.c.d. A wide variety of interfaces can be supplied for various peripherals and computers.

The Graf/Pen comprises a tablet, a stylus, and a control unit. For display, a storage c.r.t. or X-Y recorder may be added. The standard tablet has an active area  $14 \times 14$  inches, but any size and shape can be supplied: frosted (for rear-projection) and transparent plates are available. Strip sensors on two sides of the tablet receive signals from the stylus which combines a ball-point pen with a tiny spark gap; the low-energy spark generates a sonic pulse

with an extremely fast risetime used in the hypersonic ranging, and a small fraction of the energy provides the operator with a useful audible feedback. The stylus can be used with the tablet or other sensor-equipped devices.

The control unit interprets information from the sensors indicating the position of the stylus on the X and Y axes of the tablet, and discriminates against ambient noise. The data bus uses standard t.t.l. levels. A variety of operating modes is selectable by panel switches. Inherent characteristics of the sensors and filtering in the control unit limit the sensitivity of the sonic system to the wavefront generated by the spark, and prevent interference by even the highest ambient-noise level found in computer rooms. Sintrom Electronics Ltd, 2 Arkwright Road, Reading, Berks, RG2 0LS.

**WW323 for further details**

### Laboratory power unit kits

Startronic's new 160 series of laboratory power supply units are available either ready assembled, or in kit form with full assembly instructions. The four units in the 160 series are available in three versions, thus providing a choice of twelve variations of this equipment. The four models cover voltage ranges from 0 to 7.5V (0-2.5A), 0 to 15V (0-1.5A), 0 to 30V (0-600mA) and 0 to 60V (0-300mA) respectively.

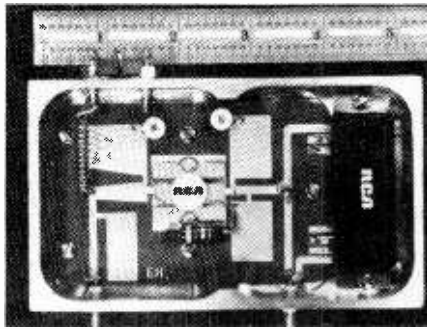


The three versions of each model offer a choice of output voltage adjustment by single-turn potentiometers (version A) by a 10-turn helical potentiometer giving a resolution of 0.1% (version B) or, (version C) the addition of a 10-turn counting dial giving a setting accuracy of better than 0.5% and a resetability of better than 0.1%. Ripple is less than 1mV peak-to-peak and regulation, zero to full load, less than 0.1%+5mV. Startronic Ltd, Beeching Road North, Bexhill-on-Sea, Sussex.

**WW324 for further details**

### "Constant Q" transistor

A transistor has been designed for the high-power u.h.f. mobile market that provides low input  $Q$  and increased input resistance for optimum broad-band design from 390 to 512MHz. The device gives 30W at 12.5V and is 100% tested for infinite output v.s.w.r. Designated the TA8172, the device



incorporates input matching techniques, developed by RCA, which raises the input resistance and maintains a substantially constant  $Q$  over the operating bandwidth. The use of integral silicon emitter ballast resistors ensures rugged in-service performance. RCA Ltd, Sunbury-on-Thames, Middx.

**WW314 for further details**

### F.E.T. multimeter

Pambry Electronics have announced details of the first product available in the U.K. from Conway of Canada, a 6in mirror scale f.e.t. multimeter, the Masteranger model 639. The advantages to be gained from this type of circuit are reflected in the instrument specification as follows:

100M $\Omega$  input impedance on all a.c. volts and d.c. volt and millivolt ranges (10M $\Omega$  on a.c. millivolts)

1.5mV to 1500V in 26 ranges

150nA to 1.5A self contained in 16 ranges, external shunts to 150A

R.f. voltage to 1000MHz with probe.

Ohms ranges from 0-10K $\Omega$  to 0-10,000M $\Omega$

13dB ranges from -80 to +66dBm.

Accuracy  $\pm 1.5\%$ .

'Floating' input facility.

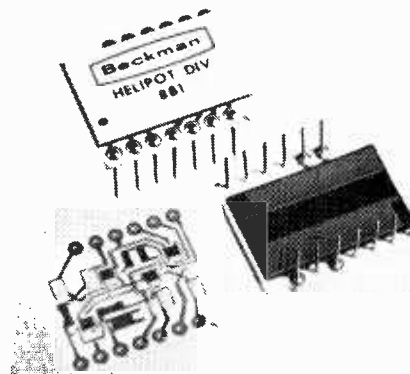
Overload protection to 1200V on all voltage ranges.

Price including leather case £75. Pambry Electronics Ltd, One Chimney, Blackpond Lane, Farnham Royal, Bucks. SL2 3EA.

**WW318 for further details**

### Active filter

Model 881 active filter, the hybrid version of an active filter design commonly known as a 'dual-integrator active filter', 'state-variable active filter', and/or a 'universal active filter' has been introduced by Beck-



man Instruments Ltd. Three operational amplifiers and internal feedback elements are used in the basic hybrid filter design. A fourth uncommitted operational amplifier is included to facilitate 'odd-pole' filter requirements and add greater system design flexibility to the basic component.

Configuration of the model 881 permits buffered bandpass, low-pass, and high-pass output to be simultaneously available. The resonant frequency is determined by the value of two external resistors and is adjustable over a frequency range from less than 1Hz to 10kHz.

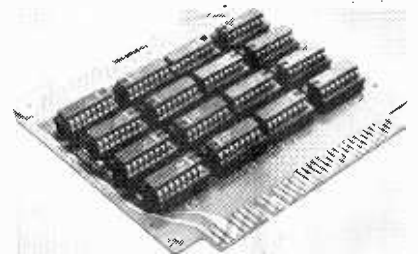
Model 881, packaged in a ceramic enclosure for operation over a temperature range of 0 to 70°C, operates from plus and minus 15-volt power supplies. Beckman Instruments Ltd, Glenrothes, Fife, Scotland.

**WW322 for further details**

### Random access memory cards

Cambion Electronic Products Ltd is now making available a family of memory cards with random access memories using normally off p-channel m.o.s. devices.

Designated part number 784-2004-01, the card shown is d.c. stable and thus requires no clock to operate. Only two power supplies (+5V and -9V) are required for operation. The cards are 4.5in



square and interconnect through a 70 finger edge connector and directly interface with Cambion's standard d.t.l. and t.t.l. family of logic cards. The specific memory card described has a capacity of 4096 words  $\times$  1 bit and contains 16 integrated circuits. Cambion Electronic Products Ltd, Customer Service Department C.12, Cambion Works, Castleton, Sheffield.

**WW321 for further details**

### Dolby module tester

A noise reduction module tester and test expander made by Dolby Laboratories forms the NRM test set No. 35. They provide rapid testing and performance verification for Dolby 360 series noise reduction equipment. As adjustments to the basic noise reduction module are made and fixed at the factory, the test set is of the go/no go type, and faults are remedied by changing modules. An internal oscillator in the A-type No.22 module provides test signals, the resulting levels under the various test con-

ditions being presented on the meter of the tester. Verification is provided for power supply regulator, internal oscillator, main signal path amplifiers, gain and law of the four compressors, low-level transfer characteristic on record, play and NR-out, Dolby tone operation and switching logic. Meter calibration and power supply of the 360 chassis are also checked. The test set relies on power from the chassis of the 360 series under test. Dolby Laboratories Inc., 346 Clapham Road, London SW9.

**WW301 for further details**

### Low-cost 50-MHz pulse generator

First of a new range of Chronetics pulse generators from SE Laboratories, the PG 11A is designed to provide a low-cost, compact and rugged pulse source for production testing and general development laboratory use. This all solid-state instrument provides a (single) delayed pulse, and either pulse pairs or pulse bursts, or both when suitably gated, and single shot via a front panel push button.

Controls include continuously variable repetition rate, delay, width and amplitude. Gating can be synchronous or asynchronous as selected by front panel switch. One PG 11A may be used to trigger several additional generators simultaneously, thus providing multiple pulse outputs synchronized at the master repetition rate while all other output parameters remain dependently variable.

Output is  $\pm 15V$  at 10Hz to 50MHz, rise time being 4 ns. This  $3\frac{1}{2} \times 8\frac{1}{2} \times 9\frac{1}{2}$ in instrument weighs only 7lb and can be rack mounted if required. SE Laboratories (Engineering) Limited, North Feltham Trading Estate, Feltham, Middlesex.

**WW306 for further details**

### Frequency trigger generator

Wavetek's Model 133 frequency trigger generator features ultra low frequency operation, complete trigger/gate operation, and sinusoidal, square, and triangle waveforms. The frequency range, calibrated from 200kHz down to 0.0001Hz, is usable in an uncalibrated mode to 0.000002Hz, or 138 hours per cycle. The instrument can be operated in the continuous, triggered, or gated mode, with trigger/gate control by an external voltage, or by manual trigger. Phase of the starting and stopping points of the triggered waveform may be varied  $\pm 90^\circ$ . The d.c. level between each triggered cycle will remain constant with any change in frequency. Utilizing voltage controlled generator circuitry, the output frequency can be a.c.-modulated, or d.c.-programmed to provide an instantaneous resultant frequency that is the sum of the dial setting and an externally applied voltage. Output signal attenuation is selectable to  $-60dB$  with overlapping 20dB vernier. U.K. Agent: Fluke International Corporation, Garnett Close, Watford, WD2 4TT.

**WW302 for further details**

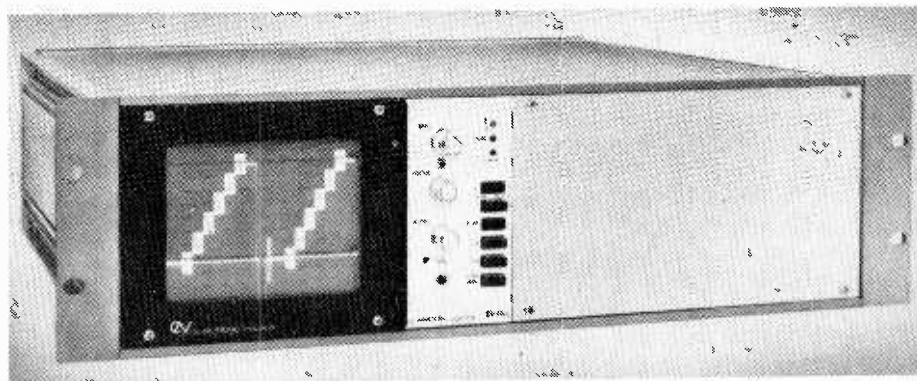
### TV waveform monitor

Electronic Visuals Ltd announce the first of a range of low-cost TV waveform monitors. The EV 4010, as it is called, is specifically designed for use with closed-circuit and educational TV systems, v.t.r.s or in broadcast control consoles where it is necessary to monitor waveforms. All major control functions are push button operated and facilities include selection of 1 line; 2 lines; 1 field; or 2 fields. Response switch-

ing includes flat, low-pass, differential gain and linearity. In addition a non-distorting black level clamp is employed.

A  $10 \times 8$  cm c.r.t. provides high brightness displays with a deflection factor of 1V for full scale. Internal or external sync may be used and both sync and video have loop-through inputs. Electronic Visuals Limited, P.O. Box 16, Staines.

**WW311 for further details**



### Noise generator

A new Rogers noise generator is now available from Pact International Electronics Ltd. Known as the model A, this portable, battery-operated, noise generator is designed for carrying out listening tests on loudspeakers fed from an appropriate power amplifier. The output can be fed directly into the majority of main amplifiers, so avoiding pre-amplifier and tone control circuitry.

No attempt has been made to peak clip the 'white' noise and the peak-to-r.m.s. range of the noise generator amplifier

is better than 4:1 with the level control at maximum. Pink or white noise can be selected by depressing the appropriate button and a further two buttons allow the output to be continuous or burst. The latter button is non-latching so that the output can be pulsed on and off. The output is continuously variable by means of the level control which also incorporates the battery on/off switch. Marketing Division, Pact International Electronics Ltd, Church Lane, Wallington, Surrey.

**WW319 for further details**



### Flat conductor ribbon cables

Gore Mylar "self-extinguishing" Multi-strip flat ribbon cables are manufactured with Mylar insulation and a flame retardant adhesive. The flexibility and flex life are said to be particularly good and a wide range of conductor materials can be incorporated, though the standard bare and tinned copper are the most readily available. The conductor sizes most commonly used are 0.063

$\times 0.005$  in and  $0.062 \times 0.003$  in on 0.1 in centres and  $0.025 \times 0.004$  in on 0.050 in centres, though other sizes of conductor and spacings are also available. These cables can be stripped thermally, chemically or by abrasive wheels. W. L. Gore & Associates (UK) Ltd., Pitreavie Industrial Estate, Queensferry Road, Dunfermline, Fife, Scotland.

**WW309 for further details**



## AND/OR, Schmitt and pulse generator t.t.l.

Seven new t.t.l. circuits in the ITT Semiconductor 74 series of i.cs have been introduced.

The MIC74130/131/138/139 is a range of quadruple, 2-input power drivers giving voltage outputs up to 30V and power drives up to 1A. AND and OR inputs allow "logical" switching of external equipment such as lamps, relays, and high level logic systems.

The MIC74135/137 are second generation quad. and hex. Schmitt trigger circuits with 15V input rating and can be driven from low current inputs such as m.o.s., high-level logic, photocells and transducers.

The MIC74124 is a clock generator/delayed pulse generator and is the first single package self-starting clock generator available in the 74 t.t.l. range. Accuracy of the free running clock pulse generator or externally synchronised gated oscillator is 20 parts per million per °C with pulse width speed and delay range from 35ns to 40s. All second generation devices are pin compatible for direct replacement in upgrading system ratings. ITT Semiconductors, Footscray, Sidcup, Kent.

**WW 325 for further details**

## High-voltage transistor

A new high-voltage transistor from Motorola and available from Celdis, is the MJ105. It can be used as a 1400-V horizontal deflection transistor in large screen black and white, or small screen colour TV receivers. The data sheet specifying this device not only provides the usual basic transistor parameters and graphical characteristics, but also gives optimization circuits relevant to the above application.

### Characteristics

$V_{CER}$ (peak)	1400V
$BV_{CEO}$	750V
$I_C$ (continuous)	2.5A
$V_C$ (sat)	5.0V (max) at $I_C$ 2.5A
turn off	0.5 sec (typical)

The 100 up price is £1.76.

Celdis Limited, 37/39 Loverock Road, Reading, Berks, RG3 1ED.

**WW303 for further details**

## "In-line" r.f. attenuators

For the first time, Antiference Ltd, have added a range of "in-line" attenuators to their TV aerial accessories. These are designed to reduce high-level v.h.f. or u.h.f. signals in domestic TV aerial installations, TV distribution systems, show-rooms and service department.

There is a choice of six attenuation values from 3dB to 36dB

TVA/3	3dB	TVA/18	18dB
TVA/6	6dB	TVA/24	24dB
TVA/12	12dB	TVA/36	36dB

with the values clearly printed on a colour-coded band for easy identification. The attenuators are made to BS 3041 specifi-

cation, with polished aluminium alloy bodies and strong 'c' springs. Recommended retail price: 48p. each.

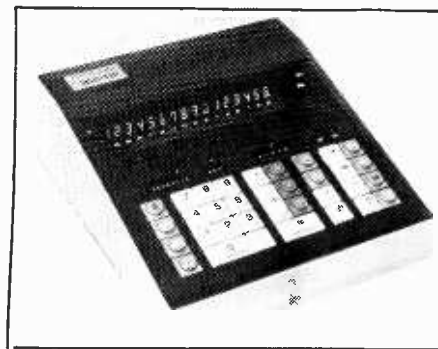
Antiference Ltd, Aylesbury, Bucks.

**WW310 for further details.**

## Electronic desk calculator

Broughton & Co. (Bristol) Limited, have introduced the new BUSICOM 162 DE electronic desk calculator which has a full entry and display capacity of 16 digits. Any number of decimals up to full capacity may be entered and retained as a constant factor, and the results may have a fixed or floating decimal point output entirely. When the 16 whole number digit capacity is exceeded an underflow system operates.

Two different totals can be accumulated at any given time either positively or negatively. The calculator also incorporates a special key for automatically entering the first factor in multiplication into memory two, which means it can be used for statist-



ical calculations (standard deviation), averaging calculations etc.

Further features include a one-touch key operation for square root and percentage calculations, also an exchange key, automatic squaring and raising to powers, and rounding.

The BUSICOM 162 DE priced at £230, also incorporates lamp indicators for memory one, memory two, negative and underflow. Broughton & Co. (Bristol) Limited, 6 Priory Road, Bristol BS8 1TZ.

**WW305 for further details**

## A 12-channel radiotelephone

A self-contained, solid-state, 12-channel v.h.f./f.m. radiotelephone for marine use has been introduced by EMI Marine, of Sevenoaks, Kent. Called the "Mariner" it is completely solid-state. The transistor power amplifier has a safeguard designed so that even if inadvertently loaded with an open- or short-circuited aerial connection no damage will result. The low current drain (less than 0.15 amp) allows continuous receiver operation in the standby mode, with only a single 12V to 14V wet-cell battery as the power source. The trans-

mitter provides 1W or 25W r.f. output. In the transmit mode, on 25W output, d.c. current consumption is 3.5 amps.

The equipment conforms to the latest Post Office specification, incorporating 25kHz channel spacing. Comprehensive fitting and operating instructions are supplied enabling the boat owner to fit the equipment.

A range of accessories is available. EMI Electronic and Industrial Operations, Blyth Road, Hayes, Middlesex.

**WW304 for further details**





## Monolithic waveform generator

Rastra Electronics have introduced the Exar XR-205 monolithic waveform generator. Encapsulated in a 16-pin d.i.l. package the device is designed as a self-contained signal generator that provides sine, square, triangle, ramp and sawtooth output waveforms which can be both amplitude and frequency modulated.

In addition Rastra offer a kit consisting of a p.c. board, assembly instructions and recommended component list, together with a circuit, enabling the device to be built into a complete signal source test unit. Rastra Electronics Ltd., 275 King Street, Hammersmith, London W6.

**WW315 for further details**

## Miniature high-resolution u.h.f. trimmer

Jackson Brothers (London) announce that their 8mm Tetfer trimmer is now available with improved performance in the higher frequency range (in excess of 500MHz). It is claimed that the trimmer, which allows eight turns from maximum capacitance (10pF) to minimum capacitance (2pF), gives a much better resolution than previously obtained. The climatic classification is H5 ( $-55^{\circ}$  to  $+125^{\circ}$ ), tropicalized and with a temperature coefficient of typically 250 p.p.m./ $^{\circ}$ C. The trimmer is available for mounting vertically (5750/VPC) or horizontally (5750/HPC) on printed circuit boards. Jackson Brothers (London) Ltd, Kingsway, Waddon, Croydon CR9 4DG.

**WW 320 for further details**

## Low-cost distortion meter

Latest in Lyons Instruments' "Interlab" series of low-cost electronic instruments is the Type D10 distortion meter—a compact, light-weight instrument for the measurement of distortion over the range 0.1% to 10%. Fundamental frequency range is from 10Hz to 100kHz and intrinsic distortion is given as less than 0.05%. Operation of the D10 requires only a gain setting of the total input followed by a null balance of the fundamental component, the mean level of the residual harmonic content then being directly indicated on the panel meter as a percentage. The meter is priced in the U.K. at £68 net. A companion low-distortion oscillator, type SQ10, is also available in the "Interlab" series at only £57. Lyons Instruments Ltd, Hoddesdon, Herts.

**WW316 for further details**

## Dynamic a.t.e.

Wayne Kerr have introduced the first of a new range of dynamic automatic test equipment. The A60, which will be shown at Internecon (Brighton, Oct 17-19), has a built-in programmable oscillator and a.c. detector system covering the audio band.

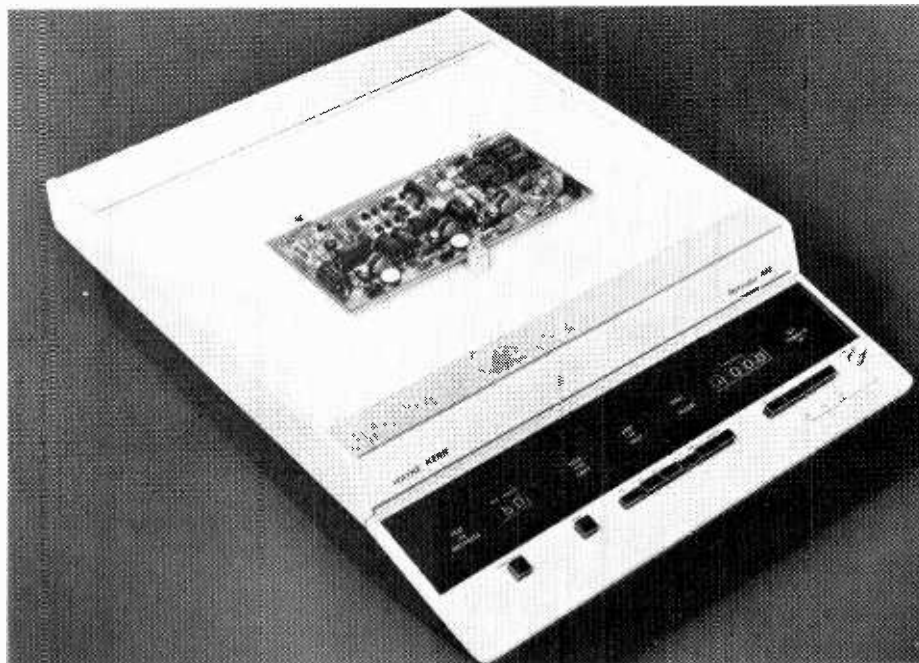
Sixty tests, each of which can be an a.c. or d.c. measurement, are made with individual pass/fail limits applied automatically; the complete cycle taking only

5-10 seconds. The testing can be in any four modes, ranging from manually controlled "step-by-step", to fully automatic repetition for locating intermittent faults. Programming is achieved quickly and easily by wiring diodes in a matrix board and fitting scaling resistors whose selection requires only a knowledge of Ohm's Law. Changes to the programme should present no problems as every track on the matrix board is clearly labelled. Applications in-

clude a.c. and d.c. voltage checks, gain measurements, frequency response checks and speed-of-response checks. Outputs are provided for controlling external sources and printers etc.

The test sequence and the percentage deviation from the programmed values of the equipment under test are displayed by l.e.d.s. Wayne Kerr Co. Ltd., Tolworth Close, Tolworth, Surrey, KT6 7ER.

**WW 326 for further details**



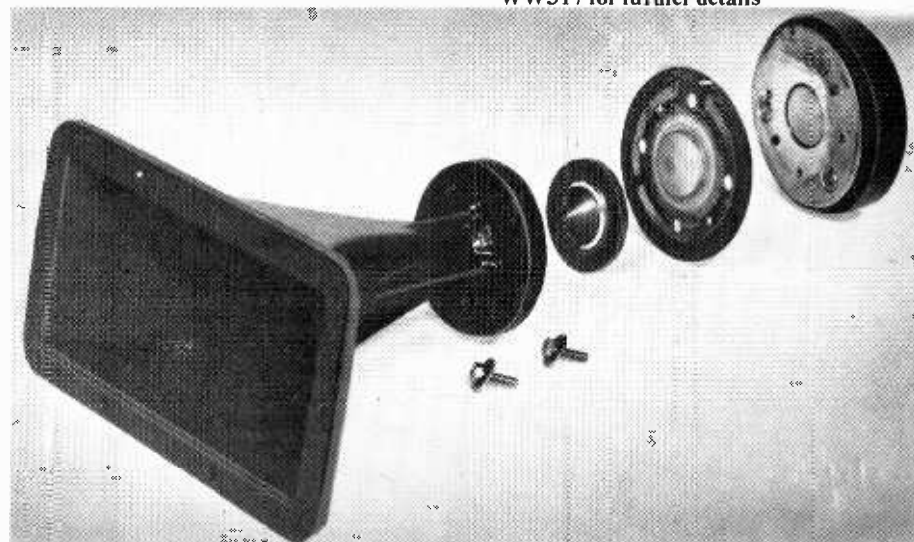
## High-power tweeter

What is believed by the designer to be the world's first printed-circuit-based loud-speaker has been developed by Fane Acoustics Ltd. The Fane 910 is a robust, high-power tweeter horn unit for a 25W input. The manufacturers claim a major benefit of the printed circuitry employed is the resulting uniformity of the speakers. Furthermore, simplified assembly procedures have made possible a list price of £12.40, which is comparable with conventionally wire-wound units.

A dowelled assembly in the Fane 910 permits the components to be assembled only in the correct way. It can therefore be

dismantled and re-assembled by the user, should a maintenance requirement ever result from damage, and the problems usually associated with sending goods away for repair are thus avoided. All Fane's dealers at home and abroad, will supply spares. The exponential, die-cast aluminium horn section has a mouth opening measuring  $6\frac{1}{2}$ in  $\times$   $3\frac{1}{2}$ in (16.8cm  $\times$  9.1cm) and the speaker employs a high-efficiency one-inch pole magnet with a 16,000 gauss rating. Overall depth of the speaker—which is available initially in a black crackle finish—is  $6\frac{1}{2}$ in (16.6cm). Fane Acoustics Ltd, Hick Lane, Batley, Yorks.

**WW317 for further details**



# Literature Received

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

## ACTIVE DEVICES

The June 1972 integrated circuit catalogue describes products manufactured by Harris Semiconductor and distributed in the U.K. by G.D.S. (Marketing) Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Bucks ..... WW401

A summary of data on thermistors and varistors is contained in the 1972/73 catalogue from ITT Components Group Europe, Standard Telephones and Cables Ltd, Edinburgh Way, Harlow, Essex. .... WW402

Specifications for programmable unijunction transistors, thyristors, s.c.r.s, power transistors, diodes and bridges are given in a booklet "C-Line Industrial Semiconductors". Unirode Corporation, European Sales Office, Schellingstrasse 92, 8 Munich 13, W. Germany. .... WW403

Quarndon Electronics (Semiconductors) Ltd, Slack Lane, Derby, have issued the revised 74 series t.t.l. catalogue (1972 edition) containing information on the Texas Instrument series of digital i.c.s ..... WW404

Brief specifications and prices of general-purpose and power transistors are included in a leaflet, with brief applications and characteristics for power types. Distic Ltd, 28 Burnt Mill, Elizabeth Way, Harlow, Essex ..... WW405

"Diodes and Transistors" (April 1972) is a leaflet specifying the range of devices available from Hewlett-Packard Ltd, 224 Bath Road, Slough SL1 4DS ..... WW406

We have received three publications from Joseph Lucas (Electrical) Ltd, Electronics Products Group, Mere Green Road, Sutton Coldfield, Warwickshire:

- An introduction to thick film hybrid circuits and to the custom design service of Centralab Semiconductor Division (U.S.A.) ..... WW407
- Silicon zener regulators (product information) — rated at 2.4 to 200V, tolerance 5% ..... WW408
- Temperature compensated reference diodes (product information) — stability at 10 parts per million per thousand hours ..... WW409

The RS component catalogue (August/November 1972) contains updated information on all the electronic components distributed by RS

Components Ltd, (formerly Radiospares), P.O. Box 427, 13-17 Epworth Street, London EC2P 2HA ..... WW410

A wall chart, showing a range of digital and linear integrated circuits, gives brief specifications and pin connections. Rastra Electronics Ltd, 275-281 King Street, Hammersmith, London W6 9NF WW411

An ultrasonic transducer, described in a data sheet, has an operation frequency of 39kHz and incorporates a TAA 960 dual in line integrated circuit. D.T.V. Group Ltd, 126 Hamilton Road, West Norwood, London SE27 9SG ..... WW412

## PASSIVE DEVICES

Polystyrene capacitors, type FSC/VM, with preformed, tinned, phosphor bronze leads (for p.c. applications) are described in a data sheet. They cover the range 100 to 10,000pF and 63 to 630V d.c. L.C.R. Components, Woodfield Works, Tredegar, Mon. NP2 4BH. .... WW413

Two data sheets describing products manufactured by Gould Ionics Inc. and distributed in the U.K. by Lyons Instruments Ltd. Hoddesdon, Herts. are:

- Bulletin No. 71922 describing the ESD "Power Pack" series of cells for standby operation with c.m.o.s./bipolar systems ..... WW415
- Bulletin No. 70107 describing the ESD series of high-charge retention capacitors ..... WW416

Transformers, regulators and chokes are among the wire-wound devices described in a series of product sheets received from Devon Transformers Ltd, Ponsandane Industrial Estate, Penzance, Cornwall ..... WW417

## APPLICATIONS

"Measuring noise spectra with variable electronic filters" is an Ithaco publication (IAN-102) sent to us by Techmaton Ltd, 58 Edgware Way, Edgware, Middlesex HA8 8JP. .... WW418

## EQUIPMENT

A data sheet describing series 200 "video terminal controllers", keyboards and monitors for c.r.t. terminal connection, includes applications and specifications. Ann Arbor Terminals Inc, 6107 Jackson Road, Ann Arbor, Michigan 48103, U.S.A. .... WW419

A wall chart (16in × 24in) gives specification information on the Westinghouse "Hyreg" range of power control modules available from GDS (Sales) Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Bucks. .... WW420

The Phase II system, for the radio control of cranes, is described in a leaflet from Telemotive U.K. Ltd, Drake House, 63 Old Woking Road, West Byfleet, Weybridge, Surrey ..... WW421

A publication describing a range of regulator equipment for variable speed motors also contains an article covering the application of thyristor regulators. U.K. representative Heberlein & Co. AG, Albany House, Swinton Hall Road, Swinton, Manchester M27 1DY ..... WW422

We have received a data sheet on Servocorder strip chart recorders model SR651 (single channel) and SR652 (dual channel). EE Environmental Equipments Ltd, Denton Road, Wokingham, Berks ..... WW423

Fibre optic products — flexible periscopes, bifurcated flexible periscopes, fibrescopes and

flexible extensions for endoscopes — are described in information sheet FO/1A. P. W. Allen & Co, 253 Liverpool Road, London N1 1NA ..... WW424

The IVC 700/705/706 series of one-inch videotape recorders for colour or monochrome recording are described in a series of product sheets. International Video Corporation, 675 Almanor Avenue, Sunnyvale, California 94086 ..... WW425

A catalogue and price list of heatsinks includes lightweight coolers, profile heatsinks and cooling packages, obtainable with or without fans. Rastra Electronics Ltd, 275 King Street, Hammersmith, London W.6 ..... WW426

Celdis Ltd, 37/39 Loverock Road, Reading, Berks RG3 1ED, have sent us a stock and price list of Hewlett-Packard opto-electric devices including i.e.ds and photon coupled isolators ..... WW427

## GENERAL INFORMATION

We have received the prospectus of the London Computer Operators Training Centre, Oxford House, 9-15 Oxford Street, London W1R 1RF, which contains details of computer operating, key-punch operating and typing courses.

The "R & D Review" published by the Research & Development Centre, General Electric Company, P.O. Box 8, Schenectady, New York 12301, provides a broad view of recent development projects (including lasers, i.e.ds, liquid crystals, metal plating plastic and the "world's strongest permanent magnet") ..... WW428

Prospectuses for the year 1972-73 from Norwood Technical College, Knights Hill, London SE27 0TX, include course and admission information in the departments of Business and Liberal Studies, Telecommunication and Electronics and Science (main building and Tower Bridge branch).

We have received the BASF product brochure for 1972 which contains details of magnetic tape, cassettes and video tape. MPR Ltd, 211 Camden High Street, London NW1 ..... WW429

A country-by-country summary of technical services provided for aviation and communications is contained in the 1972 "Review of Activities". International Aeradio Ltd, Aeradio House, Hayes Road, Southall, Middlesex ..... WW430

Two publications have been sent to us by the British Standards Institution, 2 Park Street, London W1A 2BS.

- BS4727 — "Glossary of electromechanical, power, telecommunication, electronics, lighting and colour terms. Part 1. Terms common to power, telecommunications and electronics. Group 05. Semiconductor Technology" ..... Price \*£1.25
  - BS4727 — "Part 2. Terms particular to power engineering. Group 06. Switchgear and controlgear terminology (including fuse terminology)" ..... Price \*£1.90
- \* plus 20p for orders under £2.00.

The following publications relating to silicone materials are published by Dow Corning International Ltd, Dept. DM-100, Chaussee de la Hulpe 177, 1170 Brussels, Belgium.

- A selection guide to silicone electrical-electronic materials — products, properties and applications ..... WW431
- "Information about electrical/electronic materials". Bulletin 67-005 ..... WW432
- List of distributors ..... WW433

Two publications received from Twickenham College of Technology, Egerton Road, Twickenham, Middlesex TW2 7SJ, are the 1972-73 handbook (containing details of the staff, governing body, college organization and facilities) and the 1972-73 prospectus of the Department of Engineering.

Band number, aerial group and polarization information of u.h.f. television transmitting stations (625-line colour services) are included in information sheet 4003 (15) from the BBC Information Department, BBC Broadcasting House, London W1A 4WW.

# October Meetings

## LONDON

4th. IERE — "Automatic gain control systems" by Prof. George J. Thaler at 18.00 at the Engineering Lecture Theatre, University College London, Torrington Pl., WC1.

5th. IEE — "Radar engineering — progress and prospect" president's inaugural address by Dr. E. Eastwood at 17.30 at Savoy Pl., WC2.

10th. SERT — "Decoders and c.d.as" by L. Briggs at 19.00 at the Lecture Theatre, I.B.A., 70 Brompton Rd., SW3.

10th. AES — "EMI Records' new manufacturing complex" by R. E. Mathews at 19.15 at the IEE, Savoy Pl., WC2.

11th. IERE — "Multiphonic organs" by J. H. Asbery (with demonstration by P. Powell) at 18.00 at the Engineering Lecture Theatre, University College London, Torrington Pl., WC1.

12th. IEE — "Management for the benefit of people and enterprise" by T. Mayer at 17.30 at Savoy Pl., WC2.

12th. RTS — "Developments in television optics" by G. H. Cook at 19.00 at the I.B.A. 70 Brompton Rd., SW3.

13th. IEE — Colloquium on "Electronic circuit aspects of active filters" at 10.30 at Savoy Pl., WC2.

16th. IEE — Discussion on "Proposals for a European regional communications satellite system" at 16.00 at Savoy Pl., WC2.

16th. IEE — Discussion on "The training of technical teachers" at 17.30 at Savoy Pl., WC2.

18th. IEE — "Evolution of flight control systems" by R. W. Howard at 17.30 at The Royal Aeronautical Society, 4 Hamilton Pl., W1.

20th. IEE — "MADGE — microwave aircraft digital guidance equipment" by S. J. Robinson at 17.30 at Savoy Pl., WC2.

23rd. IEE — Discussion on "Security systems" at 17.30 at Savoy Pl., WC2.

24th. IEE — Colloquium on "Research into a new modulation system for the land mobile service" at 10.00 at Savoy Pl., WC2.

25th. I.Phys./IEE — Colloquium on "Physics of display devices" at 10.00 at Imperial College.

26th. RTS — "The total communication concept for the future" by E. J. Gargini at 19.00 at the I.B.A. 70 Brompton Rd., SW3.

## BATH

18th. IERE/IEE — "Electronics in control of main machinery" by Mr. Naysmith at 18.00 at the University, Room 2 East 3.1.

## BEDFORD

19th. IEE — "Television engineering in action" by J. E. Sewter at 19.45 at Mander College.

## BELFAST

3rd. IEE — "Applications of satellites" by R. M. Armour at 18.30 at Ashby Institute, Stranmillis Road.

## BIRMINGHAM

20th. SERT — "Registration and the engineering profession" by A. J. Kenward at 19.00 at the Byng Kendrick Suite, University of Aston, Gosta Green.

## BOLTON

12th. IERE — "Automatic landing — the instrument landing system" by J. W. B. McIlwraith at 18.15 at The Bolton Institute of Technology, Deane Rd.

## BOURNEMOUTH

3rd. IERE — "Digital voltmeter techniques" by A. S. Parkinson at 19.00 at the Technical College.

24th. IEE Grads — "Is your hi-fi up to date?" by B. J. Webb at 19.30 at Durlleston Court Hotel.

## BRIGHTON

3rd. IEE — "Innovation in a small electronics company" at 18.30 at the Polytechnic.

10th. IEE Grads — "Making electronic music" by G. Rogers at 18.30 at the Polytechnic.

## CAMBRIDGE

12th. IEE — "Trapatt Diodes — high efficiency microwave sources" by Dr J. E. Carroll at 18.30 at the University Engineering Department.

26th. IERE/IEE — "Phase locked loop techniques" by C. M. Sinclair at 18.30 at The University Engineering Laboratories, Trumpington Street.

## CARDIFF

4th. SERT — "What registration means to you" by A. J. Kenward at 19.30 at Llandaff College of Technology, Western Avenue.

11th. IERE — "Optical communication by glass fibre" by R. B. Dyott at 18.30 at the University of Wales Institute of Science and Technology.

## CHATHAM

12th. IERE — "Inertial navigation" by G. U. Rands at 19.00 at The Medway College of Technology.

## CHELMSFORD

4th. IEE — "Science in space" by W. J. Raitt at 18.30 at the King Edward VI Grammar School, Broomfield Rd.

10th. IERE — Colloquium on "A new stored programme controlled electronic switching and transmission system" at 19.30 at The Marconi Athletics and Social Club, Beehive Lane.

## COLERAINE

18th. IEE — "Applications of satellites" by R. M. Armour at 19.00 at the New University.

## ENFIELD

26th. IEE — "Concorde electronics" by H. Hill at 18.30 at Enfield College of Technology, Queensway.

## EVESHAM

17th. IERE — "Colour television display devices" at 19.30 at the B.B.C. Evesham Club.

## GUILDFORD

25th. IERE — "Fibre optic guides — the communication system of the future" by Prof. W. A. Gambling at 18.30 at the University of Surrey.

## HORNCHURCH

18th. IERE — "Electronic measurement" by M. H. W. Gall at 18.00 at Havering Technical College, Ardleigh Green Rd.

## LEICESTER

10th. IERE — "Communications and control for the East Midlands Gas Board supergrid" by P. J. Brewster and L. Walton at 18.45 at Lecture Theatre "A", Physics Block, The University.

## LIVERPOOL

4th. IEE — Colloquium on "New materials, new devices, new techniques" at The University.

11th. IERE — "Concepts of adaptive control" by Dr. B. H. Swanwick at 19.00 at the Department of Electrical Engineering and Electronics, The University.

## LOUGHBOROUGH

16th. IEE — "An assessment of university education" by Dr K. R. Sturley at 19.30 at the Edward Herbert Building, Loughborough University of Technology.

## MANCHESTER

17th. IEE — "Electronic aids for medical and biological studies" by Dr. E. T. Powner at 18.15 at Renold Building at UMIST.

19th. SERT — "Decca navigational systems" by J. Thornton at 19.30 at the Renold Building, U.M.I.S.T., Sackville St.

25th. IEE — "Electronics in education" by G. G. Atkinson at 18.15 at Renold Building, UMIST.

## MIDDLESBROUGH

31st. SERT — "Storage oscilloscopes" by J. J. Leverton at 19.30 at the Cleveland Scientific Institution.

## NEWCASTLE-ON-TYNE

4th. SERT — "Technician and technician engineer registration" by A. Mead at 19.15 at the Lecture Theatre, Charles Trevelyan Technical College, Maple Terrace.

11th. IERE — "Developments in television receiver design" by B. A. Horlock at 18.00 at the Main Lecture Theatre, Ellison Building.

11th. IEE — "Electricity reconsidered" by Prof. R. L. Russell at 19.30 at the Lecture Theatre L1.01, Merz Court, The University.

## NORWICH

25th. IERE/IEE — "A sound-in-sync system for television distribution networks" by D. Allanson at 19.00 at The Assembly House.

## PORTSMOUTH

17th. SERT — "Development of high-quality loudspeakers" by D. V. Glead at 19.00 at Highbury Technical College, Dovercourt Rd., Cosham.

## READING

19th. IERE/IEE — "Environment conserving technology" by Prof. P. B. Felgett at 19.30 at The J. J. Thomson Physical Laboratory, Whiteknights Park, The University.

## REDHILL

11th. IEE — "Radio location of vehicles" by R. W. Gibson at 19.30 at Mullard Research Laboratories.

## RUGBY

25th. IEE — "Telecommunications — grass root prospectus" by A. R. Belson at 18.15 at Lanchester Polytechnic.

31st. IEE Grads — "The development of outside broadcasting" by W. Berry at 18.15 at Lanchester Polytechnic.

## SHEFFIELD

10th. IEE Grads — "Opto-electronics" by J. M. Wright at 19.30 at the University.

## SOUTHAMPTON

18th. IERE — "Value for money" by T. G. Clark at 18.30 at Lanchester Theatre, The University.

## SWANSEA

25th. IERE/IEE — "Instrumentation for road safety" by D. J. Jeffery at 18.30 at the Department of Applied Science, University College.

## SWINDON

3rd. IERE/IEE — "Developments in micro-electronics" by D. R. Hester at 18.15 at The College, Regent Circus.

## WOLVERHAMPTON

18th. IERE — "European communication satellites" by I. V. Franklin at 19.15 at R.A.F. Cosford, Albrighton.

# Real and Imaginary

by "Vector"\*

## Crisis in the West

If you live in the U.K. you may have noticed that in recent years several electronics plants of quite considerable dimensions have gone into production in the West Country, on both sides of the River Tamar. This has been widely applauded as bringing light industry into areas where it is needed, but I was never quite sure that it was the real motive, and I'll tell you why.

You may remember that in the August issue I described electronics as a Vicar of Bray industry, following in the wake of events. But in the case of the West of England what were the events it was following? On the face of it, there were none; this puzzled me and I determined to investigate. Well for England that I did so! My friends, we are tottering blindfold on the brink of disaster, as you will appreciate when my tale is done. But first, a little background for those readers who have never experienced the joys of the Exeter by-pass but have to make do with Bermuda or Florida for their annual hols.

Those of you who are students of history will not need to be told that relations between Devon and Cornwall have, from time immemorial, been poor. Saxons and Celts never did get along together anyway, but the real stumbling block is that Devon fishermen devoutly believe that all waters bounded by Portland Bill to the east and Eire to the west were created by the Almighty expressly for their sole benefit. Unfortunately this tenet is also held by the Cornish, so a certain lack of cordiality is inevitable. Then, in more recent years, the tourist trade has become a vital factor in both economies and therefore a further bone of contention. Last summer's crisis, when it was discovered that certain unscrupulous Birmingham manufacturers were providing identical genuine olde brasse pixies to both sides, is still a raw wound. It is rumoured that on that occasion hothead Devonian guerrillas were only just prevented from cutting an extension from the river Tamar through to the northern coastline, thereby isolating Cornwall completely, in the pious hope that it would drift away, or better still, sink. So much, then, for the past. Today's ominous news, which I reveal exclusively to W.W. readers, is that the Devon County Council's Dept of Research has successfully detonated a nuclear device. At this juncture you will demand to know why not a word has appeared in the dailies about this. It's because the British Government, for reasons which I'll disclose later has slapped D-notices around, right, left and centre. Indeed, even within top government circles, every effort is being made

to minimize the significance of the experiment. In a top secret memorandum which one of my fellow investigators found lying in St James's Park, weighted down by a lady's powder compact, the exalted writer (who must be nameless) is at pains to point out that "there is, of course, a vast difference between the first test of a crude device and the final emergence of the country as a major nuclear power".

Slighting comments such as these will not, I fear, stand up to close scrutiny. First, it must not be forgotten that in the person of Sir Tom Cobley, Chief Scientist of the Devon Dept of Research, the county possesses a brain of the first (and the heaviest) water. Backed as he is by the formidable team of Brewer, Stewer, Gurney, Davey, Whiddon, Hawke *et al*, — all geniuses in their own right — the British memorandum is clearly eye-wash.

Secondly, we must remember that Devon is peculiarly rich in fissionable materials. While nothing positive is known of the *modus operandi* of the device, it is practically certain that the core of the weapon is a special distillation of rough cyder, in itself a highly fissionable material.

There are many ways in which this devil's brew could be triggered. One possibility is that it is contained in a tube-filled metal receptacle (in layman's language a kind of mechanical stomach). If then an admixture of clotted cream, rhubarb, squab pie and junket be injected at high pressure into the distilled cyder, a chain reaction of extreme violence would occur, resulting in complete fission. This fact has been known for a long time; the practical snag has always been that no known metal is capable of resisting the corrosive properties of the cyder for any significant length of time. Manifestly, Sir Tom and his colleagues have somehow achieved a major breakthrough.

But let no one delude himself that Cornwall is governing helplessly at the feet of the aggressor. True, less is known about the Cornish military machine. There are reports of electronically controlled sharks cruising just outside Brixham harbour. Could they, one wonders, be in any way connected with the mysterious atrocities known to be afoot behind the heavily guarded walls of the Cornish Q-port of Fowey?

Be all this as it may, it certainly brings the presence of those electronics factories on either side of the border into perspective and, moreover, with sinister undertones. They are not, as we have been led to suppose, turning out hordes of miniature transistor radio receivers for sale to adoles-

cent foreigners east of the Somerset border, but are clearly dedicated to the manufacture of secret weapons against the time when Der Tag dawns.

With this in mind, the jigsaw begins to come together. Every visitor to the border country between Devon and Cornwall must have noticed the grotesquely elaborate aerials which surmount every building. Official publicity handouts blandly describe these as high-gain arrays for television reception in black-spot areas but — I wonder? Frequency-swept radar perhaps? And again, every one of us must, at one time or another, have wandered through the maze of passages that comprise a West-country hostelry in a vain search for the usual offices, only to be confronted at some point by a massive door marked "PRIVATE". Heaven only knows what terribly sinister electronic equipment lurks behind those locked portals.

Mercifully, up to the time of writing, the hostilities have been confined to commando raids and to skirmishes between squadrons of radio-controlled tractors which foray nightly from secret establishments known as "varmz". Nevertheless, I can reveal that extensive damage has been done. The mammoth pasty foundries at Doublebois have been wrecked while, on the other side of the coin, the vast plastic heater factory at Newton Abbot, which formerly supplied the entire needs of Devon's tourist trade, is gutted.

The actions and reactions of the British Government in this matter are, as always, devious in the extreme. My information is that its strategy is tied up with the expected arrival of a large number of immigrants. The master plan is to settle them along a strip of no-man's-land between Devon and Cornwall to act as a neutral buffer state whose territory may not be violated.

This, as Mr Stanley Unwin would say, is deep folly. What is far more likely to happen is that the belligerents will temporarily patch their differences, annihilate the settlers and set their radio-controlled tractors hurtling Londonwards to free the oppressed West of England from the foreign yoke. Even before this is in print, Chipping Sodbury may be in the front line. England, beware!

While not expecting any reward from a grateful country for alerting it to its danger, I did think that the Editor would honour my modest expense account for my on-the-spot investigation. I regret to have to tell you he did not.

\* Under the influence of rough scrumpy, I suspect. Ed.